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3.0 HYDRAULICS

This section describes the methodology and results of the hydraulic analysis performed for the Jimmy Camp Creek drainage basin. The open channel hydraulic models were prepared using the USACE HEC-RAS modeling software, version 6.3. In addition to the hydraulic analysis of open channels, existing storm sewer trunk lines 60-inches in diameter and greater were analyzed for hydraulic capacity.

3.1 PURPOSE OF HYDRAULIC ANALYSIS

The purpose of the hydraulic analysis for the Jimmy Camp Creek DBPS was to identify existing and future deficiencies in major drainageways and large storm sewer trunk lines within the Jimmy Camp Creek Drainage Basin. The hydraulic analysis aimed to document existing hydraulic deficiencies to identify the need for future feasible stormwater and flood control solutions.

Another goal of the hydraulic analysis was to identify locations where the existing conditions 100-year floodplain differs significantly from the effective FEMA floodplain shown on the Flood Insurance Rate Maps (FIRMs). The existing conditions 100-year floodplain was delineated from the hydraulic model results and compared to the regulatory floodplain to identify areas of inconsistency.

3.2 FLOOD HISTORY

According to the effective FEMA Flood Insurance Study (FIS), dated December 7, 2018, most of the flood producing storms in the study area occur from May through August and are most intense in late spring or early fall when polar air intrusions are more intense (FEMA, 2018). The available flood history for El Paso County (EPC) is almost exclusively concerned with the large-scale flooding of Fountain Creek or Monument Creek in urbanized areas. While flooding on smaller streams in the vicinity most likely simultaneously occurred, references to flooding on these smaller streams appeared only rarely in newspaper accounts until recently.

The FIS does note that downstream of the confluence where Jimmy Camp Creek meets Fountain Creek, the June 1965 flood event likely exceeded all known floods in EPC. This flood was caused primarily by Jimmy Camp Creek. Approximately 4.5 miles upstream of the Jimmy Camp Creek and Fountain Creek confluence, the estimated peak discharge was 124,000 cfs, which is estimated to be a recurrence interval far exceeding 500 years (FEMA, 2018). Additionally, according to the Pikes Peak Regional Building Department records, a Jimmy Camp Creek flood washout on July 21, 1972 caused $50,000 worth of damage to roads and bridges (Pikes Peak Regional Building Department, 2018).

3.3 HYDRAULIC MODEL REACH NAMING

The reach naming convention used within the HEC-RAS model is based on seven branches of Jimmy Camp Creek, identified as Jimmy Camp, West Fork, East Fork, Franceville, Stripmine, Corral, and Blaney. For reach naming purposes, the 7 branches were abbreviated to J, W, E, F, S, C, and B, respectively. Each reach name begins with the branch letter followed by a number, starting from the most downstream reach and increasing in the upstream direction. For example, J5 refers to reach 5 of the Jimmy Camp Creek channel. The reach names are shown in Figure 3-1.

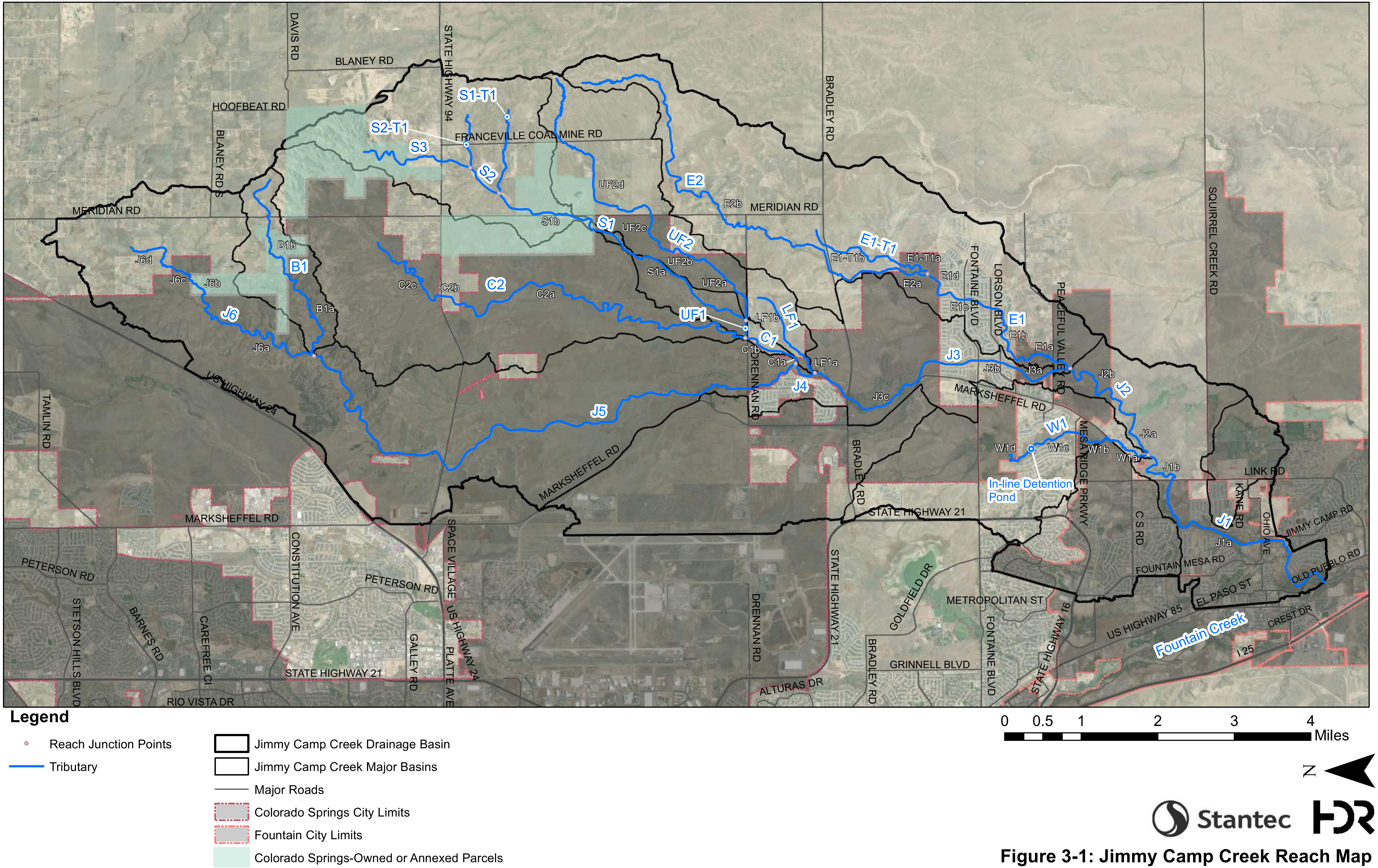


Figure 3-1: Jimmy Camp Creek Reach Map

Coordinate System: NAD 1983 StatePlane Colorado Central FIPS 0502 Feet

3.4 REACH DELINEATION

3.4.1 Included Drainageways

The major drainageways include the main stem of Jimmy Camp Creek, Blaney Tributary, West Fork Tributary, East Fork Tributary, Franceville Tributary, Stripmine Tributary, and Corral Tributary. Two smaller side branches of Stripmine Tributary and one side branch of East Fork Tributary were also included in the model.

Channel centerlines were developed from the waterline GIS shapefile data provided by EPC and the 2018 LiDAR-based Digital Elevation Model (DEM) data collected by the State of Colorado and obtained through the City of Colorado Springs. The centerlines from the original data files were adjusted to more closely follow the stream thalweg reflected in the 2018 DEM data as well as more current aerial photography. The extents of the channel centerlines were compared to flowlines in the National Hydrography Dataset (NHD). Based on this comparison, the centerlines for all the reaches in the upstream end of the drainage basin (J6, B1, C2, S3, UF2, and E2) were extended up to 10,000 feet further upstream where the DEM and aerial imagery indicated well defined channels.

Drainageways in the Jimmy Camp Creek basin run through unincorporated EPC, the City of Colorado Springs, and the City of Fountain. Table 3-1 lists all the modeled reaches, their total length, and the reach length that lies within unincorporated EPC, which is the focus of this study. Some reaches (J4, J5, and UF1) are entirely outside of the unincorporated EPC boundaries.

Franceville Tributary is split into two parts at Drennan Road, Upper (UF) and Lower (LF) Franceville. A buried culvert at Drennan Road disconnects the historic flow path and prevents Lower Franceville from receiving flows from Upper Franceville unless the flow overtops the road. The buried culvert is owned by the City of Colorado Springs and is assumed to remain non-functional and is not represented in the hydraulic model. The hydraulic model does not show flows in Upper Franceville overtopping Drennan Road. All discharge from Upper Franceville is routed westward along the north side of Drennan Road to the Corral Tributary. The Corral Tributary then crosses Drennan Road and runs south for approximately 0.8 miles to the main stem of Jimmy Camp Creek. Lower Franceville joins the main stem of Jimmy Camp Creek a short distance downstream, approximately 1.2 miles south of Drennan Road.

The effective FIS does show flows in Upper Franceville overtopping Drennan Road and continuing downstream in Lower Franceville, which runs along the east side of the Pikes Peak National Cemetery (PPNC). As of September 2023, there is a LOMR in process for the improved Lower Franceville channel that PPNC constructed to alleviate flooding on the site. Since it is based on the effective FIS, the LOMR assumes that Lower Franceville receives flows from Upper Franceville.

Table 3-1. Major Drainageway and Reach Length Summary

Drainageway	Reach ID	Total Reach Length [miles]	Unincorp. EPC Reach Length* [miles]
Jimmy Camp Creek	J1	4.3	0.8
	J2	2.3	1.2
	J3	4.0	1.0
	J4	0.4	0.0
	J5	8.4	0.0
	J6	4.0	0.9
Blaney	B1	3.2	0.9
Corral	C1	0.8	0.7
	C2	7.3	0.3
Lower Franceville	LF1	1.5	1.2
Upper Franceville	UF1	0.2	0.0
	UF2	5.4	3.4
Stripmine	S1	4.0	0.3
	S2	0.5	0.5
	S3	1.8	0.9
Stripmine South Tributary	S1-T1	1.2	1.2
Stripmine North Tributary	S2-T1	0.8	0.8
East Fork	E1	2.9	1.8
	E2	7.3	6.8
East Fork Tributary	E1-T1	2.0	1.5
West Fork	W1	2.4	1.7
TOTAL		64.9	26.0

*Unincorporated EPC reach length does not include parcels owned or annexed by Colorado Springs

3.4.2 Excluded Drainageways

3.4.2.1 Marksheffel Tributary

The Marksheffel Tributary sub-basin was included in the hydrologic analysis but the drainageway is not included in the hydraulic analysis because the main channel lies entirely within the City of Colorado Springs.

3.4.2.2 C&S Tributary

The C&S Tributary sub-basin was included in the hydrologic analysis but the drainageway is not included in the hydraulic analysis because the main channel lies entirely within the City of Fountain.

3.4.2.3 Ohio Tributary

The Ohio Tributary sub-basin was included in the hydrologic analysis but the drainageway is not included in the hydraulic analysis because the main channel lies entirely within the City of Fountain.

3.4.2.4 Chilcotte Canal Number 27

Chilcotte Canal Number 27 is an agricultural irrigation canal located in the City of Fountain. It runs generally north to south on the east side of Jimmy Camp Creek near Ohio Avenue before continuing south and leaving the basin. The canal has a negligible effect on drainage and is not included in either the hydrologic or hydraulic analysis.

3.4.2.5 Fountain Ditch

Fountain Ditch is a 35-mile water canal system including open ditch and piped sections that diverts water from Fountain Creek and runs through Colorado Springs, El Paso County, and the City of Fountain, which irrigates approximately 2,000 acres of land. Fountain Ditch has been owned and operated by Fountain Mutual Irrigation Company (FMIC) since the late 1880's. Within the Jimmy Camp Creek drainage basin, Fountain Ditch is approximately 14 miles long.

Over the years several development projects occurred in the vicinity of Marksheffel Road and Fontaine Boulevard where Fountain Ditch historically laid. Based on the drainage plan review of development projects in the area, Fountain Ditch receives no apparent stormwater discharge from existing developments except Cottonwood Meadows, which consists of approximately 46.2 acres of land bounded by Fontaine Boulevard to the south, Marksheffel Road to the east, and undeveloped land to the north and west. Per the approved *Final Drainage Report Cottonwood Meadows Filing No. 1* dated October 1999, FMIC's Drainage District accepts historic runoff within the existing irrigation ditch and maintains ditch improvements adjacent to Cottonwood Meadows Filing No. 1 and Jimmy Camp Creek. Fountain Ditch was included in the hydrologic analysis but is not included in the hydraulic analysis.

3.5 CROSS SECTIONS

The hydraulic model contains 65 miles of channel center lines and 22 roadway crossings. Approximately 26 miles of channel and 16 roadway crossings are within unincorporated EPC. The remainder lie within the City of Colorado Springs or the City of Fountain. Hydraulic model cross sections were placed at a maximum 400 feet spacing along each of the channel reaches that are within unincorporated EPC. Reaches that are within the City of Colorado Springs and the City of Fountain were not modeled in detail. All reaches within unincorporated EPC lie upstream of city reaches. At each location where a reach enters unincorporated EPC from one of the cities, at least 4 cross sections were placed downstream of the County boundary so that the hydraulic model could stabilize and establish a downstream water surface elevation for the County reach. This methodology is acceptable because the existing channel slopes are generally too steep to maintain a subcritical flow regime over an extended distance and the model frequently defaults to critical depth. At each location (11 in total) where a reach enters unincorporated EPC from one of the cities, no obvious flow constrictions were found in the downstream reach that would cause backwater conditions in the upstream reach.

The effective 100-year FEMA floodplain delineation was used as a guide to determine an approximate width of each cross section with widths extending at least 50 feet outside of the FEMA designated floodplain. Additional cross sections were placed at all major hydraulic controls, including drop structures, bridge and culvert crossings, and areas with significant change in channel geometry or slope.

3.5.1 Bridge and Culvert Cross Sectional Placement

Bridge and culvert crossings were modeled per guidance found in the *HEC-RAS 6.0 Hydraulic Reference Manual*. A total of four cross sections were placed at each bridge and culvert crossing in the model as shown in Figure 3-2. Per HEC-RAS guidance, the first cross section was placed at a location downstream of the bridge or culvert where the constricted flow from the crossing has fully expanded to the typical channel width (Cross Section 1, as shown on Figure 3-2). The distance downstream of the bridge or culvert varied depending on the degree of the constriction and the characteristics of the flow in that area. The flow transition line was drawn from the downstream edge of the bridge or culvert opening using an expansion ratio (ER) to help identify the location of the first cross section. These expansion ratios varied from 1:1 to 2:1. The expansion ratio was based on channel slope, degree of constriction, and ratio of overbank to channel roughness.

The second cross section was placed a short distance downstream from the crossing to represent the natural ground downstream of the bridge or culvert (Cross Section 2, as shown on Figure 3-2). This cross section was typically placed near the toe of the roadway embankment, as recommended in the HEC-RAS manual.

The third cross section was placed a short distance upstream from the crossing to represent the natural ground upstream of the bridge or culvert (Cross Section 3, as shown on Figure 3-2). This cross section was typically placed near the toe of the roadway embankment, as recommended in the HEC-RAS manual.

The fourth cross section for each bridge and culvert crossing was placed at a point far enough upstream of the crossing to represent the full channel width before flow contracts through the crossing (Cross Section

4, as shown in Figure 3-2). Similar to the first cross section, the fourth cross section was placed utilizing a flow transition line based upon a contraction ratio (CR) of 1:1, based upon guidance in Appendix B of the HEC-RAS manual. Flow transitions occur in a shorter distance when contracting as opposed to expanding, which is reflected in the fourth cross section as it is located closer to the modeled crossing than the first cross section.

A similar approach was used to model each of the drop structures. Cross sections were placed at the crest and toe of the drop structure and additional cross sections were placed a sufficient distance upstream and downstream.

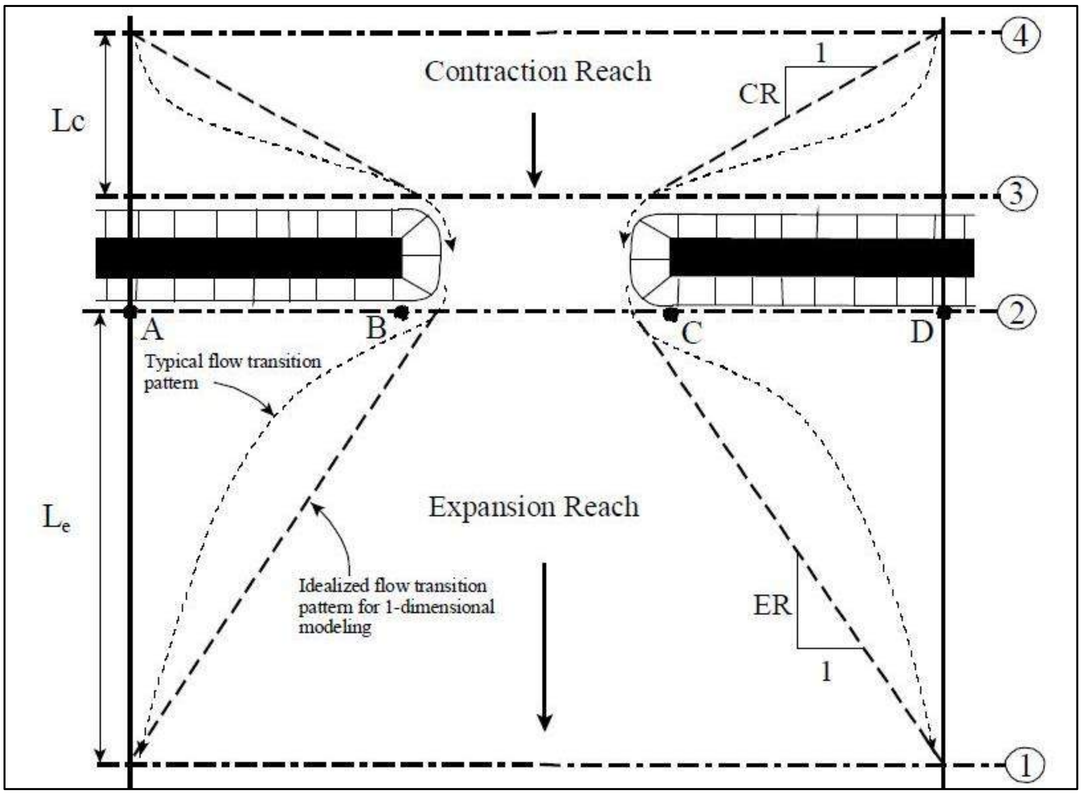


Figure 3-2. Cross Section Locations for Hydraulic Crossings

3.5.2 Manning's n Values

The 2016 National Land Cover Database (NLCD) was used to create a Land Use overlay for specifying channel and overbank roughness (Manning's n values) in the hydraulic model. The NLCD was used as a starting point and then initial assessments were verified using aerial photography. The Land Use overlay layer was used to provide roughness values on the model overbanks. Roughness values were assigned to the channel between the model bank stations.

Six channel conditions and 6 overbank conditions were selected to provide a range of representative land cover conditions within the study area. A Manning's n value was assigned to each of the 12 land cover conditions. These values were based on the El Paso County Drainage Criteria Manual (DCM) (2014),

Hydraulics

Colorado Springs DCM Volume 1 (2021), *Open-Channel Hydraulics* by Ven Te Chow (1959), and equations found in the Urban Storm Drainage Criteria Manual (USDCM) (2018). Table 3-2 shows typical roughness values for natural channels from the HEC-RAS *Hydraulic Reference Manual* that are excerpted from Chow's *Open-Channel Hydraulics*. Table 3-3 and Table 3-4 list the 12 land cover conditions and associated Manning's n values used in the model as well as the source and assumptions.

Table 3-2. Typical Manning's n Values for Natural Channels

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. **Main Channels**			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. **Flood Plains**			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200
3. **Mountain Streams, no vegetation in channel, banks usually steep, with trees and brush on banks submerged**			
a. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. Bottom: cobbles with large boulders	0.040	0.050	0.070

Source: USACE, HEC-RAS Hydraulic Reference Manual, Version 6.0, December 2020, Excerpt of Table 3-1.

Table 3-3. Hydraulic Modeling Manning's n Values for Channels

Description	**"n" Value**	**Source/Assumptions**
Sand-Silt	0.032	Colorado Spring DCM Table 12-2 and USDCM Table 8-5
Vegetated Streambed, light to medium	0.040	Colorado Springs DCM Table 12-2
Vegetated Streambed, medium to dense	0.060	Colorado Springs DCM Table 12-2
Boulder Drops	0.070	USDCM Figure 9-3 (Using approximate values)
Riprap Lining	0.040	Average roughness value of riprap. Based on USCDM equation $n=0.0395\ D_{50}^{1/6}$
Concrete Lining	0.013	Open-Channel Hydraulics

Table 3-4. Hydraulic Modeling Manning's n Values for Overbanks

Description	**"n" Value**	**Source/Assumptions**
Scattered Brush, heavy weeds	0.050	Open-Channel Hydraulics
Light brush and trees	0.060	Open-Channel Hydraulics
Medium to dense brush	0.100	Open-Channel Hydraulics
Short grass pasture	0.030	Open-Channel Hydraulics
Residential	0.100	Value to include obstructions of residential lots in lieu of creating blockages, HEC-RAS 5.0 2D Modeling User's Manual
Pavement	0.016	Open-Channel Hydraulics

Aerial photographs were used to estimate channel conditions in order to assign Manning's n values between the model bank stations. The following figures show examples of aerial images for the 4 channel conditions found in the drainageways in the hydraulic model ("sand-silt", "vegetated streambed, light to medium", "vegetated streambed, medium to dense", and "boulder drops"). The majority of the modeled drainageways are either "sand-silt channel" or "vegetated streambed, light to medium".

Figure 3-3. Representative Image of Sand-Silt Channel, n = 0.032

(located on Corral Tributary, reach C2)

Figure 3-4. Representative Image of Vegetated Streambed, Light to Medium, n=0.040

(located on Jimmy Camp Creek, reach J3, downstream of Lorson Ranch)

Figure 3-5. Representative Image of Vegetated Streambed, Medium to Dense, n=0.060

(located on Jimmy Camp Creek, reach J2, near Bonnie Cap Lane)

Figure 3-6. Representative Image of Boulder Drop, n=0.070

(located on Jimmy Camp Creek, reach J3, in Lorson Ranch)

3.5.3 Bank Stations

Once the channel centerline station and elevations were obtained from the DEM, bank stations were assigned. The bankfull channel is the deepest part of a cross section and often has a lower roughness value than the vegetated overbank terraces. In much of the Jimmy Camp Creek drainage basin, there is often a lack of a defined low flow channel, a common observation in sandy systems. Therefore, to have a consistent basis, model bank stations were set at the existing conditions 5-year water surface elevation.

3.5.4 Contraction and Expansion Coefficients

Contraction and expansion coefficients were assigned to each cross section based on transitions in cross sectional geometry. Typically, cross sections along the open channel sections of a reach have gradual transitions and contraction and expansion coefficients of 0.1 and 0.3 respectively. At bridge and culvert sections, where the transition is usually more abrupt, higher contraction and expansion values of 0.3 and 0.5, respectively, were used.

3.5.5 In Line Detention Ponds

As described in the Hydrology section, there are multiple detention ponds that are modeled in the SWMM hydrology model. Only one of these ponds is on a reach that is included in the HEC-RAS hydraulic model, on the West Fork upstream of Mesa Ridge Parkway. Only the dam embankment is included in the hydraulic model. The outfall structure of the pond was not included since the pond is included in the hydrology model. Cross sections were placed in the pond reach to model the general flow pattern through the pond. Flow rates upstream and downstream of the pond were taken from the hydrology model. The location of the in-line detention pond is shown on Figure 3-1.

3.6 HYDRAULIC STRUCTURE DATA AND INVENTORY

Data that was used to input bridge and culvert crossings into the model came from a variety of sources. Construction plans were utilized when available since they contain the most detailed information. Construction plans were located for 9 of the 22 roadway crossings in the hydraulic model. The plans were obtained from El Paso County Development Review and CDOT Staff Bridge archives. For the other crossings, where construction plans were not available, structure information was obtained from the CDOT Off-System Bridge Inspection database, EPC GIS data, or field measurements performed by Stantec or EPC.

The source of the information for each bridge or culvert structure is noted in the “Source of Data” column in Table 3-7. Jimmy Camp Creek Structure Evaluation Summary. The roadway elevations at bridges and culverts were taken directly from the DEM. The culvert invert elevations were set to match the DEM channel elevation unless more accurate elevation data was available. Structure overtopping is discussed in Section 3.9, Hydraulic Deficiencies.

3.7 FLOW DATA AND BOUNDARY CONDITIONS

Flow rates for the hydraulic model were obtained from the SWMM hydrologic model. Flow rates were input for the 2, 5, 10, 25, 50, and 100-year storm events. The 100-year storm event was used to identify hydraulic deficiencies and delineate floodplains. Floodway modeling was not included in the hydraulic analysis. Selected SWMM design points along major drainageways were used as flow change locations in the HEC-RAS model. There was no interpolation of calculated flows between SWMM design points.

The HEC-RAS model utilized a 1D steady flow regime in subcritical flow mode. The downstream boundary condition was based on Fountain Creek water surface elevations shown in the FIS flood profiles at the confluence with Jimmy Camp Creek. For storm events not evaluated in the FIS, such as the 2-year and 5-year storm events, the normal depth at the channel slope was used as the downstream boundary condition. The 25-year storm event was also not analyzed in the FIS study, therefore the 10-year water surface elevation in Fountain Creek was used as the downstream boundary condition for the 25-year storm event.

The size of the Fountain Creek drainage area is significantly larger than the Jimmy Camp Creek drainage area, therefore it was necessary to consider the coincidental probability of a given storm recurrence interval occurring at the same time in each drainage basin to select the appropriate downstream boundary water surface elevation in Fountain Creek. The Federal Highway Administration (FHWA) HEC-22 manual gives some guidance on selecting appropriate storm frequencies when two drainage basins are different in size. Table 3-5 shows the table from HEC-22 that correlates storm frequencies for coincidental occurrence based on the area ratio of the drainage basins.

In this case, the Jimmy Camp Creek drainage basin is approximately 61 square miles, while the Fountain Creek drainage basin at the confluence with Jimmy Camp Creek is approximately 606 square miles. This is an approximately 10 to 1 size difference between the basins. According to HEC-22, the 10-year storm is coincident in both basins, however, a 100-year storm at Jimmy Camp Creek corresponds to a 50-year storm at Fountain Creek. Table 3-6 lists the FIS water surface elevation at Fountain Creek for each storm event as well as the downstream boundaries used in the HEC-RAS model.

Table 3-5. Storm Frequencies for Coincidental Occurrence from HEC-22

Area Ratio	Frequencies for Coincidental Occurrence			
	10-Year Design		100-Year Design	
	Main Stream	Tributary	Main Stream	Tributary
10,000 to 1	1 10	10 1	2 100	100 2
1,000 to 1	2 10	10 2	10 100	100 10
100 to 1	5 10	10 5	25 100	100 25
10 to 1	10 10	10 10	50 100	100 50
1 to 1	10 10	10 10	100 100	100 100

Source: FHWA, Hydraulic Engineering Circular No. 22, Third Edition, August 2013, Table 7-3.

Table 3-6. Jimmy Camp Creek Downstream Boundary Conditions

Storm Event	Fountain Creek Water Surface Elevation (WSEL)	Model Downstream Boundary Condition
2-Year	N/A	Normal Depth at Channel Slope
5-Year	N/A	Normal Depth at Channel Slope
10-Year	5499.3	5499.3 (10-Year Fountain Creek WSEL)
25-Year	N/A	5499.3 (10-Year Fountain Creek WSEL)
50-Year	5502.5	5502.5 (50-Year Fountain Creek WSEL)
100-Year	5503.1	5502.5 (50-Year Fountain Creek WSEL)

3.8 HYDRAULIC MODELING RESULTS SUMMARY

The HEC-RAS model results are shown in the hydraulic data tables included in Appendix X. Large format hydraulic exhibit maps are included as an attachment to this report.

Comparison of the existing conditions 100-year floodplain with the regulatory FEMA floodplain shows that in general, the existing conditions floodplain is smaller than the regulatory FEMA floodplain. This is primarily because the flow rates from the SWMM hydrologic model are lower than the flow rates shown in the FIS, as discussed in the Hydrology section.

Another reason for differences between the existing conditions 100-year floodplain and the regulatory FEMA floodplain is the updated topographic mapping used for this study. LiDAR-based DEM data prepared in 2018 was used for this study. The FIS states that the regulatory FEMA floodplain for Jimmy Camp Creek and its tributaries is based on topographic mapping prepared from aerial photographs taken by the Soil Conservation Service (SCS) in 1973. The effective floodplain boundaries are based on 2 reports, a 1973 USACE Flood Plain Information Report, and a 1975 SCS Flood Hazard Analysis. The FIS bibliography references are listed below:

- U.S. Department of Agriculture, Soil Conservation Service, Colorado Water Conservation Board, Flood Hazard Analyses, Portions of Jimmy Camp Creek and Tributaries, El Paso County, Colorado, October 1975.
- U.S. Department of the Army, Corps of Engineers, Albuquerque District, Flood Plain Information, Fountain and Jimmy Camp Creeks, Colorado Springs. Fountain, El Paso County, Colorado, March 1973.

On the East Fork Tributary, reach E2 and side tributary E1-T1 run through a wide, relatively flat valley with no defined channel and many shallow drainage paths. This drainage pattern begins north of Bradley Road and continues south of Bradley Road. Additionally, a portion of the Upper Franceville Tributary downstream of Franceville Coal Mine Road exhibits the same shallow, undefined drainage pattern. Both areas are shown on Figure 3-8. It is difficult to accurately model flow paths in this type of terrain with a one-dimensional hydraulic model. The floodplain has been delineated to include all of the area that could be inundated by meandering flows. The floodplain extents are similar to the regulatory FEMA floodplain.

There are 2 areas where the existing conditions floodplain significantly exceeds the regulatory FEMA floodplain:

- West Fork Tributary upstream of Mesa Ridge Parkway
- Jimmy Camp Creek at Peaceful Valley Road

Upstream of Mesa Ridge Parkway, the West Fork Tributary has been channelized and runs through an inline detention pond adjacent to The Glen at Widefield residential development. It is unknown how the design criteria used for the detention pond compares to those used for this study. The hydraulic model shows that the inline detention pond overtops to the east. The one-dimensional hydraulic model cannot quantify the amount of overtopping flow or the extents of inundation, so the floodplain has been drawn to include all of the area that possibly could have areas of shallow flow or ponding from the overtopping flow.

At Peaceful Valley Road, Jimmy Camp Creek overtops the roadway and also overtops a low point on the west bank approximately 600 feet upstream the road. The floodplain on the west side of the creek has been drawn to include all areas that could be inundated by shallow flow or ponding from the overtopping flow.

3.9 HYDRAULIC DEFICIENCIES

Hydraulic deficiencies were identified that include channel stability concerns, overtopped roadway crossings, and large diameter storm sewer surcharges. This section describes how these deficiencies were determined and where they are located in the drainage basin.

3.9.1 Overtopped Roadway Crossings

The hydraulic model contains 22 roadway crossings. Sixteen of these are within unincorporated EPC. The remainder are located within the City of Colorado Springs or the City of Fountain. Roadway crossings overtopped by the 100-year storm were defined as deficiencies. The hydraulic model was used to determine which crossings are overtopped by the 100-year flood. Crossings are labeled as deficient if any part of the modeled roadway is overtopped, even if the roadway low point is not located directly above the structure. Table 3-7 summarizes the hydraulic analysis results for all 22 roadway crossings included in the hydraulic model.

Table 3-7. Jimmy Camp Creek Structure Evaluation Summary

Drainage	Reach Name	Location	Structure Description	Source of Data	Existing 100-Year (cfs)	Future 100-Year (cfs)	Existing Structure Capacity	Future Structure Capacity	Jurisdiction
Jimmy Camp	J1	Ohio Ave.	4 Span Bridge	Bridge Inspection Sketch	8,719	30,363	Adequate	Adequate	City of Fountain
Jimmy Camp	J1	Link Rd.	3 Span Bridge	Bridge Inspection Sketch	7,990	29,627	Adequate	Overtopped	City of Fountain
Jimmy Camp	J3	Peaceful Valley Rd.	4 - 30" CMP	EPC field data	7,241	26,990	Overtopped	Overtopped	City of Fountain
Jimmy Camp	J3	Lorson Blvd.	2 Span Bridge	Construction plans	7,241	26,990	Adequate	Adequate	El Paso County
Jimmy Camp	J3	Fontaine Blvd.	2 Span Bridge	Construction plans	7,241	26,990	Adequate	Adequate	El Paso County
Jimmy Camp	J3	Bradley Rd.	3 Span Bridge	Construction plans	6,570	22,100	Adequate	Adequate	City of Colorado Springs

Drainage	Reach Name	Location	Structure Description	Source of Data	Existing 100-Year (cfs)	Future 100-Year (cfs)	Existing Structure Capacity	Future Structure Capacity	Jurisdiction
West Fork	W1	Furlong Cir.	54" CMP	EPC GIS data	141	156	Overtopped	Overtopped	El Paso County
West Fork	W1	Ingle Ln.	2 - 36" CMP	EPC GIS data	141	156	Overtopped	Overtopped	El Paso County
West Fork	W1	Marksheffel Rd.	24" RCP	Stantec field data	141	156	Overtopped*	Overtopped*	City of Fountain
West Fork	W1	Mesa Ridge Pkwy.	2 Span Bridge	1-sheet construction drawing	1,183	2,833	Adequate	Adequate	El Paso County
Corral	C1	Drennan Rd.	2 Span Bridge	Bridge Inspection Sketch	4,876	11,591	Adequate	Adequate	City of Colorado Springs
Corral	C2	SH-94	1-11'x14' + 2-11'x10' CBC	Construction plans	2,720	4,475	Adequate	Adequate	El Paso County

Drainage	Reach Name	Location	Structure Description	Source of Data	Existing 100-Year (cfs)	Future 100-Year (cfs)	Existing Structure Capacity	Future Structure Capacity	Jurisdiction
Stripmine	S3	SH-94	2-12'x12' CBC	Construction plans	2,206	2,435	Adequate	Adequate	El Paso County
Stripmine South Tributary	S1-T1	Franceville Coal Mine Rd.	Single Span Bridge	EPC provided data	268	828	Adequate	Adequate	El Paso County
Stripmine North Tributary	S2-T1	Franceville Coal Mine Rd.	3 – 60” RCP	EPC provided data	617	1,155	Adequate	Overtopped	El Paso County
Upper Franceville	UF2	Franceville Coal Mine Rd.	2 - 36" CMP	EPC GIS data	182	561	Overtopped*	Overtopped*	El Paso County
East Fork	E1	Lorson Blvd.	48' wide Conspan concrete arch culvert	Construction plans	1,830	3,673	Adequate	Adequate	El Paso County
East Fork	E1	Fontaine Blvd.	48' wide Conspan concrete arch culvert	Construction plans	1,272	3,077	Adequate	Adequate	El Paso County

Hydraulics

Drainage	Reach Name	Location	Structure Description	Source of Data	Existing 100-Year (cfs)	Future 100-Year (cfs)	Existing Structure Capacity	Future Structure Capacity	Jurisdiction
East Fork Tributary	E1-T1	Bradley Rd.	2 - 66" RCP	Construction plans	424	779	Overtopped*	Overtopped*	El Paso County
East Fork	E2	Bradley Rd.	2 - 8'x12' CBC	Construction plans	601	2,187	Adequate	Adequate	El Paso County
East Fork	E2	Drennan Rd.	2 Span Bridge	Bridge Inspection Sketch	488	1,605	Adequate	Adequate	El Paso County
East Fork	E2	Meridian Rd.	2 - 36"x48" HERCP + 2 - 36" RCP	EPC GIS data	507	2,049	Overtopped*	Overtopped*	El Paso County

Notes:

* Hydraulic model shows overtopping but headwater can also be diverted away from crossing in roadside ditch. More detailed modeling is required to assess conditions at the crossing.

CMP = Corrugated Metal Pipe

RCP = Reinforced Concrete Pipe

CBC = Concrete Box Culvert

HERCP = Horizontal Elliptical Reinforced Concrete Pipe

3.9.2 Storm Sewer Surcharges

Existing storm sewer trunk lines 60-inches in diameter and greater were analyzed for hydraulic capacity. There are 3 locations within the study area that contain existing large diameter storm sewer pipes. The locations are shown in Figure 3-7**Error! Reference source not found.**. The analysis of the sewer trunk lines was completed using the Bentley FlowMaster program. Deficiencies were defined as pipe capacities insufficient to contain the 100-year flow without surcharging. None of the pipelines analyzed had adequate capacity. Table 3-8 shows the results of the large storm sewer evaluation.

Figure 3-7. Jimmy Camp Creek Storm Sewer Locations

Table 3-8. Jimmy Camp Creek 60" Storm Sewer Evaluation

Description	Material	Shape	Size (in)	Existing 100-YR (cfs)	Future 100-YR (cfs)	Max Capacity (cfs)	Existing Structure Capacity	Future Structure Capacity
Fontaine Blvd (Old Glory Dr Tract A and D)	HDPE	Elliptical	83 x 53	655	708	160	Inadequate	Inadequate
Carriage Meadows Dr (Outfall Tract A)	RCP	Round	60	568	568	282	Inadequate	Inadequate
Peaceful Ridge Dr (Tract C & F to Outfall)	RCP	Round	60	360	882	178	Inadequate	Inadequate

The flow rates shown in Table 3-8 that were used to evaluate the pipes are from the hydrology prepared for this DBPS. The pipes were actually designed using flow rates determined in the drainage study prepared for each subdivision.

The Final Drainage Report (FDR) for Pulte at Lorson Ranch (Pentacor, 2006) shows the Fontaine Boulevard pipe discharging into a detention pond on the northeast corner of Fontaine Boulevard and Jimmy Camp Creek. The StormCAD pipe design output tables show the maximum 100-year flow rate in the pipe to be 305 cfs, which surcharges the pipe. The pipe is shown to have a full flow capacity of 165 cfs.

As described in the FDR for Carriage Meadows at Lorson Ranch Filing No. 1 (Core Engineering Group, 2006), the Carriage Meadows Drive pipe conveys flow from the FMIC ditch to Jimmy Camp Creek. The report states that the 100-year flow rate in the pipe is 245 cfs under developed conditions. The pipe is shown to have a maximum capacity of approximately 270 cfs.

The FDR for Carriage Meadows at Lorson Ranch Filing No. 1 (Core Engineering Group, 2006) shows that the Peaceful Ridge Drive pipe will run along the north boundary of the Carriage Meadows subdivision and will convey runoff from the future Peaceful Ridge subdivision to Jimmy Camp Creek. The 100-year flow rate in the pipe is 184 cfs under developed conditions, which surcharges the pipe. The maximum pipe capacity is not given. The report states that detention necessary for the Carriage Meadows development will be provided on Lorson Ranch south of Fontaine Boulevard, but the Master Drainage Plan was not complete, so details of the detention and how it relates to the subject pipes is not given.

3.9.3 Channel Deficiencies

Open channel deficiencies were defined as flow velocities greater than 5 ft/s or shear stress greater than 0.6 lb/sf. These criteria are based on National Resource Conservation Service (NRCS) allowable channel velocity information presented in the National Engineering Handbook. A detailed discussion is presented in Section 4.4.1, Assumptions for Alternative Development.

The modeled reaches are described below. Values in the summary tables are only reflective of areas within unincorporated EPC. Figure 3-8 and Figure 3-9 highlight areas of high velocity and/or excessive shear stress that exceed the defined limits for existing and future conditions. In areas where the channel has been improved, these exceedances do not necessarily indicate a stability issue because flow over grade control structures will have high velocity and shear stress values. Improved channel reaches are identified in the following discussions of each drainageway.

3.9.3.1 Jimmy Camp Creek Main Branch

The main branch of Jimmy Camp Creek begins at the confluence with Fountain Creek in the City of Fountain near Old Pueblo Road and Hidden Prairie Parkway. The modeled drainageway runs upstream for approximately 23.4 miles to a point near Meridian Road at Partridge Lane. The creek was divided into 6 reaches, J1 through J6, in the hydraulic model and includes 6 bridged roadway crossings, as shown in Table 3-7. A summary of channel velocities and shear stresses for this branch is shown in Table 3-9.

Reach 1 of Jimmy Camp Creek (J1) begins at the confluence of Jimmy Camp Creek and Fountain Creek. It runs upstream for approximately 4.3 miles to the confluence with the West Fork Tributary. The only part of this reach that is within unincorporated EPC is 0.8 miles that begins at Link Road and runs upstream to the confluence with the West Fork Tributary. The maximum velocity or shear criteria are exceeded throughout the reach. Only 2 of the cross sections in the existing conditions model show velocity and shear values that do not exceed the defined limits.

Reach 2 of Jimmy Camp Creek (J2) begins at the confluence with the West Fork Tributary and runs upstream for approximately 2.3 miles to the confluence with the East Fork Tributary, which is located approximately 1,200 feet south of Peaceful Valley Road. The only part of this reach that is within unincorporated EPC is 1.2 miles at the downstream end from the confluence with the West Fork Tributary to the City of Fountain boundary line. The maximum velocity or shear criteria are exceeded throughout the reach. Only 2 of the cross sections in the existing conditions model show velocity and shear values that do not exceed the defined limits.

Reach 3 of Jimmy Camp Creek (J3) begins at the confluence with the East Fork Tributary and runs upstream for approximately 4.0 miles to the confluence with the Lower Franceville Tributary. The only part of this reach that lies within unincorporated EPC is approximately 1.0 mile that runs through Lorson Ranch. This section of the creek has been channelized and stabilized with grade control structures. It is unknown how the design criteria used for the improvements compares to those used for this study. The existing conditions model shows velocity and shear values that exceed the defined limits throughout the reach.

Reach 4 of Jimmy Camp Creek (J4) begins at the confluence with the Lower Franceville Tributary and runs upstream for approximately 0.4 miles to the confluence with the Corral Tributary. No part of the main channel in this reach lies within unincorporated EPC, although unincorporated parcels border the west side of the reach.

Reach 5 of Jimmy Camp Creek (J5) begins at the confluence with the Corral Tributary and runs upstream for approximately 8.4 miles to the confluence with the Blaney Tributary. No part of the main channel in this reach lies within unincorporated EPC, although unincorporated parcels border the west side of the lower end of this reach.

Reach 6 of Jimmy Camp Creek (J6) begins at the confluence with the Blaney Tributary and runs upstream for approximately 4.0 miles to the upstream study limit near Meridian Road and Partridge Lane. Only about 0.9 miles of the upstream end of this reach lie within unincorporated EPC. The maximum velocity and shear criteria are exceeded throughout the reach, except within a small impoundment created by an earthen embankment across the channel located approximately 0.5 miles from the upstream study limit.

Table 3-9. Jimmy Camp Creek 100-Year Velocity and Shear Stress Summary

Reach ID	Maximum Velocity (ft/s)		Maximum Shear Stress (lb/ft^2)	
	Existing Conditions	Future Conditions	Existing Conditions	Future Conditions
J1	10.6	17.4	3.6	6.5
J2	12.6	16.7	4.1	5.7
J3	12.1	16.7	8.4	11.0
J6	11.4	12.9	2.4	2.7

3.9.3.2 Blaney Tributary

Blaney Tributary lies in mostly undeveloped land east of Highway 24, 1.2 miles east of its intersection with Constitution Avenue. The modeled drainageway is approximately 3.2 miles long and runs from its confluence with Jimmy Camp Creek to Corral Bluffs View east of Meridian Road. There are no modeled roadway crossings. Only the upstream 0.9 miles of this reach lie within unincorporated EPC. A summary of channel velocities and shear stresses for this tributary is shown in Table 3-10. The maximum velocity or shear criteria are exceeded throughout the reach, except within a small impoundment created by an earthen embankment across the channel about 300 feet east of Meridian Road. Outside of the impoundment, only 1 cross section in the existing conditions model shows both velocity and shear values that do not exceed the defined limits.

Table 3-10. Blaney Tributary 100-Year Velocity and Shear Stress Summary

Reach ID	Maximum Velocity (ft/s)		Maximum Shear Stress (lb/ft^2)	
	Existing Conditions	Future Conditions	Existing Conditions	Future Conditions
B1	9.1	10.1	1.7	2.0

3.9.3.3 West Fork Tributary

The West Fork Tributary begins at the confluence with Jimmy Camp Creek located east of Link Road and south of C&S Road. The modeled drainageway runs upstream for approximately 2.4 miles to the upstream study limit in undeveloped land north of The Glen at Widefield. Two parts of this reach lie within unincorporated EPC, from Jimmy Camp Creek to Marksheffel Road and from Mesa Ridge Parkway to the upstream study limit, for a total length of 1.7 miles. The model includes 1 bridged roadway crossing and 2 culvert crossings, as shown in Table 3-7. A summary of channel velocities and shear stresses for this branch is shown in Table 3-11. Between Jimmy Camp Creek and Marksheffel Road, the velocity and shear values are generally within the acceptable range.

North of Mesa Ridge Parkway, the stream has been channelized and an inline detention pond is located near the upstream end. It is unknown how the design criteria used for the improvements compares to those used for this study. Within this improved reach, the existing conditions model shows velocity or shear values that exceed the defined limits for approximately 2,400 feet downstream of the detention pond.

Table 3-11. West Fork Tributary 100-Year Velocity and Shear Stress Summary

Reach ID	Maximum Velocity (ft/s)		Maximum Shear Stress (lb/ft^2)	
	Existing Conditions	Future Conditions	Existing Conditions	Future Conditions
W1	7.2	11.1	1.9	3.3

3.9.3.4 Corral Tributary

The Corral Tributary begins at the confluence with Jimmy Camp Creek located south of Drennan Road and southwest of Pikes Peak National Cemetery. The modeled drainageway runs upstream for approximately 8.1 miles to the upstream study limit in undeveloped land north of SH-94 and west of Corral Valley Road. The drainageway was divided into 2 reaches, C1 and C2, in the hydraulic model and includes 2 roadway crossings, as shown in Table 3-7. A summary of channel velocities and shear stresses for this tributary is shown in Table 3-12.

Reach C1 begins at the upstream end of reach J4 and runs upstream for approximately 0.8 miles to the confluence with the Upper Franceville Tributary on the north side of Drennan Road. This reach lies almost entirely within unincorporated EPC. The maximum velocity and shear criteria are exceeded throughout the reach in both existing and future conditions.

Reach C2 begins at Drennan Road and runs upstream for approximately 7.3 miles to the upstream study limit north of SH-94. Only 0.3 miles of this reach immediately south of the SH-94 crossing lie within unincorporated EPC. The maximum velocity and shear criteria are exceeded throughout the reach downstream of SH-94.

Table 3-12. Corral Tributary 100-Year Velocity and Shear Stress Summary

Reach ID	Maximum Velocity (ft/s)		Maximum Shear Stress (lb/ft^2)	
	Existing Conditions	Future Conditions	Existing Conditions	Future Conditions
C1	11.7	15.6	2.4	3.6
C2	10.3	12.0	2.0	2.5

3.9.3.5 Franceville Tributary

As discussed in Section 3.4, the Franceville Tributary was split into upper and lower reaches due to a buried culvert at Drennan Road that disconnects the historic flow path and prevents the lower reach from receiving flows from the upper reach.

Lower Franceville Tributary (LF1) begins at the confluence with Jimmy Camp Creek located north of Bradley Road and east of Marksheffel Road. The modeled drainageway runs upstream for approximately 1.5 miles to the south side of Drennan Road. This reach lies almost entirely within unincorporated EPC. The upstream end of this reach has been channelized for approximately 4,200 feet where it borders the Pikes Peak National Cemetery. Within the channelized section, the existing conditions model shows velocity or shear values that exceed the defined limits at all but 2 cross sections. In the unimproved section of the reach, the maximum velocity or shear criteria are exceeded at all cross sections except the most downstream one.

Upper Franceville Tributary begins at the confluence with the Corral Tributary on the north side of Drennan Road and runs upstream for approximately 5.6 miles to the upstream study limit in undeveloped land east of Franceville Coal Mine Road. Upper Franceville Tributary was divided into 2 reaches, UF1 and UF2, in the hydraulic model and includes 1 roadway culvert crossing, as shown in Table 3-7.

Reach UF1 begins at the confluence with the Corral Tributary and runs eastward along the north side of Drennan Road for 0.2 miles to the confluence with the Stripmine Tributary. No part of this reach lies within unincorporated EPC.

Reach UF2 begins at the confluence with the Stripmine Tributary on the north side of Drennan Road and runs upstream for approximately 5.4 miles to the upstream study limit in undeveloped land east of Franceville Coal Mine Road. Approximately 3.4 miles of the upstream end of this reach lie within unincorporated EPC. The maximum velocity and shear criteria are exceeded throughout the reach upstream of Franceville Coal Mine Road. For approximately 7,000 feet downstream of Franceville Coal Mine Road, the maximum velocity or shear values are above the defined limits. Downstream of this section, approximately 3,000 feet of channel show acceptable velocity and shear values until the stream leaves unincorporated EPC and enters Colorado Springs.

A summary of channel velocities and shear stresses for Franceville Tributary is shown in Table 3-13.

Table 3-13. Franceville Tributary 100-Year Velocity and Shear Stress Summary

Reach ID	Maximum Velocity (ft/s)		Maximum Shear Stress (lb/ft^2)	
	Existing Conditions	Future Conditions	Existing Conditions	Future Conditions
LF1	7.3	9.4	1.9	2.8
UF2	9.4	10.5	1.9	2.1

3.9.3.6 Stripmine Tributary

The Stripmine Tributary begins on the north side of Drennan Road at the confluence with Upper Franceville Tributary. The modeled drainageway runs upstream for approximately 6.4 miles to the upstream study limit in undeveloped land approximately one mile north of SH-94. The main branch of the drainageway was divided into 3 reaches in the hydraulic model (S1, S2 and S3) in order to include 2 side tributaries (S1-T1 and S2-T1). The main branch includes 1 roadway crossing and each of the side branches has 1 roadway crossing, as shown in Table 3-7. A summary of channel velocities and shear stresses for this tributary is shown in Table 3-14.

Reach S1 begins at the upstream end of UF1 on the north side of Drennan Road and runs upstream for approximately 4.0 miles to the confluence with the South Tributary (S1-T1) in undeveloped land near the Pikes Peak Gun Club shooting range. Approximately 0.3 miles of the upstream end of this reach lies within unincorporated EPC on land not owned by the City of Colorado Springs. The maximum velocity and shear criteria are exceeded throughout the reach.

Reach S2 begins at the confluence with the South Tributary (S1-T1) and runs upstream for approximately 0.5 miles to the confluence with the North Tributary (S2-T1). This reach lies entirely within unincorporated EPC. The maximum velocity and shear criteria are exceeded throughout the reach.

Reach S3 begins at the confluence with the North Tributary (S2-T1) and runs upstream for approximately 1.8 miles to the upstream study limit north of SH-94. Approximately 0.9 miles of the reach lies within unincorporated EPC. The maximum velocity and shear criteria are exceeded throughout the reach except at 2 cross sections immediately upstream of SH-94.

The South Tributary (S1-T1) begins at the upstream end of S1 and runs eastward for approximately 1.2 miles to the upstream study limit in undeveloped land east of Franceville Coal Mine Road. This reach lies entirely within unincorporated EPC. The maximum velocity and shear criteria are exceeded throughout the reach upstream of Franceville Coal Mine Road. Downstream of Franceville Coal Mine Road, the maximum velocity or shear values are above the defined limits at almost all cross sections.

The North Tributary (S2-T1) begins at the upstream end of S2 and runs eastward for approximately 0.8 miles to the upstream study limit in undeveloped land east of Franceville Coal Mine Road. This reach lies entirely within unincorporated EPC. The maximum velocity and shear criteria are exceeded throughout the reach except at 2 cross sections immediately upstream of Franceville Coal Mine Road.

Table 3-14. Stripmine Tributary 100-Year Velocity and Shear Stress Summary

Reach ID	Maximum Velocity (ft/s)		Maximum Shear Stress (lb/ft^2)	
	Existing Conditions	Future Conditions	Existing Conditions	Future Conditions
S1	10.6	11.4	2.1	2.3
S2	9.7	10.7	1.8	2.3
S3	11.3	11.4	2.4	2.4
S1-T1	8.2	10.9	1.4	2.4
S2-T1	8.3	10.3	1.6	2.1

3.9.3.7 East Fork Tributary

The East Fork of Jimmy Camp Creek begins at the confluence with Jimmy Camp Creek south of Peaceful Valley Road and east of Marksheffel Road. The modeled drainageway runs upstream for approximately 10.2 miles to the upstream study limit in undeveloped land east of Franceville Coal Mine Road. It was divided into 2 reaches, E1 and E2, and also has a side tributary, E1-T1. The model includes 6 roadway crossings, as shown in Table 3-7. A summary of channel velocities and shear stresses for this tributary is shown in Table 3-15.

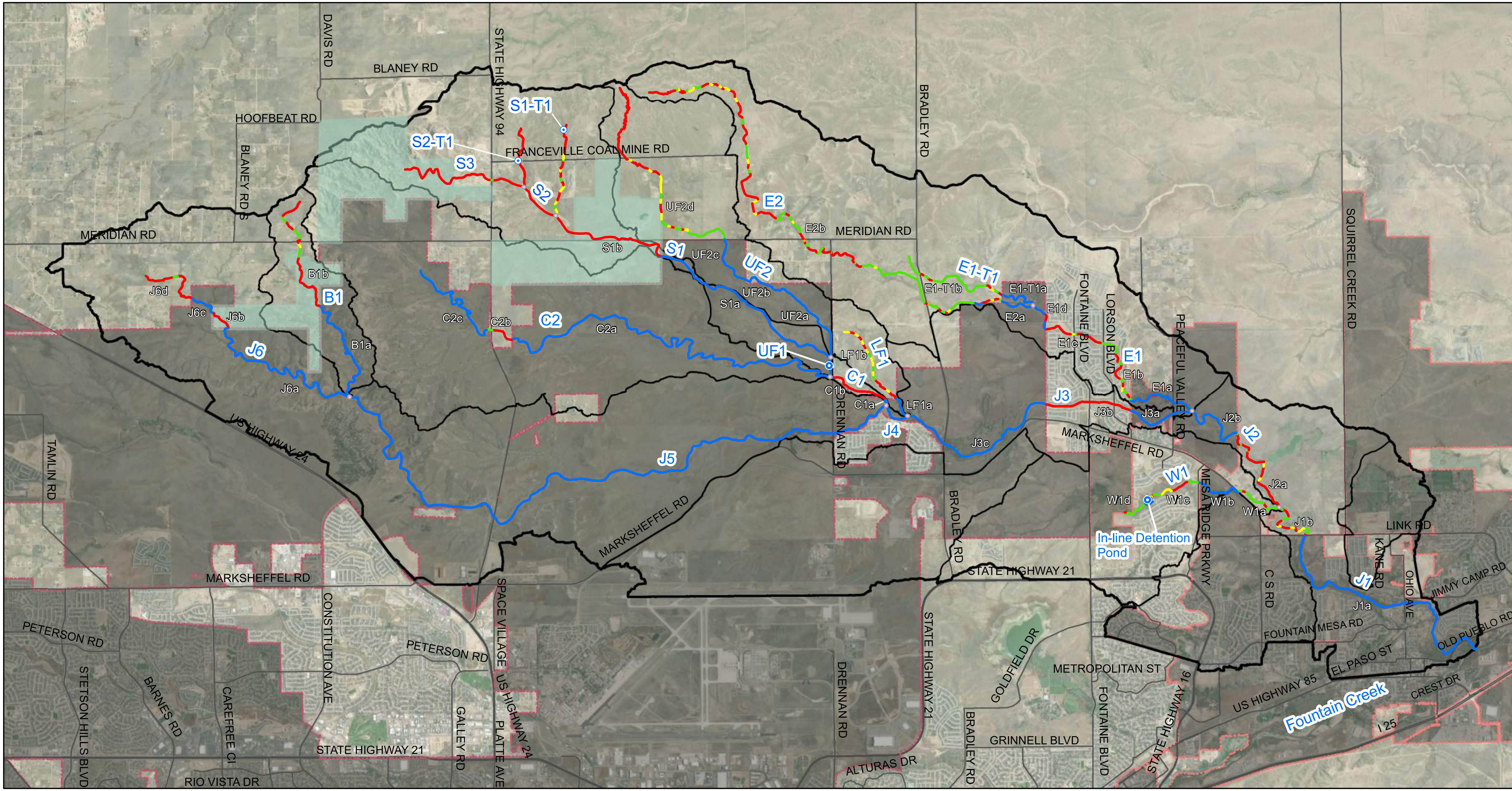
Reach E1 begins at Jimmy Camp Creek and runs upstream for approximately 2.9 miles to the confluence with side tributary E1-T1 on the north side of Lorson Ranch. Approximately 1.8 miles of this reach lies within unincorporated EPC where it runs through Lorson Ranch. Most of this section of the reach has been channelized and stabilized with grade control structures. It is unknown how the design criteria used for the improvements compares to those used for this study. The existing conditions model shows velocity and shear values that exceed the defined limits throughout the reach except for approximately 1,100 feet at the Lorson Boulevard crossing.

Reach E2 begins at the confluence with side tributary E1-T1 and runs upstream for approximately 7.3 miles to the upstream study limit in undeveloped land east of Franceville Coal Mine Road. This reach lies almost entirely within unincorporated EPC. Upstream of Drennan Road, the existing conditions model shows velocity or shear values that exceed the defined limits throughout most of the reach except for some isolated areas where the channel goes through natural depressions or wide sandy flats. South of Drennan Road, the defined main channel disappears and stream flows meander through a wide, relatively flat valley with many shallow drainage paths. This drainage pattern begins north of Bradley Road and continues south of Bradley Road to the El Paso County / Colorado Springs boundary. Most of the areas where the channel is undefined show acceptable velocity and shear values because the flow is wide and shallow.

East Fork Tributary (E1-T1) begins at the upstream end of E1 and runs northward for approximately 2.0 miles to the upstream study limit north of Bradley Road. Approximately 1.5 miles of the upstream end of this reach lies within unincorporated EPC. Most of this reach is flowing through the same wide, relatively flat area as described above for reach E2, and shows acceptable velocity and shear values until it enters a defined channel approximately 1,300 feet upstream of the El Paso County / Colorado Springs boundary. Flows in the channel exceed the maximum velocity and shear criteria.

Table 3-15. East Fork Tributary 100-Year Velocity and Shear Stress Summary

Reach ID	Maximum Velocity (ft/s)		Maximum Shear Stress (lb/ft^2)	
	Existing Conditions	Future Conditions	Existing Conditions	Future Conditions
E1	11.9	15.1	6.6	9.9
E2	10.5	12.5	2.4	2.9
E1-T1	7.6	9.1	1.2	1.8



Legend

- Reach Junction Points
- Existing Velocity Deficiency (5 ft/s or >) and Shear Deficiency (0.6 lb/sf or >)
- Existing Velocity Deficiency (5 ft/s or >)
- Existing Shear Deficiency (0.6 lb/sf or >)
- Not Deficient
- Excluded Drainageways Not Analyzed
- Jimmy Camp Creek Drainage Basin
- Jimmy Camp Creek Major Basins
- Major Roads
- Colorado Springs City Limits
- Fountain City Limits
- Colorado Springs-Owned or Annexed Parcels

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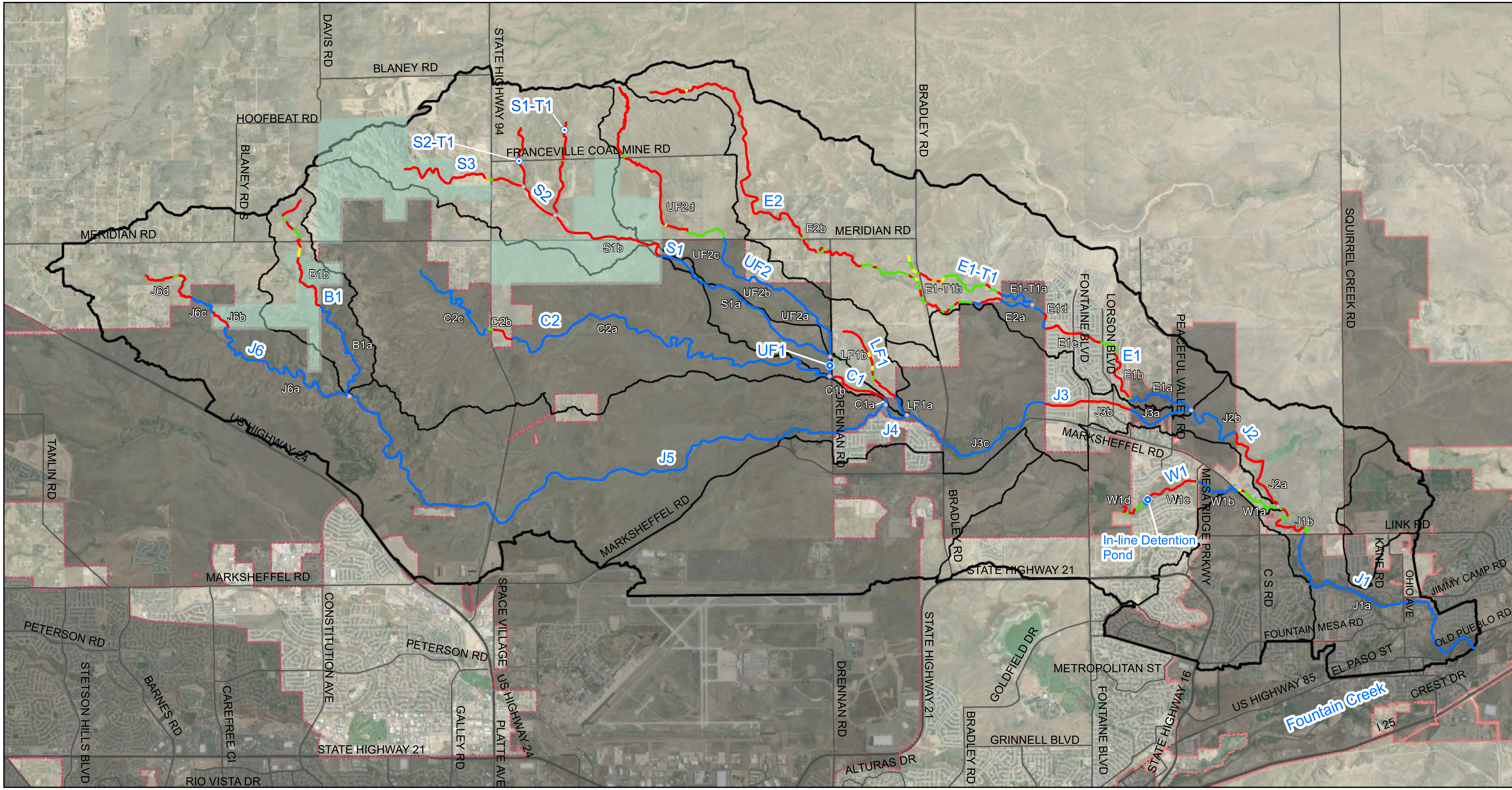
Figure 3-8: Jimmy Camp Creek - Existing Deficiencies

Coordinate System: NAD 1983 StatePlane Colorado Central FIPS 0502 Feet



Legend

- Reach Junction Points
- Future Velocity Deficiency (5 ft/s or >) and Shear Deficiency (0.6 lb/sf or >)
- Future Velocity Deficiency (5 ft/s or >)
- Future Shear Deficiency (0.6 lb/sf or >)
- Not Deficient
- Excluded Drainageways Not Analyzed
- Jimmy Camp Creek Major Basins
- Major Roads
- Jimmy Camp Creek Drainage Basin
- Colorado Springs City Limits
- Fountain City Limits
- Colorado Springs-Owned or Annexed Parcels

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Figure 3-9: Jimmy Camp Creek - Future Deficiencies

Coordinate System: NAD 1983 StatePlane Colorado Central FIPS 0502 Feet