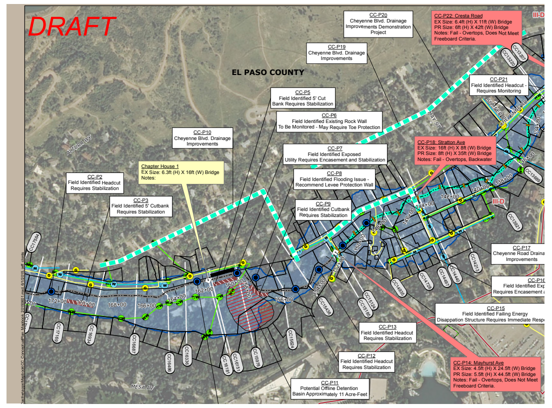

FINAL REPORT

Matrix DESIGN GROUP

THK associates, inc.

Upper Fountain Creek and Cheyenne Creek Flood Restoration Master Plan

Fountain Creek Watershed Flood Control and Greenway District

Project No. 14.526.004

June 26, 2015

Submitted to:
Larry Small, Executive Director
Fountain Creek Watershed Flood Control and Greenway District

Fountain Creek Watershed Flood Control & Greenway District

Colorado Springs Utilities
It's how we're all connected

Coalition for the Upper South Platte

COLORADO Colorado Water Conservation Board Department of Natural Resources

El Paso County Colorado

City of Colorado Springs We Create Community

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D. Geomorphic Assessment
E. Reach Alternatives and Screening Parameters
F. CDOT US-24 Corridor Plans
G. Manitou Springs Williams Canyon Project Plans

1.0 Introduction

1.1 Authorization

The Upper Fountain Creek and Cheyenne Creek Flood Restoration Master Plan (FRMP) was prepared by the Fountain Creek Watershed Flood Control and Greenway District (District) through a special release grant issued by the Colorado Water Conservation Board (CWCB) under the Colorado Watershed Restoration Program (WRP). The District was authorized in 2009 by Colorado Senate Bill 09-141 and an Amendment to Title 32 of the Colorado Revised Statues to oversee the resource management of the Fountain Creek watershed in El Paso and Pueblo Counties. Following the 2013 floods, the District was awarded the WRP grant and established the Upper Fountain Creek and Cheyenne Creek Flood Restoration Coalition (Coalition) with funding partners that included the City of Colorado Springs, El Paso County (EPC), Colorado Springs Utilities (CSU) and in-kind services provided by the Coalition for the Upper South Platte (CUSP), and the Pikes Peak Area Council of Governments (PPACG). Active participation by the City of Manitou Springs, Green Mountain Falls, Pikes Peak Regional Building Department, Cheyenne Creek Metro District, the City of Woodland Park, Teller County and numerous local residents has resulted in a strong coalition of interested parties and stakeholders with comprehensive regional representation.

1.2 Purpose

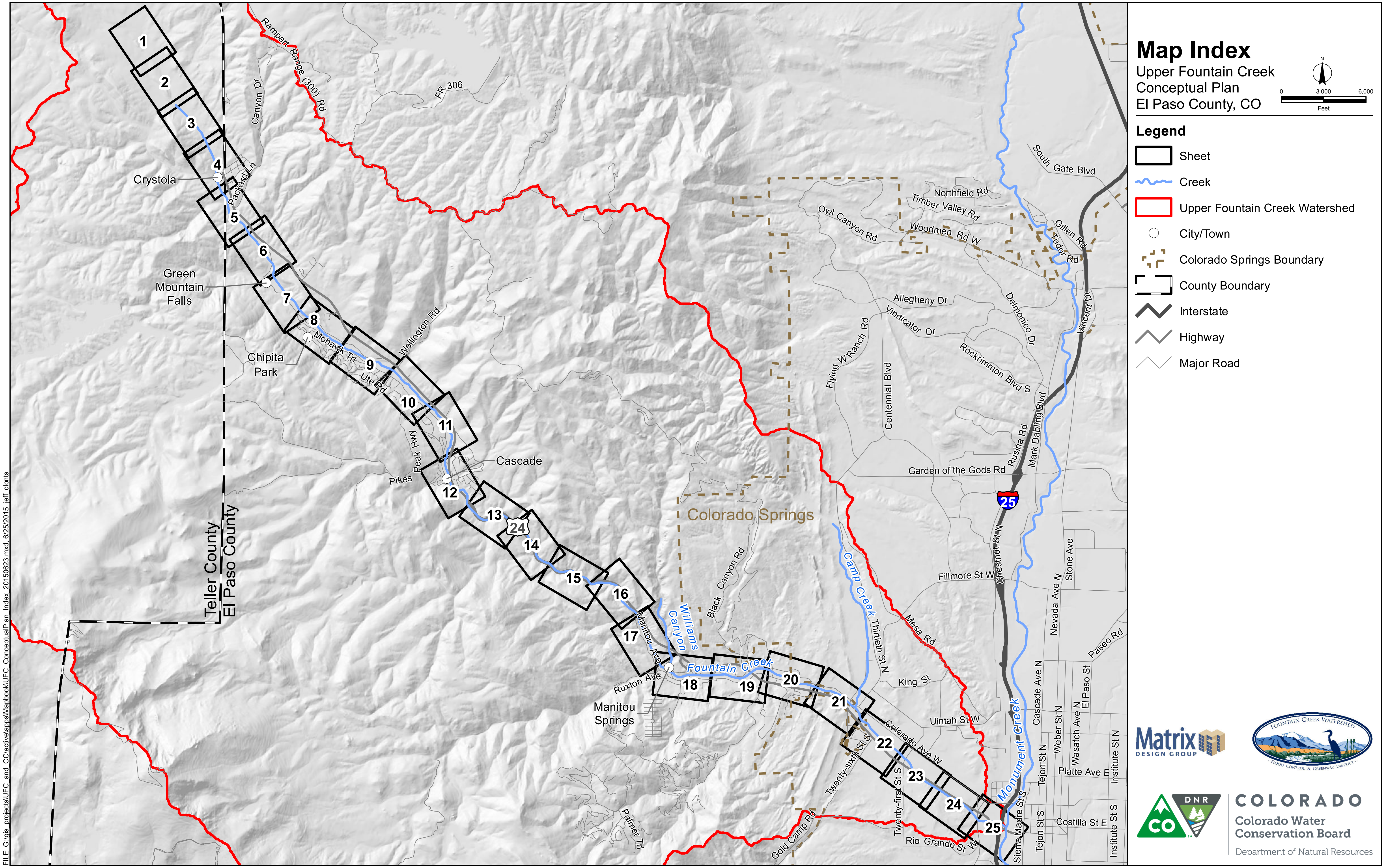
Both Upper Fountain Creek and Cheyenne Creek suffered from extensive flooding during the summer and fall of 2013. El Paso County, the City of Colorado Springs, the City of Manitou Springs and other regional municipalities and agencies have undertaken various projects to repair flood damage, mitigate flood risk, stabilize channels, and restore stream and watershed function in Upper Fountain Creek, Cheyenne Creek and a number of tributaries. The District directed the Coalition to coordinate the development of an actionable master plan to restore Upper Fountain Creek and Cheyenne Creek to pre-flood condition and mitigate the risk of future flooding.

1.3 Projects

Beyond the overall goal of planning the restoration of Upper Fountain Creek and Cheyenne Creek to pre-flood conditions, a detailed prioritized list of specific reach alternatives identifying over 165 individual projects that upon implementation, will provided for resilient, stable and healthy riparian corridors throughout both watersheds. Additionally, specific projects are classified with respect to the many needs of the stakeholders and public participants.

2.0 Upper Fountain Creek and Cheyenne Creek Conceptual Plan Mapbooks

2.1 Upper Fountain Creek Conceptual Plan Mapbook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Upper Fountain Creek
Conceptual Plan
El Paso County, CO
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6,000
Feet
Legend
Sheet
Creek
Upper Fountain Creek Watershed
City/Town
Colorado Springs Boundary
County Boundary
Interstate
Highway
Major Road
Crystola
Green Mountain Falls
Chipita Park
Cascade
Manitou Springs
Colorado Springs
Teller County
El Paso County
Fountain Creek
Williams Canyon
Camp Creek
Monument Creek
Rampart Range (300) Rd
FR 306
Canyon Dr
Packard Ln
Wellington Rd
Mohawk Trl
Ute Rd
Pikes Peak Hwy
Manitou Ave
Ruxton Ave
Black Canyon Rd
Palmer Trl
Gold Camp Rd
Twenty-sixth St S
Twenty-first St S
Thirtieth St N
Mesa Rd
King St
Uintah St W
Colorado Ave W
Rio Grande St W
Garden of the Gods Rd
Fillmore St W
Centennial Blvd
Flying W Ranch Rd
Vindicator Dr
Allegheny Dr
Rockrimmon Blvd S
Delmonico Dr
Owl Canyon Rd
Timber Valley Rd
Northfield Rd
Woodmen Rd W
South Gate Blvd
Gillen Rd
Tudor Rd
Vincent Dr
Mark Dabling Blvd
Rusina Rd
Chestnut St N
Nevada Ave N
Stone Ave
Paseo Rd
Cascade Ave N
Weber St N
Wasatch Ave N
El Paso St
Institute St N
Platte Ave E
Tejon St N
Tejon St S
Sierra Madre St S
Costilla St E
Institute St S
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FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT
CO DNR
COLORADO
Colorado Water Conservation Board
Department of Natural Resources
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UFCP-01 thru UFCP-02

Upper Fountain Creek Conceptual Plan
El Paso County, CO

0 150 300
Feet

Legend

- Wastewater Line
- Water Line
- Gas Line
- Underground Electric
- Substation Fence
- County Boundary
- Stream Centerline
- 100-yr Simulated Flood Zone
- Bridge
- Culvert
- Hydraulic Model Cross Section
- USGS Proposed Detention Pond
- Subbasin

Ownership

- Private
- Public

Immediate Response Project

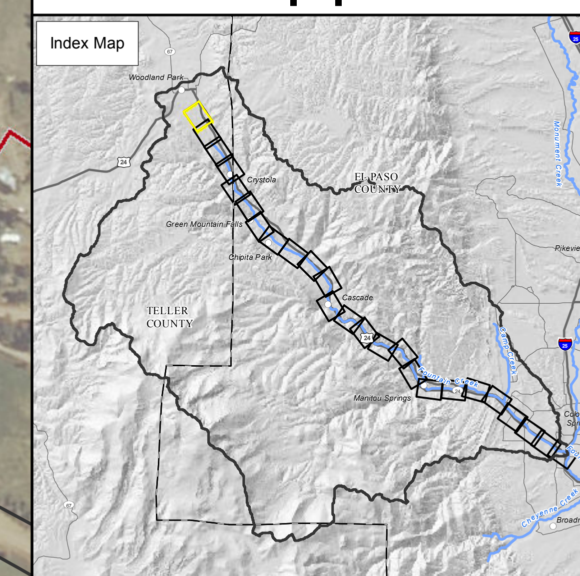
- Immediate Response Project
- Identified Projects
- Detention Potential
- Cut Banks
- Steep Slopes
- Proposed Drop Structure
- Detention Basin
- Engineered Bank / Channel
- Proposed Foot Trail

Reach Alternatives

- Natural Channel Design
- Protect In Place
- Protect In Place & Monitor
- Small Drop Structures w/ Toe Protection

Active Cutbanks

- High
- Medium
- Low



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FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

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Colorado Water Conservation Board
Department of Natural Resources

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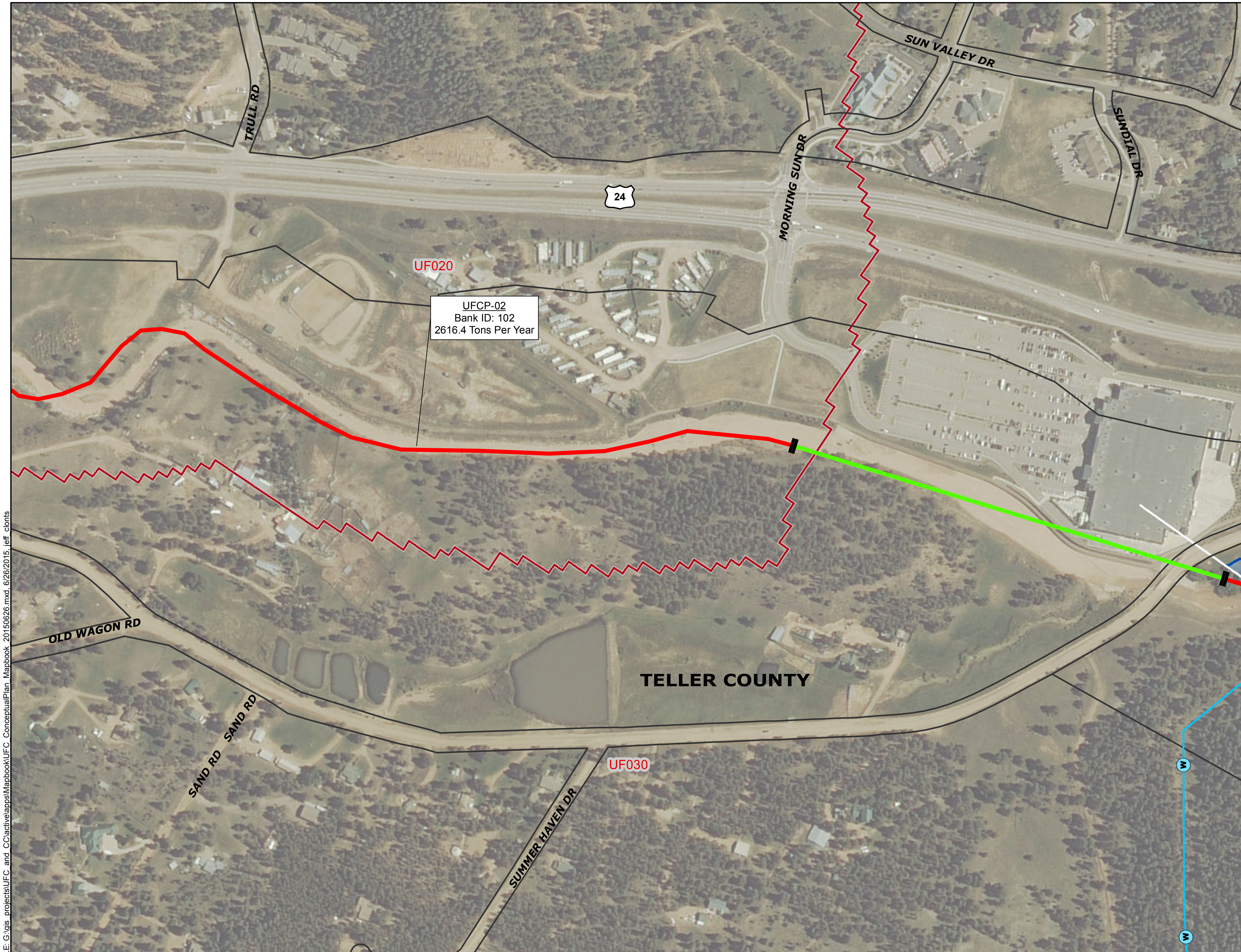

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UFCP-02

Upper Fountain Creek Conceptual Plan
El Paso County, CO

0 150 300
Feet

Legend

Wastewater Line
Water Line
Gas Line
Underground Electric
Substation Fence
County Boundary
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Ownership

Private
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Immediate Response Project
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Reach Alternatives

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Small Drop Structures w/ Toe Protection

Active Cutbanks

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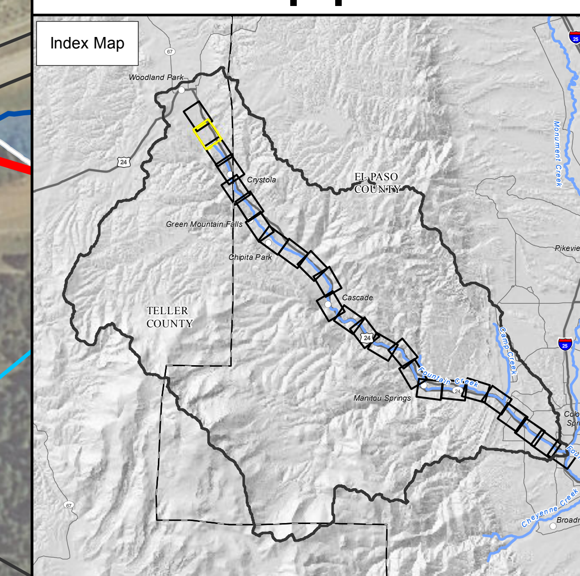
Medium
Low



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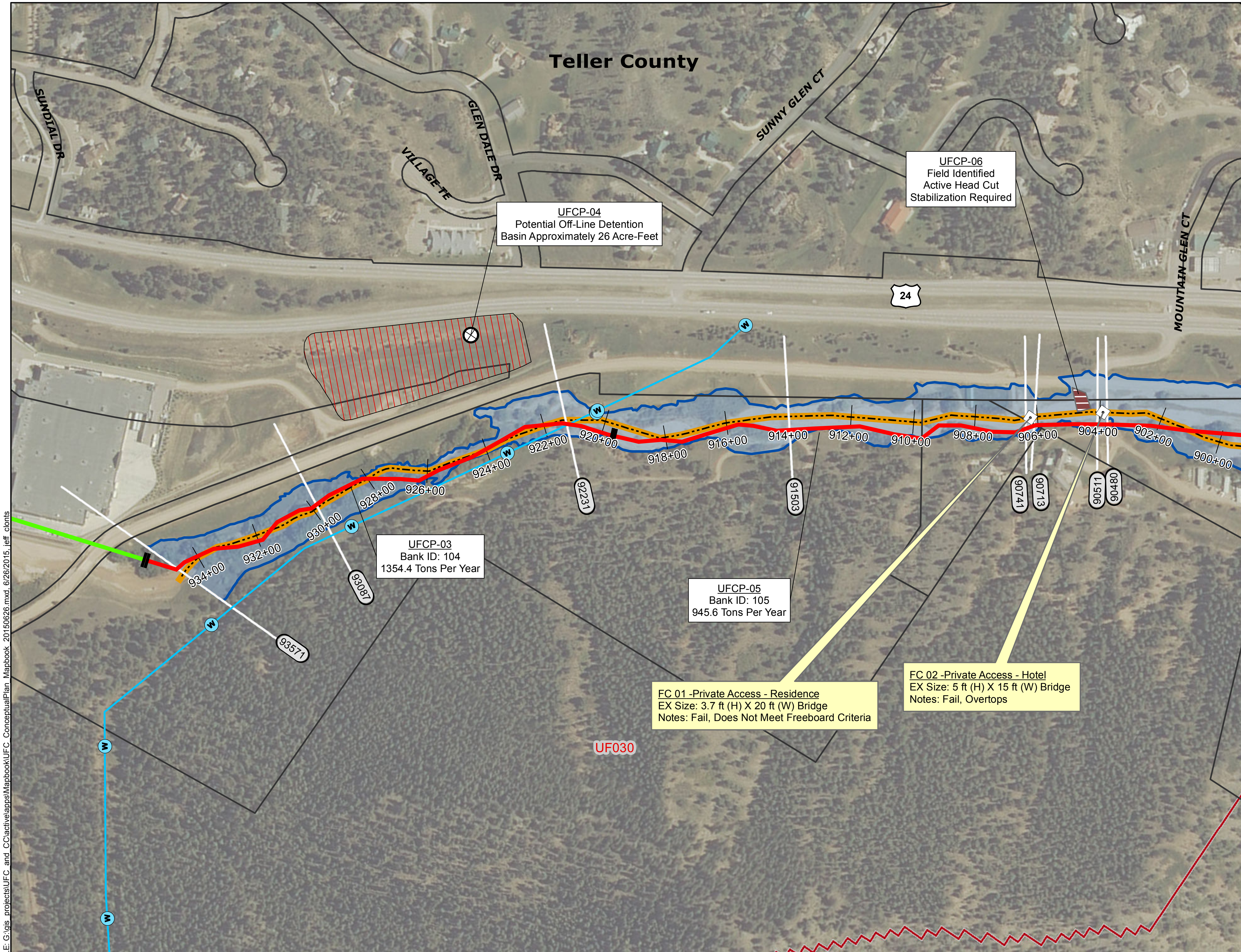

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UFCP-03 thru UFCP-06

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

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Feet

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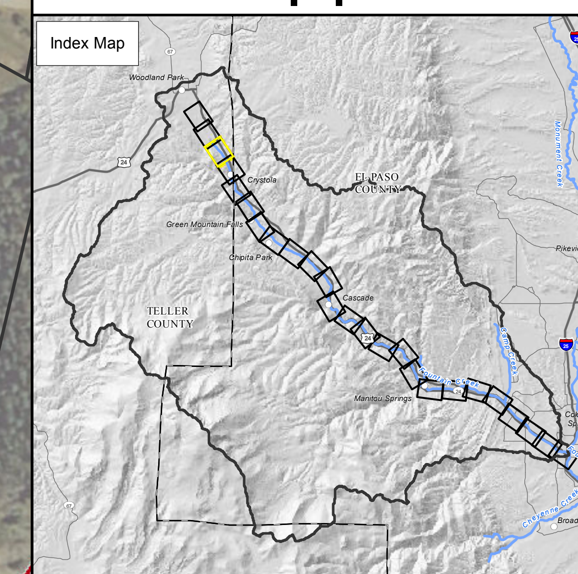
Index Map



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Department of Natural Resources

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UFCP-07 thru UFCP-11

Upper Fountain Creek Conceptual Plan
El Paso County, CO

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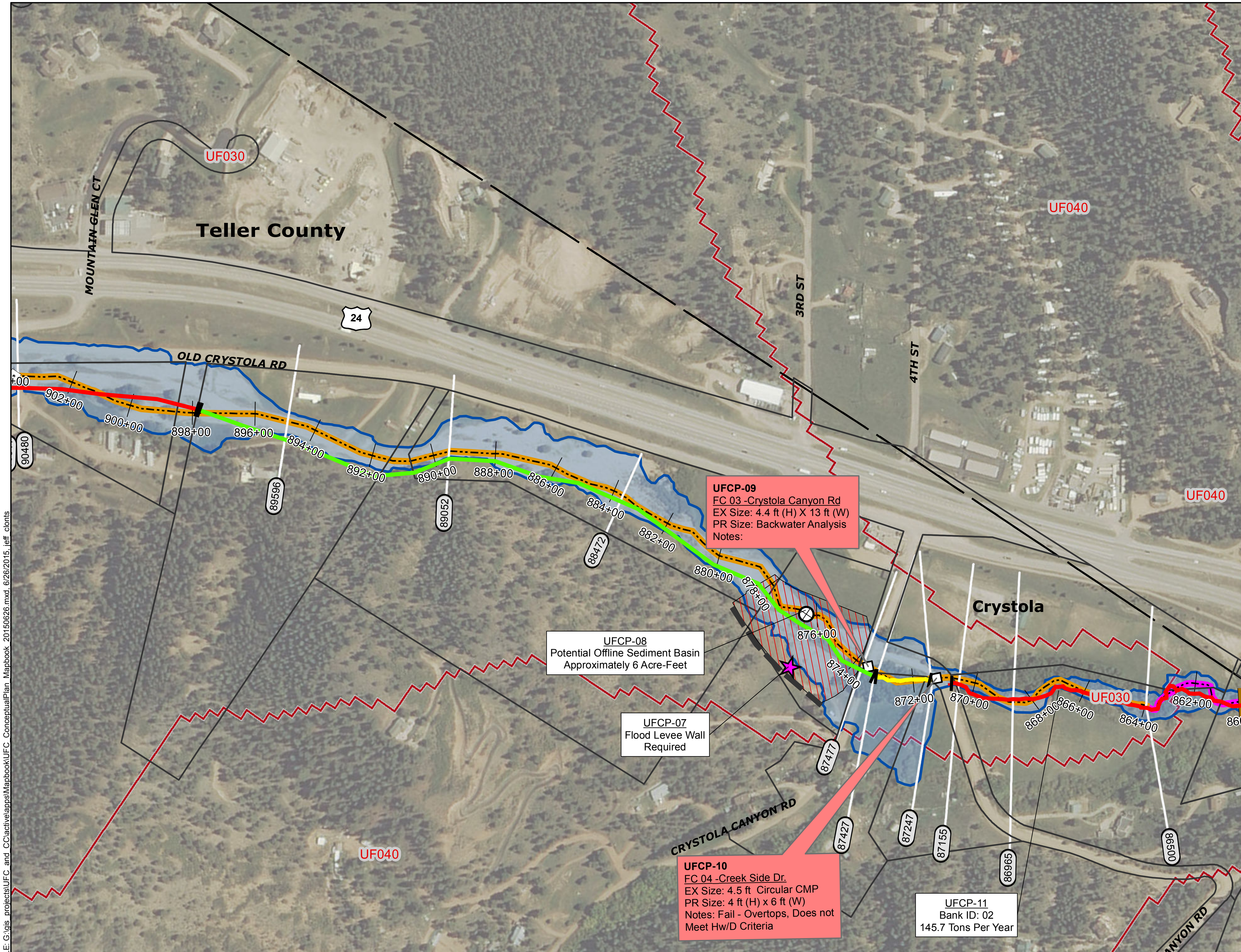

Legend

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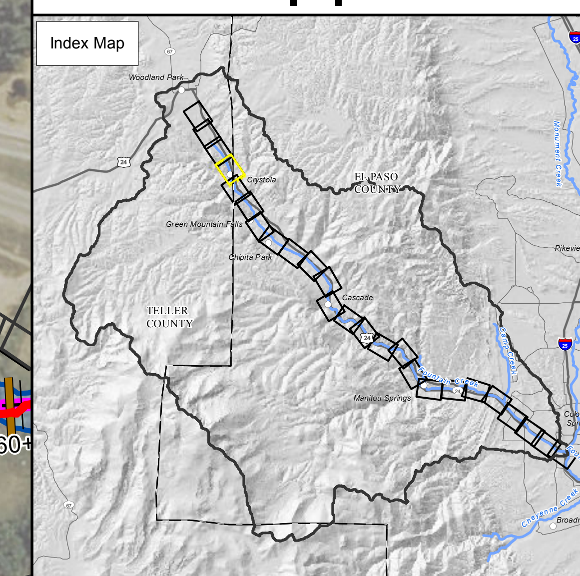

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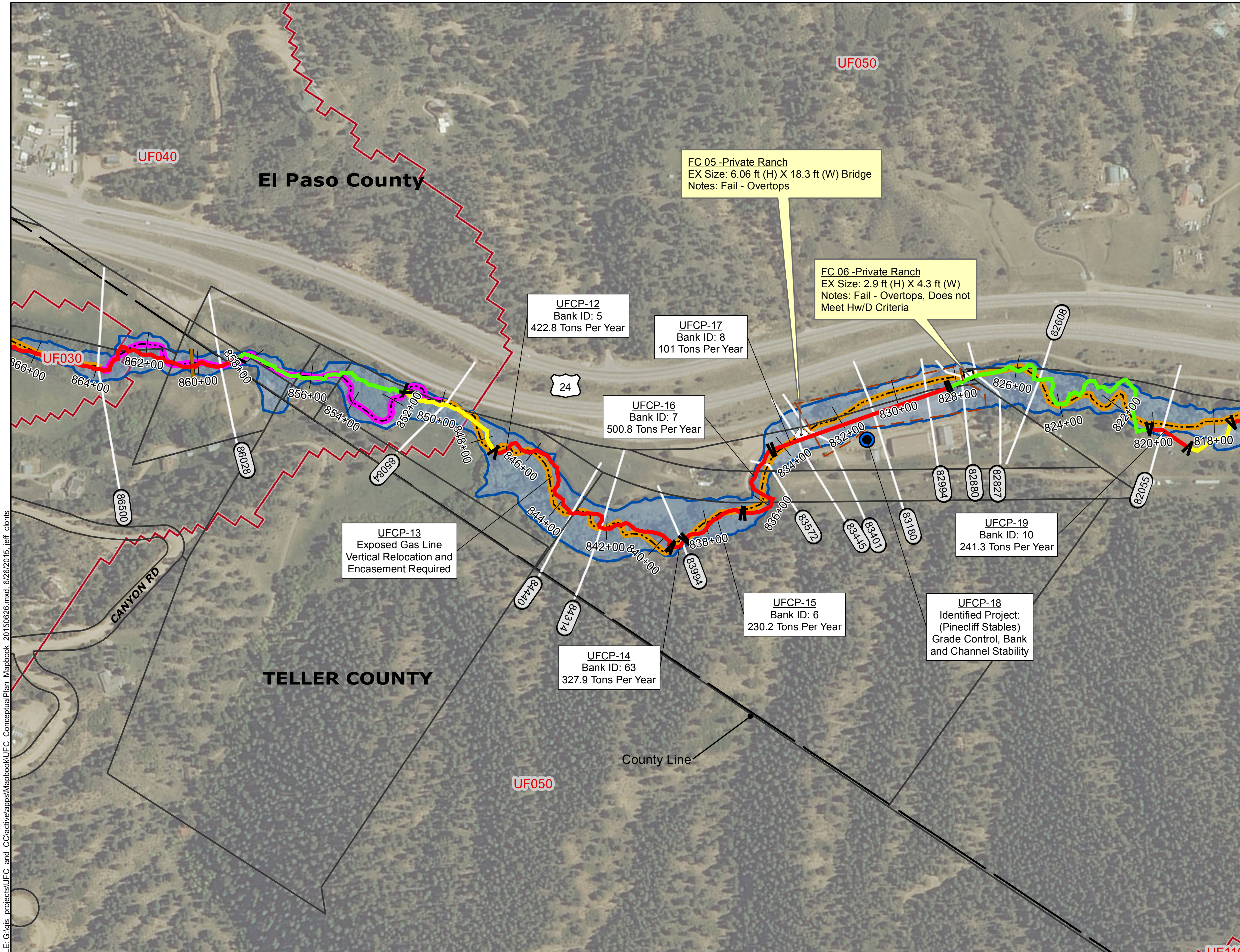

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UFCP-12 thru UFCP-19

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

0 150 300
Feet

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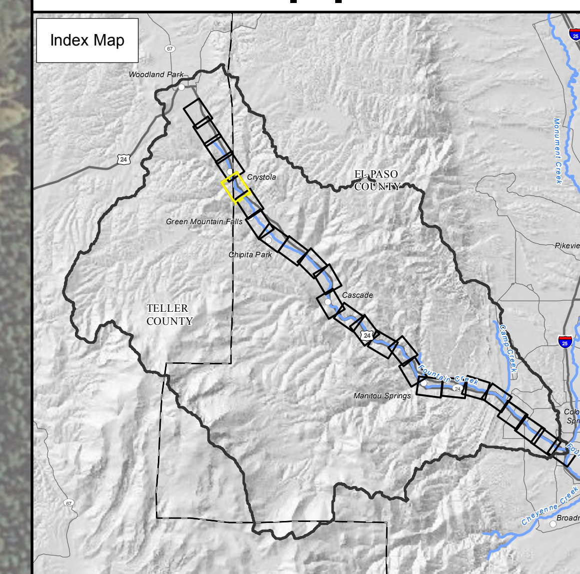

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FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

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UFCP-20 thru UFCP-24

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

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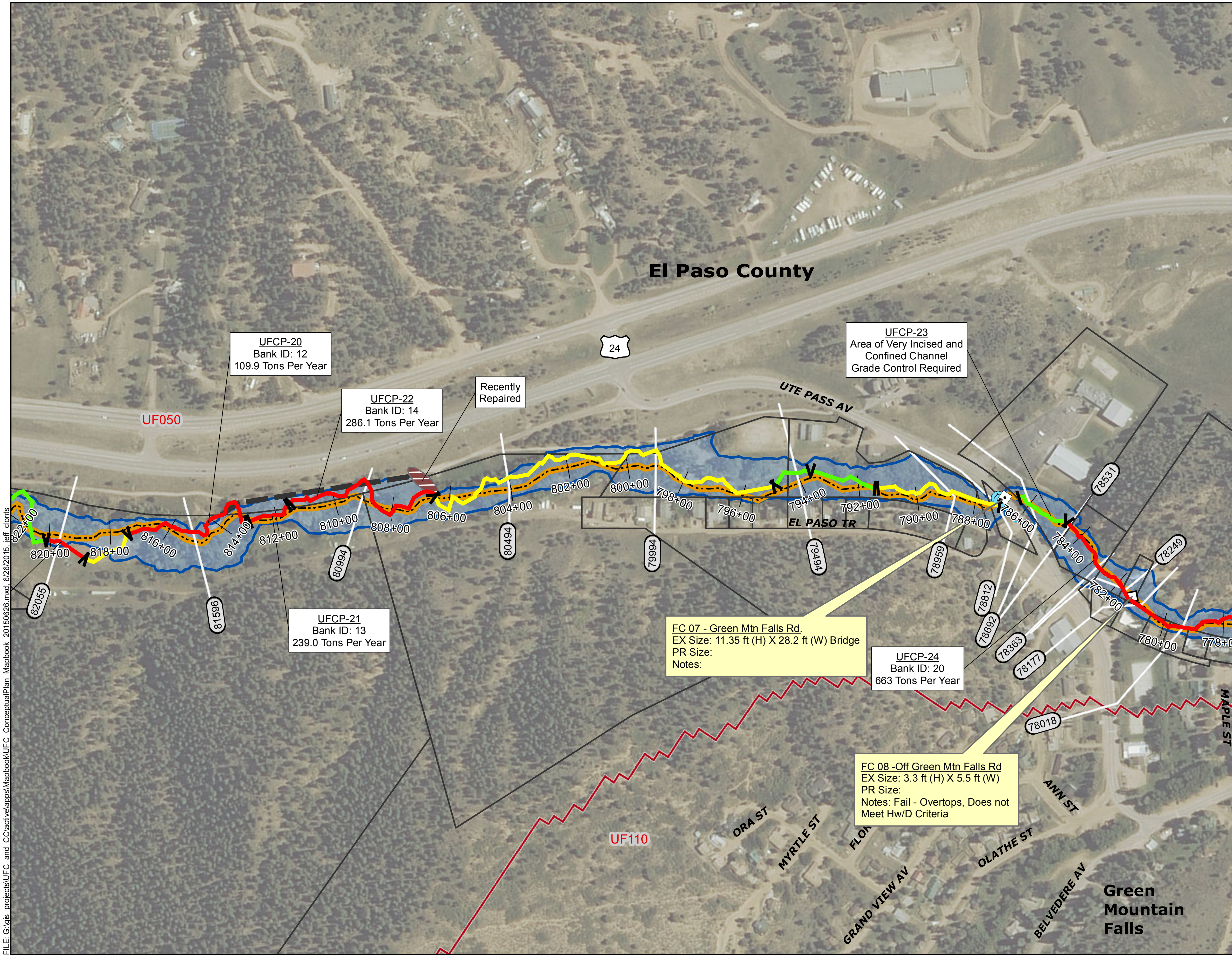

Legend

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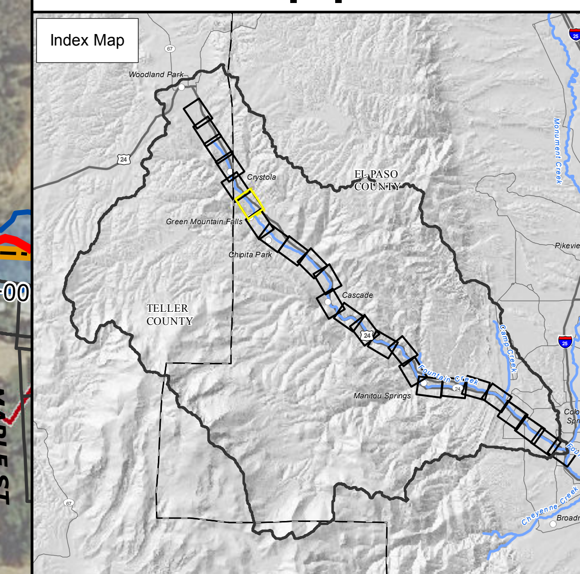

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Fountain Creek Watershed Flood Control & Greenway District

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Department of Natural Resources

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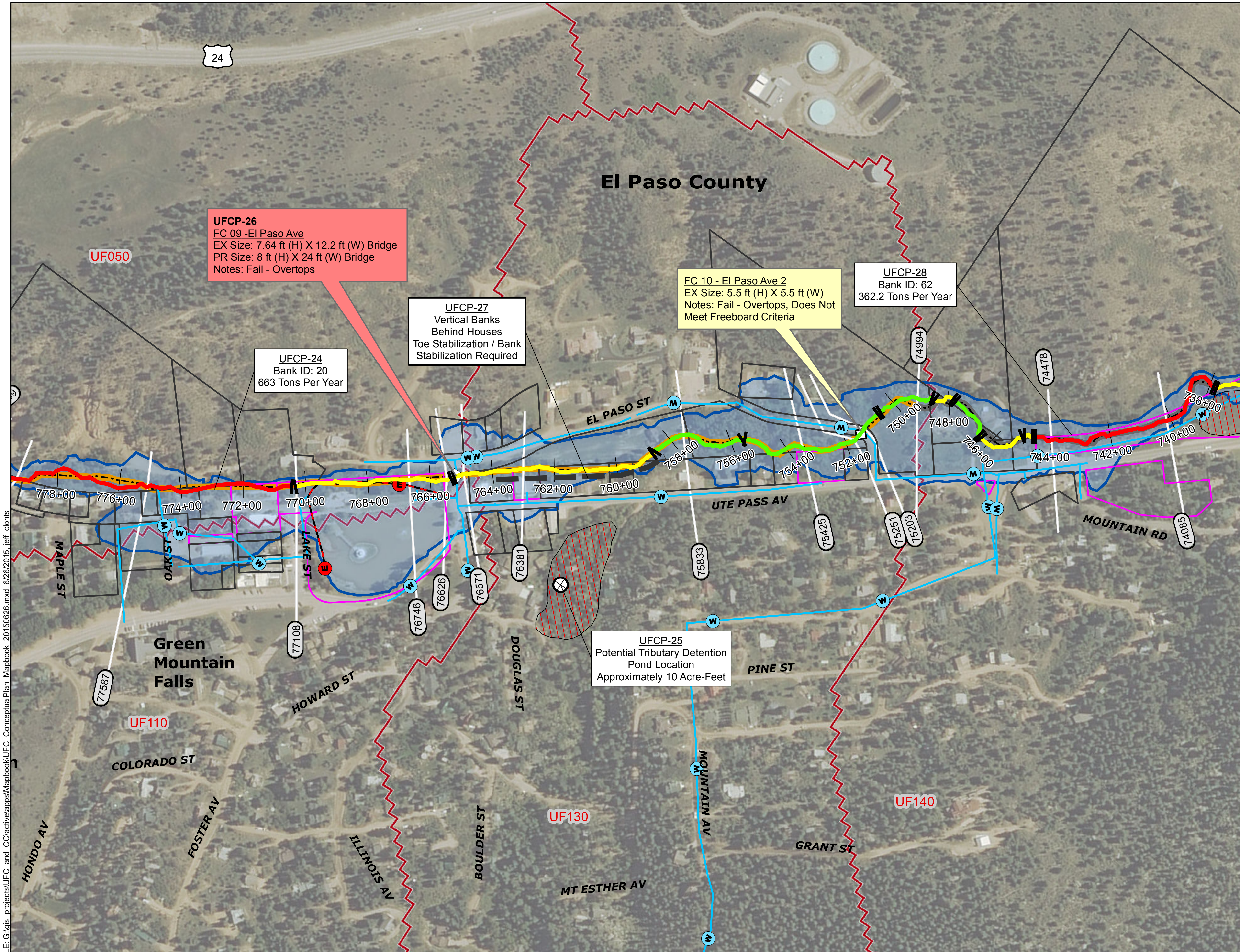

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UFCP-24 thru UFCP-28

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

0 150 300
Feet

Legend

- Wastewater Line
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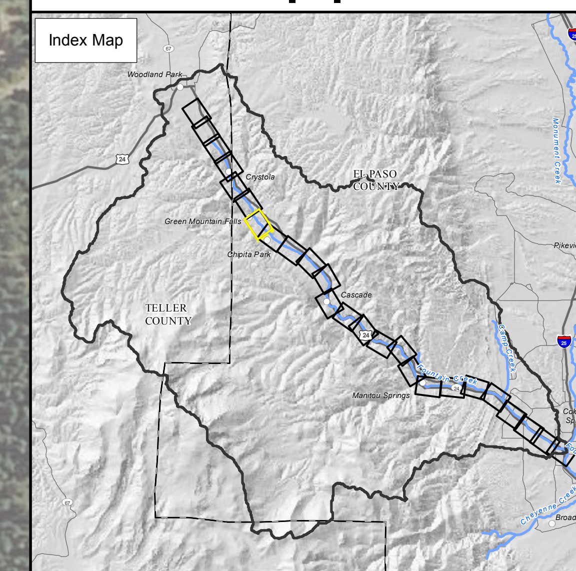
Active Cutbanks

- High
- Medium
- Low

Index Map



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FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

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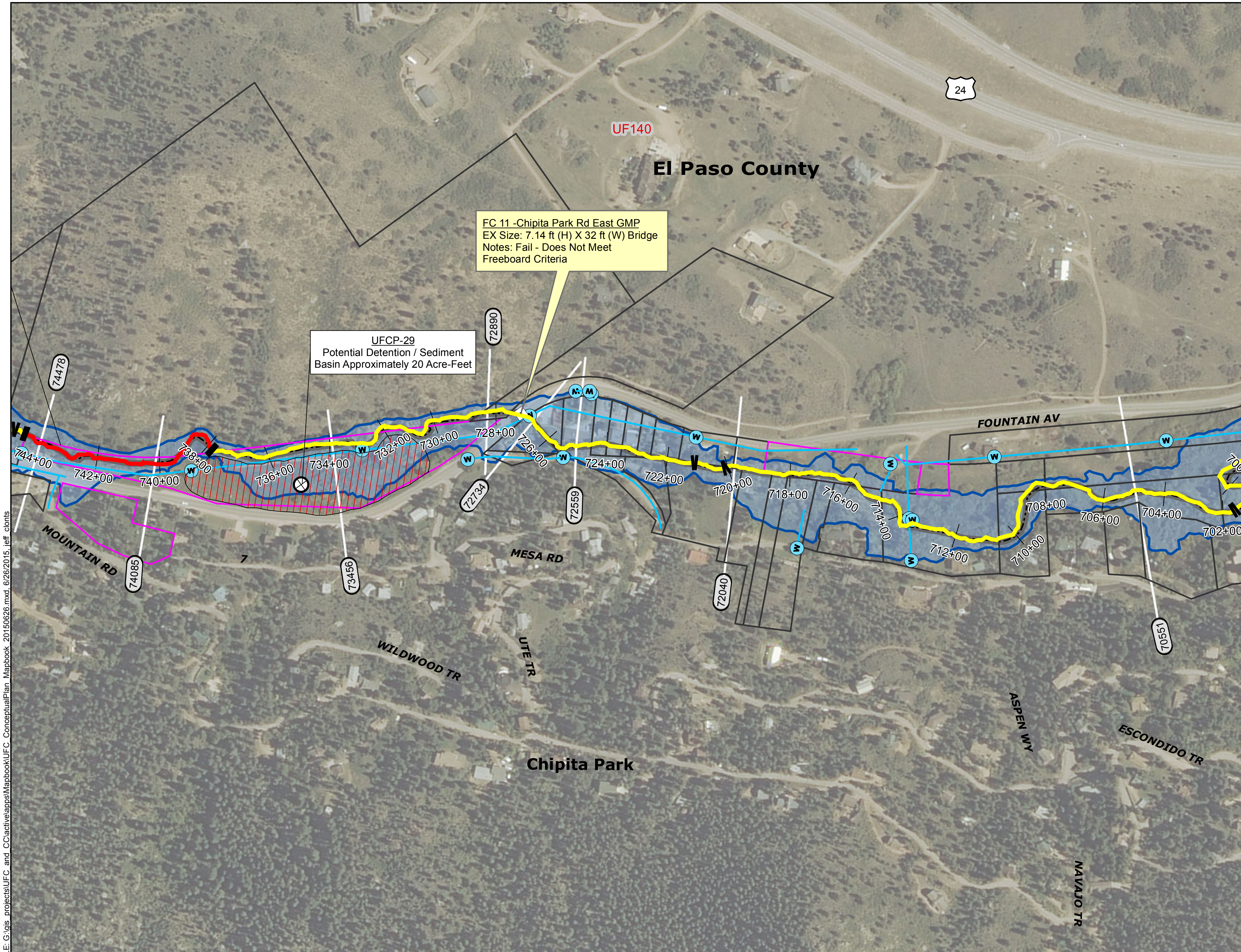
Department of Natural Resources



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UFCP-29

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

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Feet

Legend

- Wastewater Line
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Active Cutbanks

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- Medium
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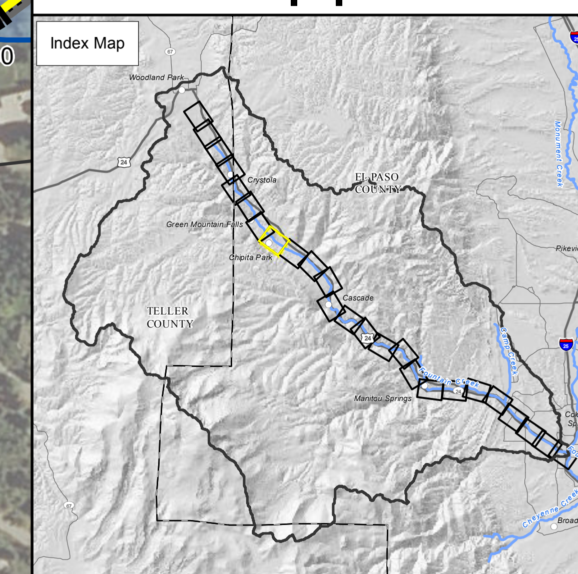
Index Map



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FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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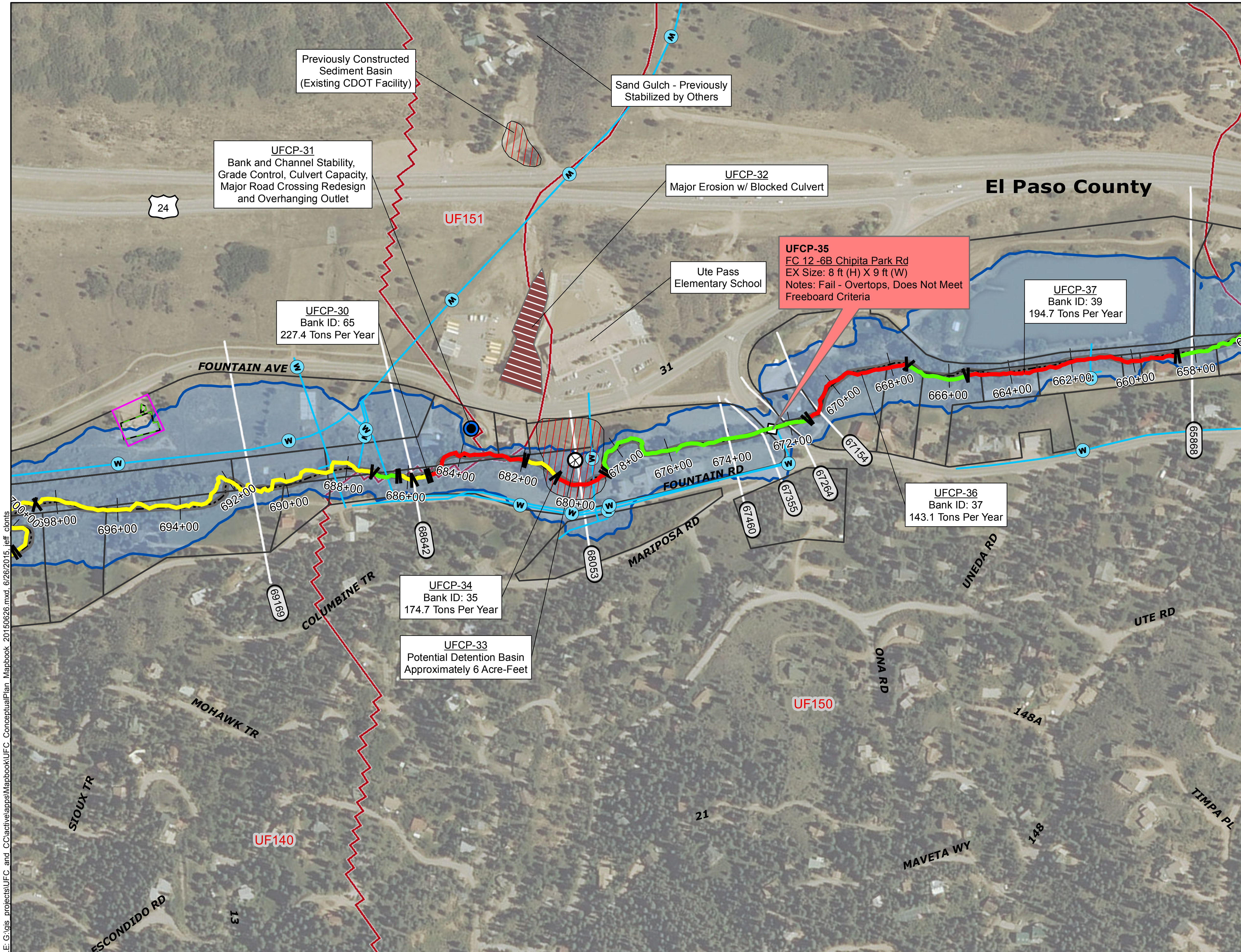
UFCP-30 thru UFCP-37

Upper Fountain Creek
Conceptual Plan
El Paso County, CO



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Legend

- Wastewater Line
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Reach Alternatives

- Natural Channel Design
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Active Cutbanks

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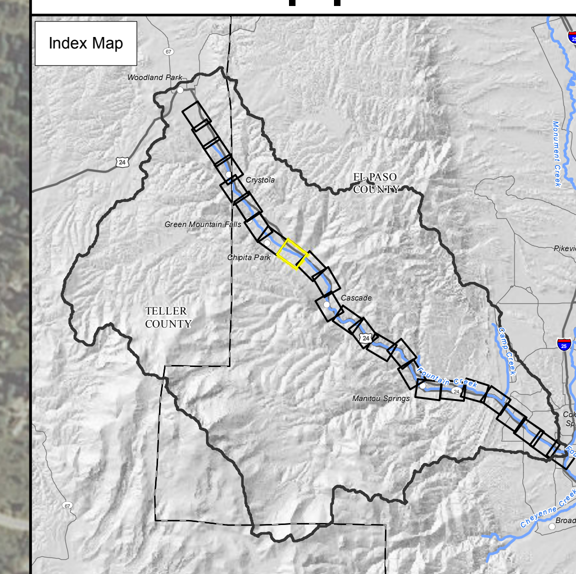

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Fountain Creek Watershed Flood Control & Greenway District

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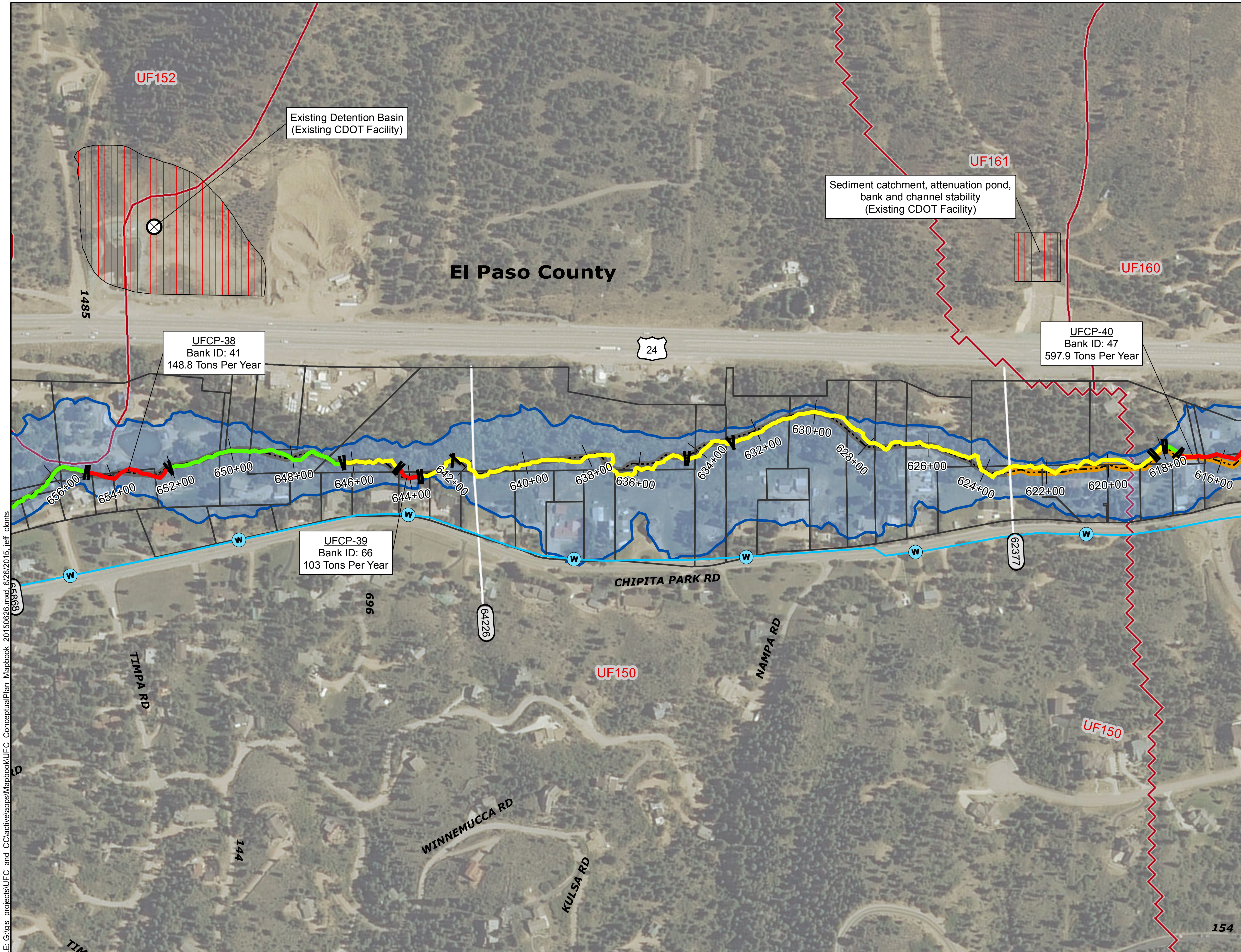

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UFCP-38 thru UFCP-40

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

0 150 300
Feet

Legend

Wastewater Line
Water Line
Gas Line
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Substation Fence
County Boundary
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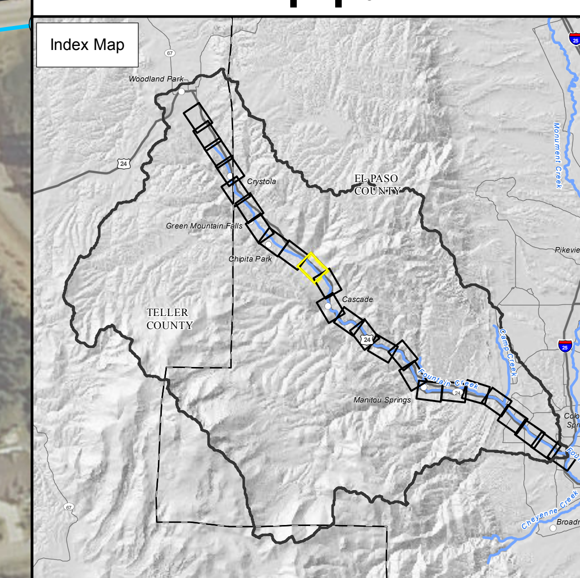
Reach Alternatives

Natural Channel Design
Protect In Place
Protect In Place & Monitor
Small Drop Structures w/ Toe Protection

Active Cutbanks

High
Medium
Low

Index Map



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FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

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UFCP-40 thru UFCP-43

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

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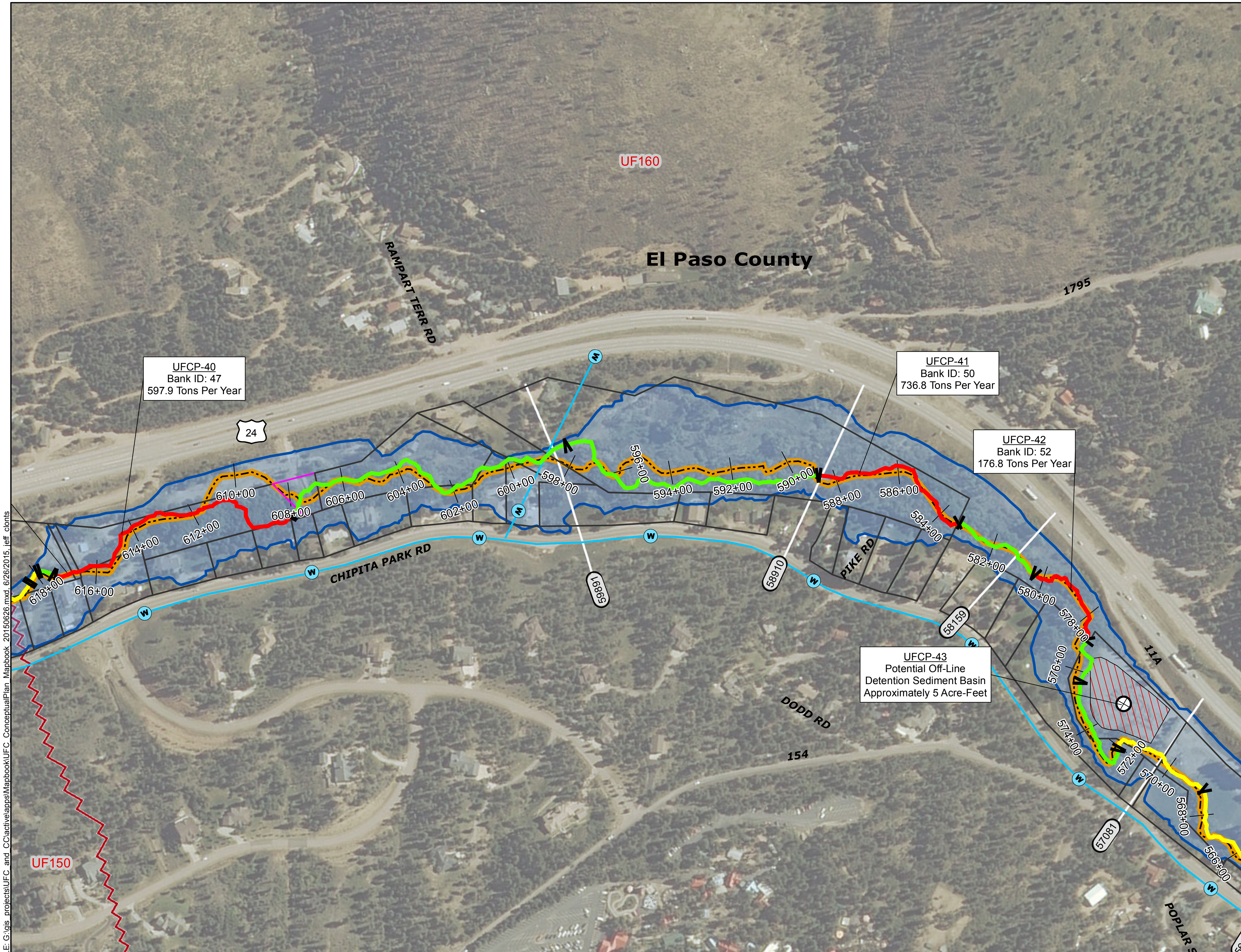
Feet



Legend

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Active Cutbanks

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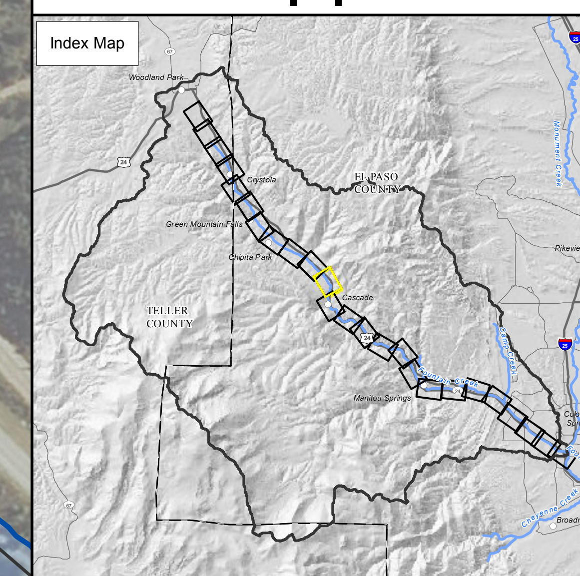
Index Map



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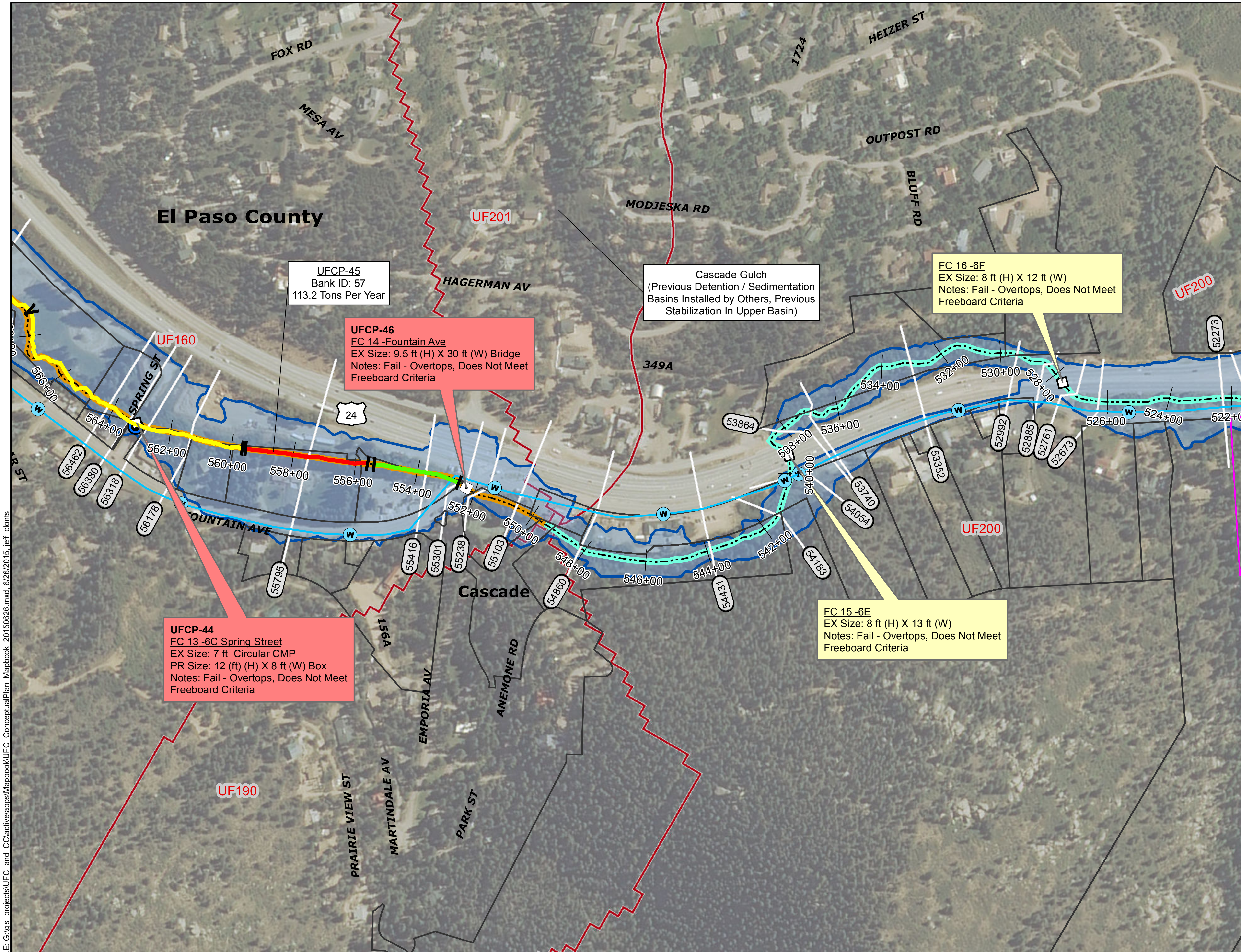
UFCP-44 thru UFCP-46

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

0 150 300
Feet



Legend

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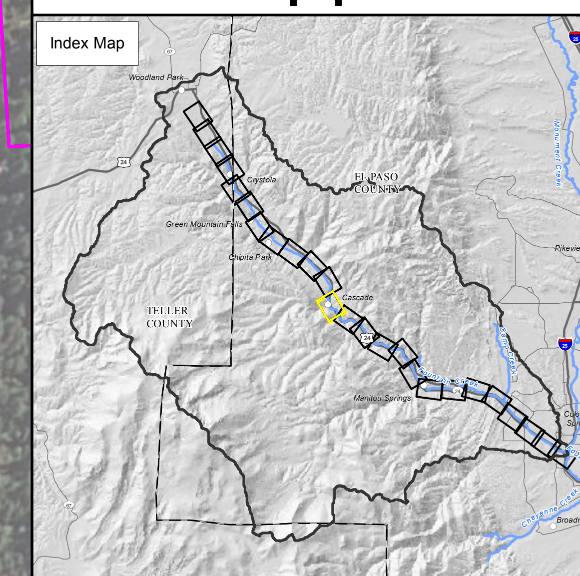
- Low

Index Map



Matrix DESIGN GROUP

FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

CO DNR

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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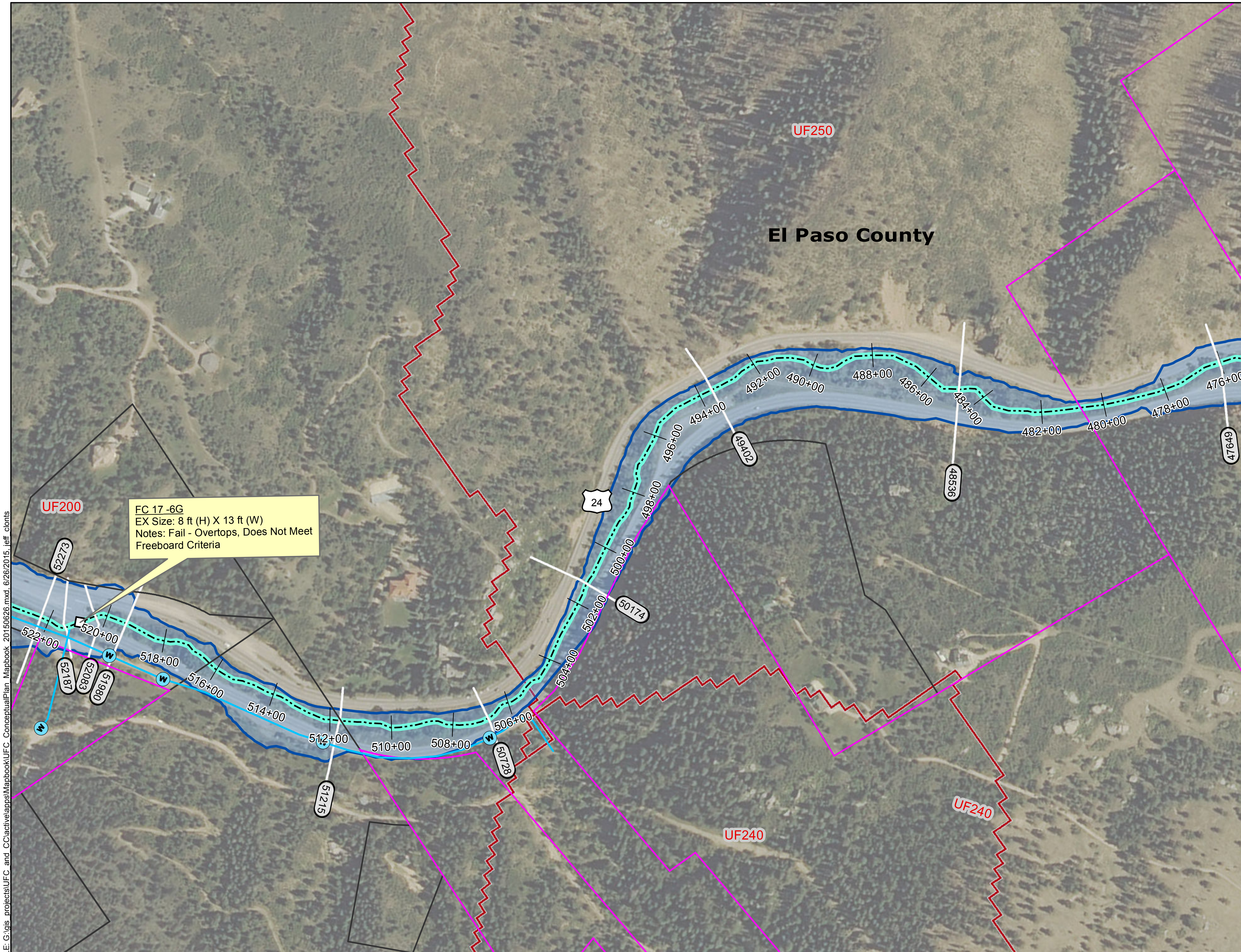


Upper Fountain Creek
Conceptual Plan
El Paso County, CO

0 150 300
Feet

Legend

- Wastewater Line
- Water Line
- Gas Line
- Underground Electric
- Substation Fence
- County Boundary
- Stream Centerline
- 100-yr Simulated Flood Zone
- Bridge
- Culvert
- Hydraulic Model Cross Section
- USGS Proposed Detention Pond
- Subbasin

Ownership

- Private
- Public

Immediate Response Project

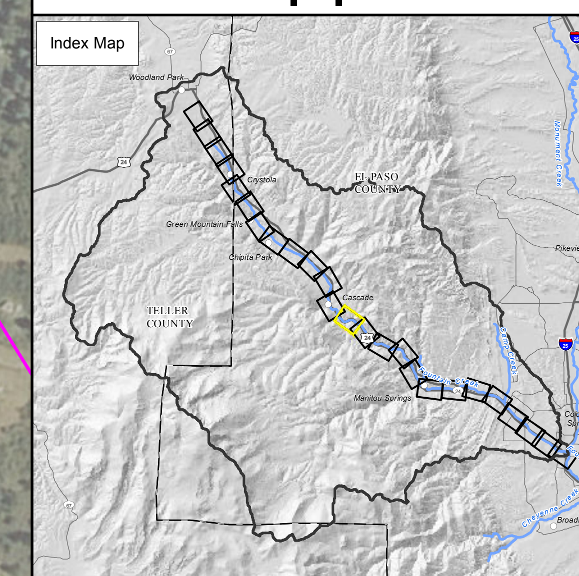
- Immediate Response Project
- Identified Projects
- Detention Potential
- Cut Banks
- Steep Slopes
- Proposed Drop Structure
- Detention Basin
- Engineered Bank / Channel
- Proposed Foot Trail

Reach Alternatives

- Natural Channel Design
- Protect In Place
- Protect In Place & Monitor
- Small Drop Structures w/ Toe Protection

Active Cutbanks

- High
- Medium
- Low



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CO DNR

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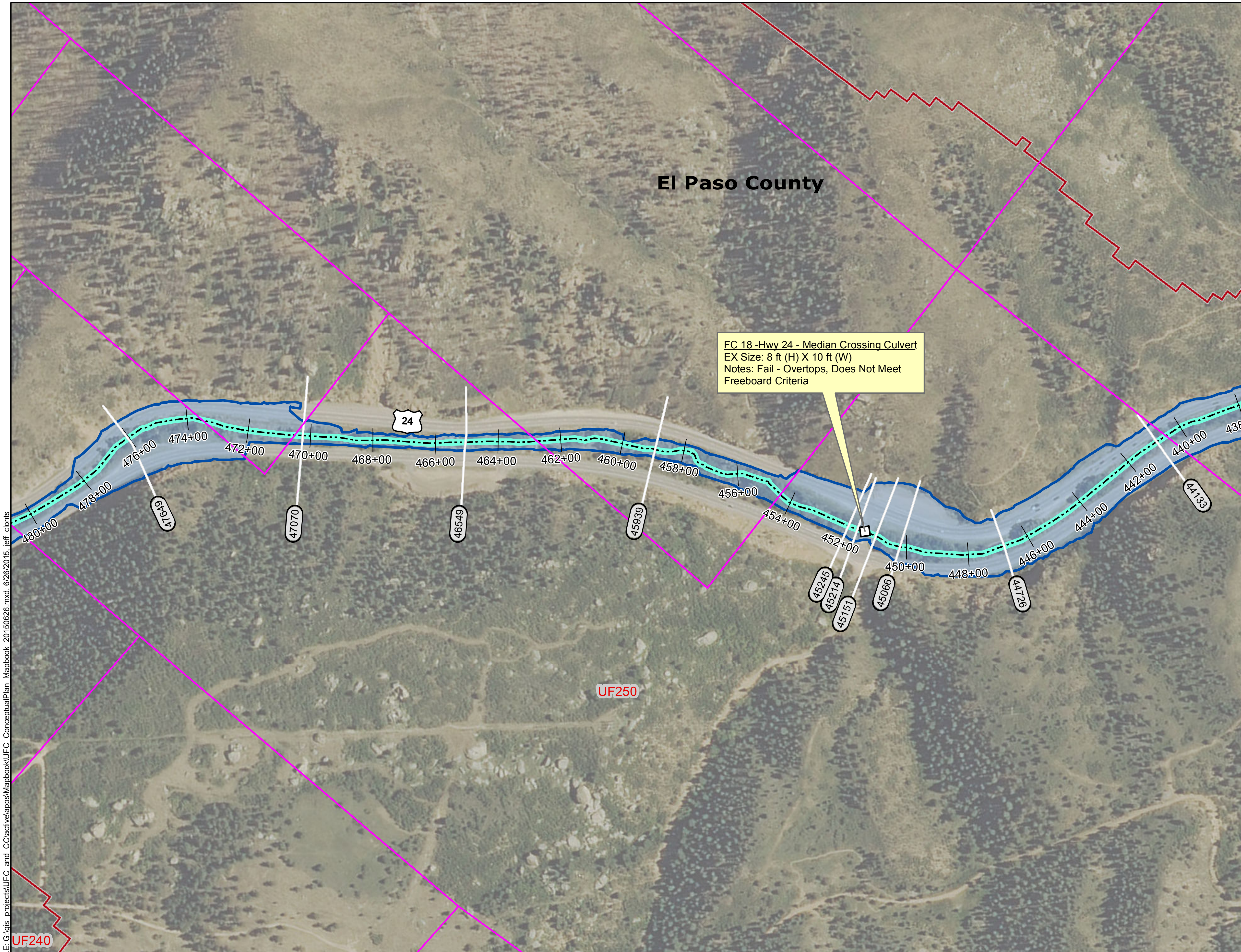
Colorado Water Conservation Board
Department of Natural Resources

Upper Fountain Creek
Conceptual Plan
El Paso County, CO



Legend

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- Water Line
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- Stream Centerline
- 100-yr Simulated Flood Zone
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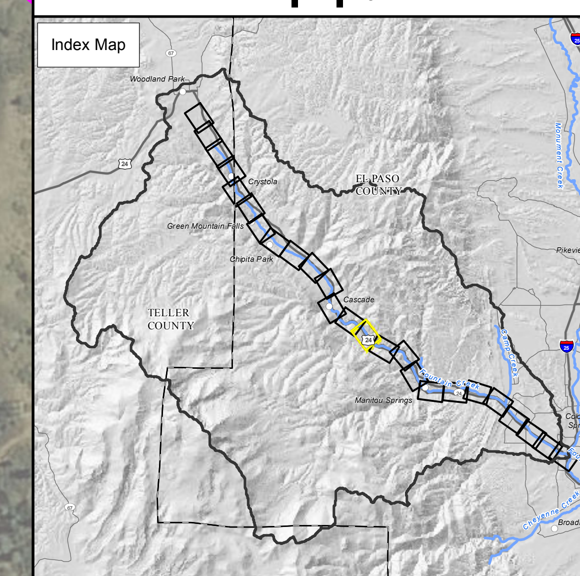
Active Cutbanks

- High
- Medium
- Low



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Colorado Water Conservation Board
Department of Natural Resources

Upper Fountain Creek Conceptual Plan
El Paso County, CO

0 150 300
Feet

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- Protect In Place & Monitor
- Small Drop Structures w/ Toe Protection

Active Cutbanks

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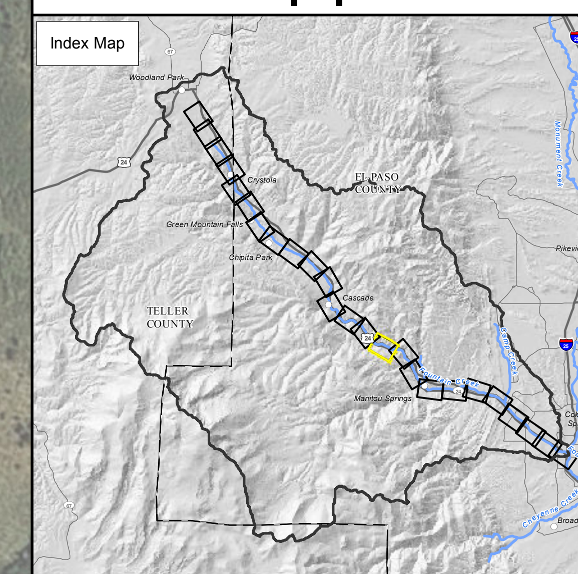
- Medium
- Low

Index Map



Matrix DESIGN GROUP
FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT
COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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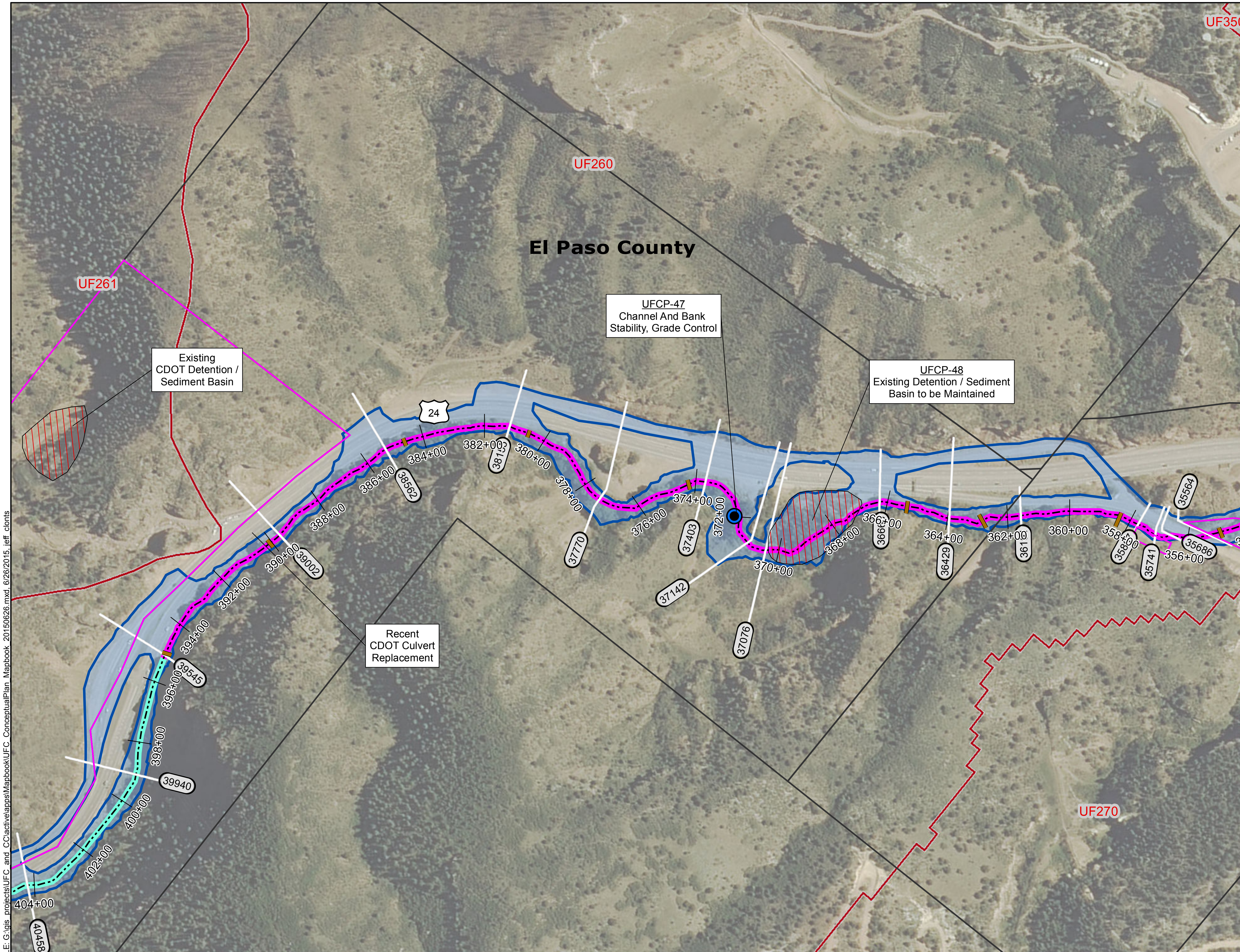

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UFCP-47 thru UFCP-48

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

0 150 300
Feet

Legend

- Wastewater Line
- Water Line
- Gas Line
- Underground Electric
- Substation Fence
- County Boundary
- Stream Centerline
- 100-yr Simulated Flood Zone
- Bridge
- Culvert
- Hydraulic Model Cross Section
- USGS Proposed Detention Pond
- Subbasin

Ownership

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- Public

Immediate Response Project

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- Identified Projects
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- Steep Slopes
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- Detention Basin
- Engineered Bank / Channel
- Proposed Foot Trail

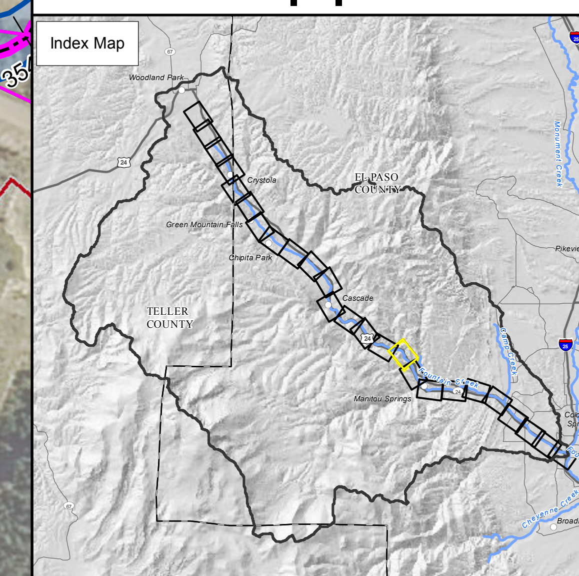
Reach Alternatives

- Natural Channel Design
- Protect In Place
- Protect In Place & Monitor
- Small Drop Structures w/ Toe Protection

Active Cutbanks

- High
- Medium
- Low

Index Map

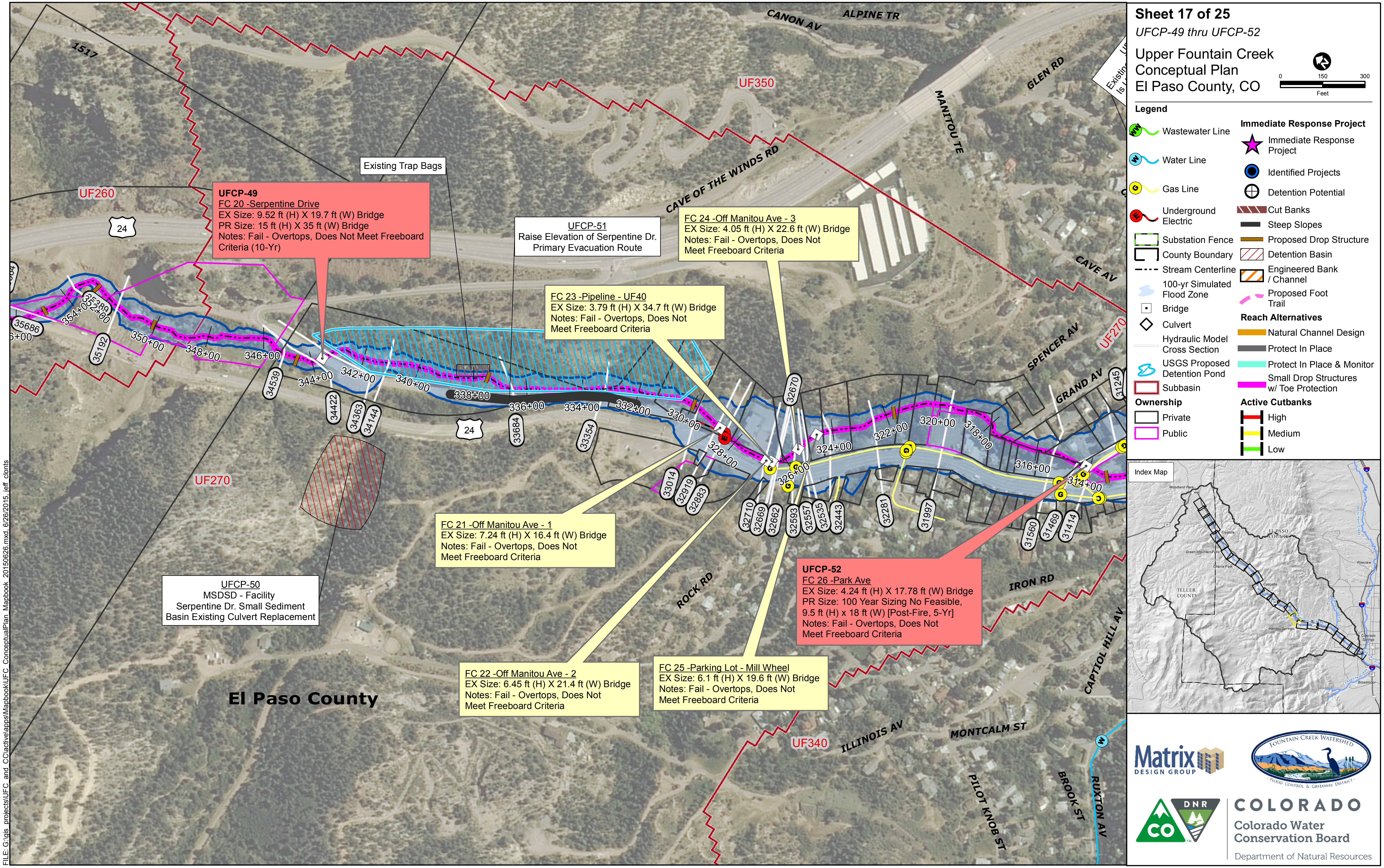


Matrix DESIGN GROUP

FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

DNR CO

COLORADO
Colorado Water Conservation Board
Department of Natural Resources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UFCP-49 thru UFCP-52
Upper Fountain Creek Conceptual Plan
El Paso County, CO
0 150 300
Feet
Legend
Wastewater Line
Water Line
Gas Line
Underground Electric
Substation Fence
County Boundary
Stream Centerline
100-yr Simulated Flood Zone
Bridge
Culvert
Hydraulic Model Cross Section
USGS Proposed Detention Pond
Subbasin
Ownership
Private
Public
Immediate Response Project
Immediate Response Project
Identified Projects
Detention Potential
Cut Banks
Steep Slopes
Proposed Drop Structure
Detention Basin
Engineered Bank / Channel
Proposed Foot Trail
Reach Alternatives
Natural Channel Design
Protect In Place
Protect In Place & Monitor
Small Drop Structures w/ Toe Protection
Active Cutbanks
High
Medium
Low
Index Map
UFCP-49
FC 20 -Serpentine Drive
EX Size: 9.52 ft (H) X 19.7 ft (W) Bridge
PR Size: 15 ft (H) X 35 ft (W) Bridge
Notes: Fail - Overtops, Does Not Meet Freeboard Criteria (10-Yr)
Existing Trap Bags
UFCP-51
Raise Elevation of Serpentine Dr. Primary Evacuation Route
FC 24 -Off Manitou Ave - 3
EX Size: 4.05 ft (H) X 22.6 ft (W) Bridge
Notes: Fail - Overtops, Does Not Meet Freeboard Criteria
FC 23 -Pipeline - UF40
EX Size: 3.79 ft (H) X 34.7 ft (W) Bridge
Notes: Fail - Overtops, Does Not Meet Freeboard Criteria
FC 21 -Off Manitou Ave - 1
EX Size: 7.24 ft (H) X 16.4 ft (W) Bridge
Notes: Fail - Overtops, Does Not Meet Freeboard Criteria
UFCP-50
MSDSD - Facility
Serpentine Dr. Small Sediment Basin Existing Culvert Replacement
UFCP-52
FC 26 -Park Ave
EX Size: 4.24 ft (H) X 17.78 ft (W) Bridge
PR Size: 100 Year Sizing No Feasible, 9.5 ft (H) x 18 ft (W) [Post-Fire, 5-Yr]
Notes: Fail - Overtops, Does Not Meet Freeboard Criteria
FC 22 -Off Manitou Ave - 2
EX Size: 6.45 ft (H) X 21.4 ft (W) Bridge
Notes: Fail - Overtops, Does Not Meet Freeboard Criteria
FC 25 -Parking Lot - Mill Wheel
EX Size: 6.1 ft (H) X 19.6 ft (W) Bridge
Notes: Fail - Overtops, Does Not Meet Freeboard Criteria
El Paso County
UF260
UF270
UF340
UF350
CANON AV
ALPINE TR
GLEN RD
MANITOU TE
CAVE OF THE WINDS RD
CAVE AV
SPENCER AV
GRAND AV
IRON RD
CAPTIOL HILL AV
ROCK RD
ILLINOIS AV
MONTCALM ST
PILOT KNOB ST
BROOK ST
RUXTON AV
1517
24
354+00 352+00 350+00 348+00 346+00 344+00 342+00 340+00 338+00 336+00 334+00 332+00 330+00 328+00 326+00 324+00 322+00 320+00 318+00 316+00 314+00
Matrix DESIGN GROUP
FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT
COLORADO
Colorado Water Conservation Board
Department of Natural Resources
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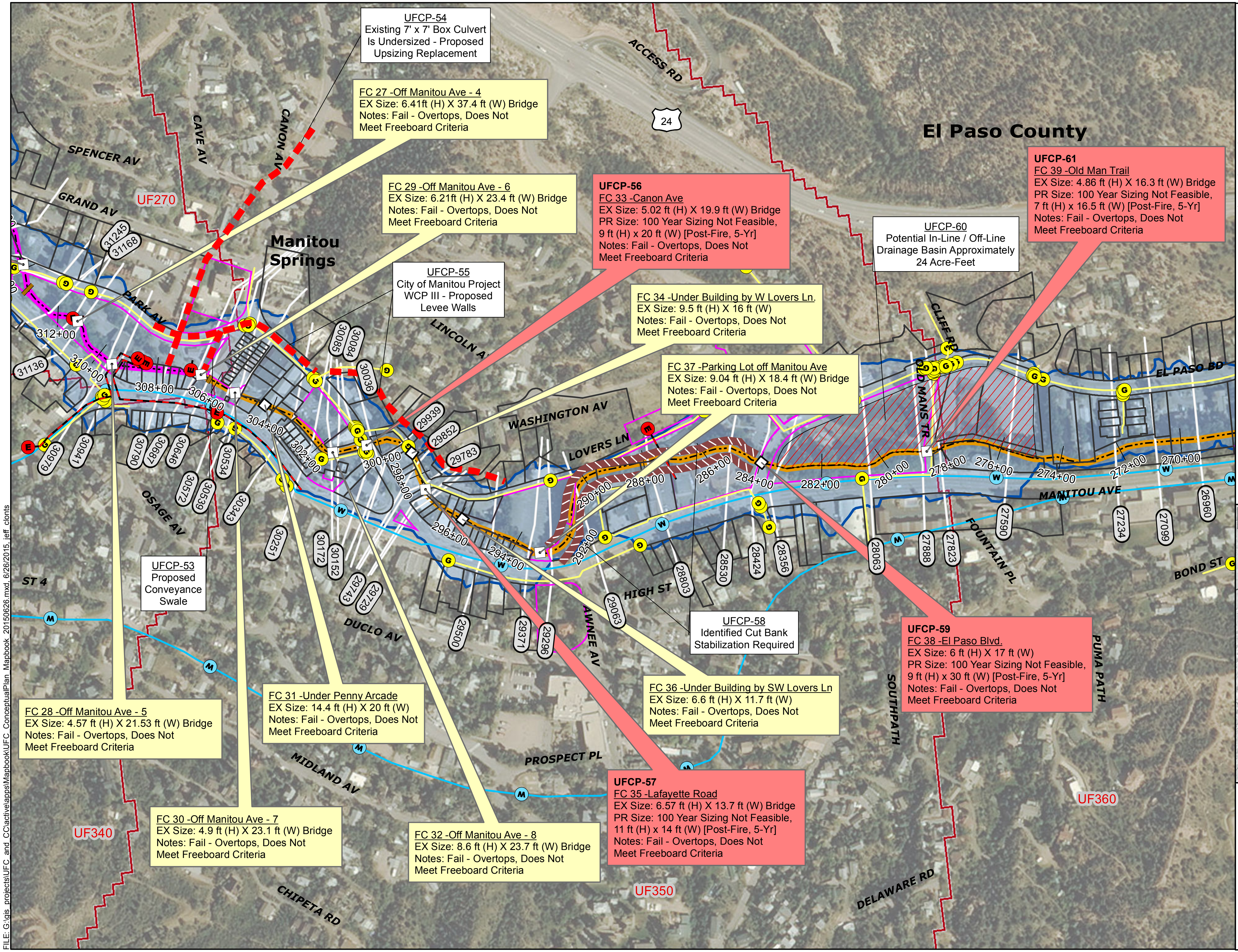
UFCP-53 thru UFCP-61

Upper Fountain Creek
Conceptual Plan
El Paso County, CO



0 150 300
Feet

Legend

- Wastewater Line
- Water Line
- Gas Line
- Underground Electric
- Substation Fence
- County Boundary
- Stream Centerline
- 100-yr Simulated Flood Zone
- Bridge
- Culvert
- Hydraulic Model Cross Section
- USGS Proposed Detention Pond
- Subbasin

Ownership

- Private
- Public

Immediate Response Project

- Immediate Response Project
- Identified Projects
- Detention Potential
- Cut Banks
- Steep Slopes
- Proposed Drop Structure
- Detention Basin
- Engineered Bank / Channel
- Proposed Foot Trail

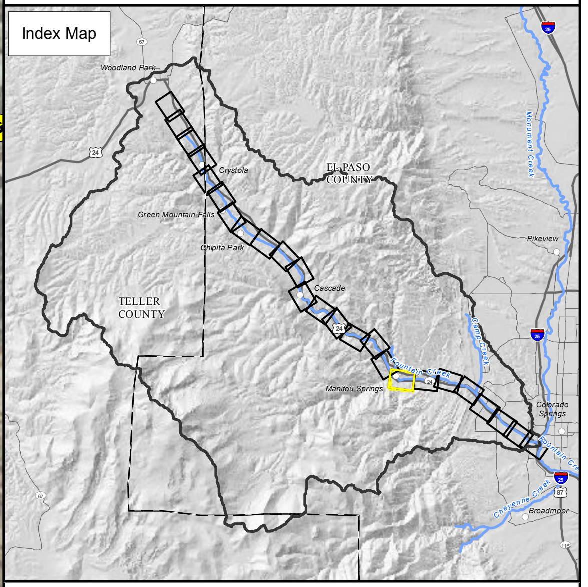
Reach Alternatives

- Natural Channel Design
- Protect In Place
- Protect In Place & Monitor
- Small Drop Structures w/ Toe Protection

Active Cutbanks

- High
- Medium
- Low

Index Map

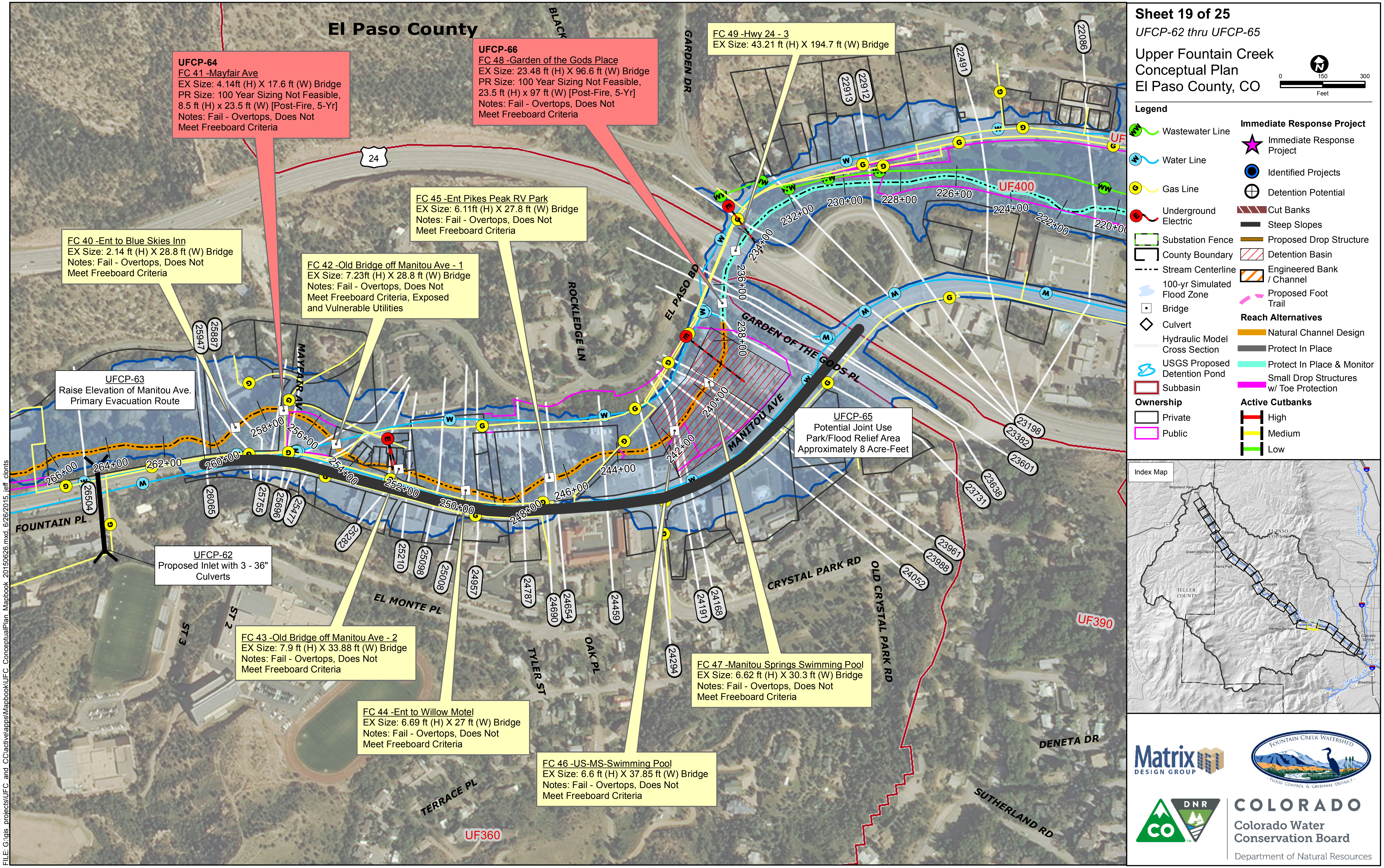


Matrix DESIGN GROUP

FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

DNR CO

COLORADO
Colorado Water Conservation Board
Department of Natural Resources



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UFCP-62 thru UFCP-65
Upper Fountain Creek
Conceptual Plan
El Paso County, CO
0 150 300
Feet
Legend
Wastewater Line
Water Line
Gas Line
Underground Electric
Substation Fence
County Boundary
Stream Centerline
100-yr Simulated Flood Zone
Bridge
Culvert
Hydraulic Model Cross Section
USGS Proposed Detention Pond
Subbasin
Ownership
Private
Public
Immediate Response Project
Immediate Response Project
Identified Projects
Detention Potential
Cut Banks
Steep Slopes
Proposed Drop Structure
Detention Basin
Engineered Bank / Channel
Proposed Foot Trail
Reach Alternatives
Natural Channel Design
Protect In Place
Protect In Place & Monitor
Small Drop Structures w/ Toe Protection
Active Cutbanks
High
Medium
Low
Index Map
El Paso County
UFCP-64
FC 41 -Mayfair Ave
EX Size: 4.14ft (H) X 17.6 ft (W) Bridge
PR Size: 100 Year Sizing Not Feasible,
8.5 ft (H) x 23.5 ft (W) [Post-Fire, 5-Yr]
Notes: Fail - Overtops, Does Not
Meet Freeboard Criteria
UFCP-66
FC 48 -Garden of the Gods Place
EX Size: 23.48 ft (H) X 96.6 ft (W) Bridge
PR Size: 100 Year Sizing Not Feasible,
23.5 ft (H) x 97 ft (W) [Post-Fire, 5-Yr]
Notes: Fail - Overtops, Does Not
Meet Freeboard Criteria
FC 49 -Hwy 24 - 3
EX Size: 43.21 ft (H) X 194.7 ft (W) Bridge
FC 45 -Ent Pikes Peak RV Park
EX Size: 6.11ft (H) X 27.8 ft (W) Bridge
Notes: Fail - Overtops, Does Not
Meet Freeboard Criteria
FC 40 -Ent to Blue Skies Inn
EX Size: 2.14 ft (H) X 28.8 ft (W) Bridge
Notes: Fail - Overtops, Does Not
Meet Freeboard Criteria
FC 42 -Old Bridge off Manitou Ave - 1
EX Size: 7.23ft (H) X 28.8 ft (W) Bridge
Notes: Fail - Overtops, Does Not
Meet Freeboard Criteria, Exposed
and Vulnerable Utilities
UFCP-63
Raise Elevation of Manitou Ave.
Primary Evacuation Route
UFCP-65
Potential Joint Use
Park/Flood Relief Area
Approximately 8 Acre-Feet
UFCP-62
Proposed Inlet with 3 - 36"
Culverts
FC 43 -Old Bridge off Manitou Ave - 2
EX Size: 7.9 ft (H) X 33.88 ft (W) Bridge
Notes: Fail - Overtops, Does Not
Meet Freeboard Criteria
FC 44 -Ent to Willow Motel
EX Size: 6.69 ft (H) X 27 ft (W) Bridge
Notes: Fail - Overtops, Does Not
Meet Freeboard Criteria
FC 46 -US-MS-Swimming Pool
EX Size: 6.6 ft (H) X 37.85 ft (W) Bridge
Notes: Fail - Overtops, Does Not
Meet Freeboard Criteria
FC 47 -Manitou Springs Swimming Pool
EX Size: 6.62 ft (H) X 30.3 ft (W) Bridge
Notes: Fail - Overtops, Does Not
Meet Freeboard Criteria
GARDEN DR
ROCKLEDGE LN
EL PASO BD
GARDEN OF THE GODS PL
MANITOU AVE
MAYFAIR AV
FOUNTAIN PL
EL MONTE PL
CRYSTAL PARK RD
OLD CRYSTAL PARK RD
TYLER ST
OAK PL
ST 2
ST 3
TERRACE PL
DENETA DR
SUTHERLAND RD
UF400
UF390
UF360
24
Matrix Design Group
Fountain Creek Watershed Flood Control & Greenway District
COLORADO
Colorado Water Conservation Board
Department of Natural Resources
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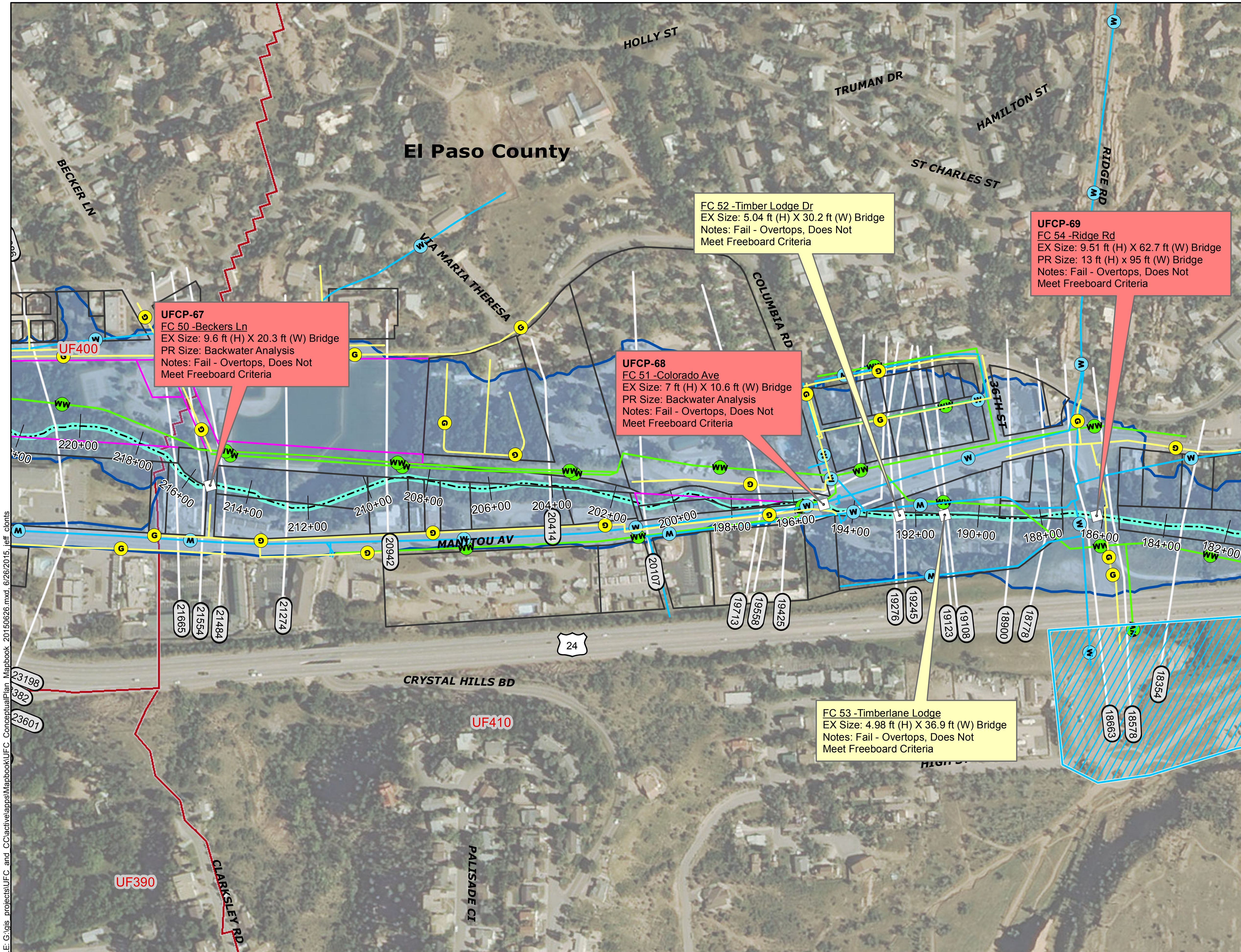
UFCP-67 thru UFCP-69

Upper Fountain Creek Conceptual Plan
El Paso County, CO

0 150 300
Feet



Legend

- Wastewater Line
- Water Line
- Gas Line
- Underground Electric
- Substation Fence
- County Boundary
- Stream Centerline
- 100-yr Simulated Flood Zone
- Bridge
- Culvert
- Hydraulic Model Cross Section
- USGS Proposed Detention Pond
- Subbasin

Ownership

- Private
- Public

Immediate Response Project

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- Identified Projects
- Detention Potential
- Cut Banks
- Steep Slopes
- Proposed Drop Structure
- Detention Basin
- Engineered Bank / Channel
- Proposed Foot Trail

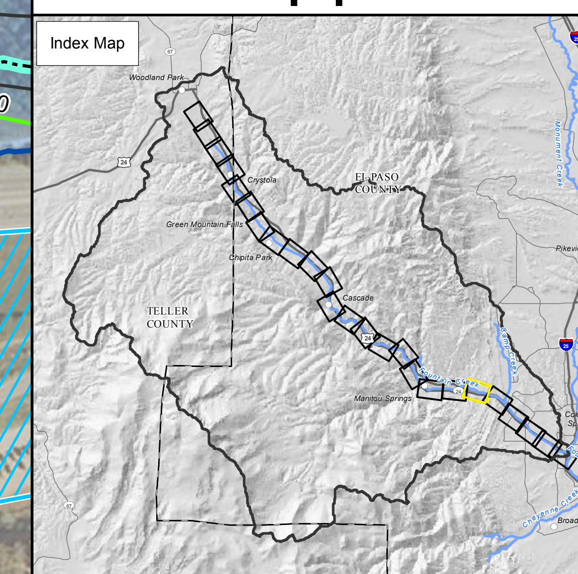
Reach Alternatives

- Natural Channel Design
- Protect In Place
- Protect In Place & Monitor
- Small Drop Structures w/ Toe Protection

Active Cutbanks

- High
- Medium
- Low

Index Map



Matrix DESIGN GROUP

FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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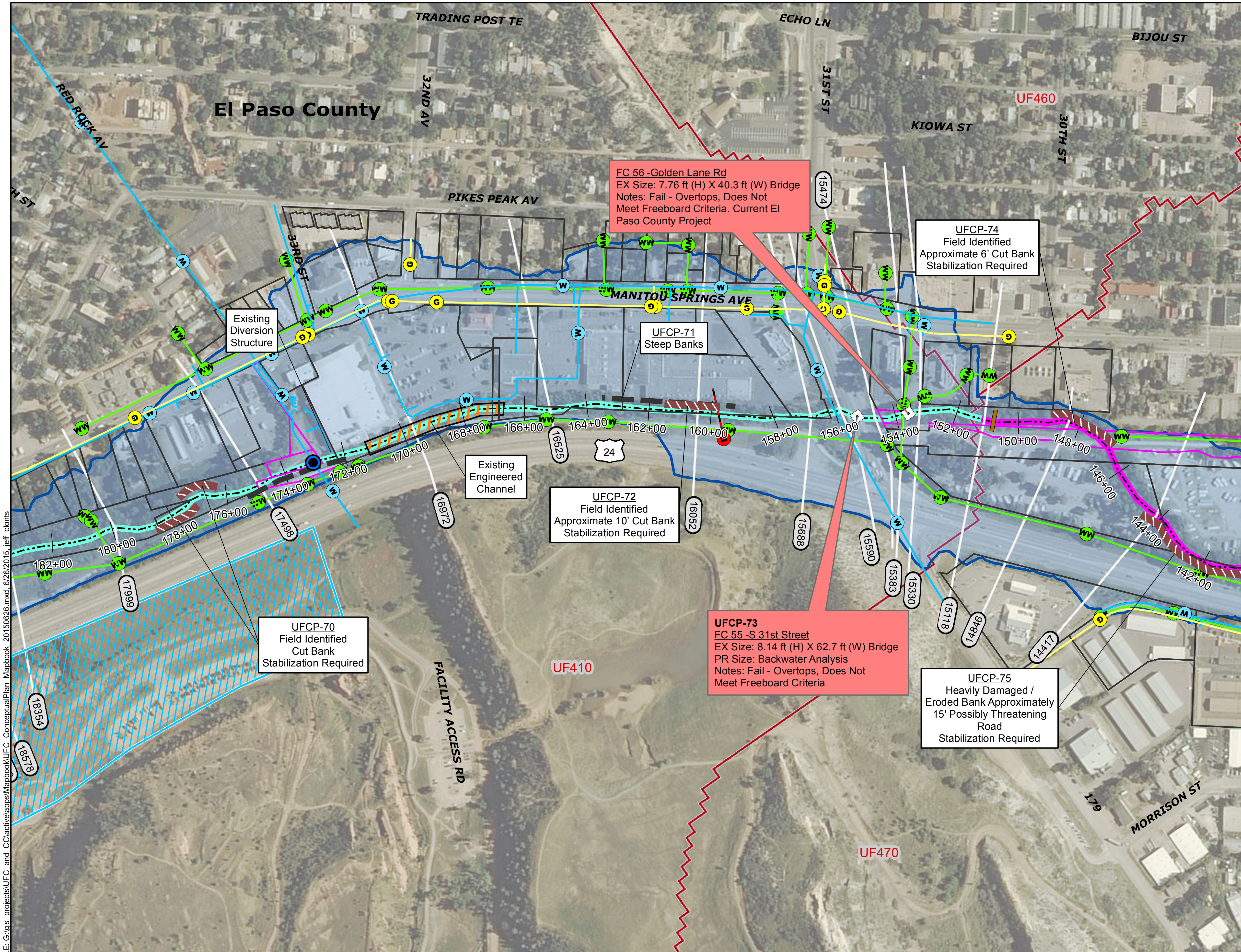
UFCP-70 thru UFCP-75

Upper Fountain Creek Conceptual Plan
El Paso County, CO



0 150 300
Feet

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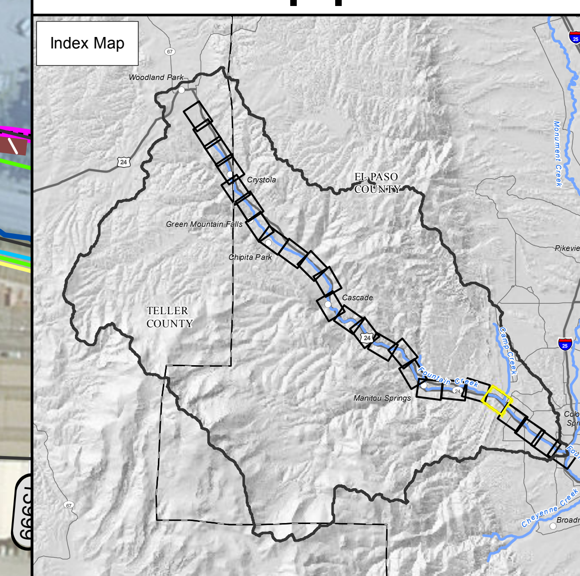

Matrix Design Group

Fountain Creek Watershed Flood Control & Greenway District

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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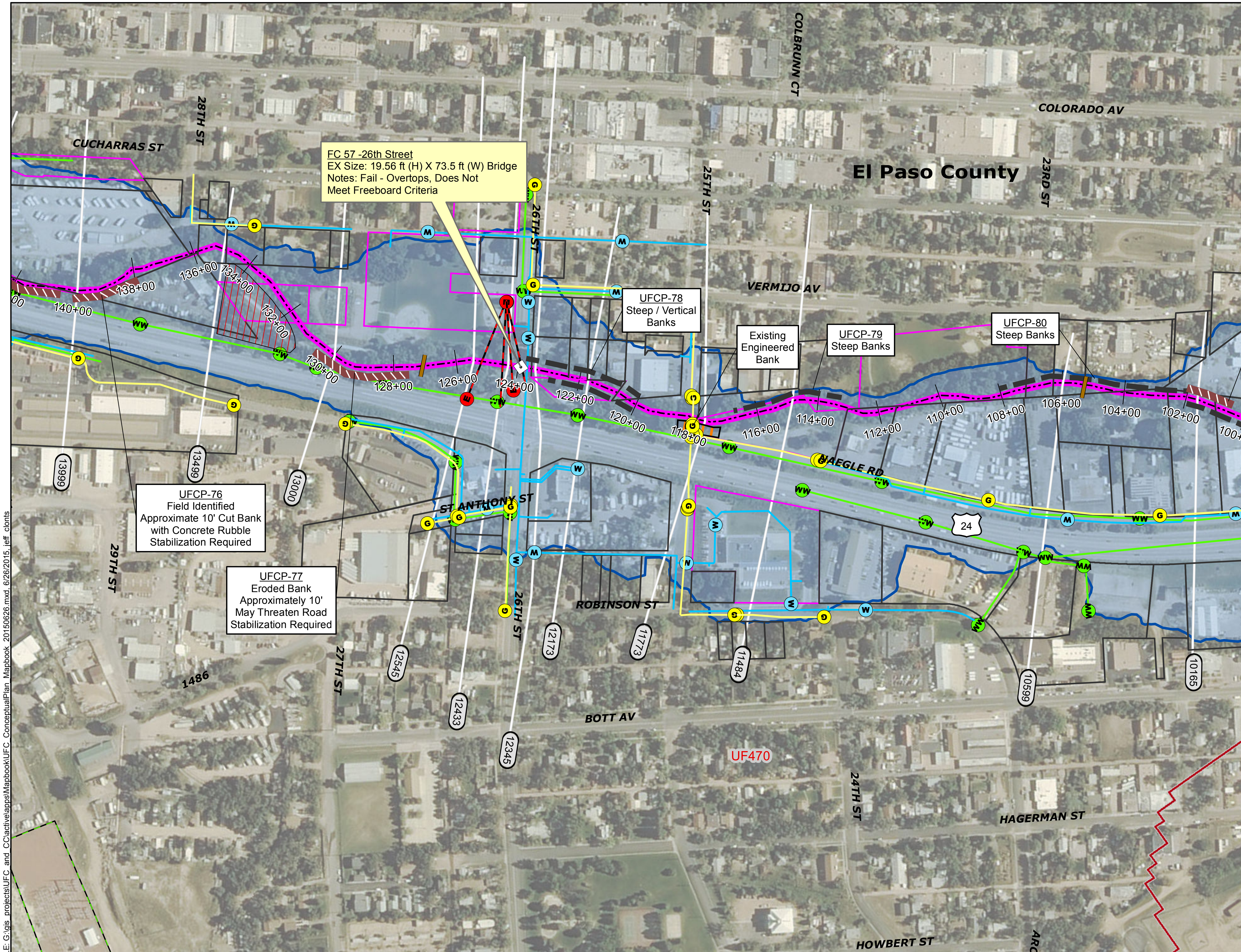

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UFCP-76 thru UFCP-80

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

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FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

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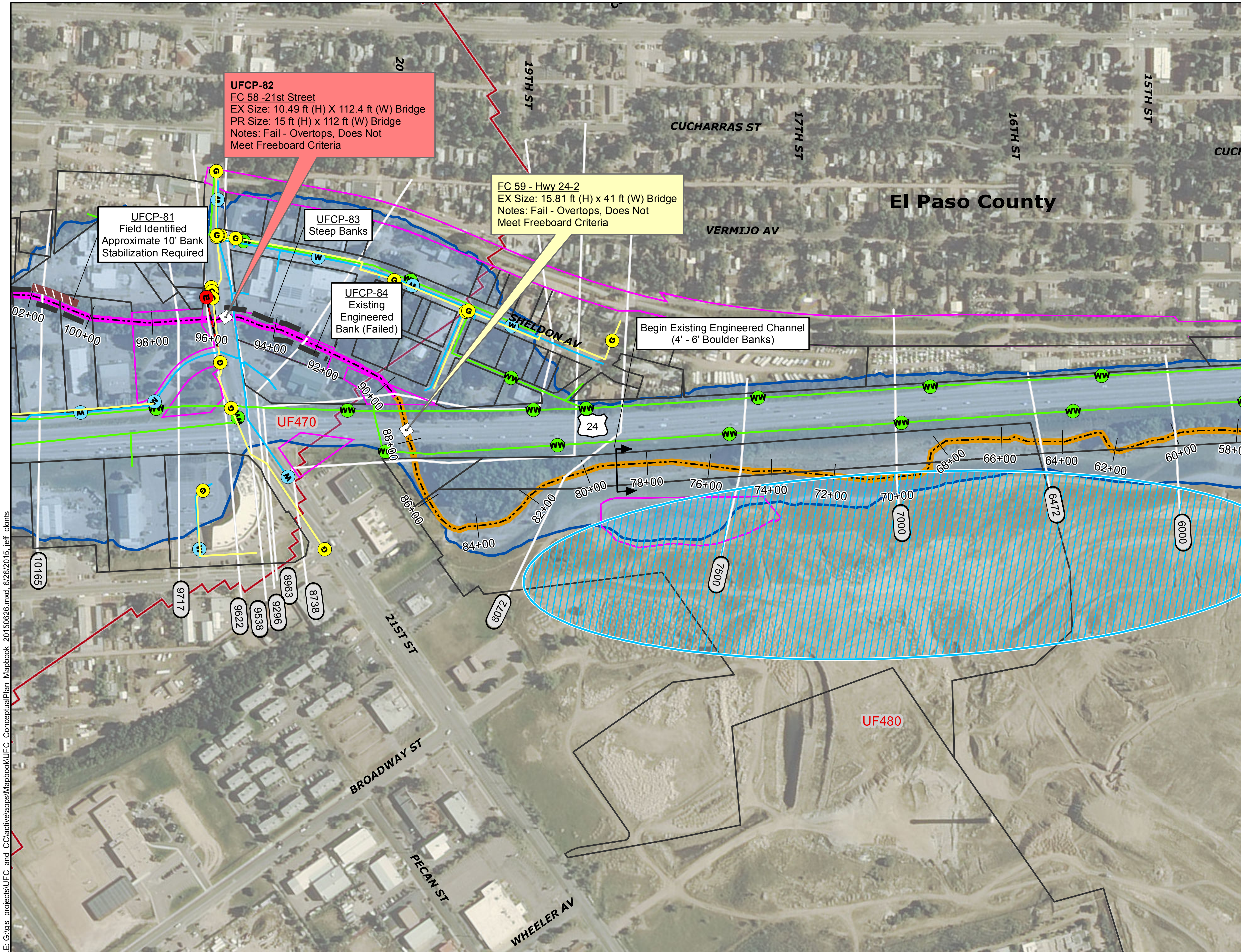
UFCP-81 thru UFCP-84

Upper Fountain Creek Conceptual Plan
El Paso County, CO

0 150 300
Feet



Legend

- Wastewater Line
- Water Line
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- Underground Electric
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- Stream Centerline
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- Culvert
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- Subbasin

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- Engineered Bank / Channel
- Proposed Foot Trail

Reach Alternatives

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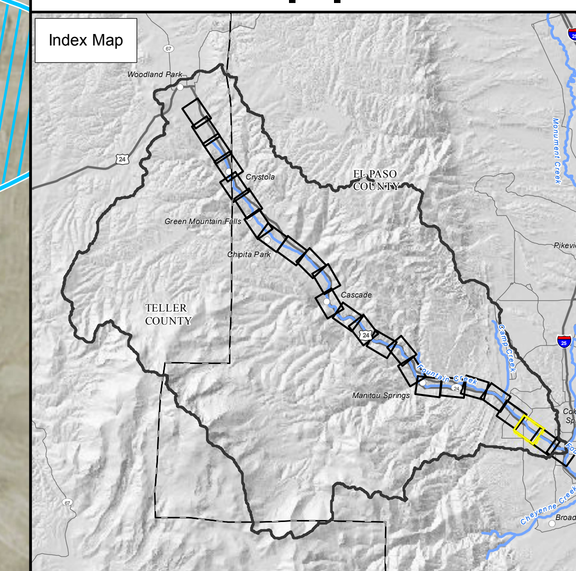
- Protect In Place & Monitor
- Small Drop Structures w/ Toe Protection

Active Cutbanks

- High
- Medium
- Low

Index Map



Matrix DESIGN GROUP

FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

CO DNR COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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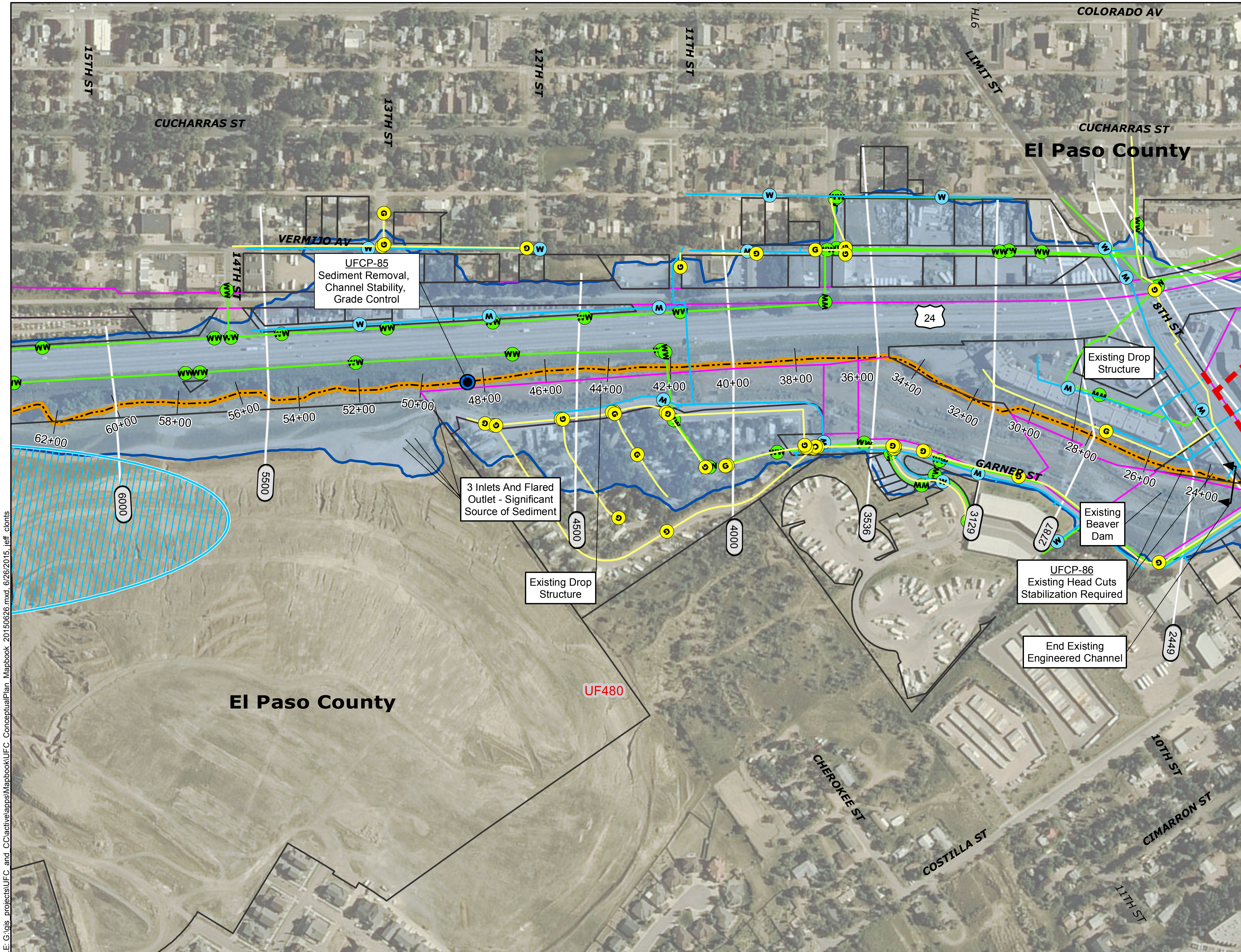

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UFCP-85 thru UFCP-86

Upper Fountain Creek
Conceptual Plan
El Paso County, CO

0 150 300
Feet

Legend

- Wastewater Line
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- Identified Projects
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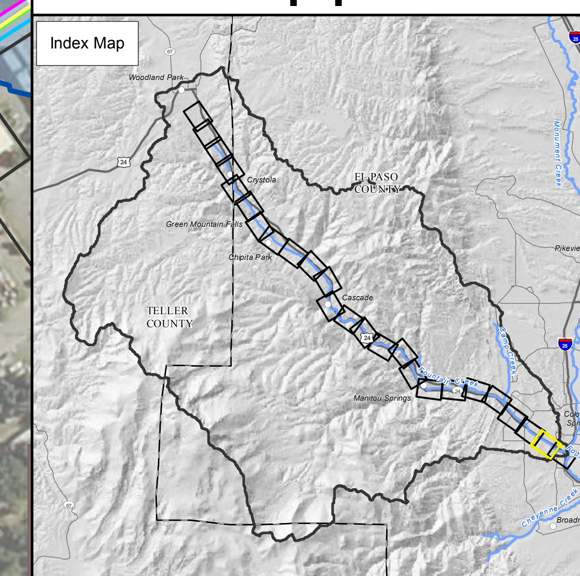
Reach Alternatives

- Natural Channel Design
- Protect In Place
- Protect In Place & Monitor
- Small Drop Structures w/ Toe Protection

Active Cutbanks

- High
- Medium
- Low

Index Map



Matrix DESIGN GROUP

FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

DNR CO COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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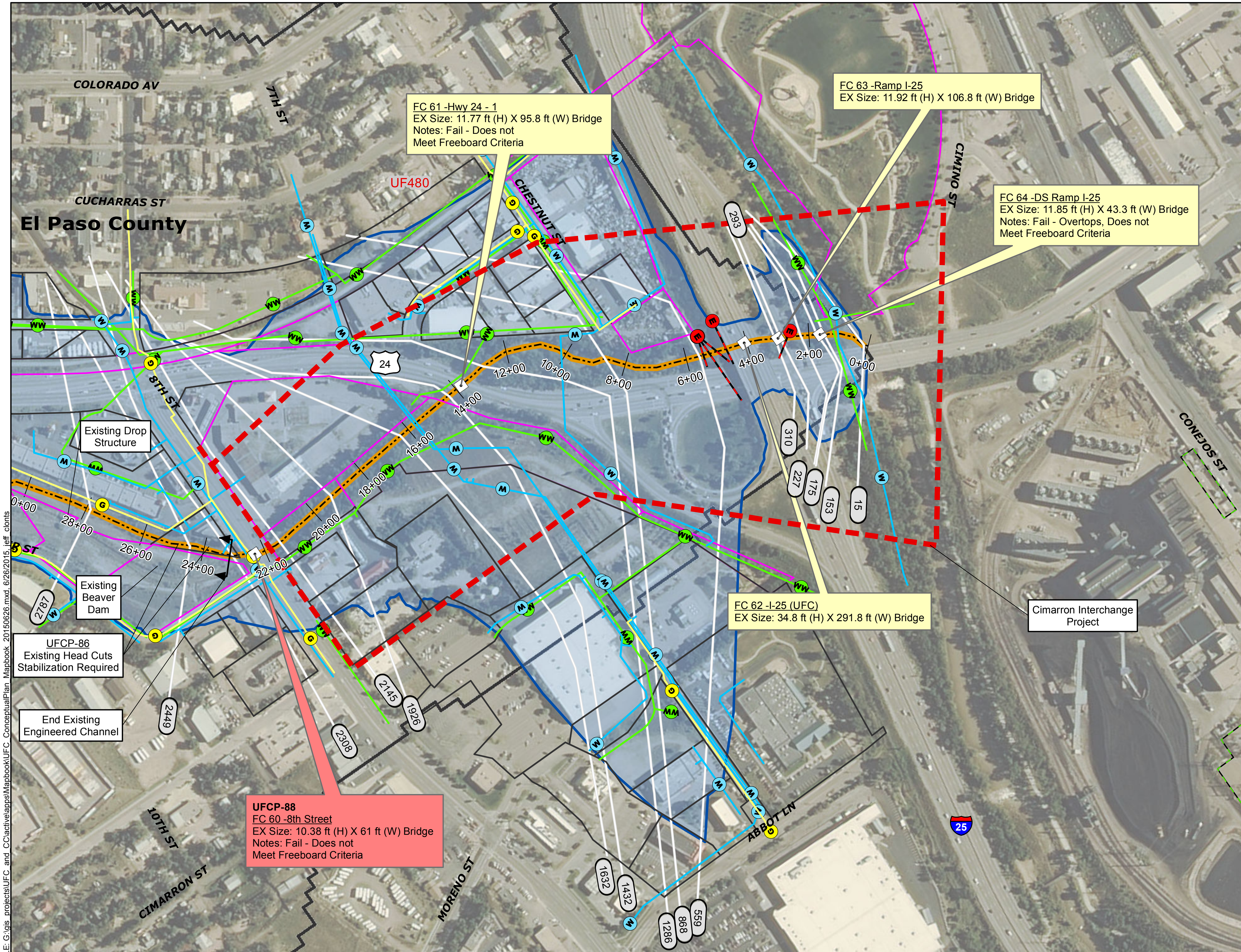
UFCP-87

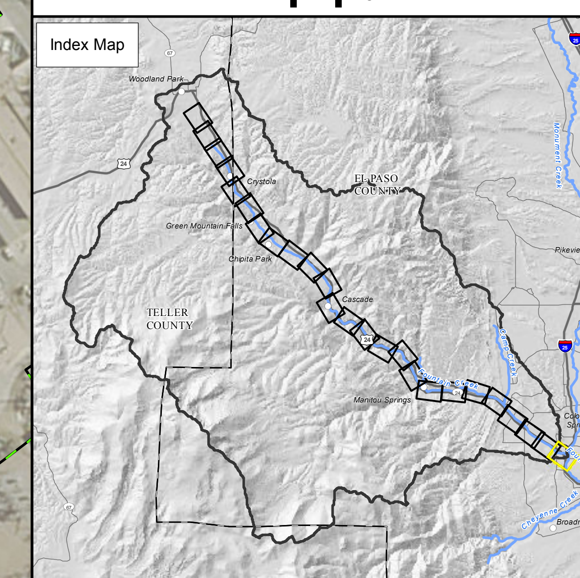
Upper Fountain Creek Conceptual Plan
El Paso County, CO



Legend

Wastewater Line	**Immediate Response Project**
Water Line	Immediate Response Project
Gas Line	Identified Projects
Underground Electric	Detention Potential
Substation Fence	Cut Banks
County Boundary	Steep Slopes
Stream Centerline	Proposed Drop Structure
100-yr Simulated Flood Zone	Detention Basin
Bridge	Engineered Bank / Channel
Culvert	Proposed Foot Trail
Hydraulic Model Cross Section	**Reach Alternatives**
USGS Proposed Detention Pond	Natural Channel Design
Subbasin	Protect In Place
Ownership	Protect In Place & Monitor
Private	Small Drop Structures w/ Toe Protection
Public	**Active Cutbanks**
	High
	Medium
	Low

Index Map

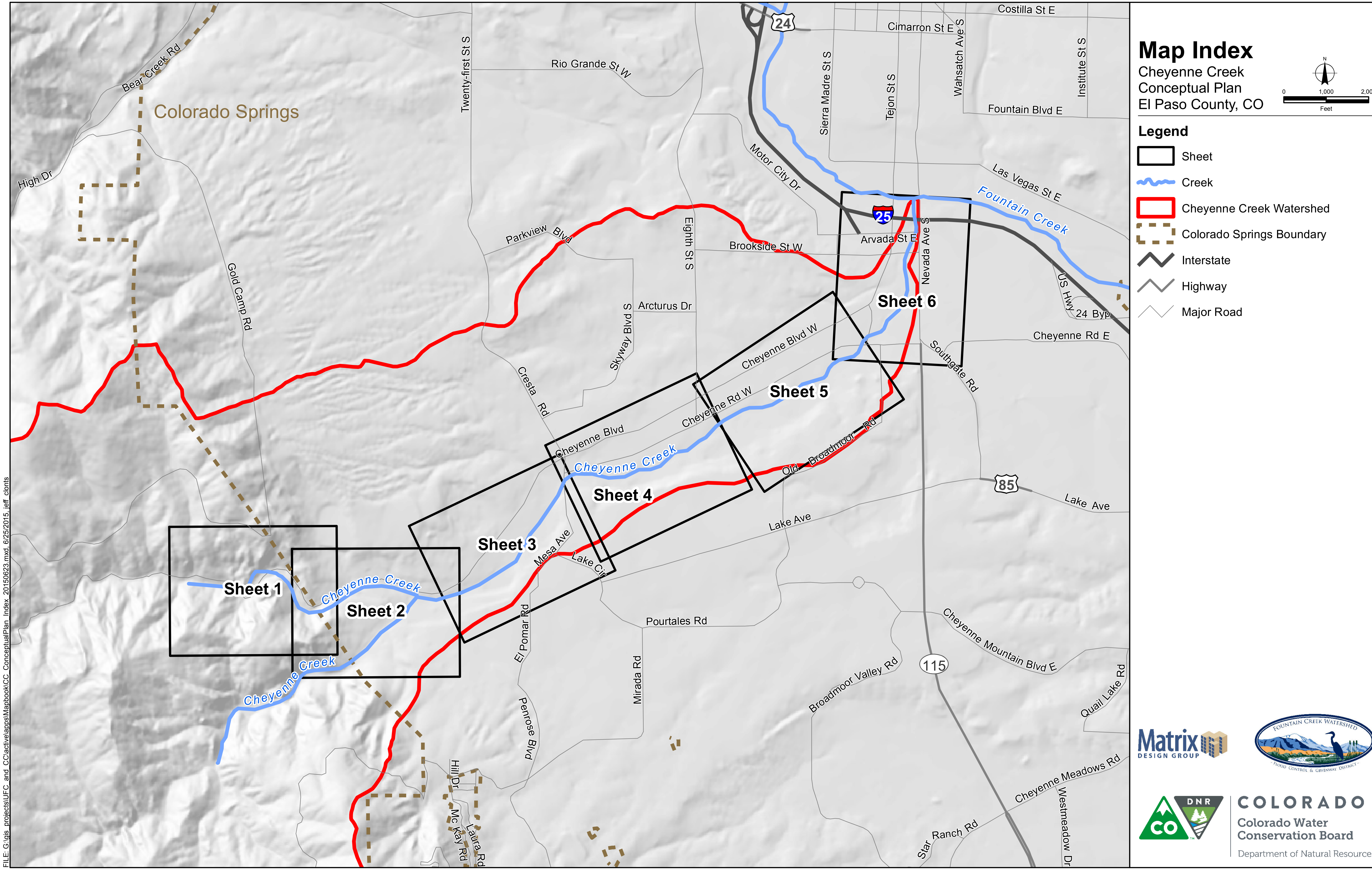


MATRIX DESIGN GROUP

FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

2.2 Cheyenne Creek Conceptual Plan Mapbook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Cheyenne Creek
Conceptual Plan
El Paso County, CO
N
0
1,000
2,000
Feet
Legend
Sheet
Creek
Cheyenne Creek Watershed
Colorado Springs Boundary
Interstate
Highway
Major Road
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High Dr
Gold Camp Rd
Rio Grande St W
Twenty-first St S
Parkview Blvd
Eighth St S
Brookside St W
Arcturus Dr
Skyway Blvd S
Cresta Rd
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Tejon St S
Wahsatch Ave S
Institute St S
Costilla St E
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Fountain Blvd E
Las Vegas St E
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US Hwy 24 Byp
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Southgate Rd
Old Broadmoor Rd
Lake Ave
Mesa Ave
Lake Cir
El Pomar Rd
Pourtales Rd
Mirada Rd
Penrose Blvd
Broadmoor Valley Rd
Cheyenne Mountain Blvd E
Quail Lake Rd
Cheyenne Meadows Rd
Westmeadow Dr
Star Ranch Rd
Hill Dr
Mc Kay Rd
Laura Rd
24
25
85
115
Matrix DESIGN GROUP
FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT
DNR CO
COLORADO
Colorado Water Conservation Board
Department of Natural Resources
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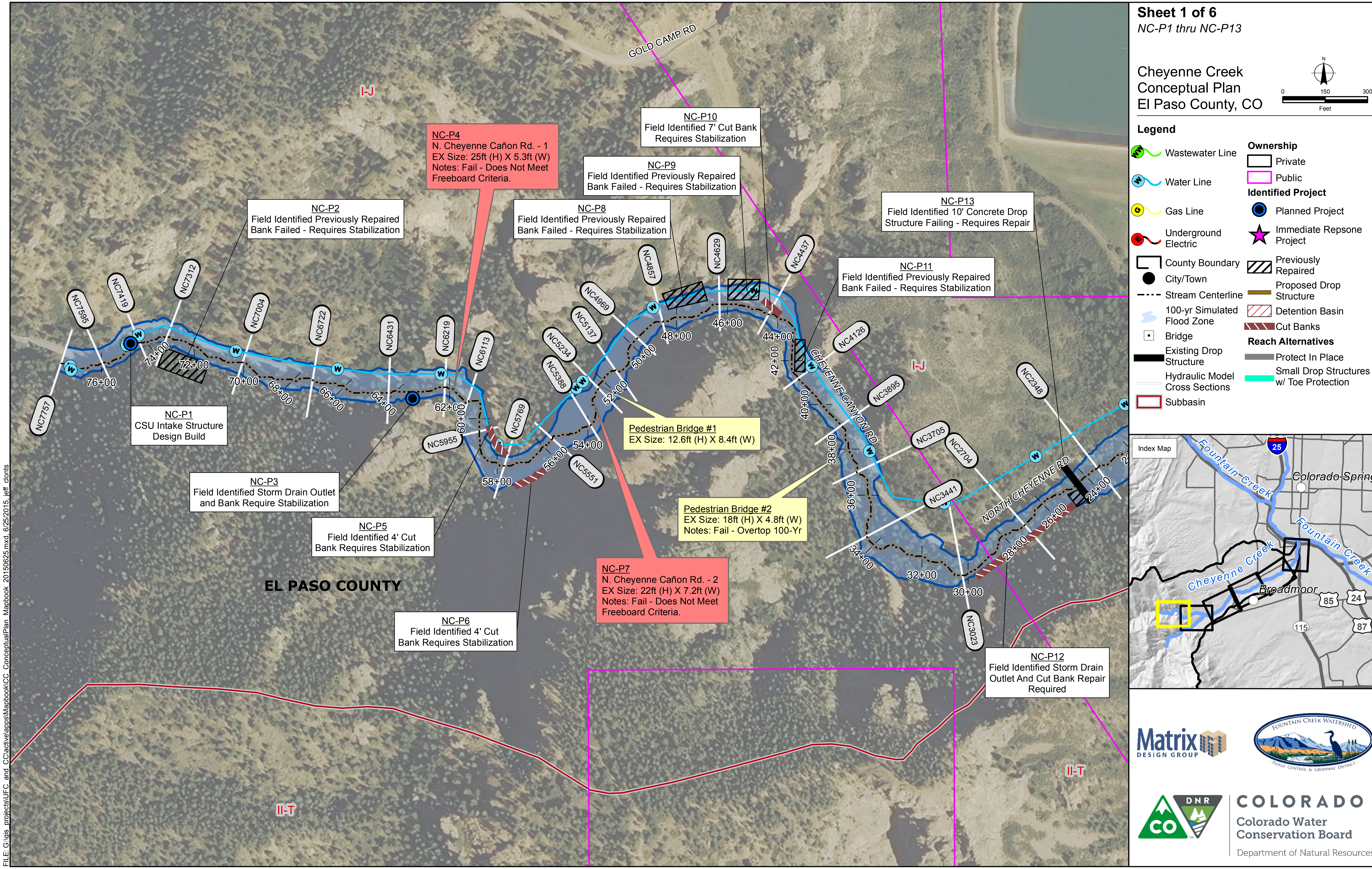
Sheet 1 of 6
NC-P1 thru NC-P13
Cheyenne Creek
Conceptual Plan
El Paso County, CO
0 150 300
Feet
Legend
Wastewater Line
Water Line
Gas Line
Underground Electric
County Boundary
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100-yr Simulated Flood Zone
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Small Drop Structures w/ Toe Protection
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CSU Intake Structure Design Build
NC-P2
Field Identified Previously Repaired Bank Failed - Requires Stabilization
NC-P3
Field Identified Storm Drain Outlet and Bank Require Stabilization
NC-P4
N. Cheyenne Cañon Rd. - 1
EX Size: 25ft (H) X 5.3ft (W)
Notes: Fail - Does Not Meet Freeboard Criteria.
NC-P5
Field Identified 4' Cut Bank Requires Stabilization
NC-P6
Field Identified 4' Cut Bank Requires Stabilization
NC-P7
N. Cheyenne Cañon Rd. - 2
EX Size: 22ft (H) X 7.2ft (W)
Notes: Fail - Does Not Meet Freeboard Criteria.
NC-P8
Field Identified Previously Repaired Bank Failed - Requires Stabilization
NC-P9
Field Identified Previously Repaired Bank Failed - Requires Stabilization
NC-P10
Field Identified 7' Cut Bank Requires Stabilization
NC-P11
Field Identified Previously Repaired Bank Failed - Requires Stabilization
NC-P12
Field Identified Storm Drain Outlet And Cut Bank Repair Required
NC-P13
Field Identified 10' Concrete Drop Structure Failing - Requires Repair
Pedestrian Bridge #1
EX Size: 12.6ft (H) X 8.4ft (W)
Pedestrian Bridge #2
EX Size: 18ft (H) X 4.8ft (W)
Notes: Fail - Overtop 100-Yr
GOLD CAMP RD
CHEYENNE CANYON RD
NORTH CHEYENNE RD
EL PASO COUNTY
I-J
II-T
NC7757
NC7595
NC7419
NC7312
NC7004
NC6722
NC6431
NC6219
NC6113
NC5955
NC5769
NC5551
NC5388
NC5234
NC5137
NC4969
NC4857
NC4629
NC4437
NC4126
NC3895
NC3705
NC3441
NC3023
NC2704
NC2348
Matrix DESIGN GROUP
FOUNTAIN CREEK WATERSHED
FLOOD CONTROL & GREENWAY DISTRICT
COLORADO
Colorado Water Conservation Board
Department of Natural Resources
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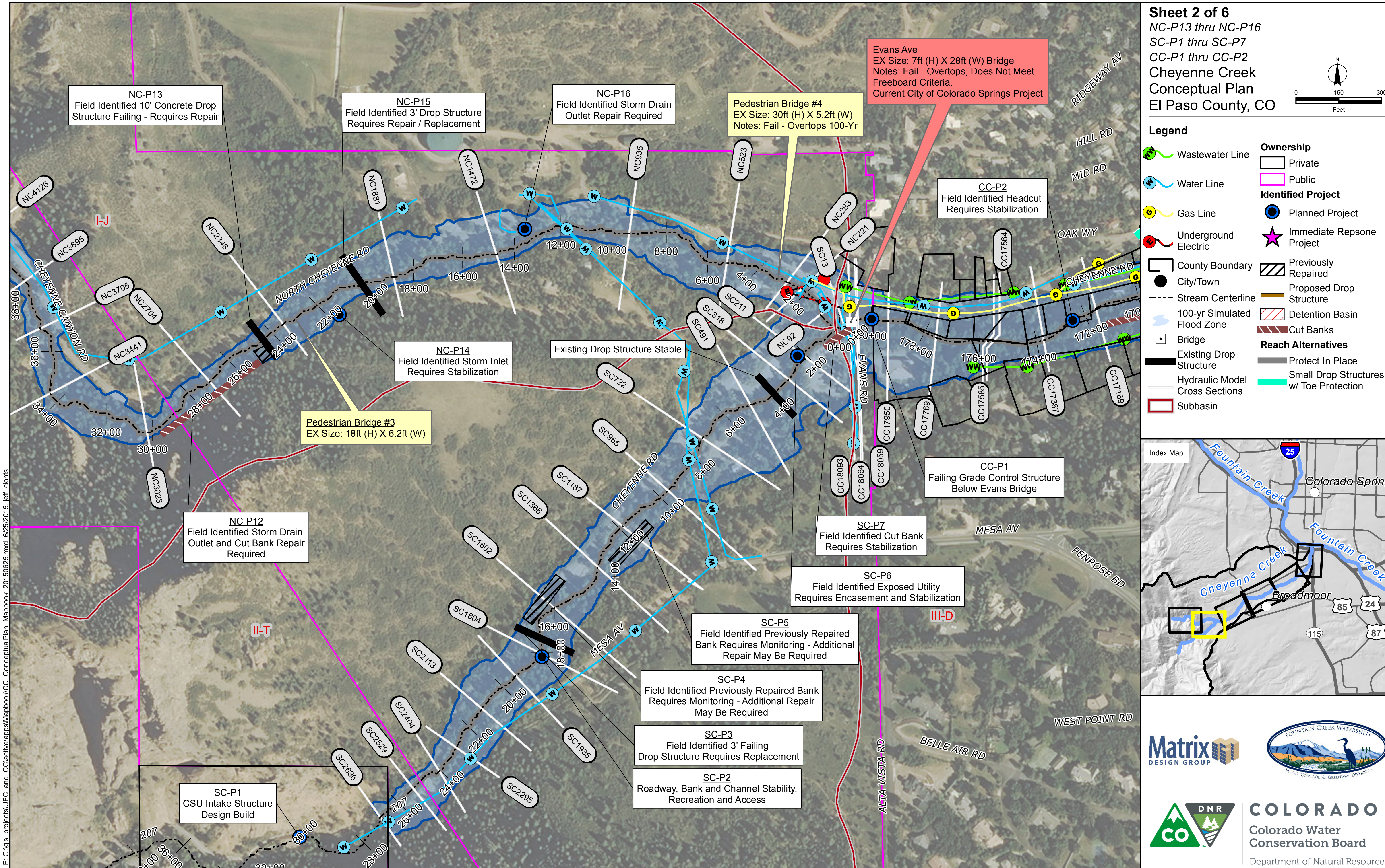
Sheet 2 of 6
NC-P13 thru NC-P16
SC-P1 thru SC-P7
CC-P1 thru CC-P2
Cheyenne Creek
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El Paso County, CO
0 150 300
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Gas Line
Underground Electric
County Boundary
City/Town
Stream Centerline
100-yr Simulated Flood Zone
Bridge
Existing Drop Structure
Hydraulic Model Cross Sections
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Private
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Small Drop Structures w/ Toe Protection
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Fountain Creek
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Cheyenne Creek
Broadmoor
NC-P13
Field Identified 10' Concrete Drop Structure Failing - Requires Repair
NC-P15
Field Identified 3' Drop Structure Requires Repair / Replacement
NC-P16
Field Identified Storm Drain Outlet Repair Required
Pedestrian Bridge #4
EX Size: 30ft (H) X 5.2ft (W)
Notes: Fail - Overtops 100-Yr
Evans Ave
EX Size: 7ft (H) X 28ft (W) Bridge
Notes: Fail - Overtops, Does Not Meet Freeboard Criteria.
Current City of Colorado Springs Project
CC-P2
Field Identified Headcut Requires Stabilization
NC-P14
Field Identified Storm Inlet Requires Stabilization
Existing Drop Structure Stable
Pedestrian Bridge #3
EX Size: 18ft (H) X 6.2ft (W)
NC-P12
Field Identified Storm Drain Outlet and Cut Bank Repair Required
CC-P1
Failing Grade Control Structure Below Evans Bridge
SC-P7
Field Identified Cut Bank Requires Stabilization
SC-P6
Field Identified Exposed Utility Requires Encasement and Stabilization
SC-P5
Field Identified Previously Repaired Bank Requires Monitoring - Additional Repair May Be Required
SC-P4
Field Identified Previously Repaired Bank Requires Monitoring - Additional Repair May Be Required
SC-P3
Field Identified 3' Failing Drop Structure Requires Replacement
SC-P2
Roadway, Bank and Channel Stability, Recreation and Access
SC-P1
CSU Intake Structure Design Build
I-J
II-T
III-D
NORTH CHEYENNE RD
CHEYENNE CANYON RD
CHEYENNE RD
MESA AV
EVANS RD
ALTA VISTA RD
RIDGEWAY AV
HILL RD
MID RD
OAK WY
PENROSE BD
WEST POINT RD
BELLE AIR RD
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FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT
COLORADO
Colorado Water Conservation Board
Department of Natural Resources
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Sheet 3 of 6

CC-P2 thru CC-P22

Cheyenne Creek
Conceptual Plan
El Paso County, CO

0 150 300
Feet

Legend

- Wastewater Line
- Water Line
- Gas Line
- Underground Electric
- County Boundary
- City/Town
- Stream Centerline
- 100-yr Simulated Flood Zone
- Bridge
- Existing Drop Structure
- Hydraulic Model Cross Sections
- Subbasin

Ownership

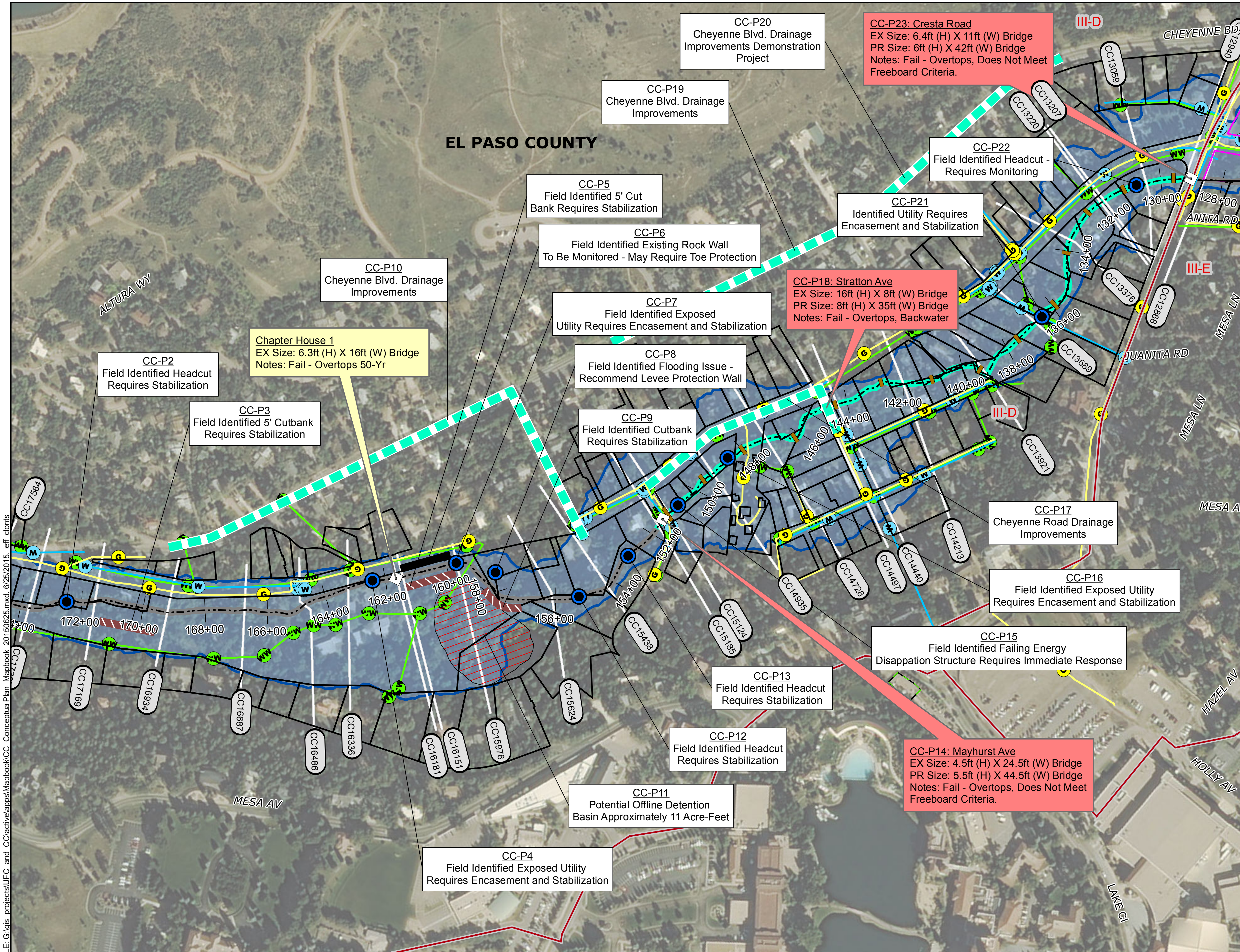
- Private
- Public

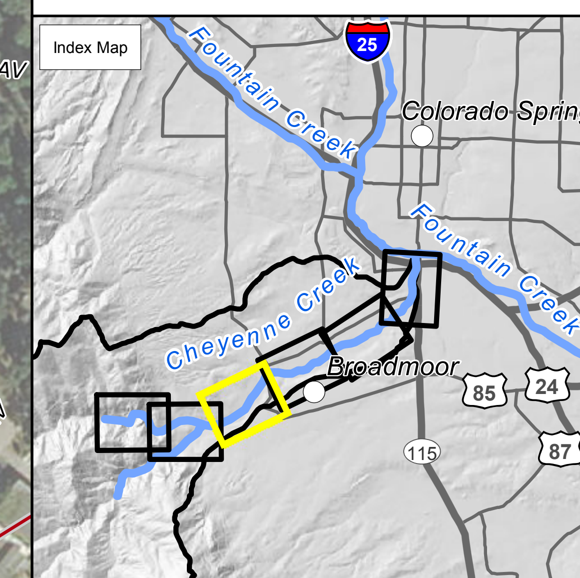
Identified Project

- Planned Project
- Immediate Repsone Project
- Previously Repaired
- Proposed Drop Structure
- Detention Basin
- Cut Banks

Reach Alternatives

- Protect In Place
- Small Drop Structures w/ Toe Protection





Matrix Design Group

Fountain Creek Watershed Flood Control & Greenway District

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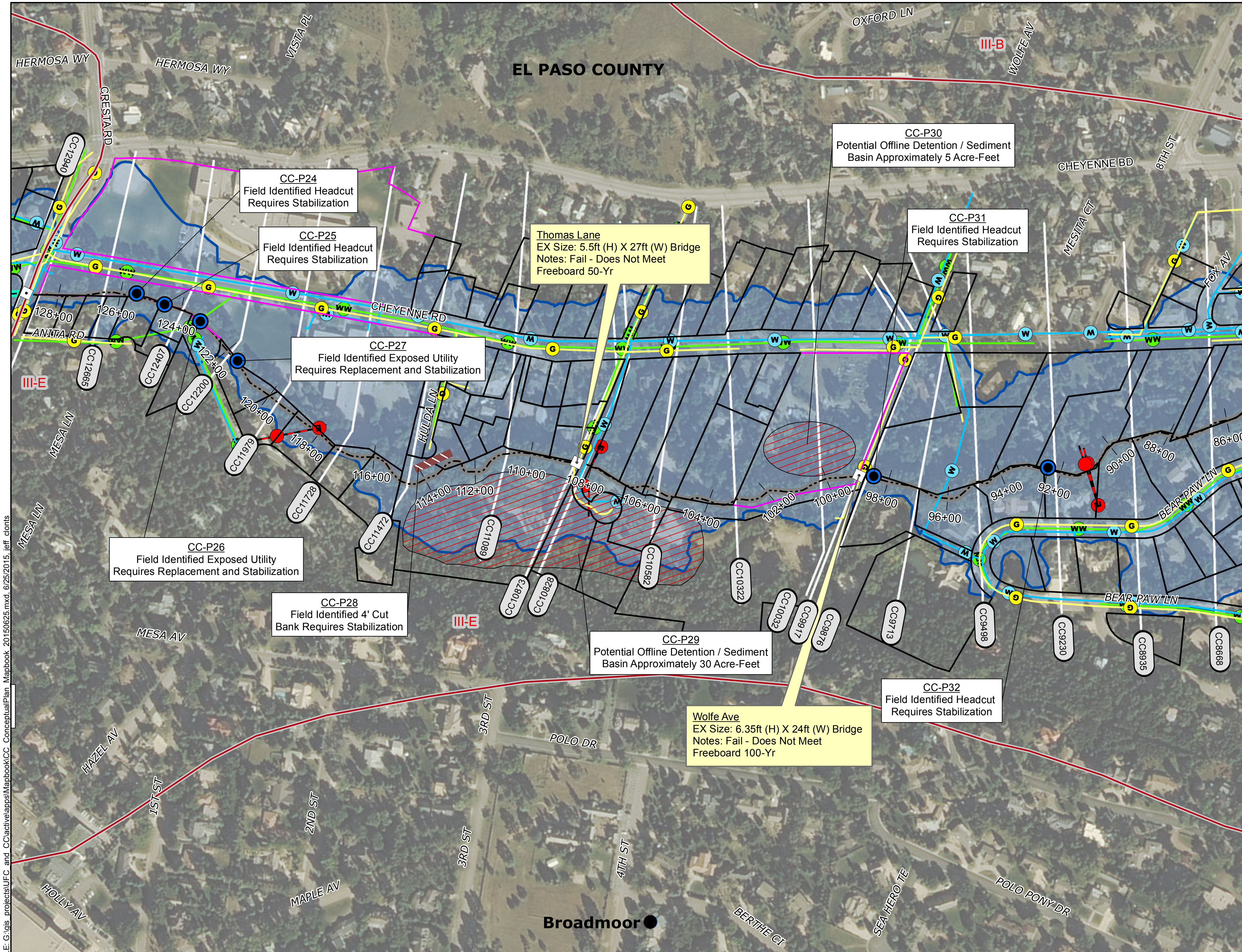
Colorado Water Conservation Board
Department of Natural Resources



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CC-P23 thru CC-P30

Cheyenne Creek
Conceptual Plan
El Paso County, CO

0 150 300
Feet

Legend

- Wastewater Line
- Water Line
- Gas Line
- Underground Electric
- County Boundary
- City/Town
- Stream Centerline
- 100-yr Simulated Flood Zone
- Bridge
- Existing Drop Structure
- Hydraulic Model Cross Sections
- Subbasin

Ownership

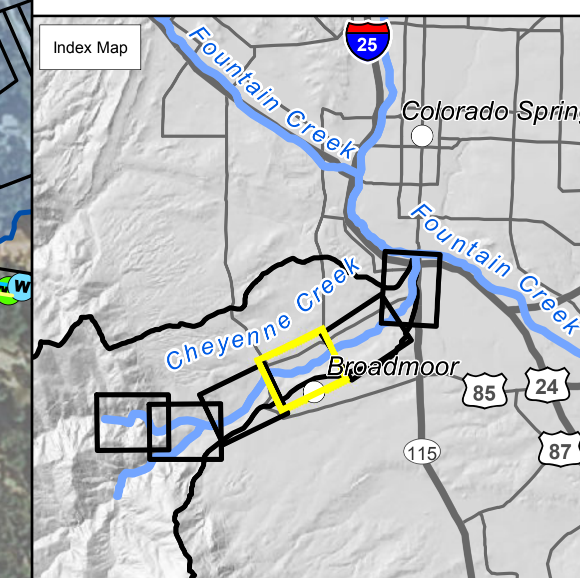
- Private
- Public

Identified Project

- Planned Project
- Immediate Repsone Project
- Previously Repaired
- Proposed Drop Structure
- Detention Basin
- Cut Banks

Reach Alternatives

- Protect In Place
- Small Drop Structures w/ Toe Protection



Colorado Water Conservation Board
Department of Natural Resources

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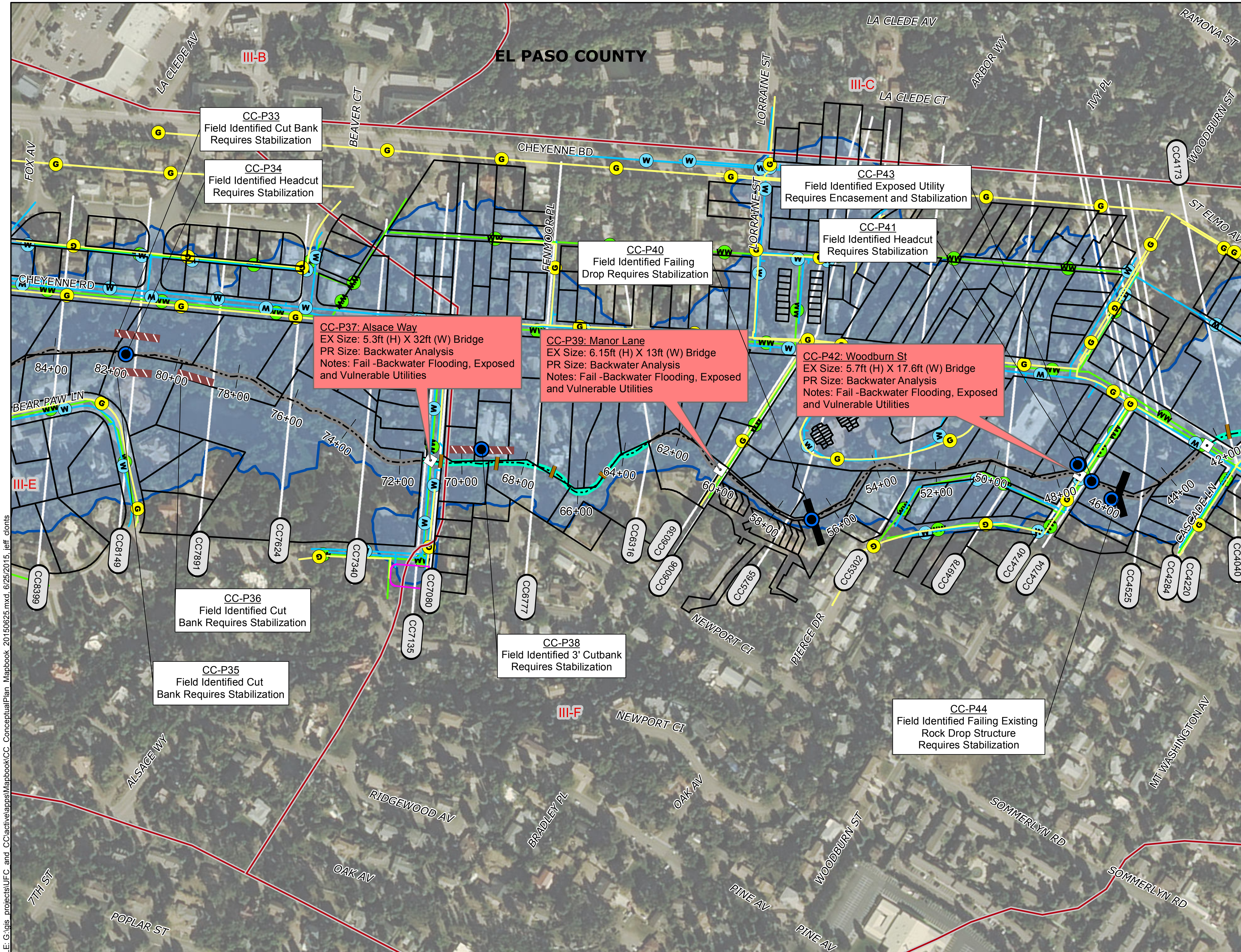


Sheet 5 of 6

CC-P31 thru CC-P42

Cheyenne Creek Conceptual Plan
El Paso County, CO

0 150 300 Feet

Legend

- Wastewater Line
- Water Line
- Gas Line
- Underground Electric
- County Boundary
- City/Town
- Stream Centerline
- 100-yr Simulated Flood Zone
- Bridge
- Existing Drop Structure
- Hydraulic Model Cross Sections
- Subbasin

Ownership

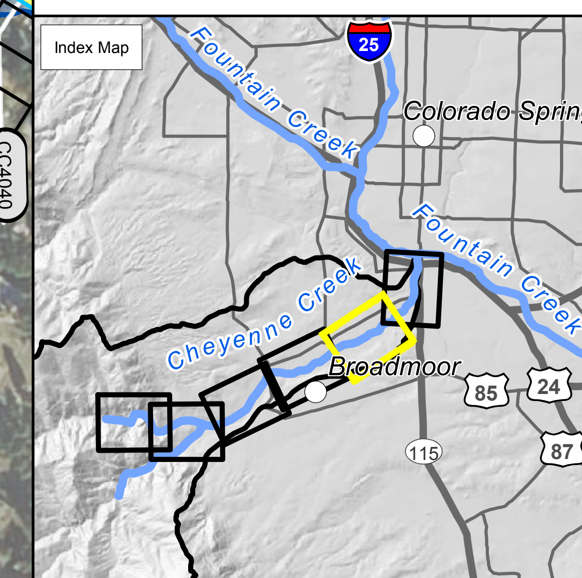
- Private
- Public

Identified Project

- Planned Project
- Immediate Repsone Project
- Previously Repaired
- Proposed Drop Structure
- Detention Basin
- Cut Banks

Reach Alternatives

- Protect In Place
- Small Drop Structures w/ Toe Protection



Matrix DESIGN GROUP

FOUNTAIN CREEK WATERSHED FLOOD CONTROL & GREENWAY DISTRICT

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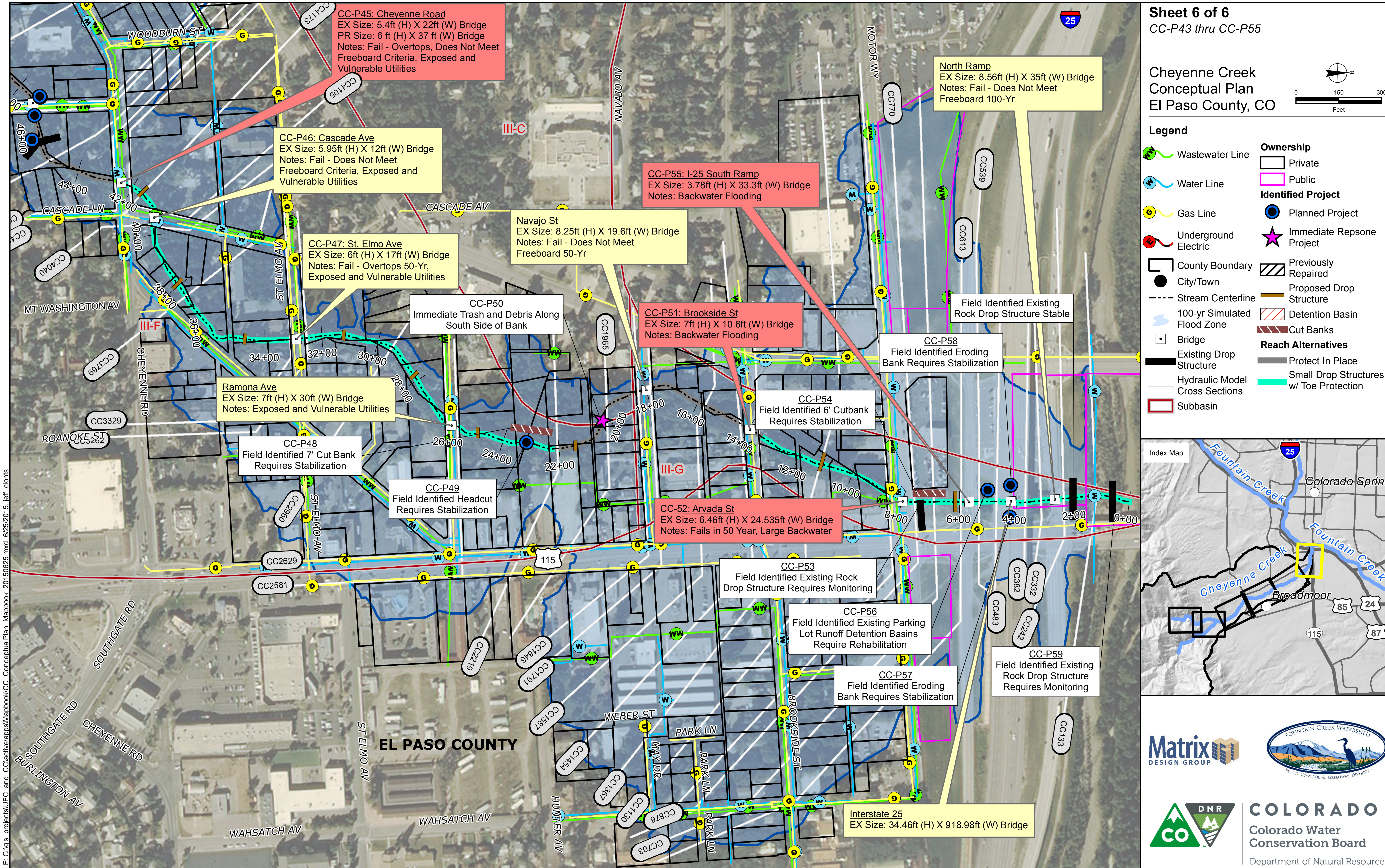
Department of Natural Resources



Sheet 6 of 6
CC-P43 thru CC-P55
Cheyenne Creek Conceptual Plan
El Paso County, CO
0 150 300
Feet
Legend
Wastewater Line
Water Line
Gas Line
Underground Electric
County Boundary
City/Town
Stream Centerline
100-yr Simulated Flood Zone
Bridge
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Hydraulic Model Cross Sections
Subbasin
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Fountain Creek
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CC-P45: Cheyenne Road
EX Size: 5.4ft (H) X 22ft (W) Bridge
PR Size: 6 ft (H) X 37 ft (W) Bridge
Notes: Fail - Overtops, Does Not Meet Freeboard Criteria, Exposed and Vulnerable Utilities
CC-P46: Cascade Ave
EX Size: 5.95ft (H) X 12ft (W) Bridge
Notes: Fail - Does Not Meet Freeboard Criteria, Exposed and Vulnerable Utilities
CC-P47: St. Elmo Ave
EX Size: 6ft (H) X 17ft (W) Bridge
Notes: Fail - Overtops 50-Yr, Exposed and Vulnerable Utilities
CC-P50
Immediate Trash and Debris Along South Side of Bank
Ramona Ave
EX Size: 7ft (H) X 30ft (W) Bridge
Notes: Exposed and Vulnerable Utilities
CC-P48
Field Identified 7' Cut Bank Requires Stabilization
CC-P49
Field Identified Headcut Requires Stabilization
Navajo St
EX Size: 8.25ft (H) X 19.6ft (W) Bridge
Notes: Fail - Does Not Meet Freeboard 50-Yr
CC-P55: I-25 South Ramp
EX Size: 3.78ft (H) X 33.3ft (W) Bridge
Notes: Backwater Flooding
CC-P51: Brookside St
EX Size: 7ft (H) X 10.6ft (W) Bridge
Notes: Backwater Flooding
North Ramp
EX Size: 8.56ft (H) X 35ft (W) Bridge
Notes: Fail - Does Not Meet Freeboard 100-Yr
Field Identified Existing Rock Drop Structure Stable
CC-P58
Field Identified Eroding Bank Requires Stabilization
CC-P54
Field Identified 6' Cutbank Requires Stabilization
CC-52: Arvada St
EX Size: 6.46ft (H) X 24.535ft (W) Bridge
Notes: Fails in 50 Year, Large Backwater
CC-P53
Field Identified Existing Rock Drop Structure Requires Monitoring
CC-P56
Field Identified Existing Parking Lot Runoff Detention Basins Require Rehabilitation
CC-P57
Field Identified Eroding Bank Requires Stabilization
CC-P59
Field Identified Existing Rock Drop Structure Requires Monitoring
Interstate 25
EX Size: 34.46ft (H) X 918.98ft (W) Bridge
III-C
III-F
III-G
EL PASO COUNTY
WOODBURN ST
CASCADE LN
CASCADE AV
MT WASHINGTON AV
ROANOKE ST
ST ELMO AV
CHEYENNE RD
NAVAJO AV
MOTOR WY
BROOKSIDE ST
WEBER ST
PARK LN
MAY DR
HUNTER AV
WAHSATCH AV
SOUTHGATE RD
BURLINGTON AV
Matrix Design Group
Fountain Creek Watershed Flood Control & Greenway District
COLORADO
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Department of Natural Resources
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3.0 Project Identification Results

A major goal of this plan is to identify potential capital improvement projects and areas of needed restoration and improvement. Our project team employed advanced modeling, technical screening, and stakeholder input to identify these recommended projects and to identify areas of needed restoration. Methods included extensive field reconnaissance, stream bank evaluation, collection and review of stakeholder capital improvement project lists, stakeholder interviews, collection and review of community input, and hydrologic and hydraulic modeling. The results of the project identification process yielded several types of projects including replacement of bridges and culverts, offline drainage improvements, flood risk reduction measures, bank restoration priorities for sediment reduction, field-identified head cuts requiring grade control, exposed and vulnerable utilities, existing unstable cut banks and steep slopes, and other unique projects.

The projects are ranked from Low to Immediate according to engineering analysis and technical evaluation and screening. Additionally, the high and immediate ranked projects have been further evaluated using a decision making matrix as described in the Project Prioritization section of this report. The results of the decision making matrix are shown below.

The following tables present the identified projects. The identified projects are also depicted on their respective project mapbook in the section above. For further explanation and details refer to the Plan Development section of this of this report.

Table 3-1. Upper Fountain Creek Project List and Priority Ranking

Upper Fountain Creek Project List and Priority Ranking							
Project No.	Reach	Project Rank	Reach Alternatives	Planning Area	Map book Sheet Number	Project Description	Project Type [1]
UFCP-01	RUF030	High	N/A	UFC-A	1	Bank ID: 101 490.2 Tons Per Year	BANCS Restoration Priority
UFCP-02	RUF030	High	N/A	UFC-A	1	Bank ID: 102 2616.4 Tons Per Year	BANCS Restoration Priority
UFCP-03	RUF030	Moderate	Natural Channel Design	UFC-A	2	Bank ID: 104 1354.4 Tons Per Year	BANCS Restoration Priority
UFCP-04	RUF030	Moderate	Natural Channel Design	UFC-A	3	Potential Offline Detention Basin Approximately 26 Acre-Feet	Flood-risk Reduction
UFCP-05	RUF030	Moderate	Natural Channel Design	UFC-A	3	Bank ID: 105 945.6 Tons Per Year	BANCS Restoration Priority
UFCP-06	RUF030	Low	Natural Channel Design	UFC-A	3	Field Identified Active Head Cut Stabilization Required	Flood-risk Reduction
UFCP-07	RUF030	Immediate	Natural Channel Design	UFC-A	4	Flood Levee Wall Required	Flood-risk Reduction
UFCP-08	RUF030	High	Natural Channel Design	UFC-A	4	Potential Offline Sediment Basin Approximately 6 Acre-Feet	Flood-risk Reduction
UFCP-09	RUF030	High	Natural Channel Design	UFC-A	4	Culvert FC 03 Backwater Analysis	Crossing Analysis
UFCP-10	RUF030	High	Natural Channel Design	UFC-A	4	Culvert FC 04 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-11	RUF030	High	Natural Channel Design	UFC-A	4	Bank ID: 02 145.7 Tons Per Year	BANCS Restoration Priority
UFCP-12	RUF050	Moderate	Natural Channel Design	UFC-A	5	Bank ID: 5 422.8 Tons Per Year	BANCS Restoration Priority
UFCP-13	RUF050	Low	Natural Channel Design	UFC-A	5	Exposed Gas Line Vertical Relocation and Encasement Required	Exposed and Vulnerable Utilities
UFCP-14	RUF050	High	Natural Channel Design	UFC-A	5	Bank ID: 63 327.9 Tons Per Year	BANCS Restoration Priority
UFCP-15	RUF050	Moderate	Natural Channel Design	UFC-A	5	Bank ID: 6 230.2 Tons Per Year	BANCS Restoration Priority
UFCP-16	RUF050	Moderate	Natural Channel Design	UFC-A	5	Bank ID: 7 500.8 Tons Per Year	BANCS Restoration Priority
UFCP-17	RUF050	Moderate	Natural Channel Design	UFC-A	5	Bank ID: 8 101 Tons Per Year	BANCS Restoration Priority
UFCP-18	RUF050	Moderate	Natural Channel Design	UFC-A	5	Identified Project: (PineCliff Stables) Grade Control, Banks and Channel Stability	Grade Control, Bank and Channel Stability
UFCP-19	RUF050	High	Natural Channel Design	UFC-A	5	Bank ID: 10 241.3 Tons Per Year	BANCS Restoration Priority
UFCP-20	RUF050	Moderate	Natural Channel Design	UFC-A	6	Bank ID: 12 109.9 Tons Per Year	BANCS Restoration Priority
UFCP-21	RUF050	Moderate	Natural Channel Design	UFC-A	6	Bank ID: 13 239.0 Tons Per Year	BANCS Restoration Priority
UFCP-22	RUF050	Moderate	Natural Channel Design	UFC-A	6	Bank ID: 14 286.1 Tons Per Year	BANCS Restoration Priority
UFCP-23	RUF050	Low	Natural Channel Design	UFC-B	6	Area of Very Incised and Confined Channel Grade Control Required	Grade Control, Bank and Channel Stability
UFCP-24	RUF050	Moderate	Natural Channel Design	UFC-B	6,7	Bank ID: 20 663 Tons Per Year	BANCS Restoration Priority
UFCP-25	RUF130	Low	Natural Channel Design	UFC-B	7	Potential Tributary Detention Pond Location Approximately 10 Acre-Feet	Flood-risk Reduction
UFCP-26	RUF130	High	Natural Channel Design	UFC-B	7	Culvert FC 09 Fail - Overtops	Crossing Analysis
UFCP-27	RUF130	Low	Natural Channel Design	UFC-B	7	Vertical Banks Behind Houses Toe Stabilization / Bank Stabilization Required	Grade Control, Bank and Channel Stability
UFCP-28	RUF140	Moderate	Protect in Place	UFC-B	7	Bank ID: 62 362.2 Tons Per Year	BANCS Restoration Priority
UFCP-29	RUF140	Low	Protect in Place	UFC-C	8	Potential Detention Basin Approximately 20 Acre-Feet	Flood-risk Reduction
UFCP-30	RUF140	High	Protect in Place	UFC-C	9	Bank ID: 65 227.4 Tons Per Year	BANCS Restoration Priority
UFCP-31	RUF140	High	Protect in Place	UFC-C	9	Bank and Channel Stability, Grade Control, Culvert Capacity, Major Road Crossing Redesign and Overhanging Outlet)	Grade Control, Bank and Channel Stability
UFCP-32	RUF150	High	Protect in Place	UFC-C	9	Major Erosion w/ Blocked Culvert	Grade Control, Bank and Channel Stability
UFCP-33	RUF150	High	Protect in Place	UFC-C	9	Potential Detention Basin Approximately 6 Acre-Feet	Flood-risk Reduction
UFCP-34	RUF150	High	Protect in Place	UFC-C	9	Bank ID: 35 174.7 Tons Per Year	BANCS Restoration Priority
UFCP-35	RUF150	Low	Protect in Place	UFC-C	9	Culvert FC 12 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-36	RUF150	Moderate	Protect in Place	UFC-C	9	Bank ID: 37 143.1 Tons Per Year	BANCS Restoration Priority
UFCP-37	RUF150	Moderate	Protect in Place	UFC-C	9	Bank ID: 39 194.7 Tons Per Year	BANCS Restoration Priority
UFCP-38	RUF150	Moderate	Protect in Place	UFC-C	10	Bank ID: 41 148.8 Tons Per Year	BANCS Restoration Priority
UFCP-39	RUF150	Moderate	Protect in Place	UFC-C	10	Bank ID: 66 103 Tons Per Year	BANCS Restoration Priority
UFCP-40	RUF160	Moderate	Natural Channel Design	UFC-C	10	Bank ID: 47 597.9 Tons Per Year	BANCS Restoration Priority
UFCP-41	RUF160	Moderate	Natural Channel Design	UFC-C	11	Bank ID: 50 736.8 Tons Per Year	BANCS Restoration Priority
UFCP-42	RUF160	Moderate	Natural Channel Design	UFC-C	11	Bank ID: 52 176.8 Tons Per Year	BANCS Restoration Priority
UFCP-43	RUF160	Low	Natural Channel Design	UFC-C	11	Potential Offline Detention Basin Approximately 5 Acre-Feet	Flood-risk Reduction
UFCP-44	RUF160	High	Natural Channel Design	UFC-C	12	Culvert FC 13 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-45	RUF160	Moderate	Natural Channel Design	UFC-C	12	Bank ID: 57 113.2 Tons Per Year	BANCS Restoration Priority

Upper Fountain Creek Project List and Priority Ranking (Cont.)

Upper Fountain Creek Project List and Priority Ranking							
Project No.	Reach	Project Rank	Reach Alternatives	Planning Area	Map book Sheet Number	Project Description	Project Type [1]
UFCP-46	RUF260	Moderate	Protect In Place and Monitor	UFC-D	12	Culvert FC 14 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-47	RUF261	Low	Small Drop Struct. W/Toe Protection	UFC-D	16	Channel and Bank Stability, Grade Control	Grade Control, Bank and Channel Stability
UFCP-48	RUF270	Low	Small Drop Struct. W/Toe Protection	UFC-E	16	Existing Detention / Sediment Basin to be Maintained	Flood-risk Reduction
UFCP-49	RUF270	Moderate	Small Drop Struct. W/Toe Protection	UFC-E	17	Culvert FC 20 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-50	RUF270	Moderate	Small Drop Struct. W/Toe Protection	UFC-E	17	MSDSD - Facility Serpentine Dr. Small Sediment Basin Existing Culvert Replacement	Flood-risk Reduction
UFCP-51	RUF270	Low	Small Drop Struct. W/Toe Protection	UFC-E	17	Raise Elevation of Serpentine Dr. Primary Evacuation Route	Flood-risk Reduction
UFCP-52	RUF270	Low	Small Drop Struct. W/Toe Protection	UFC-E	17	Culvert FC 26 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-53	RUF270	Moderate	Small Drop Struct. W/Toe Protection	UFC-E	18	Proposed Conveyance Swale	Offline Drainage Improvements
UFCP-54	RUF270	Moderate	Small Drop Struct. W/Toe Protection	UFC-E	18	Existing 7' x 7' Box Culvert Is Undersized - Proposed Upsizing Replacement	Offline Drainage Improvements
UFCP-55	RUF270	Moderate	Small Drop Struct. W/Toe Protection	UFC-E	18	City of Manitou Project WCP III - Proposed Levee Walls	Flood-risk Reduction
UFCP-56	RUF270	Low	Small Drop Struct. W/Toe Protection	UFC-E	18	Culvert FC 33 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-57	RUF270	Low	Small Drop Struct. W/Toe Protection	UFC-E	18	Culvert FC 35 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-58	RUF350	Moderate	Natural Channel Design	UFC-E	18	Identified Cut Bank Stabilization Required	Other Identified Projects
UFCP-59	RUF350	Low	Natural Channel Design	UFC-E	18	Culvert FC 38 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-60	RUF350	Low	Natural Channel Design	UFC-E	18	Potential In-line / Off-line Drainage Basin Approximately 24 Acre-Feet	Flood-risk Reduction
UFCP-61	RUF350	Low	Natural Channel Design	UFC-E	18	Culvert FC 39 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-62	RUF350	Moderate	Natural Channel Design	UFC-E	19	Proposed Inlet With 3 - 36" Culverts	Offline Drainage Improvements
UFCP-63	RUF350	Moderate	Natural Channel Design	UFC-E	19	Raise Elevation of Manitou Ave. Primary Evacuation Route	Flood-risk Reduction
UFCP-64	RUF350	Low	Natural Channel Design	UFC-E	19	Culvert FC 41 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-65	RUF350	Low	Natural Channel Design	UFC-E	19	Potential Joint Use Park/Flood Relief Area Approximately 8 Acre-Feet	Flood-risk Reduction
UFCP-66	RUF360	Moderate	Natural Channel Design	UFC-E	19	Culvert FC 48 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-67	RUF360	Moderate	Natural Channel Design	UFC-E	20	Culvert FC 50 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-68	RUF360	Low	Natural Channel Design	UFC-E	20	Culvert FC 51 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-69	RUF360	Low	Natural Channel Design	UFC-E	20	Culvert FC 54 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-70	RUF360	Low	Natural Channel Design	UFC-E	21	Field Identified Cut Bank Stabilization Required	Other Identified Projects
UFCP-71	RUF360	Low	Natural Channel Design	UFC-E	21	Steep Banks	Other Identified Projects
UFCP-72	RUF360	Low	Natural Channel Design	UFC-E	21	Field Identified Approximate 10' Cut Bank Stabilization Required	Other Identified Projects
UFCP-73	RUF360	Moderate	Natural Channel Design	UFC-E	21	Culvert FC 55 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-74	RUF400	Low	Protect In Place and Monitor	UFC-E	21	Field Identified Approximate 6' Cutbank Stabilization Required	Other Identified Projects
UFCP-75	RUF400	Moderate	Protect In Place and Monitor	UFC-E	21	Heavily Damaged / Eroded Bank Approximately 15' Possibly Threatening Road Stabilization Required	Grade Control, Bank and Channel Stability
UFCP-76	RUF410	Moderate	Protect In Place and Monitor	UFC-E	22	Filed Identified Approximate 10' Cut Bank with Concrete Rubble Stabilization Required	Other Identified Projects
UFCP-77	RUF410	Moderate	Protect In Place and Monitor	UFC-F	22	Eroded Bank Approximately 10' May Threaten Road Stabilization Required	Grade Control, Bank and Channel Stability
UFCP-78	RUF410	Low	Protect In Place and Monitor	UFC-F	22	Steep / Vertical Banks	Other Identified Projects
UFCP-79	RUF410	Low	Protect In Place and Monitor	UFC-F	22	Steep Banks	Other Identified Projects
UFCP-80	RUF410	Low	Protect In Place and Monitor	UFC-F	22	Steep Banks	Other Identified Projects
UFCP-81	RUF410	Low	Protect In Place and Monitor	UFC-F	23	Field Identified Approximate 10' Cutbank Stabilization Required	Other Identified Projects
UFCP-82	RUF410	Moderate	Protect In Place and Monitor	UFC-F	23	Culvert FC 58 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis
UFCP-83	RUF410	Low	Protect In Place and Monitor	UFC-F	23	Steep Banks	Other Identified Projects
UFCP-84	RUF470	Low	Small Drop Struct. W/Toe Protection	UFC-F	23	Existing Engineered Bank (Failed)	Grade Control, Bank and Channel Stability
UFCP-85	RUF470	Low	Small Drop Struct. W/Toe Protection	UFC-F	24	Sediment Removal, Channel Stability, Grade Control	Grade Control, Bank and Channel Stability
UFCP-86	RUF470	Moderate	Small Drop Struct. W/Toe Protection	UFC-F	24	Existing Head Cuts Stabilization Required	Field Identified Head Cuts
UFCP-87	RUF470	Moderate	Small Drop Struct. W/Toe Protection	UFC-F	25	Culvert FC 60 Fail - Overtops, Does Not Meet Freeboard Capacity	Crossing Analysis

Table 3-2. Cheyenne Creek Project List and Priority Ranking

Cheyenne Creek Project List and Priority Ranking							
Project No.	Reach	Project Rank	Reach Alternatives	Planning Area	Map Book Sheet Number	Project Description	Project Type[1]
NC-P1	NCC1	Low	Protect in Place	NC-A	1	CSU Intake Structure Design-Build	Other Identified Projects
NC-P2	NCC2	Low	Protect in Place	NC-A	1	Field Identified Previously Repaired Bank Failed - Requires Stabilization	Grade Control, Bank and Channel Stability
NC-P3	NCC2	Low	Protect in Place	NC-A	1	Field Identified Storm Drain Outlet and Bank Require Stabilization	Grade Control, Bank and Channel Stability
NC-P4	NCC2	Moderate	Protect in Place	NC-A	1	N. Cheyenne Canyon Road Crossing 1 Failed Freeboard Criteria (overtops in 50yr)	Crossing Analysis
NC-P5	NCC2	Low	Protect in Place	NC-A	1	Field Identified 4' Cut Bank Requires Stabilization	Other Identified Projects
NC-P6	NCC2	Low	Protect in Place	NC-A	1	Field Identified 4' Cut Bank Requires Stabilization	Other Identified Projects
NC-P7	NCC2	Moderate	Protect in Place	NC-A	1	N. Cheyenne Canyon Road Crossing 2 Failed Freeboard Criteria (overtops in 50yr)	Crossing Analysis
NC-P8	NCC3	Moderate	Protect in Place	NC-A	1	Field Identified Previously Repaired Bank Failed - Requires Stabilization	Grade Control, Bank and Channel Stability
NC-P9	NCC3	Low	Protect in Place	NC-A	1	Field Identified Previously Repaired Bank Failed - Requires Stabilization	Grade Control, Bank and Channel Stability
NC-P10	NCC3	Low	Protect in Place	NC-A	1	Field Identified 7' Cutbank Requires Stabilization	Other Identified Projects
NC-P11	NCC4	Moderate	Protect in Place	NC-A	1	Field Identified Previously Repaired Bank Failed - Requires Stabilization	Grade Control, Bank and Channel Stability
NC-P12	NCC4	Moderate	Protect in Place	NC-A	1	Field Identified Storm Drain Outlet and Cut Bank Repair Required	Other Identified Projects
NC-P13	NCC4	Moderate	Protect in Place	NC-A	1	Field Identified 10' Concrete Drop Structure Failing - Requires Repair	Grade Control, Bank and Channel Stability
NC-P14	NCC4	Low	Protect in Place	NC-A	2	Field Identified Storm Inlet Requires Stabilization	Other Identified Projects
NC-P15	NCC4	Low	Protect in Place	NC-A	2	Field Identified 3' Drop Structure Requires Repair / Replacement	Grade Control, Bank and Channel Stability
NC-P16	NCC5	Low	Protect in Place	NC-A	2	Field Identified Storm Drain Outlet Repair Required	Other Identified Projects
SC-P1	SCC1	Low	Small Drop Structures w/ Toe Protection	SC-A	2	CSU Intake Structure Design-Build	Other Identified Projects
SC-P2	SCC3	Low	Small Drop Structures w/ Toe Protection	SC-A	2	Roadway, Bank and Channel Stability, Recreation and Access	Grade Control, Bank and Channel Stability
SC-P3	SCC3	Moderate	Small Drop Structures w/ Toe Protection	SC-A	2	Field Identified 3' Failing Drop Structure Requires Replacement	Grade Control, Bank and Channel Stability
SC-P4	SCC3	Low	Small Drop Structures w/ Toe Protection	SC-A	2	Field Identified Previously Repaired Bank Requires Monitoring - Additional Repair May Be Required	Grade Control, Bank and Channel Stability
SC-P5	SCC3	Low	Small Drop Structures w/ Toe Protection	SC-A	2	Field Identified Previously Repaired Bank Requires Monitoring - Additional Repair May Be Required	Grade Control, Bank and Channel Stability
SC-P6	SCC5	Moderate	Small Drop Structures w/ Toe Protection	SC-A	2	Field Identified Exposed Utility Requires Encasement and Stabilization	Exposed and Vulnerable Utilities
SC-P7	SCC5	Low	Small Drop Structures w/ Toe Protection	SC-A	2	Field Identified Cut Bank Requires Stabilization	Other Identified Projects
CC-P1	CC1	High	Protect in Place	CC-A	2	Failing Grade Control Structure Below Evans Bridge	Grade Control, Bank and Channel Stability
CC-P2	CC1	Moderate	Protect in Place	CC-A	2	Field Identified Headcut Requires Stabilization	Field Identified Headcuts
CC-P3	CC1	Low	Protect in Place	CC-A	3	Field Identified 5' Cutbank Requires Stabilization	Other Identified Projects
CC-P4	CC1	Low	Protect in Place	CC-A	3	Field Identified Exposed Utility Requires Encasement and Stabilization	Exposed and Vulnerable Utilities
CC-P5	CC1	Low	Protect in Place	CC-A	3	Field Identified 5' Cutbank Requires Stabilization	Other Identified Projects
CC-P6	CC1	Low	Protect in Place	CC-A	3	Field Identified Existing Rock Wall To Be Monitored - May Require Toe Protection	Other Identified Projects
CC-P7	CC1	Low	Protect in Place	CC-A	3	Field Identified Exposed Utility Requires Encasement and Stabilization	Exposed and Vulnerable Utilities
CC-P8	CC1	Moderate	Protect in Place	CC-A	3	Field Identified Flooding Issue - Recommend Levee Protection Wall	Flood-Risk Reduction
CC-P9	CC1	Low	Protect in Place	CC-A	3	Field Identified Cutbank Requires Stabilization	Other Identified Projects
CC-P10	CC1	Moderate	Protect in Place	CC-A	3	Cheyenne Blvd. Drainage Improvements	Offline Drainage Improvements
CC-P11	CC1	Moderate	Protect in Place	CC-A	3	Potential Offline Detention Basin Approximately 11 Acre-Feet	Flood-Risk Reduction
CC-P12	CC1	Moderate	Protect in Place	CC-A	3	Field Identified Headcut Requires Stabilization	Field Identified Headcuts
CC-P13	CC1	Moderate	Protect in Place	CC-A	3	Field Identified Headcut Requires Stabilization	Field Identified Headcuts
CC-P14	CC2	Moderate	Small Drop Structures w/ Toe Protection	CC-B	3	Mayhurst Ave Culvert Fail - Overtops, Does Not Meet Freeboard Criteria	Crossing Analysis
CC-P15	CC2	Moderate	Small Drop Structures w/ Toe Protection	CC-B	3	Field Identified Failing Energy Dissipation Structure Requires Response	Other Identified Projects
CC-P16	CC2	Low	Small Drop Structures w/ Toe Protection	CC-B	3	Field Identified Exposed Utility Requires Encasement and Stabilization	Exposed and Vulnerable Utilities
CC-P17	CC2	High	Small Drop Structures w/ Toe Protection	CC-B	3	Cheyenne Road Drainage Improvements	Offline Drainage Improvements
CC-P18	CC2	High	Small Drop Structures w/ Toe Protection	CC-B	3	Stratton Ave Culvert Fail - Overtops, Backwater	Crossing Analysis
CC-P19	CC2	High	Small Drop Structures w/ Toe Protection	CC-B	3	Cheyenne Blvd. Drainage Improvements	Offline Drainage Improvements
CC-P20	CC2	Moderate	Small Drop Structures w/ Toe Protection	CC-B	3	Cheyenne Blvd. Drainage Improvements Demonstration Project	Offline Drainage Improvements
CC-P21	CC3	Moderate	Small Drop Structures w/ Toe Protection	CC-B	3	Identified Utility Requires Encasement and Stabilization	Exposed and Vulnerable Utilities
CC-P22	CC2	Moderate	Small Drop Structures w/ Toe Protection	CC-B	3	Field Identified Headcut - Requires Monitoring	Field Identified Headcuts
CC-P23	CC3	High	Protect in Place	CC-C	3	Cresta Road Culvert Fail - Overtops, Does Not Meet Freeboard Criteria	Crossing Analysis
CC-P24	CC3	Low	Protect in Place	CC-C	4	Field Identified Headcut Requires Stabilization	Field Identified Headcuts
CC-P25	CC3	Moderate	Protect in Place	CC-C	4	Field Identified Headcut Requires Stabilization	Field Identified Headcuts

Cheyenne Creek Project List and Priority Ranking (Cont.)

Cheyenne Creek Project List and Priority Ranking							
Project No.	Reach	Project Rank	Reach Alternatives	Planning Area	Map Book Sheet Number	Project Description	Project Type[1]
CC-P26	CC4	Moderate	Protect in Place	CC-C	4	Identified Utility Requires Encasement and Stabilization	Exposed and Vulnerable Utilities
CC-P27	CC3	Low	Protect in Place	CC-C	4	Field Identified Exposed Utility Requires Encasement and Stabilization	Exposed and Vulnerable Utilities
CC-P28	CC3	Low	Protect in Place	CC-C	4	Field Identified 4' Cut Bank Requires Stabilization	Other Identified Projects
CC-P29	CC3	Moderate	Protect in Place	CC-C	4	Potential Offline Detention / Sediment Basin Approximately 30 Acre-Feet	Flood-Risk Reduction
CC-P30	CC3	Moderate	Protect in Place	CC-C	4	Potential Offline Detention / Sediment Basin Approximately 5 Acre-Feet	Flood-Risk Reduction
CC-P31	CC3	Moderate	Protect in Place	CC-C	4	Field Identified Headcut Requires Stabilization	Field Identified Headcuts
CC-P32	CC3	Moderate	Protect in Place	CC-C	4	Field Identified Headcut Requires Stabilization	Field Identified Headcuts
CC-P33	CC3	Low	Protect in Place	CC-C	5	Field Identified Cutbank Requires Stabilization	Other Identified Projects
CC-P34	CC3	Moderate	Protect in Place	CC-C	5	Field Identified Head Cut Requires Stabilization	Other Identified Projects
CC-P35	CC3	Low	Protect in Place	CC-C	5	Field Identified Cutbank Requires Stabilization	Other Identified Projects
CC-P36	CC3	Low	Protect in Place	CC-C	5	Field Identified Cutbank Requires Stabilization	Other Identified Projects
CC-P37	CC4	Low	Small Drop Structures w/ Toe Protection	CC-D	5	Alsace Way Culvert Fail - Overtops, Does Not Meet Freeboard Criteria	Crossing Analysis, Exposed and Vulnerable Utilities
CC-P38	CC4	Moderate	Small Drop Structures w/ Toe Protection	CC-D	5	Field Identified 3' Cutbank Requires Stabilization	Other Identified Projects
CC-P39	CC5	Low	Protect in Place	CC-D	5	Manor Lane Culvert Fail - Backwater Flooding	Crossing Analysis, Exposed and Vulnerable Utilities
CC-P40	CC5	Moderate	Protect in Place	CC-D	5	Field Identified Failing Drop Structure Requires Stabilization	Grade Control, Bank and Channel Stability
CC-P41	CC5	Low	Protect in Place	CC-D	5	Field Identified Headcut Requires Stabilization	Field Identified Headcuts
CC-P42	CC5	Moderate	Protect in Place	CC-D	5	Woodburn St Culvert Fail - Overtops, Does Not Meet Freeboard Criteria	Crossing Analysis, Exposed and Vulnerable Utilities
CC-P43	CC5	Low	Protect in Place	CC-D	5	Field Identified Exposed Utility Requires Encasement and Stabilization	Exposed and Vulnerable Utilities
CC-P44	CC5	Moderate	Protect in Place	CC-D	5	Field Identified Failing Existing Rock Drop Structure Requires Stabilization	Grade Control, Bank and Channel Stability
CC-P45	CC6	High	Small Drop Structures w/ Toe Protection	CC-E	6	Cheyenne Road Culvert Fail - Overtops, Does Not Meet Freeboard Criteria	Crossing Analysis, Exposed and Vulnerable Utilities
CC-P46	CC7	Moderate	Small Drop Structures w/ Toe Protection	CC-E	6	Identified Utility Requires Encasement and Stabilization	Exposed and Vulnerable Utilities
CC-P47	CC8	Moderate	Small Drop Structures w/ Toe Protection	CC-E	6	Identified Utility Requires Encasement and Stabilization	Exposed and Vulnerable Utilities
CC-P48	CC6	Low	Small Drop Structures w/ Toe Protection	CC-E	6	Field Identified 7' Cutbank Requires Stabilization	Other Identified Projects
CC-P49	CC6	Low	Small Drop Structures w/ Toe Protection	CC-E	6	Field Identified Headcut Requires Stabilization	Field Identified Headcuts
CC-P50	CC7	Immediate	Protect in Place	CC-E	6	Trash and Debris Along South Side of Bank	Other Identified Projects
CC-P51	CC7	High	Protect in Place	CC-E	6	Brookside St. Fail - Backwater Flooding	Crossing Analysis
CC-P52	CC6	Moderate	Protect in Place	CC-E	6	Arvada St. Fails in 50 Year, Large Backwater	Crossing Analysis
CC-P53	CC8	Low	Small Drop Structures w/ Toe Protection	CC-E	6	Field Identified Existing Rock Drop Structure Requires Monitoring	Grade Control, Bank and Channel Stability
CC-P54	CC8	Low	Small Drop Structures w/ Toe Protection	CC-E	6	Field Identified 6' Cutbank Requires Stabilization	Other Identified Projects
CC-P55	CC8	Moderate	Small Drop Structures w/ Toe Protection	CC-E	6	I-25 South Ramp Backwater Flooding	Crossing Analysis
CC-P56	CC8	Moderate	Small Drop Structures w/ Toe Protection	CC-E	6	Field Identified Existing Parking Lot Runoff Detention Basins Require Rehabilitation	Flood-Risk Reduction
CC-P57	CC8	Low	Small Drop Structures w/ Toe Protection	CC-E	6	Field Identified Eroding Bank Requires Stabilization	Grade Control, Bank and Channel Stability
CC-P58	CC8	Low	Small Drop Structures w/ Toe Protection	CC-E	6	Field Identified Eroding Bank Requires Stabilization	Grade Control, Bank and Channel Stability
CC-P59	CC8	Low	Small Drop Structures w/ Toe Protection	CC-E	6	Field Identified Existing Rock Drop Structure Requires Monitoring	Grade Control, Bank and Channel Stability

Table 3-3. Upper Fountain Creek Project Decision Matrix Results

Fair | Better | Best

ID	Criteria	UFCP-A1: Total Bank Erosion	UFCP-A2: Total Bank Erosion	UFCP-04, 05, 06, 07, 08: Crystola	UFCP-12: Unit Bank 63 Erosion (Large Slope Above Pinecliff Stables)	UFCP-16: Unit Bank 10 Erosion (Below Pinecliff Stables)	UFCP-23: Hotel Street (El Paso Ave.), Green Mountain Falls	UFCP-27, 28, 29, 30, 31: Sand Gulch Tributary Improvements	UFCP-41: Spring Street
	Evaluation Criteria								
1	Reduces flood risk to the public and residents by providing long term solutions that increase resiliency?	Fair - no significant flood reduction	Fair - no significant flood reduction	Better - some possible flood reduction	Fair - no significant flood reduction	Fair - no significant flood reduction	Best - elimination of backwater flooding neighborhood	Better - some possible flood reduction	Better - some possible flood reduction due to elimination of back water
2	Transfers risks or creates impacts downstream to infrastructure, channel, and storm water system?	Better - little transfer of risk	Better - little transfer of risk	Best - no transfer of risk downstream	Better - little transfer of risk	Better - little transfer of risk	Fair - may affect downstream properties by increasing flows downstream	Best - no transfer of risk downstream	Fair - may affect downstream properties by increasing flows downstream
3	Physical area of watershed mitigated?	Fair - high in watershed, low flood mitigation value	Fair - high in watershed, low flood mitigation value	Better - high in watershed	Fair - low flood mitigation value	Fair - low flood mitigation value	Better - bridge backwater mitigation	Best - large area of watershed mitigation, fire affected area mitigated	Fair - bridge backwater mitigation
4	Creates infrastructure investments that are reasonable to construct and provides the best value for their lifecycle, function and purpose?	Better - large bang for the buck, return on investment	Better - large bang for the buck, return on investment	Better - good return on investment	Best - large return on investment	Best - large return on investment	Fair - very costly, low return on investment	Better - good return on investment	Fair - very costly, low return on investment
5	Meets industry and local design standards?	Better - meets industry standards	Better - meets industry standards	Better - meets industry standards	Better - meets industry standards	Better - meets industry standards	Fair - unlikely to meet 100yr flood standards	Better - meets industry standards	Fair - unlikely to meet 100yr flood standards
6	Minimizes the effort required to maintain and repair the options?	Fair -long term maintenance will be required	Fair -long term maintenance will be required	Better - some long term maintenance will be required	Fair -long term maintenance will be required	Fair -long term maintenance will be required	Best - little to no long term maintenance will be required	Better - some long term maintenance will be required	Best - little to no long term maintenance will be required
7	Compatible with forest fire mitigation?	N/A	N/A	N/A	N/A	N/A	Fair	Better - sediment and run-off issues from fire	Fair
8	Provides access and protects opportunities for enhancements to tourist destinations, community facilities and neighborhoods?	Fair - no real benefit	Fair - no real benefit	Best - protects access to Crystola Canyon	Fair - no real bennifit	Fair - no real benefit	Best - protects access to tourist destinations and neighborhoods	Fair - no real benefit	Better - protects access to neighborhood
9	Provides funding, partnering and collaboration opportunities by meeting multiple objectives?	Fair - on private property, funding difficulties	Fair - on private property, funding difficulties	Best - likely funding opportunities in the future	Fair - on private property, funding difficulties	Fair - on private property, funding difficulties	Better	Best - likely funding opportunities in the future	Better
10	Can be supported by current land use regulations or revised land use regulations?	Best - current land use supported	Best - current land use supported	Fair - possible land purchase required, possible entitlement use issues	Best - current land use supported	Best - current land use supported	Better possible ROW widening required	Fair - possible land purchase required, possible entitlement use issues	Better possible ROW widening required
11	Impacts to water rights?	Best - no water rights impacts foreseen	Best - no water rights impacts foreseen	Fair - possible water rights issues do to proposed sediment basins	Best - no water rights impacts foreseen	Best - no water rights impacts foreseen	Best - no water rights impacts foreseen	Fair - possible water rights issues do to proposed sediment basins	Best - no water rights impacts foreseen
12	Protects the habitat, water quality and geomorphology of Fountain and Cheyenne Creeks?	Better - reduces sediment, improves WQ, improves geomorphology of creek	Better - reduces sediment, improves WQ, improves geomorphology of creek	Best - major benefit to habitat, WQ, and geomorphology of creek	Better - reduces sediment, improves WQ, improves geomorphology of creek	Better - reduces sediment, improves WQ, improves geomorphology of creek	Fair - bridge project, little benefit to habitat or WQ	Best - major benefit to habitat, WQ, and geomorphology of creek	Fair - bridge project, little benefit to habitat or WQ
13	Incorporates locally available materials and environmentally friendly processes?	Best - improvements likely to be locally available and environmentally friendly	Best - improvements likely to be locally available and environmentally friendly	Better - some aspects include concrete, pipe, blocks, etc.	Best - improvements likely to be locally available and environmentally friendly	Best - improvements likely to be locally available and environmentally friendly	Fair - mainly bridge materials	Better - some aspects include concrete, pipe, blocks, etc.	Fair - mainly bridge materials

Table 3-4. Cheyenne Creek Project Decision Matrix Results

Fair | Better | Best

ID	Criteria	CC-P1 - Failing Grade Control Structure Below Evans Bridge	CC-P17 - Cheyenne Rd. Drainage Improvements	CC-P20 - Cheyenne Blvd. Drainage Improvements	CC-P18 - Stratton Ave Culvert Failed Capacity	CC-P23 - Cresta Road Culvert Failed Capacity	CC-P45 - Cheyenne Road Culvert Failed Capacity	CC-P450- Trash and Debris Along South Bank	CC-P51 - Brookside St. Culvert Failed Capacity
	Evaluation Criteria								
1	Reduces flood risk to the public and residents by providing long term solutions that increase resiliency?	Fair - no flood risk reduction	Better - some flood risk benefit	Better - some flood risk benefit	Better - results in reduced back water	Better - results in reduced back water	Best - results in reduced back water, lower in the basin	Better - reduces risk of debris causing backups on downstream bridges	Best - results in reduced back water, lower in the basin
2	Transfers risks or creates impacts downstream to infrastructure, channel, and storm water system?	Better - little to no downstream impacts	Best - lower risks of downstream flooding	Best - lower risks of downstream flooding	Fair - opens up flow down stream, may have negative downstream impacts	Fair - opens up flow down stream, may have negative downstream impacts	Fair - opens up flow down stream, may have negative downstream impacts	Best - lower risks of downstream flooding	Best - bottom of the watershed, nothing downstream to be impacted
3	Physical area of watershed mitigated?	Fair - does not apply	Best - mitigates large area	Best - mitigates large area	Fair - smaller area	Fair - smaller area	Better - lower in the basin, large area	Fair - does not apply	Better - lower in the basin, large area
4	Creates infrastructure investments that are reasonable to construct and provides the best value for their lifecycle, function and purpose?	Best - easy to construct, big bang for the buck	Better - easy to construct, large for the buck, long term maintenance required	Better - easy to construct, large for the buck, long term maintenance required	Fair - very expensive, large investment for returns	Fair - very expensive, large investment for returns	Fair - very expensive, large investment for returns	Best - easy to address, big bang for the buck, large reduction in flood risk down stream	Fair - very expensive, large investment for returns
5	Meets industry and local design standards?	Best - likely to meet all standards	Best - likely to meet all standards	Best - likely to meet all standards	Fair - very unlikely to meet 100yr flood criteria	Better - unlikely to meet 100yr flood critera	Better - unlikely to meet 100yr flood criteria	Fair - very unlikely to meet 100yr flood criteria	Fair - very unlikely to meet 100yr flood criteria
6	Minimizes the effort required to maintain and repair the options?	Better - requires some ongoing maintenances	Fair - requires ongoing maintenance	Fair - requires ongoing maintenance	Best - requires little to no maintenance	Best - requires little to no maintenance	Best - requires little to no maintenance	Best - requires little to no maintenance	Best - requires little to no maintenance
7	Compatible with forest fire mitigation?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	Provides access and protects opportunities for enhancements to tourist destinations, community facilities and neighborhoods?	Best - protects access to several tourist destinations, community facilities	Best - protects access to several tourist destinations, community facilities	Best - protects access to several tourist destinations, community facilities	Better - protects access to neighborhoods	Better - protects access to neighborhoods	Better - protects access to neighborhoods	Fair - no significant tourist destinations, neighborhood mainly commercial	Fair - no significant tourist destinations, neighborhood mainly commercial
9	Provides funding, partnering and collaboration opportunities by meeting multiple objectives?	Better - likely to be funded, involves private property owner and City collaborations	Best - definite funding opportunities, opportunity to meet multiple objectives, flood reduction, water quality improvements, etc.	Best - definite funding opportunities, opportunity to meet multiple objectives, flood reduction, water quality improvements, etc.	Better - likely to be funded, involves private property owner and City collaborations	Better - likely to be funded, involves private property owner and City collaborations	Best - grant opportunities will be likely be available, savaral funding partners	Fair - unlikely to have funding opportunities, on private property	Better - likely to be funded, involves private property owner and City collaborations
10	Can be supported by current land use regulations or revised land use regulations?	Fair - limits of work may fall on private property	Better - work most likely within current right-of-way	Better - work most likely within current right-of-way	Fair - limits of work may fall on private property	Fair - limits of work may fall on private property	Fair - limits of work may fall on private property	Fair - limits of work may fall on private property	Fair - limits of work may fall on private property
11	Impacts to water rights?	Best - no impacts on water rights foreseen	Fair - possible water rights issue	Fair - possible water rights issue	Best - no impacts on water rights foreseen	Best - no impacts on water rights foreseen	Best - no impacts on water rights foreseen	Best - no impacts on water rights foreseen	Best - no impacts on water rights foreseen
12	Protects the habitat, water quality and geomorphology of Fountain and Cheyenne Creeks?	Best - preventing headcut will protect geomorphology and habitat	Better - will increase water quality of main stem	Better - will increase water quality of main stem	Fair - no water quality and little geomorphological benefit	Fair - no water quality and little geomorphological benefit	Fair - no water quality and little geomorphological benefit	Best - major improvement to water quality and habitat	Fair - no water quality and little geomorphological benefit
13	Incorporates locally available materials and environmentally friendly processes?	Fair - materials not local	Better - provides water quality treatment options local plantings, soils	Better - provides water quality treatment options local plantings, soils	Fair - materials not local	Fair - materials not local	Fair - materials not local	Best - major improvement to water quality	Fair - materials not local

3.1 Project Prioritization

Projects were identified throughout Upper Fountain Creek and Cheyenne Creek through field investigation, technical analysis, and input from the community and stakeholders, as described in Section 5.7. After an initial project list was created, identified projects were considered amongst the project team and Coalition engineers, planners, stakeholders, and local citizens for their importance and potential risks to infrastructure, development, and impact downstream and upstream of the project location. After the projects were identified and illustrated in the mapbooks, as discussed in Section 3.1, the projects were presented to the community in public forums and to the stakeholders in several meetings for input, planning, and impact. Depending on the nature of the project, severity, and potential of other problems occurring if not addressed, a prioritization list was ultimately established, and the highest priority projects were deliberated on amid the stakeholders and project team. This process was used to select specific projects of high priority on which to focus attention.

3.1.1 Stakeholder Input

After the initial projects for both watersheds were identified, the project lists were presented to the stakeholders for input regarding the importance of each potential project and its impact on the surrounding area. Considered were other issues that may be resolved when addressing the project: potential flood reduction, impact to surrounding development, potential of additional damages if not addressed, and other factors that would allow for input regarding the projects priority.

3.1.2 Community Input

Public meetings were held throughout the process of identifying projects and while determining each projects importance. During this time, citizens were able to voice their concerns and point out additional issues and projects that were considered to be important to the public. Additional flooding occurred during the FRMP's development, creating additional projects that were brought to the attention of the project team and stakeholders through public involvement. This also gave the project team and stakeholders the opportunity to discuss potential projects with the public, and give an explanation as to why various projects were identified and their importance to the overall creek study. Public comments are presented in Appendix A.

3.1.3 Technical Ranking

A project prioritization list was created for both Upper Fountain Creek and Cheyenne Creek to rank each project based on several technical factors. This process served as a method for determining each project's importance as compared to the other projects in the creek, while also highlighting projects requiring immediate attention and ultimately illustrating a plan to address each project in order of importance. The technical ranking for all projects in both Cheyenne Creek and Upper Fountain Creek is detailed in the summary project tables above.

<u>Low Priority</u>

Projects were ranked as Low Priority if they were identified as a project with little potential of developing into a bigger issue. These projects pose minimal threat to life, safety, and infrastructure, but should be addressed at some point to ensure that large flood events do not cause the problem to increase in magnitude. The color ranking for these projects is shown as white.

<u>Moderate Priority</u>

Projects were ranked as Moderate Priority if they were identified as projects that could potentially result in damages to infrastructure if not addressed in the near term. These potential projects should be monitored regularly to ensure that the problem does not develop into a larger and potentially more hazardous issue. Projects in this category pose long-term threat to infrastructure if not addressed or stabilized in the near future; however, these projects may take several years to manifest into larger issues. The color ranking for these projects is shown as yellow.

<u>High Priority</u>

Projects were ranked as High Priority if they were identified as a project with high potential of damaging infrastructure if not addressed in the near future. These projects are due to unstable conditions that could result in significant bank damage, creek migration, roadway or urban flooding, roadway collapse, or damage to utilities. These projects should be addressed soon to ensure that they do not develop into much larger problems. The color ranking for these projects is shown as orange.

<u>Immediate Priority</u>

Projects were ranked as Immediate Priority if they pose imminent potential for public safety or significant loss or damage of infrastructure. These projects show characteristics of very unstable conditions which threaten areas of dense urbanization, utility crossings such as gas lines, vital infrastructure, critical access roadways, bridges and culvert crossings, and heavily populated areas. These projects should be addressed immediately to ensure safety in the surrounding areas, and to reduce the risk of creating additional critical problems. The color ranking for these projects is shown as red.

3.1.4 High and Immediate Action Projects

For the purposes of this study, high and immediate action projects were limited to 10% of the overall project list. While this serves the purpose of not overwhelming the stakeholders with projects that are of high and immediate priority, it also allows for the stakeholders to focus attention on the highest priority projects in the project team's opinion. However, several moderate projects are on the borderline of the high ranking, and it is suggested by the project team that all of these projects be addressed in the near future to ensure that the stability and function of both watersheds is protected.

3.1.5 Decision Making Matrix

A decision making matrix was created by the stakeholders and project team to further evaluate the immediate and high priority projects beyond technical merit alone. This process served the purpose of determining which of the high and immediate projects are most important to stakeholders and community interests, and thus should be the first in the strategy of addressing each creek. The matrix allowed the project team to rank the projects with the stakeholders input, allowing for prioritization of the highest ranked projects identified through the technical screening rubric. The decision matrices for both Cheyenne Creek and Upper Fountain Creek can be seen in Appendix B.

3.2 Immediate and High Priority Project Descriptions

Utilizing several methods and procedures to identify recommended projects, our team ranked each project according to the methodology described in the prioritization section of this report. Below are descriptions of all the projects that were ranked as immediate or high priority for both Upper Fountain Creek and Cheyenne Creek. Detailed cost estimates have been prepared for each of the listed immediate or high priority projects and can be found in the Project Cost Estimates section of this report.

3.2.1 Upper Fountain Creek Immediate and High Priority Projects

UFCP-01: Sediment Supply Bank 101

This project is a sediment supply bank contributing a total of 490 tons/year of sediment to Upper Fountain Creek. Stabilization requires using bank stabilization and natural channel design methods.

Figure 3-1. Bank 101 Erosion Example

UFCP-02: Sediment Supply Bank 102

This project is a sediment supply bank contributing a total of 2600 tons/year of sediment to Upper Fountain Creek. Stabilization requires using bank stabilization and natural channel design methods.

Figure 3-2. Bank 102 Erosion Example

UFCP-07, 08, 09, 10, 11: Crystola Canyon Road Improvements

This group of projects consists of replacing the downstream culvert (FC 04 – Creek Side Dr.), adding an offline sediment basin (approx. 6 ac-ft), performing a backwater analysis on Culvert FC 03 – Crystola Canyon Road and stabilizing bank 02 which generates 145 tons/year of sediment to Upper Fountain Creek. A flood levee wall is also proposed to be considered for flood risk reduction.

Figure 3-3. Culvert FC 03, Sediment, and Channel Degradation

UFCP-14: Sediment Supply Bank 63

This project is a sediment supply bank contributing a total of 330 tons/year of sediment to Upper Fountain Creek. Stabilization requires using bank stabilization and natural channel design methods.

Figure 3-4. Bank 62 Erosion Example

UFCP-19: Sediment Supply Bank 10

This project is a sediment supply bank contributing a total of 240 tons/year of sediment to Upper Fountain Creek. Stabilization requires using bank stabilization and natural channel design methods.

Figure 3-5. Bank 10 Erosion Example

UFCP-26 Culvert FC 09 – El Paso Ave

A backwater analysis is recommended to be performed as part of flood risk reduction. The project will alleviate flooding issues on upstream property and prevent further degradation of the creek.

Figure 3-6. Bridge at Hotel St. and El Paso Ave

UFCP-31, 32, 33, 34: Sand Gulch Tributary Confluence Improvements

This grouping includes improvements to the confluence of the Sand Gulch Tributary and Upper Fountain Creek. Sub-projects include bank and channel stability control, major erosion reduction, the addition of a sediment basin with a volume of approximately 6 ac-ft and the stabilizing of bank 35 (175 tons/year of sediment) and bank 65 (227 tons/year).

Figure 3-7. Sand Gulch Erosion and Culvert

UFCP-44: Culvert FC-13 Spring Street

Replace culvert FC-13 – Spring Street to aid in flood risk reduction.

3.2.2 Cheyenne Creek Immediate and High Priority Projects

CC-P1: Grade Control Structure below Evans Bridge

This project consists of replacement of the grade control structure below Evans Bridge, protecting the bridge and protecting the channel from further stream degradation. This project will also prevent the existing head cut from propagating further upstream. Evans Bridge is a current City of Colorado Springs project requiring coordination with the on-going project planning effort.

CC-P17: Cheyenne Road Drainage Improvements

This project consists of improving roadway drainage conveyance along Cheyenne Road between Mayhurst Ave. and Stratton Ave.

Figure 3-8. Evans Bridge Failed Grade Control

CC-P18: Stratton Ave Bridge

This project consists of replacing the bridge on Stratton Ave spanning Cheyenne Creek. The crossing does not pass the 100-yr flow and the project will aid with flood risk reduction.

Figure 3-9. Stratton Ave Bridge

CC-P20: Cheyenne Boulevard Drainage Improvements

This project consists of improving roadway drainage conveyance along Cheyenne Boulevard.

CC-P23: Cresta Road Bridge

This project consists of replacing the bridge on Cresta Road spanning Cheyenne Creek. The crossing does not pass the 100-yr flow, and the project will aid with flood risk reduction.

Figure 3-10. Cresta Road Bridge

CC-P45: Cheyenne Road Bridge

This project consists of replacing the bridge on Cheyenne Road spanning Cheyenne Creek. The crossing does not pass the 100-yr flow and creates a large backwater negatively affecting the upstream neighborhood. Project will aid with flood risk reduction.

Figure 3-11. Cheyenne Road Bridge

CC-P50: Trash and Debris Removal

This project consists of removing trash and debris from a specific property on the creek. A flood event may cause piles to break apart and obstruct crossings or damage property downstream. Trash and debris also threatens safety and habitat along the creek. This is an immediate risk.

Figure 3-12. Trash and Debris along Bank

CC-P51: Brookside Street Bridge

This project consists of replacing the bridge on Brookside Street spanning Cheyenne Creek. The crossing does not pass the 100-yr flow and creates a large backwater negatively affecting the upstream neighborhood. Project will aid with flood risk reduction.

Figure 3-13. Brookside St. Bridge

3.3 Project Cost Estimates

Cost estimates have been provided for the above identified projects. There are two types of estimates used in this project: individual project cost estimates and high and immediate project cost estimates. The individual cost estimates include projects ranked with a moderate or low ranking. The high and immediate estimates include the projects with high and immediate rankings and are more detailed than the individual project costs. For a more detailed explanation of the cost estimates refer to the cost estimates section of this report. Summary tables for the individual project costs, as well as detailed tables for the high and immediate priority projects can be found below.

Table 3-5. Individual Project Cost Estimates for Moderate and Low Projects – Upper Fountain Creek

Project Number	Project Type	Total
UFCP-01	BANCS Restoration Priority	See High Priority Cost Tables
UFCP-02	BANCS Restoration Priority	See High Priority Cost Tables
UFCP-03	BANCS Restoration Priority	$ 488,664.87
UFCP-04	Flood-risk Reduction	$ 850,000.00
UFCP-05	BANCS Restoration Priority	$ 682,000.00
UFCP-06	Flood-risk Reduction	$ 6,500.00
UFCP-07	Flood-risk Reduction	See High Priority Cost Tables
UFCP-08	Flood-risk Reduction	
UFCP-09	Crossing Analysis	
UFCP-10	Crossing Analysis	
UFCP-11	BANCS Restoration Priority	
UFCP-12	BANCS Restoration Priority	$ 252,358.80
UFCP-13	Utilities Locations and Coordination	TBD by Utility
UFCP-14	BANCS Restoration Priority	See High Priority Cost Tables
UFCP-15	BANCS Restoration Priority	$ 66,442.94
UFCP-16	BANCS Restoration Priority	$ 100,549.59
UFCP-17	BANCS Restoration Priority	$ 179,651.69
UFCP-18	Grade Control, Bank and Channel Stability	$ 350,000.00
UFCP-19	BANCS Restoration Priority	See High Priority Cost Tables
UFCP-20	BANCS Restoration Priority	$ 157,447.74
UFCP-21	BANCS Restoration Priority	$ 47,982.03
UFCP-22	BANCS Restoration Priority	$ 190,807.08
UFCP-23	Grade Control, Bank and Channel Stability	$ 100,000.00
UFCP-24	BANCS Restoration Priority	$ 452,229.26
UFCP-25	Flood-risk Reduction	$ 350,000.00
UFCP-26	Crossing Analysis	See High Priority Cost Tables
UFCP-27	Grade Control, Bank and Channel Stability	$ 100,000.00
UFCP-28	BANCS Restoration Priority	$ 216,138.74
UFCP-29	Flood-risk Reduction	$ 650,000.00
UFCP-30	BANCS Restoration Priority	See High Priority Cost Tables
UFCP-31	Grade Control, Bank and Channel Stability	
UFCP-32	Grade Control, Bank and Channel Stability	
UFCP-33	Flood-risk Reduction	
UFCP-34	BANCS Restoration Priority	
UFCP-35	Crossing Analysis	$ 373,000.00
UFCP-36	BANCS Restoration Priority	$ 123,099.31
UFCP-37	BANCS Restoration Priority	$ 209,326.24
UFCP-38	BANCS Restoration Priority	$ 88,784.28

UFCP-39	BANCS Restoration Priority	$ 25,364.80
UFCP-40	BANCS Restoration Priority	$ 285,465.10
UFCP-41	BANCS Restoration Priority	$ 173,605.06
UFCP-42	BANCS Restoration Priority	$ 105,497.12
UFCP-43	Flood-risk Reduction	$ 165,000.00
UFCP-44	Crossing Analysis	See High Priority Cost Tables
UFCP-45	BANCS Restoration Priority	$ 121,657.17
UFCP-46	Crossing Analysis	$ 365,000.00
UFCP-47	Grade Control, Bank and Channel Stability	General Maintenance
UFCP-48	Flood-risk Reduction	$ 150,000.00
UFCP-49	Crossing Analysis	$ 340,000.00
UFCP-50	Flood-risk Reduction	$ 150,000.00
UFCP-51	Flood-risk Reduction	$ 650,000.00
UFCP-52	Crossing Analysis	Backwater Analysis
UFCP-53	Offline Drainage Improvements	$ 35,000.00
UFCP-54	Offline Drainage Improvements	$ 1,000,000.00
UFCP-55	Flood-risk Reduction	$ 300,000.00
UFCP-56	Crossing Analysis	$ -
UFCP-57	Crossing Analysis	$ -
UFCP-58	Other Identified Projects	$ 250,000.00
UFCP-59	Crossing Analysis	$ -
UFCP-60	Flood-risk Reduction	$ 750,000.00
UFCP-61	Crossing Analysis	$ -
UFCP-62	Offline Drainage Improvements	$ 200,000.00
UFCP-63	Flood-risk Reduction	$ 5,000,000.00
UFCP-64	Crossing Analysis	$ -
UFCP-65	Flood-risk Reduction	$ 260,000.00
UFCP-66	Crossing Analysis	$ -
UFCP-67	Crossing Analysis	Backwater Analysis
UFCP-68	Crossing Analysis	Backwater Analysis
UFCP-69	Crossing Analysis	$ 949,000.00
UFCP-70	Other Identified Projects	$ 100,000.00
UFCP-71	Other Identified Projects	$ 100,000.00
UFCP-72	Other Identified Projects	$ 50,000.00
UFCP-73	Crossing Analysis	$ 1,222,000.00
UFCP-74	Other Identified Projects	$ 60,000.00
UFCP-75	Grade Control, Bank and Channel Stability	$ 150,000.00
UFCP-76	Other Identified Projects	$ 50,000.00
UFCP-77	Grade Control, Bank and Channel Stability	$ 65,000.00
UFCP-78	Other Identified Projects	$ 400,000.00
UFCP-79	Other Identified Projects	$ 400,000.00
UFCP-80	Other Identified Projects	$ 600,000.00
UFCP-81	Other Identified Projects	$ 100,000.00
UFCP-82	Crossing Analysis	$ 1,572,000.00
UFCP-83	Other Identified Projects	$ 150,000.00
UFCP-84	Grade Control, Bank and Channel Stability	$ 100,000.00
UFCP-85	Grade Control, Bank and Channel Stability	Maintenance
UFCP-86	Field Identified Head Cuts	$ 600,000.00
UFCP-87	Crossing Analysis	Backwater Analysis

Table 3-6. Individual Project Cost Estimates for Moderate and Low Projects – Cheyenne Creek

Project Number	Project Type	Total
NC-P1	Other Identified Projects	See CSU Capital Improvement Budget
NC-P2	Grade Control, Bank and Channel Stability	$ 50,000.00
NC-P3	Grade Control, Bank and Channel Stability	$ 20,000.00
NC-P4	Crossing Analysis	$ 340,000.00
NC-P5	Other Identified Projects	$ 15,000.00
NC-P6	Other Identified Projects	$ 15,000.00
NC-P7	Crossing Analysis	$ 193,000.00
NC-P8	Grade Control, Bank and Channel Stability	$ 12,000.00
NC-P9	Grade Control, Bank and Channel Stability	$ 12,000.00
NC-P10	Other Identified Projects	$ 12,000.00
NC-P11	Grade Control, Bank and Channel Stability	$ 12,000.00
NC-P12	Other Identified Projects	$ 45,000.00
NC-P13	Grade Control, Bank and Channel Stability	$ 100,000.00
NC-P14	Other Identified Projects	$ 10,000.00
NC-P15	Grade Control, Bank and Channel Stability	$ 45,000.00
NC-P16	Other Identified Projects	$ 7,500.00
SC-P1	Other Identified Projects	See CSU Capital Improvement Budget
SC-P2	Grade Control, Bank and Channel Stability	$ 10,000.00
SC-P3	Grade Control, Bank and Channel Stability	$ 45,000.00
SC-P4	Grade Control, Bank and Channel Stability	$ 10,000.00
SC-P5	Grade Control, Bank and Channel Stability	$ 10,000.00
SC-P6	Exposed and Vulnerable Utilities	$ 25,000.00
SC-P7	Other Identified Projects	$ 10,000.00
CC-P1	Grade Control, Bank and Channel Stability	See High Priority Cost Tables
CC-P2	Field Identified Headcuts	$ 50,000.00
CC-P3	Other Identified Projects	$ 60,000.00
CC-P4	Exposed and Vulnerable Utilities	$ 20,000.00
CC-P5	Other Identified Projects	$ 20,000.00
CC-P6	Other Identified Projects	$ 25,000.00

CC-P7	Exposed and Vulnerable Utilities	$ 20,000.00
CC-P8	Flood-Risk Reduction	$ 45,000.00
CC-P9	Other Identified Projects	$ 10,000.00
CC-P10	Offline Drainage Improvements	$ 1,200,000.00
CC-P11	Flood-Risk Reduction	$ 350,000.00
CC-P12	Field Identified Headcuts	$ 50,000.00
CC-P13	Field Identified Headcuts	$ 50,000.00
CC-P14	Crossing Analysis	$ 589,000.00
CC-P15	Other Identified Projects	$ 150,000.00
CC-P16	Exposed and Vulnerable Utilities	$ 20,000.00
CC-P17	Offline Drainage Improvements	See High Priority Cost Tables
CC-P18	Crossing Analysis	See High Priority Cost Tables
CC-P19	Offline Drainage Improvements	See High Priority Cost Tables
CC-P20	Offline Drainage Improvements	$ 325,000.00
CC-P21	Exposed and Vulnerable Utilities	
CC-P22	Field Identified Headcuts	$ 50,000.00
CC-P23	Crossing Analysis	See High Priority Cost Tables
CC-P24	Field Identified Headcuts	$ 50,000.00
CC-P25	Field Identified Headcuts	$ 50,000.00
CC-P26	Exposed and Vulnerable Utilities	$ 10,000.00
CC-P27	Exposed and Vulnerable Utilities	
CC-P28	Other Identified Projects	$ 10,000.00
CC-P29	Flood-Risk Reduction	$ 1,000,000.00
CC-P30	Flood-Risk Reduction	$ 175,000.00
CC-P31	Field Identified Headcuts	$ 50,000.00
CC-P32	Field Identified Headcuts	$ 50,000.00
CC-P33	Other Identified Projects	$ 10,000.00
CC-P34	Other Identified Projects	$ 10,000.00
CC-P35	Other Identified Projects	$ 50,000.00
CC-P36	Other Identified Projects	$ 10,000.00
CC-P37	Crossing Analysis, Exposed and Vulnerable Utilities	$ 380,000.00
CC-P38	Other Identified Projects	$ 15,000.00
CC-P39	Crossing Analysis, Exposed and Vulnerable Utilities	$ 46,000.00
CC-P40	Grade Control, Bank and Channel Stability	$ 50,000.00
CC-P41	Field Identified Headcuts	$ 50,000.00
CC-P42	Crossing Analysis, Exposed and Vulnerable Utilities	Backwater Analysis
CC-P43	Exposed and Vulnerable Utilities	$ 10,000.00
CC-P44	Grade Control, Bank and Channel Stability	$ 15,000.00
CC-P45	Crossing Analysis, Exposed and Vulnerable Utilities	See High Priority Cost Tables
CC-P46	Exposed and Vulnerable Utilities	
CC-P47	Exposed and Vulnerable Utilities	
CC-P48	Other Identified Projects	$ 20,000.00
CC-P49	Field Identified Headcuts	$ 35,000.00
CC-P50	Other Identified Projects	See High Priority Cost Tables
CC-P51	Crossing Analysis	$ 284,000.00
CC-P52	Crossing Analysis	Backwater Analysis
CC-P53	Grade Control, Bank and Channel Stability	Monitoring
CC-P54	Other Identified Projects	$ 10,000.00
CC-P55	Crossing Analysis	Backwater Analysis
CC-P56	Flood-Risk Reduction	$ 40,000.00
CC-P57	Grade Control, Bank and Channel Stability	$ 10,000.00
CC-P58	Grade Control, Bank and Channel Stability	$ 10,000.00
CC-P59	Grade Control, Bank and Channel Stability	Monitoring

3.3.1 High and Immediate Project Cost Tables

Table 3-7. UFCP-01: Sediment Supply Bank 101

Item	QTY	Unit Cost	Unit	Total
Mobilization	1	$10,000.00	LS	$ 10,000.00
Dewatering	1	$10,000.00	LS	$ 10,000.00
Sediment Removal	6600	$ 25.00	CY	$ 165,000.00
Erosion Control	1180	$ 5.00	LF	$ 5,900.00
General Earthwork	300	$ 30.00	CY	$ 9,000.00
Riprap Mat	600	$ 100.00	CY	$ 60,000.00
Natural Channel Design Reach	1180	$ 300.00	LF	$ 354,000.00
Subtotal				$ 613,900.00
Engineering and Construction Mgmt	15%			$ 92,085.00
Contingency	20%			$ 122,780.00
Total				$ 829,000.00

Table 3-8. UFCP-02: Sediment Supply Bank 102

Item	QTY	Unit Cost	Unit	Total
Mobilization	1	$10,000.00	LS	$ 10,000.00
Dewatering	1	$10,000.00	LS	$ 10,000.00
Sediment Removal	28000	$ 25.00	CY	$ 700,000.00
Erosion Control	4195	$ 5.00	LF	$ 20,975.00
General Earthwork	2800	$ 30.00	CY	$ 84,000.00
Riprap Mat	3100	$ 100.00	CY	$ 310,000.00
Natural Channel Design Reach	4195	$ 300.00	LF	$ 1,258,500.00
Subtotal				$ 2,393,475.00
Engineering	15%			$ 359,021.25
Contingency	20%			$ 478,695.00
Total				$ 3,231,000.00

Table 3-9. UFCP-07, 08, 09, 10, 11: Crystola Canyon Road Improvements

Item	QTY	Unit Cost	Unit	Total
Bridge Mobilization	1	$75,000.00	LS	$ 75,000.00
Bridge Dewatering	1	$50,000.00	LS	$ 50,000.00
Demolition	1	$10,000.00	LS	$ 10,000.00
Bridge Demolition	1520	$ 10.00	SF	$ 15,200.00
Sediment Removal	6700	$ 25.00	CY	$ 167,500.00
Erosion Control	1500	$ 5.00	LF	$ 7,500.00
General Earthwork	15080	$ 30.00	CY	$ 452,400.00
Levee Wall	200	$ 100.00	LF	$ 20,000.00
Riprap Mat	1400	$ 100.00	CY	$ 140,000.00
Boulder Structure	150	$ 800.00	LF	$ 120,000.00
Culvert Pipe	90	$ 125.00	LF	$ 11,250.00
Bridge Replacement	1520	$ 270.00	SF	$ 410,400.00
Natural Channel Design Reach	1500	$ 300.00	LF	$ 450,000.00
Subtotal				$ 1,068,850.00
Engineering and Construction Mgmt	15%			$ 160,327.50
Contingency	20%			$ 213,770.00
Total				$ 1,443,000.00

Table 3-10. UFCP-14: Sediment Supply Bank 63

Item	QTY	Unit Cost	Unit	Total
Mobilization	1	$10,000.00	LS	$ 10,000.00
Dewatering	1	$10,000.00	LS	$ 10,000.00
Sediment Removal	300	$ 25.00	CY	$ 7,500.00
Erosion Control	60	$ 5.00	LF	$ 300.00
General Earthwork	100	$ 30.00	CY	$ 3,000.00
Riprap Mat	100	$ 100.00	CY	$ 10,000.00
Natural Channel Design Reach	60	$ 300.00	LF	$ 18,000.00
Subtotal				$ 58,800.00
Engineering and Construction Mgmt	15%			$ 8,820.00
Contingency	20%			$ 11,760.00
Total				$ 79,000.00

Table 3.11. UFCP-19: Sediment Supply Bank 10

Item	QTY	Unit Cost	Unit	Total
Mobilization	1	$10,000.00	LS	$ 10,000.00
Dewatering	1	$10,000.00	LS	$ 10,000.00
Sediment Removal	800	$ 25.00	CY	$ 20,000.00
Erosion Control	150	$ 5.00	LF	$ 750.00
General Earthwork	900	$ 30.00	CY	$ 27,000.00
Riprap Mat	200	$ 100.00	CY	$ 20,000.00
Natural Channel Design Reach	150	$ 300.00	LF	$ 45,000.00
Subtotal				$ 132,750.00
Engineering and Construction Mgmt	15%			$ 19,912.50
Contingency	20%			$ 26,550.00
Total				$ 179,000.00

Table 3-12. UFCP-26: Culvert FC 09 - El Paso Ave

Item	QTY	Unit Cost	Unit	Total
Bridge Mobilization	1	$75,000.00	LS	$ 75,000.00
Bridge Dewatering	1	$50,000.00	LS	$ 50,000.00
Traffic Control	1	$10,000.00	LS	$ 10,000.00
Demolition	1	$10,000.00	LS	$ 10,000.00
Erosion Control	400	$ 5.00	LF	$ 2,000.00
General Earthwork	200	$ 30.00	CY	$ 6,000.00
Bridge Replacement	450	$ 270.00	SF	$ 121,500.00
Boulder Structure	50	$ 800.00	LF	$ 40,000.00
Natural Channel Design Reach	200	$ 300.00	LF	$ 60,000.00
Subtotal				$ 374,500.00
Engineering and Construction Mgmt	15%			$ 56,175.00
Contingency	20%			$ 74,900.00
Total				$ 506,000.00

Table 3-13. UFCP-30, 31, 32, 33, 34: Sand Gulch Tributary Improvements

Item	QTY	Unit Cost	Unit	Total
Mobilization	3	$10,000.00	LS	$ 30,000.00
Dewatering	3	$10,000.00	LS	$ 30,000.00
Demolition	2.5	$10,000.00	LS	$ 25,000.00
Traffic Control	2	$10,000.00	LS	$ 20,000.00
Erosion Control	700	$ 5.00	LF	$ 3,500.00
General Earthwork	2700	$ 30.00	CY	$ 81,000.00
Riprap Mat	500	$ 100.00	CY	$ 50,000.00
Culvert Pipe	90	$ 125.00	LF	$ 11,250.00
Road Drainage Improvements	200	$ 1,150.00	LF	$ 230,000.00
Roadway Replacement	200	$ 60.00	SY	$ 12,000.00
Protect in Place Reach	700	$ 300.00	LF	$ 210,000.00
Subtotal				$ 702,750.00
Engineering and Construction Mgmt	15%			$ 105,412.50
Contingency	20%			$ 140,550.00
Total				$ 949,000.00

Table 3-14. UFCP-44: Culvert FC 13 - Spring St.

Item	QTY	Unit Cost	Unit	Total
Bridge Mobilization	1	$75,000.00	LS	$ 75,000.00
Bridge Dewatering	1	$50,000.00	LS	$ 50,000.00
Traffic Control	1	$10,000.00	LS	$ 10,000.00
Demolition	1	$10,000.00	LS	$ 10,000.00
Erosion Control	520	$ 5.00	LF	$ 2,600.00
General Earthwork	300	$ 30.00	CY	$ 9,000.00
Bridge Replacement	1300	$ 270.00	SF	$ 351,000.00
Boulder Structure	100	$ 800.00	LF	$ 80,000.00
Natural Channel Design Reach	260	$ 300.00	LF	$ 78,000.00
Subtotal				$ 587,600.00
Engineering and Construction Mgmt	15%			$ 88,140.00
Contingency	20%			$ 117,520.00
Total				$ 793,000.00

Table 3-15. CC-P1: Grade Control Structure - Evans Bridge

Item	QTY	Unit Cost	Unit	Total
Mobilization	1	$10,000.00	LS	$ 10,000.00
Dewatering	1	$10,000.00	LS	$ 10,000.00
Demolition	1	$10,000.00	LS	$ 10,000.00
Traffic Control	1	$10,000.00	LS	$ 10,000.00
Erosion Control	200	$ 5.00	LF	$ 1,000.00
Boulder Structure	60	$ 800.00	LF	$ 48,000.00
Subtotal				$ 89,000.00
Engineering and Construction Mgmt	15%			$ 13,350.00
Contingency	20%			$ 17,800.00
Total				$ 120,000.00

Table 3-16. CC-P17: Cheyenne Road Drainage Improvements

Item	QTY	Unit Cost	Unit	Total
Mobilization	1	$10,000.00	LS	$ 10,000.00
Demolition	1	$10,000.00	LS	$ 10,000.00
Traffic Control	1	$10,000.00	LS	$ 10,000.00
Erosion Control	900	$ 5.00	LF	$ 4,500.00
Road Drainage Improvements	900	$ 1,150.00	LF	$ 1,035,000.00
Subtotal				$ 1,069,500.00
Engineering and Construction Mgmt	15%			$ 160,425.00
Contingency	20%			$ 213,900.00
Total				$ 1,444,000.00

Table 3-17. CC-P18: Stratton Ave Bridge

Item	QTY	Unit Cost	Unit	Total
Bridge Mobilization	1	$75,000.00	LS	$ 75,000.00
Bridge Dewatering	1	$50,000.00	LS	$ 50,000.00
Bridge Demolition	1	$ 10.00	SF	$ 10.00
Erosion Control	200	$ 5.00	LF	$ 1,000.00
General Earthwork	200	$ 30.00	CY	$ 6,000.00
Bridge Replacement	1575	$ 270.00	SF	$ 425,250.00
Protect in Place Reach	100	$ 300.00	LF	$ 30,000.00
Subtotal				$ 587,260.00
Engineering and Construction Mgmt	15%			$ 88,089.00
Contingency	20%			$ 117,452.00
Total				$ 793,000.00

Table 3-18. CC-P20: Cheyenne Blvd. Drainage Improvements

Item	QTY	Unit Cost	Unit	Total
Mobilization	1	$10,000.00	LS	$ 10,000.00
Demolition	1	$10,000.00	LS	$ 10,000.00
Traffic Control	1	$10,000.00	LS	$ 10,000.00
Erosion Control	2500	$ 5.00	LF	$ 12,500.00
Road Drainage Improvements	2500	$ 1,150.00	LF	$ 2,875,000.00
Subtotal				$ 2,917,500.00
Engineering and Construction Mgmt	15%			$ 437,625.00
Contingency	20%			$ 583,500.00
Total				$ 3,939,000.00

Table 3.19. CC-P23: Cresta Rd. Bridge

Item	QTY	Unit Cost	Unit	Total
Bridge Mobilization	1	$75,000.00	LS	$ 75,000.00
Bridge Dewatering	1	$50,000.00	LS	$ 50,000.00
Bridge Demolition	1	$ 10.00	SF	$ 10.00
Erosion Control	200	$ 5.00	LF	$ 1,000.00
General Earthwork	200	$ 30.00	CY	$ 6,000.00
Bridge Replacement	2478	$ 270.00	SF	$ 669,060.00
Small Drop Reach	100	$ 1,000.00	LF	$ 100,000.00
Subtotal				$ 901,070.00
Engineering and Construction Mgmt	15%			$ 135,160.50
Contingency	20%			$ 180,214.00
Total				$ 1,216,000.00

Table 3-20. CC-P45: Cheyenne Rd. Bridge

Item	QTY	Unit Cost	Unit	Total
Bridge Mobilization	1	$75,000.00	LS	$ 75,000.00
Bridge Dewatering	1	$50,000.00	LS	$ 50,000.00
Bridge Demolition	1	$ 10.00	SF	$ 10.00
Erosion Control	300	$ 5.00	LF	$ 1,500.00
General Earthwork	300	$ 30.00	CY	$ 9,000.00
Bridge Replacement	1850	$ 270.00	SF	$ 499,500.00
Small Drop Reach	150	$ 1,000.00	LF	$ 150,000.00
Subtotal				$ 785,010.00
Engineering and Construction Mgmt	15%			$ 117,751.50
Contingency	20%			$ 157,002.00
Total				$ 1,060,000.00

Table 3-21. CC-P50: Trash and Debris Removal

Item	QTY	Unit Cost	Unit	Total
Mobilization	1	$10,000.00	LS	$ 10,000.00
Dewatering	1	$10,000.00	LS	$ 10,000.00
Debris Removal	800	$ 50.00	CY	$ 40,000.00
Erosion Control	100	$ 5.00	LF	$ 500.00
Subtotal				$ 60,500.00
Engineering and Construction Mgmt	15%			$ 9,075.00
Contingency	20%			$ 12,100.00
Total				$ 82,000.00

Table 3-22. CC-P51: Brookside St. Bridge

Item	QTY	Unit Cost	Unit	Total
Bridge Mobilization	1	$75,000.00	LS	$ 75,000.00
Bridge Dewatering	1	$50,000.00	LS	$ 50,000.00
Bridge Demolition	1	$ 10.00	SF	$ 10.00
Erosion Control	400	$ 5.00	LF	$ 2,000.00
General Earthwork	400	$ 30.00	CY	$ 12,000.00
Bridge Replacement	1053	$ 270.00	SF	$ 284,310.00
Small Drop Reach	200	$ 1,000.00	LF	$ 200,000.00
Subtotal				$ 623,320.00
Engineering and Construction Mgmt	15%			$ 93,498.00
Contingency	20%			$ 124,664.00
Total				$ 841,000.00

4.0 Recommended Restoration Techniques

4.1 Alternative Restoration Techniques

When approaching the restoration of identified projects or sections of channel throughout Upper Fountain Creek and Cheyenne Creek, there are various design applications and techniques that can be applied based upon the unique characteristics in the reach. Depending on the planning alternative developed for each reach, explained in detail in the Alternatives Analysis section, a specific restoration plan can be applied to a length of channel to repair the identified deficiencies while also increasing the stability throughout the length of channel. For each alternative, various design applications are utilized to manage the identified projects.

4.2 Natural Channel Design Alternative

The goal of the Natural Channel Design Alternative is to use natural form and materials to restore stream function and establish a low flow channel which connects to the adjacent floodplain, to allow for overflow across the floodplain in large events. This can be achieved through the implementation of geomorphic practices and various grade control and bank protection measures to aid in returning the channel to a naturally stable cross section, slope, and pattern. Detailed guidance for natural channel design scenarios is provided in The Waldo Canyon Fire Master Plan for Watershed Restoration & Sediment Reduction completed for CUSP in April 2013. Restoration scenarios are based on converting an impaired stream reach from its existing stream type to a proposed, or potential, stream type. Existing and proposed stream types for Upper Fountain Creek mainstem are identified in Section 7, Table 7-17.

Structures such as rock cross vanes, constructed riffles, and log rollers allow for grade control and energy dissipation, while ensuring the channel will attain a stable slope between structures. .A concept design section for the natural channel alternative can be seen in figures 4.1, 4-2, 4.3, and 4-4 along with a rock cross vane and riffle detail. Also shown is a typical log roller design in plan view.

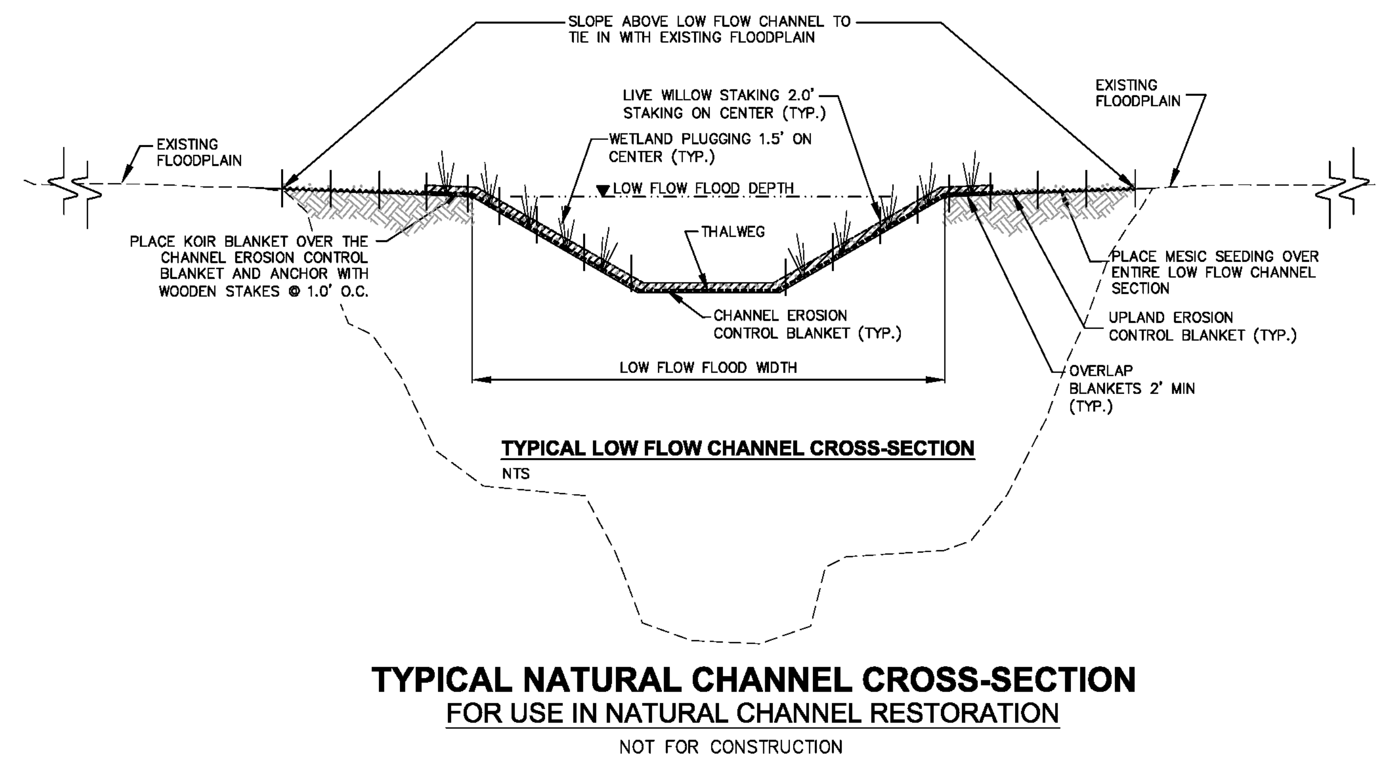

Figure 4-1. Natural Channel Section

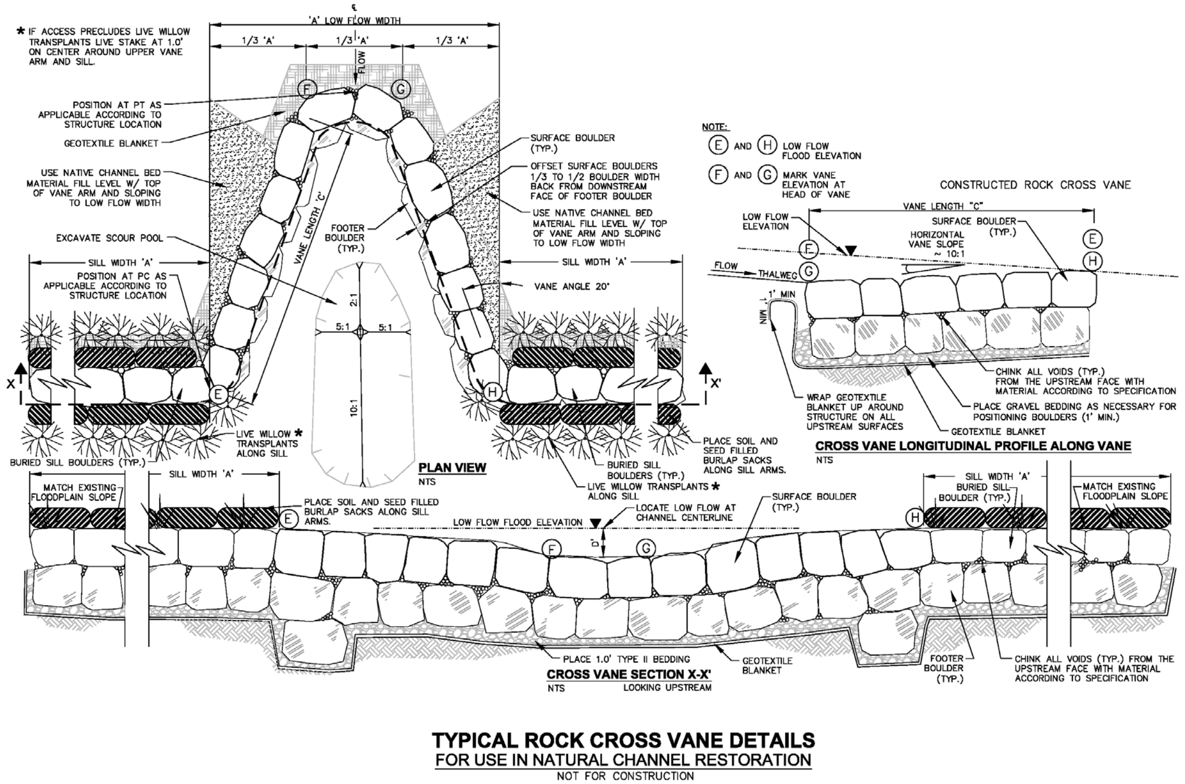

Figure 4-2. Rock Cross Vane Details

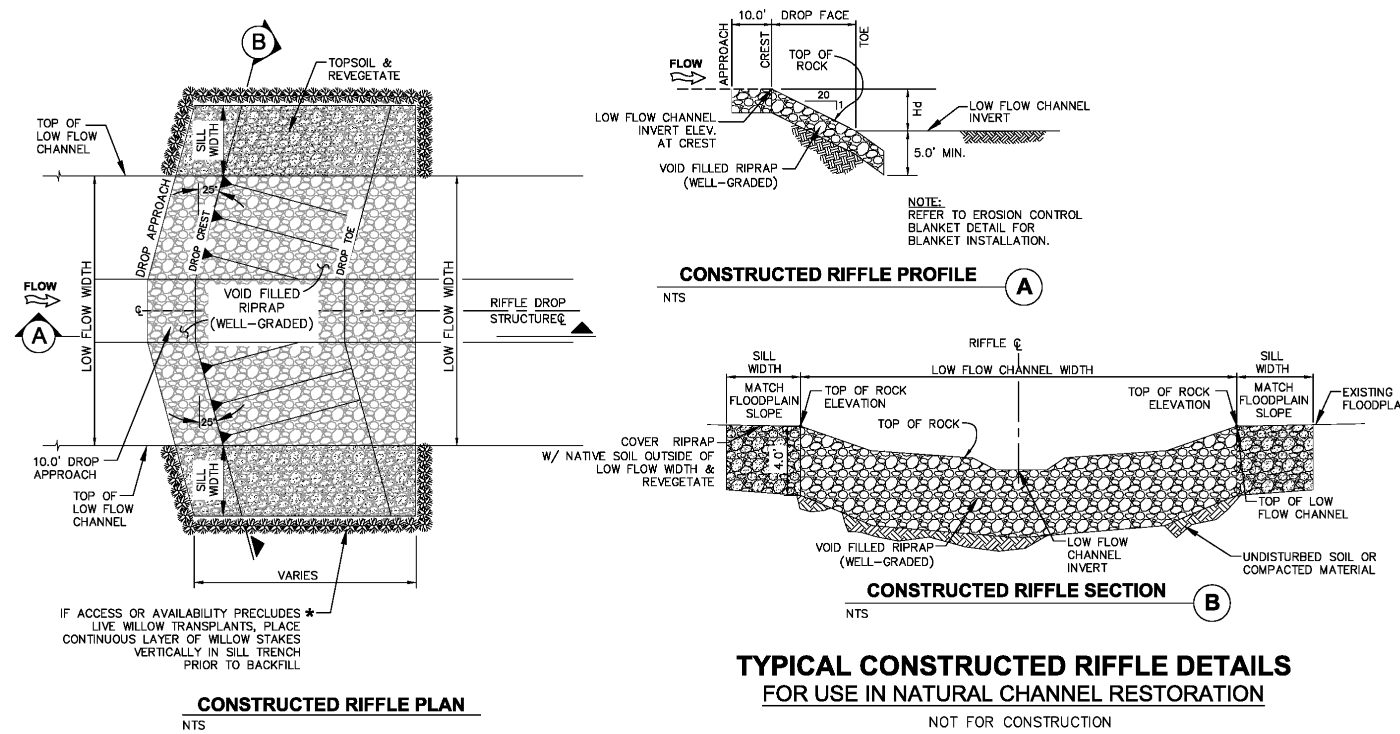

Figure 4-3. Riffle Details

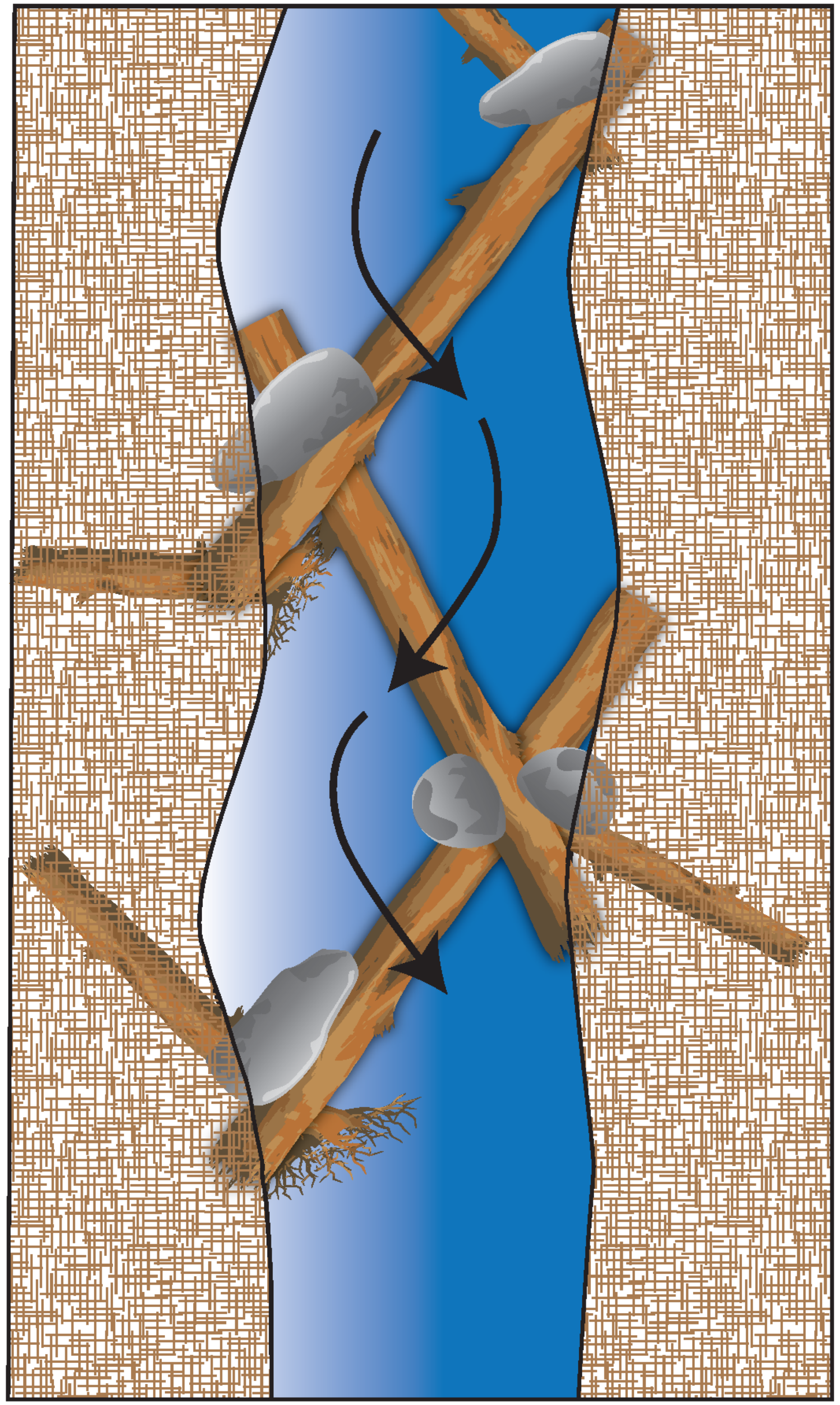

Figure 4-4. Log Roller Design in Plan View
(from TheWaldo Canyon Fire Master Plan for Watershed Restoration & Sediment Reduction)

4.3 Small Drop Structures with Toe Protection Alternative

The Small Drop Structures with Toe Protection Alternative utilizes small drop structures up to 3-ft in height, with reinforced side slope toes throughout the channel. This alternative is necessary when channel widths, shear stresses, or slopes do not readily allow for a natural channel design applications. The small drop alternative is discussed in greater detail in the Alternative Analysis section. Figure 4-5 illustrates a typical small drop structure detail in plan view and profile view. Pictures of a constructed small drop structure and side slope toe protection are also provided.

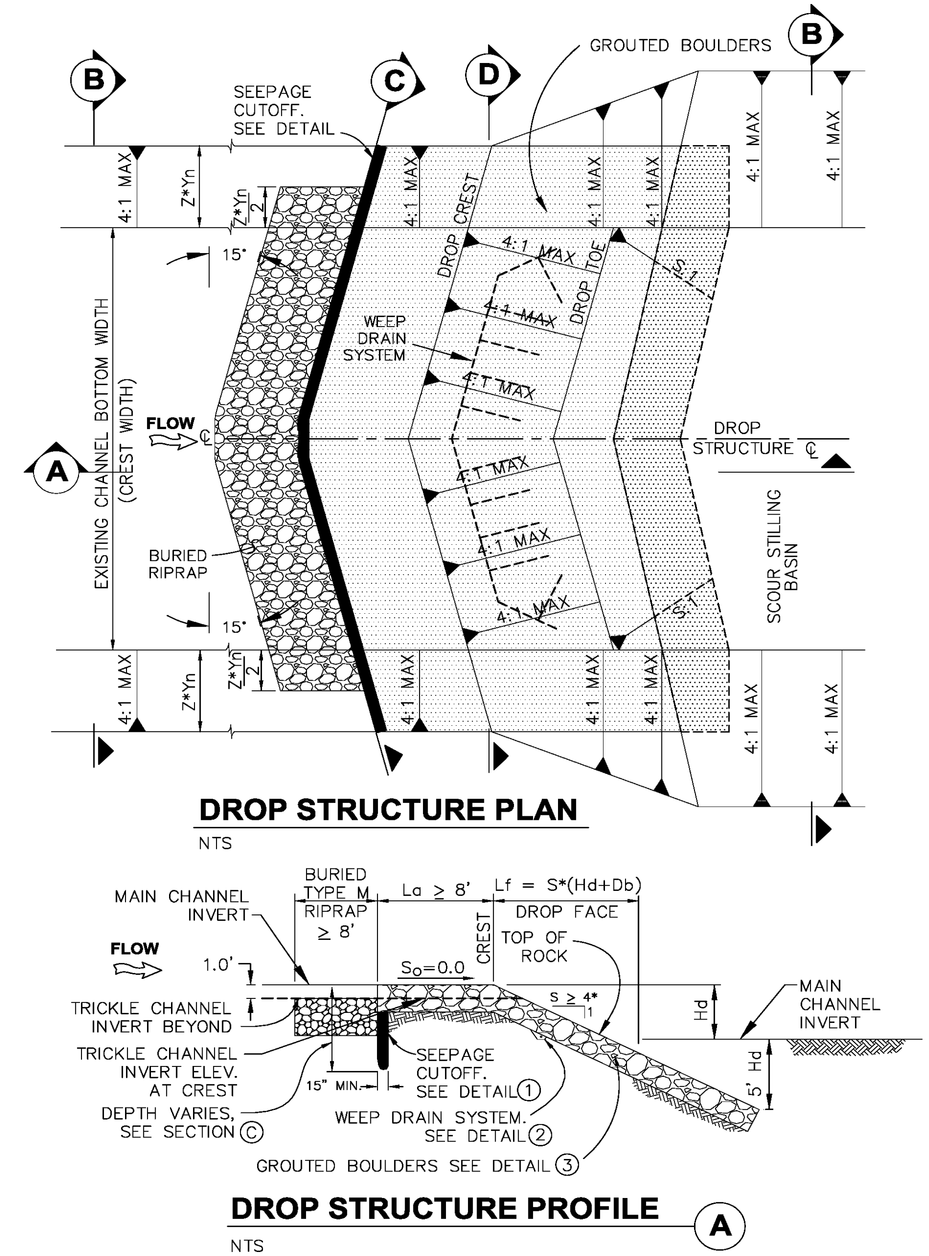

Figure 4-5. Drop Structure Details

Figure 4-6. Constructed Small Drop Structure in Greencrest Channel, Colorado Springs

Figure 4-7. Constructed Side Slope Toe Protection in Greencrest Channel, Colorado Springs

4.4 Large Drop Structures with Toe Protection Alternative

The Large Drop Structures with Toe Protection Alternative utilizes large drop structures greater than 3-ft in height, with reinforced side slope toes throughout the channel. This alternative may be necessary when small drop structures are not feasible due to the large quantity of small drop structures that would be required to account for the vertical drop necessary to address the channel profile. The large drop alternative is discussed in greater detail in the Alternatives Analysis section. Figure 4-8 is an example of a constructed large drop structure.

Figure 4-8. Constructed Large Drop Structure in Camp Creek, Colorado Springs

4.5 Fully-Lined Channel Alternative

The Fully Lined Channel Alternative is necessary when all other alternatives are not practical due to unique or extreme conditions. This alternative is typically used as a last resort, when velocity, slope, or channel width prevents other means of stabilizing the channel. This alternative involves fully lining the channel, including bottom and side slopes, typically with rip rap or concrete. Both rip rap and concrete lined channels are shown in the figures 4-9 and 4-10.

Figure 4-9. Full- Lined Concrete Trapezoidal Channel in Douglas Creek, Colorado Springs

Figure 4-10. Fully-Lined Rip Rap Channel in Greencrest Channel, Colorado Springs

4.6 Drainage, Bank Stabilization, and Detention Restoration Techniques

While the reach planning alternatives aid in stabilizing channel segments experiencing high velocities, confinement, lack of floodplain, unstable slopes, and other deficiencies, some restoration improvements may require additional infrastructure to accommodate the flows associated with large events. These structures include sediment basins, detention basins, swales, pavements, and reinforced banks.

4.7 Sediment and Detention Basins

Attenuation of flood flows and high sediment delivery can be achieved through the construction of detention and sediment basins. Detention basins serve as a tool for mitigating downstream flooding, while sediment basins provide collection areas for significant sediment resulting from upstream erosion and/or sediment transported as a result of the recent wild fires. Both types of basins can be installed in-line or off-line depending on the hydrology of the project stream and availability of land in the project area. More information regarding sediment and detention basins can be referenced in the Project Identification section. The following figures show detention and sediment basin details as well as a constructed sediment basin.

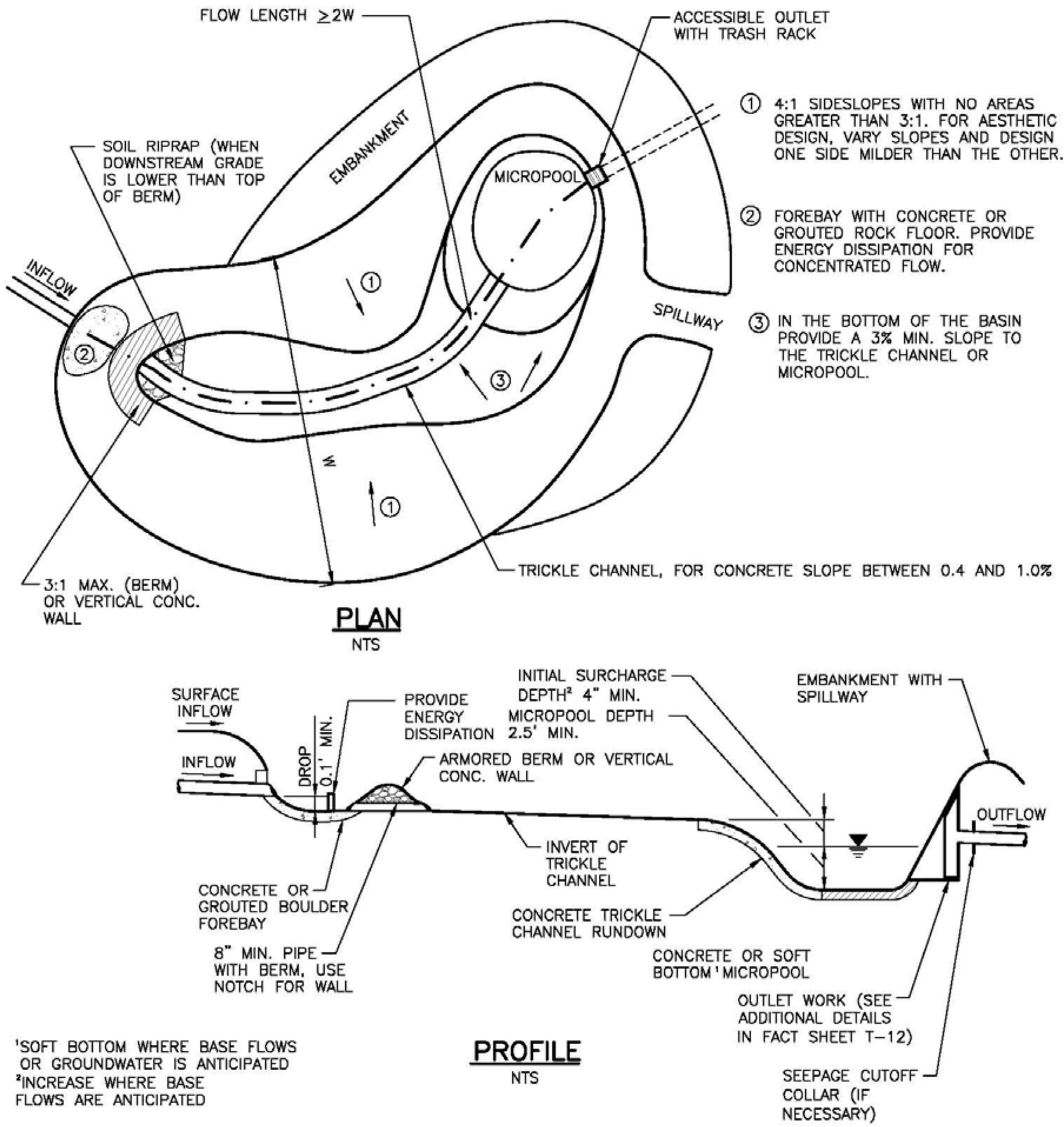

Figure 4-11. Detention Basin Details (from UDFCD Criteria Manual Vol. 3)

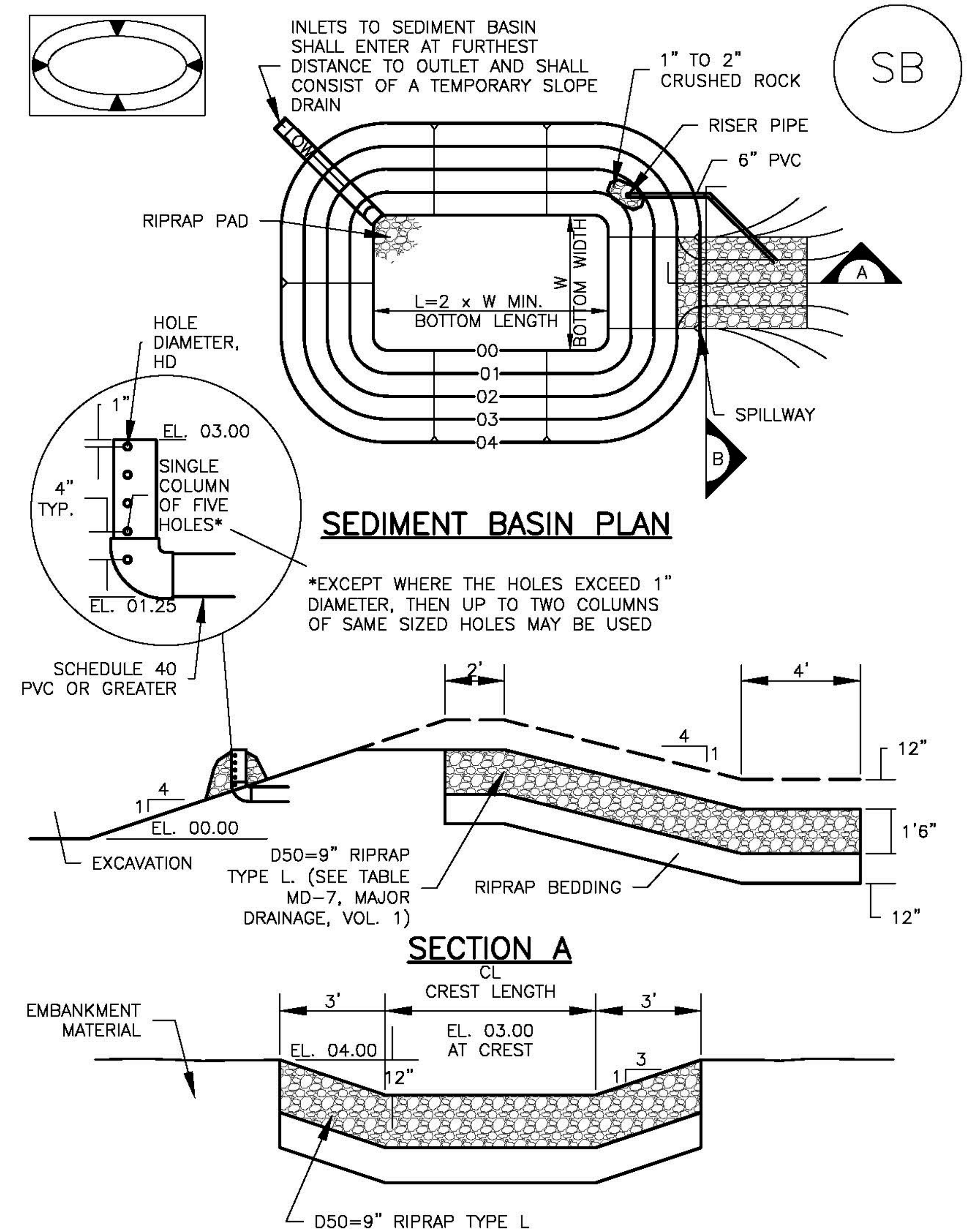

Figure 4-12. Sediment Basin Detail (from UDFCD Criteria Manual Vol. 3)

Figure 4-13. Constructed Sediment Basin at North Douglas Creek, Colorado Springs

4.8 Bank Restoration Techniques

There are several options available for bank restoration or stabilization efforts. Most options include reinforcing the bank with stronger material to ensure that future erosion is prevented. This can be achieved through the use of rip rap, soil rip rap, brush layering, toe wood, and geotextile fabrics.

4.8.1 Rip Rap

Rip rap, while typically the most expensive option for bank stabilization, allows for a detailed design utilizing rock of a specific size to accommodate scouring and erosion associated with high velocities and meandering bends throughout a channel. Contractors tend to be familiar with the installation of this material, however there are greater costs associated with hauling and placing the rock when compared to other options. When utilizing rip rap consisting of larger rocks or boulders, void spaces must be properly filled and the use of a geotextile material should be used to prevent scouring undercutting. This material is usually not suitable for vegetation, and thus isn't able to acquire the aesthetic look associated with a natural channel design.

4.8.2 Soil Rip Rap

Soil rip rap consists of a mixture of rocks and soil used to stabilize banks and channel bottoms. This material is less costly than rip rap alone, and can be just as effective if installed properly when designed for the right conditions. The mixture of material allows for replacement of more erosive, finer material, and generates greater slope and channel stability than backfill alone. However, this option is more difficult to vegetate due to the rock material mixed in. An example of soil rip rap is shown in Figure 4-14.

Figure 4-14. Soil Rip Rap Channel with Rip Rap Bank Stabilization at Greencrest Channel

4.8.3 Brush Layering

Brush layering is an additional option for stabilization when velocities and flows are less violent. This material is inexpensive, and is easier to vegetate than soil rip rap. However, the installation can be quite labor intensive. Brush layering can be desirable because of its natural look, however if large flows or debris flow is experienced, the material can tear and result in erosion and additional loss of bank or channel material.

4.8.4 Toe Wood / Brush Layering

Toe wood with brush layering is an inexpensive option when stabilizing banks. However, the desired trees and material needed should be easily accessible and in abundant supply. This design can be susceptible to uplift though, and should be used in channels experiencing low flows and low velocities. This application can be desirable if the design goals pertain to aquatic habitat restoration.

4.8.5 Geotextile Stabilization

Geotextile fabrics or blankets can be an effective means of stabilizing banks. When installed properly, the material can help prevent erosion in channels experiencing low flows and smaller scale velocities while also allowing vegetation growth through the woven fabric. Natural biodegradable fabrics allow native vegetation to establish itself, further increasing the stability throughout the bank. This material, if not staked and installed in the proper design and lifts, can be susceptible to tearing and migrating down the channel.

4.9 Additional Drainage and Channel Restoration Techniques

4.9.1 Swales

Depending on the surrounding terrain, offline drainage improvements may create a possible means of flooding relief. For instance, many roadway corridors contain ample space necessary for the installation of bio-swales. The swales consist of planted depressions which collect and covey runoff from surrounding impervious surfaces. The bio-swales improve water quality and promote infiltration.

Grassed swales on both sides of the roadway, along with driveway cross culverts for the purposes of runoff conveyance, can help facilitate runoff in large events. In cases where roadway swales have been filled in, paved over, and/or eliminated, the reconstruction of the classic rural roadway section would serve as a viable option for provided overland flow roadway drainage facilities.

4.9.2 Roadway Improvements

Proper design of classic stormwater infrastructure including concrete curb and gutter, roadway and ditch bottom inlets, underground piping, manholes, and outlet structures, can help improve runoff and drainage from large events. Additionally, pervious pavements, also known as porous asphalts, can be used for municipal and private development flood relief applications. The solution provides stormwater runoff reduction and control, as well as water quality benefits.

4.9.3 Flood Levee Walls

Levee walls can be utilized in already urbanized areas to prevent overflow during large events causing high water levels neighborhoods adjacent to channels and creeks. These walls can be constructed vertically in the floodplain, or in the channel itself, with the intent of providing a barrier that prevents flooding into undesired areas, such as highly populated, residential areas. These walls are also useful in providing roadway protection in large events. Examples of these additional restoration techniques can be seen in the Project Identification section.

4.10 Forest Management

A key component to the resiliency of Upper Fountain Creek and Cheyenne Creek to withstand future flooding events is tied to the restoration and sustainability of healthy watershed forest environments. The effects of the 2012 Waldo Canyon Fire demonstrate the extreme pressure from high flows and sediment load that fire-affected watersheds can put on downstream riparian and in-stream environments. The resiliency of forested watersheds and streams to withstand flooding and other post-fire impacts is directly connected to the forests ability to endure fire through preventative forest management and fuels reduction. The development of interagency management frameworks such as the Upper Fountain Creek and Cheyenne Creek Flood Restoration Coalition present opportunities for interdisciplinary resource management practices that work to protect the resiliency of both the forests and water resources.

5.0 References for Implementation

5.1 References to Other Watershed Plans and Studies

There are a number of plans and studies that complement this FRMP and represent ongoing efforts by stakeholders in the watershed. Any future project design, forest management, or watershed planning efforts in Upper Fountain Creek and Cheyenne Creek corridors and watersheds need to make reference to these complementary documents. A list of these watershed references and source information is provided in Appendix A.

5.2 Funding

5.2.1 Grant Sources of Funding

Funding for disaster recovery is available through Federal and State programs that make funds available for planning and implementation of proposed projects and pre-project planning activities. Federal grants are being funded by the U.S. Housing and Urban Development (HUD) Community Development Block Grants – Disaster Recovery (CDBG- DR) Program. These funds are not emergency response related as the Federal Emergency Management Agency (FEMA) or land resource-related as those available through the Natural Resources Conservation Service (NRCS). Both FEMA and NRCS funds were instrumental in the initial recovery from both the 2012 Waldo Canyon Fire and the 2013 floods on Upper Fountain Creek and Cheyenne Creek. Long term management programs will be funded with a combination of CDBG – DR funds in conjunction with local and regional matching funds.

Additional Sources of Grant funding are identified in the Fountain Creek Corridor Restoration Master Plan (October 2011) and listed below:

- Colorado Water Conservation Board
  - Watershed Restoration Program
  - The Healthy Rivers Fund
  - Fish and Wildlife Resources Fund
  - Non-Reimbursable Project Investment Program
  - Floodplain technical Services Program
  - Colorado Watershed Protection Fund
  - Species Conservation Trust Fund
  - Rivers of Colorado Water Watch Network
  - In Stream Flow Protection

- Colorado Department of Public Health and Environment
  - Section 319 Clean Water Act- Colorado Nonpoint Source Management Area

- Colorado Division of Wildlife
  - Wetland Wildlife Conservation Program
  - Fishing is Fun

- U.S. Army Corps of Engineers
  - General Investigations
  - Continuing Authorities Program Section 14
  - Regional Priority Grant Program
  - Community Action for a Renewed Environment

- U.S. Bureau of Reclamation
  - WaterSMARTWater And Energy Efficiency Program

- U.S. Environmental Protection Agency
  - Targeted Watershed Implementation Grant
  - Five Star Restoration Grant
  - Water Quality Cooperative Agreements
  - Nonpoint Source Pollution
  - Environmental Education Regional Grants

- Natural Resources Conservation Service
  - Wetlands Reserve Program
  - Emergency Watershed Protection Program

- U.S. Fish and Wildlife Service
  - National Fish Passage Program
  - National Fish Habitat Program

- Colorado Division of Wildlife
  - Wildlife Habitat Protection Program
  - Wetland Wildlife Conservation Program

- National Fish and Wildlife Foundation
  - Bring Back the Natives
  - Five Star Restoration Program
  - Native Plant Conservation Initiative

- Colorado State Parks
  - Non-Motorized Trail Grant

- Great Outdoors Colorado
  - Local Government, Parks, Outdoor Recreation & Environment Education Facility Grants
  - Planning Grants
  - Legacy Grants

- Trout Unlimited
  - Home Rivers Initiative
- Ducks Unlimited

5.2.2 Loan Sources of Funding

- Colorado Water Control Board
  - Water Project Loan Program
  - Construction Loan Program

- U.S. Environmental Protection Agency
  - Clean Water State Revolving Loan Program

- Natural Resources Conservation Service
  - Environmental Quality Incentives Program (EQUIP)
  - Conservation Innovation Grants
  - Conservation Stewardship Program
  - Emergency Watershed Protection/EWP Program
  - Wildlife Habitat Incentive Program (WHIP)
  - Wetlands Reserve Program
  - Grasslands Reserve Program
  - Farm and Ranch Land Protection Program

5.3 Implementation

Project implementation follows the identification of problems, investigation and evaluation of the identified problems, definition of alternative solutions to the problems and organization and prioritization of the solutions. A common goal of the District and Coalition members is to produce not just an extensive list of projects and priorities but to organize those projects and priorities into an actionable plan that can be implemented efficiently and effectively and produce measured results. Following the development of the master plan, work to identify proper project phasing is required to fit into funding and procurement rules and to attract project specific funds that may have limitations with respect to the overall priorities identified in the FRMP. As Coalition members identify projects within their specific jurisdiction, they will need to design implementation schemes applicable to their needs and constraints.

5.3.1 Partnering/Volunteer Opportunities

Opportunities to involve non-coalition partners and volunteers may improve the implementation of certain projects, especially those with a high public profile or interdisciplinary nature.

5.3.2 Potential Leveraging

It is likely that most of the funding grants and loan opportunities identified above are contingent upon leveraging locally-sourced funds and funds from complementary, multi-objective projects such as transportation and trails and recreation projects. Not only does this invest the local community in the implementation of the projects, it provides an avenue for local ownership of the process and results.

6.0 Planning Area Description

6.1 Watershed Descriptions

The areas covered in the FRMP include the full watershed areas of Upper Fountain Creek (118.6 mi^2) and Cheyenne Creek (25.3 mi^2). Both watersheds contain a mix of urban and rural development within a predominantly natural area typical of the Rocky Mountain foothills.

Upper Fountain Creek drains the western slopes of the Rampart Range including a majority of the Waldo Canyon Fire area, and the northeastern slope of Pikes Peak. The undeveloped mountain slopes are covered in forests of ponderosa pine and douglas fir, as well as alpine meadows, with a well-developed network of streams and creeks that flow into Upper Fountain Creek. The stream corridor is dominated by natural riparian areas intersected with areas of development the extent of the riparian corridor is reduced proportionally to the amount of urbanization as can be seen in the cities of Manitou Springs and Colorado Springs.

South Cheyenne Creek drains the western slopes of Cheyenne Mountain and North Cheyenne Creek drains the eastern slopes of Almagre Mountain. The sub watersheds of North and South Cheyenne Creeks are dominated by natural ponderosa pine and douglas fir forests on steep slopes. Below the confluence of the North and South Cheyenne Creeks, the corridor is dominated by urban development. This urbanization has resulted in many parts of the creek being confined between concrete or engineered walls with the floodplains extending into residential neighborhoods and commercial areas.

6.2 Land use

The majority of the urban and commercial development in the watershed is located in the lower elevations in Manitou Springs and Colorado Springs. In recent years, urban development along Upper Fountain Creek has occurred in Woodland Park with suburban and rural residential development throughout the corridor between Manitou Springs and Woodland Park.

Similar to Upper Fountain Creek, the urban land use in Cheyenne Creek watershed is concentrated in the lower elevations below predominantly natural or undeveloped areas. A key difference between conditions of the watersheds with respect to flooding is influence of the Waldo Canyon Fire in the Upper Fountain Creek watershed.

6.3 Environmental Studies

The water quality and environmental conditions in Upper Fountain Creek and Cheyenne Creek are described in detail in the U.S. Army Corps of Engineers 2009 Fountain Creek Watershed Study (FCWS), see Appendix A, and are identified on the Colorado Department of Public Health and Environment Water Quality Control Commission, *Colorado's Section 303(D) List of Impaired Waters and Monitoring and Environmental List.* In addition to excess sediment from the Waldo Canyon Fire burn scar, water quality constituents of concern in Upper Fountain Creek include E. coli.

6.4 Recreation

Recreation opportunities in Upper Fountain Creek watershed include public resources such as trails for hiking, bicycling, and horseback riding. EPC Park Operations Division is currently developing the Ute Pass Regional Park, a network of trails that connect Manitou Springs to Teller County through the Upper Fountain Creek corridor. Other resources are available on private property or through private outfitters with access to fishing and hunting resources.

Cheyenne Creek offers similar recreational opportunities that are maintained as public and private resources. Hiking trails maintained by the City of Colorado Springs connect public parking areas at the Starsmore Discovery Center to City open space and park lands along North Cheyenne Creek, Helen Hunt Falls and Gold Camp Road. Private access to EPC park land and trails is available at the Seven Falls Resort.

6.5 Upper Fountain Creek

The Upper Fountain Creek planning corridor extends from the CR21 Bridge crossing near the city limits of Woodland Park to the confluence with Fountain Creek in Colorado Springs. The City of Woodland Park has participated in the Coalition stakeholder meetings and decided to maintain their on-going stormwater management planning. The authority of the District does not extend to Woodland Park and Teller County so the section of Upper Fountain Creek between the CR21 Bridge and the El Paso County line was included in the planning study on behalf of Teller County in order to include all reaches of Upper Fountain Creek downstream of Woodland Park in the FRMP.

The following section lists the obvious problem areas addressed in the FRMP and provides a brief description of the flooding and sedimentation problems encountered in those reaches. Further delineation of the corridor and identification of problems was performed for the geomorphic assessment and alternatives analysis and included the following projects in greater detail.

6.5.1 CR21 – Creekside Road Crossing

The reach extending from the CR21 Bridge to the El Paso County border is characterized by a channel of unconsolidated sandy alluvium that has been accumulating during past number of years. Flows are perennial upstream of the confluence of Crystola Canyon Creek just upstream from the Creekside Rd culverts. Crystola Canyon Rd crosses Upper Fountain Creek via a single arch concrete span at a fairly wide section of the floodplain. The 2013 and 2014 flooding events exceeded the capacity of the creek, inundated the floodplains and deposited excess sediment on the floodplains adjacent to the upstream face of the bridge. According to witnesses, the bridge was overwhelmed during the September 2013 flood curtailing access to the residences on the southwest side of the creek. The excessive sediment deposition on the floodplain has affected the drainage and caused minor seepage into adjacent buildings.

Figure 6-1. Crystola Canyon Rd Bridge Downstream Abutment

Located approximately 200 feet downstream of the Crystola Canyon Rd bridge crossing, Creekside Rd crosses Upper Fountain Creek through a pair of 60 inch CMP culverts. The upstream inverts of the culverts are buried in the accumulated sediment and the downstream inverts have filled with sediment from a deficit of nearly 2 feet in the spring of 2014. This reach requires expanded capacity and significant grade control through the Creekside Rd and Crystola Canyon Rd crossings.

Figure 6-2. Creekside Rd April 2014 (left) and October 2014

6.5.2 Pinecrest Boarding Stables

Located approximately 1 mile downstream and east of the El Paso-Teller county line, the Pinecrest Stables suffered significant effects during from the 2013 and 2014 storm events. In addition to private access being affected, the stream channel and banks throughout this reach are unstable and eroding at an accelerated pace. Extensive sedimentation has occurred along the floodplain that is being grazed and compacted by the stable's horses. The unstable channel and banks extend upstream and will require bank and channel stabilization and grade control.

Figure 6-3. Bank Erosion Above Pinecrest Stables

6.5.3 Green Mountain Falls – El Paso Ave Access

Two bridges that access El Paso Ave in Green Mountain Falls have limited capacity and may affect the residences and municipal properties on El Paso Ave. Both bridges are overtopped during the 10-year and greater storms.

Figure 6-4. Hotel St/ El Paso Ave Access in Green Mountain Falls

6.5.4 Sand Gulch Outfall

The 2013 floods were devastating for Sand Gulch and in 2013 and 2014 EPC and CDOT spent considerable resources to mitigate the immediate effects with emergency funds. Those efforts involved siting and constructing two sediment catchment basins on the east side of US24. CDOT constructed a cleanable sediment basin and debris rack at the upstream side of US24 and EPC constructed a sediment catchment basin approximately half a mile up Sand Gulch above the CDOT basin. CDOT plans for sediment control improvements are located in Appendix F.

Below US24, Sand Gulch exits the highway culvert and flows in a channel past the Ute Pass School. This channel has been lined with trap bags to prevent flood water from inundating the school and school grounds. Below the school grounds, Sand Gulch flows through a culvert passing beneath Chipita Park Rd and two adjacent properties. The outfall into Upper Fountain Creek is perched approximately 3 feet above the invert of the creek.

Flood mitigation of the lower reach and culverts is required. Channel stabilization and grade control in the reach between the US24 culvert and the Chipita Park Rd culvert is advisable. Further hydraulic analyses of flood heights and discharges will be required for design of a channel and banks that can convey the discharge that has been attenuated by the EPC and CDOT sediment basins. This analysis will also be recommended for design and construction of a new Chipita Park Rd culvert with increased capacity. EPC has indicated the intention to purchase and remove the two private properties adjacent to the Sand Gulch outfall. Recommended mitigation measures for the confluence include, bank and channel stability, grade control, drop structures and possible additional sediment basin.

Figure 6-5. The Lower channel section and outfall of Sand Gulch

6.5.5 Wellington Gulch

Wellington Gulch was burned during the Waldo Canyon Fire and exhibits excessive sediment transport and accumulation in the reaches east of US24. Similar to the emergency response actions in Sand Gulch, CUSP, EPC, and CDOT have installed sediment basins, debris rack, and erosion control in the reach upstream of US24.

Figure 6-6. Sediment Catchment Facility at in Lower Wellington Gulch

6.5.6 Fern Gulch

With no roadway access, the existing condition of Fern Gulch is not obvious from US24. CUSP staff has investigated and indicated that there are large amounts of sediment poised for delivery to the highway corridor. CDOT has installed a ramp and small sediment collection basin adjacent to the highway at the mouth of the canyon. It is likely that the small sediment basin will be overwhelmed during large storms but the relatively small basin area of Fern Gulch will limit the magnitude of future flood flows.

6.5.7 East Cascade Creek

East Cascade Creek drains the Pyramid Mountain area of the Waldo Canyon Fire scar. Considerable work has been done in the upper reaches of East Cascade Creek by EPC and the U.S. Forest Service (USFS) following the Waldo Canyon Fire Watershed Assessment of River Stability and Sediment Supply (WARSSS) Report. The effects of the fire were widespread throughout this tributary to Upper Fountain Creek and the post fire mitigation efforts include revegetation, hill slope, stream bank, channel stabilization, and installation of sediment catchment basins.

Figure 6-7. Trap Bags and Blocked Culvert in East Cascade Canyon

6.5.8 Cascade Mainstem

The section of Upper Fountain Creek between Chipita Park and Cascade had limited degradation as a result of the 2013 floods. The geomorphic assessment classified one section of the mainstem as "poor" condition but the majority of this reach is classified as "fair". This is partially due to the location of US24 situated between the Waldo Canyon Fire and the mainstem of Upper Fountain Creek. The highway creates a barrier that reduced the sediment flowing into Upper Fountain Creek during the flood events.

6.5.9 U.S. Highway 24 Corridor between Cascade and Rainbow Falls

This reach is characterized by the design and maintenance of Colorado Department of Transportation (CDOT) who has effectively maintained the hydraulic and sediment transport capacity of the mainstem of Upper Fountain Creek in this reach. CDOT responded quickly in the summer of 2013 to address the culvert limitations at the mouth of Waldo Canyon by installing a sediment catchment basin in lower Waldo Canyon, debris collection fences and replacing the previous undersized culverts beneath US24 with a 24' x 10' box culvert.

Below Waldo Canyon, the effects of the flooding in 2013 exposed a historic sediment catchment basin that was installed by the Civilian Conservation Corps in the 1930's. The basin had been filled for many years and was excavated for continued use by EPC in 2014.

Figure 6-8. CCC Designed and Renovated Sediment Catchment above Rainbow Falls

6.5.10 Manitou Springs

Below Rainbow Falls, Upper Fountain Creek flows into Manitou Springs. Significant historic development has resulted in sections of the creek being confined in a walled channel between more natural channel sections. Numerous traffic and pedestrian bridges are in place that limits conveyance during infrequent storm events.

Below US24, Upper Fountain Creek is confined to a steep walled channel with elevated banks that are extensively developed. High flows during the 2013 floods caused some bank erosion in this and the downstream reaches. Contact reference for Manitou Springs coalition membership is included in Appendix A. Significant emergency engineering was performed in lower Williams Canyon in 2013 and 2014 and plans for the emergency action are included in Appendix G.

6.5.11 Colorado Springs

As with the reaches in east Manitou Springs, Upper Fountain Creek flows through a relatively steep walled channel with developed floodplains above 21st Street that exhibit similar degradation as the adjacent upstream reach. Below 21st St., the creek flows between US24 corridor and the tailings piles of Gold Hill Mesa. Colorado Springs made channel and bank improvements within the past 10 years that were partially buried during the floods of 2013. A significant plug of sediment accumulated above the 8th St. crossing that was the result of drainage features below the Gold Mesa tailings became overwhelmed and overtopped the berm between the tailings and Upper Fountain Creek.

6.6 Cheyenne Creek

The flooding on Cheyenne Creek was the result of excessive rainfall on September 12, 2013. The fundamental difference in the flooding condition in Cheyenne Creek and Upper Fountain Creek is in the volume of sediment transported. The Cheyenne Creek watershed has not burned in recent history and the upper portions of the watershed are predominantly under natural conditions. The lower reach (below Evans Ave) has been heavily developed and the channel has been confined to a walled channel in many areas.

6.6.1 North Cheyenne Creek

North Cheyenne Creek was spared significant effects from the flooding 2013 since the most intense rainfall was centered to the south and east, above Cheyenne Mountain and 7-Falls. However, the storms did produce enough rain above North Cheyenne Creek that higher than normal flows destabilized some sections of banks of the reach between the CSU intake structure and the confluence with South Cheyenne Creek.

6.6.2 South Cheyenne Creek

As noted above, the September 2013 storm produced significant amounts of rainfall above the South Cheyenne Creek watershed that contributed the majority of the runoff that affected the neighborhoods of Cheyenne Creek in Colorado Springs. The current study extends to the junction of South Cheyenne Creek Rd and Mesa Avenue. Above the project area, the 7-Falls Resort and EPC have done extensive restoration of South Cheyenne Creek above the project area. A CSU intake structure is located at the gate to 7-Falls on Mesa Ave.

The study reach of South Cheyenne Creek extends downstream to the confluence with North Cheyenne Creek at the Evans Ave crossing and suffered extensive erosion during the 2013 floods. This reach consists of a relatively natural channel and floodplain situated next to South Cheyenne Creek Rd with the floodplain dedicated to recreation with picnic areas and a cycling/walking trail. The planned projects in that reach were designed to maintain the natural channel with stabilized banks and grade control through the use of small drop structures.

6.6.3 Lower Cheyenne Creek

The lower section of Cheyenne Creek between Evans Ave. and the confluence with Fountain Creek suffered more damage from the flooding in 2013 than the North Cheyenne Creek or South Cheyenne Creek. The history of urban development and the historic channeling of the creek over the past 150 years have exacerbated the combined effects of flooding from the two contributing sub basins. The development increased the amount of local runoff as well as decreased the time of concentration for runoff in the lower urban reach.

The effects of the 2013 flood on the urban reach of Cheyenne Creek was mainly borne by the residents that live along Cheyenne Rd and Cheyenne Blvd and the connectors that cross the creek throughout the reach. Many of the bridges had reduced capacity during the flood due to the large amount of debris that collected on the upstream sides of the bridges causing excess inundation and structural flooding of the buildings and residences along the creek. Other deficiencies in curb drainage, especially along Cheyenne Blvd caused many residents to report that the flood waters originated on the hill slopes above the creek and inundated their property as overland runoff.

7.0 Plan Development

7.1 The Planning Process

The path to a comprehensive management plan involving the input of stakeholders, technical experts and citizens at large begins with defining the goals and structure of the plan. The following tasks were developed to define the common goals and establish a level of service that could be achieved with such a master plan.

- Problem Identification – Identified what the stakeholders want addressed by the plan and what types of projects will be addressed. Defines the geographic extents of the study areas.
- Technical Analysis – Identified what data and analyses are required to evaluate the problems and project needs. Identified the appropriate tools and methods to evaluate the results.
- Alternatives Selection – Identified the options available to address the identified problems. This task developed a set of alternatives and restoration techniques to achieve the goals of the coalition in an efficient and effective manner.
- Plan Development – Developed a decision making process to organize, manage, and prioritize projects. This task connects the identified problems and identified solutions into a comprehensive comparison that can help stakeholders and resource managers evaluate their needs with respect to regional needs and objectives.

In order to develop an actionable plan with stakeholder involvement integrated into the project prioritization, the team developed a detailed stakeholder decision making process to facilitate comparisons between numerous similarly ranked projects. The decision making process was used to establish the appropriate projects and criteria to include in each Decision Matrix described in Section 3.1. The decision making process defines the context of the restoration goals and objectives, the core values, critical issues, and evaluation criteria over and above technical analysis and ranking. A diagram of the decision making process can be found in Appendix B.

7.2 Project Team

The project was managed and overseen by Mr. Larry Small, District Executive Director. Engineering and planning consultation was provided by Matrix Design Group, Inc. and its team that included planning expertise provided by THK Associates, Inc., and geomorphology and sediment transport expertise provided by Wildland Hydrology Inc. and Blue Mountain Consultants, LLC. Hydrologic modeling in the Cheyenne Creek watershed was provided by Kiowa Engineering Corporation.

Funds used for the development of the FRMP were provided by a WRP special release grant awarded to the District by the CWCB and matching funds provided by the District and funding stakeholders: City of Colorado Springs, CSU, and EPC. Additional in-kind funds were provided by the remaining members of the Coalition and took the form of data resources for topography and utility location (EPC, CSU) and field survey and QA (CUSP), meeting facilities and coordination (PPACG, Manitou Springs).

7.3 Public Involvement

7.3.1 Stakeholder Input

The District put together a coalition of stakeholders with specific interest in the recovery of the Upper Fountain Creek and Cheyenne Creek. With representatives from Colorado Springs, Manitou Springs, El Paso County, Woodland Park, PPACG, Pikes Peak Regional Building Department, CDOT, and U.S. Forest Service, the coalition has met monthly to discuss the progress of the FRMP and provide a platform for coalition members to voice their needs and concerns, be directly involved with the process and provide project oversight. As the planning process matured and more interested private parties became involved, the coalition grew to include representatives of citizen action groups such as the Cheyenne Creek Metro District, Black Forest Together, and concerned private citizens.

7.3.2 Community Input

The District held a total of six public outreach meetings during the course of the master planning. These were held in tandem at three times during the past year and conducted in open house format where members of the public were invited to participate in the planning process. Since each of the study creeks involves local stakeholders, community groups, and public participants, each community was provided a public forum at the beginning, mid-point and end of the planning process. Meetings were held on July 14th and 15th, December 9th and 10th, and May 12th and 13th.

The open house meetings were chosen to allow face-to-face interaction between coalition members and citizens and allow them to share their flooding experience and voice their concerns. Information was solicited on voluntary comment forms provided to each meeting participant. The initial open houses in July sought input on citizens' flooding experience in 2013 and whether any action had been taken by them or any agency to mitigate the effects of the flooding or future flooding risk.

7.4 Technical Analysis

7.4.1 Data Collection

<u>GIS Data</u>

Detailed planning studies rely heavily on accurate special representations of the watershed's characteristics. The assessment of flooding and the associated erosion and sediment transport is aided by the use of geographical information systems (GIS). GIS is used as a geo-referenced database that facilitates pre and post processing of analytical input data, data control via relational databases and post processing of spatially dependent data to create map products.

Spatial data representing topography, soils classification, meteorology, vegetation, land use, and other physical characteristics of the watersheds is primarily developed and maintained at a moderate resolution by many of the Federal, State, and Municipal land and resource management agencies. Data was acquired from NRCS (soils), NOAA (meteorology), EPC (LiDAR Topography), EPC and City of Colorado Springs, (land use and vegetation). CSU provided GIS resources for the location of utility infrastructure in the study areas via the FIMS database.

Hydrology and Hydraulics Data

The hydrology of the Upper Fountain Creek and Cheyenne Creek watersheds has been estimated for many years and in response to several events. The Fountain Creek Watershed Study (2006) developed the current model tools in HEC-HMS, the U.S. Corps of Engineers comprehensive rainfall-runoff modeling package. Since 2006 both the Cheyenne Creek watershed and Upper Fountain Creek sub models have been developed and updated for additional evaluations. In 2008, Kiowa Engineering Inc. (Kiowa) updated the Cheyenne Creek watershed model to evaluate the regulatory floodplain delineation. The Upper Fountain Creek watershed was also updated in 2013 by Matrix for EPC to reflect the effects of the Waldo Canyon Fire. The data from both updated models provided the baseline conditions for the current evaluations that were further augmented per the 2014 Colorado Springs Drainage Criteria Manual (DCM) as part of this study.

The hydraulic model development was also extended to evaluate the hydraulics of Upper Fountain Creek above the burn scar and below CR21 Bridge in Woodland Park. Data for this model development was acquired from the U.S. Geological Survey (USGS), GIS tools, and from a field survey provided as an in-kind contribution by CUSP.

The hydraulic model for Cheyenne Creek initially developed by Kiowa was also extended to include South Cheyenne Creek between 7-Falls and Evans Avenue. North Cheyenne Creek was also included in the hydraulic analysis between the CSU intake and Evans Avenue. These extended hydraulic models were developed by defining additional cross sections from the EPC LiDAR using GIS tools.

Waldo Canyon Fire Study

The data developed for the Waldo Canyon Fire was incorporated from the 2013 Waldo Canyon Post- Fire Flood Study. This study investigated the changes in the hydrology and subsequent hydraulic analysis resultant of the devastating Waldo Canyon Fire in 2012. That study applied the modeling approach developed for the Colorado Spring Drainage Criteria Manual update and included refined data for soil classifications for regional soils and detailed burn conditions defined by regional post-fire studies for the recent Hayman, Four Mile, and High Park Fires. The current study was developed from the Waldo Canyon Post-fire hydrologic models and the methods developed were also applied to the Cheyenne Creek hydrologic models.

Cheyenne Creek LOMR

In 2008 the City of Colorado Springs contracted Kiowa to update the existing hydrology study and hydraulic analysis in an effort to improve the previous regulatory flood analysis, see Appendix A. Kiowa developed a Cheyenne Creek watershed scaled hydrology model based on the 2006 Fountain Creek Watershed Study (URS).

Matrix contracted with Kiowa to further update the hydrology model to reflect the 2014 DCM update and provide comparable results to the Upper Fountain Creek updated hydrology model. The data from the original model was updated to include changes to the soils Hydrologic Soils Group (HSG) classification and Curve Numbers.

Geomorphic and Sediment Data

Data for the Geomorphic and Sediment Transport analyses was developed from previous studies and field reconnaissance. Matrix contracted Wildland Hydrology Inc. and Blue Mountain Consultants Inc. (Wildland Team) to provide detailed training, modeling and analysis to Matrix. Matrix attempted to collect additional sediment loading data for suspended and bedload sediment yet no appropriate storm event occurred during the study period and therefor, the loading was calculated using data developed for the Waldo Canyon Fire WARSSS report and other regional geomorphic studies.

Field Reconnaissance

Although no Upper Fountain Creek suspended load and bedload sediment samples were acquired, the Wildland Team performed a field survey of the existing conditions of the sections of Upper Fountain Creek that are prone to erosion and supply sediment. The data collected was used to estimate the sediment supply with respect to existing and restored conditions.

Waldo Canyon Fire WARSSS

The Waldo Canyon Fire WARSSS report provided the back ground sediment supply data and methodology for estimating the bankfull sediment discharge. These data were developed from regional fire studies that included empirical studies of sediment supply and transport on reference streams in other burned areas that are similar in nature to the streams flowing from the Waldo Canyon Fire area. The Waldo Canyon Fire WARSSS can be found in Appendix B and online through the EPC website.

U.S. Geological Survey Flood Study

The District cooperated with the USGS on a comprehensive flood study and report, *Remediation Scenarios for Attenuating Peak Flows and Reducing Sediment Transport in Fountain Creek, Colorado, 2013.* This study provided data used to extend the Upper Fountain Creek hydraulic model and provide comparison estimates of Upper Fountain Creek sediment transport.

Colorado Springs Drainage Criteria Manual

The recently updated DCM provides the basis for engineering criteria for the FRMP. Although the study areas include numerous jurisdictions, the DCM was referred to for engineering criteria continuity in the plan. The exception to this was for culvert sizing criteria for El Paso County projects.

EPC

El Paso County provided specific criteria used in culvert sizing for crossings of Upper Fountain Creek in unincorporated County areas. EPC contributed valuable GIS data, high resolution topography, and land use. EPC Assessor provided land ownership data and parcel maps.

7.4.2 Hydrology and Hydraulics

A key element to understanding the effects of flooding throughout a watershed is the hydrology of the watershed. This technical memorandum describes the detailed hydrologic studies conducted on Cheyenne Creek and Upper Fountain Creek that was conducted to assess the amount and characteristics of flood flows, on geomorphic processes such as erosion and sedimentation. On Cheyenne Creek, the technical hydrologic study is related to previous hydrologic and hydraulic evaluations performed for FEMA floodway mapping. On Upper Fountain Creek, the technical hydrologic study is a continuation of the investigations and evaluations developed in the past 2 years to address the conditions that followed the Waldo Canyon Fire. The Waldo Canyon Fire located northwest of Colorado Springs, occurred June 23 through July 10, 2012. The burn area covers 18,247 acres and generally extends north from U.S. Highway 24 to West Monument Creek, and northwest from the Colorado Springs city limits to Rampart Reservoir. The previous Waldo Canyon Post Fire Hydrology Study and the WARSSS projects produced technical methods, tools and results that are the basis for the current technical hydrologic evaluations.

The hydrology was assessed with the aid of a hydrologic model designed to evaluate the discharge and volume of runoff resultant from storm events. The model evaluates the accumulation and dispersal of flows into respective basins and divided the subsequent watershed areas into subbasins exhibiting similar hydrologic characteristics.

The hydrologic model utilizes an estimation of runoff potential based on physical properties of the watershed to calculate the percentage of rainfall that becomes runoff. Model parameters account for slope, soil type, vegetation cover, and percentage of impervious cover, and in the case of post-fire evaluations, degree of soil burn severity (SBS). In addition to the studies referenced above, recent studies have been conducted for the Waldo Canyon fire and High Park fire that provide a guide and reference for understanding the effects of wildfire on hydrology and subsequent sediment supply.

In addition to the attention paid to flooding associated with wildland fires, this study evaluates the effects of the 2013 floods on Cheyenne Creek, a pair of steep rocky basins typical of the Rocky Mountain foothills terrain. The recently approved revisions to the Colorado Springs Drainage Criteria Manual (DCM) recommend improved hydrologic evaluations that were applied to the 2008 hydrologic study performed by Kiowa. Figure 7-1 illustrates the extents of the two study watersheds.

The purpose of this memorandum is to document the detailed analysis completed for Upper Fountain and Cheyenne Creeks including the results of post-fire flood hydrology, and the development and adjustment of hydrologic models used in the evaluation. This effort included updating and adjusting hydrologic models to simulate the rainfall-runoff process and estimate peak stream flows resulting from five, 2-hour design storm events. An additional 24 hour, 100-year uniform rainfall event was simulated to provide an stochastic maximum peak flood. The two hour storms provide intermediate peak discharges with a high likely hood of occurrence, since most of the storm events in the region are short term, locally centered, high intensity storms rather than lower intensity long term regional events. The hydrology for Cheyenne Creek includes a 6-hour storm analysis for comparison to the previous modeling and flood analysis conducted for the City of Colorado Springs by Kiowa.

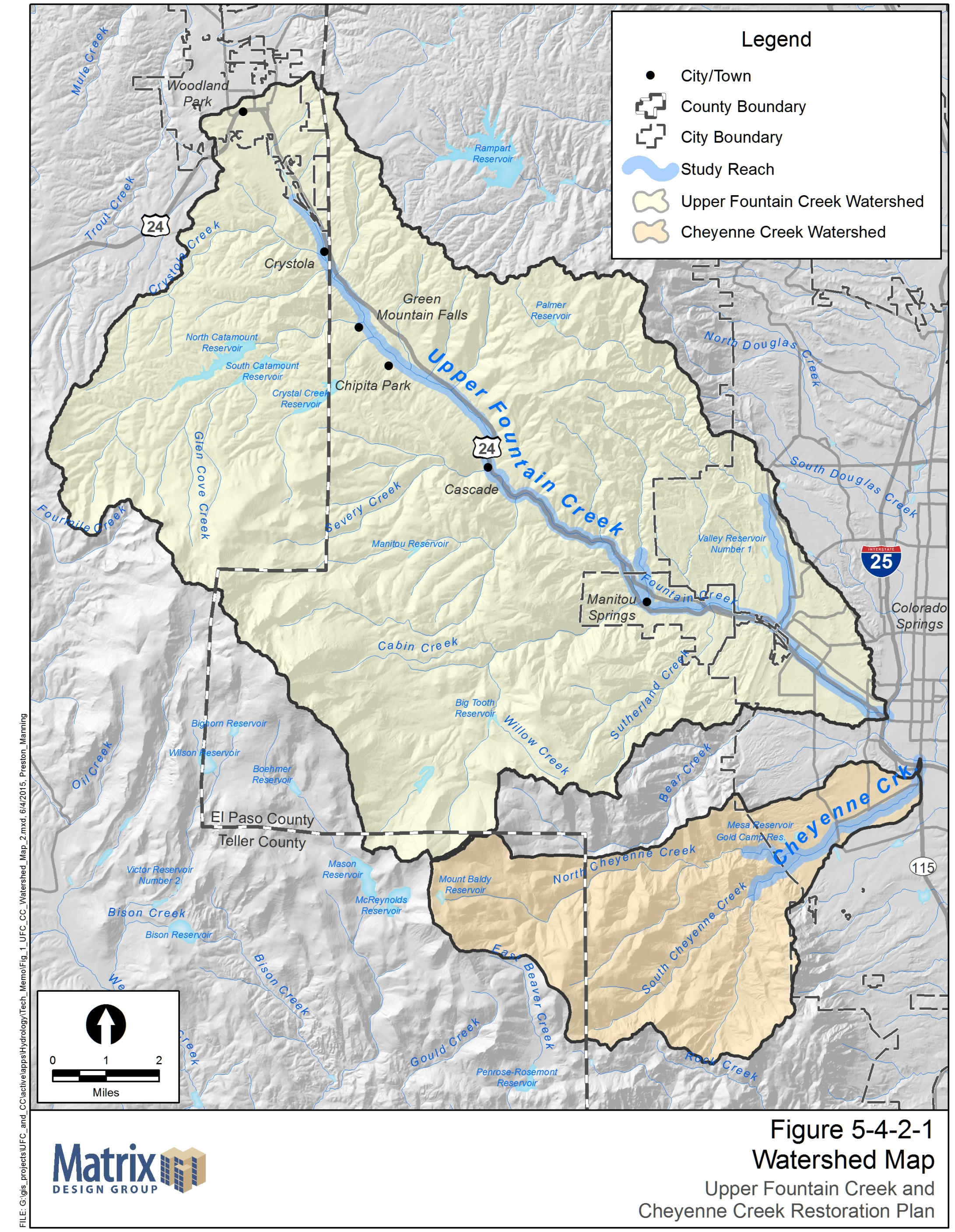

Figure 7-1. Project Watersheds Map Summary of Results

A summary of simulated hydrology results is presented in Table 7-1. More detailed results and comparisons are presented later in this memorandum.

Table 7-1. Upper Fountain Creek Peak Discharge Summary

Model Element	2 Hour Storms 2 Year	5 Year	10 Year	50 Year	100 Year	24 Hour Storm 100 Year	Location
JUF020	65	124	200	480	660	1,080	CR 21
JUF030	80	177	290	740	1,040	1,780	Crystola
JUF040	90	200	340	910	1,300	2,390	Pinecrest Stables
JUF110	110	268	470	1,360	1,970	3,700	Green Mountain Falls
JUF130	120	275	480	1,400	2,030	3,830	Green Mountain Falls
JUF140	145	340	600	1,750	2,540	4,780	Sand Gulch Outfall
JUF150	370	631	940	2,170	3,060	5,610	Rampart Terrace
JUF190	460	801	1,220	2,910	4,070	7,630	Cascade
JUF240	540	966	1,490	3,610	5,030	9,380	US 24 Corridor
JUF250	590	1,071	1,670	4,040	5,620	9,900	US 24 Corridor
JUF260	720	1,317	2,050	4,970	6,900	10,990	Rainbow Falls
JUF340	780	1,476	2,340	5,900	8,280	14,000	Manitou Springs
JUF350	1,160	2,114	3,280	7,890	10,890	16,600	Red Rocks Park
JUF390	1,310	2,432	3,810	9,360	12,970	18,790	33rd St
JUF400	1,450	2,720	4,270	10,470	14,480	20,380	Camp Creek Outfall
JUF460	2,080	3,829	5,980	14,570	20,080	26,370	21st St
JUF470	2,230	4,077	6,380	15,580	21,460	27,650	Gold Hill Mesa
JUF480	2,430	4,417	6,880	16,630	22,830	28,980	Monument Creek

Upper Fountain Creek

The hydrology assessment of the Upper Fountain Creek watershed was improved by updating the 2012 Waldo Fire hydrologic model that estimates the accumulation and routing of stormwater throughout the watershed above the confluence with Monument Creek in Colorado Springs. The Upper Fountain Creek hydrology model was originally developed for the US Army Corps of Engineers (USACE) in 2006. Since then, it has been updated for a number of purposes; most recently by Matrix Design Group, Inc. (Matrix) to assess the effects of the Waldo Canyon Fire on the hydrology of the Upper Fountain Creek watershed.

Additional improvements were incorporated into the hydrologic assessments that had been developed by the City of Colorado Springs in the 2014 update of the DCM (City of Colorado Springs 2014). The methods developed for the Waldo Canyon Fire hydrology study, including the DCM guidelines were similarly applied to the existing Cheyenne Creek hydrology model that was developed by Kiowa in 2008.

Matrix evaluated the flood hydrology for the Upper Fountain Creek watershed and 53 contributing subbasins by developing hydrologic models using the USACE Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) software. The Runoff Curve Number (CN) method was selected to simulate infiltration loss and subsequent runoff potential of soils within each contributing watershed.

The detailed hydrologic modeling consisted of the following steps, which are described in more detail in the sections below:

1. Delineate the Upper Fountain Creek watershed and further divide the watersheds into topographic subbasins with similar hydrologic characteristics.
2. Define the flow paths and relative locations of overland flow, shallow concentrated flow, and channel flow for each subbasin.
3. Estimate pre-fire CN values for each subbasin with respect to soil types, percent of impervious surface and antecedent runoff condition (ARC).
4. Develop Time of Concentration (T_C) and Lag Time (T_L) for each subbasin.
5. Adjust the pre-fire CN values for burned areas based on SBS mapped via BARC process to create the post-fire HEC-HMS model.

Basin Delineation and Flow Path Definition

Matrix acquired high resolution topographic data from El Paso County and used the Geographic Information System (GIS) tools, 3-D Analyst, HEC GeoHMS and ArcHydro, to define the extents of the subbasins. GeoHMS and ArcHydro are processing tools for geospatial hydrologic analysis that operate in a GIS environment. Topography is represented by a Digital Elevation Model (DEM) that are processed to calculate basin characteristics and parameter estimates that are imported into the HEC-HMS model. Further manual refinements were required to account for site-specific features such as storm drains, city streets, parking lots, and desired design points (such as Sand Gulch outfall). The Upper Fountain Creek watershed encompasses and area of approximately 118 square-miles and the updated hydrologic model includes 53 subbasins. Figure 7-2 illustrates the watershed and subbasin delineation.

Additional detail was added to the subbasin delineation with the inclusion of detailed subbasins of Sand Gulch, Wellington Gulch, Fern Gulch, Cascade Gulch, and Waldo Canyon. The subdivision of these subbasins increases the model resolution and provides more explicit results for those subbasins that were burned during the Waldo Canyon Fire.

Flow paths were defined for each subbasin to represent the combined routing of overland, shallow concentrated, and channel routing features. GeoHMS and ArcHydro stream delineation tools were used to define the longest flow path and other physical characteristics of each subbasin (slope, channel width, side slopes of channels). The spatial stream and subbasin delineation data was used to calculate the temporal parameters T_C and T_L that represent the hydrologic response of each subbasin. CN, T_L, and T_C for the additional subbasins and the remainders of the original "parent" subbasins were recalculated from the source data. The hydrographs and discharges at the key design points for each subdivided subbasin matched the hydrographs and discharges for the same locations in the Waldo Fire model.

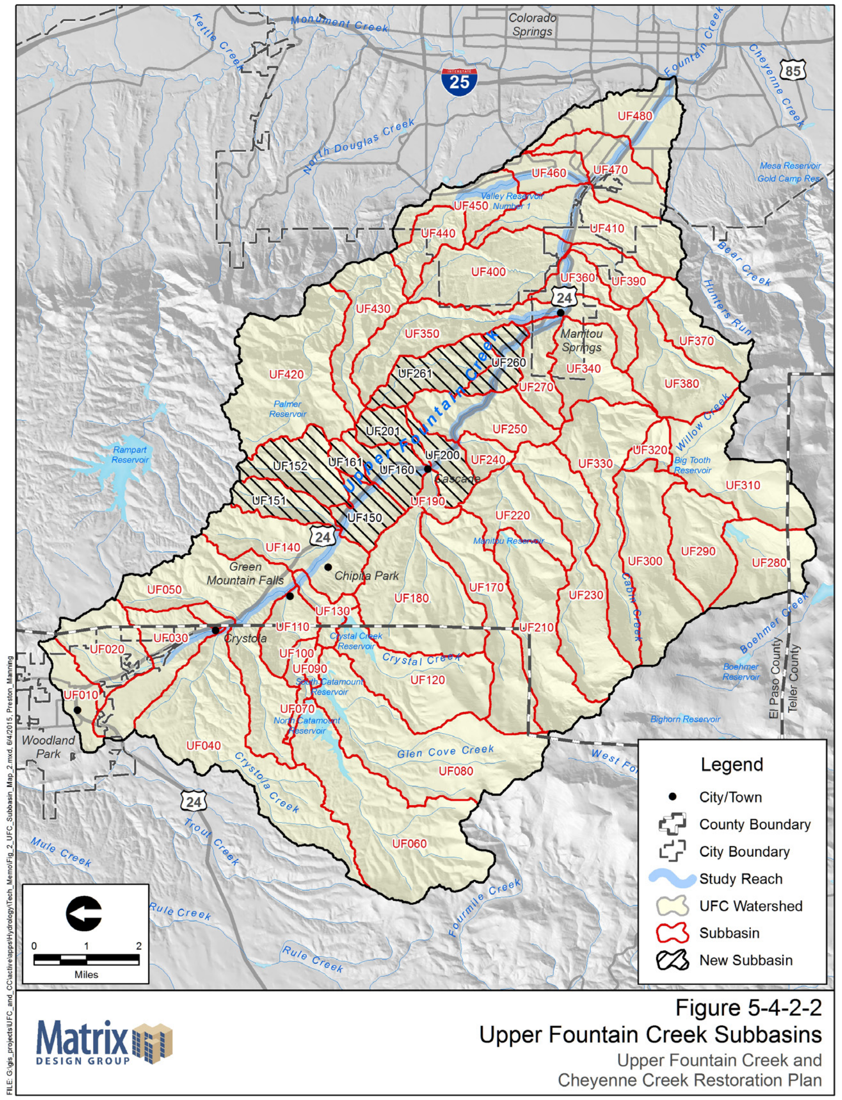

Figure 7-2. Upper Fountain Creek Subbasins

Hydrologic Model Development

The Upper Fountain Creek hydrology model was developed to calculate the amount of anticipated runoff and the time it takes for that runoff to accumulate in the drainage network of the watershed. The analyses incorporated updated design rainfall depths, improved hydrologic soil information, and results from other hydrologic studies of the Upper Fountain Creek, Waldo Canyon Fire burn area and Pikes Peak regional watersheds.

Per the revised DCM, Matrix selected the 2-hour design storm to represent the rainfall distribution. This synthetic storm applies 112% of a 1-hour rainfall depth over 2 hours, with 100% of the rainfall depth applied in the first 60 minutes and the remaining 12% applied over the second 60 minutes. To account for orographic effects, the 1-hour rainfall depths were obtained at the centroid of each subbasin from the *2013 National Oceanographic and Atmospheric Administration (NOAA) Rainfall Atlas 14*. Figure 7-3 illustrates the distribution of rainfall across the Upper Fountain Creek Watershed.

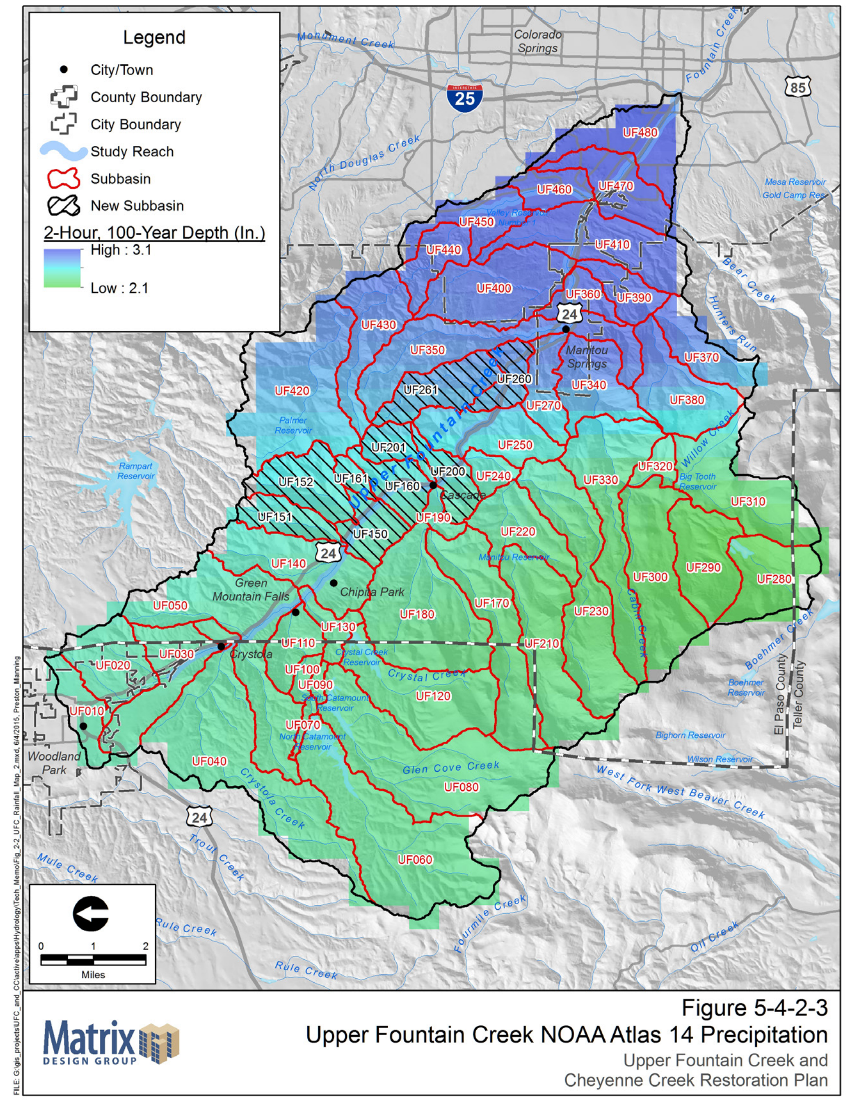

Figure 7-3. Upper Fountain Creek NOAA Atlas 14 Precipitation

Table 6-8 of the revised DCM recommends that significant areas of the watersheds be reclassified into a different Hydrologic Soil Group (HSG) than the original NRCS classification. Specific soils were historically classified as HSG 'D' soils with high runoff potential were modified to HSG 'B' with moderate-low runoff potential following detailed review of the hydrologic properties of the soils in the Pikes Peak area. The CN values for these areas were adjusted to reflect the change in HSG classifications. Figure 7-4 illustrates the extents of the HSG soil classifications in the Upper Fountain Creek watershed.

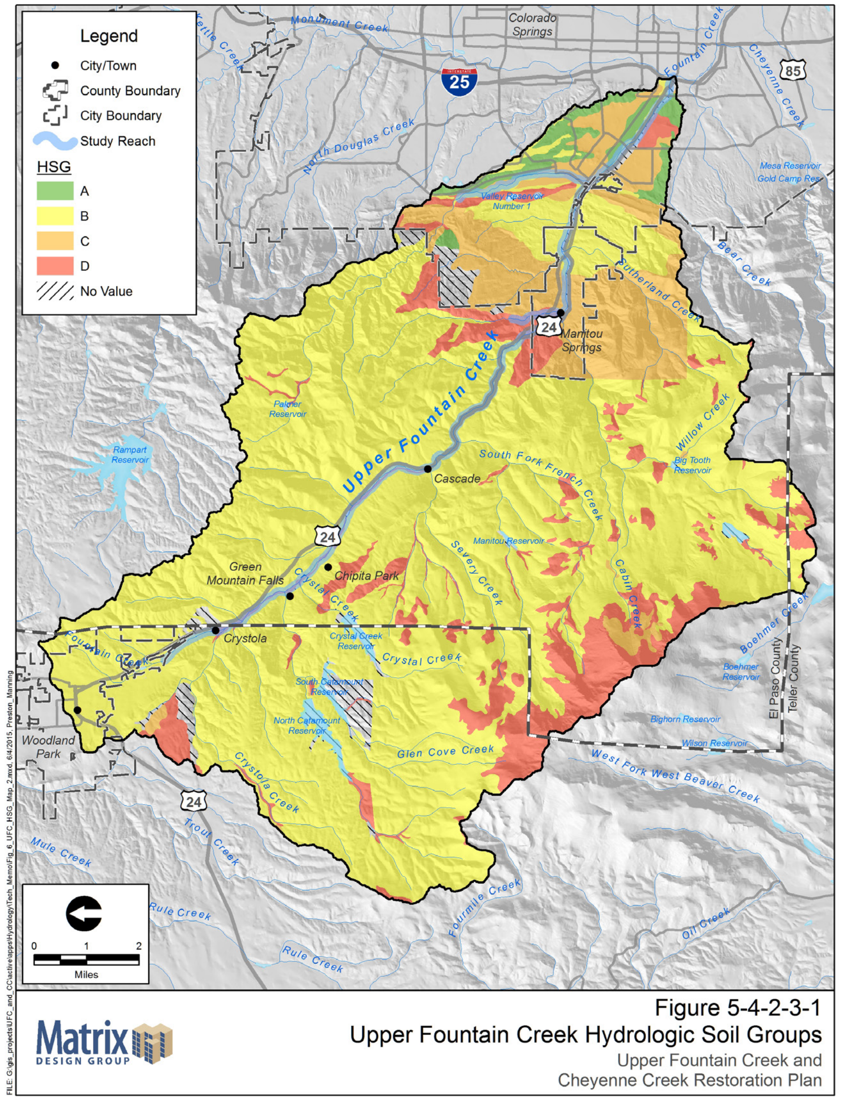

Figure 7-4. Upper Fountain Creek Hydrologic Soils Groups

Composite CN values were calculated for each subbasin using updated soils data spatially evaluated in GIS. The CN values were calculated to account for ARC1. ARC1 assumes that the soil is dry at the beginning of the simulation and a greater percentage of the rainfall will infiltrate the soils at the onset of the model. The result is that a lower CN is applicable for ARC1. This assumption is based on hydrologic modeling of the Upper Fountain Creek watershed that was done for the previous Waldo Fire Study that adjusted the CN and initial abstraction (Ia) values to the USGS flow gage *Fountain Creek near Colorado Springs, CO (USGS Gage 07103700).*

Table 7-2. CN Adjustments for Reclassified Soils

Source	Watershed Average CN
FCWS	72
Matrix – Modified for HSG B Soils (ARC II)	66
Matrix – Modified for HSG B Soils (ARC I)	47

Post-fire Hydrology Model Adjustments

Waldo Canyon Fire burn area was studied by the U.S. Forest Service Burn Area Emergency Response (BAER) team with support from the USGS in July and August of 2012. The BAER team produced a field-based soil burn severity (SBS) map dated July 14, 2012 and a post-fire hydrology report dated July 16, 2012. A more detailed burn map was released on August 2, 2012 with improved satellite remote sensing and burned area reflectance classification (BARC) processing. The BARC data revealed an average SBS classification of "low" to "moderate". The fire burned inconsistently, however, resulting in intermixed patches of severe burn and unburned areas throughout. The results of the BAER team report were evaluated with respect to soil conditions and comparison of hydrologic results.

The Upper Fountain Creek hydrology model was modified to represent the hydrologic conditions that resulted from the Waldo Canyon Fire. The adjustments required to represent the post-fire conditions were increased CN values for burned areas based where higher discharges have been observed since the fire. The arguably secondary effect of the fire on Upper Fountain Creek and its tributaries has been a significant increase in the amount of sediment that is migrating from the higher elevations. Although the effects of the fire on the hydrology in the burn area is not thoroughly understood and specific published estimates of burn effects on CN are limited, Matrix reviewed several recent documents containing post-fire CN information including:

- Waldo Canyon Fire BAER Assessment Appendix A: Design Flow Runoff Response (Moore and Park 2012),
- High Park Fire: Increased Flood Potential Analysis, NRCS (Yochum 2012), and
- Final Summary of Findings – Fourmile Canyon Post-fire Hydrology and Discussion of Conceptual Mitigation Measures, (WWE 2011).

The runoff potential increased in burned areas because losses to infiltration, evapotranspiration, and canopy capture are significantly reduced after a fire. For subbasins with burned areas, CN values were adjusted based on the SBS and percentage of area burned. Figure 7-5 illustrates the SBS distribution in the Upper Fountain Creek watershed.

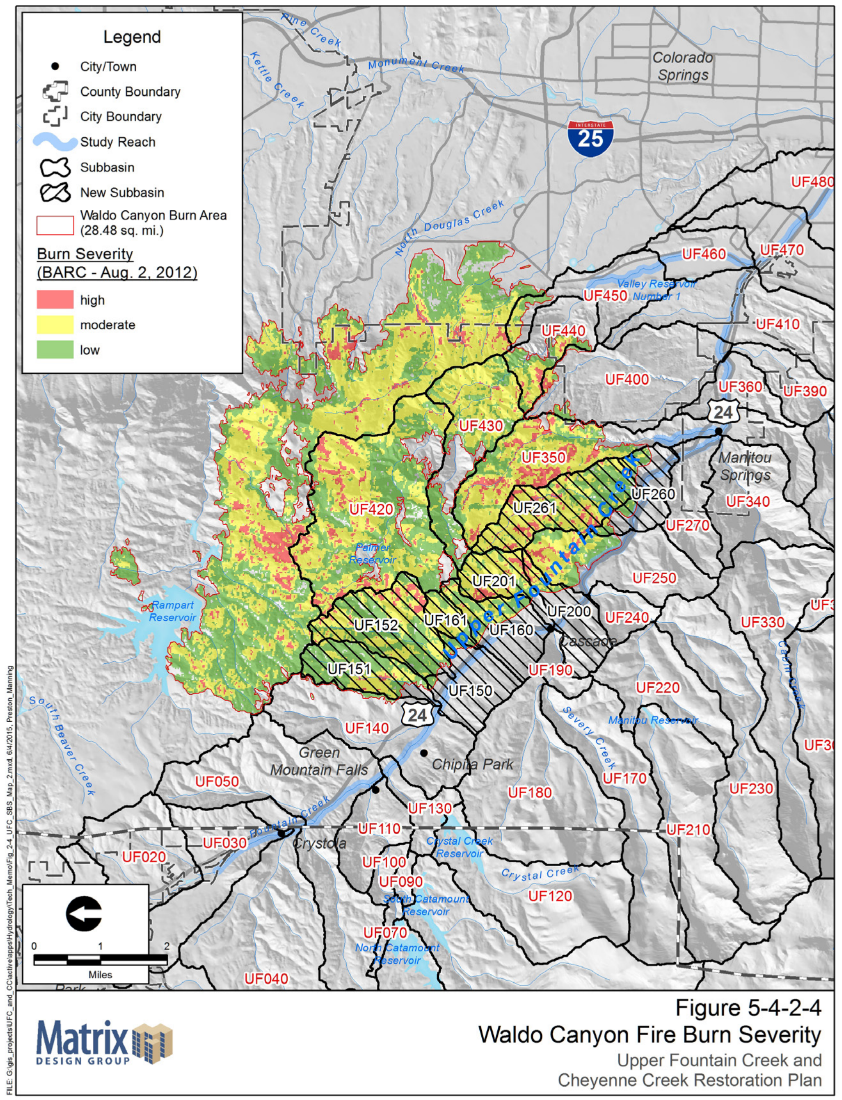

Figure 7-5. Waldo Canyon Fire Burn Severity

Burn Area Curve Number Adjustment

The method comparison of previous post-fire hydrology studies led Matrix to conclude that the Waldo Canyon Fire BAER and High Park Fire NRCS reports utilized nearly identical post-fire curve numbers for ponderosa pine forest. Additionally, for the previous Waldo Canyon post-fire hydrology model, Matrix adopted the BAER report recommendation to replace high SBS curve numbers for moderate SBS areas. This recommendation had been made to account for the anticipated increased hydrologic response from severe vegetation burn that may not be reflected in the moderate soil burn severity data. As figure 7-5 illustrates, the majority of the Upper Fountain Creek watersheds are classified as moderate burn severity. The BAER recommendation was not applicable to the Upper Fountain Creek watersheds due to the large percentage of moderate burn area and since the use of high SBS CN's would skew the discharge estimates to unreasonable levels. The moderate SBS CN's would best represent the runoff potential for the moderately burned areas of the Upper Fountain Creek watershed. Burn area CN values per HSG classification are presented in Table 7-3. Figure 7-6 illustrates the post-fire CN values applied in the Upper Fountain Creek Restoration Master Planning hydrology evaluation.

Table 7-3. Burn Area Curve Number Selection

Post-Fire CN Selection For Waldo Canyon Fire Study - Douglas Creeks				
Post-Fire CN Source	Hydrologic Soils Group	Burn Severity		
		Low	Medium	High
Previous Post-Fire Hydrology Studies Highpark Fire and BAER Report	A	45	65	77
	B	66	75	86
	C	80	80	89
	D	85	90	92

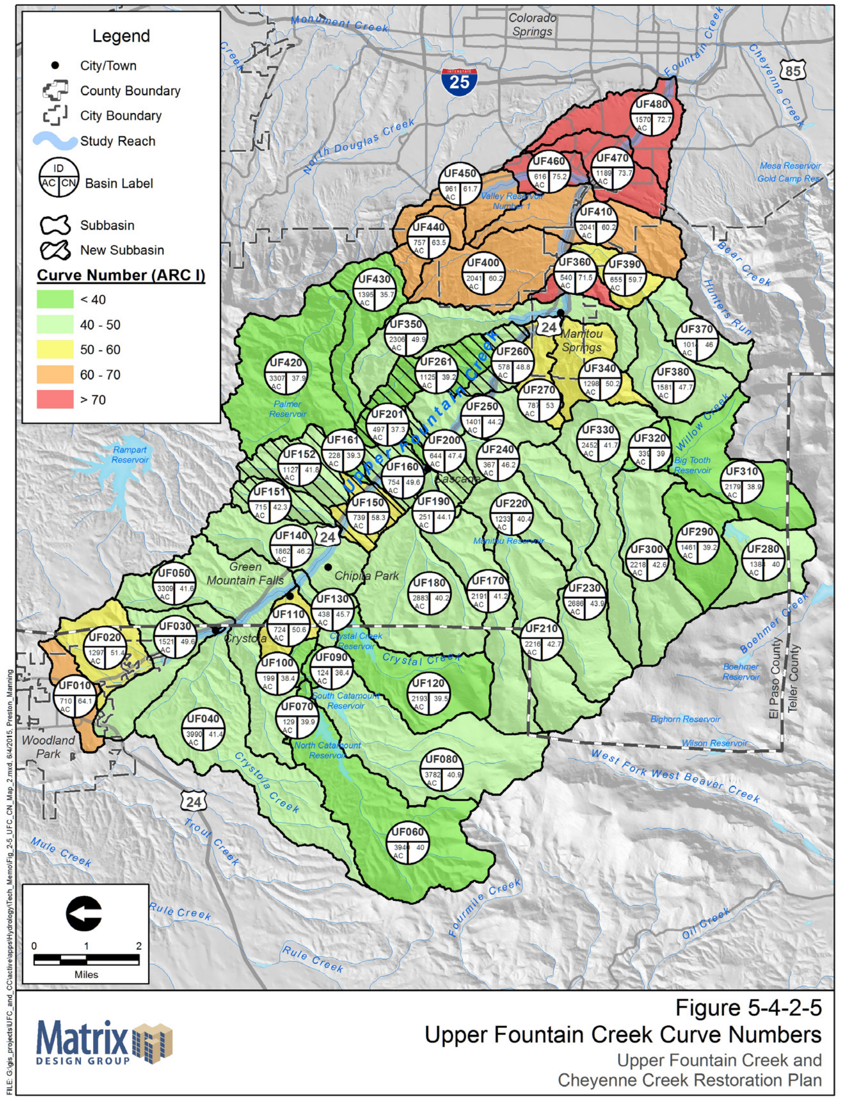

Figure 7-6. Upper Fountain Creek Curve Numbers

Hydrology Results

Table 7-4 presents the simulated post-fire hydrology results for clear water flows at select locations. These results present a range of discharges that are expected from the 2 hour storm with predictable probabilities of annual recurrence of 50%, 20%, 10% 2%, and 1%. (2-yr, 5-yr, 10-yr, 50-yr, and 100-yr storms). Additionally, the SCS method that simulates the discharge resulting from the 24 hour storm with a 1% recurrence probability (100-yr recurrence interval) was included to provide an upper limit to the range of predictable discharges. The hydrology modeling results are found in Appendix C.

Table 7-4. Upper Fountain Creek Discharges at Select Locations

Model Element	2 Hour Storms					24 Hour Storm	Location
	2 Year	5 Year	10 Year	50 Year	100 Year	100 Year	
JUF020	65	124	200	480	660	1,080	CR 21
JUF030	80	177	290	740	1,040	1,780	Crystola
JUF040	90	200	340	910	1,300	2,390	Pinecrest Stables
JUF110	110	268	470	1,360	1,970	3,700	Green Mountain Falls
JUF130	120	275	480	1,400	2,030	3,830	Green Mountain Falls
JUF140	145	340	600	1,750	2,540	4,780	Sand Gulch Outfall
JUF150	370	631	940	2,170	3,060	5,610	Rampart Terrace
JUF190	460	801	1,220	2,910	4,070	7,630	Cascade
JUF240	540	966	1,490	3,610	5,030	9,380	US 24 Corridor
JUF250	590	1,071	1,670	4,040	5,620	9,900	US 24 Corridor
JUF260	720	1,317	2,050	4,970	6,900	10,990	Rainbow Falls
JUF340	780	1,476	2,340	5,900	8,280	14,000	Manitou Springs
JUF350	1,160	2,114	3,280	7,890	10,890	16,600	Red Rocks Park
JUF390	1,310	2,432	3,810	9,360	12,970	18,790	33rd St
JUF400	1,450	2,720	4,270	10,470	14,480	20,380	Camp Creek Outfall
JUF460	2,080	3,829	5,980	14,570	20,080	26,370	21st St
JUF470	2,230	4,077	6,380	15,580	21,460	27,650	Gold Hill Mesa
JUF480	2,430	4,417	6,880	16,630	22,830	28,980	Monument Creek

7.4.3 Cheyenne Creek

The extensive flooding that occurred in the Cheyenne Creek watershed in September of 2013 has prompted the City of Colorado Springs to address the complex problem of heightened flood risk for urban areas below drainage basins in the foothills. The hydrology and hydraulic response of Cheyenne Creek was studied in detail by Kiowa in 2008. Following the flooding of 2013, Colorado Springs requested an update to the hydrology evaluation to incorporate the changes specified in the 2014 DCM and applies the methods and parameter assessments used in the recent updates of the Upper Fountain Creek post Wald Canyon Fire hydrology studies. Figure 7-7 identifies the extent of the Cheyenne Creek Watershed.

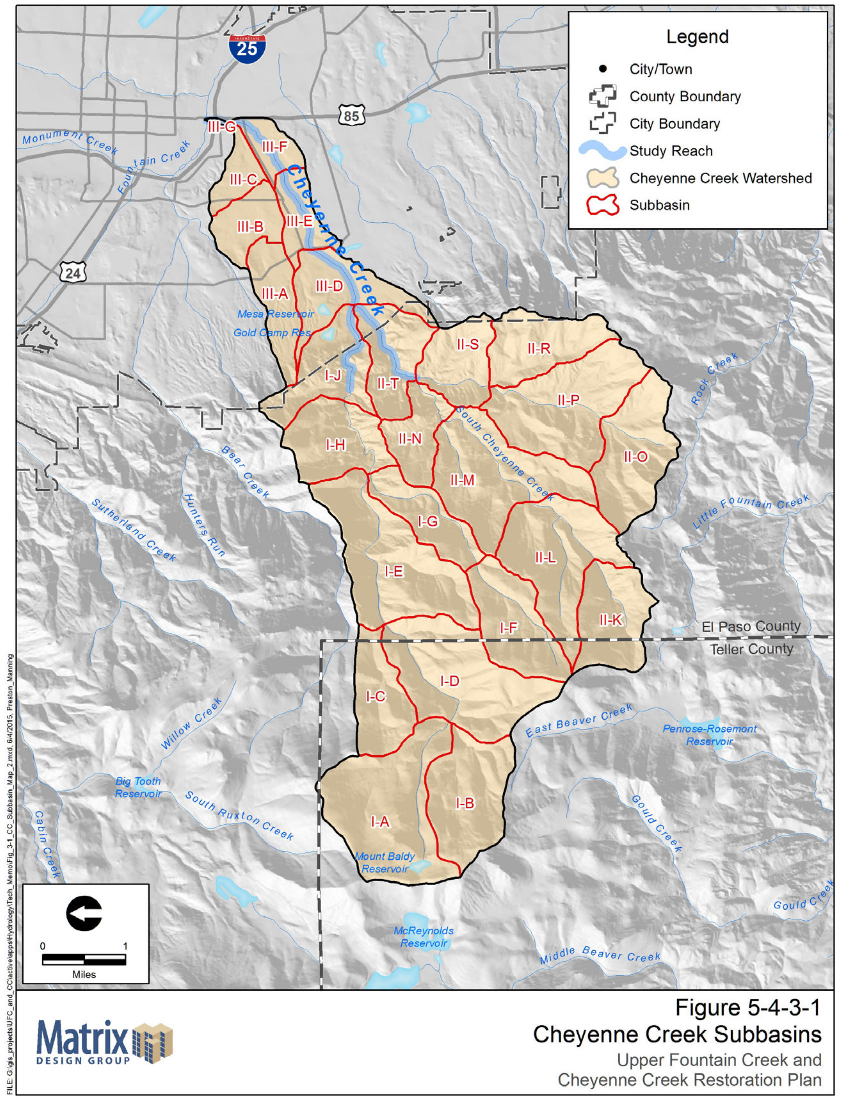

Figure 7-7. Cheyenne Creek Subbasins

The 2008 Kiowa study was completed to provide a revision to the FEMA Flood Insurance Study (FIS) and includes a hydraulic analysis of the reach of Cheyenne Creek between Evans Avenue and the confluence with Fountain Creek. The 2008 discharge estimates, flood profiles and inundation maps were approved by FEMA and will be represented on the pending Digital Flood Insurance Rate Map (DFIRM). The Kiowa study estimated the peak discharge at Fountain Creek resulting from the 100-year rainfall event in Cheyenne Creek to be approximately 8850 cubic feet per second (cfs). This is a reduction from the 1976 FEMA FIS discharge estimate of 13,300 cfs. A reference to Kiowa's 2008 hydrology report and revised FIS FIRM plates are included in Appendix A.

Kiowa performed a detailed hydrologic evaluation of the Cheyenne Creek watershed with HEC-HMS and applied the CN method to estimate hydrologic response from design storms with uniform rainfall distribution. Per the former City of Colorado Springs DCM the rainfall depths were derived from NOAA's Atlas 3 Vol III and the temporal distribution was Type IIA, developed to improve representation of the orographic effects in the Front Range of the Rocky Mountain west. This distribution is no longer recommended by NOAA and the 2014 DCM recommends the use of a Type II distribution for analyses in Colorado Springs and the vicinity. Figure 7-8 illustrates the updated Type II rainfall distribution used for the current Cheyenne Creek hydrologic evaluation.

The 2014 DCM also recommends a reclassification of the soils in the Cheyenne Creek watershed that required that dependent model parameters, CN and Ia be adjusted. The resulting updated hydrology mimics the methodology and subsequent technical analysis that was developed for Upper Fountain Creek during the Waldo Canyon Post Fire Hydrology Study in 2013.

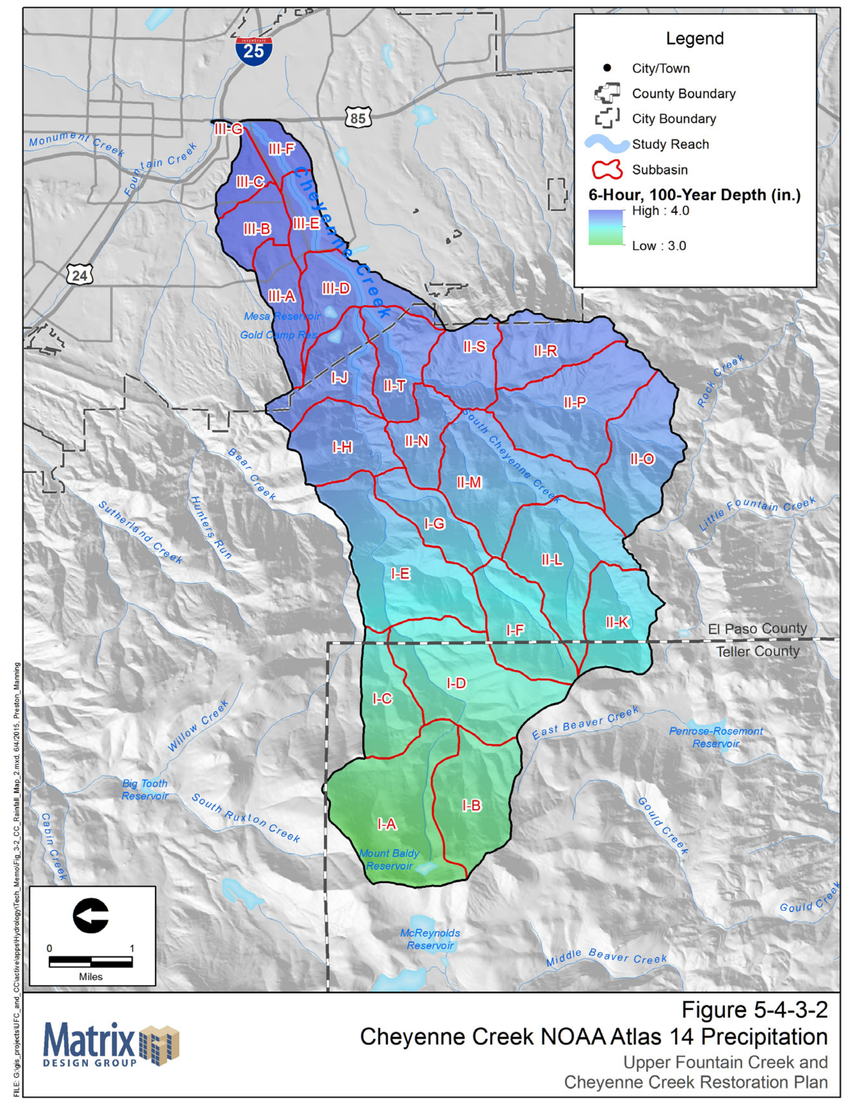

Figure 7-8. Cheyenne Creek NOAA Atlas 14 Precipitation

At the request of the City, the current flood recovery planning efforts include evaluation of the hydrology and hydraulics of the Cheyenne Creek to determine the effects of the changes to evaluation methods that incorporate the revised recommendations of the 2014 DCM. Matrix contracted with Kiowa to perform a series of model parameter updates on the 2008 HMS model to address the recommendations of the 2014 DCM. The updates involved the aforementioned change to the rainfall distribution (Type IIA to Type II) and the application of CN's derived from the HSG reclassification of the watershed soils. Further HEC-HMS model adjustments were made that applied the Ia values developed during the previous model calibration of the Waldo Canyon Post Fire Hydrology Study.

Rainfall Estimate

Since Kiowa designed the 2008 study to evaluate the regulatory FIS flood study and recommend changes to the FIS FIRM maps, they were afforded some assumptions relevant to that type of study. The current evaluation attempts to build on that study while incorporating the updates in the 2014 DCM. For the current study, three fundamental adjustments were made to the way rainfall is accounted in the 2008 Kiowa evaluation.

- Uniform rainfall: Kiowa the same rainfall depth throughout the watershed. The current study evaluated rainfall depths for each individual subbasin.
- Type II vs Type IIA distribution: The temporal distribution of the rainfall was adjusted per NOAA and DCM recommendations.
- Rainfall depths: NOAA Atlas 14 has refined the design storm rainfall depth estimates for the standard recurrence interval storms.

Curve Number Estimates

The 2008 Kiowa FIS estimated CN's by evaluating the land use and soils of the individual subbasins included in the HEC-HMS model. By breaking down the land use into poor, fair and good classification of vegetative cover, Kiowa was able to estimate site specific conditions for each subbasin. The soil classification preceded the work done by the City that reclassified the soil types and so the HSG components were primarily described as HSG D soils per the NRCS soil survey for El Paso County. Kiowa based the CN estimates on the NRCS HSG classification and adjusted the estimates based on their land use evaluation. The 2008 Cheyenne Creek watershed and NRCS HSG distribution is shown on Figure 7-9.

The 2014 evaluation applied CN estimates that were based on the 2014 revised DCM HSG reclassification with a uniform land use classification for ponderosa pine for the upper natural subbasins of the watershed. This reclassification affected many of the soils previously classified as HSG C and HSG D soils to HSG B soils as indicated on Figure 7-10 and the reclassified soils distribution is shown on Figure 7-11. The effect of the HSG reclassification is greater infiltration on HSG B soils than on HSG C and D soils. This in turn results in a reduction of the percentage of rainfall that becomes runoff from those soils.

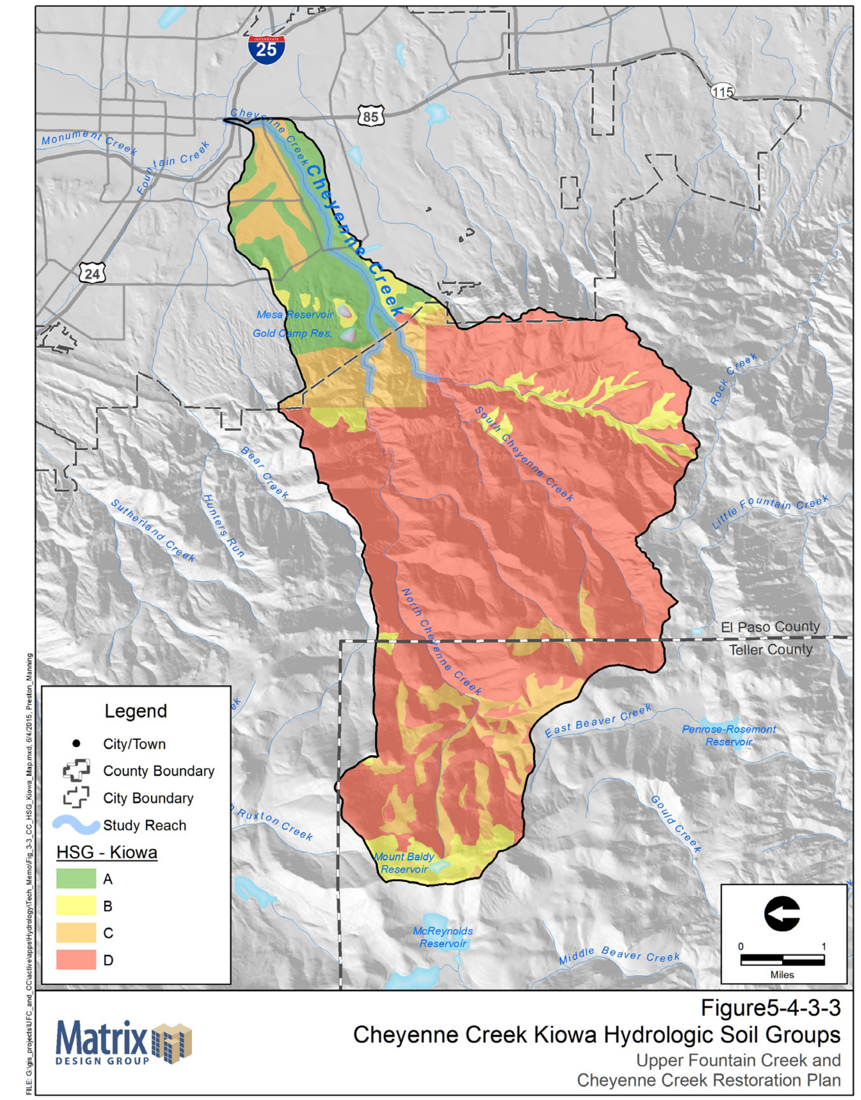

Figure 7-9. Cheyenne Creek Kiowa Hydrologic Soils Groups

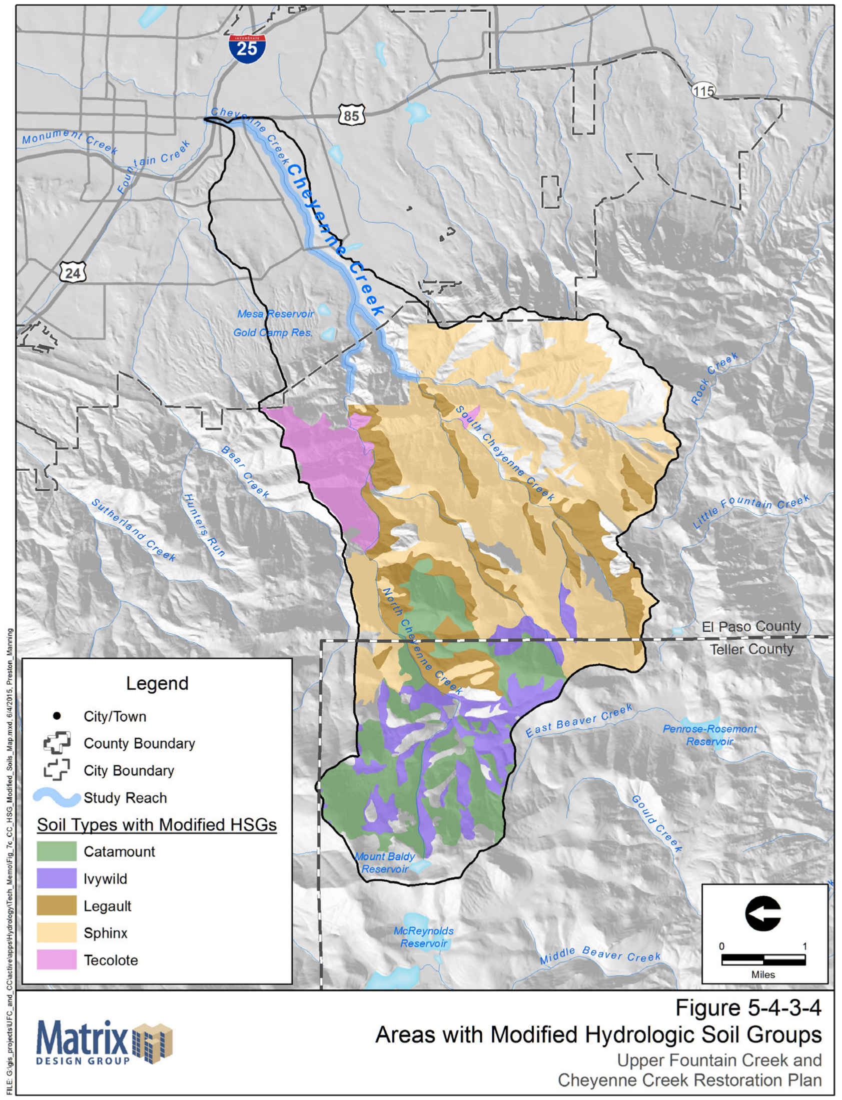

Figure 7-10. Areas of Cheyenne Creek with Modified Hydrologic Soils Groups

The result of the reclassification of soils on the CN values was significant for the soils in the upland portion of the watersheds where natural soil conditions prevail. In the urban areas, the former FCWS CN's were applied to maintain conformity with the Upper Fountain Creek hydrology evaluation. The CN differences between the 2014 Matrix evaluation and the 2008 Kiowa evaluation is shown in Table 7-5.

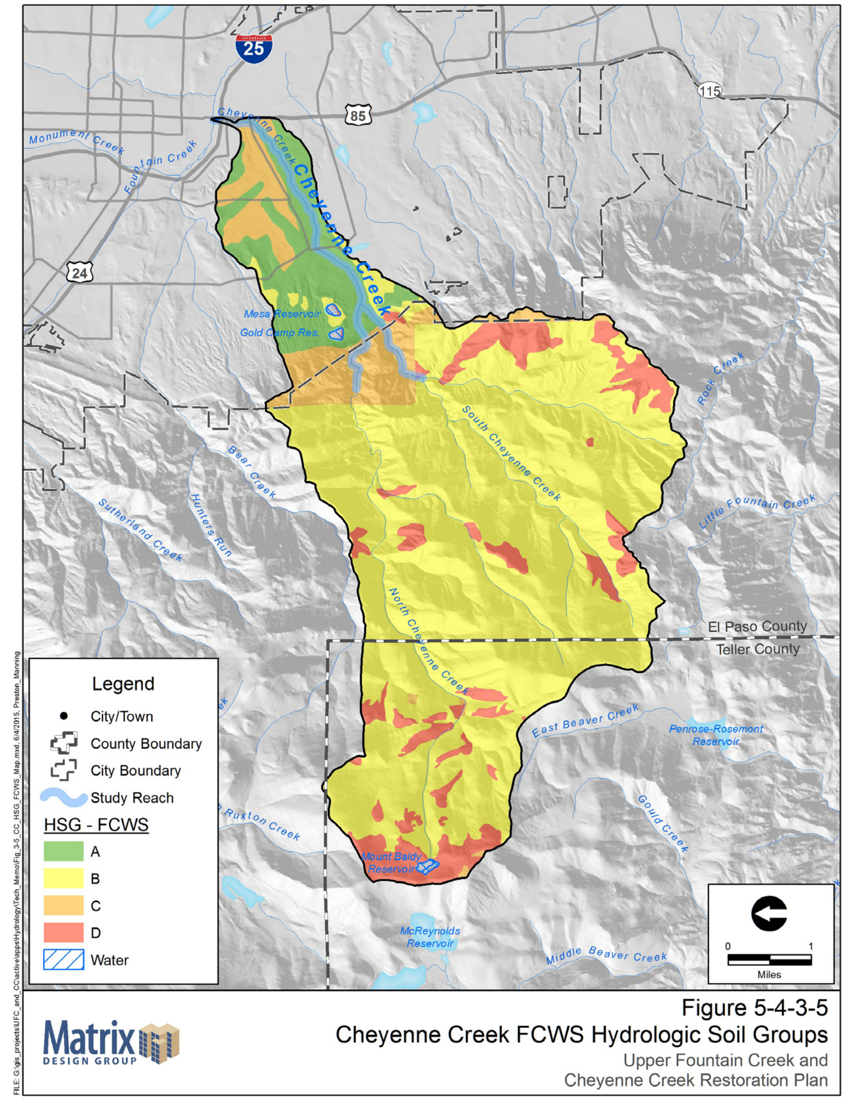

Figure 7-11. Cheyenne Creek FCWS Hydrologic Soils Groups

Additional Parameter Adjustments

In an effort to create comparable hydrology evaluations for both Cheyenne Creek and Upper Fountain Creek, further adjustments were made in the Cheyenne Creek model in the representation of ARC in the CN values. ARC represents the moisture condition of the soils at the onset of the runoff calculation. Under ARC1, the ground is dry and has a high capacity to absorb runoff; as a result, the runoff potential represented by lower CN's is greatly reduced along with the subsequent simulated flows and runoff volumes. In 2008, Kiowa's ARC estimates were evaluated for each CN approach although the dry antecedent condition, ARC1, was found to produce minimal runoff and therefore was not applied in the Kiowa evaluation.

Further adjustments to Ia values are recommended by the 2014 DCM and have been applied in the Upper Fountain Creek hydrology evaluation. The short duration storms are more common in these Front Range watersheds and therefore the evaluations have focused on the shorter duration storms. These shorter storms preclude the use of ARC1 as the most realistic antecedent runoff condition. The 2014 DCM recommends using an Ia that fine tunes the role of ARC1 in the HEC-HMS modeling and produces runoff in Cheyenne Creek under ARC1. Since Kiowa calculated flows and discharge volumes under ARC2 CN's however , to evaluate the effects of the parameter changes recommended by the DCM and NOAA, the results of the ARC2 CN are presented separately from the ARC1 CN results.

Table 7-5. Curve Number Estimates

Basin Name	Basin Area (Ac)	CN Matrix 2014 (ARC2)	CN Kiowa 2008 (ARC2)	ARC 2 Difference 2014-2008	CN Matrix 2014 (ARC1)	CN Kiowa 2008 (ARC1)	ARC1 Difference 2014-2008
I-A	1312.4	65.0	69.2	-4.2	44.5	59.2	-14.7
I-B	820.9	63.1	68.4	-5.3	42.2	58.4	-16.2
I-C	521.4	61.0	57.8	3.2	39.8	47.8	-8.0
I-D	1187.9	60.8	61.2	-0.4	39.6	51.2	-11.6
I-E	1226.4	61.0	65.9	-4.9	39.8	55.9	-16.1
I-F	684.2	60.6	61.2	-0.6	39.3	51.2	-11.9
I-G	462.7	62.4	60.2	2.2	41.1	50.2	-9.1
I-H	623.8	57.0	63.5	-6.5	35.9	53.5	-17.6
I-J	609.8	66.8	60.8	6.0	47.5	87	-39.5
II-K	629.9	62.4	66.3	-3.9	41.1	43.6	-2.5
II-L	1012.3	62.2	62.5	-0.3	40.9	47.9	-7.0
II-M	1108.5	60.7	57.2	3.5	39.4	51.3	-11.9
II-N	391.0	61.8	56.5	5.3	40.4	49.3	-8.9
II-O	803.2	61.7	58.6	3.1	40.6	68.7	-28.1
II-P	1089.0	61.1	53.6	7.5	40.1	67.3	-27.2
II-R	594.4	65.1	53.6	11.5	44.2	41.4	2.8
II-S	484.5	65.4	57.9	7.5	44.9	46.7	-1.8
II-T	542.1	65.2	61.3	3.9	45.2	61	-15.8
III-A	420.5	64.2	59.3	4.9	48.0	50.8	-2.8
III-B	352.1	86.2	78.7	7.5	74.7	56.3	18.4
III-C	217.3	89.1	77.3	11.8	78.8	52.5	26.3
III-D	574.6	65.7	51.4	14.3	50.3	47.2	3.1
III-E	305.6	81.4	56.7	24.7	67.0	46.5	20.5
III-F	226.1	88.1	71.0	17.1	77.2	48.6	28.6
III-G	13.0	93.9	94.0	-0.1	87.2	43.6	43.6

Cheyenne Creek Hydrology Results

For comparison purposes, Matrix looked at the model results for flow and runoff volume at two primary design points, Evans Avenue and the outfall at Fountain Creek. Kiowa's FIS study reported flows and volumes for the 6-hour storm with a 1% recurrence probability (100-yr. 6-hr storm). Hydrology results for Cheyenne Creek are tabulated in Appendix C.

Revised Curve Number and Rainfall Distribution

Table 7-6 presents the discharge and runoff volume estimates for the two soils/CN configurations, NRCS CN (Kiowa 2008) and DCM CN (City of Colorado Springs 2014) at Evans Ave. Table 7-7 presents the same comparative information calculated at the Cheyenne Creek confluence with Fountain Creek.

Table 7-6. ARC2 Discharge and Runoff Volumes computed at Evans Ave.

100-yr, 6-hour Storm at Evans Ave			
ARC 2 (Wet)	Type II - 2014 DCM	Type IIA - 2008 DCM	Sensitivity to Rainfall (%)
Discharge (cfs)			
NRCS CN - 2008	7,045	8,345	-18.5
DCM CN - 2014	7,035	8,230	-17.0
Sensitivity to CN (%)	-0.1	-1.4	
Volume (in)			
NRCS CN - 2008	0.70	0.57	18.6
DCM CN - 2014	0.73	0.59	19.2
Sensitivity to CN (%)	4.1	3.4	

Table 7-7. ARC2 Discharge and Runoff Volumes computed at Fountain Creek

100-yr, 6-hour Storm at Fountain Creek			
ARC 2 (Wet)	Type II - 2014 DCM	Type IIA - 2008 DCM	Sensitivity to Rainfall (%)
Discharge (cfs)			
NRCS CN - 2008	7,470	8,845	-18.4
DCM CN - 2014	8,260	9,770	-18.3
Sensitivity to CN (%)	9.6	9.5	
Volume (in)			
NRCS CN - 2008	0.71	0.59	16.9
DCM CN - 2014	0.83	0.70	15.7
Sensitivity to CN (%)	14.5	15.7	

The comparison of the ARC2 results indicate that there was a slight decrease in peak discharge flowing from North and South Cheyenne Creeks as a result of the modification of the CN values for those areas with modified soil HSG classifications under ARC2. This effect though is negated by the revised CN's for the urban subbasins below Evans Ave. The land use derived CN estimate applied in the 2014 DCM update was based on the 2006 Fountain Creek Watershed Study (FCWS) land use designation. Kiowa used land use data derived from the USGS sources and does not include the detailed land use designations applied in the FCWS. The result is higher CN's for the urban subbasins in the 2014 revision and subsequent increase in runoff and discharge from the urban areas of the Cheyenne Creek watershed.

The other primary parameter effecting the peak and volume of runoff is the rainfall depths. As the results above indicate, the additional volume of runoff is substantial at both locations and the relative increase in volume is consistent throughout. At both Evans Ave and Fountain Creek, the discharge is reduced approximately 16-18% with the Atlas 14 depths and Type II distribution. This is congruent with a significant increase in the volume of runoff volume. Therefore, the runoff is spread out across a longer hydrograph than with the previous Atlas 2, Type IIA distribution.

The primary modifications to the Cheyenne Creek HEC-HMS model produced an increase in runoff volume with a corresponding reduction in peak discharge. The updated rainfall depths and distribution produces approximately 20% more runoff at Evans Ave and 17% more runoff at Fountain Creek with an approximately 18% drop in peak discharge from the 2008 analyses.

Revised ARC condition and Initial Abstraction

Comparison of results with respect to ARC conditions are indicated in Tables 7-8 and 7-9. These results compare the discharge and volume simulated with 2014 DCM CN for ARC1 and the 2014 DCM CN for ARC2.

Table 7-8. ARC1 vs ARC2 Discharge and Runoff Volumes computed at Evans Ave.

100-yr, 6-hour Storm at Evans Ave			
	Type II - 2014 DCM ARC1	Type II - 2014 DCM ARC2	Sensitivity to ARC (%)
Discharge (cfs)			
DCM CN - 2014	6,980	7,035	-0.8
Volume (in)			
DCM CN - 2014	0.49	0.73	-49.0

Table 7-9. ARC1 vs ARC2 Discharge and Runoff Volumes computed at Fountain Creek

100-yr, 6-hour Storm at Fountain Creek			
	Type II - 2014 DCM ARC1	Type II - 2014 DCM ARC2	Sensitivity to ARC (%)
Discharge (cfs)			
DCM CN - 2014	8,750	8,260	5.6
Volume (in)			
DCM CN - 2014	0.61	0.83	-36.1

The use of ARC1 CN (with adjusted Ia) results in a slight reduction in peak discharge on the upland portions of the watershed as indicated by the slight drop in discharge at Evans Ave but that reduction is overshadowed by the increase in discharge in the lower urban portion of the watershed. The adjusted Ia in the urban area, resulted in an increase discharge at Fountain Creek. The runoff volume is much more sensitive to ARC than the peak discharge. Therefore peak discharge is representative of the physical nature of the steep, rocky subbasins rather than amount of rainfall that becomes runoff.

The modified model maintains consistency with the Upper Fountain Creek hydrology modeling methodology and calculates peak discharges and runoff volumes under the same assumptions and parameter estimates employed in the Upper Fountain Creek hydrology assessment.

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7.4.4 Hydraulic Analyses

Upper Fountain Creek

The response of the hydraulic features to the updated hydrology throughout Upper Fountain Creek was evaluated with a detailed hydraulic model developed for the USACE FCWS in 2006 and expanded in 2013 for evaluations of the effects of the Waldo Canyon Fire and for USGS studies and FEMA floodway and flood plain delineations. The hydraulic model was developed with the USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 4.1. For the current flood restoration evaluation, the model was extended to the crossing of CR 21 south of Woodland Park.

Preceding versions of the Upper Fountain Creek HEC-RAS model were developed and maintained for the reach in El Paso County. The current model was extended to include the reach that parallels CR21 from Crystola Canyon Rd to the CR21 Bridge, downstream from the Woodland Park city limits. The HEC-RAS model extension was performed to meet the needs of the current planning study and the updates were developed from recent air photos and high-resolution digital elevation models (DEM) developed from the 2011 EPC LiDAR survey. Limited ground-truthing was conducted for the three public and two private bridges/road crossings in the extended reach by Larry VonDeBur, PLS a volunteer provided by CUSP. The survey was used to tie in the bridge and culvert geometry to the DEM and HEC-RAS model. The cross section and structural geometry of the Upper Fountain Creek and Cheyenne Creek HEC-RAS models are provided in Appendix C.

The hydraulic evaluation was used to determine the effect of the updated hydrology on the river channels, banks, floodplains, road crossings and private property. Hydraulic model results were used to develop the inundation maps and extent of an extreme event, the 24-hour storm with a 1% chance of annual recurrence, or the 24-hour, 100-year storm. This storm produced the highest peak water level profile when compared to the 2-hour storm events and was thus used to delineate the inundation area. This inundation map does not represent the regulatory floodplain used to delineate the requirements for flood hazard insurance as directed by the National Flood Insurance Program (NIFP) and administered by FEMA.

Hydraulic model results were also applied to the Alternatives Analysis to determine the range of effects that could put the channels, banks, and floodplains at risk. The risk to the stability and ecology of these features and engineered structures varies as the water rises and the appropriate mitigation measure must likely accommodate a range of conditions observed during low flow frequent storms and those seen during less frequent, extreme events.

Cheyenne Creek

The hydraulic evaluation for Cheyenne Creek was based on the 2008 HEC-RAS model developed for the City of Colorado Springs by Kiowa. The Kiowa HEC-RAS model extends from Evans Avenue to the confluence with Fountain Creek for a total stream channel distance of approximately 3.4 miles. No changes were made to the model configuration or parameters and for purposes of the flood restoration master planning, the updated hydrology (Type II DCM ARC1) was used to assess the hydraulic conditions.

The hydraulic analysis was extended upstream to include South Cheyenne Creek between the 7-Falls property line and Evans Ave and North Cheyenne Creek to upstream of CSU's N. Cheyenne Creek diversion intake to the Starsmore Discovery Center and confluence with South Cheyenne Creek. The extension was developed with EPC LiDAR and included simple steady state evaluations to provide flood inundation extents and shear stress analysis for alternatives selection.

Inundation Maps

Inundation maps indicate the spatial extent of flood waters that should be expected from a simulated storm event. The hydraulic model results provide explicit water levels at the cross sections and GIS tools were used to interpolate the flood elevations for locations between the cross sections.

The inundation area for Upper Fountain Creek represents the extent of floodwater inundation resultant from the 100 yr., 24 hour storm. The flows were distributed throughout the river corridor at the model locations shown on Table 7-10.

Table 7-10. Upper Fountain Creek Inundation Map Peak Discharge

Model Element	24 Hour Storm 100 Year Discharge (cfs)	Location
JUF020	1,080	CR 21
JUF030	1,780	Crystola
JUF040	2,390	Pinecrest Stables
JUF110	3,700	Green Mountain Falls
JUF130	3,830	Green Mountain Falls
JUF140	4,780	Sand Gulch Outfall
JUF150	5,610	Rampart Terrace
JUF190	7,630	Cascade
JUF240	9,380	US 24 Corridor
JUF250	9,900	US 24 Corridor
JUF260	10,990	Rainbow Falls
JUF340	14,000	Manitou Springs
JUF350	16,600	Red Rocks Park
JUF390	18,790	33rd St
JUF400	20,380	Camp Creek Outfall
JUF460	26,370	21st St
JUF470	27,650	Gold Hill Mesa
JUF480	28,980	Monument Creek

The Cheyenne Creek inundation maps were developed for comparison to the 2008 City of Colorado Springs Cheyenne Creek Floodplain Study. For that study, Kiowa produced hydrology and inundation maps for the 100 yr., 6 hour storm. The hydrology was updated in 2014 by Matrix and the updated hydrology results for the 100 yr., 6 hour storm were used to produce the attached inundation maps. The flow distribution was applied at the locations listed on Table 7-11.

Table 7-11. Cheyenne Creek Inundation Map Peak Discharge

Subbasin Design Points	Location	100yr-6hr Discharge (cfs)
J11	Above Seven Falls	3,702
J12S	Below Seven Falls	4,062
J5	Above CSU Intake	2,894
J12N	Starsmor Center	3,314
J12	Evans Ave	6,985
J13	Cresta Blvd	7,409
J14	Alsace Way	7,748
J20	Fountain Creek	8,749

7.5 Geomorphology and Sediment

The floods of 2013 caused considerable damage to public and private property and infrastructure in El Paso County and particularly in the stream corridors of Upper Fountain Creek and Cheyenne Creek. In El Paso County, the unique combination of high rainfall amounts and post-2012 Waldo Canyon Fire conditions resulted in not only historically high water levels and stream flows, but also excessive amounts of sediment transport and deposition.

The Waldo Canyon Fire prompted the need for detailed sediment assessments and in 2012 the CUSP and the USFS completed the WARSSS report for those areas affected by the fire. A considerable portion of the Upper Fountain Creek watershed was burned and the WARSSS was the primary report on the amount and distribution of annual sediment supply in the watershed.

A primary goal of WARSSS was to set priorities of specific subwatersheds for restoration based on the magnitude and potential adverse consequences of sediment contributions and flood risks associated with the Waldo Canyon Fire. The identification of specific post-fire actions led to the design and installation of sediment catchment ponds and other erosion controls in Sand Gulch, Wellington Gulch, Cascade Gulch, Waldo Canyon, and on the mainstem of Upper Fountain Creek above Rainbow Falls. Furthermore, the City of Manitou Springs invested in extensive channel improvements, a cleanable sediment catchment basin in Williams Canyon following the destructive flooding that occurred in September of 2013. The current project continues that prioritization for the Upper Fountain Creek corridor to address the long term stability and resilience of Upper Fountain Creek.

For the current study, the Matrix team, including subconsultants Wildland Hydrology, Inc. and Blue Mountain Consultants, LLC performed a more detailed bank and channel stability assessment to supplement sediment supply and evaluate the geomorphic condition of the mainstem of Upper Fountain Creek in the areas identified as primary sources of excess sediment. Further analysis of these data coupled the sediment loading to a hydraulic model to estimate sediment transport and downstream delivery.

Geomorphic assessment was conducted on the reaches of Upper Fountain Creek between Woodland Park and Cascade. This reach exhibits unstable and erodible channels and banks that are in an impaired condition. The reaches below Cascade have been engineered by highway and urban development through El Paso County, Manitou Springs, and Colorado Springs. The lower reaches are typically receiving the sediment moving from the more unstable upper reaches.

7.5.1 Methods

The sediment and geomorphic assessment of Upper Fountain Creek is a product of field reconnaissance and both empirical and simulated evaluations to determine the mainstem stream bank conditions, tributary watershed condition, available sediment supply, relationship of sediment supply to flood hydrology, the capacity of the stream to transport the sediment supply, and the resulting estimate of sediment delivery at key locations along Upper Fountain Creek. Much of the analysis is based on information developed during the WARSSS study and applied to site-specific existing conditions. WARSSS provides dimensionless sediment rating curves for streams that are representative of the Upper Fountain Creek and its tributaries. These curves were dimensioned to hydrologic junction points on the mainstem as a function of bankfull discharge to establish estimates of bedload transport rate and suspended sediment concentrations. These values were integrated with 2- and 10-year flood hydrographs to determine total sediment load for each flood event at hydrologic junction points and provide an estimate of the flow-related sediment load for each planning reach of Upper Fountain Creek mainstem.

With a load calculation for each planning reach, the sediment transport capacity was evaluated with respect to the hydraulic capacity of the reach. Cumulative sediment transport capacity for the mainstem of Upper Fountain Creek was calculated by balancing the transport capacity of each reach with the incoming sediment load including any carryover load being supplied by the adjacent upstream reach to provide a cumulative sediment delivery estimate at key points along Upper Fountain Creek.

7.5.2 Mainstem Bank Condition

Field reconnaissance was completed to describe the morphology of the Upper Fountain Creek channel and associated valley and floodplain. The team mapped the reaches of the Upper Fountain Creek mainstem and classified the existing stream condition. The reaches of Upper Fountain Creek were classified into five (5) Rosgen stream types described in Table 7-12.

Table 7-12. Stream Types of Upper Fountain Creek

Rosgen Stream Type	General Description	Entrenchment Ratio	W/D Ratio	Sinuosity	Slope	Landforms/Soils/Features	Percentage of Upper Fountain Creek
B	Moderately entrenched, moderate gradient, riffle-dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 - 2.2	>12	>1.2	0.02 - 0.39	Moderate relief, colluvial deposition and/or mstructural. Moderate entrenchment and width/depth ratio. Narrow, gently sloping valleys. Rapids predominate with scour pools.	40%
C	Low gradient, meandering, point bar, riffle/pool, alluvial channels with broad, well-defined floodplains.	>2.2	>12	>1.2	<0.02	Broad valleys with terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.	10%
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	N/A	>40	N/A	<0.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment with abundance of sediment supply. Convergence. Divergence of bed features, aggradational processes, high bedload and bank erosion.	3%
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.2	<0.02	Entrenched in highly weathered material. Gentle gradients with a high width/depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle/pool morphology.	15%
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<1.4	<12	>1.2	<0.039	Gullies, step/pool morphology with moderate slopes and low width/depth ratio. Narrow valleys or deeply incised in alluvial or colluvial materials; i.e., fans or deltas. Unstable with grade control problems and high bank erosion rates.	32%

Included in the evaluation of stream morphology were conditional criteria that reflect the potential local erosion rate were estimated as a function of mainstem stream condition as "poor", "poor-fair", "fair", and "good". A reach under" poor" condition will supply significantly more sediment than a similar reach classified as "fair" or "good" condition. The percentages of the evaluated reaches in Upper Fountain Creek are listed in Table 7-13. The bank condition evaluation for the mainstem sediment supply reaches is shown in Figure 7-12.

Table 7-13. Upper Fountain Creek Mainstem Stream Condition

Percent of Stream Condition	
Poor	5%
Fair-Poor	21%
Fair	74%
Good	0%

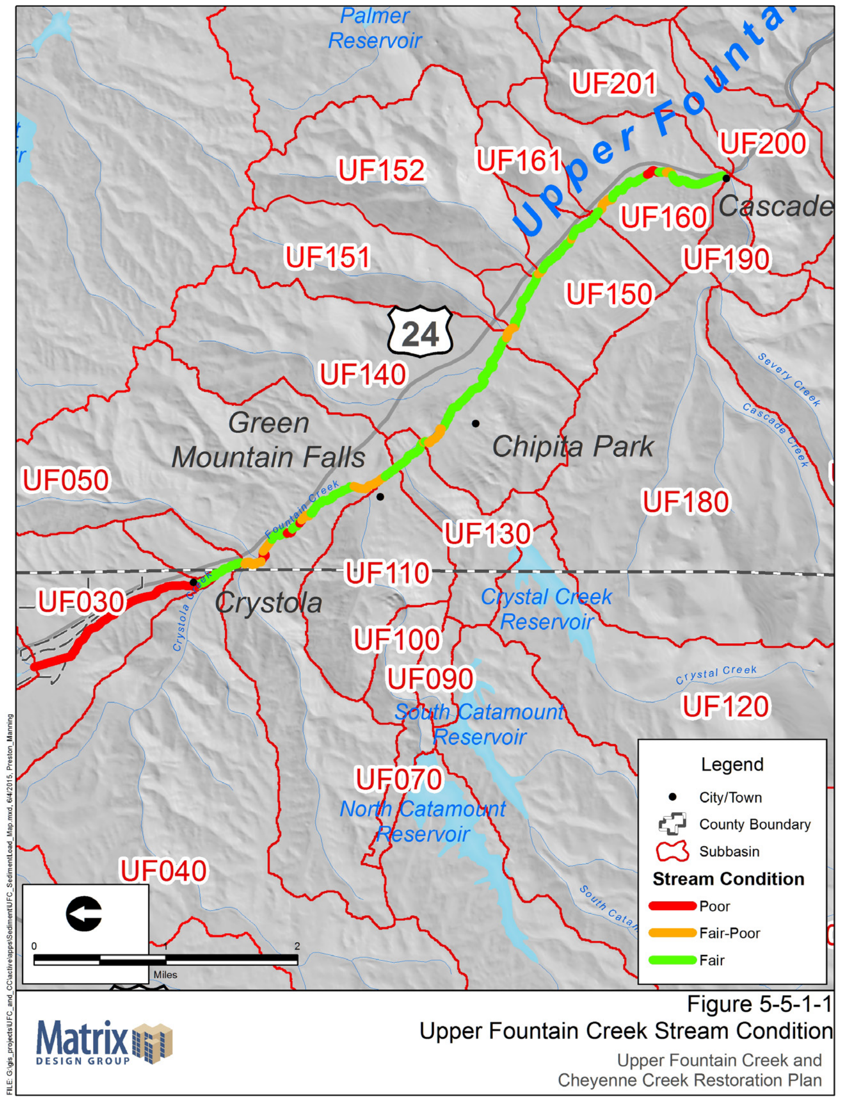

Figure 7-12. Upper Fountain Creek Stream Condition

The Upper Fountain Creek mainstem stream type, condition, erosion rate, and total erosion are tabulated by reach on Table 7-14. The Stream Bank Erosion Table is also presented in Appendix D.

Table 7-14. Existing Stream Type, Condition, and Total Erosion by Reach

Reach ID	Valley Type	Valley Width (ft)	Average Bank Ht (ft)	Length (ft)	Existing		
					Existing Stream Type	Erosion Rate (tons/ft/yr)	Total Erosion (tons/yr)
1	8c	>120	4	186	G4 Fair	0.279	52
2	8c	>120	7	1220	F4 Fair	0.119	146
3	8c	>120	2.5	601	C4 Fair	0.012	7
4	8b	40-80	3	381	G4 Fair	0.209	80
5	8b	80-120	4	841	G4 Fair-Poor	0.503	423
6	8a	40-80	5	221	F4 Poor	1.039	230
7	8a	40-80	8	335	F4 Poor	1.910	640
8	8b	40-80	1.5	599	F4 Fair-Poor	0.169	101
9	8b	40-80	1.5	1004	C4 Fair	0.007	7
10	8b	40-80	9	144	F4 Poor	2.149	308
11	8b	80-120	2	183	F4 Poor	0.416	76
12	8b	80-120	3	525	G4 Fair	0.209	110
13	8b	40-80	8	160	F4 Poor	1.910	305
14	8b	80-120	4	636	F4 Fair-Poor	0.450	286
15	8a	20-40	1.5	1368	B4 Fair	0.025	34
16	8a	40-80	3	141	G4 Fair	0.209	30
17	8b	40-80	1.5	228	C4 Fair	0.007	2
17	8b	40-80	1.5	228	C4 Fair	0.007	2
18	8b	40-80	3	447	G4 Fair	0.209	94
19	8b	40-80	1.5	193	C4 Fair	0.007	1
19	8b	40-80	1.5	193	C4 Fair	0.007	1
20	8b	20-40	3.5	1507	G4 Fair-Poor	0.440	663
21	8c	>120	7	522	F4 Fair	0.119	62
22	8b	80-120	6	674	F4 Fair	0.102	69
23	8b	>120	3	328	F4 Fair	0.051	17
24	8b	80-120	3	513	B4 Fair	0.050	26
25	8b	>120	0	198	D4 Deposition Fair	0.000	0
25	8b	>120	0	198	D4 Deposition Fair	0.000	0
26	8b	>120	3	81	G4 Fair-Poor	0.377	31
27	8b	80-120	2	155	B4 Fair	0.034	5
28	8b	80-120	4	167	G4 Fair-Poor	0.503	84
29	8b	80-120	3	1717	B4 Fair	0.050	87
30	8b	>120	6	105	G4 Fair	0.419	44
31	8b	>120	2	1935	B4 Fair	0.034	65
32	8b	>120	4	328	G4 Fair	0.279	91
33	8b	>120	2	1284	B4 Fair	0.034	43
34	8b	>120	5	53	G4 Fair-Poor	1.258	67
35	8b	>120	6	179	F4 Fair-Poor	1.146	205
36	8b	80-120	2	787	B4 Fair	0.034	26
37	8b	>120	5	410	G4 Fair	0.349	143
38	8b	80-120	2.5	205	B4 Fair	0.042	9
39	8b	>120	4	698	G4 Fair	0.279	195
40	8b	>120	2	395	B4 Fair	0.034	13
41	8b	>120	4	296	G4 Fair-Poor	0.503	149

Reach ID	Valley Type	Valley Width (ft)	Average Bank Ht (ft)	Length (ft)	Existing		
					Existing Stream Type	Erosion Rate (tons/ft/yr)	Total Erosion (tons/yr)
42	8b	>120	2	599	B4 Fair	0.034	20
43	8b	>120	4	197	G4 Fair	0.279	55
44	8b	>120	2	910	B4 Fair	0.034	31
45	8b	>120	4	173	G4 Fair-Poor	0.503	87
46	8b	>120	2	1551	B4 Fair	0.034	52
47	8b	>120	5	952	G4 Fair-Poor	0.628	598
48	8b	>120	1.5	1092	C4 Fair	0.007	8
49	8b	>120	0	957	D4 Deposition Fair	0.000	0
49	8b	>120	0	957	D4 Deposition Fair	0.000	0
50	8b	>120	7	579	G4 Poor	1.273	737
51	8b	80-120	2	317	B4 Fair	0.034	11
52	8b	80-120	4	352	G4 Fair-Poor	0.503	177
53	8b	>120	3	166	C4 Fair	0.014	2
54	8b	>120	2	351	B4 Fair	0.034	12
55	8b	>120	3	359	G4 Fair	0.209	75
56	8b	>120	2	943	B4 Fair	0.034	32
57	8b	80-120	4	406	G4 Fair	0.279	113
58	8b	>120	1.5	289	B5 Fair	0.025	7
59	8b	>120	2	137	B4 Fair	0.034	5
60	8b	>120	5	119	G4 Fair-Poor	0.628	75
61	8b	80-120	4	37	G4 Fair-Poor	1.195	44
62	8b	80-120	4	720	G4 Fair-Poor	0.503	362
63	8b	80-120	4	58	G4 Fair-Poor	5.644	328
64	8b	>120	2	51	G4 Poor	1.126	57
65	8b	>120	5	362	G4 Fair-Poor	0.628	227
66	8b	>120	4	85	G4 Fair	1.218	103
67	8b	>120	4	129	G4 Fair	0.279	36
68	8b	>120	2	47	G4 Poor	1.421	67
69	8b	>120	2	53	B4 Fair	0.034	2
101	8b	>120	2	1179	F4 Poor	0.416	490
102	8b	>120	3	4196	F4 Poor	0.624	2616
103	8b	>120	0	1440	D4 Deposition Fair	0.000	0
104	8b	>120	4	1629	F4 Poor	0.831	1354
105	8b	>120	2	2275	F4 Poor	0.416	946
106	8b	>120	0	2420	D4 Deposition Fair	0.000	0

The reach delineation shown in the Table 7-14 is based on physical conditions of the channel and banks of Upper Fountain Creek. The sediment supply estimates are related to the amount of erosion on an annual (non-flood) discharge basis.

Below Cascade, the creek flows through a confined reach in the median of the US Highway 24 corridor. No significant sediment supply problems were identified on the mainstem of Upper Fountain Creek between the major fire- affected tributaries within that reach, Cascade Gulch and Waldo Canyon. A combination of slope, bed material, and hydraulic transport capacity create unique conditions that convey sediment and limit erosion making this primarily a transport reach.

7.5.3 Sediment Load

Mainstem Sediment Load

The results of the mainstem condition and sediment supply survey presented above provided a detailed stream type classification, condition estimate, and associated erosion potential. The condition of the mainstem of upper Fountain Creek contributes potential sediment supply in varying degrees through the stream corridor. The field survey provided post flood mainstem stream type classification and condition. The sediment supply from the mainstem is conditionally available with respect to erosional forces with "poor" condition providing the greatest supply, and "fair" conditions providing least supply and representing a reasonable restoration condition target.

Subbasin Sediment Load

The field survey completed for this project provided post-flood mainstem stream type classification and condition that does not include tributary sediment supply information. The geomorphic condition of the tributary contributions was developed from WARSSS and incorporated into the evaluation of sediment transport capacity (described later in this memorandum). Tributary conditions were described as "fair" for unburned subbasins and "poor" for the burned subbasins.

7.5.4 Bankfull Sediment Discharge

The bankfull discharge regional curve was developed for the Waldo Canyon Fire WARSSS. Limited empirical data is available for suspended or bedload discharge in Upper Fountain Creek, so regional estimates relating hydrologic and geomorphic characteristics were applied. The following italicized section is taken from WARSSS with figure numbers changed as necessary. The baseline hydraulic condition that is applied in the evaluation of sediment transport is bankfull discharge. Bankfull is the wetted area contained within the banks and below the floodplain. The bankfull discharge is representative of channel-forming flows resulting from frequently recurring small events.

Discharge is estimated from for each subbasin pour point as a function of subbasin area and similarly, the bankfull sediment load is determined from a regional curve of bankfull discharge vs. drainage area (see Figure 7-13). In the absence of measured bankfull sediment data, similar to the approach used to estimate bankfull discharge, bankfull bedload and suspended sediment data by drainage area can be developed for a given geological region by stability.

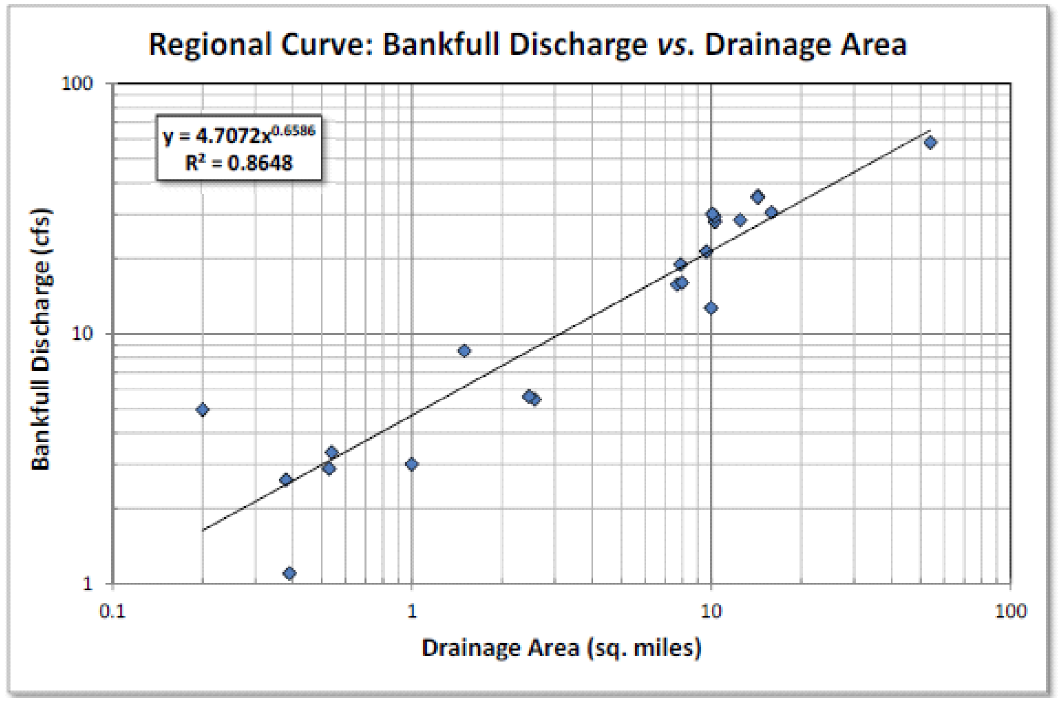

Figure 7-13. Bankfull Discharge vs. Drainage Area (from WARSSS)

Regional sediment curves were developed by stability for the batholith geology (Pikes Peak, grussic granite geology) for this assessment as shown in Figures 7-14 and 7-15. The bankfull sediment values from the regional curves can then be used to convert the dimensionless sediment rating curves to dimensional curves that are unique and scaled for each subwatershed.

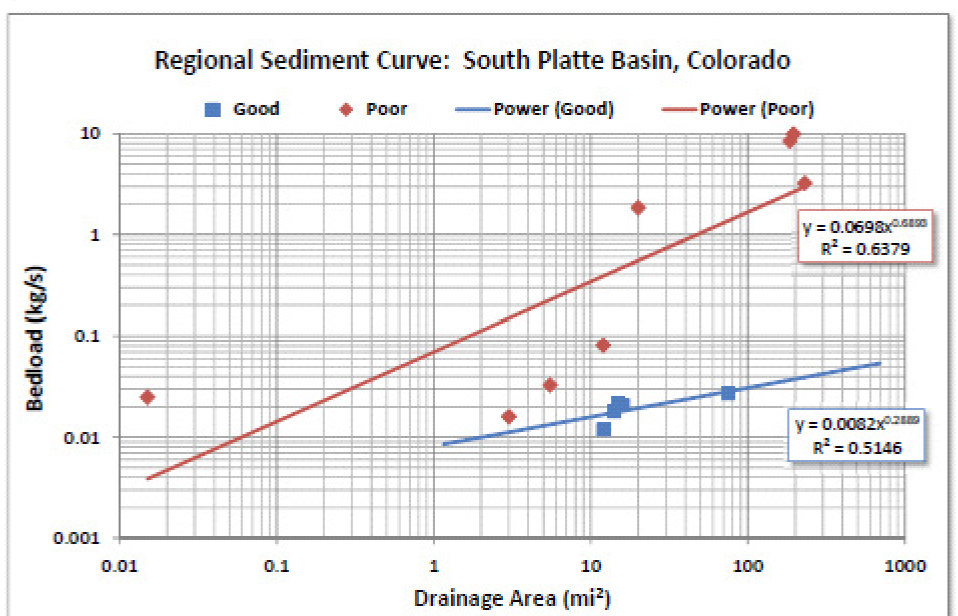

Figure 7-14. Regional Bedload Sediment Curve, South Platte Basin (from WARSSS)

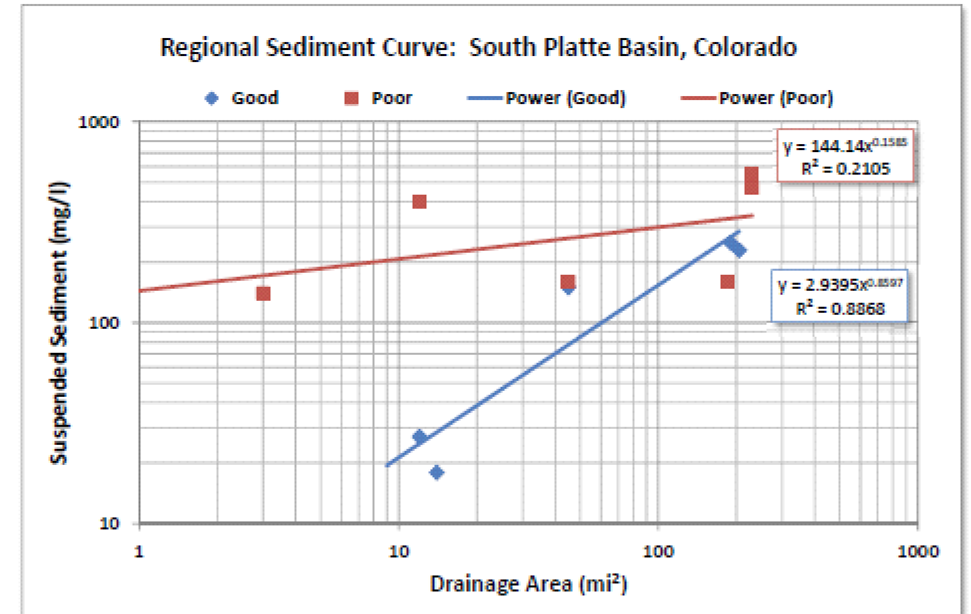

Figure 7-15. Regional Suspended Sediment Curve, South Platte Basin (from WARSSS)

The estimate of bankfull sediment discharge for suspended and bedload constituents at the specific hydrologic junction points, regional sediment curves can be linked to hydrographs to determine the overall potential sediment discharge. By tying the potential sediment load to discharge hydrographs, the controlling feature of the relationship will become the condition of the subbasin with respect to stability and sediment supply. The rating curves for the regional representative streams are developed for good condition or "poor" condition. For areas that have been affected by the Waldo Canyon Fire, the rating curve for "poor" condition provides a more reasonable approximation of the annual sediment load that can be expected from the burned basins. Likewise, the relatively stable subbasins upstream and west of the Waldo Fire scar are more representative of "fair" conditions and can be expected to supply lower sediment loads than the burned areas.

Relative sediment loads for bankfull sediment discharge from "poor" and "good" condition rating curves are listed for the hydrologic junction points in Table 7-15 . The relative difference between sediment loads from areas in "poor" condition can be 2-3 orders of magnitude greater than loads originating from areas in "fair" or "good" condition.

Table 7-15. Mainstem Sediment Loads Developed from Regional Sediment Discharge Curves

Hydrologic Junction Point	Location	Drainage Area (mi^2)	Existing Condition	Bankfull Discharge (cfs)	Fair Condition Bankfull Bedload (lbs/sec)	Fair Condition Bankfull Suspended Discharge (mg/l)	Poor Condition Bankfull Bedload (lbs/sec)	Poor Condition Bankfull Suspended Discharge (mg/l)
JUF020	CR 21	3.14	Poor	10	0.03	7.85	1.28	172.78
JUF030	Crystola	5.51	Fair	14	0.03	12.76	1.78	188.93
JUF040	Pinecrest Stables	11.75	Fair	24	0.04	24.44	2.77	213.00
JUF110	Green Mountain Falls	30.82	Fair	45	0.05	56.00	4.85	248.18
JUF130	Green Mountain Falls	34.93	Poor	49	0.05	62.37	5.22	253.15
JUF140	Sand Gulch Outfall	38.97	Poor	53	0.05	68.52	5.56	257.58
JUF150	Rampart Terrace	41.87	Fair	55	0.05	72.89	5.80	260.53
JUF190	Cascade	51.73	Fair	63	0.06	87.41	6.56	269.41
JUF240	US 24 Corridor	63.67	Fair	73	0.06	104.50	7.41	278.42
JUF250	US 24 Corridor	65.86	Fair	74	0.06	107.58	7.55	279.92
JUF260	Rainbow Falls	68.52	Fair	76	0.06	111.31	7.73	281.68
JUF340	Manitou Springs	87.46	Fair	89	0.07	137.29	8.91	292.79
JUF350	East Manitou Springs	91.06	Fair	92	0.07	142.14	9.12	294.67
JUF390	Sutherland Creek	96.98	Fair	96	0.07	150.05	9.47	297.63
JUF400	Red Rocks Park	100.17	Fair	98	0.07	154.28	9.65	299.16
USGS Gage	33rd St	102	Fair	99	0.07	156.70	9.75	300.02
JUF460	21st St	114.35	Fair	107	0.07	172.88	10.42	305.50
JUF470	Gold Hill Mesa	116.21	Fair	108	0.07	175.30	10.52	306.29
Monument Creek	Monument Creek	118.67	Fair	109	0.07	178.47	10.65	307.30

The sediment loads estimated at each hydrologic junction point are based on the regional dimensionless rating curves established as part of the Waldo Canyon Fire WARSSS. Validation of the bankfull suspended sediment concentration and bedload transport rate via field sampling was not possible in Upper Fountain Creek during the current study. Therefore, the dimensionless sediment rating curves were dimensioned to bankfull flows and flood sediment loads were extrapolated by integration with simulated 2- and 10-year flood hydrographs as opposed to using a flow duration curve from a gaged site, as would be done when determining annual sediment load.

It is reasonable to extrapolate the estimated sediment load for a 2-year flood event from the bankfull discharge, since it is only slightly above the bankfull value. However, the 10-year flood-related sediment load is less reliable due to the non-linear relationships of sediment rating curves. This plays a role in evaluations of the sediment transport capacity of Upper Fountain Creek and its balance with sediment load to estimate downstream sediment delivery for the 2-year and 10-year storm events as described in the following section. Sediment loading model results (FlowSed results) are included in Appendix D.

7.5.5 Sediment Transport Capacity

Sediment transport capacity relates to the ability of the stream to transport the sediment load by assessing sediment transport potential with respect to the hydraulic capacity of the stream and its overbank conveyance. Sediment transport capacity was calculated with the HEC-RAS Hydraulic Design Functions module.

7.5.6 Planning Reach Delineation

The primary planning reach delineation for flood restoration and geomorphic assessment was based on physical and hydraulic characteristics of Upper Fountain Creek. The capacity of the stream to convey water is based on various physical and structural characteristics of the mainstem stream corridor. These characteristics include slope, bank height, and width and elevation of floodplains. The sediment transport capacity was evaluated with respect to the hydraulic capacity for each cross section and averaged over the planning reach.

7.5.7 Sediment Transport Capacity Modeling

Matrix applied Yang's sediment transport equation using HEC-RAS to calculate the sediment transport capacity of 60 planning reaches of Upper Fountain Creek.

For a steady state numerical approximation, the hydraulic capacity (and related sediment transport capacity) is calculated for static peak flow rather than a dynamic hydrograph. The results of sediment capacity modeling provide an estimate of sediment that can be transported over a 24-hour period in tons/day. In order to normalize the flood generated loading estimates, mean daily flows were calculated from the discharge records for the USGS stream flow gage near Colorado Springs (07103700) for the 2-year event. The simulated 2-year peak at the USGS gage is approximately 1450 cfs and the historic flow data at that location indicates that on days the peak approached or exceeded the 1450 cfs, the daily mean flow was 83 cfs, on average. Since no recorded floods had occurred that produced the post-fire 10-year discharge of approximately 4500 cfs, the 2-year ratio of peak to mean daily flow was applied to the 10-year peak for a 10-year mean daily estimate of 250 cfs. In HEC-RAS, sediment transport capacity is calculated on a daily basis, the mean daily flow of 83 cfs and 250 cfs were used to evaluate the 2-year sediment transport capacity and the 10-year sediment transport capacity, respectively.

7.5.8 Sediment Delivery

In an approximation of sediment routing through the Upper Fountain Creek mainstem, the sediment transport capacity was calculated for each planning reach based on the load estimates for that reach. In the event that a reach had sufficient capacity to transport the sediment load, i.e. supply is less than capacity, then the carryover load was applied to the adjacent downstream reach in addition to the sediment load of the receiving reach. This provides an accounting of sediment load for each respective segment that is compared to the reach-averaged sediment transport capacity. If the estimated accumulated sediment load exceeds the capacity of a given reach, aggradation, or deposition of sediment, can be expected. Likewise, if the sediment load is less than the sediment transport capacity, then the entire load is conveyed and degradation, or bed erosion, is possible.

Table 7-16 indicates the relationships between loading estimates based on flood sediment discharge and simulated hydrographs and the average capacity of each hydrologic subbasin for the 2- and 10-year floods.

Table 7-16. Sediment Supply vs. Sediment Transport Capacity

Location	Hydrologic Junction	Planning Reach	2-Year Storm Supply vs Capacity	2-Year Storm Supply-Capacity (tons/day)	2-Year Storm Result	10-Year Storm Supply vs Capacity	10-Year Storm Supply-Capacity (tons/day)	10-Year Storm Result
CR 21	JUF020	RUF030	Supply < Capacity	-35,812	Erosion/Degradation	Supply > Capacity	37,415	Deposition/Aggradation
Crystola	JUF030	RUF040	Supply < Capacity	-41,899	Erosion/Degradation	Supply > Capacity	30,059	Deposition/Aggradation
Pinecrest Stables	JUF040	RUF050	Supply < Capacity	-38,090	Erosion/Degradation	Supply < Capacity	-30,229	Erosion/Degradation
Green Mountain Falls	JUF110	RUF051	Supply < Capacity	-31,797	Erosion/Degradation	Supply < Capacity	-47,264	Erosion/Degradation
Green Mountain Falls	JUF110	RUF052	Supply < Capacity	-71,485	Erosion/Degradation	Supply < Capacity	-117,224	Erosion/Degradation
Green Mountain Falls	JUF110	RUF053	Supply < Capacity	-35,106	Erosion/Degradation	Supply < Capacity	-55,370	Erosion/Degradation
Green Mountain Falls	JUF130	RUF130	Supply < Capacity	-55,707	Erosion/Degradation	Supply < Capacity	-91,756	Erosion/Degradation
Sand Gulch Outfall	JUF140	RUF140	Supply < Capacity	-15,221	Erosion/Degradation	Supply > Capacity	17,424	Deposition/Aggradation
Wellington Gulch	JUF140	RUF141	Supply < Capacity	-35,962	Erosion/Degradation	Supply > Capacity	14,938	Deposition/Aggradation
Rampart Terrace	JUF150	RUF150	Supply < Capacity	-28,269	Erosion/Degradation	Supply > Capacity	298,740	Deposition/Aggradation
Cascade	JUF150	RUF151	Supply > Capacity	3,586	Deposition/Aggradation	Supply > Capacity	266,043	Deposition/Aggradation
Cascade	JUF190	RUF160	Supply < Capacity	-26,314	Erosion/Degradation	Supply > Capacity	533,935	Deposition/Aggradation
US 24 Corridor	JUF240	RUF200	Supply < Capacity	-51,608	Erosion/Degradation	Supply > Capacity	606,934	Deposition/Aggradation
US 24 Corridor	JUF250	RUF250	Supply > Capacity	1,794	Deposition/Aggradation	Supply > Capacity	1,000,442	Deposition/Aggradation
US 24 Corridor	JUF260	RUF260	Supply < Capacity	-32,684	Erosion/Degradation	Supply < Capacity	-55,401	Erosion/Degradation
Waldo Canyon	JUF260	RUF261	Supply < Capacity	-16,181	Erosion/Degradation	Supply > Capacity	1,823,586	Deposition/Aggradation
Rainbow Falls	JUF260	RUF262	Supply > Capacity	8,919	Deposition/Aggradation	Supply > Capacity	493,326	Deposition/Aggradation
Manitou Springs	JUF340	RUF270	Supply > Capacity	10,016	Deposition/Aggradation	Supply > Capacity	368,622	Deposition/Aggradation
East Manitou Springs	JUF350	RUF350	Supply > Capacity	50,299	Deposition/Aggradation	Supply > Capacity	5,374,688	Deposition/Aggradation
Sutherland Creek	JUF390	RUF360	Supply > Capacity	41,252	Deposition/Aggradation	Supply > Capacity	5,342,044	Deposition/Aggradation
Red Rocks Park	JUF400	RUF400	Supply > Capacity	56,182	Deposition/Aggradation	Supply > Capacity	6,937,121	Deposition/Aggradation
21st St	JUF460	RUF410	Supply > Capacity	628,041	Deposition/Aggradation	Supply > Capacity	66,062,465	Deposition/Aggradation
Gold Hill Mesa	JUF470	RUF470	Supply > Capacity	240,525	Deposition/Aggradation	Supply > Capacity	25,367,370	Deposition/Aggradation
Monument Creek	JUF480	RUF480	Supply > Capacity	385,804	Deposition/Aggradation	Supply > Capacity	38,102,357	Deposition/Aggradation

The experience of the past two years indicates that the upper reaches of the watershed provide a supply of sediment that is routinely transported by common storm flows on a regular basis. The sediment capacity evaluation also indicates that the lower reaches of the watershed, most notably below Rainbow Falls and Williams Canyon, are receiving the sediment supply that has exceeded the capacity of the creek to transport it further. Manitou Springs and Colorado Springs have made, and will likely continue to make, considerable effort to remove and manage the resultant sediment deposition.

7.5.9 Mainstem Channel Restoration

The existing condition of Upper Fountain Creek is contributing sediment supply that is likely to be transported to the lower reaches that include the jurisdictions of Manitou Springs, Colorado Springs and El Paso County. This sediment supply could be reduced if the stability of the stream corridor is improved, and grade and hydraulic capacity are maintained.

The Matrix team assessed the existing, post-2013 flood condition of the mainstem erosion and resulting sediment supply along Upper Fountain Creek. In addition to assessing the existing condition and associated total erosion as described on Table 7-17, our team made recommendations to restore respective reaches in the corridor to stable stream types that would reduce the mainstem sediment supply. Table 7-18 identifies the amount of erosion reduction that could be reasonably achieved by restoring eroding reaches, and effectively reducing the supply from the mainstem. The potential for erosion reduction also provides a metric for establishing restoration priority.

With the development of restoration projects that are designed to improve the stability of the channel bed and banks, the conditional target as indicated on Table 7-18 could have a considerable effect on mainstem sediment supply. It is reasonable to assert that a restoration goal of retuning "poor" condition reaches to a "fair" condition will result in a more balanced transport that will keep the excess sediment moving through the stream corridor.

Table 7-17. Proposed Restoration Stream Type and Potential Erosion Reduction

Reach ID	Existing: Existing Stream Type	Existing: Erosion Rate (tons/ft/yr)	Existing: Total Erosion (tons/yr)	Proposed: Stream Type	Proposed: Total Erosion (tons/yr)	Potential Erosion Reduction (tons)	Erosion Reduction (tons/foot)
1	G4 Fair	0.279	52	B4	0.868	51	0.274
2	F4 Fair	0.119	146	C4	7.723	138	0.113
3	C4 Fair	0.012	7	B4	2.798	4	0.007
4	G4 Fair	0.209	80	B4	1.774	78	0.205
5	G4 Fair-Poor	0.503	423	B4	3.920	419	0.498
6	F4 Poor	1.039	230	B4	1.032	229	1.035
7	F4 Poor	1.910	640	B4	1.562	639	1.905
8	F4 Fair-Poor	0.169	101	B4	2.791	98	0.164
9	C4 Fair	0.007	7	B4	4.678	2	0.002
10	F4 Poor	2.149	308	B4	0.669	308	2.144
11	F4 Poor	0.416	76	B4	0.851	75	0.411
12	G4 Fair	0.209	110	B4	2.446	107	0.205
13	F4 Poor	1.910	305	B4	0.745	305	1.905
14	F4 Fair-Poor	0.450	286	B4	2.964	283	0.445
15	B4 Fair	0.025	34	B4	6.375	28	0.021
16	G4 Fair	0.209	30	B4	0.658	29	0.205
17	C4 Fair	0.007	2	B4	1.061	1	0.002
17	C4 Fair	0.007	2	B4	1.061	1	0.002
18	G4 Fair	0.209	94	B4	2.085	92	0.205
19	C4 Fair	0.007	1	B4	0.898	0	0.002
19	C4 Fair	0.007	1	B4	0.898	0	0.002
20	G4 Fair-Poor	0.440	663	B4	7.025	656	0.435
21	F4 Fair	0.119	62	B4	2.434	60	0.115
22	F4 Fair	0.102	69	B4	3.142	66	0.098
23	F4 Fair	0.051	17	B4	1.528	15	0.047
24	B4 Fair	0.050	26	B4	2.391	23	0.046
25	D4 Deposition Fair	0.000	0	C4	1.255	0	0.000
25	D4 Deposition Fair	0.000	0	C4	1.255	0	0.000
26	G4 Fair-Poor	0.377	31	B4	0.378	30	0.372
27	B4 Fair	0.034	5	B4	0.724	4	0.029
28	G4 Fair-Poor	0.503	84	B4	0.779	83	0.498
29	B4 Fair	0.050	87	B4	8.001	79	0.046
30	G4 Fair	0.419	44	B4	0.488	43	0.414

Reach ID	Existing			Proposed		Potential Erosion Reduction (tons)	Erosion Reduction (tons/foot)
	Existing Stream Type	Erosion Rate (tons/ft/yr)	Total Erosion (tons/yr)	Stream Type	Total Erosion (tons/yr)		
31	B4 Fair	0.034	65	B4	9.018	56	0.029
32	G4 Fair	0.279	91	B4	1.526	90	0.274
33	B4 Fair	0.034	43	B4	5.985	37	0.029
34	G4 Fair-Poor	1.258	67	B4	0.248	67	1.253
35	F4 Fair-Poor	1.146	205	B4	0.833	204	1.142
36	B4 Fair	0.034	26	B4	3.667	23	0.029
37	G4 Fair	0.349	143	B4	1.912	141	0.344
38	B4 Fair	0.042	9	B4	0.957	8	0.037
39	G4 Fair	0.279	195	B4	3.252	191	0.274
40	B4 Fair	0.034	13	B4	1.839	11	0.029
41	G4 Fair-Poor	0.503	149	B4	1.379	147	0.498
	B4 Fair	0.034	20	B4	2.789	17	0.029
	G4 Fair	0.279	55	B4	0.919	54	0.274
	B4 Fair	0.034	31	B4	4.243	26	0.029
45	G4 Fair-Poor	0.503	87	B4	0.805	86	0.498
46	B4 Fair	0.034	52	B4	7.227	45	0.029
47	G4 Fair-Poor	0.628	598	B4	4.434	593	0.624
48	C4 Fair	0.007	8	B4	5.089	3	0.002
49	D4 Deposition Fair	0.000	0	C4	6.059	-6	-0.006
49	D4 Deposition Fair	0.000	0	C4	6.059	0	0.000
50	G4 Poor	1.273	737	B4	2.697	734	1.269
51	B4 Fair	0.034	11	B4	1.476	9	0.029
52	G4 Fair-Poor	0.503	177	B4	1.639	175	0.498
53	C4 Fair	0.014	2	B4	0.773	2	0.009
54	B4 Fair	0.034	12	B4	1.635	10	0.029
55	G4 Fair	0.209	75	B4	1.674	74	0.205
56	B4 Fair	0.034	32	B4	4.394	27	0.029
57	G4 Fair	0.279	113	B4	1.890	111	0.274
58	B5 Fair	0.025	7	B4	1.345	6	0.021
59	B4 Fair	0.034	5	B4	0.639	4	0.029
60	G4 Fair-Poor	0.628	75	B4	0.556	74	0.624
61	G4 Fair-Poor	1.195	44	B4	0.170	44	1.190
62	G4 Fair-Poor	0.503	362	B4	3.357	359	0.498
63	G4 Fair-Poor	5.644	328	B4	0.271	328	5.639
64	G4 Poor	1.126	57	B4	0.236	57	1.121
65	G4 Fair-Poor	0.628	227	B4	1.687	226	0.624
66	G4 Fair	1.218	103	B4	0.394	103	1.213
67	G4 Fair	0.279	36	B4	0.603	36	0.274
68	G4 Poor	1.421	67	B4	0.219	67	1.417
69	B4 Fair	0.034	2	B4	0.246	2	0.029
101	F4 Poor	0.416	490	C4	7.464	483	0.409
102	F4 Poor	0.624	2616	C4	26.558	2590	0.617
103	D4 Deposition Fair	0.000	0	C4	9.113	0	0.000
104	F4 Poor	0.831	1354	C4	10.311	1344	0.825
105	F4 Poor	0.416	946	C4	14.398	931	0.409
106	D4 Deposition Fair	0.000	0	C4	15.320	0	0.000

Table 7-18. Upper Fountain Creek Sediment Transport Capacity Under Restored Condition

			2-Year Storm			10-Year Storm		
Location	Hydrologic Junction	Planning Reach	Supply vs Capacity	Supply-Capacity (tons/day)	Result	Supply vs Capacity	Supply-Capacity (tons/day)	Result
Crystola	JUF030	RUF040	Supply < Capacity	-42,577	Erosion/Degradation	Supply < Capacity	-26,154	Erosion/Degradation
Pinecrest Stables	JUF040	RUF050	Supply < Capacity	-38,769	Erosion/Degradation	Supply < Capacity	-56,383	Erosion/Degradation
Green Mountain Falls	JUF110	RUF051	Supply < Capacity	-32,476	Erosion/Degradation	Supply < Capacity	-73,418	Erosion/Degradation
Green Mountain Falls	JUF110	RUF052	Supply < Capacity	-72,163	Erosion/Degradation	Supply < Capacity	-143,378	Erosion/Degradation
Green Mountain Falls	JUF110	RUF053	Supply < Capacity	-35,784	Erosion/Degradation	Supply < Capacity	-81,524	Erosion/Degradation
Green Mountain Falls	JUF130	RUF130	Supply < Capacity	-56,386	Erosion/Degradation	Supply < Capacity	-117,909	Erosion/Degradation
Sand Gulch Outfall	JUF140	RUF140	Supply < Capacity	-15,917	Erosion/Degradation	Supply < Capacity	-16,513	Erosion/Degradation
Wellington Gulch	JUF140	RUF141	Supply < Capacity	-36,730	Erosion/Degradation	Supply < Capacity	-32,708	Erosion/Degradation
Rampart Terrace	JUF150	RUF150	Supply < Capacity	-30,898	Erosion/Degradation	Supply > Capacity	88,852	Deposition/Aggradation
Cascade	JUF150	RUF151	Supply < Capacity	-904	Erosion/Degradation	Supply > Capacity	88,864	Deposition/Aggradation
Cascade	JUF190	RUF160	Supply < Capacity	-30,056	Erosion/Degradation	Supply > Capacity	74,174	Deposition/Aggradation
US 24 Corridor	JUF240	RUF200	Supply < Capacity	-58,199	Erosion/Degradation	Supply > Capacity	72,047	Deposition/Aggradation
US 24 Corridor	JUF250	RUF250	Supply < Capacity	-9,252	Erosion/Degradation	Supply > Capacity	352,892	Deposition/Aggradation
US 24 Corridor	JUF260	RUF260	Supply < Capacity	-41,936	Erosion/Degradation	Supply < Capacity	-55,401	Erosion/Degradation
Waldo Canyon	JUF260	RUF261	Supply < Capacity	-37,252	Erosion/Degradation	Supply > Capacity	349,688	Deposition/Aggradation
Rainbow Falls	JUF260	RUF262	Supply < Capacity	-14,121	Erosion/Degradation	Supply > Capacity	247,676	Deposition/Aggradation
Manitou Springs	JUF340	RUF270	Supply < Capacity	-4,105	Erosion/Degradation	Supply > Capacity	368,622	Deposition/Aggradation
East Manitou Springs	JUF350	RUF350	Supply > Capacity	46,194	Deposition/Aggradation	Supply > Capacity	5,374,688	Deposition/Aggradation
Sutherland Creek	JUF390	RUF360	Supply > Capacity	41,252	Deposition/Aggradation	Supply > Capacity	5,342,044	Deposition/Aggradation
Red Rocks Park	JUF400	RUF400	Supply > Capacity	56,182	Deposition/Aggradation	Supply > Capacity	6,937,121	Deposition/Aggradation
21st St	JUF460	RUF410	Supply > Capacity	628,041	Deposition/Aggradation	Supply > Capacity	66,062,465	Deposition/Aggradation
Gold Hill Mesa	JUF470	RUF470	Supply > Capacity	240,525	Deposition/Aggradation	Supply > Capacity	25,367,370	Deposition/Aggradation
Monument Creek	JUF480	RUF480	Supply > Capacity	385,804	Deposition/Aggradation	Supply > Capacity	38,102,357	Deposition/Aggradation

Attempts to mitigate the sediment supply identified in the Waldo Canyon Fire WARSSS report have been undertaken through the efforts of the USFS, the City of Colorado Springs, El Paso County, and CUSP during the three years since the fire occurred. The magnitude of sediment load quantified in the WARSSS report will likely remain until the effects of the burn are reduced by the reestablishment of the healthy forest ecosystem.

The Waldo Canyon Fire WARSSS report, estimated relative discharge and flow related sediment loading from pre-fire and post-fire conditions. A summary of those results estimates the pre-fire annual water yield from the 15.58 square miles of the burn scar that drains to Upper Fountain Creek as approximately 2825 Ac-Ft and subsequent pre-fire sediment loading of 110 tons/yr. The WARSSS estimate for post-fire annual water yield increases 1.83 times to 5180 Ac-Ft with sediment loading increasing 230 times to approximately 25,000 tons/yr.,

Further study of the Fountain Creek watershed by the USGS in 2013 estimated sediment transport prior to the fire, based on hydraulic capacity and grain size distribution and evaluated various sediment catchment scenarios. The USGS study proposed 4 sediment basins in Upper Fountain Creek in the reach below Rainbow Falls and 8th St in Colorado Springs. The USGS study provided sediment grain size sample curves from 4 locations along Upper Fountain Creek (Kohn, et al. 2013). A link to the USGS report is included in Appendix A.

The USGS evaluated pre-fire discharge and sediment transport in HEC-RAS for a specific simulated flood event. The USGS proposed that flood reduction and subsequent sediment loading could be managed with the installation of four attenuation/sediment basins, located along Upper Fountain Creek between west of Manitou Springs and 8th Street in Colorado Springs. The USGS estimates that these ponds will reduce the peak flow from 5,790 cfs to 1910 cfs or a reduction of 67%. The associated estimate of sediment load reduction with the four proposed basins is from 3240 tons/storm or a 14 % decrease in sediment transport.

7.5.10 References

D. Rosgen, B. Rosgen, S. Collins, J. Nankervis, K. Wright, (2013) “Waldo Canyon Fire Watershed Assessment: The *WARSSS* Results”

M. S. Kohn, J. W. Fulton, C. A. Williams, and R. W. Stogner, Sr. USGS Scientific Investigations Report 2014–5019 I2013) “Remediation Scenarios for Attenuating Peak Flows and Reducing Sediment Transport in Fountain Creek, Colorado, 2013”

7.6 Alternatives Analysis

7.6.1 Introduction

The purpose of the Alternatives Analysis was to evaluate reach characteristics and develop reach alternative recommendations based upon hydrologic conditions, hydraulic factors and field investigation. The outcome of this section is a recommended reach alternative prioritization that can be carried forward to the conceptual design phase for further analysis. All backup calculations and data are provided in Appendix E.

7.6.2 Reach Delineation

In order to effectively establish reach alternatives throughout the Cheyenne Creek and Upper Fountain Creek Watersheds, the creeks were broken down into reaches based upon unique characteristics and features that were observed throughout a given length of channel. Initial delineation was possible through hydrologic modeling that was performed in HEC-HMS, as explained in the Hydrology Section of this report. Additional reach delineation was necessary to subdivide these established reaches into planning reaches that could then be comprehensively analyzed to come up with appropriate design alternatives. The design alternatives and examples are discussed in greater detail in the Restoration Techniques section.

<u>Initial Delineation of Reaches Based on Hydrologic and Hydraulic Modeling</u>

Planning reaches within the Upper Fountain Creek and Cheyenne Creek Watersheds were first delineated based on their HEC-HMS hydrologic modeling, as discussed in the Hydrology Section of this report. The reaches established in these models, based on the characteristics of each watershed, were used to initially divide the creeks into smaller reaches for analysis. However, as these reaches were delineated solely by the basin catchment areas of which they are located, it was necessary to further break down the reaches into “planning reaches” in order to effectively determine appropriate design alternatives.

<u>Planning Reach Delineation</u>

After the initial model delineation, reaches were further broken down into *planning reaches* based on the geomorphology throughout the creeks. After plotting the profiles of Upper Fountain Creek and Cheyenne Creek from the HEC-RAS models, notable changes in slope were identified throughout each reach. These grade breaks were then compared to the initial reach delineations to determine if the slope breaks corresponded with the original reach delineations. If the slope breaks did not correspond to the reach delineation boundaries, the reaches were broken out further into smaller reaches that contained consistent slopes throughout a given length. Finally, based on common characteristics identified in the field throughout various lengths of creek that were not visible in HEC-HMS or HEC-RAS, the reaches were yet again delineated. These characteristics included lengths of channel with consistent confined widths due to urban areas or manmade channel sections, lengths of channel that experienced unique and consistent degradation or aggradation, or sections of channel that classified as stable or unstable based on field observations.

7.6.3 Analysis of Planning Reach Alternatives

Reaches throughout Cheyenne Creek and Upper Fountain Creek require various levels of intervention and management to ensure long-term stability and to minimize the risks of flooding and the associated consequential damages. Because each reach has unique characteristics and experiences distinctive flows, the selection of potential design alternatives for each length of channel required a comprehensive analysis of several variables and parameters present in the creeks. The overall methodology used in the planning reach alternatives was consistent throughout Upper Fountain Creek and Cheyenne Creek; however, some of the parameters were adjusted based on the unique geomorphology of each creek. The screening parameters and associated reference materials can be seen in Appendix E.

<u>Evaluation of Reach Alternatives</u>

Alternatives for each of the planning reaches were evaluated using the peak flows calculated for each reach from the 2-Yr 2-Hr and 100-Yr 2-Hr events, as detailed in the Hydrology Section. The result of this process was a recommended planning alternative to be used when addressing each project outlined in the Project Identification Section. These alternatives serve the purpose of providing a methodology to be used in repairing the identified projects while also creating a stable reach in hopes of minimizing similar potential problem areas in future flooding. The process for arriving at the suggested planning alternatives for each reach using the established screening parameters can be seen in Figure 7-16. A total of six different reach alternatives were considered in the screening process and are described below.

Protect In Place

There are several pristine sections of channel throughout the Cheyenne Creek and Upper Fountain Creek Watersheds that are currently in a stable condition. These reaches typically consist of a small low-flow channel that is connected to a very wide floodplain which allows for the effective conveyance of all flood flows by dissipating erosive energy over the entire floodplain area. These sections also provide water quality benefit due to the amount of surface area available for infiltration. Preserving these reaches would not require a direct channel improvement cost. However, detention improvements may be required depending on the location of the reach. Reaches had to meet the following criteria in order to fall into this category:

- The reach has to be currently in stable condition
- The 2-yr flood flows within the reach have to be at or below historical conditions

Protect In Place and Monitor

Reaches were observed in Upper Fountain Creek that did not appear to require intervention, but did not fall under the Protect In Place alternative. These reaches therefore require future monitoring with the potential of projects at a later date. Reaches had to meet the following criteria in order to fall into this category:

- The reach is in stable condition, but has not yet returned to historical conditions
- The reach has a slope that is less than the max slope of the stable reaches throughout the watershed

Natural Channel Design

The goal of this reach alternative is to restore the low-flow channel and connect it to the adjacent floodplain. This alternative allows for channel sheer stress to be reduced by allowing flood flows to access the floodplain where the erosive energy is dissipated over the entire floodplain area. This reach alternative can be used where mild longitudinal slopes exist and where floodplain sheer stresses are within a range that can be withstood by vegetation. These reaches also have tremendous water quality benefit due to the amount of surface area available for infiltration and because they limit channel erosion. The target slope and channel section for this alternative would be maintained through grade control structures. Reaches had to meet the following criteria in order to fall into this category:

- Existing slope of less than or equal to 0.059 ft/ft in Upper Fountain Creek and 0.12 ft/ft in Cheyenne Creek. This was based on the average slope in channel sections that are currently stable.
- Max available width is at least 40-ft in Upper Fountain Creek or 13-ft in Cheyenne Creek
- Shear stress at the 2-yr flood stage of less than or equal to 3.94 lb/ft^2
    - Based on the average shear stress in channel sections that are currently stable
    - Calculated using the 2-yr flood stage from the Hydrology Section of this report within the existing channel section

Small Drop Structures with Toe Protection

This reach alternative involves hardening the lower portion of the side slopes of the channel cross-section while relying on smaller (< 3 ft) drop structures to maintain a target longitudinal slope. Reaches had to meet the following criteria in order to fall into this category:

- A calculated spacing between drops greater than or equal to 40-ft in Cheyenne Creek or 100-ft in Upper Fountain Creek (assuming 3ft drops). Spacing between drop structures in Cheyenne Creek of less than 40 ft or less than 100 ft in Upper Fountain Creek would result in too many drop structures in a reach.

Large Drop Structures with Toe Protection

This reach alternative involves hardening the lower portion of the side slopes of the channel cross-section while relying on larger (6 ft > drop height > 3 ft) drop structures to maintain the stable longitudinal slope. Large drop structures were only used if the spacing required for small drop structures was less than 100 ft.

Fully-Lined Channel

This reach alternative involves lining a portion of the channel cross-section with riprap for the full length of the reach. Riprap should be sized to handle the projected shear stress for the 100-year flood event with limited or no grade control. Fully lined channels are only required where it is determined that large drop structures are not suitable due to spacing or width constraints. Fully-lined channels were not required anywhere.

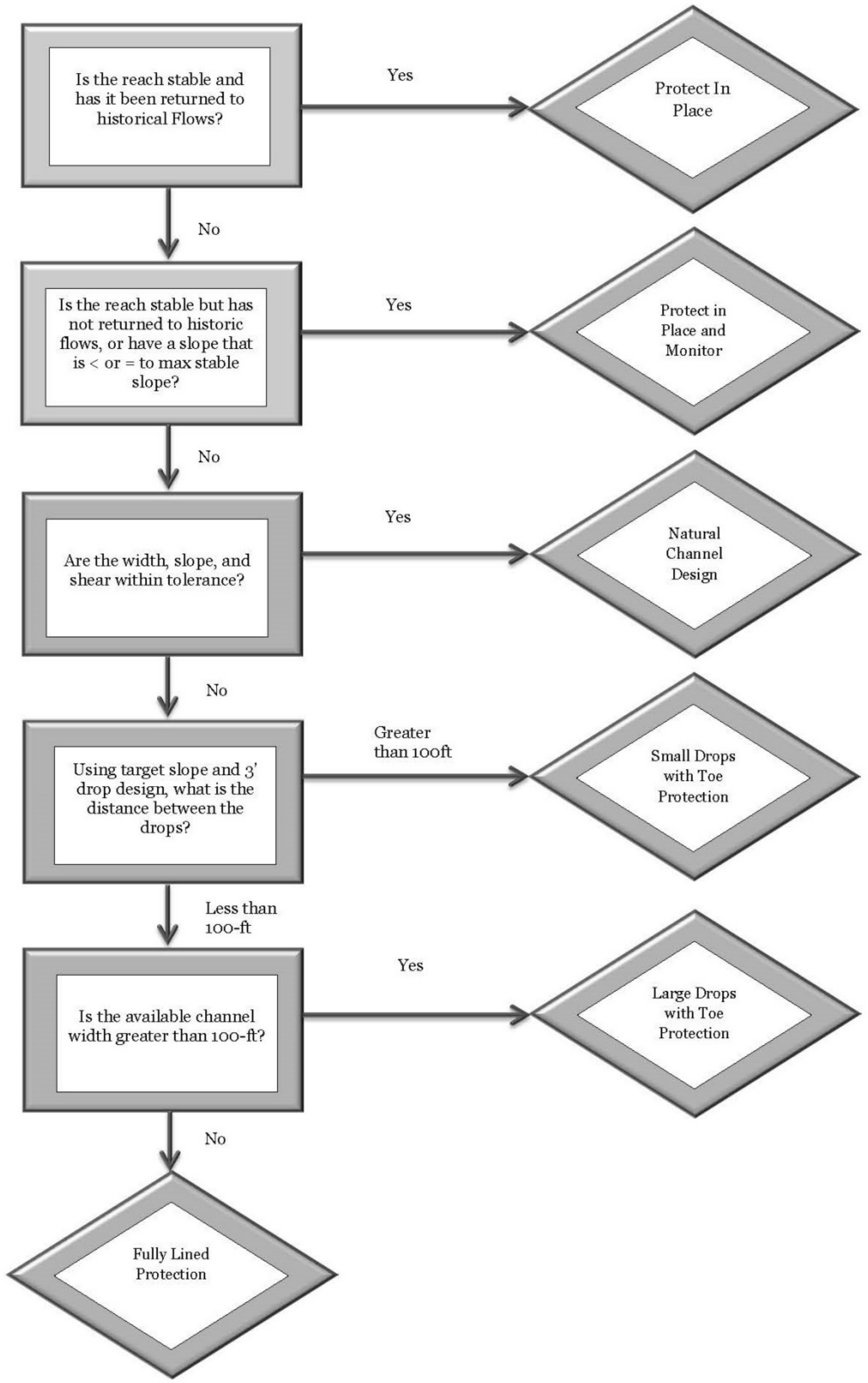

Figure 7-16. Alternative Analysis Screening Flow Chart

7.6.4 Results of Reach Alternatives Analysis

A summary of the analysis of both Cheyenne Creek and Upper Fountain creek reach alternatives can be seen in Tables 7-19 and 7-20. The calculations and spreadsheets used to determine these alternatives can be seen in Appendix E.

Table 7-19. Upper Fountain Creek Alternative Summary

Reach	Reach Length (ft)	Reach Alternative
RUF020	6,651	Natural Channel Design
RUF030	9,189	Natural Channel Design
RUF040	1,227	Small Drop Structures w/ Toe Protection
RUF050	3,184	Natural Channel Design
RUF051	2,400	Natural Channel Design
RUF052	1,700	Natural Channel Design
RUF053	1,400	Natural Channel Design
RUF130	1,425	Natural Channel Design
RUF140	1,825	Protect In Place
RUF141	4,500	Protect In Place
RUF150	2,300	Protect In Place
RUF151	3,850	Protect In Place
RUF160	7,124	Natural Channel Design
RUF200	4,504	Protect In Place & Monitor
RUF250	7,784	Protect In Place & Monitor
RUF260	4,476	Protect In Place & Monitor
RUF261	2,700	Small Drop Structures w/ Toe Protection
RUF262	1,281	Small Drop Structures w/ Toe Protection
RUF270	4,329	Small Drop Structures w/ Toe Protection
RUF350	2,789	Natural Channel Design
RUF360	4,312	Natural Channel Design
RUF400	1,918	Protect In Place & Monitor
RUF410	6,959	Protect In Place & Monitor
RUF470	6,243	Small Drop Structures w/ Toe Protection
RUF480	9,350	Natural Channel Design

Table 7-20. Upper Fountain Creek Alternative Summary

Reach	Reach Length (ft)	Reach Alternative
NCC1	445	Protect In Place
NCC2	1,453	Protect In Place
NCC3	1,493	Protect In Place
NCC4	1,824	Protect In Place
NCC5	1,380	Protect In Place
SCC1	282	Small Drop Structures w/ Toe Protection
SCC2	360	Small Drop Structures w/ Toe Protection
SCC3	617	Small Drop Structures w/ Toe Protection
SCC4	243	Small Drop Structures w/ Toe Protection
SCC5	478	Small Drop Structures w/ Toe Protection
CC1	2,908	Protect In Place
CC2	2,241	Small Drop Structures w/ Toe Protection
CC3	5,799	Protect In Place
CC4	354	Small Drop Structures w/ Toe Protection
CC5	2,032	Protect In Place
CC6	2,060	Small Drop Structures w/ Toe Protection
CC7	599	Protect In Place
CC8	996	Small Drop Structures w/ Toe Protection

7.7 Project Identification

A major goal of this study is to identify potential capital improvement projects and areas of needed restoration and improvement. Our team utilized several methods and procedures to identify these recommended projects and to identify areas of needed restoration, including extensive field reconnaissance, stream bank evaluation, collection and review of stakeholder capital improvement project lists, stakeholder interviews, collection and review of community input, and hydrologic and hydraulic modeling. Several of these methods and procedures are described below.

The results of the project identification process yielded several types of identified projects, including replacement of bridges and culverts, offline drainage improvements, flood risks reduction measures, BANCS restoration priority sediment banks, field identified head cuts, exposed and vulnerable utilities, existing cut banks and steep slopes, and other unique projects.

The identified projects are shown on the *Cheyenne Creek Conceptual Plan* and *Upper Fountain Creek Conceptual Plan* mapbooks and project lists, located in the results section of this report.

The following sections describe the project types and provide additional detail.

7.7.1 Methods and Procedures used for Identifying Projects

<u>Existing Conditions Field Reconnaissance</u>

A detailed field investigation was performed for both Upper Fountain and Cheyenne Creeks. The purpose of the investigation was to document the exiting conditions of the creeks and identify areas of concern, including cut banks, headcuts, incised reaches, steep banks, etc. In addition, the Bank Assessment for Non-point Source Consequences of Sediment (BANCS) method was utilized to assess and provide estimates of bank erosion rates for the reaches of Upper Fountain Creek from Woodland Park to Cascade.

<u>Qualitative Creek Walk and GIS/Photo Documentation</u>

During the field reconnaissance, GIS located photos were taken every 100-ft and areas of concern were marked on field maps. The photos were subsequently downloaded into Google Earth mapping files. Copies of the mapping files and photos have been included in the compact disc and are located in the back sleeve of this report.

<u>Quantitative BANCS Evaluation for UFC (Woodland Park to Cascade)</u>

The BANCS method utilizes two bank erodibility estimation tools: the Bank Erosion Hazard Index (BEHI) and the Near Bank Stress (NBS). This method was utilized to provide estimates of sediment supply and rate the identified banks according to specific risk categories. The results of the BANCS evaluation are discussed further in the *Geomorphic Assessment and Sediment Transport Analysis* of this report. The highest priority banks, as a result of the BANCS analysis, are to be identified projects and are detailed in the project list and alternatives maps. See the *BANCS Restoration Priority* section below.

<u>Project Identification through Hydrologic and Hydraulic Modeling</u>

HEC-RAS and HEC-HMS were used to analyze all existing crossings along the main stems of both Upper Fountain and Cheyenne Creeks. The analysis considered several storm events, for both pre- and post-fire conditions.

7.7.2 Bridge and Culvert Analysis, Replacement, and Recommended Sizing

<u>Modeling</u>

To model the conditions of the crossings on Upper Fountain and Cheyenne Creeks, the project team utilized HEC-RAS and HEC-HMS. These programs, developed by Army Corps of Engineers, aid in the study of hydrologic and hydraulic conditions of drainage basins, creeks, and conveyance infrastructure. HEC-HMS was used to model the hydrology of the basins contributing to each respective creek. Various storms are modeled and a summary of the hydrologic method and results can be found in section 5.4 of this report. HEC-RAS was used to analyze the existing crossings and to provide the suggested bridge or culvert sizing.

Cheyenne Creek uses the 10-yr, 2hr storm, as well as the 50-yr, 2hr storm for the purposes of sizing crossings. Upper Fountain Creek uses the 5-yr, 2hr "post-fire" flow, as well as the 100-yr "pre-fire" flow. The section of Upper Fountain Creek modeled between the Walmart in Woodland Park and Sand Gulch in Green Mountain Falls is not affected by the change between pre- and post-fire flows. The fire only affects hydrology below Sand Gulch. The project team is using the 100-yr "pre-fire" flow, working under the assumption that the forest affected by the fire will return to its "pre-fire" state at some point in the future, thus reducing flows back to original conditions and allowing for a smaller crossing.

In the following sections, note that the models and analysis of the crossings are static, not dynamic. This means that the analysis of crossings is not affected by the upstream changes. Note also, crossings located on private land, although thoroughly analyzed, are not considered for identified projects nor sized for replacement. In Manitou, culverts listed as failing, without an associated project number, are either private or pedestrian crossings. These crossings are not part of the criteria used in the culvert sizing process; therefore, are not considered in the analysis.

Failure Analysis

There are multiple criteria used in the spreadsheet to determine the failure modes for the crossings noted as failing in the project lists and mapbooks. The spreadsheet uses the flowchart found in Figure 7-17 to determine the failure modes. The analysis of the crossings and suggest failure modes, including overtopping, failing freeboard, or failing headwater depending on whether the crossing falls under a culvert or bridge classification. The criteria used in determining failure modes are the Colorado Springs Drainage Criteria Manual and the El Paso County Drainage Criteria.

Additional Causes

There are two additional failure modes in the report; backwater analysis and critical access routes. Below are descriptions of the additional failure modes. These options were added as possible failure modes to address failures/problems the spreadsheet does not identify.

Backwater Conditions

A backwater analysis is to be performed on crossings that create a backwater in which the upstream neighborhood is significantly negatively affected. Backwater typically occurs in populated areas due to insufficient space for the required crossing size. Sizes are not proposed for culverts associated with backwater conditions. A detailed analysis of the backwater is required to determine a sufficient culvert size. Reference the *Flood Risk Reduction* section of this report for a more detailed description of a backwater analysis.

Critical Access Routes

After screening the crossings using the failure analysis and the backwater analysis, the critical routes need to be analyzed. The current version of the *City of Colorado Springs Snow Route* map and the *El Paso County Critical Roadway Tables* where used to determine whether a crossing was a critical access route or not. Crossings that fall into the Critical Access Route criteria are noted on the mapbook in Appendix E.

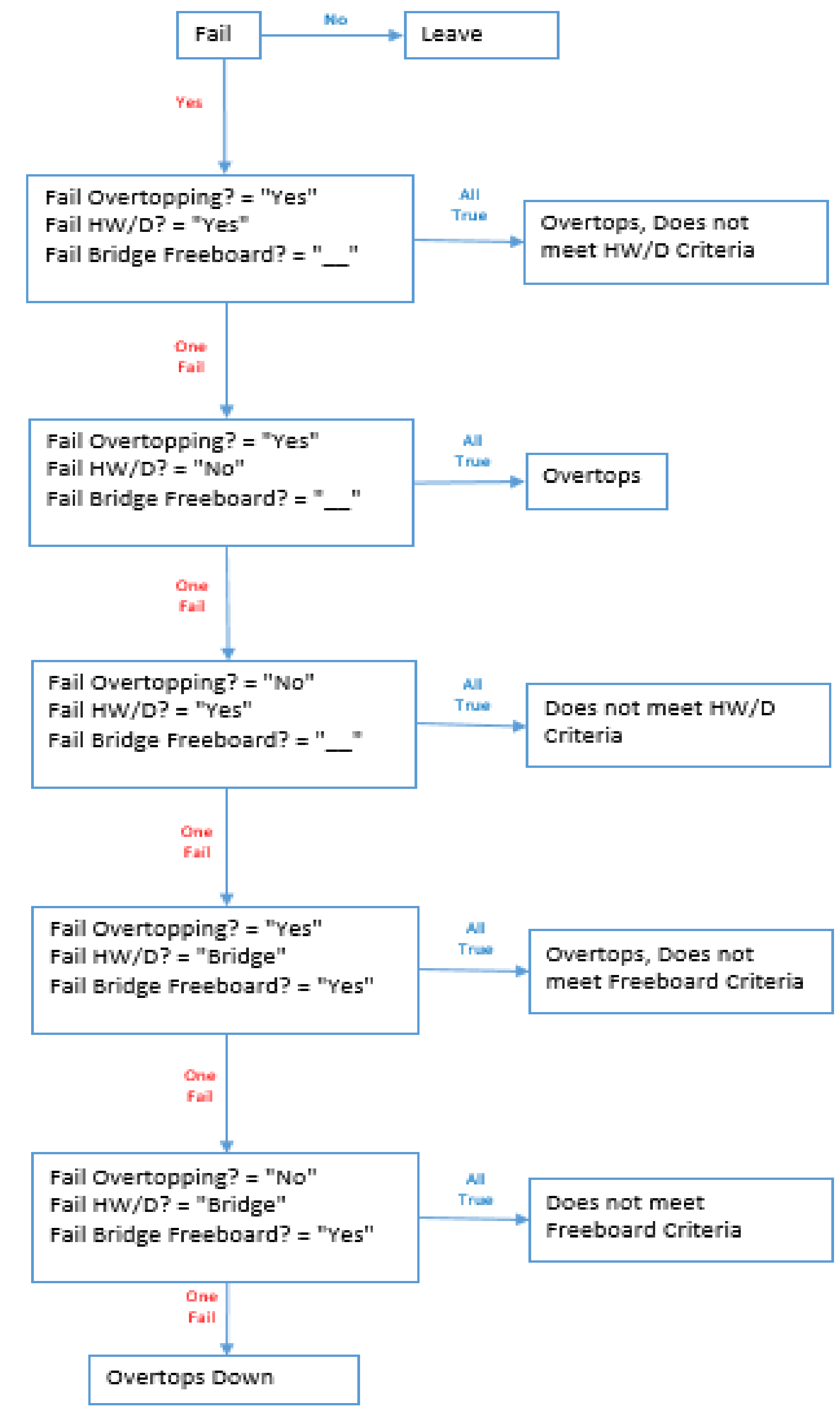

Figure 7-17. Bridge and Culvert Failure Analysis

Recommended Size

The recommended sizes for the culverts listed as failing can be found in Appendix E. When referring to the mapbook to determine failing crossings, it is important to understand that culverts listed as failing were determined using different flows. On upper fountain creek, a culvert is listed as failing if it fails any of the above criteria using the 5-yr "post-fire" flow. The crossings on Cheyenne Creek are listed as failing if the culvert fails any of the above criteria in the 10-yr flow. Culverts listed as failing will be marked with red callouts in the mapbook. An example of a failing crossing can be found in Figure 7-18. The recommended size is being used for planning/budgeting needs and should not be considered final.

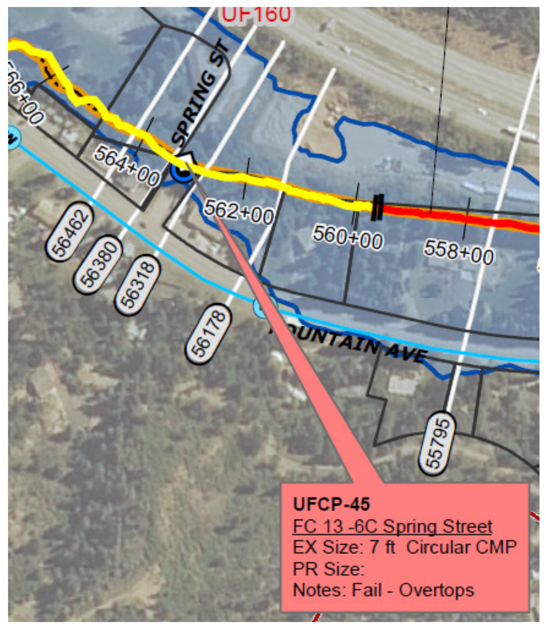

Figure 7-18. Example of Failing Structure

The screening criteria above determined which crossings need updating. A list of the crossing that fail City/County criteria can be found in Appendix E. Crossings were sized according to the screening criteria, as well as a large event. Crossings on Upper fountain creek are sized for the 5-yr "post-fire" flow as well as the 100-yr "pre-fire" flow. Crossings on Cheyenne creek are sized for the 10-yr and the 50-yr flows. The larger storm was used in order to determine rough costs for the crossing updates, as well as to meet city criteria.

7.7.3 Offline Drainage Improvements

Although the scope and intent of this study is to focus on the main stem portions of both Upper Fountain and Cheyenne Creeks, several issues related to offline drainage were recognized and documented during the public outreach, stakeholder input, and project identification phases of the study. These specific areas and issues have been studied and are recognized as identified projects when and where they are appropriate.

Current Issues, Causes, and Possible Solutions

Severe surface flooding was experienced and documented within both the Cheyenne Boulevard and Cheyenne Road corridors during the September 2013 flooding events. The existing infrastructure within both roadway sections is inadequate, rendered inoperable, or no longer in existence due to development and insufficient maintenance. The original roadway sections were rural in nature and consisted of side swales and driveway culvert crossings. Over time these swales have been filled in and, in some cases, paved over to provide additional travel lanes. The areas are delineated by a thick dashed green and white line in Section 2.0 *Cheyenne Creek Conceptual Plan* mapbook and project list. The mitigation of the identified sections of roadway drainage will provide several important benefits, including:

- Protection of existing homes and businesses
- Providing and maintaining clear emergency access routes
- Increasing water quality in the main stem of Cheyenne Creek
- Minimizing downstream flooding by lagging hydrograph peeks in contributing streams and outlets to the main stem of Cheyenne Creek

The following are possible solutions for mitigating the offline drainage issues.

Classic Stormwater Infrastructure

Classic stormwater infrastructure includes concrete curb and gutter, roadway and ditch bottom inlets, underground piping, manholes, and outlet structures.

Low Impact Development (LID) Solutions

LID solutions may be more appropriate considering the age and character of the neighborhood. These types of solutions are more likely to provide the kind of water quality improvements and flood reduction results sought by the City, while provided an aesthetic solution the residents of the area are likely to expect. The following are three examples of LID solutions suitable for roadway corridors.

Bio-swales/Rain Gardens

Much of the roadway corridors contain ample space necessary for the installation of bio-swales. The swales consist of planted depressions which collect and covey runoff from surrounding impervious surfaces. The bio-swales improve water quality and promote infiltration. Figure 7-19 illustrates an example of the potential solution.

Figure 7-19. Bio-swale

Grassed Swales, Rural Roadway Sections

Cheyenne Boulevard and Cheyenne Road were originally designed and constructed using classic rural roadway design sections. The section utilized grassed swales on both sides of the roadway along with driveway cross culverts for the purposes of runoff conveyance. As previously discussed, the original roadway section has been modified over time. The roadway swales have been filled in, paved over, and/or eliminated. The reconstruction of the classic rural roadway section would serve as a viable option for provided overland flow roadway drainage facilities. Figure 7-20 below depicts a classic rural roadway section.

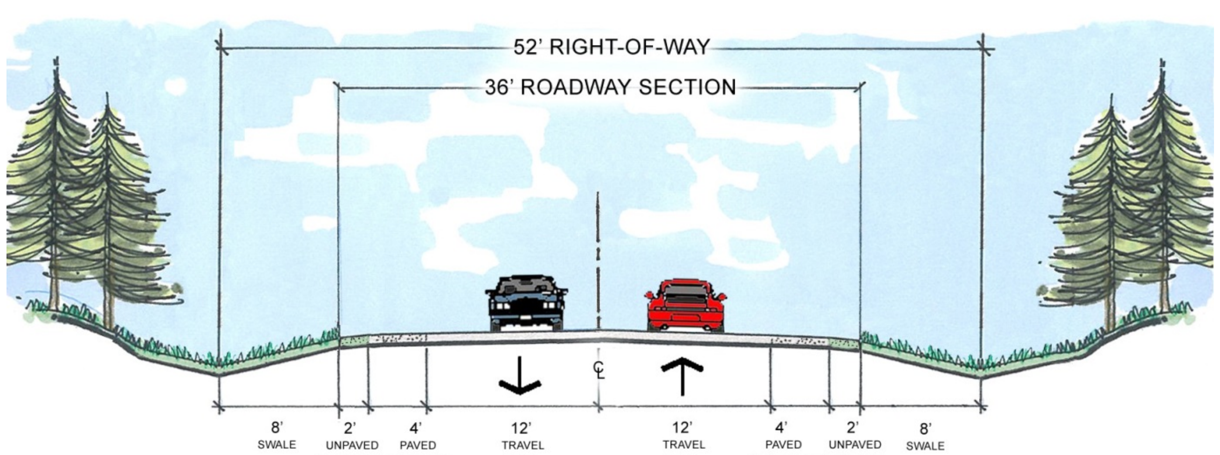

Figure 7-20. Rural Roadway Section

Pervious Pavements

Pervious pavements, also known as porous asphalts, can be used for municipal and private development applications. The solution provides stormwater runoff reduction and control, as well as water quality benefits as shown in Figure 7-21.

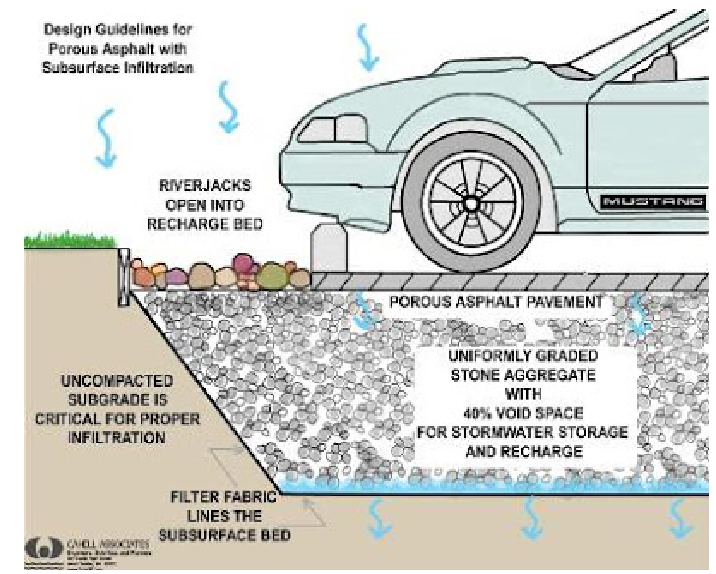

Figure 7-21. Pervious Pavements

7.7.4 Flood Risk Reduction

Flood risk reduction is a major goal of this study. Several specific projects for achieving flood risk reduction within both Upper Fountain Creek and Cheyenne Creek corridors have been identified on the conceptual plans and project lists. Although this study is limited in size and scope, several opportunities exist, including the addition of potential detention/sedimentation basins, construction of flood levee walls, floodplain remapping, property buyout, and backwater relief. The following descriptions detail the extent of consideration for each opportunity within this study.

<u>Potential Detention/Sedimentation Basins</u>

Several potential detention/sediment collection basins have been identified throughout the course of this study. The sites have been identified through review of previous studies, field reconnaissance, land ownership map review, and stakeholder input. The potential detention basin sites serve as a tool for mitigating downstream flooding. The potential sediment basin sites provide collection areas for significant sediment resulting from upstream erosion and/or sediment transported as a result of the recent wild fires.

The project lists and conceptual plan mapbooks detail the location and possible volume of the identified basins. Although identified as possible facilities, the detention basins have not been included in any hydraulic modeling to simulate future conditions. Further hydraulic studies will be required in order determine the possible downstream flood risk reduction benefits of any and all identified basin facilities.

Flood Levee Walls

Potential levee walls have been identified as flood reduction projects in several areas of both Upper Fountain and Cheyenne Creek. The identified walls are necessary to prevent either in stream or offline flooding depending upon the area of concern. The proposed levee walls are identified on the *Cheyenne Creek Conceptual Plan* and *Upper Fountain Creek Conceptual Plan* mapbooks and project lists.

Floodplain Remapping

Floodplain remapping is a viable means of providing flood risk reduction by removing properties from the FEMA regulatory flood plain. This study is limited in its scope and does not include recommendations for flood risk reduction through floodplain remapping.

Property Buyout

This study does not include or identify possible areas of potential property buyout. Stakeholders will be responsible for identifying possible areas. Further hydraulic study will be necessary to determine the true cost/benefit of property buyout as it relates to flood risk reduction.

Backwater Relief (Culvert and/or Bridge Replacement)

Backwater relief is a significant and very realistic means of providing flood risk reduction. This study seeks to identify the most significant areas of backwater and at the same time, provides realistic recommendations for bridge and culvert replacements. Although several of the bridges and culverts responsible for most significant backwater effects are identified as projects on the Cheyenne Creek Conceptual Plan and Upper Fountain Creek Conceptual Plan mapbooks and project lists, several are not specifically called out. The project team considered several factors in the decision to identify a bridge or culvert replacement due to backwater flooding including:

- Physical ability to replace structure (Several culverts and bridges are not likely to be replaced due to space limitations or physical conditions. This is specifically the case for several structures within the City of Manitou and within the Cheyenne Creek corridor.)
- Cost/benefit analysis of bridge or culvert replacement
- Private or public infrastructure (the study only seeks to identify infrastructure owned and maintained by public entities)

The bridges and culverts recommended for replacement due to backwater effects are identified as projects on the *Cheyenne Creek Conceptual Plan* and *Upper Fountain Creek Conceptual Plan*. Although identified as future projects, these structures will require a detailed backwater analysis to determine the true cost/benefit of replacement, as well as the amount of flood reduction to be realized.

7.7.5 BANCS Restoration Priority

A previously discussed, the BANCS method utilizes two bank erodibility estimation tools: the BEHI and the NBS. This method was utilized to provide estimates of sediment supply and rate the identified banks according to specific risk categories. The analysis provided several key pieces of information. First, the method provided a unit erosion rate for study banks in the form of tons of sediment per year per foot. Second, the method provided a total erosion rate for study banks in the form of tons per year. Wildland Hydrology provided the project team with prioritized list of banks according to the calculated unit rates of erosion.

The results of the analysis were used to rank the study banks according to the erosion rate in the form of tons per year. The ranked list was then divided into thirds and classified as high, medium, and low. The classification is depicted on the *Upper Fountain Creek Conceptual Plan* mapbook and project list. On the plans, the high priority is shown in red, the medium priority is shown in yellow, and low priority is shown in green. In each of the plans, the highest priority (red) banks are determined to be identified individual projects.

The results of the BANCS evaluation are discussed further in the *Geomorphic Assessment and Sediment Transport Analysis* of this report.

7.7.6 Field Identified Head Cuts

Several existing head cuts have been identified on both Upper Fountain and Cheyenne Creeks. The head cuts were identified and documented during the initial existing conditions field reconnaissance performed by the project team. The identified head cuts are both active and in-active and in either case represent a threat to the geomorphological stability, the existing and current water quality, habitat, and infrastructure to both creeks. Each field head cut has been identified as an individual project and represented on both the *Cheyenne Creek Conceptual Plan* and *Upper Fountain Creek Conceptual Plan* mapbooks and project lists.

7.7.7 Exposed and Vulnerable Utilities

Colorado Springs Utilities (CSU) provided their most up-to-date and accurate utility mapping data in the form of GIS files for the purposes of this study. The information is included and depicted in both the *Cheyenne Creek Conceptual Plan* and *Upper Fountain Creek Conceptual Plan* mapbooks. In addition, field investigation and stakeholder input led to the discovery of several exposed and/or vulnerable utilities. The status of the utilities was verified to greatest extent possible, although the status of several exposed utilities remains unknown. Whether verified as active or unverified, existing utilities found to be exposed or vulnerable are identified as projects on the conceptual plan mapbooks and project lists. Further, utility investigation may be required to verify the necessity of utility stabilization or encasement.

7.7.8 Existing Cut Banks and Steep Slopes

Several existing cut banks and areas with steep channel side slopes have been identified on both Upper Fountain and Cheyenne Creeks. The cut banks and areas with steep channel were identified and documented during the initial existing conditions field reconnaissance performed by the project team. The identified cut banks and areas with steep channel side slopes are both active and in-active and in either case represent a threat to the geomorphological stability, the existing and current water quality, habitat, and infrastructure to both creeks. Each cut bank and areas with steep channel have been identified as an individual project and represented on both the *Cheyenne Creek Conceptual Plan* and *Upper Fountain Creek Conceptual Plan* mapbooks and project lists.

7.7.9 Grade Control, Bank and Channel Stability

Several stretches of creek have been identified on both Upper Fountain and Cheyenne Creeks as showing grade and channel instability. The areas were identified and documented during the initial existing conditions field reconnaissance performed by the project team. The identified areas are both active and in-active and in either case represent a threat to the geomorphological stability, the existing and current water quality, habitat, and infrastructure to both creeks. Each area has been identified as an individual project and represented on both the *Cheyenne Creek Conceptual Plan* and *Upper Fountain Creek Conceptual Plan* mapbooks and project lists.

7.7.10 Other Identified Projects

Several other issues have been identified as an individual project. These issues rang from identified areas of required maintenance, existing debris piles, failed or failing drop channel drop structures, etc. Each specific issue is identified as a project and represented on either the *Cheyenne Creek Conceptual Plan* or *Upper Fountain Creek Conceptual Plan* mapbooks and project lists.

7.8 Project Cost Estimates

7.8.1 Detailed High and Immediate Priority Cost Estimates

Projects ranked as "high and immediate" on the project priority spreadsheets have semi-detailed cost estimates associated with them. The remainders of the projects have a rough estimate of project cost based on available cost information and engineering judgment. The high and immediate priority project cost tables are located in the plan and results section of this report. They include estimates of major project components in order to determine a more detailed cost estimate. A project ranking of immediate is given when there is a potential risk to public safety, high when there is a significant risk to infrastructure failure, moderate when there is a risk of infrastructure damage and possible failure, but there is no risk of upstream propagation of the problem.

7.8.2 Individual Project Cost Estimates for Moderate and Low Projects

The majority of project cost estimates are estimates of what the project team thinks a project would cost considering similar projects from the past and using engineering judgment. There are groupings of various projects in which the project team believes construction should occur at the same time. An example of one of these groupings is the Sand Gulch project area along Upper Fountain Creek. A listing of the individual projects cost, as well as a high priority semi-detailed cost table are located in the plan and results section of this report. Figure 7-22 below is a picture of the Sand Gulch project grouping. UFCP-30, 31, 32, 33, and 34 are all associated with Sand Gulch. Several of the projects have been given a rating of high in the priority table and are considered a single project for cost/planning purposes. See the project description section of this report for a further description of the groupings.

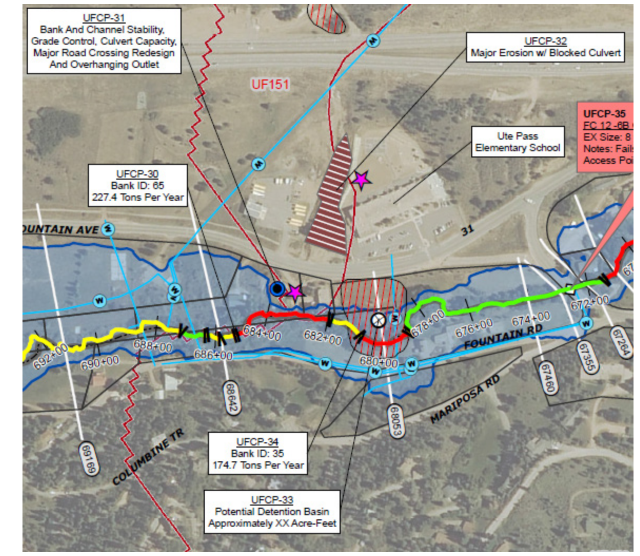

Figure 7-22. Sand Gulch Project Grouping

7.8.3 Reach Alternatives Costs

Reach alternative costs were determined to aid in the estimate of costs for projects within specific reaches. The costs listed below are used to determine individual project costs. The individual cost estimates are on the following assumptions:

- Natural Channel Design reach cost of $300/LF
- Small Drops Structures reach cost of $1000/LF
- Protect in Place reach cost of $300/LF
- 15% engineering and construction administration fee
- 20% contingency

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