4.0 ALTERNATIVE EVALUATION

4.1 INTRODUCTION

This chapter describes the development and evaluation of drainage alternatives in the Jimmy Camp Creek Drainage Basin that were designed to address existing and future problem areas. Drainage problem areas in the basin were identified based on the hydrologic and hydraulic analyses described in previous chapters and the geomorphic assessments and other information described in this chapter.

Drainage alternatives represent comprehensive solutions to current and future flooding and channel stability issues in the overall Jimmy Camp Creek Drainage Basin. They consist of a collection of individual options for specific locations that provide a consistent approach to drainage management from the upper end of the watershed to the outfall at Fountain Creek.

4.2 HYDRAULIC DEFICIENCIES AND EXISTING CONDITIONS

The Basin Characteristics chapter details a field and desktop geomorphic assessment that identified sediment sources and sinks, as well as potential areas of channel and floodplain instability, providing a general understanding of the health and stability of the watershed given the current conditions. Documentation of existing observed problem areas demonstrated that there are currently limited drainage system issues in the Jimmy Camp Creek drainage basin as it is largely undeveloped and the impacts associated with increased runoff, decreased sediment supply and river encroachment have not yet occurred in most of the upper basin. The DBPS alternatives are focused on maintaining this stability in the channels and preserving current channel infrastructure while at the same time maintaining current channel capacity under existing and future conditions. There are locations where channelization may be necessary if development in the reach is desired, such as areas without a defined main channel where the flood flows spread across a large portion of the valley. These areas include the East Fork tributary (E2) and side tributary to East Fork (E1-T1) extending from north of Bradley Road to South of Bradley Road and a portion of the Upper Franceville tributary downstream of Franceville Coal Mine Road.

In addition, the hydraulic analysis detailed in the Hydraulics Chapter 3 identified locations where excessive velocity or shear stress is present that could create channel erosion problems under a developed scenario.

The alternatives were developed to address areas in the Jimmy Camp Creek Drainage Basin that have experienced historical problems with flooding or channel stability, or that are anticipated to experience problems in the future based on anticipated land use and hydrology changes.

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4.3 EVALUATION CRITERIA

This section describes the development and purpose of criteria to evaluate and compare Jimmy Camp Creek DBPS alternatives. Application of the evaluation criteria is described in Section 4.4.

4.3.1 Purpose of Evaluation Criteria in Jimmy Camp Creek DBPS

Multiple evaluation criteria are used to evaluate alternatives and select a preferred alternative that best meets the various objectives of the plan. This section describes the evaluation criteria and how it will be used in the evaluation.

4.3.2 Description of Evaluation Criteria

The evaluation criteria adopted for the Jimmy Camp Creek DBPS were based on goals to define project success. These goals are defined in Table 4-1 and are organized in four categories: Channel and Floodplain Goals, Environmental Goals, Multiple Benefit Goals, and Cost Goals. Alternatives were compared using the evaluation criteria through a semi-quantitative process.

Table 4-1. Jimmy Camp Creek DBPS Goals and Evaluation Criteria

Goal Category	Goals and Evaluation Criteria
Channel and Floodplain Goals	• Remove insurable structures from 100-year floodplain by reducing 100-year peak discharge or relocating structures from the floodplain; note the DBPS itself will not modify the regulated FEMA floodplain • Reduce impact upon major thoroughfares and utilities, existing and future, by improving channel and bridge/culvert capacity • Improve channel stability by reducing or eliminating areas of channel scour, downcutting and lateral migration through creation of stable slopes, grade control, or bank stabilization measures • Minimize the need for intergovernmental negotiations due to jurisdictional boundaries
Environmental Goals	• Improve environmental resources by approximating naturally functioning systems: channels with active floodplains, efficient low flow channels, and natural channel and floodplain vegetation • Improve Fountain Creek water quality by reducing the discharge of potential pollutants, primarily in the form of excess sediment from Jimmy Camp Creek to Fountain Creek • Minimize need for grade control structures • Minimize regulatory issues (e.g., wetlands permitting)
Multiple Benefit Goals	• Provide open space and trail opportunities by allowing stream corridors to be used for multiple public recreation benefits • Reduce peak flows by using detention or land management to reduce 10-year and 100-year peak flows to as close to pre-development conditions as possible as required of new development under the El Paso County Drainage Criteria Manual (EPC DCM)
Cost Goals	• Minimize cost for construction and property/right-of-way acquisition • Minimize cost for maintenance, repair, and replacement

4.4 ALTERNATIVE DEVELOPMENT

This section describes the process and basic information used to develop Jimmy Camp Creek DBPS alternatives and the resulting three alternatives developed for the DBPS.

4.4.1 Assumptions for Alternative Development

At the beginning of the alternative development process, a number of assumptions were adopted to focus the effort and avoid exploring alternatives that would ultimately not meet EPC's objectives for the DBPS. The key assumptions framing the alternative development process are listed below:

- **Include effect of onsite detention.** The EPC DCM requires new developments to install extended detention basins or other permanent control measures to maintain post-development runoff rates at pre-development conditions and to mitigate impacts of land development on receiving water quality. Therefore, the peak flows from the existing conditions hydrology were used to develop DPBS alternatives. Development is assumed to increase flow volumes and it was assumed that the volumes of runoff would be similar to the future condition hydrology. The DPBS assumes that Green Infrastructure (as described in the Colorado Springs Green Infrastructure Guidance Manual; COS 2022) is not incorporated into the developed parcels, however, GI should be considered as it can significantly reduce runoff volumes and reduce the need for channel stabilization.

- **Adopt stable channel slope for planning.** The stable channel slope used for planning was based upon criteria given in the Colorado Springs Drainage Criteria Manual City DCM. Figure 4-1 shows design slope guidance for sand bed channels that is presented in Figure 12-4 of the City DCM. The stable slope is intended to approximate the slope at which flow velocities and shear stresses allow sediment transport to be roughly balanced to avoid excessive channel erosion. While the current channel under the current flow regime is predominantly stable, development will increase flow volumes and likely decrease coarse (sand and larger) sediment supply. These factors will cause channel and bank erosion and require channel stabilization measures. There are two reasons why increased flow volumes can cause channel instability. One is that the increase in flow volume increases the total sediment transport capacity of the system without a commensurate increase in sediment supply and the imbalance causes erosion of the channel bed. The other reason is that vegetation and cohesive material can destabilize during extended flow durations. An example of this is given in Figure 4-2. In this figure, the 5 ft/s velocity criteria used to identify hydraulic deficiencies is also shown (note that the figure is in m/s). Based upon in Figure 4-2 a channel with good grass cover would be stable for an extended period at 5 ft/s. Currently, large portions of the channels exceed 5 ft/s and with increasing duration of those velocities, channel erosion could occur. The City DCM also recommends the maximum design velocity of 5 ft/s during the 100-yr flood for natural erodible channels such as exist in Jimmy Camp Creek basin (Table 4-2). The City DCM recommends a maximum shear stress of 0.6 lb/ft^2. These are the criteria used to determine if channel stabilization is necessary.

  It is recommended that before specific stabilization measures are implemented into a reach, a more comprehensive sediment transport analysis is performed where bed material data is collected in each tributary and hydrographs developed to determine sediment loads. The City DCM also discusses interim channel designs for situations where development will not immediately change the existing sediment balance. Because development will occur gradually, the impacts to the channel will occur gradually and the channel improvements could be staged based upon observed channel response.

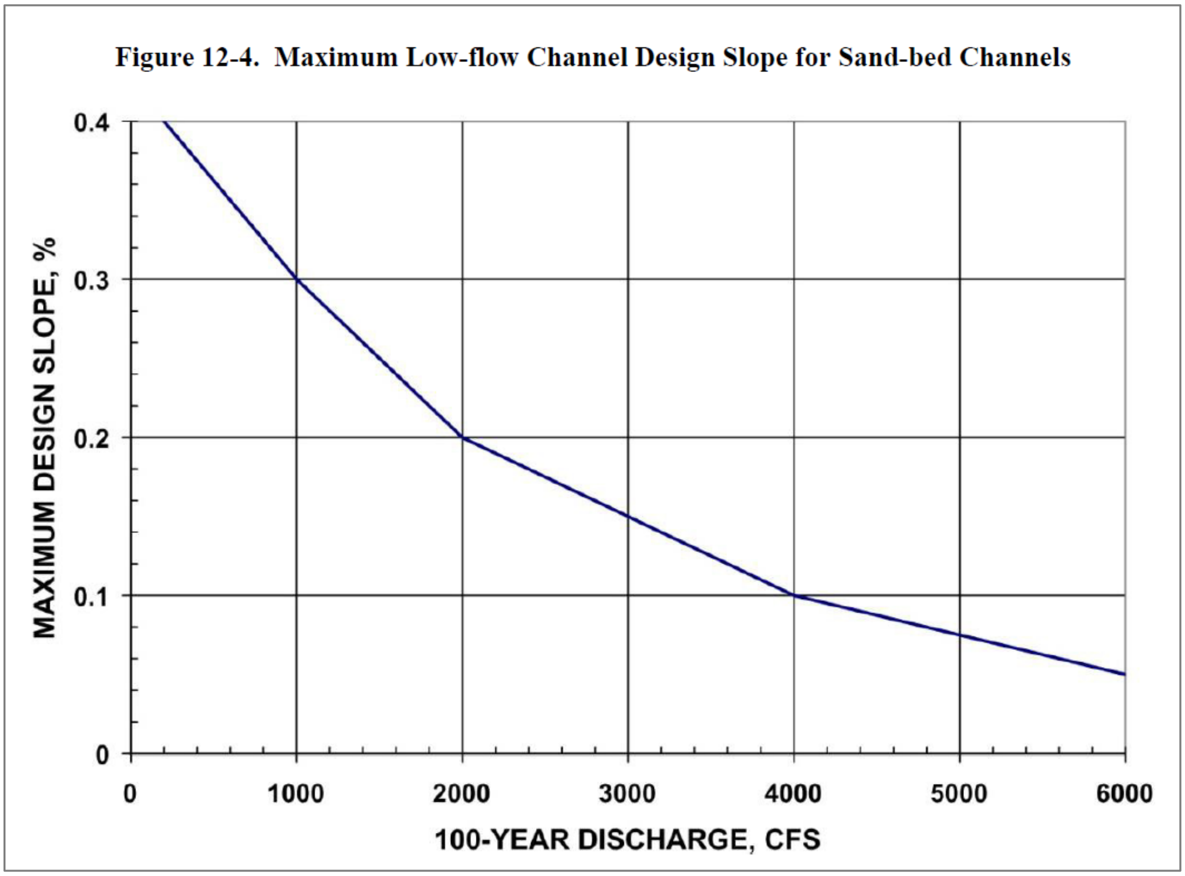


Figure 4-1. Stable Slope Relationship used in JCC DBPS. Taken from City DCM Vol. 1.

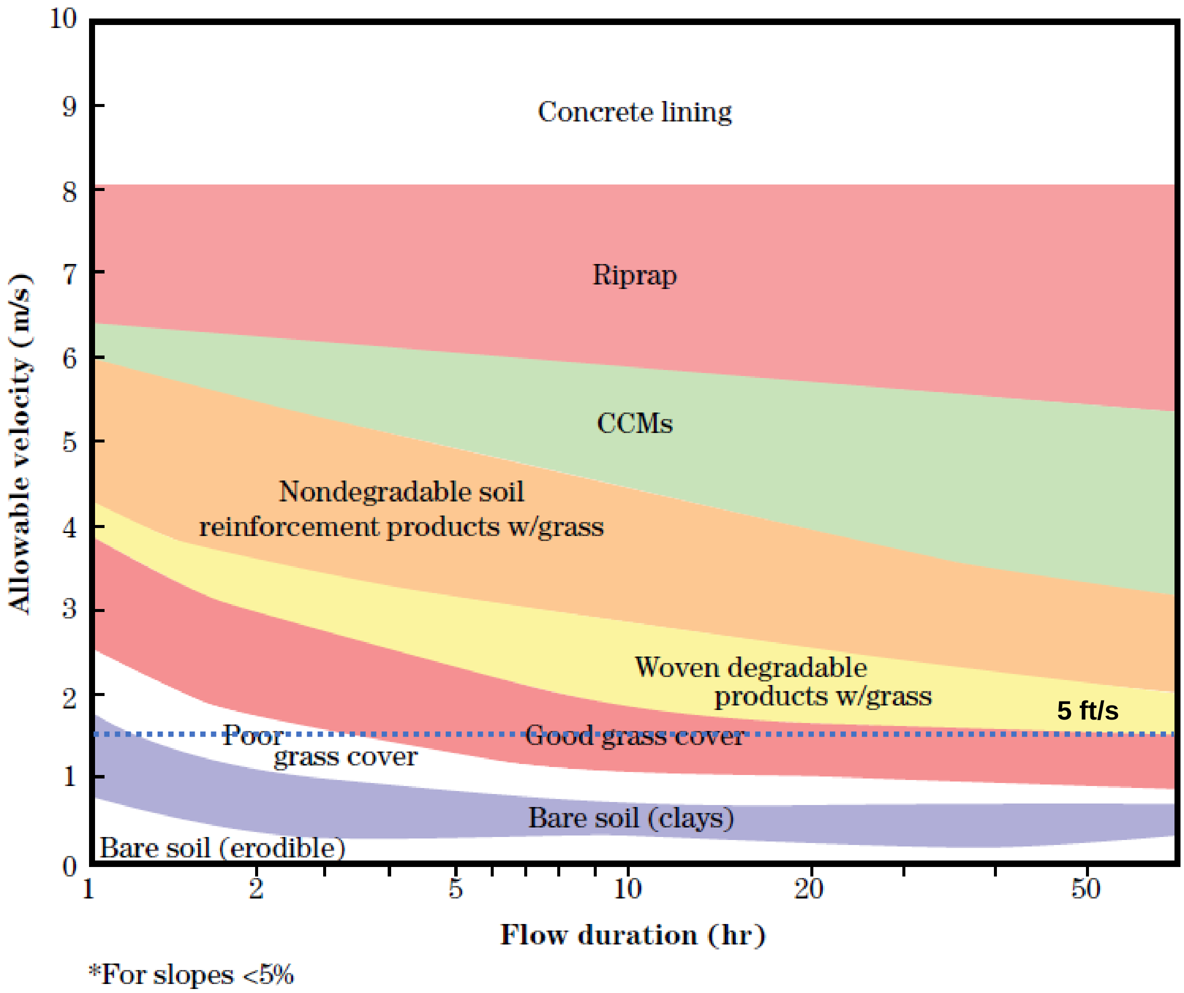


Figure 4-2. Effect of flow duration on allowable velocities for various channel linings From NRCS Part 654, Part 654 Stream Restoration Design, National Engineering Handbook, 2007. Note vertical scale is m/s.

Table 4-2. Hydraulic Design Criteria for Natural Unlined Channels for from City DCM Table 12-3 from Chapter 12.

Design Parameter	Erosive Soils or Poor Vegetation	Erosion Resistant Soils and Vegetation
Maximum Low-Flow Velocity (ft/s)	3.5	5.0
Maximum 100-year Velocity (ft/s)	5.0	7.0
Froude No. Low Flow	0.5	0.7
Maximum Shear Stress for 100-yr (lb/ft^2)	0.60	1.0

[1]Velocities, Froude Number and Shear Stress are average values for the cross section

[2]Erosion Resistant soils are those with 30% or greater clay content.

- **Incorporate existing improvements to the maximum extent practical.** Some stream reaches in the Jimmy Camp Creek drainage basin have been improved through installation of grade control structures and bank stabilization measures. These improvements will be incorporated into any alternatives, except in the case where the improvements exhibit signs of failure and would have to be replaced. No improvements are included where existing measures are performing as intended.

- **Detention for Water Quality.** It is assumed that the effect of water quality attenuation features is negligible to 100-year flows.

- **Grade Control Design.** Maximum grade control height will be 6 ft for constructed channel drops and 4 ft for natural and natural constructed channels. This is based upon the maximum height per City of Colorado Springs (City) DCM Section 4.2.2 Constructed Channel Drop Structures and Table 12-7 Maximum Grade Control Structure Drop Heights.

- **Online Detention**. We assume that online detention will not be permitted and the maximum height of the off-line embankments of detention structures will be 10 ft. This is to prevent the structure from becoming a "Jurisdictional Dam", which is a dam which impounds water above the elevation of the natural surface of the ground creating a reservoir with a capacity of more than 100 acre-feet, or creates a reservoir with a surface area in excess of 20 acres at the high-water line, or exceeds 10 feet in height measured vertically form the elevation of the lowest point of the natural surface of the ground where that point occurs along the longitudinal centerline of the dam up to the flowline crest of the emergency spillway of the dam. For reservoirs created by excavation, the vertical height shall be measured from the invert of the outlet.

4.4.2 Channel Types

Based on the consideration of the evaluation criteria, existing channel segments were categorized into four types depending on if the channel is improved and if the channel would experience capacity or stability problems based on the existing or future flows. Table 4-3 shows the definition of the four channel categories. Channel types designated for each channel segment in the Jimmy Camp Creek drainage basin are shown on Figure 4-3.

Table 4-3. Description of Jimmy Camp Creek Channel Types

Channel Types	Description
Type 1	Improved, and no existing or future problems anticipated during peak flows or longer duration high flows • No additional improvements needed • Focus on maintaining existing improvements
Type 2	Improved, but existing or future problems anticipated during peak flows or longer duration high flows • Unless existing improvements are failing or undersized, existing improvements will be maintained to minimize cost • Additional improvements needed to stabilize existing channels and protect existing infrastructure
Type 3	Unimproved, with existing or future problems anticipated during peak flows or longer duration high flows • Extensive improvements will be needed
Type 4	Unimproved, and no existing or future problems anticipated during peak flows or longer duration high flows • No additional improvements needed

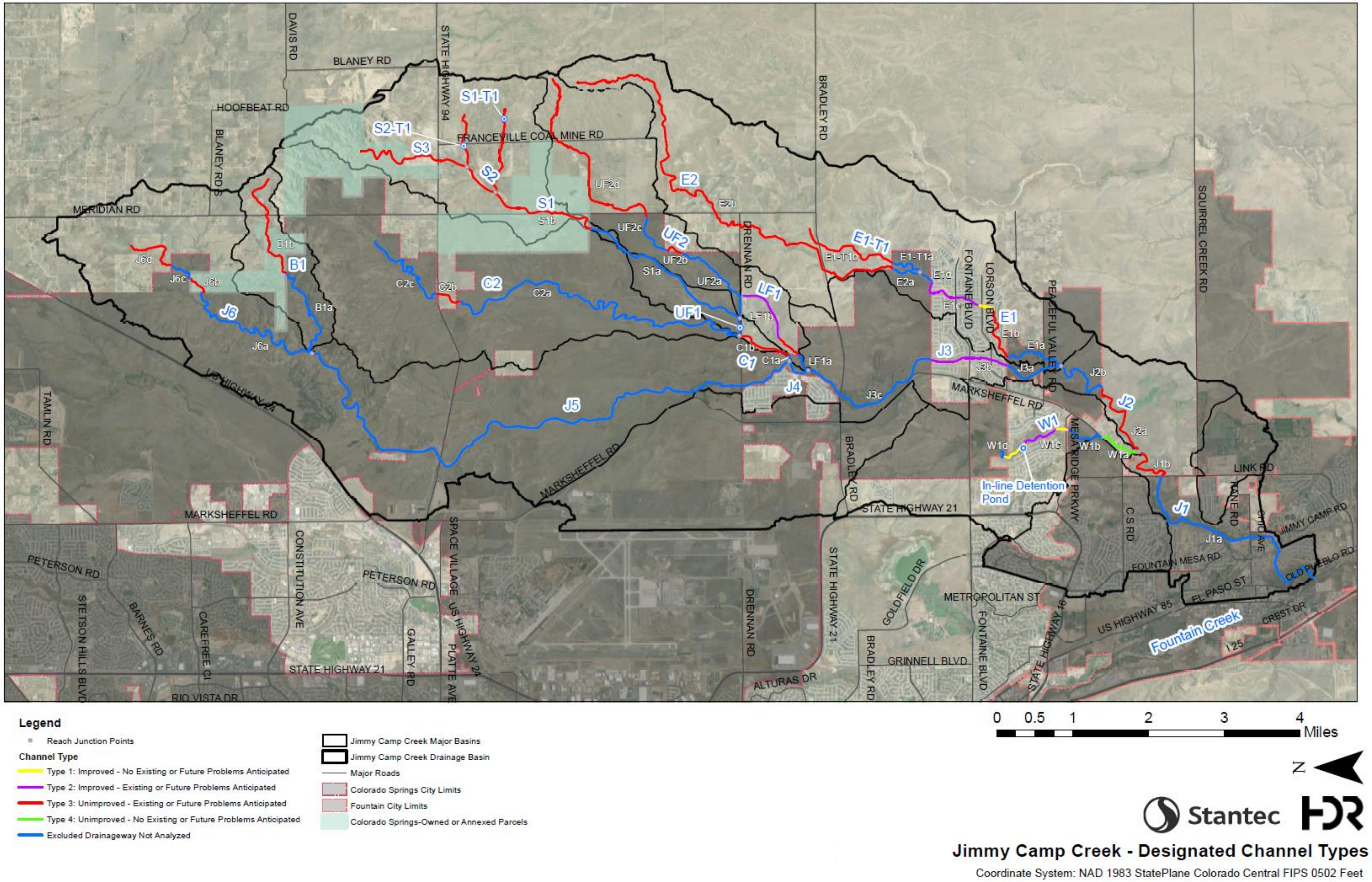


Figure 4-3. Jimmy Camp Creek Drainage Basin Designated Channel Types.

4.4.3 Channel Improvement Themes

4.4.3.1 Description of Channel Improvement Themes

Based on the channel improvement options that were acceptable to the County and the existing channel types, channel improvement themes were created to organize and standardize improvement decisions. Because the Jimmy Camp Creek drainage basin analysis includes approximately 65 stream miles, standard channel improvement themes were needed to simplify the development of conveyance options. Table 4-4 shows the definition of the three themes adopted for the Jimmy Camp Creek DBPS. Figure 4-4 shows the themes assigned to each of the channel segments in the basin. Table 4-5 shows a summary of the channel type and channel theme for each reach in the basin. A brief description of the reasoning for each theme is given in the table as well.

Additional explanation for Reach J1 and J2 of Jimmy Camp Creek is warranted given that Maintenance only is recommended. Both Reach J1 and J2 of Jimmy Camp are densely vegetated with a small main channel and well-connected floodplain. An assessment of these reaches is given in Chapter 2 (Basin Characteristics) and it was determined that maintenance is the preferred method. The flow volumes are expected to increase in this reach as well, but the soils are more cohesive, the vegetation much denser and the upstream channels will supply sediment to this reach even if the upstream hillslope production is decreased.

Table 4-4. Channel Improvement Themes

Channel Theme	Description
Maintenance Only	For some locations, improvements have been made over time or the channel does not need to be modified for future conditions. Proper maintenance and minor localized improvements may be needed but are not included in project costs.
Constructed Channel	For some reaches a constructed channel will be necessary to contain flood flows because there is no defined channel currently. A balanced engineered solution with a terraced floodplain will be used in conjunction with grade control, allowing for some restoration of ecological value within the existing limitations of the right-of-way.
Constructed Natural Channel	In most of the upper portion of the basin, the channels are unimproved as development has not occurred on a large scale. Most of these channel segments fall into Type 3 (see Table 4-3). As flows increase, these channels will experience additional flow and may begin to erode if no stabilization measures are used. A balanced solution allowing some natural stream processes to occur within a defined corridor is preferred. .

Table 4-5. Jimmy Camp Creek Channel Types

Drainageway	Reach ID	Channel Type	Channel Theme / Comments
Jimmy Camp	J6b	3	Constructed Natural Channel / Grade Stabilization
	J6d	3	Constructed Natural Channel / Grade Stabilization
	J3b	1 or 2	Maintenance / Reach through Lorson Ranch has been improved.
	J2a	3 or 4	Maintenance / Floodplain preservation because of dense riparian corridor
	J1b	3 or 4	Maintenance / Floodplain preservation because of dense riparian corridor
Blaney	B1b	3	Constructed Natural Channel / Grade Stabilization
West Fork	W1a	4	Maintenance / Reach downstream of Marksheffel Rd runs through large lot development. No structures in floodplain and velocities generally acceptable.
	W1c	1 or 2	Maintenance / Reach upstream of Mesa Ridge Pkwy has been improved.
Corral	C2b	3	Constructed Natural Channel / Grade Stabilization
	C1b	3	Constructed Natural Channel / Grade Stabilization
Stripmine	S3	3	Constructed Natural Channel / Grade Stabilization
	S2	3	Constructed Natural Channel / Grade Stabilization
	S1	3	Constructed Natural Channel / Grade Stabilization
Stripmine North Tributary	S2-T1	3	Constructed Natural Channel / Grade Stabilization

Stripmine South Tributary	S1-T1	3	Constructed Natural Channel / Grade Stabilization
Lower Franceville	LF1b	2	Maintenance / Upper part of reach has already been channelized in Pikes Peak National Cemetery.
	LF1c	3	Constructed Natural Channel / Grade Stabilization
Upper Franceville	UF2b	3	Constructed Natural Channel / Grade Stabilization. Sub-regional Detention also a possibility.
	UF2d	3	Constructed Natural Channel / Grade Stabilization. Sub-regional Detention also a possibility.
East Fork	E2b	3	Constructed Natural Channel / Grade Stabilization. Sub-regional Detention also a possibility.
	E1b	3	Constructed Natural Channel / Grade Stabilization Unimproved channel downstream of Lorson Ranch likely to be developed soon.
	E1c	1 or 2	Maintenance / Reach through Lorson Ranch has been improved.
East Fork Tributary	E1-T1b	3	Constructed Natural Channel / Grade Stabilization.

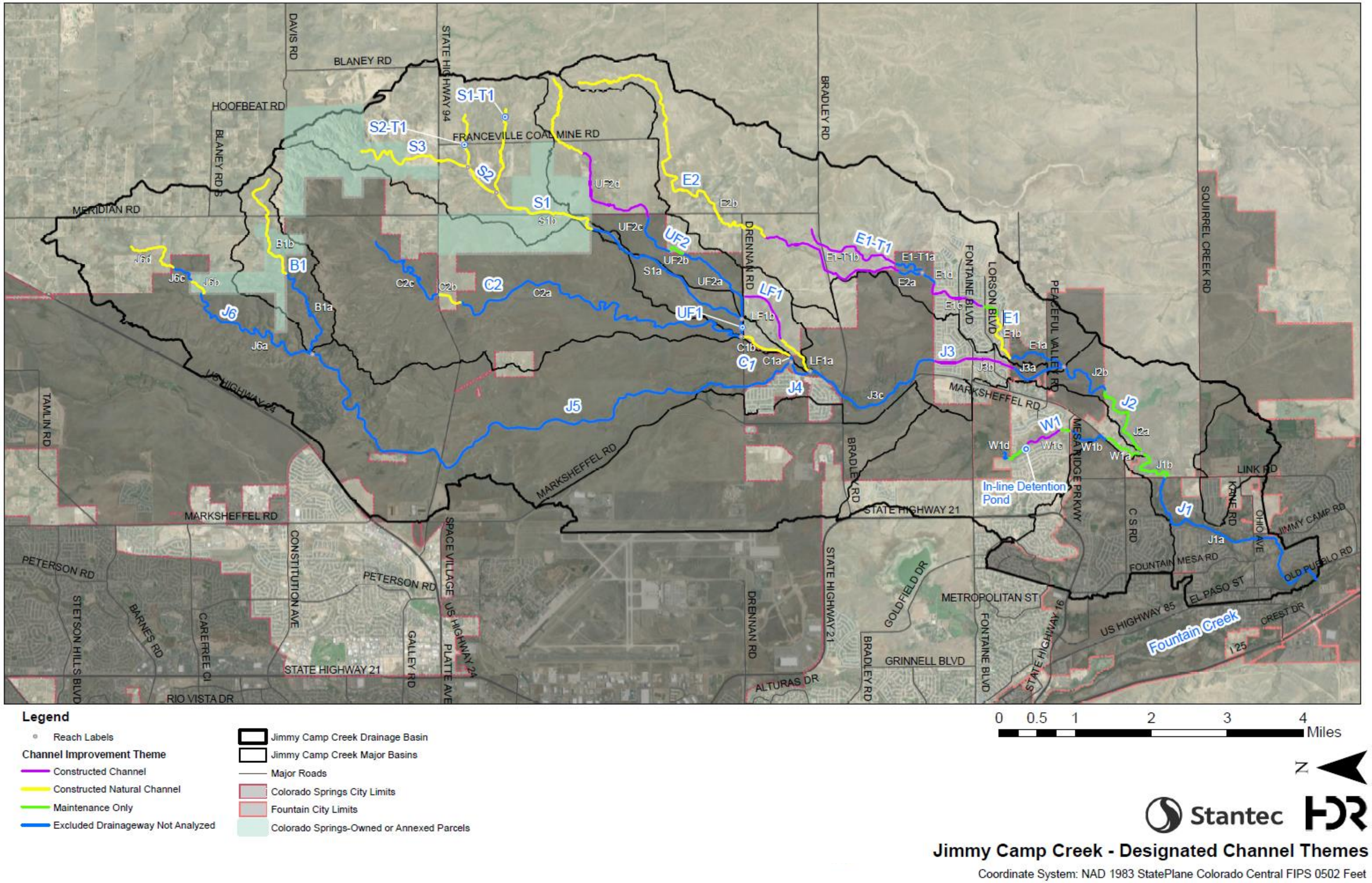


Figure 4-4. Jimmy Camp Creek Drainage Basin Designated Channel Themes.

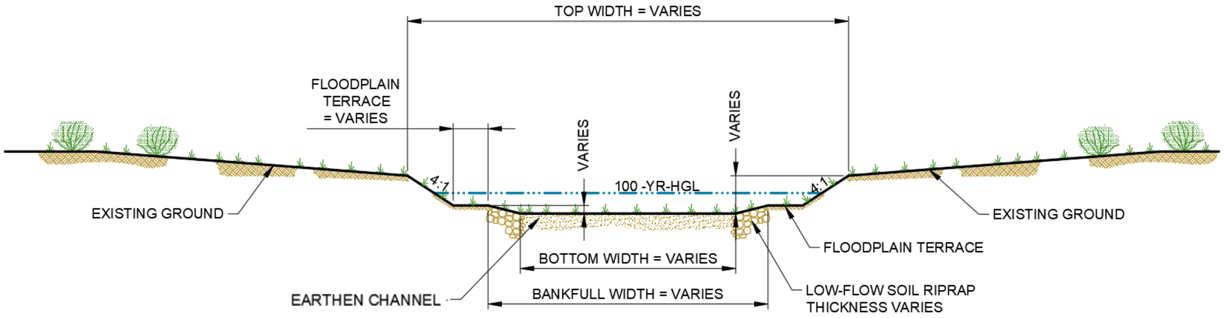
4.4.3.2 Typical Cross Sections

Typical cross sections were designed as guidelines for both the Constructed Channel and the Natural Constructed Channel themes to help with cost estimating and projection of right-of-way requirements. These typical cross sections are based on assumptions of the estimated stable slope and geomorphic parameters of the two themes. Additional geomorphic and sediment transport data will be needed to properly design any specific channel improvement project within these segments.

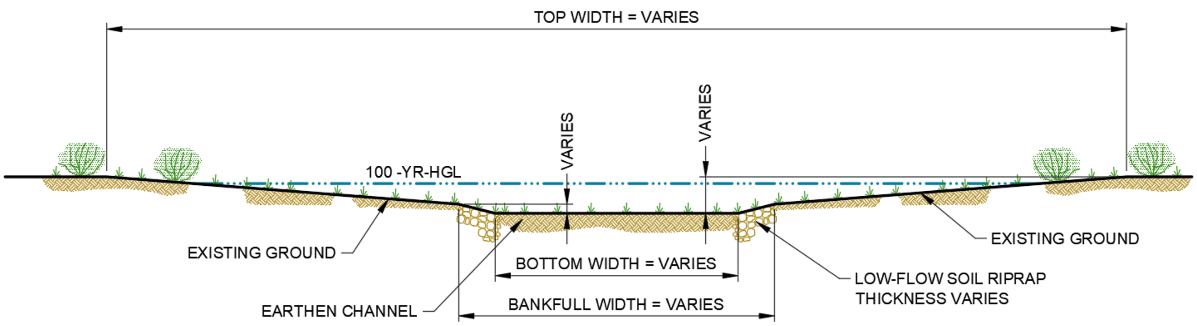
The low flow (defined as bankfull for the purposes of this report) channel dimensions for each stream reach were estimated using guidance from the Colorado Springs DCM. Chapter 12 Section 3.1.1 of the City DCM contains equations for calculating the low flow cross sectional area, width, and depth. These equations are based on analyses of channels in the Jimmy Camp Creek drainage basin. The design cross sectional area of the low flow channel is based on the size of the contributing drainage area. The estimated low flow dimensions for each stream reach have widths ranging from 20 ft to 48 ft and depths ranging from 0.7 ft to 1.6 ft. It is important to note that the County DCM has guidance on design of low flow channels that is different than the City DCM guidance. Differences between County and City guidance will have to be resolved on an individual project basis.

As described in Section 2.5.2, Geomorphic Field Assessment, estimates of the low flow (bankfull) dimensions were also developed from the geomorphic assessment that was completed for this study. Reference cross sections were identified at various locations within the basin. Table 2-2 shows a summary of the reference cross section attributes. The estimated low flow dimensions of the reference sections have widths ranging from 3.5 ft to 43.7 ft and depths ranging from 0.8 ft to 3.4 ft. Examination of Table 2-2 shows that the narrowest width values and highest depth value appear to be outliers of the overall dimension results. The range of widths and depths estimated using the City DCM guidance is in general agreement with the reference section bankfull attributes.

Figure 4-5 shows the typical cross sections for Constructed Channels and Natural Constructed Channels. The Natural Constructed Channel incorporates low flow stabilization and full floodplain preservation to provide natural channel functions. The Constructed Channel has a stabilized low flow and overbank floodplain terraces; however, itis entirely graded in a general trapezoidal shape with no preservation of the existing natural floodplain. The design intent should be to provide sufficiently wide floodplain terraces that limit maximum flow depth and, in combination with grade controls, result in flow velocities that do not require a fully lined channel section.



CONSTRUCTED CHANNEL SECTION



CONSTRUCTED NATURAL CHANNEL SECTION

Figure 4-5. Typical Channel Sections

4.4.4 Channel Stabilization Options

4.4.4.1 Grade Control Options

Due to more runoff and lower sediment yields, long-term stable low-flow channel slopes are expected to be significantly flatter than existing channel slopes. To achieve the desired stable condition, grade control structures are proposed to mitigate steeper channel sections and stabilize the stream reach. The proposed channel is assumed to keep the existing alignment.

The maximum height per City DCM is 6 ft for Constructed Channels, but these channels are not being proposed in this DBPS. The maximum height for Constructed Natural Channels is 4 ft based upon the City DCM, Table 12-7. We assumed that smaller drop structures would result in less maintenance and less interruption of natural sediment processes, so drop structures with a height of 1.5 ft were preferred. If the structure spacing required for a drop height of 1.5 ft became less than 200 ft, the drop height was increased to 2.5 ft, then to 4 ft, as necessary, and 6 ft. for constructed channels (Table 4-2). This was done to avoid an excessive number of drops in short channel reaches. However, in some steep reaches, the structure spacing had to be decreased to less than 200 ft to meet the stabilization goals with a maximum drop height of 4 ft.

In final design, grade control structures may consist of void filled riprap in a natural configuration or grouted boulders with different heights based on the local features. It is not intended that the final design match the sizes and spacing shown in the alternatives. The final design should provide adequate channel stabilization while incorporating aesthetic design characteristics.

Any modification wetlands/Waters of the State could require permitting and mitigation. The recently implemented Colorado Mitigation Procedures (COMP), Colorado Stream Quantification Tool (CQST) and mitigation banking are used by the U.S. Army Corps of Engineers Regulatory Office to analyze permit applications under Section 404 of the Clean Water Act. The COMP, developed by Colorado regulatory offices, provides regulatory specialists with a framework to objectively evaluate a wetland or a stream's functional condition by providing a measurable and repeatable method of calculating debits and credits for wetland and waterway impacts caused by permitted activities. These procedures utilize the CSQT, also developed by the Colorado regulatory offices in partnership with the U.S. Environmental Protection Agency, to evaluate a stream's hydrology, hydraulics, geomorphology, chemistry, and biology. The tool uses a combination of metrics based on watershed data as well as common survey and field measurements, such as width-depth ratios and bank erosion.

4.4.4.2 Bank Stabilization Options

Channel improvements proposed in the DBPS will alter the existing grade of channels in the areas identified for improvements and reshape the channel and active floodplain to provide additional stability within the system. Bank stabilization measures are included in the Constructed Channel and the Natural Constructed Channel templates to ensure that the grade stabilization features are not flanked by the river. No significant bank stabilization measures are recommended under existing conditions based upon the geomorphic assessment given in Chapter 2 (Basin Characteristics and Environmental Resources). In some locations, however, additional bank stabilization could be required to protect critical infrastructure that is built in the future.

Bank stabilization could consist of one or more of the following techniques specified in Chapter 12 of the Colorado Springs DCM.

1. Reduction of Bank Slopes: Reducing banks slopes to 6H:1V or flatter in locations with sufficient right-of-way (ROW) and channel width will assist with vegetation establishment and overall stability. Steeper slopes may be required where site constraints do not allow for shallower slopes, with a maximum of 3H:1V being allowed with appropriate slope protection for the sandy soils present in the basin. This option would also involve revegetation to stabilize regraded banks.

2. Riprap/Boulder Protection: Large riprap or boulder bank protection can be used at locations where ROW conditions limit shallower bank slopes. Riprap or boulder protection should be designed using the tractive force method and as defined in the DCM. Riprap bank protection may also be designed to be buried and revegetated to improve channel aesthetics. The decision about whether to use riprap or natural boulders will be based upon cost and aesthetic considerations.

3. Bioengineered Bank: In places where establishment of vegetation is feasible, bioengineered channel banks can provide stability with a more natural look and feel than other armoring techniques. This option would involve use of surface stabilization measures (straw mats, geotextile fabrics, log toes, root wads, etc.) in combination with strategic revegetation selected for the specific application. Bioengineered banks could be used throughout the basin, provided that an appropriate design and plant species are used. In the upper basin, it may be difficult to establish woody species and the design may have to rely upon herbaceous plants with limited rooting depths and therefore may not be advisable for tall banks. In many areas, however, the bank heights are small and the bankfull depth is less than 1.5 feet in many of the streams (see Table 2-2). The final selection of appropriate bank stabilization techniques is dependent upon several factors including proximity of infrastructure, climate, soils, water table, and hydraulic conditions (NRCS Technical Supplement 14I, Streambank Soil Bioengineering).

4.4.5 Improvements to Existing Hydraulic Structures

Existing culverts and bridges with inadequate capacity for existing conditions are listed in Table 4-6. 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 on top of the structure.

New hydraulic structures included in the alternatives are listed in Sections 4.4.10 and 4.4.11. Necessary improvements to these structures were determined by sizing a new structure to carry the 100-year peak flow without causing pressure flow in the new structure. A structure that doesn’t allow pressure flow will more likely pass debris and will cause less scour downstream of the structure.

Table 4-6. Evaluation of Existing Structures.

Drainage	Reach Name	Location	Structure Description	Source of Data	Existing 100-Year Flow (cfs)	Existing Structure Capacity	Jurisdiction
Jimmy Camp	J3	Peaceful Valley Rd.	4 – 30" CMP	EPC field data	7,241	Overtopped	City of Fountain
West Fork	W1	Furlong Cir.	54" CMP	EPC GIS data	141	Overtopped	El Paso County
West Fork	W1	Ingle Ln.	2 - 36" CMP	EPC GIS data	141	Overtopped	El Paso County
West Fork	W1	Marksheffel Rd.	24" RCP	Stantec field data	141	Overtopped*	City of Fountain
Upper Franceville	UF2	Franceville Coal Mine Rd.	2 - 36" CMP	EPC GIS data	182	Overtopped*	El Paso County
East Fork Tributary	E1-T1	Bradley Rd.	2 - 66" RCP	Construction plans	424	Overtopped*	El Paso County
East Fork	E2	Meridian Rd.	2 - 36"x48" HERCP + 2 - 36" RCP	EPC GIS data	507	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.

** Criteria allows for some overtopping for roads classified as collectors or local roads.

CMP = Corrugated Metal Pipe

RCP = Reinforced Concrete Pipe

CBC = Concrete Box Culvert

HERCP = Horizontal Elliptical Reinforced Concrete Pipe

4.4.6 Regional Detention Options

As part of the alternatives analysis, regional detention alternatives were evaluated. The objectives of regional detention were the following:

- Reduce channel velocities to less than 5 ft/s,
- Reduce number of structures affected by flooding
- Reduce areas flood extents, particularly where 100-yr flood plain is much larger than the main channel

There are many considerations when designing detention structures. As mentioned previously, to prevent it from becoming a dam under the jurisdiction of the state, the embankment height must be less than 10 feet. Online detention basins are not considered feasible alternatives because of the water quality regulations that prevent degradation of water quality (Regulation No. 31 – The Basic Standards and Methodologies for Surface Water 5 CCR 1002-31) and the fact that these online detention basins would trap significant amounts of sediment and require sediment excavation. On-line or Off-line Detention basins also have the potential to expose the project to water right liabilities as defined under Senate Bill 15-212 / Colorado Revised Statute (CRS) §37-92-602 (8) which states that the operation of the detention facility will not cause a reduction to the natural hydrograph as it existed prior to the upstream development.

Another constraint on detention alternative is that the facility has to be within unincorporated El Paso County and provide significant benefit to parcels in the unincorporated areas. For example, a previous detention analysis for the Jimmy Camp Creek basin had detention facilities further down in the watershed where there would be limited benefits to County parcels, and most of the benefit was realized in City owned parcels. Based upon this constraint, only East Fork, Upper Franceville, and Stripmine have significant lengths of stream within the County that could benefit from detention.

The stream velocities in East Fork, Upper Franceville, and Stripmine were analyzed to determine how much the 100-year flow would have to be reduced to have channel velocities below 5 ft/s. In Upper Franceville and East Fork, it was found that the flow would have to be reduced to the 25-year flood to have channel velocities less than 5 ft/s. In Stripmine, it was found that the 100-year flow would have to be reduced down to the 2-year flood level to have channel velocities less than 5 ft/s. This would equate to a flow reduction from 2,074 cfs to 177 cfs in Stripmine at Highway 94. The 100-year floodplain is also generally well contained within the channel for the majority of its length in the County. For these reasons, it was determined that detention within Stripmine is not feasible.

Potential locations for detention along East Fork and Upper Franceville were determined by placing the detention in the upper portion of the watershed so as to have the maximum potential benefit to parcels within the County.

The three regional detention locations identified for evaluation in the DBPS are presented on Figure 4-6. Two locations are on the Upper Franceville tributary and the third location is on the East Fork Tributary. These locations result in 4 separate scenarios as defined in Table 4-7.

Table 4-7. Regional Detention Scenarios

Scenario	Name	Note
Scenario 1	Location 1 on the Upper Franceville tributary	Single regional detention location on the Upper Franceville tributary at Location 1.
Scenario 2	Location 2 on the Upper Franceville tributary	Single regional detention location on the Upper Franceville tributary at Location 2.
Scenario 3	Location 1 and Location 2 on Upper Franceville tributary	Two regional detention locations on the Upper Franceville tributary. Location 1 is sized similar to Scenario 1, with a reduction in size of Location 2.
Scenario 4	Location 1 on East Fork tributary	Single regional detention location on the East Fork tributary.

The objectives of regional detention are to attenuate existing and future 100-year peak flow rates down to existing 25-year peak flow rates. The 25-year flow rate was chosen because that is approximately the flow rate when the flow velocities were limited to less than 5 ft/s downstream of the detention basin.

County regulations and design criteria require post-development 100-year peak flow rates to be mitigated to existing conditions. Given that the future conditions hydrologic modeling only assumed future imperviousness and that modeling onsite detention is beyond the scope of this DBPS, a SWMM based modeling solution is not available to estimate detention requirements with respect to future flow rates. However, the future conditions modeling is representative of future volumes and, therefore, a spreadsheet model was used to estimate regional detention requirements to mitigate flows to existing 25-year rates. Table 4-8 summarizes the future 100-year flow volumes and existing 25-year flow rates used as metrics in this analysis.

The spreadsheet model was developed to limit the channels downstream of the conceptual regional detention locations to exiting 25-year maximum flow rates. Based on these exiting 25-year maximum flow restrictions coupled with the 100-year total volumes associated with future land use impervious percentages, the regional detention volume estimations are provided in Table 4-9. Table 4-9 also provides estimations of the corresponding areas required to accommodate these volumes. Given that area requirements are highly variable depending upon how the site is graded, the accommodation of access roads, and other area considerations, ranges of values are provided. The lower value in the area range is calculated based on a flat pond bottom, a square footprint, 4-foot horizontal to 1-foot vertical side slopes, and a 30 percent increase to accommodate access roads and easements. The maximum height of the embankment is assumed to be 10 ft as stated in Section 4.4.1. The upper value in the area range is calculated based on grading plans associated with pond designs that have much less volume at the lower depths due to water quality features, trickle channels, pond bottom slopes, etc. If regional detention is pursued, area requirements should be reevaluated developing site-specific grading plans based on County criteria.

Table 4-8. Regional Detention Volume and Flow Metrics

Scenario	Location 1 on the Upper Franceville Tributary		Location 2 on the Upper Franceville Tributary		Location 1 on East Fork Tributary	
	Existing 25-year Peak Flow Rate	Future 100-Year Total Flow Volume	Existing 25-year Peak Flow Rate	Future 100-Year Total Flow Volume	Existing 25-year Peak Flow Rate	Future 100-Year Total Flow Volume
Scenario 1	53 cfs	24 ac-ft	N/A	N/A	N/A	N/A
Scenario 2	N/A	N/A	61 cfs	46 ac-ft	N/A	N/A
Scenario 3*	53 cfs	24 ac-ft	61 cfs	46 ac-ft	N/A	N/A
Scenario 4	N/A	N/A	N/A	N/A	87 cfs	131 ac-ft
* Location 1 unchanged between Scenarios 1 and 3 due to the same flow rates and subsequent attenuation objectives						

Table 4-9. Regional Detention Size Requirements

Scenario	Location 1 on the Upper Franceville Tributary		Location 2 on the Upper Franceville Tributary		Location 1 on East Fork Tributary	
	Approximate Volume Requirement	Approximate Grading Area Requirement	Approximate Volume Requirement	Approximate Grading Area Requirement	Approximate Volume Requirement	Approximate Grading Area Requirement
Scenario 1	10.5 ac-ft	2.3 – 3.0 acres	N /A	N/A	N/A	N/A
Scenario 2	N/A	N/A	22 ac-ft	4.5 – 5.7 acres	N/A	N/A
Scenario 3*	10.5 ac-ft	2.3 – 3.0 acres	13.5 ac-ft	3.0 – 3.5 acres	N/A	N/A
Scenario 4	N/A	N/A	N/A	N/A	80 ac-ft	13.8 – 19.5 acres
* Location 1 unchanged between Scenarios 1 and 3 due to the same flow rates and subsequent attenuation objectives						

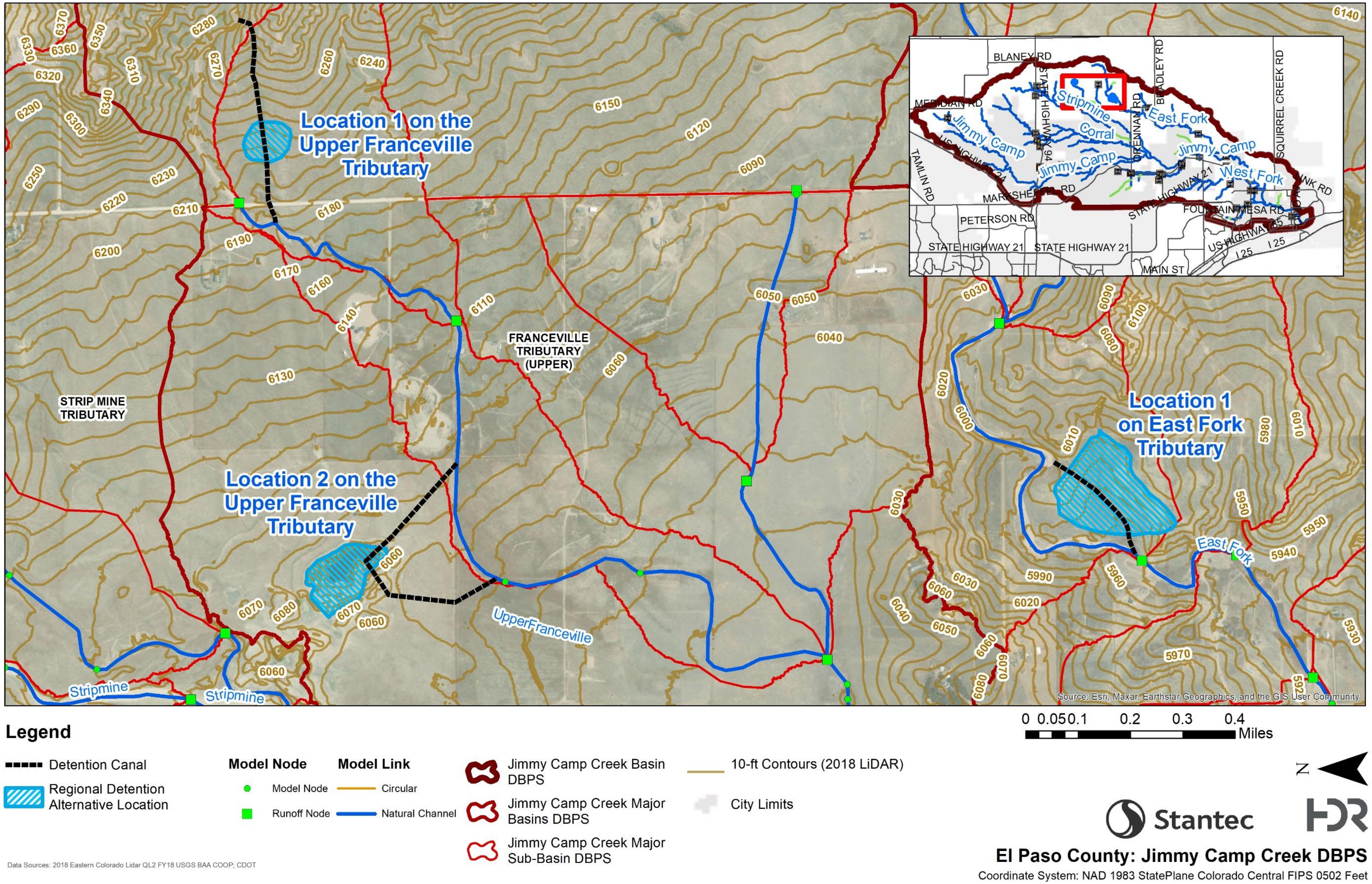


Figure 4-6. Analyzed Locations for Conceptual Regional Detention.

4.4.7 Storm Drain Improvements

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 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 4-10 shows the results of the large storm sewer evaluation and locations are shown in Figure 4-7.

Suggested improvements to the structures are included in the alternatives and can be found in Table 4-13 and location are given in Figure 4-7.

Table 4-10. 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

Figure 4-7. Jimmy Camp Creek Storm Sewer Locations.

4.4.8 Overview of Alternatives

Alternatives were developed to address areas in the Jimmy Camp Creek drainage basin that have experienced historical problems with flooding or channel stability, or that are anticipated to experience problems in the future based on anticipated land use and hydrology changes. Three alternatives were considered for the basin:

- No Action
- Alternative 1 – Conveyance Improvements with No Regional Detention
- Alternative 2 – Conveyance Improvements with Maximum Feasible Regional Detention

The only significant difference between Alternatives 1 and 2 is the inclusion of regional detention in Alternative 2. The primary objective of detention within Alternative 2 was to decrease 100-year flow velocities downstream of the detention basins to less than 5 ft/s to reduce costs of channel improvements. The stream stabilization measures in the East Fork and Upper Franceville tributaries could be reduced because of the reduction in peak flows. In all other stream segments the channel improvements (typical cross sections and grade control structures) are the same for both alternatives. The roadway crossings and storm drain improvements required for existing and future proposed facilities are also the same in both alternatives.

The Alternative development did not consider potential impacts of the Colorado Mitigation Procedures (COMP) on design and costs of stream restoration. The COMP was developed in response to 2008 Mitigation Rule (33 CFR 332),

(https://www.spa.usace.army.mil/Portals/16/docs/civilworks/regulatory/Mitigation/2020.06.23.COMP.v2.pdf)https://www.ecfr.gov/current/title-33/chapter-II/part-332) .

4.4.9 No Action Alternative

4.4.9.1 No Action Hydrology

The No Action alternative would allow for development but contain no channel improvements. The peak flows under the No Action Alternative would be consistent with the existing conditions peak flows. As described previously, the City EPC DCM requires new developments to install extended detention basins or other permanent control measures to maintain post-development runoff rates at pre-development conditions and to mitigate impacts of land development on receiving water quality. Therefore, the peak flows from the existing conditions hydrology were used to develop DPBS alternatives. However, the increase in impervious area would increase the volumes of runoff and runoff volumes would be similar to the future condition hydrology. The assumed percent impervious for the majority of the basins is above 30% (see Figure 1-9 from Hydrology report) and this will have significant impacts on runoff volumes. A plot of the 10-yr flood volumes under existing and future conditions is shown in Figure 4-8. The flow volumes increased by an average factor of over 6 for drainage areas over 10 sq mi. There are several locations within the Sand Creek Watershed where extensive erosion has and continues to occur (Figure 4-9).

4.4.9.2 No Action Channel Response

This large increase in flow volume without a commensurate increase in sediment supply will result in significant erosion of the stream channels. No future channel improvements are assumed to occur under the No Action Alternative and therefore erosion is expected to occur throughout the river system under the No Action Alternative. The erosion would result first in vertical incision followed by bank failure as the bank height increases to unstable heights. The bank failure will result in channel widening and potential loss of property. The most common conceptual model of channel evolution resulting from an increase in flow volume was given in Section 2.5.2.2. Because the stream beds are primarily composed of erodible sandy material, the erosion response will likely be rapid and relatively large. There are well documented erosion problems in the Sand Creek Basin due to increased flow after development (Sand Creek Drainage Basin Planning Study, January 2021). A similar response is expected in Jimmy Camp Creek watershed after development without adequate stream channel design and planning.

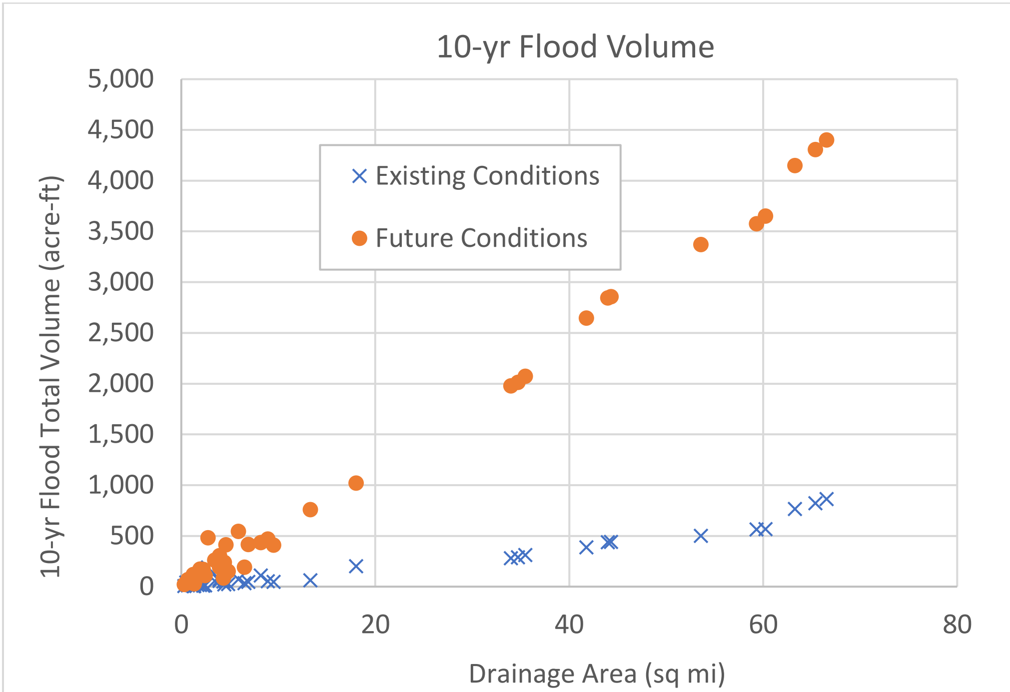


Figure 4-8. Change in flow volumes due to future development based upon Existing and Future Conditions Hydrologic Model.

Figure 4-9. Example of degradation in Sand Creek near Barnes Road Bridge in Colorado Springs.

4.4.10 Alternative 1 – Conveyance Improvements with No Regional Detention

4.4.10.1 Alternative 1 Hydrology

Hydrology for Alternative 1 was based on the existing conditions peak flows, but the volume of flow would be consistent with future conditions. As described previously, the City DCM requires new developments to install extended detention basins or other permanent control measures to maintain post-development runoff rates at pre-development conditions and to mitigate impacts of land development on receiving water quality. Therefore, the peak flows from the existing conditions hydrology were used to develop DPBS alternatives. It was assumed that the volumes of runoff would be similar to the future condition hydrology.

The existing conditions peak flows are given in the Hydrology Chapter. Alternative 1 was developed with no assumption of any hydrologic adjustment for effects of proposed conveyance system improvements such as altered cross section geometry or flatter channel slope due to proposed installation of grade control structures to maintain maximum allowable slopes.

4.4.10.2 Alternative 1 Channel Improvements

The channel improvements associated with Alternative 1 were based on the channel themes described previously. Maintenance Only, Constructed Channel, and Natural Constructed Channel themes were applied to each stream reach based on existing conditions and future opportunities.

Alternative 1 includes grade control structures in every channel reach in which the current slope exceeds the stable slope, with the exception of reaches J1 and J2, where dense vegetation is present along banks and the floodplain.

An example of conveyance improvements associated with Alternative 1 are shown in large format plan and profile drawings included in Appendix A. Table 4-11 gives a summary of the channel and grade control improvements in each stream reach.

Table 4-11. Alternative 1 Conveyance Improvements

Drainageway	Reach ID	Unincorp. EPC Reach Length [ft]	Reach Length to be Improved and Included in Cost Estimate [ft]	Channel Type	Selected Channel Theme	Assumed Stable Slope	Low Flow Channel Geometry		# of Grade Control Structures		
							Width [ft]	Depth [ft]	1.5 ft	2.5 ft	4 ft
Jimmy Camp Creek	J1b	4,447	0	Type 3 – Unimproved – Existing or Future Problems	Maintenance Only	0.05%	---	---	---	---	---
	J2a	6,460	0	Type 3 – Unimproved – Existing or Future Problems	Maintenance Only	0.05%	---	---	---	---	---
	J3b	5,464	0	Type 2 – Improved – Existing or Future Problems	Constructed Channel*	0.05%	48	1.6	20	2	0
	J6	6,147	6,147	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.30%	30	1.0	5	31	5
Blaney	B1b	8,783	8,783	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.35%	23	0.8	0	7	52
Corral	C1b	3,679	3,679	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.06%	41	1.4	14	3	0
	C2b	1,737	1,528	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.15%	32	1.1	7	1	0
Lower Franceville	LF1b	2,191	2,191	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.35%	22	0.7	0	10	0
		4,281	0	Type 2 – Improved – Existing or Future Problems	Constructed Channel*	0.35%	---	---	---	---	---
Upper Franceville	UF2b	1,281	0	Type 3 – Unimproved – Existing or Future Problems	Maintenance Only	0.35%	---	---	---	---	---
	UF2d	9,617	8,336	Type 3 – Unimproved – Existing or Future Problems	Constructed Channel	0.35%	22	0.7	0	4	24
		8,093	8,093	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.35%	20	0.7	0	0	60
Stripmine	S1b	7,981	7,981	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.10%	33	1.1	1	33	0
	S2	2,763	2,763	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.15%	30	1.0	0	14	0
	S3	9,567	9,388	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.15%	27	0.9	0	24	22
Stripmine South Tributary	S1-T1	6,417	6,417	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.35%	24	0.8	0	1	36
Stripmine North Tributary	S2-T1	4,141	3,921	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.30%	21	0.7	0	2	21
East Fork	E1b	4,117	4,117	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.20%	37	1.2	19	1	0
	E1b	970	0	Type 1 – Improved – No Existing or Future Problems	Maintenance Only	0.20%	---	---	---	---	---
	E1c	4,438	0	Type 2 – Improved – Existing or Future Problems	Constructed Channel*	0.20%	---	---	---	---	---
	E2b	11,226	11,226	Type 3 – Unimproved – Existing or Future Problems	Constructed Channel	0.30%	33	1.1	30	0	0
	E2b	25,089	25,089	Type 3 – Unimproved – Existing or Future Problems	Constructed Natural Channel	0.30%	29	1.0	0	37	70
East Fork Tributary	E1-T1b	7,698	7,698	Type 3 – Unimproved – Existing or Future Problems	Constructed Channel	0.30%	23	0.8	20	7	0
West Fork	W1c	8,929	0	Type 2 – Improved – Existing or Future Problems	Constructed Channel	0.20%	---	---	---	---	---
TOTAL		153,714	117,357								

4.4.10.1 Alternative 1 Improvements to Existing Hydraulic Structures

Based upon the structure evaluations in the hydraulic analysis, the required roadway crossing improvements are shown in Table 4-12. For the purposes of the alternative analysis, we assumed that a box culvert would be used to convey water through the crossing. The proposed structure is designed to convey the 100-yr flood with no overtopping, which may be in excess of design criteria that allows overtopping of collector and local roads.

Table 4-12. Proposed Improvements to Hydraulic Structures

Drainage	Reach Name	Location	Existing Structure Description	Source of Data	Existing 100-Year Flow (cfs)	Proposed Structure
West Fork	W1	Furlong Cir.	54” CMP	EPC GIS data	141	1 – 8’ x 4’ CBC
West Fork	W1	Ingle Ln.	2 – 36” CMP	EPC GIS data	141	1 – 8’ x 4’ CBC
Upper Franceville	UF2	Franceville Coal Mine Rd.	2 – 36” CMP	EPC GIS data	182	1 – 10’ x 4’ CBC
East Fork Tributary	E1-T1	Bradley Rd.	2 – 66” RCP	Construction plans	424	1 – 10’ x 8’ CBC
East Fork	E2	Meridian Rd.	2 – 36”x48” HERCP + 2 – 36” RCP	EPC GIS data	507	3 – 12’ x 4’ CBC

4.4.10.2 Alternative 1 Regional Detention Improvements

Alternative 1 includes no additional regional detention.

4.4.10.3 Alternative 1 Storm Drain Improvements

The proposed upgrades to existing storm drains are shown in Table 4-13.

Table 4-13. Proposed Storm Drain Improvements

Description	Existing Material	Existing Shape	Existing Size (in)	Existing 100-YEAR (cfs)	Max Capacity (cfs)	Proposed Structure
Fontaine Blvd (Old Glory Dr Tract A and D)	HDPE	Elliptical	83 x 53	655	160	9’ x 8’ CBC
Carriage Meadows Dr (Outfall Tract A)	RCP	Round	60	568	282	6’ x 6’ CBC
Peaceful Ridge Dr (Tract C & F to Outfall)	RCP	Round	60	360	178	6’ x 6’ CBC

4.4.11 Alternative 2 – Conveyance Improvements with Regional Detention

4.4.11.1 Alternative 2 Hydrology

Hydrology for Alternative 2 was based on the Existing Conditions peak flows, but assuming Future Conditions volumes. As described previously, the County DCM requires new developments to install extended detention basins or other permanent control measures to maintain post-development runoff rates at pre-development conditions and to mitigate impacts of land development on receiving water quality. Therefore, the peak flows from the existing conditions hydrology were used to develop DPBS alternatives, while the volume of runoff was taken from the future condition's hydrology.

Alternative 2 includes all three proposed detention structures (scenario 3 and 4 as defined in Section 4.4.6) on the East Fork and Upper Franceville Tributaries. As described previously, the conceptual regional detention facilities were designed to limit peak flows downstream of the ponds to the existing conditions 25-year flow rates to limit flow velocities to approximately 5 ft/s downstream of the detention basin. Table 4-14 summarizes the peak flows for Alternative 2 where they are reduced from the Alternative 1 flows. The 100-year flows downstream of the detention basins for Alternative 2 were computed by assuming that the reduction in flow for the 100-year flood immediate downstream of the basin is constant throughout the tributary.

Table 4-14. Locations where Alternative 2 Peak Flows are reduced from Alternative 1.

				Existing		Alternative 2	
Major Drainageway	**Reach ID**	**SWMM Model Node ID**	**Location Description**	**100-Year Flow (cfs)**	**25-Year Flow (cfs)**	**100-Year Flow (cfs)**	**25-Year Flow (cfs)**
East Fork	E2	DSNPT_E2_6	Drennan Rd	486	97	97	97
	E2	DSNPT_E2_2	Bradley Rd (West)	568	112	179	112
	E2	DSNPT_E1_8	At City of Colorado Springs Boundary	699	252	310	252
	E1	DSNPT_E1_2	Upstream of Confluence with JCC (Peaceful Valley Rd)	1,087	308	698	308
Upper Franceville	F1	DSNPT_F1_11	S Franceville Coal Mine Rd	182	73	73	73
	F1	DSNPT_F1_10	D/S of S Franceville Coal Mine Rd	207	76	76	76
	F1	DSNPT_F1_9	Confluence of Upper Franceville and Tributary	349	134	217	134
	F1	DSNPT_F1_6	Near Mocking Bird Ln	402	106	271	106

On the East Fork, the 100-year flood is decreased from 486 to 97 cfs immediately downstream of the proposed detention basin on East Fork. The reduction in the 100-year flow rate (a decrease of 389 cfs) is assumed constant from the detention basin to the confluence with Jimmy Camp Creek. Downstream of the confluence with Jimmy Camp Creek, the effect of attenuation within East Fork is considered insignificant because the 100-yr flow in Jimmy Camp Creek is approximately 8 times the 100-yr flow in East Fork. The reduction in velocity due to the detention is given in Figure 4-10 for East Fork. The reduction in velocity is substantial and the velocities are reduced below 5 ft/s for all of East Fork reach upstream of the tributary (E1-T1). Downstream of this tributary, the velocities are not reduced below the 5 ft/s threshold. The channel velocity shown in the figure is a moving average of the 5 nearest cross sections. The averaging is done to see the effect of the alternative more easily, and to more accurately understand the reach average effect of the detention.

On Upper Franceville, the 100-year flood is reduced from 182 to 73 cfs immediately downstream of the most downstream detention basin on Upper Franceville. This reduction in the 100-year flow rate (109 cfs) is assumed constant from the detention basin until the confluence with Jimmy Camp Creek.. The reduction in velocity due to detention on Upper Franceville is given in Figure 4-11, the magnitude of reduction is less than in East Fork. The velocities are reduced for the majority of the stream below the detention except for the lower end because the effect of detention is less, and because this section of Upper Franceville has been somewhat channelized by development. Below the confluence with Stripmine the detention does not decrease the velocities below the 5 ft/s threshold.

These results do not make any hydrologic adjustment for effects of proposed conveyance system improvements such as altered cross section geometry or flatter channel slope due to proposed installation of grade control structures to maintain maximum allowable slopes.

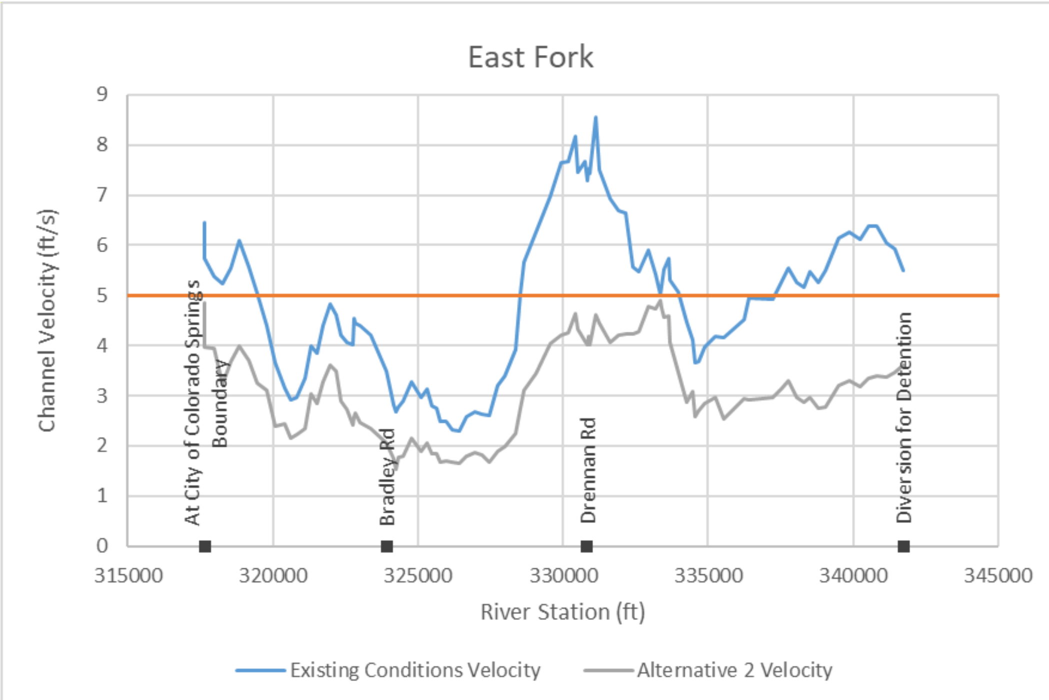


Figure 4-10. Reduction in Velocity in East Fork due to Alternative 2 detention for 100-year flood.

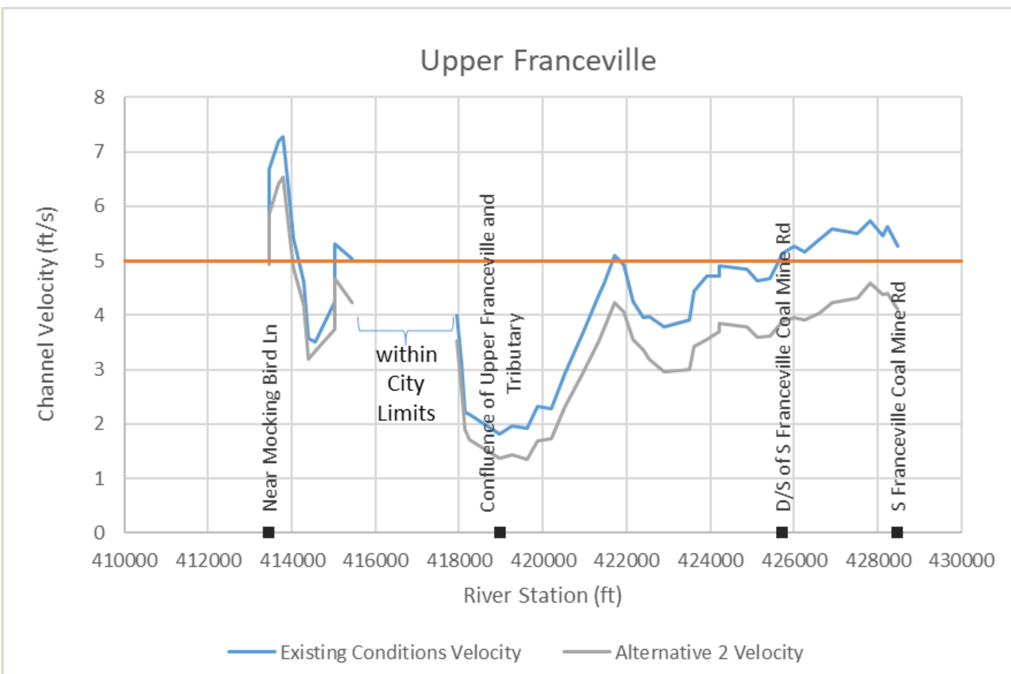


Figure 4-11. Reduction in Velocity in Upper Franceville due to Alternative 2 detention for 100-year flood.

4.4.11.2 Alternative 2 Channel Improvements

Channel cross sections, grade control structures and bank stabilization measures are the same for Alternative 2 as they were for Alternative 1 with the exception of the locations where peak flows are reduced on East Fork and Upper Franceville Tributaries. The reduction in peak flows allows for smaller constructed channels and fewer grade control structures. The same templates and typical cross sections would be used, but dimensions would be fit to the Alternative 2 hydrology. The same channel lengths will still need to be improved, but the number of grade control structures will be substantial reduced as shown in Table 4-15.

Table 4-15. Reduction in number of Grade Control Structures for Alternative 2.

Drainageway	Reach ID and Channel Theme	# of Grade Control Structures			Reduction in Number of Grade Control structures		
		1.5 ft	2.5 ft	4 ft	1.5 ft	2.5 ft	4 ft
Upper Franceville	UF2d Constructed Channel	0	0	0	0	4	24
	UF2d Constructed Natural Channel	0	0	46	0	0	14
East Fork	E2b Constructed Channel	0	0	0	30	0	0
	E2b Constructed Natural Channel	0	27	65	10	0	5

4.4.11.3 Alternative 2 Regional Detention Improvements

Alternative 2 includes detention on the Upper Franceville and East Fork Tributaries. The approximate requirements for these detention facilities are given in Table 4-16. The assumed locations of the facilities have been shown in Figure 4-6.

We chose to combine scenario 3 and 4 for the purposes of analyzing Alternative 2. This combination of alternatives will give the maximum benefit of detention and this combination includes all identified potential detention locations.

In addition to construction of the detention basins, the following facilities to divert and convey water to and from the structures will need to be constructed as the detention basins are off-stream:

- Weir at the entrance to the canal leading to the basin
- Channels with sufficient capacity leading to and from detention facility.
- Spillway for volumes that exceed basin and outlet capacity.
- Low-level outlet facility.

Table 4-16. Assumed Detention Size Requirements for Alternative 2.

Scenario	Location 1 on the Upper Franceville Tributary		Location 2 on the Upper Franceville Tributary		Location 1 on East Fork Tributary	
	Approximate Volume Requirement	Approximate Grading Area Requirement	Approximate Volume Requirement	Approximate Grading Area Requirement	Approximate Volume Requirement	Approximate Grading Area Requirement
Scenario 3 and 4	10.5 ac-ft	2.3 – 3.0 acres	13.5 ac-ft	3.0 – 3.5 acres	80 ac-ft	13.8 – 19.5 acres

4.4.11.4 Alternative 2 Storm Drain Improvements

Storm drain improvements for Alternative 2 are the same as described for Alternative 1.

4.4.12 Alternative Costs

Alternative costs were developed using the Mile High Flood District UD-MP Cost Estimator tool Version 2.2. The unit costs used in the tool were developed based on numerous sources, including the UDFCD Bid Tabs Program, the Colorado of Transportation's Cost Data Book, bid tab data from the City and County of Denver, and the City and County of Denver's Storm Drainage Master Plan. The tools uses unit costs from 2012 as a baseline and escalates costs using the Colorado Construction Cost (CCI) Index. The CCI Index for Calendar Year 2022 4th Quarter was used for the inflation index. This results in costs that are 190% of calendar year 2012.

Assuming the acreage of the Jimmy Camp Creek drainage within El Paso County is 14,018 acres gives a per unit acre cost of $TBD.

The costs were compared to the 2015 DBPS. The 2015 costs included the costs for major drainageway improvements and major sub-tributaries withing City of Colorado Springs. The 2015 did not estimate local sewer improvements, roadway crossings, or utility relocation, which is consistent with the estimates includes in this DBPS. The unplatted acreage is land that is considered developable and was estimated to be 13,489 acres within the City of Colorado Springs. The Capital Cost per acre from the study was $6,519. It is not clear how price escalation was determined for the study, or if it was considered. For example, the 2015 study assumed unit storage costs of $23,762 and $24,353 per acre-foot for regional and sub-regional detention, respectively. These costs were based upon construction costs from previous costs of detention basins in the area, but there was no escalation of costs to the current year. For comparison, the unit cost from the MHFD cost estimator was $86,749 per acre-ft escalated to 2023 dollars. This is an increase in costs of 250%. As another example, the 2015 DBPS assumed a unit cost of type M soil Riprap was $60 per cubic yard, which is less than the 2012 cost of $70 per cubic yard. With escalation to 2023, we assumed $133 per cubic yard, an increase in costs of 121% relative to the 2015 DBPS. We estimate that the 2015 DBPS assumed the unit costs were on average of 25% less than 2012 costs recommended in by the MHFD cost estimator, based upon comparison of riprap and boulder costs.

Because of the large difference in unit cost assumptions, it is difficult to directly compare the cost from the 2015 study to the current study. The 2015 study also did not include Legal, Administration, or Contract administration cost and assumed 10% engineering and 10% contingency. These are significantly less than recommended in the MHFD cost estimator. A summary of the major cost assumption differences between the 2015 DBPS and the current study is given in Table 4-17. The 2022 unit costs resulting from the escalation procedure are given in Table 4-18. Table 4-19 shows the estimated costs for Alternative 1. The estimated costs for Alternative 2 are shown in Table 4-20.

The difference between Alternative 2 and Alternative 1 for the reaches affected by detention is given in Table 4-21. Note the Alternative 2 does substantially reduce the cost of grade control within the reaches, but the costs of constructing the detention structures is greater than the reduction in grade control costs. The total costs of Alternative 1 is $217,600,000 and the costs of Alternative 2 is $225,100,000 (rounded to nearest 100,000).

Table 4-17. Summary of Escalation and Non-Contract Costs for Current Study and 2015 DBPS.

Item	Current study	2015 DBPS
Escalation relative to MHFD 2012 unit costs	90%	-25%
Engineering	15%	10%
Legal/Administration	5%	0%
Contract Administration	10%	0%
Contingency	25%	10%
Total Percentage Increase from 2012 Construction Cost	**145%**	**-5%**

Table 4-18. Summary of Assumed Unit Costs

Item	Unit	Unit Cost 2012 Q1	Adjusted Unit Cost 2022 Q4
Flared End Sections			
12-inch	EA	$710	$1,351
18-inch	EA	$920	$1,750
24-inch	EA	$970	$1,845
30-inch	EA	$1,570	$2,987
36-inch	EA	$1,610	$3,063
42-inch	EA	$1,700	$3,234
48-inch	EA	$2,060	$3,919
Hydraulic Structures			
Grouted Boulders, 36-inch	C.Y.	$190	$361
Soil Riprap, Type M	C.Y.	$70	$133
Excavation, Complete-in-Place	C.Y.	$11	$21
Bedding, Granular Type II	C.Y.	$58	$110
Grout	C.Y.	$240	$457
Check Structure, Concrete	L.F.	$270	$514
Channel Improvements			
Boulder Edging, 12" High	L.F.	$60.00	$114.00
Boulder Edging, 24" High	L.F.	$75.00	$143.00
Boulder Edging, 36" High	L.F.	$90.00	$171.00
Grouted Boulders, 24"	S.Y.	$170.00	$323.00
Grouted Boulders, 36"	S.Y.	$190.00	$361.00
Grouted Boulders, 48"	S.Y.	$200.00	$380.00
6-inch Riprap, Type VL	C.Y.	$45.00	$86.00
9-inch Riprap, Type L	C.Y.	$55.00	$105.00
12-inch Riprap, Type M	C.Y.	$60.00	$114.00
18-inch Riprap, Type H	C.Y.	$80.00	$152.00
24-inch Riprap, Type VH	C.Y.	$85.00	$162.00
Soil Riprap, Type VL	C.Y.	$50.00	$95.00
Soil Riprap, Type L	C.Y.	$60.00	$114.00
Soil Riprap, Type M	C.Y.	$70.00	$133.00
Soil Riprap, Type H	C.Y.	$80.00	$152.00
Soil Riprap, Type VH	C.Y.	$90.00	$171.00
Excavation, Low Range	C.Y.	$11.00	$21.00
Excavation, Mid Range	C.Y.	$24.00	$46.00
Excavation, High Range	C.Y.	$31.00	$59.00
Detention/Water Quality Facilities			
Excavation, Low Range	C.Y.	$11.00	$21.00
Excavation, Mid Range	C.Y.	$24.00	$46.00
Excavation, High Range	C.Y.	$31.00	$59.00
Detention (Complete-in-Place)	AC-FT	$45,600	$86,749
Landscaping and Recreation Improvements			
Reclamation & seeding (native grasses)	ACRE	$1,000	$1,902
Concrete and Steel			
Concrete	C.Y.	$600	$1,141
Steel	LB.	$0.90	$2.00

1. Assumed 2022 unit costs are from the MHFD calculator

Table 4-19. Summary of Alternative 1 costs

Drainageway	Reach ID	Improved Reach Length in Cost Estimate [ft]	Channel Improvements [$]	Grade Control [$]	Detention [$]	Other Costs * [$]	Sub-Total [$]
Jimmy Camp Creek	J6	6,147	2,456,034	5,096,431	0	766,545	8,319,010
Blaney	B1	8,783	3,433,935	6,110,077	0	967,164	10,511,176
Corral	C1	3,679	1,549,710	2,772,044	0	441,591	4,763,345
	C2	1,528	616,344	1,044,733	0	169,247	1,830,324
Lower Franceville	LF1	2,191	853,356	791,937	0	167,459	1,812,752
Upper Franceville	UF2d-constructed	8,336	9,264,222	2,225,267	0	1,189,747	12,679,236
	UF2d-natural	8,093	3,131,097	4,836,535	0	806,179	8,773,811
Stripmine	S1, S2, S3	7,981	8,047,068	11,921,757	0	2,033,915	22,002,740
Stripmine South Tributary	S1-T1	6,417	2,515,005	3,357,810	0	596,905	6,469,720
Stripmine North Tributary	S2-T1	3,921	1,523,769	2,317,703	0	389,377	4,230,849
East Fork	E1	4,117	1,694,256	2,025,309	0	381,371	4,100,936
	E2d-constructed	11,226	15,459,495	2,686,459	0	1,814,596	19,960,550
	E2d-natural	25,089	10,028,850	11,071,810	0	2,110,066	23,210,726
East Fork Tributary	E1-T1	7,698	8,768,475	1,894,115	0	1,077,349	11,739,939
					Capital Costs	--->	140,405,114
					Engineering	15%	21,060,768
					Legal/Administration	5%	7,020,257
					Contract Administration	10%	14,040,513
					Contingency	25%	35,101,280
						Total	217,627,932

* Other costs include revegetation, mobilization @ 5%, stormwater management/erosion control @ 5%

Table 4-20. Summary of Alternative 2 costs

Drainageway	Reach ID	Improved Reach Length in Cost Estimate [ft]	Channel Improvements [$]	Grade Control [$]	Detention [$]	Other Costs * [$]	Sub-Total [$]
Jimmy Camp Creek	J6	6,147	2,456,034	5,096,431	0	766,545	8,319,010
Blaney	B1	8,783	3,433,935	6,110,077	0	967,164	10,511,176
Corral	C1	3,679	1,549,710	2,772,044	0	441,591	4,763,345
	C2	1,528	616,344	1,044,733	0	169,247	1,830,324
Lower Franceville	LF1	2,191	853,356	791,937	0	167,459	1,812,752
Upper Franceville	UF2d-constructed	8,336	9,264,222	0	0	967,221	10,231,443
	UF2d-natural	8,093	3,131,097	3,708,010	4,531,976	1,146,523	12,517,606
Stripmine	S1, S2, S3	7,981	8,047,068	11,921,757	0	2,033,915	22,002,740
Stripmine South Tributary	S1-T1	6,417	2,515,005	3,357,810	0	596,905	6,469,720
Stripmine North Tributary	S2-T1	3,921	1,523,769	2,317,703	0	389,377	4,230,849
East Fork	E1	4,117	1,694,256	2,025,309	0	381,371	4,100,936
	E2d-constructed	11,226	15,459,495	0	0	1,601,108	17,005,445
	E2d-natural	25,089	10,021,242	9,570,433	7,414,920	2,709,028	29,715,623
East Fork Tributary	E1-T1	7,698	8,768,475	1,894,115	0	1,077,349	11,739,939
					Capital Costs	--->	145,250,908
					Engineering	15%	21,787,636
					Legal/Administration	5%	7,262,545
					Contract Administration	10%	14,525,092
					Contingency	25%	36,312,728
						Total	225,138,909

* Other costs include revegetation, mobilization @ 5%, stormwater management/erosion control @ 5%

Table 4-21. Cost of Alternative 1 subtracted from Alternative 2 for Reaches UF2 and E2.

Reach	Channel Improvements [$]	Grade Control [$]	Detention [$]	Other Costs * [$]	Sub-Total [$]
UF2	0	-3,353,792	4,531,976	117,818	1,296,002
E2	-7,608	-4,187,836	7,414,920	385,474	3,549,792

4.5 EVALUATION OF ALTERNATIVES

This section evaluates the alternatives in terms of their ability to meet the project goals as defined in Section 4.3. The two DBPS alternatives and the No Action alternative were scored using the evaluation criteria described previously. All alternatives, including the No Action alternative, are based on the watershed hydrology modeling performed for the DBPS. All alternatives assume existing conditions peak flows as discussed in Section 4.4.10.1, except where detention is proposed on Upper Franceville and East Fork for Alternative 2.

Alternatives were evaluated using a semi-quantitative approach whereby each alternative was given a score from 1 to 5, 5 being best, for each evaluation criterion based on the combined knowledge and experience of the group. The breakdown of the score is as follows: 1 (worst), 2 (bad), 3 (average), 4 (good), and 5 (best). Results are shown in Table 4-22. Because Alternative 1 and 2 differ only in the magnitude of improvements needed in the Upper Franceville and East Fork mainstem downstream of the detention basins, their scores are very similar. Both alternatives have superior evaluations compared to the No Action alternative.

Table 4-22. Evaluation of DBPS Alternatives

Evaluation Criterion	Alternative Score (1 to 5), higher is better			Comments
	No Action	Alternative 1 (Channel Improvements)	Alternative 2 (Detention and Channel Improvements)	
Channel and Floodplain Goals				
Remove insurable structures from 100-year floodplain	3	3	3	No Action: based on DBPS 100-year existing condition flows. There are few structures currently in 100-year floodplain. Alternative 1: peaks flows based on DBPS 100-year existing condition flows. Alternative 2: peaks flows based on DBPS 100-year existing condition flows. Except for Upper Franceville and East Fork DBPS itself does not change regulated FEMA floodplain
Improve channel stability	1	5	5	No Action: Development will increase flow volumes and potentially reduce sediment delivery to streams. Alternative 1 and 2: maintain stable slope to reduce bed and bank erosion.
Reduce impact upon major thoroughfares and utilities, existing and future, by improving channel and bridge/culvert capacity	1	5	5	No Action: No Improvements to hydraulic structures. Alternative 1 and 2: Alternatives improve hydraulic structures.
Environmental Goals				
Approximate naturally functioning system	2	4	4	No Action: erosion in unstable upper and middle basin segments will create incised or overly wide channels Alternatives: preserve stable grade and semi-active controlled overbank area
Improve environmental resources	1	4	4	Alternatives prevent further environmental degradation. Environmental benefits are associated with improved channel stability and sediment control.
Improve Fountain Creek water quality	1	4	4	No Action: more sediment produced from channels after development Alternatives: less upstream sediment production from channels
Minimize regulatory issues	4	3	1	No Action does not require permitting for channel modification or detention basins Alternative 1 requires permitting for channel modification Alternative 2 requires permitting for channel modification and detention basins
Multiple Benefit Goals				
Reduce peak flows to pre-development conditions	4	4	5	All Alternatives: The County DCM requires new developments to install extended detention basins or other permanent control measures to maintain post-development runoff rates at pre-development conditions and to mitigate impacts of land development on receiving water quality. Alternative 2 would further reduce flows in Upper Franceville and East Fork.
Provide open space and trails opportunities	1	2	2	No Action: there no proposed channel improvements and lack of improvements could limit access to drainage paths. Alternative 1 and 2: Channel alternatives in upper undeveloped areas could accommodate open space and trails.

Evaluation Criterion	Alternative Score (1 to 5), higher is better			Comments
	No Action	Alternative 1 (Channel Improvements)	Alternative 2 (Detention and Channel Improvements)	
Cost Goals				
Minimize construction cost	5	2	1	Alternative 1 proposes channel improvements throughout basin. Alternative 2 requires construction of off-line detention basin. The detention basins reduces costs of some channel improvements, but the cost of the detention is significantly larger.
Minimize maintenance cost	1	4	3	No Action: substantial annual maintenance, increasing as upper basin develops. Includes reconstruction of failing facilities. Alternative 1: Reduced maintenance in stable channels, though channels will still require maintenance, though less than the No Action alternatives Alternative 2: Reduced maintenance in stable channels, detention basin will likely require maintence activities at diversions, channels, and within the basin themselves.
Total Score	**24**	**40**	**37**	

4.6 SELECTED ALTERNATIVE

The final alternative will be based on review of the alternative evaluation matrix, input from stakeholders, and the goals for sediment management in the Jimmy Camp Creek Drainage Basin and the overall Fountain Creek watershed.

APPENDIX A. EXAMPLE OF CONVEYANCE IMPROVEMENTS IN JIMMY CAMP CREEK

APPENDIX B. DETAILED COSTS ESTIMATES BY REACH