

DRAFT

**REQUEST FOR
LETTER OF MAP REVISION**

**LOWER
BEAR CANYON CREEK**

Boulder, Colorado
August 6, 2014

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DBC Project No. 20636-00BLWR

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1.0 INTRODUCTION

Community Name: City of Boulder
County: Boulder County
State: Colorado

1.1 Purpose of Study

This Letter of Map Revision (LOMR) request is being submitted for Lower Bear Canyon Creek within the City of Boulder (City), Colorado. The project limits of this LOMR extend from approximately the intersection of Foothills Parkway and Colorado Avenue, downstream to the confluence with Boulder Creek, a reach length of approximately 0.75 miles.

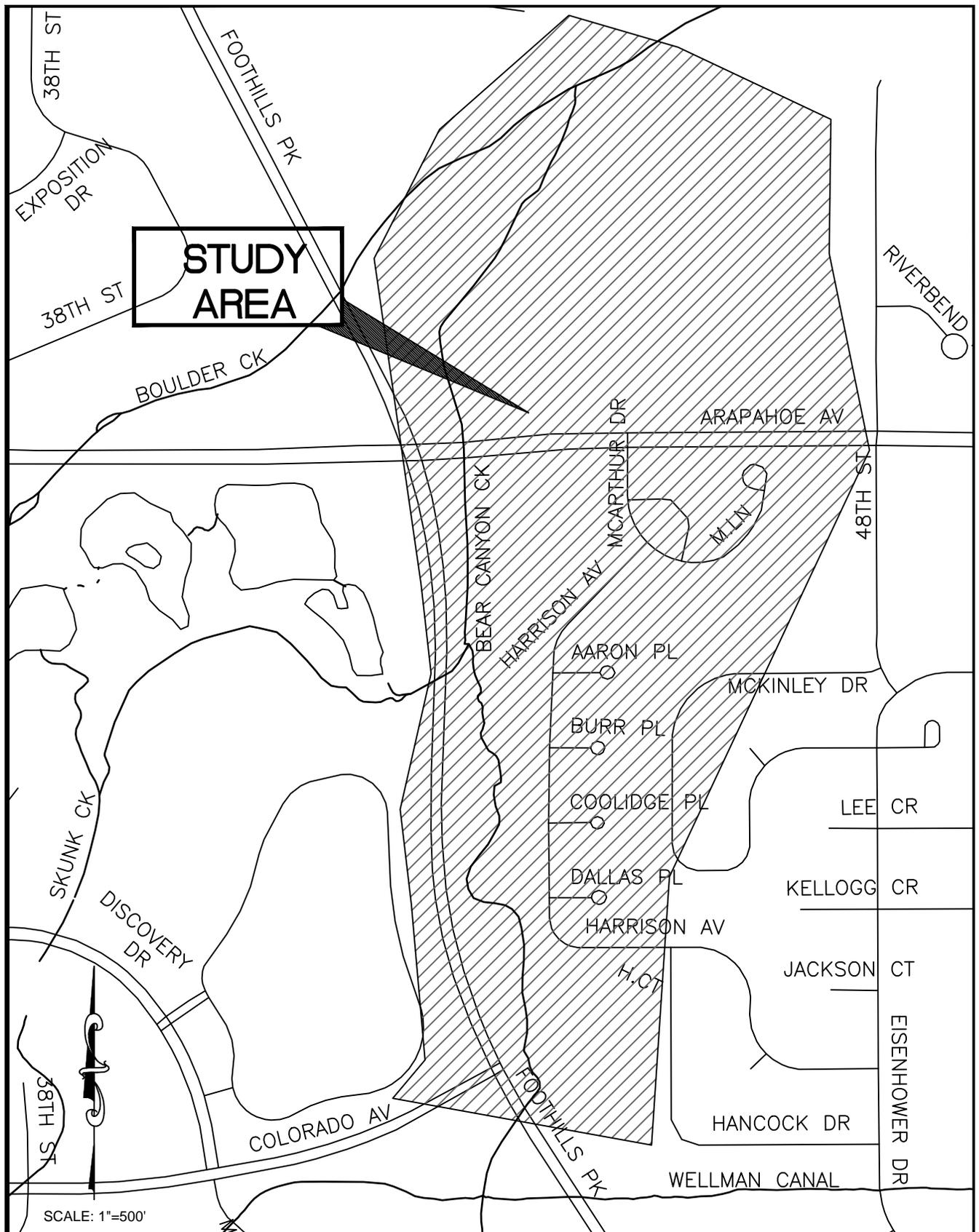
This LOMR is being requested to incorporate the impacts of recently constructed projects and revised starting water surface elevations and floodplain delineations of Boulder Creek.

The projects addressed by this LOMR include the Arapahoe Avenue and Foothills Parkway Intersection Improvements and Arapahoe Bike/Pedestrian Underpass Structure D-16-DQ at Bear Canyon Creek (Project Code Number 14366) as well as Harrison Avenue Levee (Harrison Levee) Improvements. Project 14366 was completed in 2008 and the Harrison Avenue Levee Improvements were completed in 2003.

The Project 14366 consisted of roadway re-grading, widening, and resurfacing, shoulder widening, median and curb and gutter replacement and relocation, a new pedestrian underpass box culvert at Bear Canyon Creek at Arapahoe Avenue, extension of the seven existing box culverts at Bear Canyon Creek at Arapahoe Avenue, Bear Canyon Creek channel regrading and instream wetland mitigation. Project 14366 is located within an area influenced by the floodplains of Bear Canyon Creek, Skunk Creek and Boulder Creek. This LOMR addresses project impacts to Bear Canyon Creek. The Lower Bear Creek LOMR study area is shown on the vicinity map in Figure 1.

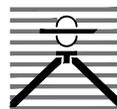
The Harrison Avenue Levee is located along the east bank of Bear Canyon Creek between Arapahoe Avenue and Foothills Parkway and was originally constructed in the 1970's. Levee improvements completed in 2003 included northward extension of the levee, levee widening, and raising the height of the levee to provide adequate, FEMA-required freeboard. Levee certification documents are submitted with this LOMR.

The Boulder Creek floodplain was recently restudied and the results published *Boulder Creek Floodplain Mapping Study* (Anderson 2013)



VICINITY MAP
 LOWER BEAR CANYON
 CREEK LOMR

PREPARED BY:



Drexel, Barrell & Co.
Engineers • Surveyors
 1800 38TH STREET
 BOULDER, COLORADO 80301
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FIGURE 1

1.2 Authority and Acknowledgments

This LOMR study was started by Love & Associates Inc./Belt Collins West, under contract with the City in 2006 and work was put on hold in September 2009. The LOMR study effort was resumed by Drexel, Barrell & Co (DBC), under contract with the City, in January 2014.

Project 14366 was sponsored jointly by the City and the Colorado Department of Transportation (CDOT) and was designed by Loris and Associates, Inc. Harrison Levee improvements were designed by DBC. DBC also completed the levee certification documents in support of this LOMR.

Base mapping in the form of 1-ft topographic contours was commissioned by the City and provided by Merrick & Company in 2003. The horizontal datum of the base map is NAD83 Colorado State Plane Coordinates and the vertical datum is NAVD 88. Pre-project and as-built field survey and cross sections obtained between 2005 and 2009 were provided by Boulder Land Consultants, Inc.

The regulatory hydraulic model and Flood Hazard Area Delineation (FHAD) for Bear Canyon Creek was completed in 1987 by Greenhorne & O'Mara. The most upstream Bear Canyon Creek cross section in this study (Cross Section 80) was updated by a LOMR approved by FEMA on February 27, 2003 (Love & Associates, Inc., 2002).

1.3 Coordination

The Bear Canyon Creek floodplain commingles with the floodplains of Boulder Creek and Skunk Creek within the study reach.

A Physical Map Revision (PMR) to the Boulder Creek floodplain was technically approved by FEMA but not published in Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRM), dated December 18, 2012. Starting water surface elevations, cross section geometry, and floodplain delineations north of Arapahoe Road are consistent with those identified in the Boulder Creek PMR.

Skunk Creek discharges into Bear Canyon Creek within the project reach. Flood discharge rates in Bear Creek increase at the confluence with Skunk Creek in accordance with the discharges identified in the FIS and FIRM.

This study and pertinent modeling and mapping decisions have been discussed and coordinated with the City of Boulder Public Works Department, the Urban Drainage and Flood Control District (UDFCD), and Michael Baker Corporation.

An independent peer review of the Bear Canyon Creek hydraulic modeling was initiated by the City in 2008. Peer review comments were discussed at a meeting on July 30, 2008 and modifications were incorporated into the hydraulic modeling.

2.0 STUDY AREA

2.1 Scope of Study

This study includes a detailed hydraulic analysis of the lower reach of Bear Canyon Creek. The segment of Bear Canyon Creek included in this study extends from the confluence with Boulder Creek to Cross Section 80 located approximately 80-ft downstream of Foothills Parkway at Bear Canyon Creek, a stream distance of approximately 3900-ft (see Figure 1). The FIRM panel to be revised by this study is panel 08013C0413J, dated December 18, 2012.

The Boulder Community Foothills Hospital (Hospital) was completed in 2003. The Hospital is a 200,000 sf facility. It is located within the study area and the development placed fill in the Bear Canyon Creek and Boulder Creek floodplains. FEMA granted the Hospital a LOMR-F dated October 15, 2003. A detailed hydraulic analysis was not undertaken as part of the Hospital LOMR-F. The fill placed on the Hospital site is modeled in the Bear Canyon Creek pre-project and post-project hydraulic models, however, it is not considered a part of the “project” described in Section 1.1 for which this LOMR is being submitted.

2.2 Community Description

The City of Boulder is located northwest of Denver on the east side of the Rocky Mountains in Colorado. The area of the City is approximately 26 sq. mi. and the population is approximately 102,000. The City is located within central Boulder County along the foothills of central Colorado.

The climate is relatively dry and averages approximately 20-inches of precipitation per year. Most precipitation occurs in the winter and spring, with average annual snowfall totaling approximately 80-inches. The mean daily maximum temperature in Boulder is 64°F and the mean daily minimum temperature is 38°F (NOAA, 2009). The elevation ranges from 8,520-ft to 5,155-ft (FIS). The upslope areas are covered with a variety of rock outcrop, thin residual soils on bedrock, and thicker debris, alluvium, and slope wash deposits and are vegetated with grasses, trees, and shrubs. Deeper soils and wetland vegetation are found on alluvial deposits adjacent to streams (FIS).

The zoning code regulates development of each parcel of land within the City with respect to allowable uses, placement of fill, protection of wetlands, density, setbacks, height, etc. Development has altered historic channels, stormwater flow paths, runoff characteristics, and surface water quality. There is little vacant land left within the City and, therefore, most new development will occur through redevelopment. The City promotes floodplain preservation and, when possible, preserves floodplain areas through public land acquisition of high hazard properties and private land dedication.

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Bear Canyon Creek is an intermittent stream originating in the foothills west of the City and flowing generally in a northeastwardly direction. The stream channel consist of topsoil in the C and D hydrologic soils groups. Bear Canyon Creek drains an area of 8.24 sq. mi.

2.3 Principal Flooding Problems

The principal cause of flooding is intense, localized thunderstorms. Because headwaters are below 9,000 ft for Bear Canyon Creek, peak discharges are not highly affected by snowmelt.

Boulder experienced a 100-yr flood in 1894 which caused extensive damage. Nearly all bridges in the City were washed out by the 1894 flood. A significant flood occurred in 1969 and according to newspaper accounts Bear Canyon Creek overflowed its banks during this flood. Bear Canyon Creek, within the project reach, also overflowed its banks during September 2013 flooding; however flood damages were relatively minor and the floodplain geometry was not altered.

2.4 Flood Protection Measures

The Harrison Levee protects numerous residential structures along the east side of Harrison Avenue, McKinley Drive, and adjacent streets from inundation by the base flood. The Harrison Levee is currently a Provisionally Accredited Levee (PAL) and the expectation is the Levee will become fully certified following acceptance of this LOMR.

3.0 ENGINEERING METHODS

3.1 Hydrologic Analysis

10-, 50-, 100-, and 500-year peak flood discharges published in the FIS were used for this study. 25-year peak discharges were interpolated from the FIS values using Annual Peak Flow Frequency Analysis graph paper. Table 1 summarizes flood peak discharges within the study area for various flood recurrence intervals.

Table 1 - Bear Canyon Creek, Peak Discharges (cfs)

Location	10-year	25-year	50-year	100-year	500-year
Below Confluence with Skunk Creek	2,050	3,050	3,762	4,880	7,500
Above Confluence with Skunk Creek	1,170	1,800	2,360	3,070	5,100

3.2 Hydraulic Analysis

The hydraulic analysis for this study was performed using HEC-RAS Version 4.1.0 developed by the US Army Corps of Engineers (USACE, 2010).

3.2.1 Vertical Datum and Base Survey

Following current FEMA guidelines, the vertical datum used for the hydraulic modeling is the North American Vertical Datum of 1988 (NAVD 88). All field survey data commissioned for this study is also on NAVD 88. The regulatory hydraulic models for Bear Canyon Creek are on the National Geodetic Vertical Datum of 1929 (NGVD 29) and a conversion factor was required to translate NGVD 29 to NAVD 88. The conversion equation is given below and was obtained from Corpscon version 6.0 (USACE, 2004).

$$\text{NGVD 29} + 3.22 = \text{NAVD 88}$$

Several field surveys were commissioned for this study to define pre-project and post-project conditions (BLC, 2005-2009). Table 3 lists the dates of these surveys and describes the data obtained on each date.

Table 2 - Dates and Descriptions of Project Field Surveys

Date of Survey	Description
March 12, 2004	Pre-project survey of Arapahoe Avenue and Foothills Parkway, Arapahoe Avenue culverts at Bear Canyon Creek, and Bear Canyon Creek channel just upstream and downstream of the Arapahoe Avenue culverts.
February 6, 2007	Cross section survey for Bear Canyon Creek section 15 and portions of sections 49, 50, and 55
May 25, 2007	Post-project survey of Harrison Levee. Survey of Bear Canyon Creek cross sections 61-80.
December 28, 2008	Post-project survey of Arapahoe Avenue culverts and new underpass at Bear Canyon Creek
June 1, 2009	Post-project survey of Arapahoe Avenue and Foothills Parkway

Digital files of these surveys are included on the digital LOMR submittal CD.

3.2.2 Definition of Cross Sections

Bear Canyon Creek cross sections for pre-project conditions were generally defined using the field survey from 3/12/04, 2/6/07, and 2/25/07 supplemented with the City's 1-ft topographic contour mapping. The pre-project Harrison Levee was defined using the City's 2-ft topographic contour mapping from 1993.

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Bear Canyon Creek cross sections for post-project conditions were generally defined using field surveys dated 2/6/07, 2/25/07, 12/28/08, and 6/1/09 supplemented with the City's 1-ft topographic contour mapping. Cross sections 5, 10, 15 and 17 match those used in the Bear Canyon Creek PMR. The project did not impact the main channel at cross sections 49 to 80 (excluding the encroachment on sections 55 – 76 resulting from widening and raising the Harrison Levee).

3.2.3 Roughness

Bear Canyon Creek - Manning's 'n' roughness coefficients for the pre-project and post-project models were determined in the field and range from 0.02 to 0.13. The effective coefficients were maintained downstream of Arapahoe Avenue. Unlike the effective model which contained only three roughness coefficients per cross section, the pre-project and post-project cross sections upstream of Arapahoe Avenue have more than three roughness coefficients per section to reflect the presence of brushy areas, grassy areas, the Harrison Levee, Foothills Parkway, the pedestrian trail, and the Viewpoint office complex. The "horizontal variation in n-values" function was used to define roughness for cross sections where changes in roughness do not necessarily correspond to the transition point between the left bank, main channel, and right bank.

Several cross sections extend west onto Foothills Parkway. The road surface was assigned a Manning's "n" of 0.02. The right bank of Cross Sections 55 through 76 is located on the Harrison Levee. The levee will be maintained by the City with a short grass cover and the roughness coefficient for this area was set to 0.035.

The left bank of Cross Sections 40 through 72 was assigned a roughness coefficient of 0.035 for the portion of the cross section in the vicinity of the new pedestrian trail east of Foothills Parkway. Brushy, wooded areas on the left bank were assigned a roughness coefficient of 0.06. The main channel is characterized by a roughness coefficient of 0.04 from the downstream limit to Cross Section 55 and 0.045 from Cross Section 61 to the upstream limit. Roughness coefficients of the right bank of these cross sections between the main channel and the levee equal 0.075 in riparian forest areas and 0.045 for areas occupied by grasses and shrubs. A Manning's 'n' of 0.13 is used for the Viewpoint office complex.

For the spill reach west of Foothills Parkway, a roughness coefficient of 0.035 was assigned to the grassed area characterizing the spill channel. A paved roadway and parking lot are located through portions of the spill area. A roughness coefficient of 0.02 was used for the roadway and 0.08 for the parking lot.

3.2.4 Debris Blockage and Obstructions

Following consultation with City staff, debris blockage at the Arapahoe Avenue box culverts on Bear Canyon Creek was set to 25% blockage. A 25% blockage value is in general conformance with the blockage values used in the Boulder Creek floodplain study (Debris Obstruction Category 4) and was deemed appropriate for an eight cell

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culvert crossing with seven divider walls. The post-project model includes a blocked obstruction at the pedestrian underpass box below the top of wall elevation of the divider wall separating the pedestrian underpass and the main channel. This divider wall keeps the pedestrian underpass dry during low flows and over tops during major storm events. Flow below the top of wall elevation was assumed ineffective. The pedestrian box was modeled with an invert elevation equal to the downstream top of divider wall.

3.2.5 Starting Water Surface Elevations

Bear Canyon Creek - The Bear Canyon Creek regulatory model uses the Boulder Creek 100-year water surface elevation at the confluence as the starting water surface elevation for the 10-, 50-, 100-, and 500-year events. The Bear Canyon Creek starting water surface elevation is revised by this study to use the 10-yr Boulder Creek water surface elevation (5232.91-ft) at the confluence as the starting water surface elevation for all Bear Canyon Creek flood profiles. The 10-year water surface elevation in Boulder Creek was taken from the proposed Boulder Creek Model at cross section 17485.

Use of the 10-year water surface elevation of the larger receiving stream is the generally accepted methodology for defining the starting water surface elevation of the smaller stream at a confluence.

3.2.6 Lateral Weirs and Spill Flows

Bear Canyon Creek – Four lateral weirs are defined along Bear Canyon Creek. The first is the Foothills Parkway weir. A spill occurs along the left bank of the Bear Canyon Creek main channel over Foothills Parkway during the 500-year event (see Table 2 for spill flows). The lateral weir is located along the high point of Foothills Parkway between Bear Canyon Creek cross sections 61 and 79. The high point of the lateral weir is located along the west shoulder of Foothills Parkway for approximately the southern two-thirds of the weir length and along the Foothills Parkway median for the northern third of the weir length. The Foothills Parkway weir is approximately 1275-ft long. Project 14366 raised the roadway surface approximately 1-ft over much of the length of the weir, thereby decreasing the 500-yr spill flow from 649 cfs for existing conditions to 485 cfs for post-project conditions. Project 14366 decreased the 100-yr spill over Foothills Parkway from 34 cfs to a negligible 4 cfs.

The Bear Canyon Creek spill reach includes cross sections 1061 - 1074 located on the west side of Foothills Parkway. The spill reach is included in both the pre-project and post-project models.

The remaining 3 lateral weirs are modeled on the right bank of Bear Canyon Creek just downstream of the north end of the Harrison Levee. Spill flows leave the main channel downstream of the levee and spill eastward. The Harrison Levee improvements extended the levee northward and decreased the spill east of the levee for post-project conditions. The 100-yr levee spill decreased from 355 cfs for pre-project conditions to 70 cfs for

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post-project conditions. The 500-yr spill remained approximately the same, 1,114 cfs for pre-project conditions and 1,100 cfs for post-project conditions.

A broad-crested weir with a weir coefficient of 2.6 was assumed for both the Foothills Parkway and Harrison levee weirs on Bear Canyon Creek given the relatively long crest length compared to the relatively small head.

Under pre and post-project conditions, there is a left bank spill flow from Bear Canyon Creek over Foothills Parkway. There are also a right bank spills from the Bear Canyon Creek main channel at the downstream end of the Harrison Levee. Lateral weirs are included in the hydraulic pre-project and post-project hydraulic models to quantify spill flows. Pre and Post Project spills are summarized in Table 2.

Table 3 - Bear Canyon Creek, Pre and Post-Project Spill Discharges

Flood Event	Spill Discharges (cfs)			
	Foothills Parkway Spill (left bank)		Spill Downstream of Harrison Levee (right bank)	
	Pre-Project	Post-Project	Pre-Project	Post-Project
10-yr	0	0	0	0
25-yr	0	0	15	0
50-yr	0	0	103	2
100-yr	34	4	355	70
500-yr	649	485	1,114	1,099

3.2.7 Arapahoe Avenue Box Culverts on Bear Canyon Creek

Extensive analysis was performed to define the hydraulic control conditions at the Arapahoe Avenue culvert.

The pre-project culvert was analyzed using Energy (standard step) methodologies for low flows and Pressure/Weir flow for higher flows. The pre-project culvert operated under inlet control conditions due to the lesser capacity of the pre-project culverts and significant head upstream of the culverts resulting in overtopping of the Arapahoe Avenue roadway: 293 cfs, 50-yr; 770 cfs, 100-yr; and 1,735 cfs, 500-yr.

The post project culvert was analyzed using Energy (standard step) methodologies with the highest upstream energy option for low flows and Pressure/Weir flow for higher lows. The culvert operates under outlet control for post-project conditions. The new structure greatly reduces the overtopping of the Arapahoe Avenue roadway: 0 cfs, 50-yr; 31 cfs, 100-yr; and 1,269 cfs, 500-yr.

3.2.8 Effective and Duplicate Effective Hydraulic Models

The effective and duplicate effective models for Bear Canyon Creek are included on the digital LOMR submittal CD.

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There are two Bear Canyon Creek effective models for the study area. The first, BEAR.dat, contains the reach from the confluence with Boulder Creek to Cross Section 80 (Greenhorn & O'Mara Inc., 1987). Cross Section 80 was updated by a 2003 LOMR model, REVdsmtp.dat (Love & Associates, 2002). Following current FEMA guidelines, the two effective models were combined in HEC-RAS in the duplicate effective model, BEARde09.prj.

Direct import of the single culvert at Arapahoe Avenue as modeled in the effective model as a special bridge is not possible. The culvert was modeled using the HEC-RAS pressure bridge routine. The Bear Canyon Creek effective and duplicate effective 100-year water surface elevations are shown in Table 4, BFE Comparison Table.

3.2.9 Pre-Project Hydraulic Model

Pre-project models for Bear Canyon Creek are included on the digital LOMR submittal CD.

A pre-project conditions model, BEARprep09.prj, was created for Bear Canyon Creek. The pre-project model includes the pre-project Harrison Levee before it was raised, widened, and extended and the pre-project Arapahoe Avenue culverts. The Arapahoe Avenue culverts were modeled using a bridge routine in the effective model. For the pre-project model, box culvert routines were used to model these structures rather than the bridge routine to more accurately reflect existing conditions.

The starting water surface elevation (WSE) was revised to the effective 10-yr WSE in Boulder Creek at the confluence with Bear Canyon Creek. This results in a decrease in the starting WSE of 2.44-ft from the effective model. Cross sections were updated using pre-project field survey and 1-ft contours and new cross sections were added to the pre-project model. Reach lengths were updated. Pre-project 100-year water surface elevations are shown in Table 4, BFE Comparison Table.

3.2.10 Post-Project Hydraulic Model

Post-project models for Bear Canyon Creek are included on the digital LOMR submittal CD.

Post-project field survey data was input into the post-project model for the new pedestrian underpass at Arapahoe Avenue, the raised roadway and shoulder elevations on Arapahoe Avenue and Foothills Parkway, and the raised, widened, and extended Harrison Levee. Post-project 100-year water surface elevations are shown in Table 4, BFE Comparison Table.



UDFCD DLOMC Submittal - BFE Comparison Table

Project Name :	Lower Bear Canyon Creek - LOMR
Flooding Source:	Bear Canyon Creek
Company:	Drexel, Barrell & Co.
Completed By:	Steve Leslie, P.E.

SOURCE DATA						COMPARISONS									
HYDRAULIC CROSS-SECTION INFO.						BASE FLOOD ELEVATIONS (NAVD88)									
Effective Cross-Section ID (Letter)	Corrected Effective Cross-Section ID (1)(2)	Corrected Effective Stream Station	Existing Cross-Section ID	Proposed Cross-Section ID	Proposed Stream Station	EFFECTIVE	DUP. EFF.	COR. EFF.	EXISTING	PROPOSED	DUP. EFF vs. EFF.	COR. EFF. vs. EFF.	EX. vs. COR. EFF.	PP. vs. COR. EFF.	PP. vs. EFF.
						BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE
Main Channel															
--	--	--	5	5	54	--	--	--	5232.91	5232.91	--	--	--	--	--
10	10	300	--	--	--	5235.35	5235.35	5235.35	--	--	0.00	0.00	--	--	--
--	--	--	10	10	356	--	--	--	5235.25	5235.25	--	--	--	--	--
--	--	--	15	15	625	--	--	--	5236.59	5236.59	--	--	--	--	--
15	15	700	NA	NA	--	5237.08	5237.08	5237.08	--	--	0.00	0.00	--	--	--
--	--	--	17	17	862	--	--	--	5238.28	5238.28	--	--	--	--	--
20 (A)	20 (A)	1380 (2)	--	--	--	5240.39	5240.50	5240.50	--	--	0.11	0.11	--	--	--
--	--	--	21	21	1346	--	--	--	5240.47	5240.06	--	--	--	--	--
22	22	1410	22	22	1374	5241.39	5241.23	5241.23	5240.24	5239.96	-0.16	-0.16	-0.99	-1.27	-1.43
32	32	1520	32	32	1545	5243.67	5244.02	5244.02	5243.56	5242.85	0.35	0.35	-0.46	-1.17	-0.82
40	40	1625	40	40	1625	5244.90	5244.89	5244.89	5243.97	5243.08	-0.01	-0.01	-0.92	-1.81	-1.82
--	--	--	44	44	1700	--	--	--	5244.27	5243.65	--	--	--	--	--
--	--	--	48	48	1791	--	--	--	5244.31	5243.74	--	--	--	--	--
--	--	--	49	49	1839	--	--	--	5244.54	5244.07	--	--	--	--	--
--	--	--	49.5	49.5	1964	--	--	--	5244.73	5244.49	--	--	--	--	--
50	50	1955	50	50	1977	5245.62	5245.70	5245.70	5245.01	5244.55	0.08	0.08	-0.69	-1.15	-1.07
55	55	2185	55	55	2140	5246.22	5246.35	5246.35	5245.80	5245.60	0.13	0.13	-0.55	-0.75	-0.62
57	57	2280	--	--	--	5246.51	5246.63	5246.63	--	--	0.12	0.12	--	--	--
60 (B)	60 (B)	2480 (2)	61	61	2478	5247.29	5247.33	5247.33	5247.28	5247.58	0.04	0.04	-0.05	0.25	0.29
--	--	--	72	72	2835	--	--	--	5251.97	5251.91	--	--	--	--	--
70 (C)	70 (C)	3380 (2)	74	74	3293	5258.64	5258.70	5258.70	5258.95	5258.28	0.06	0.06	0.25	-0.42	-0.36
--	--	--	76	76	3569	--	--	--	5262.02	5262.27	--	--	--	--	--
--	--	--	79	79	3854	--	--	--	5264.84	5264.79	--	--	--	--	--
80	80	3930	80	80	3901	5265.39	5265.03	5265.03	5265.40	5265.40	-0.36	-0.36	0.37	0.37	0.01
Spill Channel															
--	--	--	1061	1061	119	--	--	--	5246.25	5246.27	--	--	--	--	--
--	--	--	1072	1072	448	--	--	--	5248.36	5247.93	--	--	--	--	--
--	--	--	1074	1074	993	--	--	--	5253.16	5253.02	--	--	--	--	--

-- = Not applicable or no direct comparison available

5225.98 = Interpolated value or value pulled directly from the effective FIS profile

(1) Duplicate Effective = Corrected Effective

(2) LOMR Table 5, 2/17/2003. Remaining stations from effective model

Drexel, Barrell Co.

H:\20636-00BLWR\Reports\Floodplain\Bear Creek LOMR\CD\Comparison Tables\DLOMC BFE Comparison Table.xlsx DLOMC BFE Comp Table

8/11/2014

3.2.11 Floodway

In addition to minimum FEMA requirements, the City regulates the floodway using maximum 0.5-ft rise criteria which has been approved by FEMA. A 0.5-ft rise floodway is defined for Bear Canyon Creek.

Flood elevations downstream of Arapahoe Avenue are controlled by BFEs in Boulder Creek. Following conversations with UDFCD, the Bear Canyon Creek floodway is defined only upstream of Arapahoe Avenue. The floodway was initially defined using HEC-RAS Method 4 for a target water surface rise of 0.5-ft and an equal conveyance reduction. Method 4 resulted in significant negative surcharges and surcharges in excess of 0.5-ft. The floodway was then adjusted using Method 1 encroachments to eliminate negative surcharges.

The Bear Canyon Creek floodway is located primarily within the City of Boulder open space and CU property which will not be developed. Full flows were run through the main channel to define the floodway and base flood elevations (spill flows were not subtracted). The post-project floodway hydraulic model Creek is included on the digital LOMR submittal CD.

4.0 NFIP REGULATION COMPLIANCE

4.1 FEMA Forms

The appropriate FEMA forms and supporting documentation are located in Appendix 1 of this document.

4.2 Floodplain Tie-ins

The revised Bear Canyon Creek floodplain ties to the effective floodplain on the upstream end of the study reach at the downstream face of the Foothills Parkway culvert (just upstream of Cross Section 80).

On the west side of Bear Canyon Creek, the revised 100-yr floodplain joins the Skunk Creek floodplain on the downstream end of the double box culvert beneath Foothills Parkway. The revised 500-yr floodplain joins the 500-yr floodplain of Skunk Creek immediately west of Foothills Parkway.

On the east side of Bear Canyon Creek, the floodplain is located on the stream side of the Harrison Levee to the downstream end of the levee at cross section 50. Flows spill from the main channel, behind and east of the Harrison Levee. There are existing Zone X and Zone AO flood zones east of the Harrison Levee and south of Arapahoe Avenue. The existing Zone X floodplain is slightly widened by this LOMR. This floodplain revision slightly extends the existing Zone AO boundary southward. The revised 100-yr

REQUEST FOR LETTER OF MAP REVISION
LOWER BEAR CANYON CREEK

floodplain ties into the existing Zone AO on the east side of Harrison Avenue southwest of the intersection of Harrison Avenue and MacArthur Lane.

The revised Bear Canyon Creek floodplain ties to the proposed Boulder Creek PMR 100- and 500-year floodplains at Arapahoe Road. North of Arapahoe Road the Bear Canyon Creek floodplain is coincident with the proposed Boulder Creek PMR floodplains

4.3 Floodway Tie-ins

The downstream end of the revised floodway (Conveyance) Zone terminates at the upstream end of the Arapahoe Road culvert. The upstream end of the revised floodway ties to the effective floodway at the downstream end of the Foothills Parkway culvert.

4.4 Floodplain Work Maps

The effective and post-project 100-yr and 500-yr floodplains and the floodway for Bear Canyon Creek are delineated on the Work Maps, located in Appendix 2. Also included on the Works Maps are the effective floodplain and floodways as well as the proposed Boulder Creek PMR floodplains. Digital files of the Work Maps are also included on the LOMR submittal CD.

4.5 Annotated FIRM, Profiles and Floodway Data Table

The annotated FIRM panel, Flood Profiles, and Floodway Data Table are included in Appendix 3. Digital files are also included on the LOMR submittal CD.

4.6 Agreement Checklists

Agreement check lists are included on the LOMR submittal CD.

4.7 Notifications

Notification and Certification letters are included on the LOMR submittal CD.

5.0 CONCLUSIONS

The information contained in this LOMR is intended as a revision to the effective FIS and FIRM to incorporate roadway improvements along Arapahoe Avenue and Foothills Parkway, addition of the pedestrian underpass at Arapahoe Avenue at Bear Canyon Creek, improvements to the Harrison Levee, and to identify Bear Canyon Creek floodplain impacts resulting from the proposed Boulder Creek PMR.

REQUEST FOR LETTER OF MAP REVISION
LOWER BEAR CANYON CREEK

6.0 REFERENCES

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**REQUEST FOR LETTER OF MAP REVISION
LOWER BEAR CANYON CREEK**

APPENDICES

**REQUEST FOR LETTER OF MAP REVISION
LOWER BEAR CANYON CREEK**

APPENDIX 1

**FEMA FORMS AND
SUPPORTING
DOCUMENTATION**

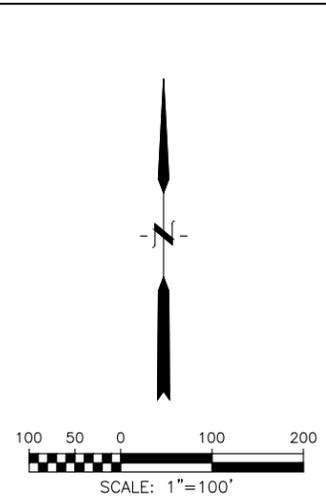
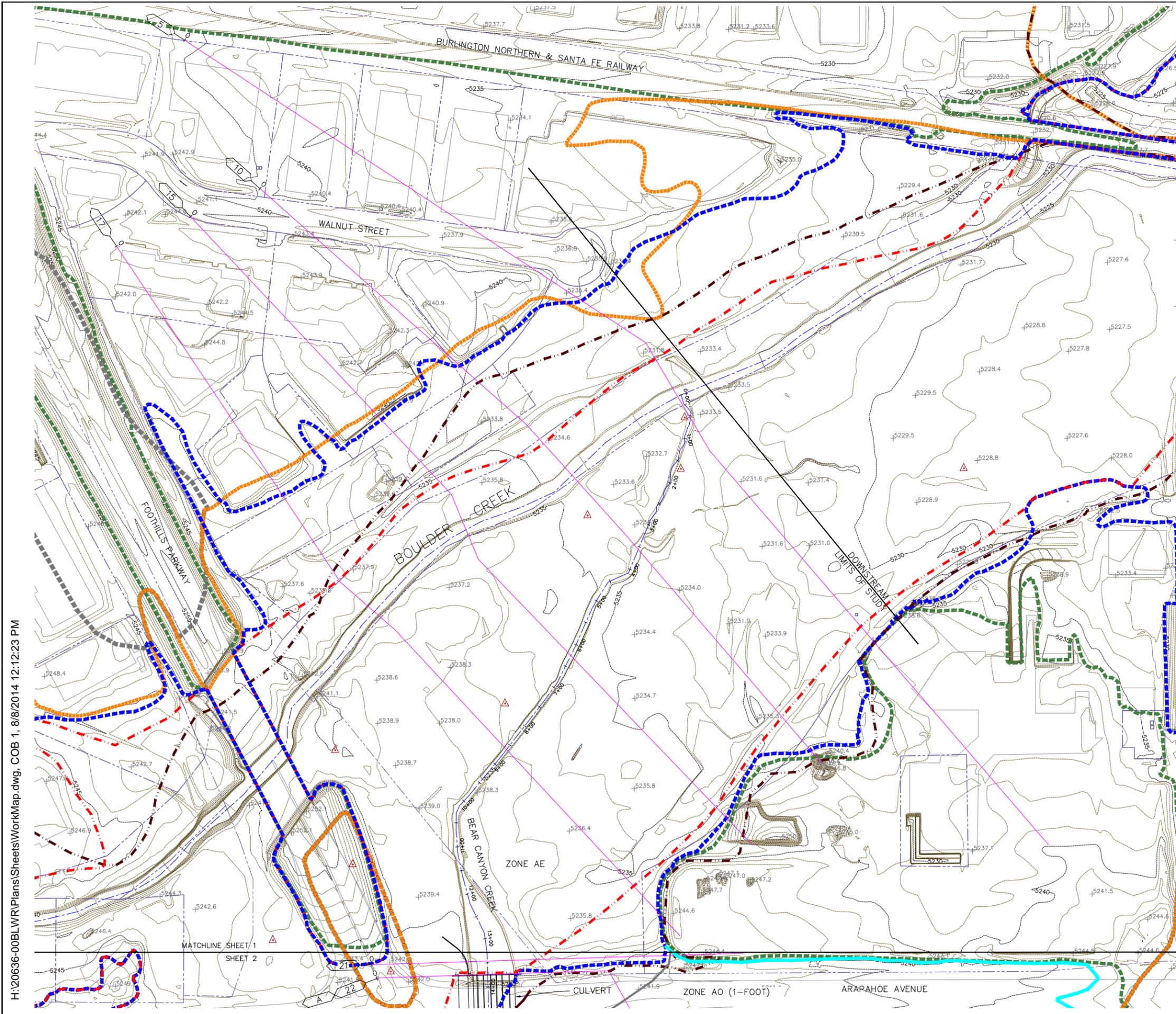
**REQUEST FOR LETTER OF MAP REVISION
LOWER BEAR CANYON CREEK**

Work in Progress

**REQUEST FOR LETTER OF MAP REVISION
LOWER BEAR CANYON CREEK**

APPENDIX 2

FLOODPLAIN WORK MAPS



SURVEY NOTES:
 GROUND CONTROL SURVEY BY: MERRICK & COMPANY
 AERIAL PHOTOGRAPHY BY: MERRICK & COMPANY
 TOPOGRAPHIC MAPPING BY: MERRICK & COMPANY
 CONTOUR INTERVAL: ONE FEET
 DATE FLOWN: 2003
 DATUM: HORIZONTAL - NAD83, COLORADO STATE
 PLANE COORD. - NORTH; VERTICAL - NAVD88

LEGEND

- CROSS SECTION AND START STATION
- EFFECTIVE 100-YEAR FLOODPLAIN
- EFFECTIVE 500-YEAR FLOODPLAIN
- EFFECTIVE HIGH HAZARD ZONE
- EFFECTIVE CONVEYANCE ZONE
- PROPOSED 100-YEAR BOULDER CREEK FLOODPLAIN
- PROPOSED 500-YEAR BOULDER CREEK FLOODPLAIN
- PROPOSED HIGH HAZARD ZONE BOULDER CREEK FLOODPLAIN
- PROPOSED CONVEYANCE ZONE BOULDER CREEK FLOODPLAIN
- REVISED 100-YEAR BEAR CANYON CREEK FLOODPLAIN
- REVISED 500-YEAR BEAR CANYON CREEK FLOODPLAIN
- REVISED HIGH HAZARD ZONE BEAR CANYON CREEK FLOODPLAIN
- REVISED CONVEYANCE ZONE BEAR CANYON CREEK FLOODPLAIN
- HARRISON LEVEE
- LATERAL WEIR
- GUTTER LINE
- STREAM CENTERLINE
- BASE FLOOD ELEVATION
- SURVEY CONTROL POINT

PREPARED BY:

DREXEL, BARRELL & CO.
 Engineers • Surveyors
 1800 38TH STREET
 BOULDER, COLORADO 80301
 CONTACT: STEVE LESLIE, P.E.
 (303) 442-4338
 BOULDER
 COLORADO SPRINGS
 GRAND JUNCTION

OWNER:

CITY OF BOULDER
 UTILITIES DIVISION

FLOODPLAIN MAP FOR:
LOWER BEAR CANYON CREEK
 BOULDER, COLORADO

ISSUE	DATE
CITY SUBMITTAL	08/11/14
DESIGNED BY:	SKG
DRAWN BY:	SKG
CHECKED BY:	SDL
FILE NAME:	WORKMAP

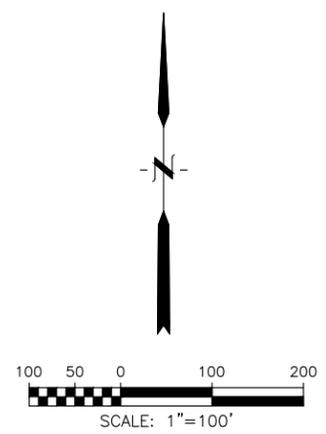
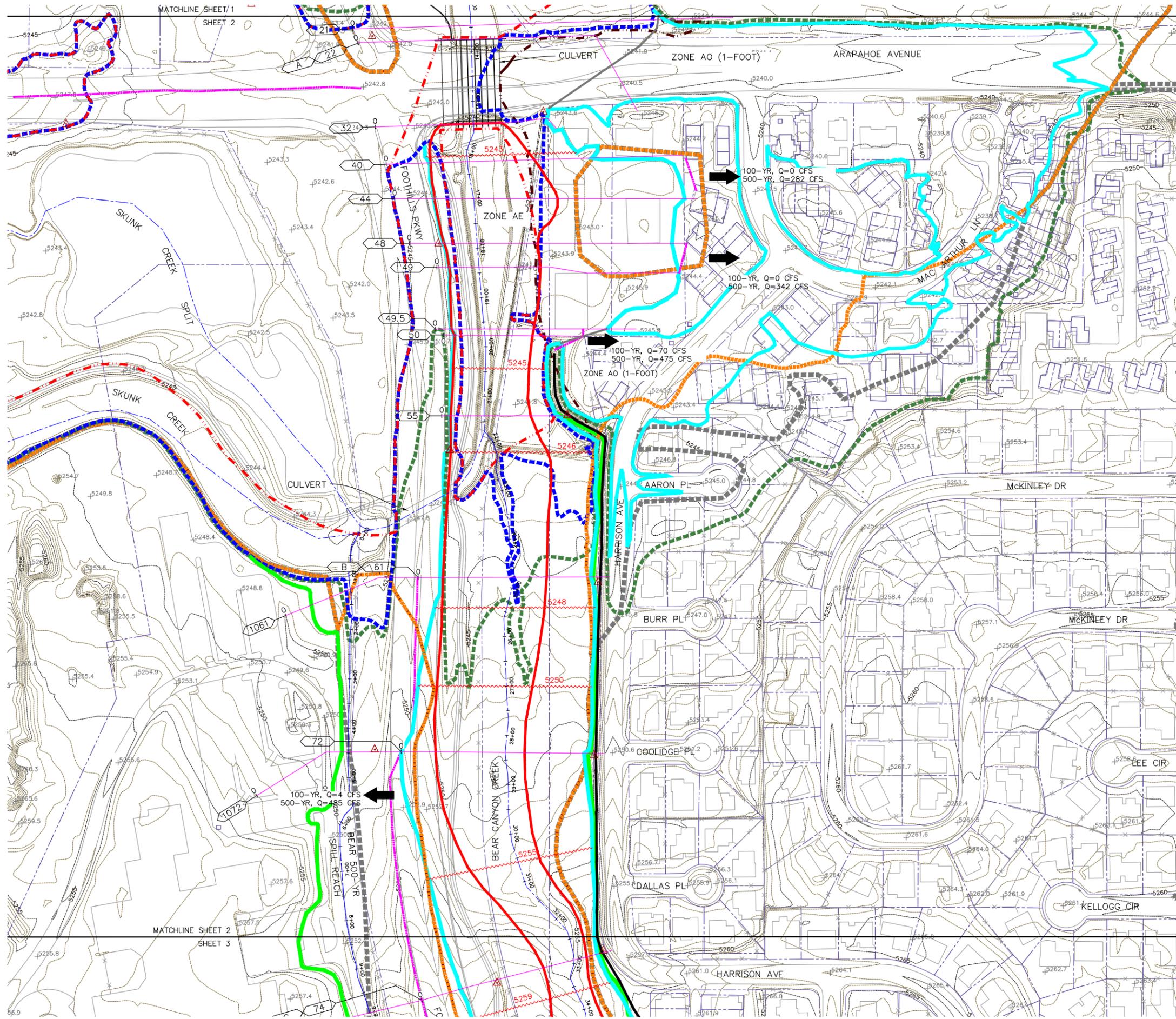
DRAWING SCALE:
 HORIZONTAL: 1" = 100'
 VERTICAL: N/A

LOWER BEAR CANYON CREEK WORKMAP

PROJECT NO. 19784-07BLCV

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 SHEET: 1 OF 3

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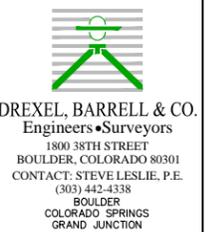


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 AERIAL PHOTOGRAPHY BY: MERRICK & COMPANY
 TOPOGRAPHIC MAPPING BY: MERRICK & COMPANY
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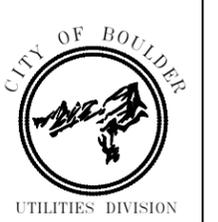
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- EFFECTIVE 500-YEAR FLOODPLAIN
- EFFECTIVE HIGH HAZARD ZONE
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- REVISED CONVEYANCE ZONE BEAR CANYON CREEK FLOODPLAIN
- HARRISON LEVEE
- LATERAL WEIR
- GUTTER LINE
- STREAM CENTERLINE
- BASE FLOOD ELEVATION
- SURVEY CONTROL POINT

PREPARED BY:



OWNER:



FLOODPLAIN MAP FOR:
LOWER BEAR CANYON CREEK
 BOULDER, COLORADO

ISSUE	DATE
CITY SUBMITTAL	08/11/14
DESIGNED BY:	SKG
DRAWN BY:	SKG
CHECKED BY:	SDL
FILE NAME:	WORKMAP

DRAWING SCALE:
 HORIZONTAL: 1" = 100'
 VERTICAL: N/A

LOWER BEAR CANYON CREEK WORKMAP

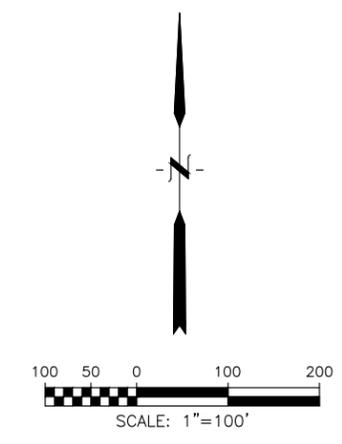
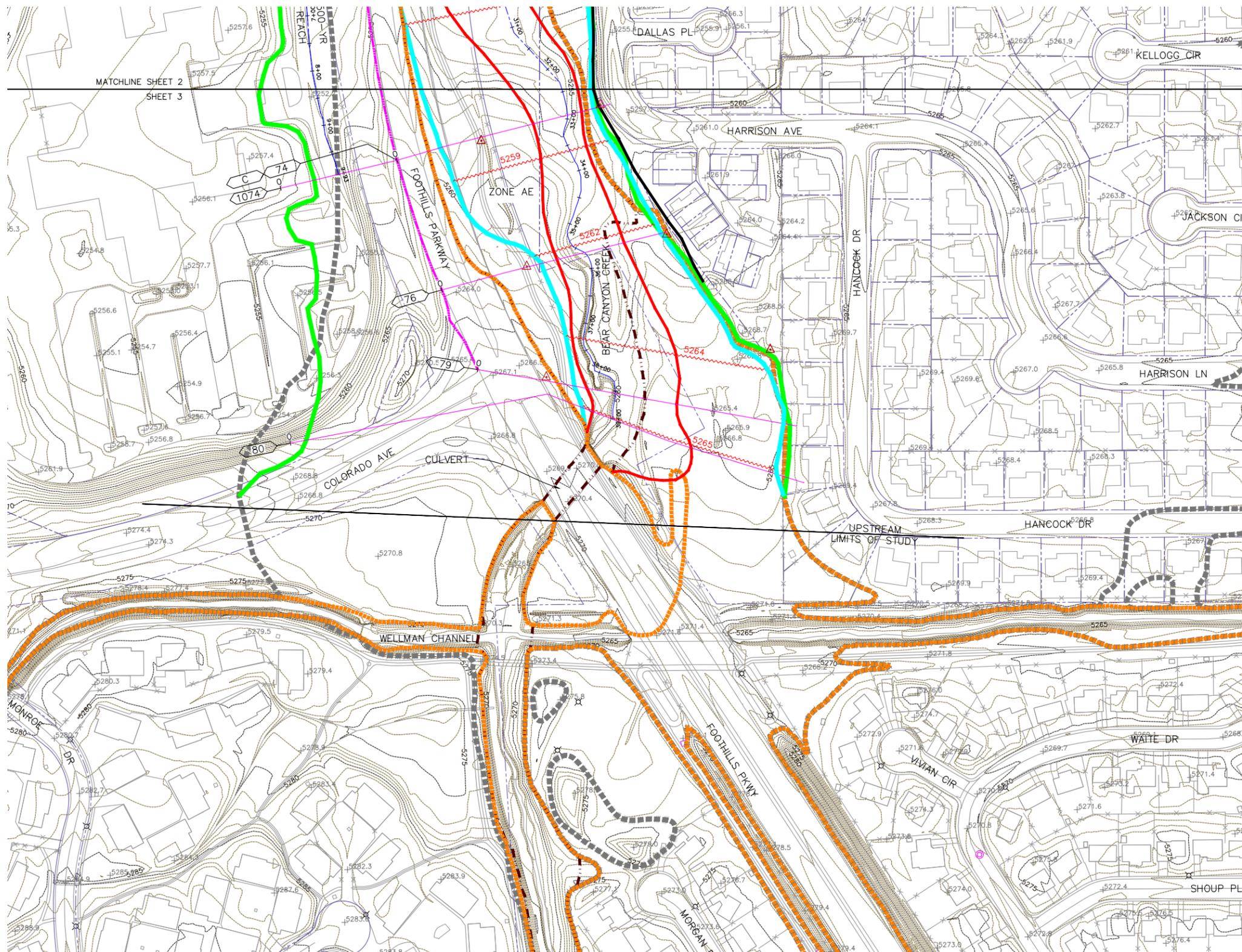
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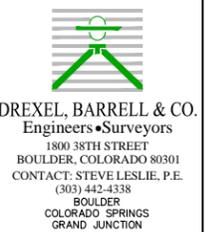


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 AERIAL PHOTOGRAPHY BY: MERRICK & COMPANY
 TOPOGRAPHIC MAPPING BY: MERRICK & COMPANY
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 DATE FLOWN: 2003
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 PLANE COORD. - NORTH; VERTICAL - NAVD88

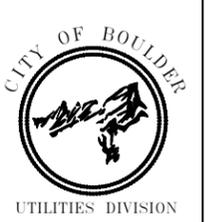
LEGEND

- CROSS SECTION AND START STATION
- EFFECTIVE 100-YEAR FLOODPLAIN
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- HARRISON LEVEE
- LATERAL WEIR
- GUTTER LINE
- STREAM CENTERLINE
- BASE FLOOD ELEVATION
- SURVEY CONTROL POINT

PREPARED BY:



OWNER:



FLOODPLAIN MAP FOR:

LOWER BEAR CANYON CREEK

BOULDER, COLORADO

ISSUE	DATE
CITY SUBMITTAL	08/11/14
DESIGNED BY:	SKG
DRAWN BY:	SKG
CHECKED BY:	SDL
FILE NAME:	WORKMAP

DRAWING SCALE:
 HORIZONTAL: 1" = 100'
 VERTICAL: N/A

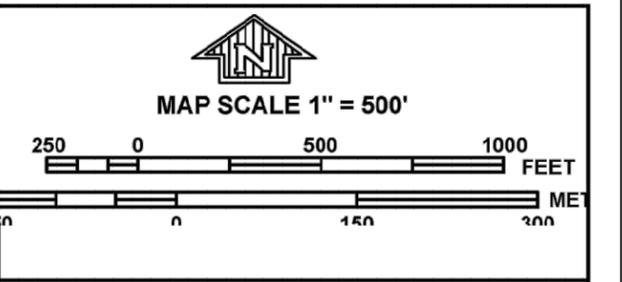
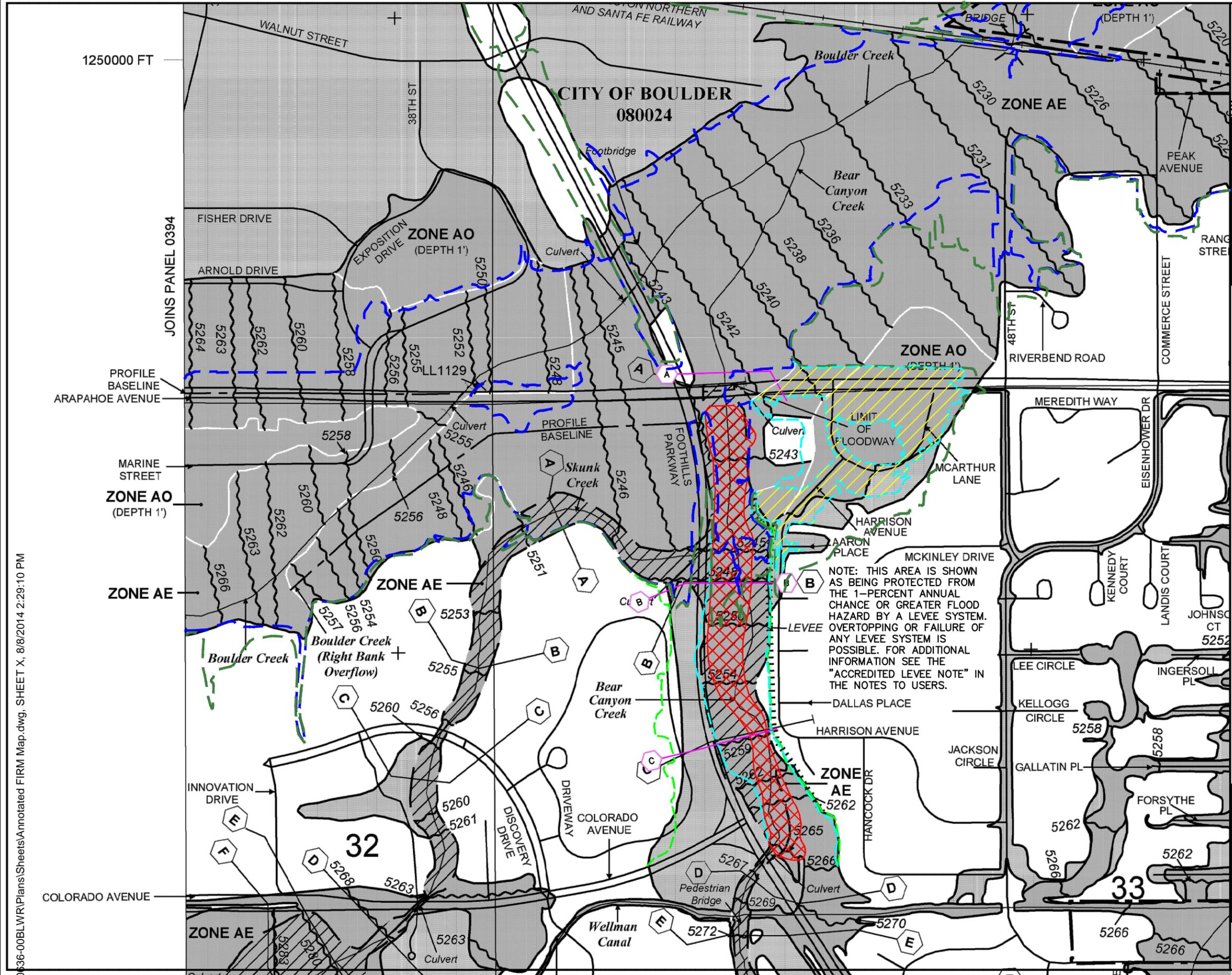
LOWER BEAR CANYON CREEK WORKMAP

PROJECT NO. 19784-07BLCV

**REQUEST FOR LETTER OF MAP REVISION
LOWER BEAR CANYON CREEK**

APPENDIX 3

**ANNOTATED FIRM, PROFILES,
AND FLOODWAY DATA TABLE**



- 1% ANNUAL CHANCE FLOODPLAIN (BOULDER CREEK PROPOSED)
- 0.2% ANNUAL CHANCE FLOODPLAIN (BOULDER CREEK PROPOSED)

PANEL 0413J

FIRM
FLOOD INSURANCE RATE MAP
BOULDER COUNTY,
COLORADO
AND INCORPORATED AREAS

PANEL 413 OF 615
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

<small>COMMUNITY</small>	<small>NUMBER</small>	<small>PANEL</small>	<small>SUFFIX</small>
BOULDER, CITY OF	080024	0413	J
BOULDER COUNTY	080023	0413	J

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.

MAP NUMBER
08013C0413J

MAP REVISED
DECEMBER 18, 2012

Federal Emergency Management Agency

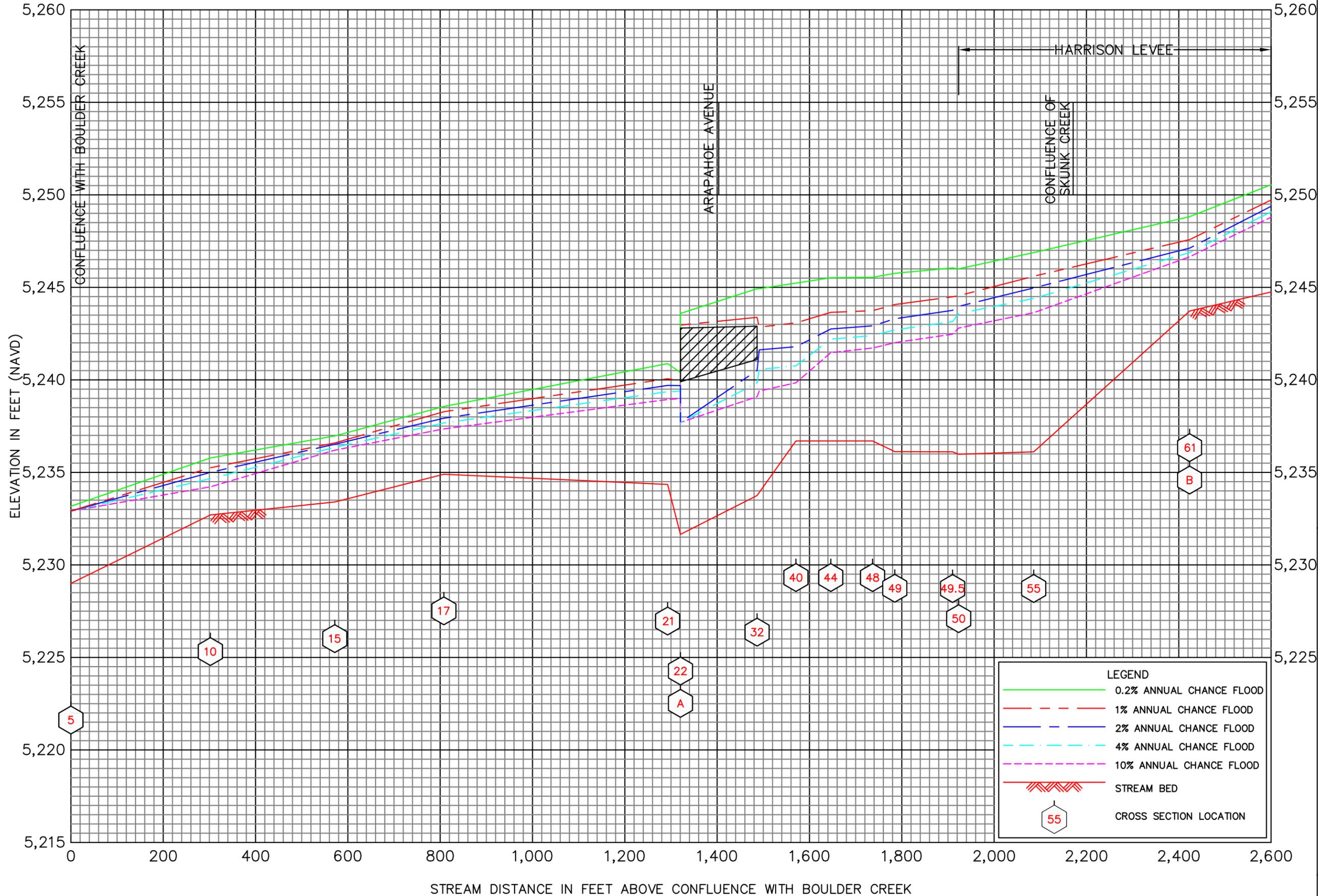
- 1% ANNUAL CHANCE FLOODPLAIN
- 0.2% ANNUAL CHANCE FLOODPLAIN
- 0.5-FIT RISE FLOODWAY
- SHALLOW FLOODING LESS THAN 1-FIT DEPTH ZONE AO

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

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LOWER BEAR CANYON CREEK LOMR – ANNOTATED FIRM MAP

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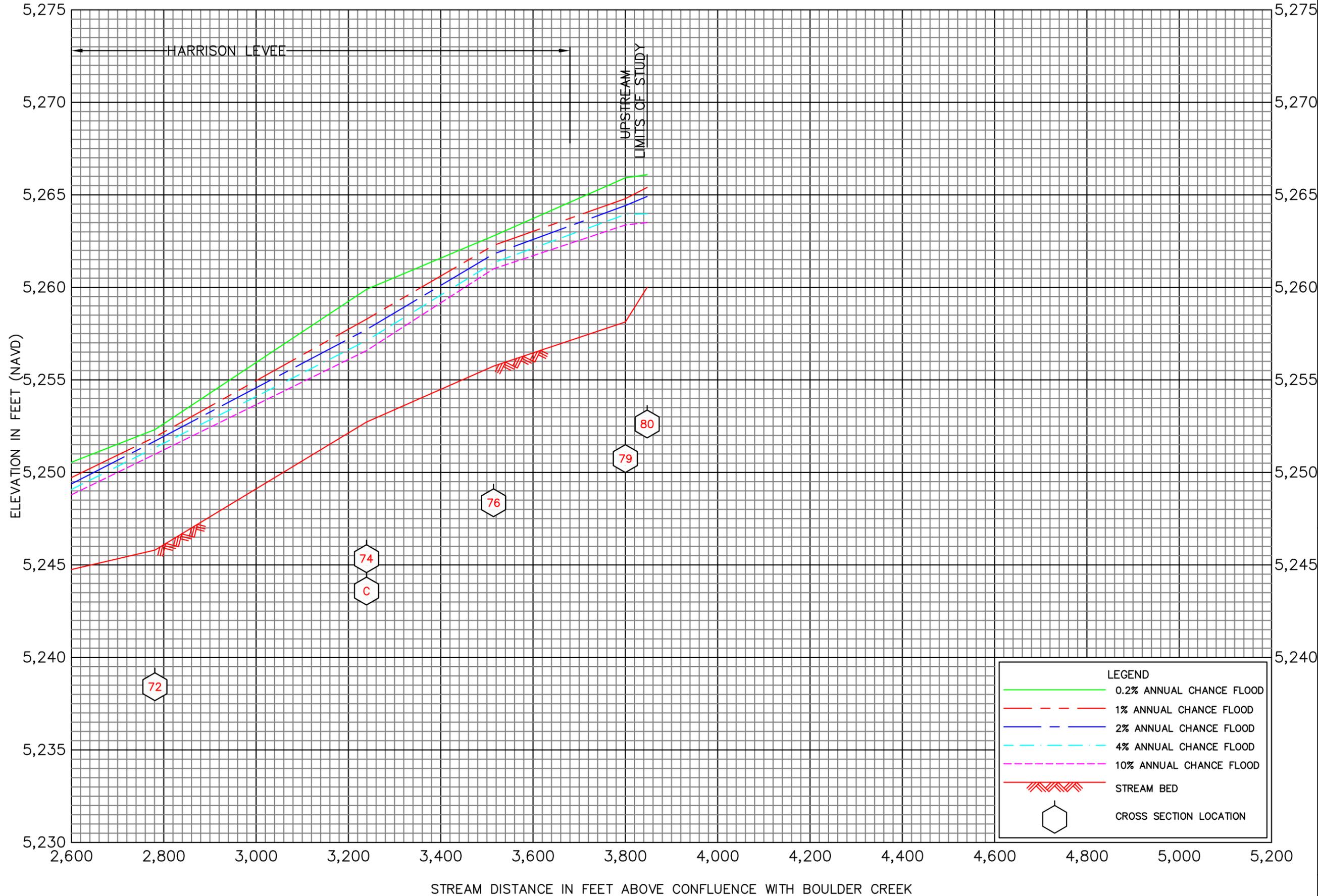
FLOOD PROFILES

BEAR CREEK CANYON

FEDERAL EMERGENCY MANAGEMENT AGENCY

BOULDER, CO
AND INCORPORATED AREAS

01P



FLOOD PROFILES

BEAR CREEK CANYON

FEDERAL EMERGENCY MANAGEMENT AGENCY

BOULDER, CO
AND INCORPORATED AREAS

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANGE FLOOD WATER SURFACE ELEVATION				
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)	
BEAR CANYON CREEK									
REVISED DATA	A	1,374	117	608	8.2	5,240.0	5,240.0	5,240.0	0.0
	B	2,478	210	508	6.1	5,247.6	5,247.6	5,248.1	0.5
	C	3,293	90	305	10.1	5,258.3	5,258.3	5,258.3	0.1
	D	4,191	70	321	9.6	5,267.4	5,267.4	5,267.4	0.0
	E	4,498	78	362	8.5	5,272.4	5,272.4	5,272.4	0.0
	F	4,844	138	389	7.9	5,273.8	5,273.8	5,273.8	0.0
	G	6,512	70	272	11.3	5,290.3	5,290.3	5,290.3	0.0
	H	7,489	300	987	3.1	5,306.2	5,306.2	5,307.0	0.8
	I	7,567	100	796	3.9	5,307.4	5,307.4	5,307.7	0.3
	J	8,363	335	539	5.4	5,319.6	5,319.6	5,319.6	0.0
	K	8,498	276	590	5.0	5,322.1	5,322.1	5,322.3	0.2
	L	9,474	260	658	4.4	5,332.2	5,332.2	5,333.1	0.9
	M	9,855	175	492	6.0	5,336.2	5,336.2	5,336.8	0.6
	N	11,104	51	217	10.2	5,360.6	5,360.6	5,360.6	0.0
	O	11,717	73	386	4.1	5,374.4	5,374.4	5,374.4	0.0
	P	12,334	137	275	7.6	5,384.8	5,384.8	5,384.8	0.0
Q	12,536	101	256	8.2	5,390.1	5,390.1	5,390.1	0.0	
R	13,695	65	199	10.0	5,416.3	5,416.3	5,416.3	0.0	
S	14,807	99	208	8.8	5,443.6	5,443.6	5,443.6	0.0	
T	15,213	116	204	8.5	5,455.7	5,455.7	5,455.7	0.0	
U	15,553	121	205	8.5	5,465.6	5,465.6	5,465.6	0.0	
V	15,910	133	218	7.6	5,477.1	5,477.1	5,477.1	0.0	

¹Feet above confluence with Boulder Creek

²Elevation computed without consideration of flooding controlled by Boulder Creek

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

**BOULDER COUNTY, CO
AND INCORPORATED AREAS**

FLOODWAY DATA

BEAR CANYON CREEK

**REQUEST FOR LETTER OF MAP REVISION
LOWER BEAR CANYON CREEK**

CD

**REQUEST FOR LETTER OF MAP REVISION
LOWER BEAR CANYON CREEK**

Work in Progress