

**CITY OF BOULDER
WATER RESOURCES ADVISORY BOARD
AGENDA ITEM**

MEETING DATE: May 18, 2015

AGENDA TITLE: Public hearing and consideration of a recommendation to City Council regarding the Skunk Creek, Bluebell Canyon Creek and King’s Gulch Floodplain Mapping Update

PRESENTER/S:

Jeff Arthur, Director of Public Works for Utilities
Annie Noble, Acting Principal Engineer for Flood and Greenways
Katie Knapp, Engineering Project Manager

EXECUTIVE SUMMARY

Floodplain mapping provides the basis for flood management by identifying the areas at the highest risk of flooding. This information is essential for determining areas where life safety is threatened and property damage is likely and is the basis for floodplain regulations and the National Flood Insurance Program (NFIP). The city’s floodplain maps need to be periodically updated to reflect changes in the floodplain resulting from land development, flood mitigation improvements, new topographic mapping information and new mapping study technologies.

The Skunk Creek Floodplain Mapping Update includes the King’s Gulch, Skunk and Bluebell Canyon Creek floodplains between the city limits to east of Foothills Parkway where Skunk Creek confluences into Bear Canyon Creek as shown in red below.



Engineering consultants provided hydraulic modeling to update the existing Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) and City of Boulder floodplains, water surface elevations, conveyance and high hazard zones.

The proposed mapping of the Skunk Creek Floodplain would result in a net:

- Increase of 38 structures identified in the 100-year floodplain;
- Decrease of 22 structures identified in the conveyance zone and;
- Decrease of 19 structures identified in the high hazard zone.

STAFF RECOMMENDATION:

Staff requests Water Resources Advisory Board consideration of this matter and action in the form of the following motion:

Motion to recommend that City Council adopt the Skunk Creek, Bluebell Canyon Creek and King’s Gulch floodplain mapping update.

COUNCIL FILTER IMPACTS:

- **Economic:** Flood insurance is required for properties located in the 100-year floodplain if they are financed by a federally-backed mortgage. Flood insurance rates are set by FEMA based on the flood risk as shown on the flood insurance rate maps. Accurate floodplain mapping helps facilitate accurate flood insurance rates. The average annual rate for flood insurance within the city in 2014 was \$760 (3,830 policies), including “preferred risk” policies for structures outside of the 100-year floodplain. Flood protection land use regulations also create costs for property owners in the form of permit fees, increased costs of remodeling, and restrictions on development. Flood insurance and land use regulations do, however, provide protection from potentially catastrophic losses due to floods.
- **Environmental:** Flood events can result in damage or destruction to buildings and corresponding release of man-made contaminants. Flood waters can also cause erosion and damage to areas of the natural environment that are not capable of conveying high-velocity stormwater. Updated flood mapping more accurately identifies the areas with the greatest flooding risks and potential mitigation opportunities.
- **Social:** Floodplain mapping provides the basis for flood management by identifying the areas subject to flooding. This information is essential for determining areas where life safety is threatened and property damage is likely. Land use regulations help reduce risks to people and property in these high flood-risk areas. Accurate mapping of flood risks also helps implement effective flood preparedness and response programs, thereby increasing the safety of people living, working or visiting the City of Boulder.

OTHER IMPACTS:

- **Fiscal:** Funding for this study is included in the Department of Public Works Utilities Division budget.

- **Staff Time:** Time for completing the study is included in existing work plans.

BOARD AND COMMISSION FEEDBACK

The Skunk Creek, Bluebell Canyon Creek and King's Gulch floodplain mapping was first presented to the WRAB as an information item on August 18, 2014. The board requested that staff continue to work with the public to inform them about the proposed floodplain mapping and address comments and concerns. It was also requested that information about FEMA's Letter of Map Amendment (LOMA) process be made available on the city's website. In response to the WRAB's feedback, staff worked with the public and will continue to send out notification letters and postcards. Information about FEMA's LOMA process has also been included on the project website and on the city's general website about floodplain mapping.

The floodplain mapping was then presented to the WRAB on September 15, 2014. At the time of the WRAB meeting, additional refinements were being done to the mapping. The WRAB passed the following motion with a vote of 3-2 (Clancy, Squillace opposed):

Motion to recommend that City Council adopt the Skunk Creek floodplain mapping update including potential additional refinements made prior to Council's consideration and with the understanding that should such additional refinements result in substantial modifications to affected properties, that WRAB would have the opportunity to review the results prior to Council's review.

The opposition expressed a concern that an additional peer review should be conducted for the work completed by Icon Engineering.

Icon Engineering had completed an initial peer review for the project in 2013 when the mapping study was being done by Belt Collins. To address the boards concerns, a second peer review was completed in January, 2015 by a third party consultant, Anderson Consulting Engineers, Inc. The peer review comments are included as **Attachment A**. In response to the peer review comments, additional clarifications and minor revisions were made to the study as described in **Attachment B**.

After WRAB considers the mapping update, it will be provided to the Planning Board as an informational item and presented to City Council for their consideration.

PUBLIC FEEDBACK

Public notification post cards about the mapping update have been sent to all property owners in the study area and a project web site has been developed to provide information (<https://bouldercolorado.gov/water/skunk-creek-floodplain-mapping-update>).

An open house was held on August 18, 2014 immediately prior to the WRAB meeting to inform the public about the mapping update and hear comments and concerns about the study. Staff has also met with residents in person and responded to phone calls and emails. In general, most of the comments and questions have been about impacts to specific properties and requests for more detailed information such as proposed base

flood water elevations. There were also concerns about the high hazard zone delineations and the distribution of the Bluebell Canyon Creek split flow paths downstream of 15th St. In response to the public feedback, the high hazard zone delineations have been re-evaluated and refined. The flow distribution at 15th Street has also been reviewed. A summary of the public feedback is provided in **Attachment C**.

BACKGROUND

The risk of flash flooding is an important issue for the City of Boulder primarily due to its location at the mouth of Boulder Canyon and other canyon creeks. Approximately 13 percent of the city is located within the 100-year floodplains of Boulder Creek and its 14 tributaries. Additional information about the city's floodplain management program, floodplain regulations and flood insurance can be found at: [Floodplain Management Overview](#).

The city delineates four flood zones as described below:

500-year floodplain: The 500-year floodplain delineates the flood limits resulting from a storm that has a 0.2 percent chance of occurring in any given year.

100-year floodplain: The 100-year floodplain delineates the flood limits resulting from a storm that has a one percent chance of occurring in any given year (26 percent chance over a 30-year mortgage).

Conveyance zone: The conveyance zone is defined as the areas in the floodplain that are reserved for the main passage of the entire 100-year flood flow when the 100-year floodplain is artificially narrowed until a maximum six-inch increase in flood water depth is created. This zone is delineated to allow development to occur up to the narrowed floodplain and still provide passage of 100-year storm flows.

High hazard zone: The high hazard zone defines the area of the floodplain where water depth and velocity pose a threat to life and safety. This area is delineated for areas in the floodplain where water depths are four feet or greater or where the water velocity multiplied by water depth equals or exceeds the number four.

Skunk Creek, Bluebell Canyon Creek, and Kings Gulch were first studied in 1987 by the consulting firm Greenhorne & O'Mara and the resulting Flood Hazard Area Delineation (FHAD) report included the delineation of the 100-year floodplain along these creeks. The Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM) approved for these creeks were originally based on the 1987 FHAD and included a federally-regulated one-foot rise floodway. Since that time, both the City of Boulder and the State of Colorado have adopted a ½ foot rise floodway, which the City refers to as the Conveyance Zone.

In 1989, Love and Associates delineated the High Hazard Zone and City of Boulder Conveyance Zone (½ foot rise floodway). The delineations were based on the hydraulic models used in the 1987 FHAD.

On May 6, 1991, FEMA issued a Letter of Map Revision (LOMR) for Skunk Creek to incorporate the results of a channel improvement project. The limit of the LOMR was in the University of Colorado's Research Park, downstream of Colorado Avenue to just upstream of the confluence of Boulder Creek.

Several road-crossing structures for Skunk Creek have been improved since the regulatory floodplain was adopted in 1991. Culverts at Broadway and at 27th Way, crossings at Anderson Ditch and the cemetery maintenance road, and the low water crossing upstream of 27th Way were not included in the 1991 regulatory model, but were incorporated into the current mapping study.

The City initially contracted with Belt Collins to develop the updated floodplain maps but they closed their Boulder office in 2013. ICON Engineering provided a peer review of Belt Collin's 2011 initial study and was selected to complete the project.

In 2013, the city acquired state-of-the-art Light Detection and Ranging (LiDAR) technology to produce high-resolution topographic mapping. The new LiDAR mapping was compared to the 2003 topographic base mapping and areas showing substantial differences were updated in the hydraulic models.

In December, 2014, Anderson Consulting Engineers was selected to complete a peer review of the floodplain mapping study completed by ICON Engineering. The peer review comments are included as **Attachment A**. In response to the peer review comments, additional clarifications and minor revisions were made to the study as described in **Attachment B**.

ANALYSIS

This mapping study updates the hydraulic models and flood hazard mapping for the 100-year floodplain, Conveyance and High Hazard Zones for the entire reach of Skunk Creek, including the King's Gulch, and Bluebell Canyon Creek tributaries.

A 2-dimensional hydraulic model was developed for the creek system to determine primary flow paths and split flow areas. Information from the 2-dimensional model was used as a "roadmap" to develop the conventional 1-dimensional hydraulic model used for the analysis.

The existing 100-year floodplain for Skunk Creek, King's Gulch and Bluebell Canyon Creek is primarily along the creek corridors and roadway areas with some spillage into surrounding properties. The proposed 100-year floodplain is more extensive than the existing mapping in most areas and bears resemblance to the September 2013 flood extents. The September 2013 flood extents were not used to delineate the floodplains but were used to check assumptions on flow paths. For Skunk Creek, King's Gulch and Bluebell Canyon Creek, the September 2013 flood extents are similar to the proposed floodplain mapping.

The existing Conveyance and High Hazard Zone mapping for Bluebell Canyon Creek and King's Gulch did not include a significant neighborhood area that has a history of flooding east of 15th Street. The proposed mapping extends the Conveyance and High Hazard Zones through this residential area to their confluence with Skunk Creek along Broadway. The proposed mapping also extends the Conveyance and High Hazard Zones for Skunk Creek north of Broadway to include more roadways, split flows and other areas not previously mapped.

The revised mapping indicates a greater flood risk area in the Skunk Creek Drainage Basin than was shown in the previous mapping. A majority of the structures newly identified as being at risk are located within the bounds of 15th Street to the east, Broadway to the west, Baseline to the north and King Avenue to the south.

The High Hazard Zone (HHZ) was initially delineated based solely on the 1-dimensional model results, which was the standard approach used in previous studies. Similar to the new approach taken for the Upper Goose Creek and Two-Mile Canyon Creek floodplain mapping study, the HHZ areas were re-evaluated by reviewing the 2-dimensional model results. The proposed mapping was revised to delineate HHZ only in areas where results from both the 2-dimensional and 1-dimensional models indicate HHZ areas. As a result, several of the HHZ areas were modified and some isolated pockets were eliminated.

Attachment D includes figures showing a comparison between existing and proposed floodplain mapping and how the mapping impacts existing structures.

NEXT STEPS:

Following a recommendation of approval from the WRAB, the floodplain mapping study will be provided to the Planning Board as an informational item so that it can be considered for planning purposes. The study will also be considered by City Council for adoption. If City Council approves the study, the city will submit a request to FEMA for review. During the 2-4 year FEMA review and approval process, it is recommended that the new mapping be used for regulatory purposes by regulating to the more restrictive of the existing and proposed mapping. This would mean that development within the newly identified flood zones would be subject to the city floodplain regulations. In accordance with FEMA requirements, development within areas being removed from the floodplain are subject to the city's floodplain regulations until FEMA officially adopts the new floodplain mapping. Following formal adoption by FEMA, the city would regulate solely based on the new mapping.

ATTACHMENTS

- A. Peer Review Memo dated Feb. 5, 2015
- B. Response to Peer Review Apr. 27, 2015
- C. Public Comments
- D. Existing and Proposed Floodplain Maps

MEMORANDUM



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DATE: February 5, 2015 **ACE PROJECT NO.:** COBLDR16
TO: Katie Knapp, City of Boulder Planning and Development Department
FROM: Brian Van Zanten, Anderson Consulting Engineers, Inc. *BLV*
Greg Koch, Anderson Consulting Engineers, Inc. *GTK*
SUBJECT: Peer Review – Skunk Creek, Bluebell Canyon Creek, and King’s Gulch Request for Physical Map Revision Report, Boulder, Colorado

Report/Peer Review Summary

Anderson Consulting Engineers, Inc. (ACE) has completed our peer review of the report entitled "Skunk Creek, Bluebell Canyon Creek, and King’s Gulch, Request for Physical Map Revision (PMR)," ICON Engineering, Inc., draft, August 1, 2014. The City of Boulder (COB) contracted with ACE to perform the current peer review which focuses on minor hydrologic adjustments, hydraulic modeling and techniques, and flood hazard delineations, including 100-year, 500-year, conveyance zone (CZ), and high hazard zone (HHZ) limits. This report is requesting a Physical Map Revision (PMR) for Skunk Creek, Bluebell Canyon Creek, and King’s Gulch.

ICON provided ACE with the PMR report, along with all associated hydraulic models and flood hazard mapping in GIS format. Effective FHAD hydrology for Bluebell Canyon Creek and King’s Gulch as well as effective FEMA hydrology for Skunk Creek were compiled as part of ICON’s study. ICON interpolated 25-year discharge values for all three drainages and extrapolated the 500-year discharges for Bluebell Canyon Creek and King’s Gulch. Additional flow change locations were added along each stream in order to further refine existing discharge profiles.

Effective hydraulics on Skunk Creek (downstream study limit to downstream side of King Avenue) were also compiled. Skunk Creek upstream of this location as well as Bluebell Canyon Creek and King’s Gulch are currently approximate studies. Information related to current hydraulic modeling, including the use of boundary conditions, roughness coefficients, hydraulic structures (including assumed and updated blockage percentages for the current study), blocked obstructions, split flow modeling, and conveyance zone modeling were also included.

Due to the complexity of the hydraulic modeling, including the use of junctions, lateral structures, and the two-dimensional hydraulic model FLO-2D, numerous flow and convergence instabilities were encountered. As a result multiple geometry files were created, with each file specific to a specified discharge profile. In some instances hydraulic modeling software, such as HY-8, external to HEC-RAS was required in order to determine discharge/water surface elevation rating curves for select hydraulic structures.

Both a conveyance zone (CZ – aka 0.5-foot rise floodway) and high hazard zone (HHZ) mapping were also defined using HEC-RAS along all relevant flow paths for the 100-year event. The 10-, 25-, 50-, and 500-year discharges were also evaluated. Flood hazard mapping was completed on all streams including base flood elevations (BFEs), 100- and 500-year floodplain boundaries, CZ boundaries, and HHZ boundaries.

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Comments and Recommendations

The following comments and recommendations are offered below, related to the report, hydraulic models, and flood hazard mapping.

Report Text

- (1) On Page 6, Table 1, please change the location of Flow Change ID from 20th Street to 16th Street. Also, the 500-year discharge value appears to be incorrect at the upstream study limit (the table indicates a discharge of 50 cfs, which is lower than the 100-year discharge at this location). Please add a flow change location at Cross Section No. 4282 in order to account for the inflow from Node B_2 from the FLO-2D analysis as well as providing some explanation as to how this value was determined.
- (2) On Page 8, the FHAD Design Point on the Skunk Creek outfall should be labeled "306" instead of "302".
- (3) On Page 9, Table 2 please change the River Station ID at Flow Change ID No. 1 from 4034 to 3841.
- (4) It is unclear as to why the 100-year discharge on King's Gulch is 14 cfs lower at the upstream study limit than at Bellevue Drive. It seems unlikely the discharge would change over this short distance. Consider maintaining the higher discharge at the upstream study limit for all return periods.
- (5) Please explain why the peak discharges are lower (approximately 8-9%) in the last line of Table 2 on page 9 than what is listed in the FHAD. For example, the 100-year discharge in King's Gulch is stated as 340 cfs in the table; the FHAD lists the 100-year discharge equal to 373 cfs.
- (6) The first paragraph on page 10 describing a hydrologic adjustment factor and the distribution of flows into the Skunk Creek model from Bluebell Canyon Creek and King's Gulch is confusing. We would recommend reviewing the effective HEC-1 model in order to ascertain the timing of the flows at confluences. For example, it appears as if the peak 100-year discharge between FHAD DP 301 and FHAD DP 302 should be between 640 and 710 cfs (based on the FHAD, the peak 100-year discharge of 640 cfs at FHAD DP 301 appears to include the King's Gulch drainage area; however, this should be verified). The model indicates the total flow coming from these two drainages to this point is approximately 900 cfs.
- (7) On Page 10, Table 3 of the report please change River Station ID from 11437 to 11847. It appears that Flow Change ID No. 2 was omitted when it should be included in the table as well. Please provide justification as to how the discharges were determined at FHAD DP 302. For consistency, the values in this row should not be bolded as they are not listed as being effective discharges. River Station 1022 associated with FHAD DP is located along Baseline Road and not the main Skunk Creek flow path. Please include a cross section in the table along Skunk Creek associated with the flow change. Please change Flow Change Location from "Upstream of 29th Street" to "Downstream of 29th Street". Please change the River Station ID from 5277 to 4497 and Flow Change Location from "Upstream of Euclid Avenue" to "Upstream of 34th Street".

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Also, to be consistent, the Flow Change ID No. 7 row should be bold and include all applicable 500-year discharges as they were included in the FIS.

- (8) On Page 16 in the first paragraph, the second to last sentence is not clear. Please revise this discussion to provide additional clarity.
- (9) On Page 18 in the first paragraph at the top of the page, revise “27th Street” to “27th Way”.
- (10) On Page 18, please consider revising the downstream boundary condition on the King’s Gulch reaches to normal depth to be consistent with the other flow paths. It is standard for FEMA to require using normal depth. The use of tailwater from receiving streams normally requires justification (which can simply be previous precedent).
- (11) On Page 28, the description of the hydraulic model from its upstream limit to 20th Street along Bluebell Canyon Creek does not describe how flows are able to split out to the east along the Mariposa-US-16th flow path. Also, the 500-year spill is mentioned upstream of 15th Street to the south along Mariposa Avenue, but not the 100-year spill. Junctions are mentioned at 16th and 17th Streets that distribute the flow; however, they do not appear to be present in the HEC-RAS model. Also, a majority of the flow is said to go north and east along Columbine; however, it appears a majority of flow heads east down Mariposa Avenue. Please revise the text as necessary.
- (12) On Page 28 under the “Baseline Spills” section, it states that flows are lost to the north along Baseline Road but return at the US-36 interchange in the Skunk Creek model. It does not appear that local topography would support this assumption. Please justify. Also, this 100-year spill appears to be approximately 90 cfs; a split flow path or shallow flooding zone may need to be defined for this spill.
- (13) On Page 29 under the “Broadway to Skunk Creek” section, the discussion regarding the adding in of flows to satisfy the hydrology of DP 212 is confusing. Please revise as necessary.
- (14) On Page 29 under the “Kings Gulch from the upstream limit to 20th Street” section, it mentions that the 500-year floodplain upstream of 15th Street includes Bellevue Drive from 15th Street to the Bellevue Drive culvert pipe. The 500-year floodplain mapping appears to be confined to the main channel in this reach. Please revise as necessary.
- (15) On Page 30 change any references from “22nd Avenue” to “22nd Street”.
- (16) On Page 31, the final paragraph describes how flow splits were determined for the 25-, 50-, and 500-year events into the NIST reach by pro-rating the 100-year spill along the right bank lateral structures. Please provide additional explanation for this assumption. Also, it states that the discharges were pro-rated down to Bluebell Avenue which is downstream of the NIST reach. Please provide clarification.

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- (17) Page 34 indicates the 100-year discharge was increased by 10 percent at Cross Section No. 7407 (increases from 1,350 cfs to 1,525 cfs, an increase of 175 cfs). Please provide justification for this increase. It is noted the FHAD hydrology indicates that not until Madison Avenue and 35th Street does the 100-year discharge increase by 520 cfs (1,350 cfs to 1,870 cfs).
- (18) On Page 35 under the "Wellman Canal" section at the bottom of the page, the second sentence is lengthy and confusing. Please revise to provide additional clarity.

Skunk Creek HEC-RAS Model

- (1) The HEC-RAS model indicates the downstream boundary condition along the main flow path is normal depth. It appears that the culverts immediately downstream at Foothills Parkway could create backwater. Please consider moving the downstream cross section for the Skunk Creek model downstream of Foothills Parkway.
- (2) The lateral structures modeled along the left overbank immediately upstream of Foothills Parkway (12 total) are modeled using a weir coefficient of 2.4. The report states in Section 3.5.2 (page 36) that "weirs were coded...using a weir coefficient of 2.4 to reflect high backwater in the left overbank (Boulder Creek floodplain)." This assumes concurrent flood peaks. Please verify that these weir coefficients are reasonable.
- (3) Cross Section No. 1635 is being exceeded along the left overbank during the 100-year event. Consider placing a lateral structure(s) upstream and downstream of this cross section.
- (4) It appears that Lateral Structure No. 12535 (Reach 1.020-Innova, located along the left overbank between Cross Section Nos. 12550 and 12500) spills across the flow path into Reach 1.010-Inova, which is located along the right overbank. Please confirm this model configuration is appropriate. Please consider eliminating the lateral structure as the spill appears to be minimal and mapping the floodplain as a backwater area.
- (5) Both ends of Cross Section No. 12000 are being exceeded during the 100-year event. Please extend the endpoints of this cross section to contain the flow.
- (6) The cross sections along Innovation Drive between Discovery Drive and Colorado Avenue show 100-year water surface elevations exceeding the left overbank ground elevations. Please extend the left ends of the cross sections in order to contain the water surface elevation.
- (7) Cross sections between Euclid Avenue and Colorado Avenue along Skunk Creek do not appear to be perpendicular to flow streamlines; it appears as if two flow paths could be modeled through this area. Please review and revise if necessary.
- (8) There appear to be a number of areas that have limited or no use of blocked obstructions and/or ineffective flow areas. Rather, higher assumed n-values appear to have been used to represent the presence of flow obstructions. This is not consistent with other areas in the model and may influence the definition of the CZ and HHZ. Please review, along all flow paths, including Bluebell Canyon Creek and King's Gulch, and explain or revise as necessary.

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- (9) The report (Table 3) indicates the total 100-year discharge at Cross Section No. 6517 should be 1,780 cfs; the model indicates a total flow coming to this point (before splits) of approximately 1,529 cfs. Also, the report (Table 3) indicates the 100-year discharge should be 2,230 cfs at Cross Section No. 4886; however, the FHAD indicates that this is the discharge at the outfall. Please revise as necessary.
- (10) The cross sections immediately upstream of 29th Street are very tightly spaced (within approximately five feet in the overbank). Please consider eliminating some of these cross sections, unless the spacing is necessary for modeling accuracy.
- (11) The flow path along Baseline Road crosses over the Skunk Creek hydraulic baseline, and the lateral spill along the right overbank spills back underneath Baseline Road. Please clarify the flow splits in this area.
- (12) Flows that split from Skunk Creek (334 cfs) south along U.S. Highway 36 are assumed to return to the creek north of Baseline Road. It appears that the local topography might preclude this from happening. Please review and revise as necessary. If this is justified, an additional flow path may be required to define this split.
- (13) The total 100-year discharge passing beneath Broadway on Skunk Creek is approximately 1,090 cfs. Was the timing of the hydrographs from FHAD Design Points 212 and 302 investigated in order to define this peak discharge? It appears the discharge at this point could be roughly between 1,200 and 1,300 cfs. Please explain or revise as necessary.
- (14) There are a number of lateral structures in the model that are not optimized. Please provide justification as to why these structures were not optimized (notes in the model are also recommended) and justification for the split flows that are represented.
- (15) There are a number of locations where discharges change across crossing structures. Please verify modeling results in these cases are appropriate. It is recommended that discharges remain constant through each crossing.

Bluebell Canyon Creek/King's Gulch HEC-RAS Model

- (1) Lateral Structure No. 2450 (King's Gulch – Kings-US-17th Reach) should have the tailwater set at Cross Section No. 15814 instead of Cross Section No. 15731. Please revise as necessary.
- (2) It appears that split flow paths should be considered off of King Avenue along 18th and 19th Streets. Please review and add flow paths as required.
- (3) It appears that several cross sections along Bluebell Avenue east of 20th Street are angled downstream farther than would be consistent with lines of constant water surface elevation. Please re-orient these cross sections to be more perpendicular to the flow (this would apply to BFEs as well).

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- (4) Cross Section Nos. 1885, 1936, and 2055 along King's Gulch have Manning's n-values of 0.45. Please provide justification as to the use of such conservatively high values. Also, please refer to Comment No. 8 in the Skunk Creek HEC-RAS model comments section concerning the use of flow obstructions and physically representative n-values.
- (5) It appears as if there is a flow split occurring along the right overbank between Cross Section Nos. 5696 and 5828 (37 cfs toward Bellevue Drive) on Bluebell Canyon Creek; however, the discharge profile along Bluebell Canyon Creek does not reflect this reduction in flow. Please revise or explain as necessary.
- (6) Based on the flow split occurring between Cross Section Nos. 4282 and 4258 on the Bluebell Canyon Creek flow path, it appears to be reasonable that the flow change along Mariposa Avenue should occur at Cross Section No. 3141 (adjacent to Cross Section No. 4258) instead of at Cross Section No. 3081 (i.e., upstream of 15th Street). Please revise as necessary.
- (7) Cross sections in the vicinity of 20th Street and Columbine Avenue do not appear to be oriented perpendicular to the flow and, in some cases, cross over one another, or are nearly concurrent with one another. The 5440 BFE also crosses Cross Section No. 11998 on 20th Street. Please revise.
- (8) It does not appear that the discharge profile in the HEC-RAS model along Bluebell Canyon Creek matches the profile provided in the report. For example, the 100-year discharge along Mariposa Avenue just east of 19th Street is 273 cfs, and the discharge one block north along Columbine Avenue just east of 19th Street is 121 cfs. The total discharge at this point is 394 cfs, and according to the table, the discharge at Flow Change ID No. 3 should be 590 cfs. Please revise or explain as necessary.
- (9) The lateral structures along Baseline Road between 21st Street and Broadway are not optimized. Please explain how these splits are determined. Also, adding notes within the model is highly recommended.
- (10) The 100-year flow splits to the north from the main Bluebell Canyon Creek flow path to the upstream end of Columbine Avenue do not match. It appears as if there is 70 cfs splitting to the north (121 cfs to 51 cfs), while the Columbine flow path has 65 cfs. Please revise as necessary.
- (11) The flow is reduced from approximately 80 cfs to 20 cfs during the 100-year event between Cross Section Nos. 11100 and 11030 along Baseline Road. Is there a flow split occurring to the north? If so, please explain how the split was determined.
- (12) The 100-year flows at the intersection of Baseline Road and Broadway do not seem to maintain continuity. The model indicates there is approximately 20 cfs along Baseline Road both upstream and downstream of Broadway, whereas the upstream end of Broadway has 150 cfs, directly downstream of Baseline Road. The 100-year WSEL at Cross Section No. 14900 is also nearly 0.3 feet higher than at Cross Section No. 10725 immediately upstream. Please revise as necessary.

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- (13) The source of an additional 70 cfs along Broadway between Baseline Road and Columbine Avenue during the 100-year event is not apparent. Please explain.
- (14) According to the 100-year discharges in each reach, the total flow that could potentially reach Broadway (assuming no splits north off of Baseline Road and no splits south off of Mariposa Avenue toward Bluebell Avenue) is 616 cfs (Bluebell Canyon Creek only). Assuming that the split of 37 cfs off of Bluebell Canyon Creek onto Bellevue Drive should be accounted for, the total discharge would drop to 579 cfs. Table 1 indicates the total discharge should be 740 cfs. Please revise accordingly.
- (15) The residual 100-year discharge along Baseline Road is approximately 20 cfs, and the flows in front of the Basemar Shopping Center are approximately 41 cfs. The discharge east of this intersection is approximately 10 cfs rather than what would appear to be 61 cfs. Please explain or revise as necessary. Further downstream, the flows tie into the Skunk Creek model, and the flow at the upstream end of this reach (Cross Section No. 1548) is 225 cfs. It appears continuity may be an issue at this location. Please review and revise.
- (16) Cross Section Nos. 1570 and 1520 along Columbine Avenue have n-values for the street portion of the cross section of 0.1. Please provide justification for this roughness value or revise as necessary.
- (17) Cross Section No. 2793 has a negative surcharge (-0.2 ft) in the conveyance zone plan. Please revise as necessary.

Floodplain Workmaps

- (1) According to the HEC-RAS model, 100-year flows begin spilling over the left overbank on the main Skunk Creek flow path downstream of Cross Section 1437. Figure 4.9 depicts the 100-year floodplain boundary extending past this point to Cross Section 1237. Please revise as necessary.
- (2) The 100- and 500-year floodplain mapping limits along the split flow path 1.020-Innova, in particular between Discovery Drive and Colorado Avenue, are mapped against adjacent structures. Please use the bare earth topography to map the floodplain limits.
- (3) General mapping note: BFEs need to be coincident with the 100-year floodplain limits as well as the associated contour elevation unless being tied to the DEM. As an example, BFE 5255 on Skunk Creek, immediately upstream of Cross Section No. 1968, extends past the 100-year floodplain limit (as well as the 5255 contour). Other examples include the 5590 BFE (King's Gulch; ties to the 5591 contour on one side) and the 5595 BFE (King's Gulch; extends past the 5595 contour on one side and doesn't reach it on the other).
- (4) The 5490 BFEs along Bluebell Avenue and King Avenue should tie to the floodplain limits and not extend into the shallow flooding area.
- (5) It appears that Shaded Zone X should be mapped between 19th Street and 22nd Street and Mariposa Avenue and Bluebell Avenue. Please review and revise as needed.

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- (6) There are a number of locations where cross section alignments intersect one another on differing flow paths, in particular at the intersection of King Avenue and Skunk Creek. Please orient the cross sections to not intersect.
- (7) The BFEs along and south of Columbine Avenue between 18th and 19th Streets are generally not parallel to the adjacent cross sections and some cross between flow paths. Also, as an example, the 5470 BFE is shown crossing the 5472 contour elevation. Please adjust as necessary.
- (8) A detailed floodplain with BFEs is mapped along Columbine Avenue between 20th Street and 22nd Street at a 100-year discharge of 13 cfs; however, a detailed floodplain is not mapped along Bellevue Drive and Mariposa Avenue upstream of 15th Street for a 100-year discharge of 37 cfs (mapped as Shaded Zone X). Please explain or revise as necessary.
- (9) The 100- and 500-year floodplain limits do not extend upstream through Cross Section No. 20270 on the Skunk Creek – 7.122 NIST S flow path. It appears as if there is a split occurring along the main Skunk Creek flow path into this flow path. Also, please add a gutter line between the Skunk 7.121 NIST N and 7.122 NIST S flow paths.
- (10) Please indicate that minor flows would leave the system east of the intersection of 29th Street and Baseline Road. One option would be to use dashed floodplain boundaries with a flow arrow heading east.
- (11) BFE 5335 at the intersection of 29th Street and Skunk Creek crosses two separate flow paths, crosses Cross Section 7489, and runs parallel to the flow split going north down 29th Street. BFEs 5300 and 5305 have similar orientation issues. Please revise as necessary.
- (12) Please show the 500-year floodplain boundary on the south side of Mariposa Avenue west of 19th Street.
- (13) Please add flow path identification on the work maps.



Planning



Design



Management

April 27, 2015

Ms. Katie Knapp, P.E.
Engineering Project Manager
Department of Public Works / Utilities Division
1739 Broadway, 2nd Floor
Boulder, Colorado 80302

RE: Skunk Creek, Bluebell Canyon Creek, and King's Gulch Request for Physical Map Revision

Dear Ms. Knapp,

This letter provides responses to the comments provided by Anderson Consulting Engineers as part of their peer review regarding the Skunk Creek, Bluebell Canyon Creek, and King's Gulch Request for Physical Map Revision – Hydraulic Report, dated August 1, 2014. A revised Hydraulic report will be provided under separate cover.

Report Text

- 1. On Page 6, Table 1, please change the location of Flow Change ID from 20th Street to 16th Street. Also, the 500-year discharge value appears to be incorrect at the upstream study limit (the table indicates a discharge of 50 cfs, which is lower than the 100-year discharge at this location). Please add a flow change location at Cross Section No. 4282 in order to account for the inflow from Node B_2 from the FLO-2D analysis as well as providing some explanation as to how this value was determined.**

Table 1 has been updated. The 500-year discharge has been revised. A flow change occurs at cross section 4258 in order to account for the inflow from Node B_2. Please note that the flow distribution between the Bluebell Canyon Creek and Mariposa Avenue has been determined by the 2D model. The B_2 inflow value was determined by its relative contributing size within the full drainage basin (flows to design point 212 in the effective information).

- 2. On Page 8, the FHAD Design Point on the Skunk Creek outfall should be labeled "306" instead of "302".**

The label has been revised.

- 3. On Page 9, Table 2, please change the River Station ID at Flow Change ID No. 1 from 4034 to 3841.**

The table has been revised.

4. It is unclear as to why the 100-year discharge on King's Gulch is 14 cfs lower at the upstream study limit than at Bellevue Drive. It seems unlikely that discharge would change over this short distance. Consider maintaining the higher discharge at the upstream study limit for all return periods.

This was done to reflect reduced contributing area at the upstream limit of the study. Discharges have not been revised.

5. Please explain why the peak discharges are lower (approximately 8-9%) in the last line of Table 2 on page 9 than what is listed in the FHAD. For example, the 100-year discharge in King's Gulch is stated as 340 cfs in the table; the FHAD lists the 100-year discharge equal to 373 cfs.

This was done as part of the original project approach in order to address slight changes in contributing area between this study and the FHAD.

6. The first paragraph on page 10 describing a hydrologic adjustment factor and the distribution of flows into the Skunk Creek model from Bluebell Canyon Creek and King's Gulch is confusing. We would recommend reviewing the effective HEC-1 model in order to ascertain the timing of the flows at confluences. For example, it appears as if the peak 100-year discharge between FHAD DP 301 and FHAD DP 302 should be between 640 and 710 cfs (based on the FHAD, the peak 100-year discharge of 640 cfs at FHAD DP 301 appears to include the King's Gulch drainage area; however, this should be verified). The model indicates the total flow coming from these two drainages to this point is approximately 900 cfs.

The revised models have approximately 1098 cfs flowing into Skunk Creek from Bluebell Canyon Creek and King's Gulch. The total increase in discharge along Skunk Creek is 630 cfs as a result Bluebell Canyon Creek and King's Gulch. In order for the discharge along Skunk Creek to not exceed the effective hydrology, the flow increases along Skunk Creek were reduced in order to match the effective hydrology total discharges. This was done as described in the first paragraph on page 10.

7. On Page 10, Table 3 of the report please change River Station ID from 11437 to 11847. It appears that Flow Change ID No. 2 was omitted when it should be included in the table as well. Please provide justification as to how the discharges were determined at FHAD DP 302. For consistency, the values in this row should not be bolded as they are not listed as being effective discharges. River Station 1022 associated with FHAD DP is located along Baseline Road and not the main Skunk Creek flow path. Please include a cross section in the table along Skunk Creek associated with the flow change. Please change Flow Change Location from "Upstream of 29th Street" to "Downstream of 29th Street". Please change the River Station ID from 5277 to 4497 and Flow Change Location from "Upstream of Euclid Avenue" to "Upstream of 34th Street". Also, to be consistent, the Flow Change ID No. 7 row should be bold and include all applicable 500-year discharges as they were included in the FIS.

The table has been revised.

- 8. On Page 16 in the first paragraph, the second to last sentence is not clear. Please revise this discussion to provide additional clarity.**

The text has been revised.

- 9. On Page 18 in the first paragraph at the top of the page, revise “27th Street” to “27th Way”.**

The text has been revised.

- 10. On Page 18, please consider revising the downstream boundary condition on the King’s Gulch reaches to normal depth to be consistent with the other flow paths. It is standard for FEMA to require using normal depth. The use of tailwater from receiving streams normally requires justification (which can simply be previous precedent).**

The starting water surface elevations for King’s Gulch have been revised to normal depth.

- 11. On Page 28, the description of the hydraulic model from its upstream limit to 20th Street along Bluebell Canyon Creek does not describe how flows are able to split out to the east along the Mariposa-US-16th flow path. Also, the 500-year spill is mentioned upstream of 15th Street to the south along Mariposa Avenue, but not the 100-year spill. Junctions are mentioned at 16th and 17th Streets that distribute the flow; however, they do not appear to be present in the HEC-RAS model. Also, a majority of the flow is said to go north and east along Columbine; however, it appears a majority of flow heads east down Mariposa Avenue. Please revise the text as necessary.**

Report text has been revised.

- 12. On Page 28 under the “Baseline Spills” section, it states that flows are lost to the north along Baseline Road but return at the US-36 interchange in the Skunk Creek model. It does not appear that local topography would support this assumption. Please justify. Also, this 100-year spill appears to be approximately 90 cfs; a split flow path or shallow flooding zone may need to be defined for this spill.**

The watershed boundary and spill flows north of Baseline Road were discussed with the City of Boulder and Belt Collins West, who initiated the mapping update. It was agreed that these flows would predominately return to Skunk Creek further downstream, closer to Aurora Avenue. However, the flows were requested by the City to be added back to Skunk Creek at the US-36 interchange to remain consistent with the current effective FEMA discharges at that location. This decision was believed to be consistent with past

input provided by both the City of Boulder and UDFCD. No additional revisions have been completed.

- 13. On Page 29 under the “Broadway to Skunk Creek” section, the discussion regarding the adding in of flows to satisfy the hydrology of DP 212 is confusing. Please revise as necessary.**

Report text has been revised.

- 14. On Page 29 under the “Kings Gulch from the upstream limit to 20th Street” section, it mentions that the 500-year floodplain upstream of 15th Street includes Bellevue Drive from 15th Street to the Bellevue Drive culvert pipe. The 500-year floodplain mapping appears to be confined to the main channel in this reach. Please revise as necessary.**

Report text has been revised.

- 15. On Page 30 change any references from “22nd Avenue” to “22nd Street”.**

Report text has been revised.

- 16. On Page 31, the final paragraph describes how flow splits were determined for the 25-, 50-, and 500-year events into the NIST reach by pro-rating the 100-year spill along the right bank lateral structures. Please provide additional explanation for this assumption. Also, it states that the discharges were pro-rated down to Bluebell Avenue which is downstream of the NIST reach. Please provide clarification.**

Based on the original modeling approach and discussions with the City, this method of split flow determination is considered reasonable. The text has been reviewed and revised to provide additional clarification.

- 17. Page 34 indicates the 100-year discharge was increased by 10 percent at Cross Section No. 7407 (increases from 1,350 cfs to 1,525 cfs, an increase of 175 cfs). Please provide justification for this increase. It is noted the FHAD hydrology indicates that not until Madison Avenue and 35th Street does the 100-year discharge increase by 520 cfs (1,350 cfs to 1,870 cfs).**

This reflects the previous modeling approach and provides a more gradual increase in discharge. No revisions have been made.

18. On Page 35 under the “Wellman Canal” section at the bottom of the page, the second sentence is lengthy and confusing. Please revise to provide additional clarity.

Report text has been revised.

Skunk Creek HEC-RAS Model

19. The HEC-RAS model indicates the downstream boundary condition along the main flow path is normal depth. It appears that the culverts immediately downstream at Foothills Parkway could create backwater. Please consider moving the downstream cross section for the Skunk Creek model downstream of Foothills Parkway.

The downstream tie-in area with both Bear Creek and Boulder Creek has been revised. The HEC-RAS model now extends downstream of Foothills and ultimately to Boulder Creek using modeling taken from the pending Boulder Creek and Bear Creek studies.

20. The lateral structures modeled along the left overbank immediately upstream of Foothills Parkway (12 total) are modeled using a weir coefficient of 2.4. The report states in Section 3.5.2 (page 36) that “weirs were coded...using a weir coefficient of 2.4 to reflect high backwater in the left overbank (Boulder Creek floodplain).” This assumes concurrent flood peaks. Please verify that these weir coefficients are reasonable.

The weir coefficients have not been revised as they consider the backwater (from spill out of Skunk Creek – not from concurrent flood peaks) in the Boulder Creek overbank.

21. Cross Section No. 1635 is being exceeded along the left overbank during the 100-year event. Consider placing a lateral structure(s) upstream and downstream of this cross section.

Cross section 1635 has been revised to reflect the ground elevations at the top of the embankment. The cross section is now contained.

22. It appears that Lateral Structure No. 12535 (Reach 1.020-Innova, located along the left overbank between Cross Section Nos. 12550 and 12500) spills across the flow path into Reach 1.010-Innova, which is located along the right overbank. Please confirm this model configuration is appropriate. Please consider eliminating the lateral structure as the spill appears to be minimal and mapping the floodplain as a backwater area.

This configuration reflects the storm sewer system that collects discharges in the left overbank and then outfalls into the open channel on the east side of Innovation Drive. No revisions to the model have been made.

- 23. Both ends of Cross Section No. 12000 are being exceeded during the 100-year event. Please extend the endpoints of this cross section to contain the flow.**

Cross section 12000 has been revised and is now contained.

- 24. The cross sections along Innovation Drive between Discovery Drive and Colorado Avenue show 100-year water surface elevations exceeding the left overbank ground elevations. Please extend the left ends of the cross sections in order to contain the water surface elevation.**

This reach of innovation drive is bounded by large buildings on the left overbank. It is not necessary to extend the sections as the flow will be adequately contained by the structures.

- 25. Cross sections between Euclid Avenue and Colorado Avenue along Skunk Creek do not appear to be perpendicular to flow streamlines; it appears as if two flow paths could be modeled through this area. Please review and revise if necessary.**

This approach reflects the original modeling efforts. This area has also undergone a 2D confirmation of split flows that confirmed the original modeling approach.

- 26. There appear to be a number of areas that have limited or no use of blocked obstructions and/or ineffective flow areas. Rather, higher assumed n-values appear to have been used to represent the presence of flow obstructions. This is not consistent with other areas in the model and may influence the definition of the CZ and HHZ. Please review, along all flow paths, including Bluebell Canyon Creek and King's Gulch, and explain or revise as necessary.**

This approach was discussed with the City. With exception to areas where new modeling was developed, the original modeling approach was maintained.

- 27. The report (Table 3) indicates the total 100-year discharge at Cross Section No. 6517 should be 1,780 cfs; the model indicates a total flow coming to this point (before splits) of approximately 1,529 cfs. Also, the report (Table 3) indicates the 100-year discharge should be 2,230 cfs at Cross Section No. 4886; however, the FHAD indicates that this is the discharge at the outfall. Please revise as necessary.**

These discharge issues were reviewed and the application of the flow was not changed. The 2233 cfs total occurs somewhere between Madison Avenue and the confluence with Bear Creek. Given the presence of multiple split flow paths and the tributary basin partially located both north and south of Colorado Avenue, the total discharge values were considered reasonable.

- 28. The cross sections immediately upstream of 29th Street are very tightly spaced (within approximately five feet in the overbank). Please consider eliminating some of these cross sections, unless the spacing is necessary for modeling accuracy.**

This was done per the original modeling approach and will not be revised.

- 29. The flow path along Baseline Road crosses over the Skunk Creek hydraulic baseline, and the lateral spill along the right overbank spills back underneath Baseline Road. Please clarify the flow splits in this area.**

The right overbank spill will enter a multi-use trail underpass and flow north underneath Baseline Road.

- 30. Flows that split from Skunk Creek (334 cfs) south along U.S. Highway 36 are assumed to return to the creek north of Baseline Road. It appears that the local topography might preclude this from happening. Please review and revise as necessary. If this is justified, an additional flow path may be required to define this split.**

This reflects original project approach and is based on previous direction provided by the City of Boulder. This area was reviewed with the City, who elected to not add the additional flow path.

- 31. The total 100-year discharge passing beneath Broadway on Skunk Creek is approximately 1,090 cfs. Was the timing of the hydrographs from FHAD Design Points 212 and 302 investigated in order to define this peak discharge? It appears the discharge at this point could be roughly between 1,200 and 1,300 cfs. Please explain or revise as necessary.**

As a result of revisions to drainage basin B-2, there is a portion of that basin that contributes discharge to Skunk Creek downstream of Broadway. This contribution of approximately 293 cfs accounts for the noted discrepancy.

- 32. There are a number of lateral structures in the model that are not optimized. Please provide justification as to why these structures were not optimized (notes in the model are also recommended) and justification for the split flows that are represented.**

Some lateral structures were not optimized in order to get the model(s) to converge. Split flows that are represented are based on vertically extended cross sections and topography that indicates that the split flow would not immediately return to the main flow path.

- 33. There are a number of locations where discharges change across crossing structures. Please verify modeling results in these cases are appropriate. It is recommended that discharges remain constant through each crossing.**

In these areas it has been assumed that surface discharge will flow from the roadways and enter the channel on the downstream side of the crossing structure. For this reason it was common for discharges to change across crossing structures.

Bluebell Canyon Creek & King's Gulch HEC-RAS Model

- 34. Lateral Structure No. 2450 (King's Gulch – Kings-US-17th Reach) should have the tailwater set at Cross Section No. 15814 instead of Cross Section No. 15731. Please revise as necessary.**

Discharge that flows through lateral structure no. 2450 will flow into cross section no. 15731. The model has not been revised.

- 35. It appears that split flow paths should be considered off of King Avenue along 18th and 19th Streets. Please review and add flow paths as required.**

The depth of flow that would travel north along 18th and 19th Streets is estimated to be less than 0.5 feet, which is consistent with the Zone X shaded designation that has been used in these areas. Additionally, these two flow paths were not identified during flooding in September 2013.

- 36. It appears that several cross sections along Bluebell Avenue east of 20th Street are angled downstream farther than would be consistent with lines of constant water surface elevation. Please re-orient these cross sections to be more perpendicular to the flow (this would apply to BFEs as well).**

Due to the split flows in this area and the ditch influence, the cross sections are aligned as best possible to facilitate reasonable floodplain delineation. The cross sections have not been revised.

- 37. Cross Section Nos. 1885, 1936, and 2055 along King's Gulch have Manning's n-values of 0.45. Please provide justification as to the use of such conservatively high values. Also, please refer to Comment No. 8 in the Skunk Creek HEC-RAS model comments section concerning the use of flow obstructions and physically representative n-values.**

Manning's n values at cross sections 1885, 1936, 2055, and 2208 have been reduced to a value of 0.06. Please note that this change affects the flow over the adjacent lateral weir and downstream flow distributions which have been revised accordingly.

- 38. It appears as if there is a flow split occurring along the right overbank between Cross Section Nos. 5696 and 5828 (37 cfs toward Bellevue Drive) on Bluebell Canyon Creek; however, the discharge profile along Bluebell Canyon Creek does not reflect this reduction in flow. Please revise or explain as necessary.**

This flow split was identified by the 2D model but is not evident by the 1D model. In an effort to remain conservative with the main channel of Bluebell Canyon Creek, yet show the identified flow split, the minor reduction in discharge for flows leaving the main channel has not been accounted for along the main channel.

- 39. Based on the flow split occurring between Cross Section Nos. 4282 and 4258 on the Bluebell Canyon Creek flow path, it appears to be reasonable that the flow change along Mariposa Avenue should occur at Cross Section No. 3141 (adjacent to Cross Section No. 4258) instead of at Cross Section No. 3081 (i.e., upstream of 15th Street). Please revise as necessary.**

The discharge increase for Mariposa Avenue has been moved upstream from cross section 3081 to 3141.

- 40. Cross sections in the vicinity of 20th Street and Columbine Avenue do not appear to be oriented perpendicular to the flow and, in some cases, cross over one another, or are nearly concurrent with one another. The 5440 BFE also crosses Cross Section No. 11998 on 20th Street. Please revise.**

The cross section layout in this area is complicated by the Anderson Ditch, junction of a split flow reach, and the start of another split flow reach. As a result, the cross sections were aligned as best possible given the modeling and topographic constraints.

- 41. It does not appear that the discharge profile in the HEC-RAS model along Bluebell Canyon Creek matches the profile provided in the report. For example, the 100-year discharge along Mariposa Avenue just east of 19th Street is 273 cfs, and the discharge one block north along Columbine Avenue just east of 19th Street is 121 cfs. The total discharge at this point is 394 cfs, and according to the table, the discharge at Flow Change ID No. 3 should be 590 cfs. Please revise or explain as necessary.**

Upon further review of the hydrology for drainage basin B-2 (draining to FHAD design point 212) it was determined that the area north of Baseline Road does not contribute to Bluebell Canyon Creek upstream of US Highway 36. As a result, B_2 inflow node has been adjusted and the B_3 inflow node has been removed. The 394 cfs value is valid from 15th street east to Broadway.

- 42. The lateral structures along Baseline Road between 21st Street and Broadway are not optimized. Please explain how these splits are determined. Also, adding notes within the model is highly recommended.**

All lateral structures along Baseline Road between 21st Street and Broadway are now optimized and reflect the split flows that occur in this area.

- 43. The 100-year flow splits to the north from the main Bluebell Canyon Creek flow path to the upstream end of Columbine Avenue do not match. It appears as if there is 70 cfs splitting to the north (121 cfs to 51 cfs), while the Columbine flow path has 65 cfs. Please revise as necessary.**

At this location, the discharge values have been based on a 2D model and compare within 5 cfs (4% of total flow). This difference was not further refined.

- 44. The flow is reduced from approximately 80 cfs to 20 cfs during the 100-year event between Cross Section Nos. 11100 and 11030 along Baseline Road. Is there a flow split occurring to the north? If so, please explain how the split was determined.**

Yes, a flow split occurs at this location. Discharge values are now based on lateral weir spills that are now optimized accordingly.

- 45. The 100-year flows at the intersection of Baseline Road and Broadway do not seem to maintain continuity. The model indicates there is approximately 20 cfs along Baseline Road both upstream and downstream of Broadway, whereas the upstream end of Broadway has 150 cfs, directly downstream of Baseline Road. The 100-year WSEL at Cross Section No. 14900 is also nearly 0.3 feet higher than at Cross Section No. 10725 immediately upstream. Please revise as necessary.**

This is a result of the B_4 inflow location. No model revisions were completed.

- 46. The source of an additional 70 cfs along Broadway between Baseline Road and Columbine Avenue during the 100-year event is not apparent. Please explain.**

This errant addition of 70 cfs along Broadway between Baseline Road and Columbine Avenue has been fixed. The B_4 inflow is the only discharge increase in this general vicinity.

- 47. According to the 100-year discharges in each reach, the total flow that could potentially reach Broadway (assuming no splits north off of Baseline Road and no splits south off of Mariposa Avenue toward Bluebell Avenue) is 616 cfs (Bluebell Canyon Creek only). Assuming that the split of 37 cfs off of Bluebell Canyon Creek onto Bellevue Drive should be accounted for, the total discharge would drop to 579 cfs. Table 1 indicates the total discharge should be 740 cfs. Please revise accordingly.**

This discrepancy is the result of recent changes to Basin B-2 in order to more accurately account for the portion of the basin north of Baseline Road that will not be accounted for until downstream of US Highway 36. Table 1 has been revised and Figures 3.1 and 3.2 have been created to provide a map showing the flow increases and discharges along the various split flow reaches of Bluebell Canyon Creek. Please note that the flow profiles reflect total flow and may not necessarily accurately reflect discharge within a given split flow reach.

- 48. The residual 100-year discharge along Baseline Road is approximately 20 cfs, and the flows in front of the Basemar Shopping Center are approximately 41 cfs. The discharge east of this intersection is approximately 10 cfs rather than what would appear to be 61 cfs. Please explain or revise as necessary. Further downstream, the flows tie into the Skunk Creek model, and the flow at the upstream end of this reach (Cross Section No. 1548) is 225 cfs. It appears continuity may be an issue at this location. Please review and revise.**

Due to minor changes the residual discharge along Baseline Road is now approximately 23 cfs and the flows in front of the Basemar Shopping Center are approximately 29 cfs. The discharge east of the intersection of these two split flows has been revised to 52 cfs. Further downstream the discharge increase to 225 cfs is a result of an increase in discharge as a result of flows that originate or spill into the drainage basin on the north side of Baseline Road. In order to match the FEMA flows along Bluebell Canyon Creek and ultimately Skunk Creek, the full discharge has been returned to the model at US Highway 36, as discussed previously.

- 49. Cross Section Nos. 1570 and 1520 along Columbine Avenue have n-values for the street portion of the cross section of 0.1. Please provide justification for this roughness value or revise as necessary.**

The Manning's n values have been revised to reflect a value of 0.03 within the roadway sections in similar fashion to sections upstream and downstream.

- 50. Cross Section No. 2793 has a negative surcharge (-0.2 ft) in the conveyance zone plan. Please revise as necessary.**

This section does not have floodway encroachment into the effective conveyance area. Also note that the change in energy grade is +0.49 feet.

Floodplain Workmaps

- 51. According to the HEC-RAS model, 100-year flows begin spilling over the left overbank on the main Skunk Creek flow path downstream of Cross Section 1437. Figure 4.9 depicts the 100-year floodplain boundary extending past this point to Cross Section 1237. Please revise as necessary.**

This area has been revised to reflect the spill downstream of cross section 1437.

- 52. The 100- and 500-year floodplain mapping limits along the split flow path 1.020-Innova, in particular between Discovery Drive and Colorado Avenue, are mapped against adjacent structures. Please use the bare earth topography to map the floodplain limits.**

Given the size of these structures and the mapping source (LiDAR) there is not reasonable bare earth topography available for use. Additionally, the size of structures is such that they will provide significant containment of the floodplain. In order to remove any ambiguity, the floodplain mapping limits were adjusted in order to clearly show buildings that are impacted by the adjacent floodplain boundary.

- 53. General mapping note: BFEs need to be coincident with the 100-year floodplain limits as well as the associated contour elevation unless being tied to the DEM. As an example, BFE 5255 on Skunk Creek, immediately upstream of Cross Section No. 1968, extends past the 100-year floodplain limit (as well as the 5255 contour). Other examples include the 5590 BFE (King's Gulch; ties to the 5591 contour on one side) and the 5595 BFE (King's Gulch; extends past the 5595 contour on one side and doesn't reach it on the other).**

This issue (generally less than 2 feet in size) appears to result from the use of survey data in place of mapping.

- 54. The 5490 BFEs along Bluebell Avenue and King Avenue should tie to the floodplain limits and not extend into the shallow flooding area.**

These BFEs have been revised.

- 55. It appears that Shaded Zone X should be mapped between 19th Street and 22nd Street and Mariposa Avenue and Bluebell Avenue. Please review and revise as needed.**

This area has been revised to reflect a Zone X shaded designation.

- 56. There are a number of locations where cross section alignments intersect one another on differing flow paths, in particular at the intersection of King Avenue and Skunk Creek. Please orient the cross sections to not intersect.**

The cross sections were aligned as best possible given the modeling and topographic constraints. This issue is generally a result of the alignment of multiple flow paths where there is not a reasonable approach to alternative orientation.

- 57. The BFEs along and south of Columbine Avenue between 18th and 19th Streets are generally not parallel to the adjacent cross sections and some cross between flow paths. Also, as an example, the 5470 BFE is shown crossing the 5472 contour elevation. Please adjust as necessary.**

The orientation of the BFEs reflect the condition of discharges transferring from the south to the north. The 5470 BFE is shown as crossing the 5472 contour in order to avoid showing a small island in the middle of the floodplain.

- 58. A detailed floodplain with BFEs is mapped along Columbine Avenue between 20th Street and 22nd Street at a 100-year discharge of 13 cfs; however, a detailed floodplain is not mapped along Bellevue Drive and Mariposa Avenue upstream of 15th Street for a 100-year discharge of 37 cfs (mapped as Shaded Zone X). Please explain or revise as necessary.**

The 13 cfs along Columbine has been shown as detailed study as it eventually receives additional discharges for a total flow of 58 cfs. The 37 cfs along Mariposa Avenue has been mapped as Shaded Zone X as a result of continuously shallow flooding and a lack of discharge increase.

- 59. The 100- and 500-year floodplain limits do not extend upstream through Cross Section No. 20270 on the Skunk Creek – 7.122 NIST S flow path. It appears as if there is a split occurring along the main Skunk Creek flow path into this flow path. Also, please add a gutter line between the Skunk 7.121 NIST N and 7.122 NIST S flow paths.**

The delineation for 20270 reflects the original modeling approach and has not been revised. Similarly, the gutter line has not been added as the floodplains are joined.

- 60. Please indicate that minor flows would leave the system east of the intersection of 29th Street and Baseline Road. One option would be to use dashed floodplain boundaries with a flow arrow heading east.**

The flows leaving have been determined to be insignificant and shallow enough to not warrant additional designation. Likewise, the full discharge has been accounted for within Skunk Creek to remain conservative. No revisions have been completed.

- 61. BFE 5335 at the intersection of 29th Street and Skunk Creek crosses two separate flow paths, crosses Cross Section 7489, and runs parallel to the flow split going north down 29th Street. BFEs 5300 and 5305 have similar orientation issues. Please revise as necessary.**

Given the urban shallow flooding condition, this has been a challenge to depict. The BFEs have been drawn to best illustrate the respective flood risk and also to reflect the major flow directions. In an effort to keep the mapping simple, extensive use of gutter lines has not been used.

- 62. Please show the 500-year floodplain boundary on the south side of Mariposa Avenue west of 19th Street.**

This area has been designated as Zone X shaded.

- 63. Please add flow path identification on the work maps.**

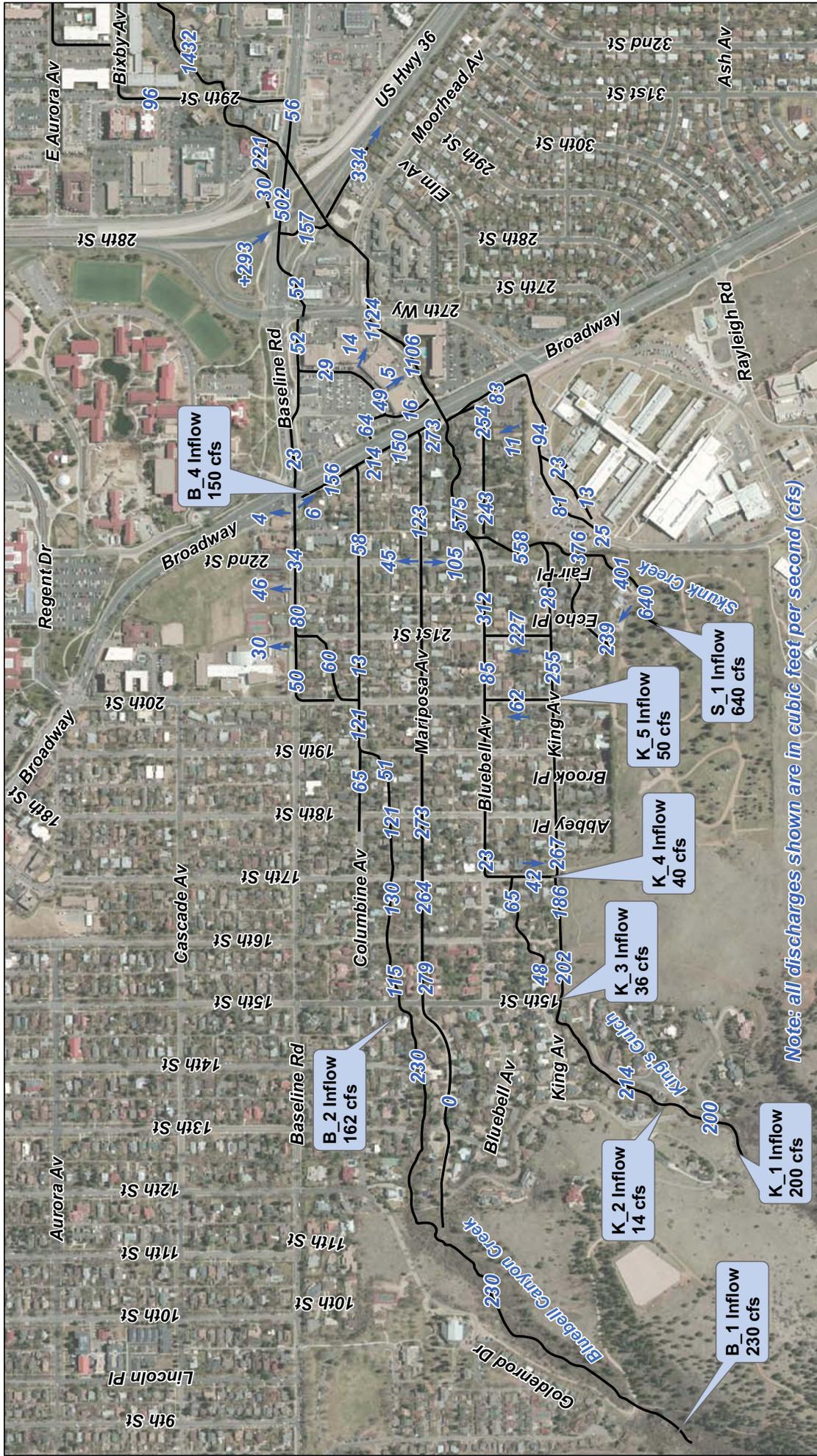
Separate flow path identification work maps have been prepared. Please see figures 4 and 5.

Please let me know if there is any additional information needed to clarify our responses to the above review comments.

Sincerely,

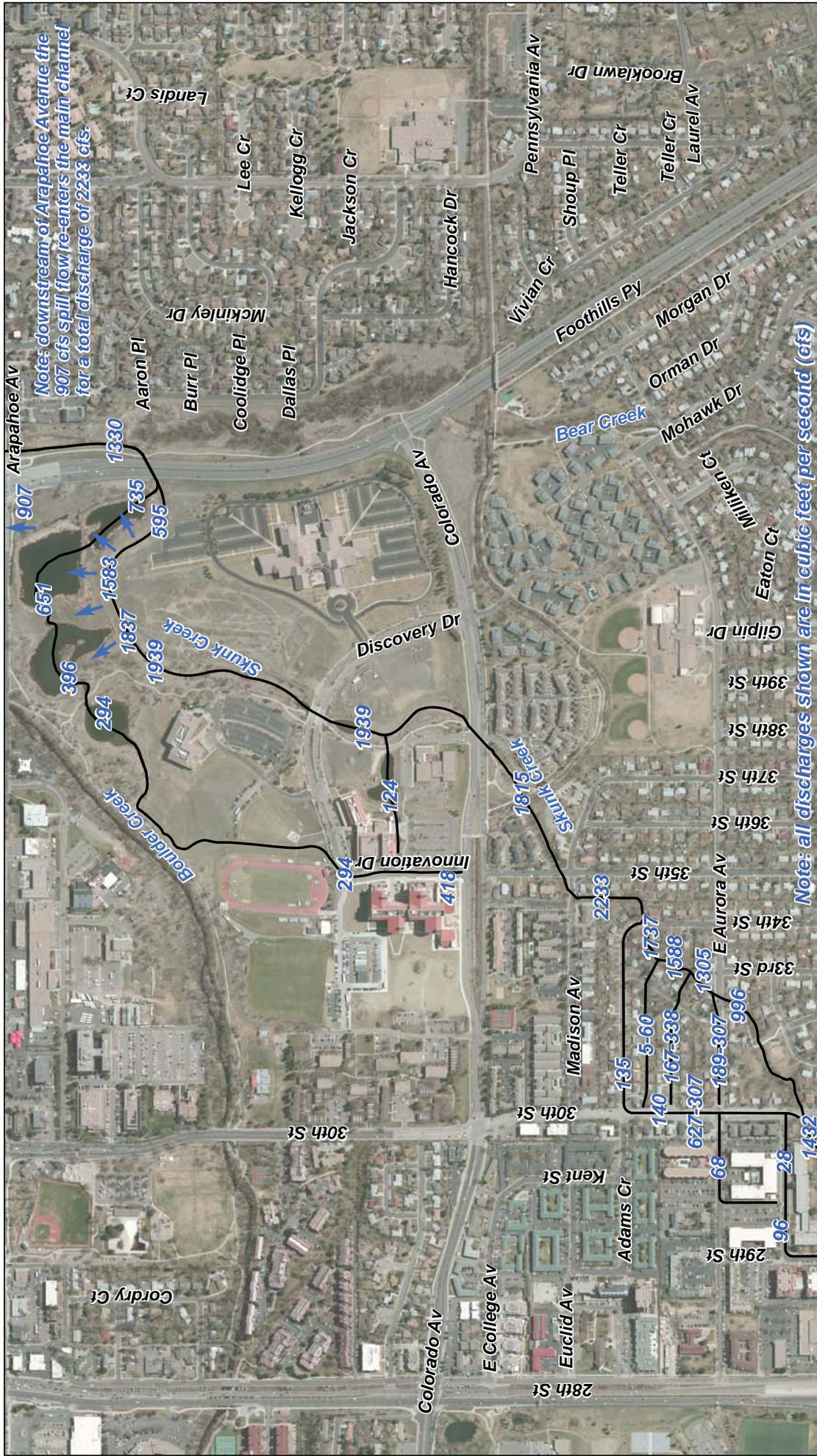


Brian LeDoux, P.E., CFM
ICON Engineering, Inc.



Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
Figure 3.1: HEC-RAS 100-Year Discharges Upstream of Highway 36

500 Feet



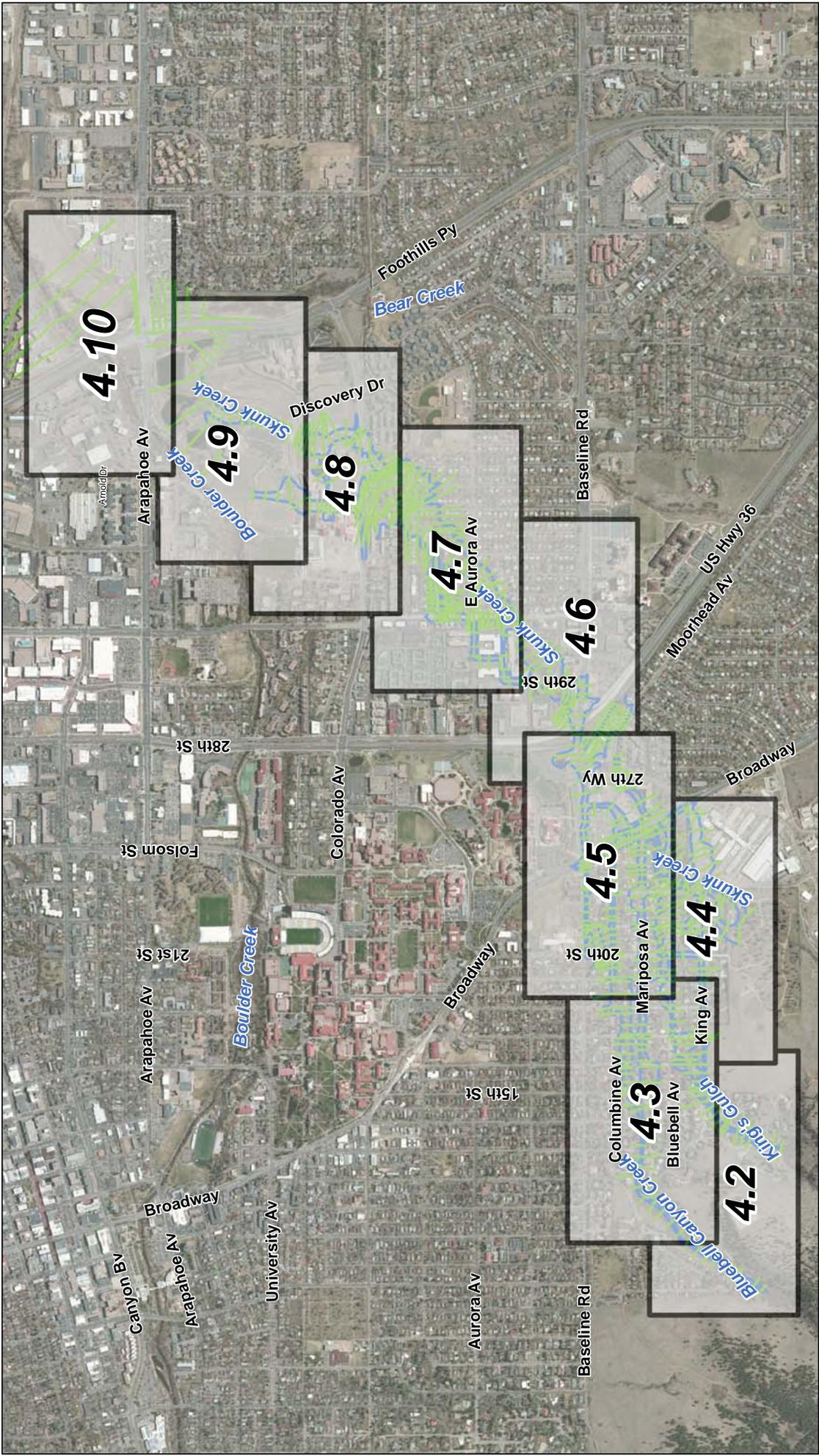
Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
Figure 3.2: HEC-RAS 100-year Discharges Downstream of Highway 36



500 Feet

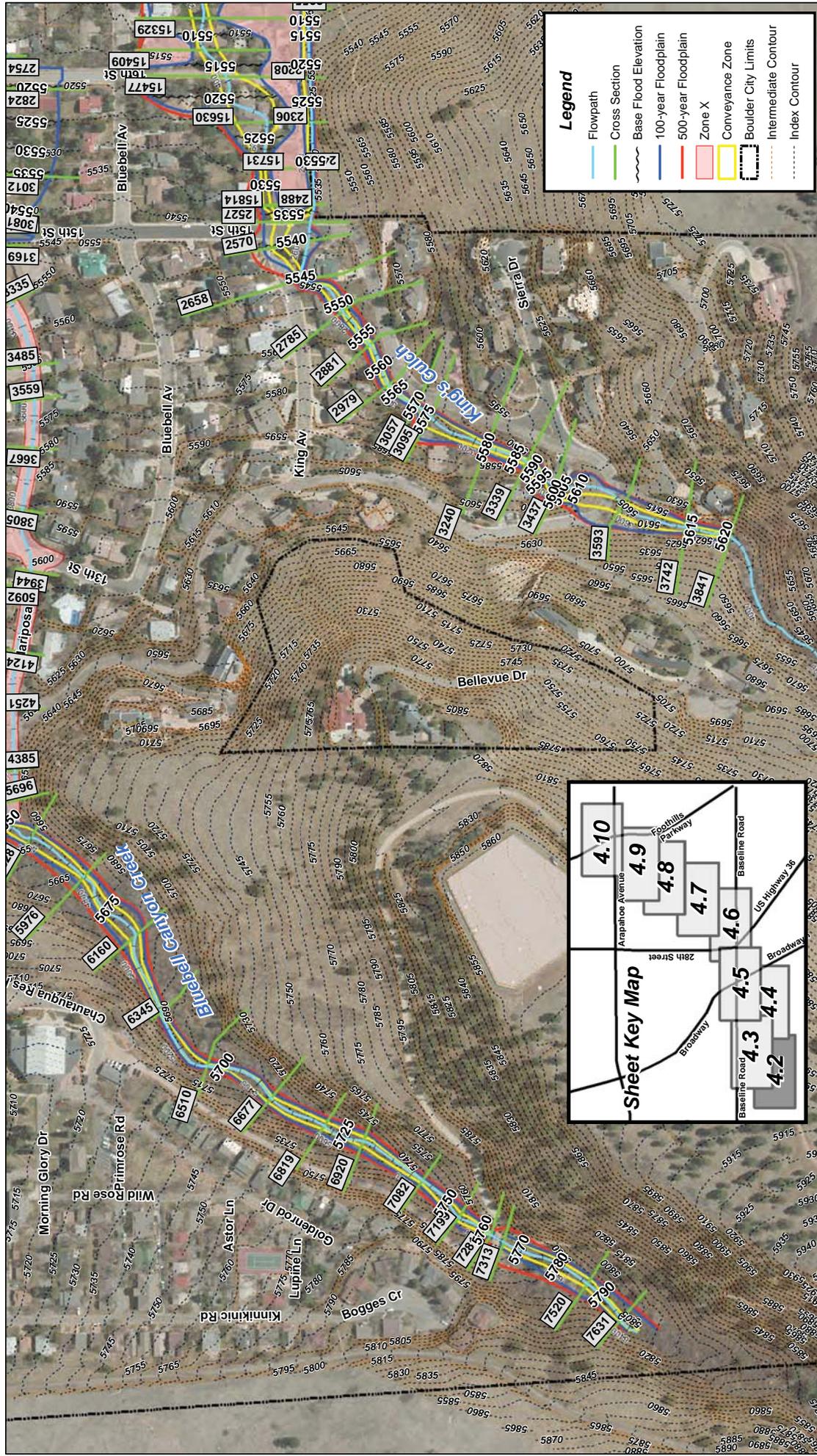


Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
Figure 4: HEC-RAS Reach Names Upstream of Highway 36

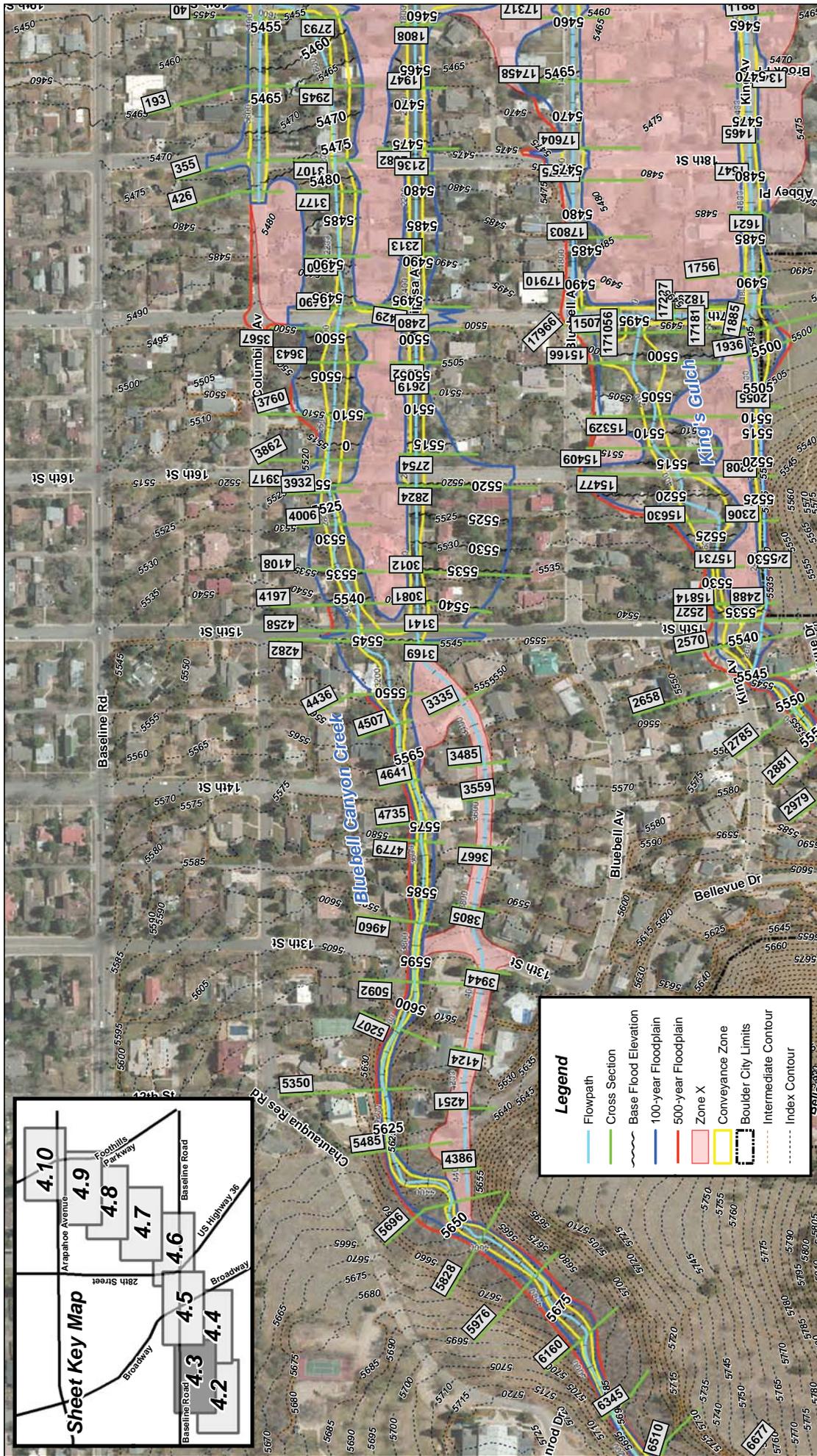


Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
 Figure 4.1: Floodplain Workmap Index



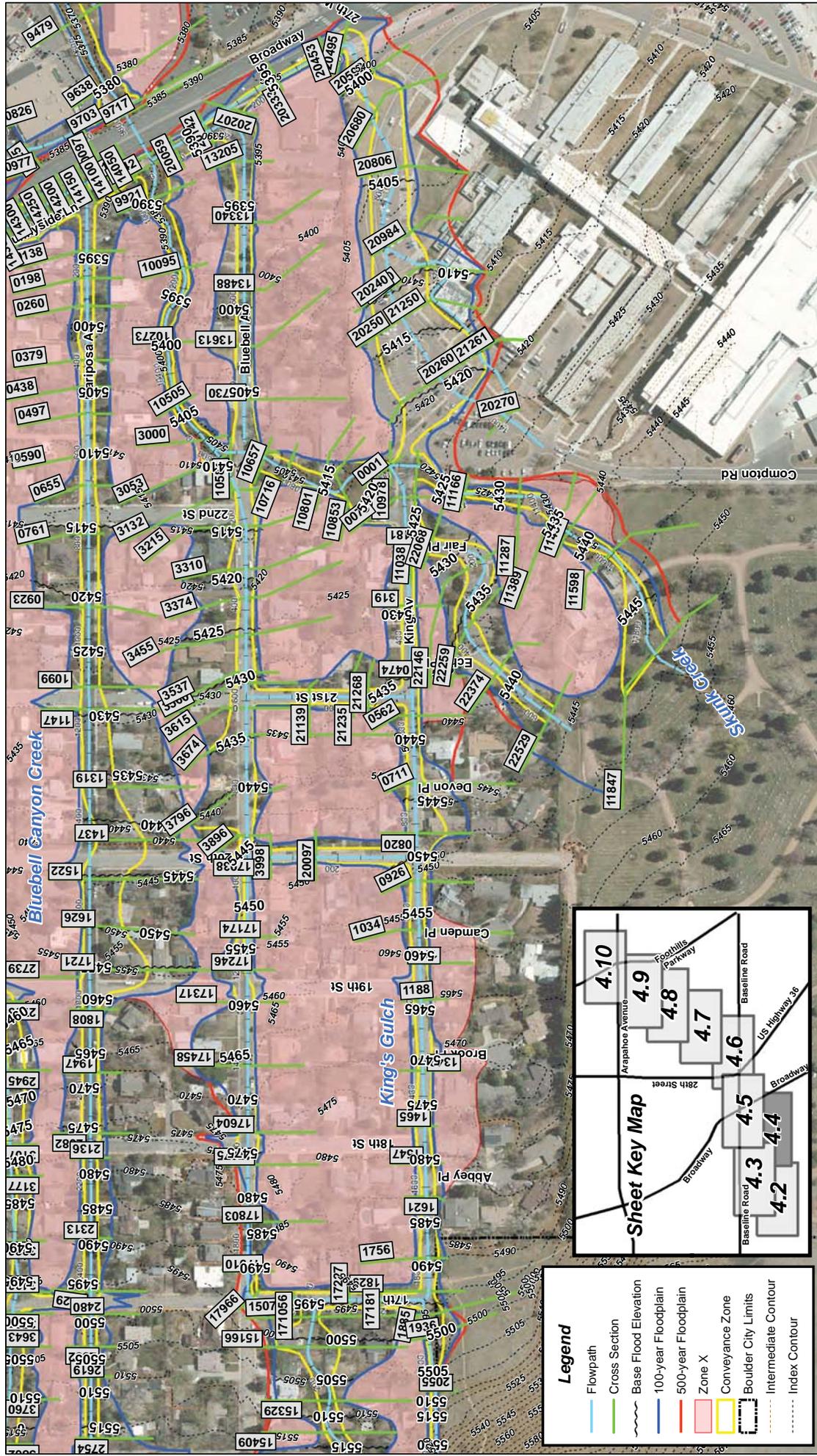


Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
 Figure 4.2: Floodplain Workmap



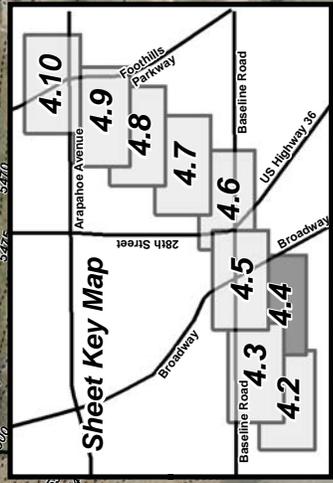
Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
 Figure 4.3: Floodplain Workmap

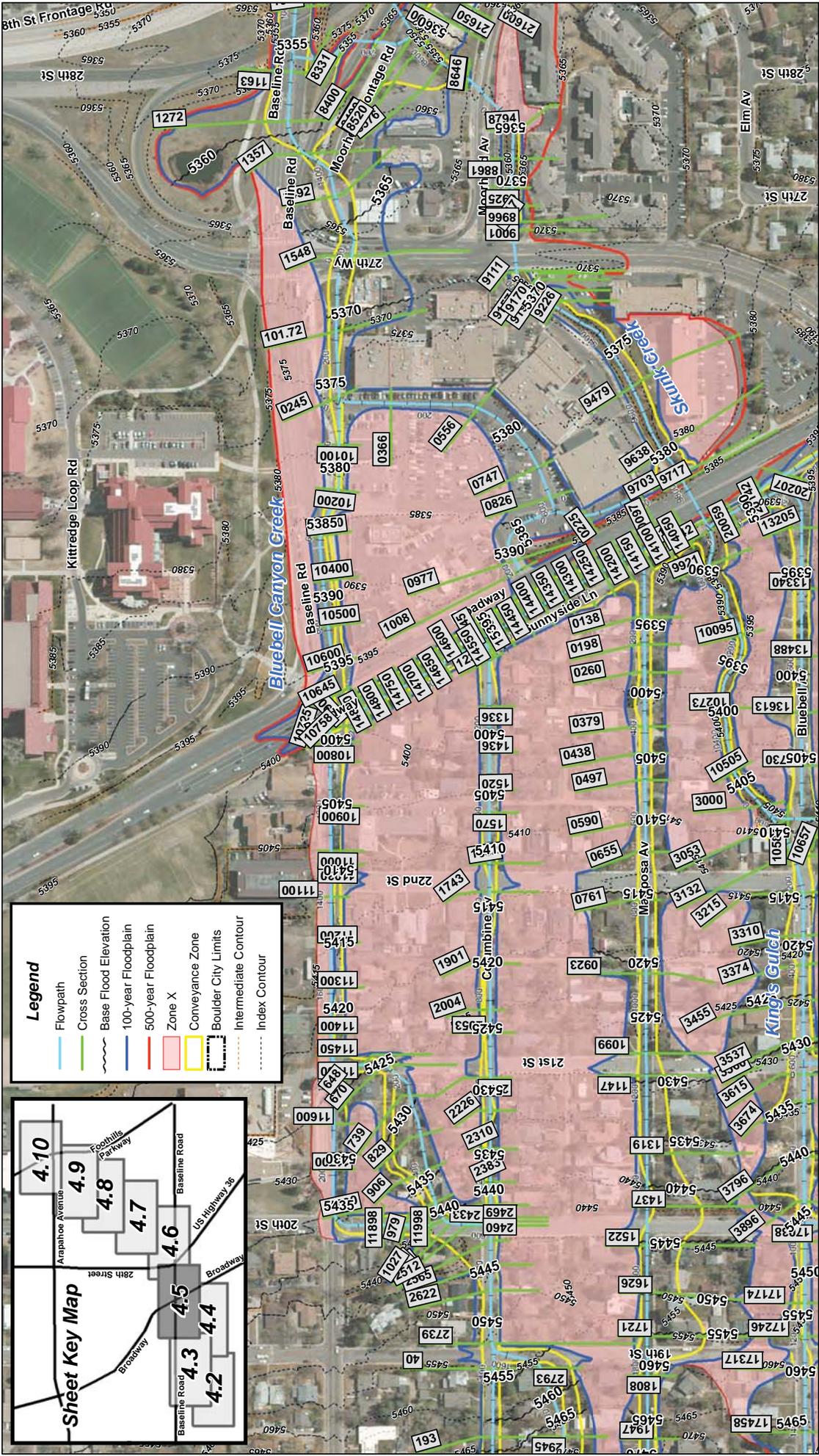




Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
 Figure 4.4: Floodplain Workmap

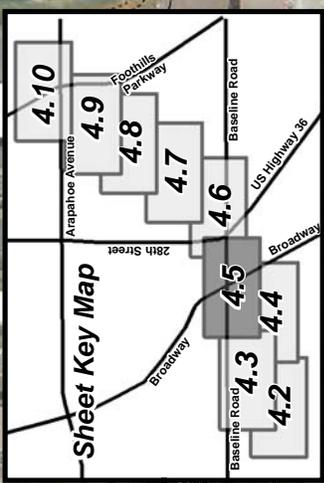
- Legend**
- Flowpath
 - Cross Section
 - Base Flood Elevation
 - 100-year Floodplain
 - 500-year Floodplain
 - Conveyance Zone
 - Boulder City Limits
 - Intermediate Contour
 - Index Contour





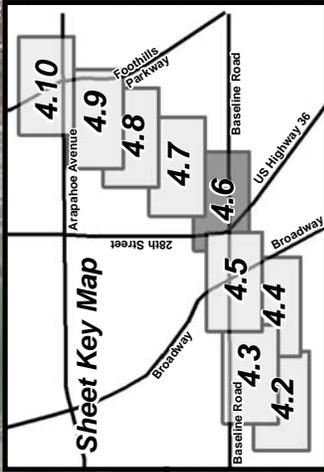
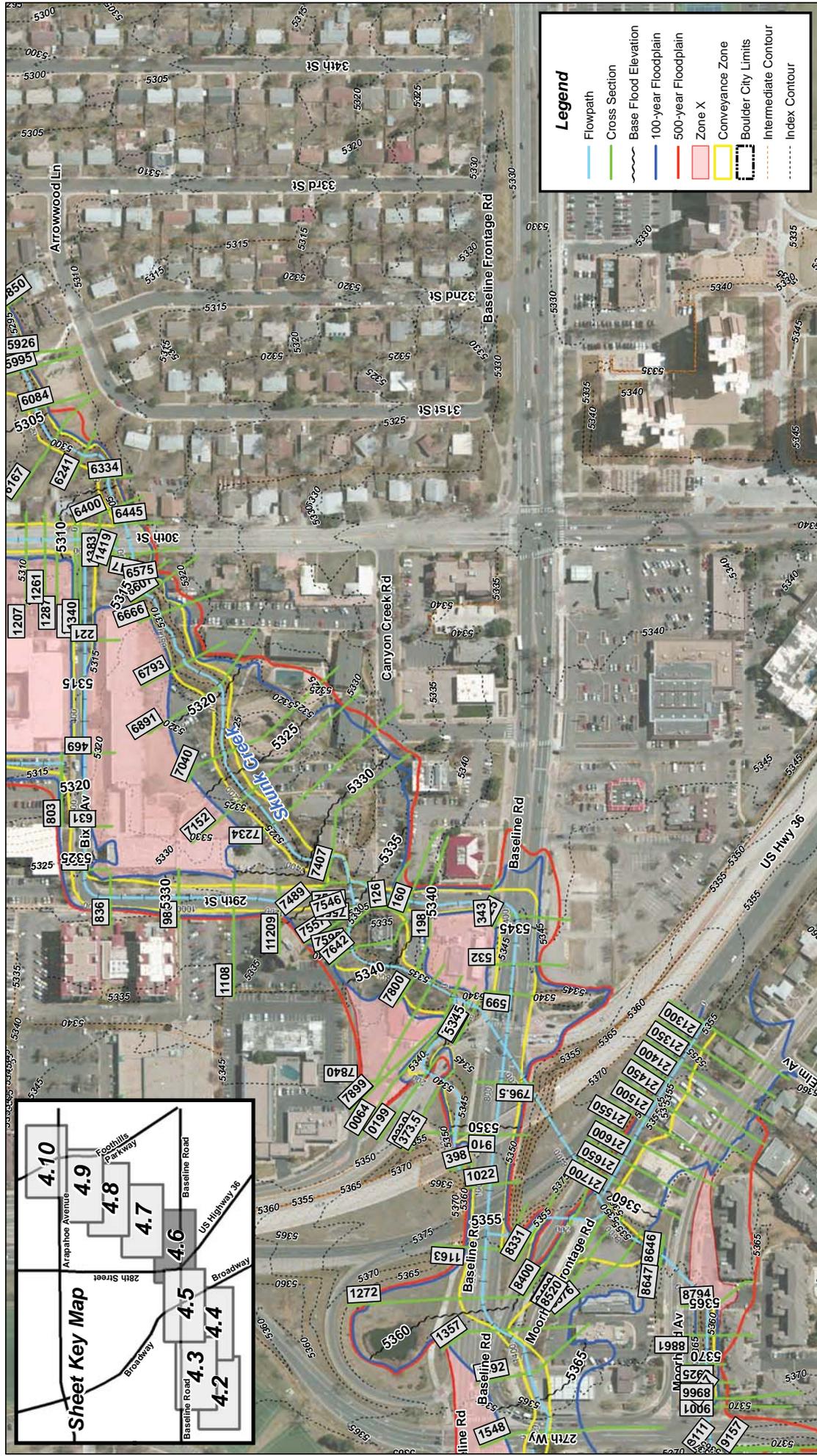
Legend

- Flowpath
- Cross Section
- Base Flood Elevation
- 100-year Floodplain
- 500-year Floodplain
- Zone X
- Conveyance Zone
- Boulder City Limits
- Intermediate Contour
- Index Contour



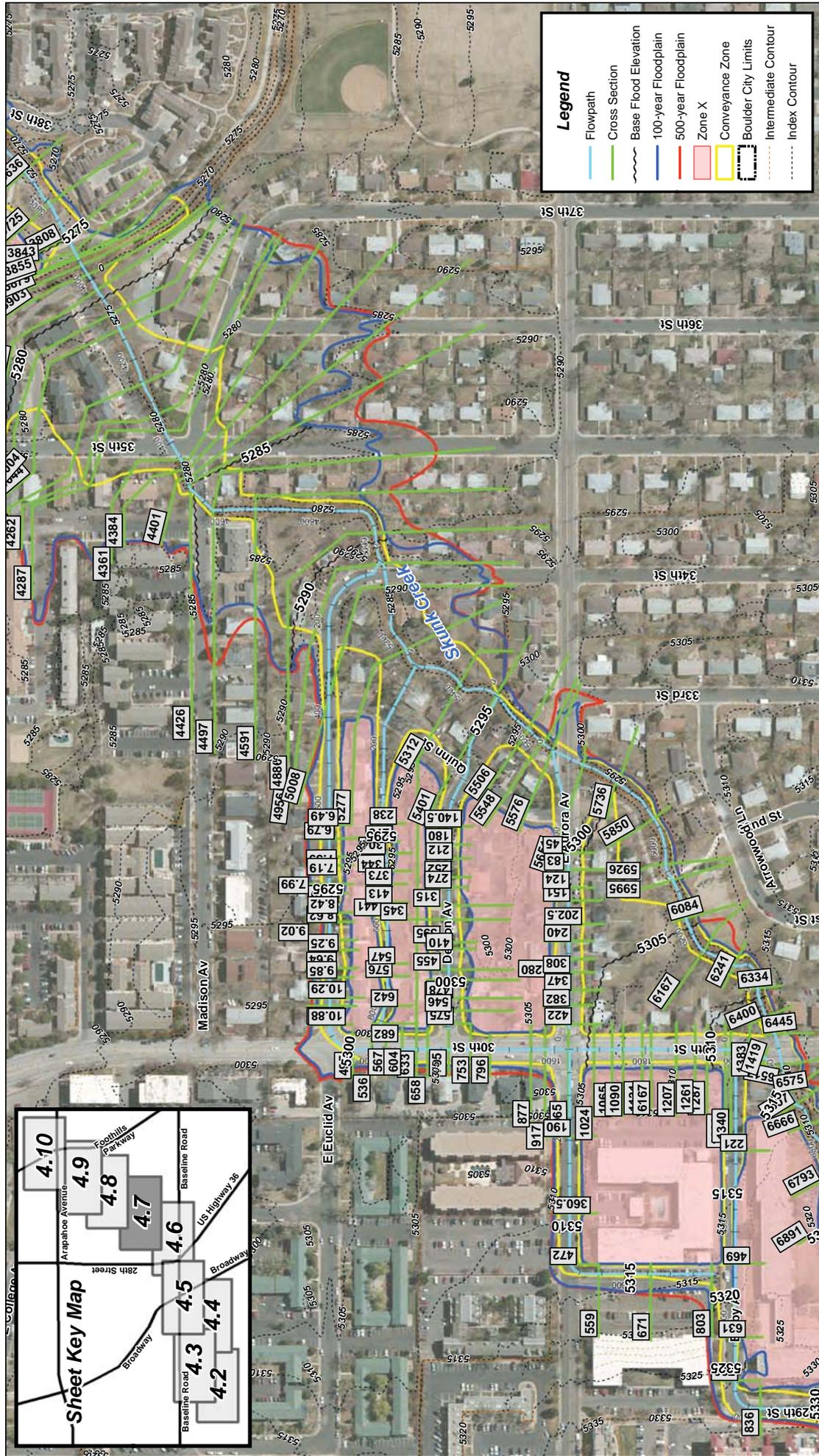
Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
 Figure 4.5: Floodplain Workmap





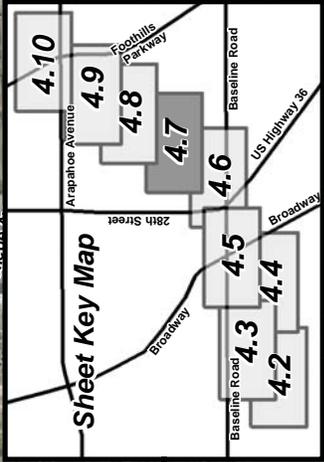
Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
 Figure 4.6: Floodplain Workmap

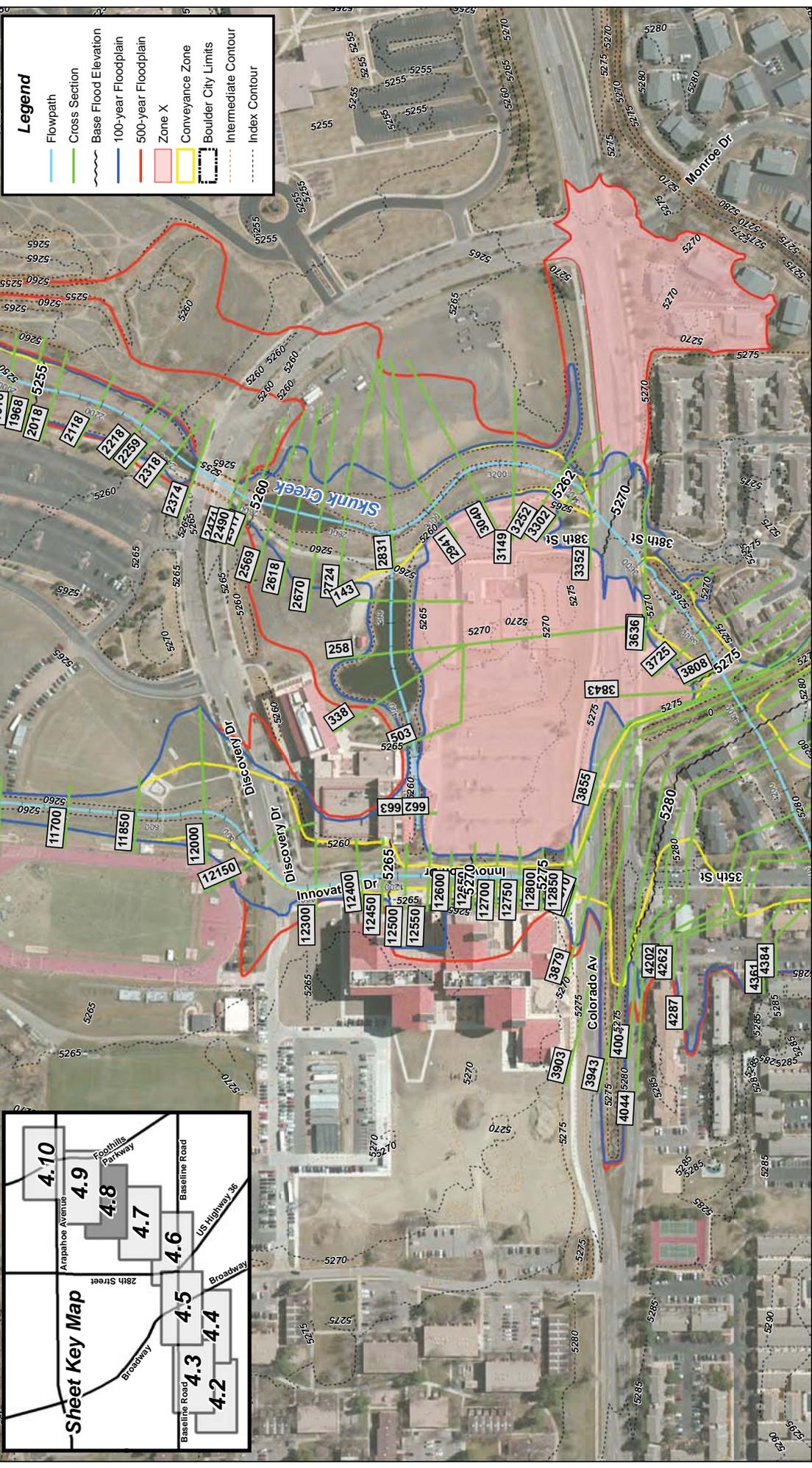




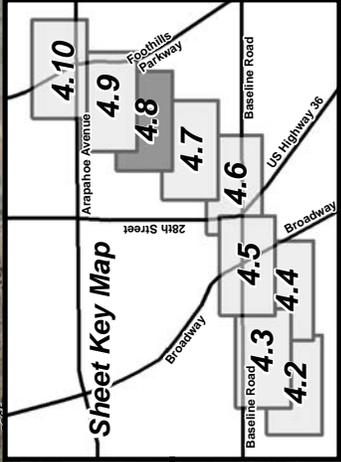
Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
 Figure 4.7: Floodplain Workmap

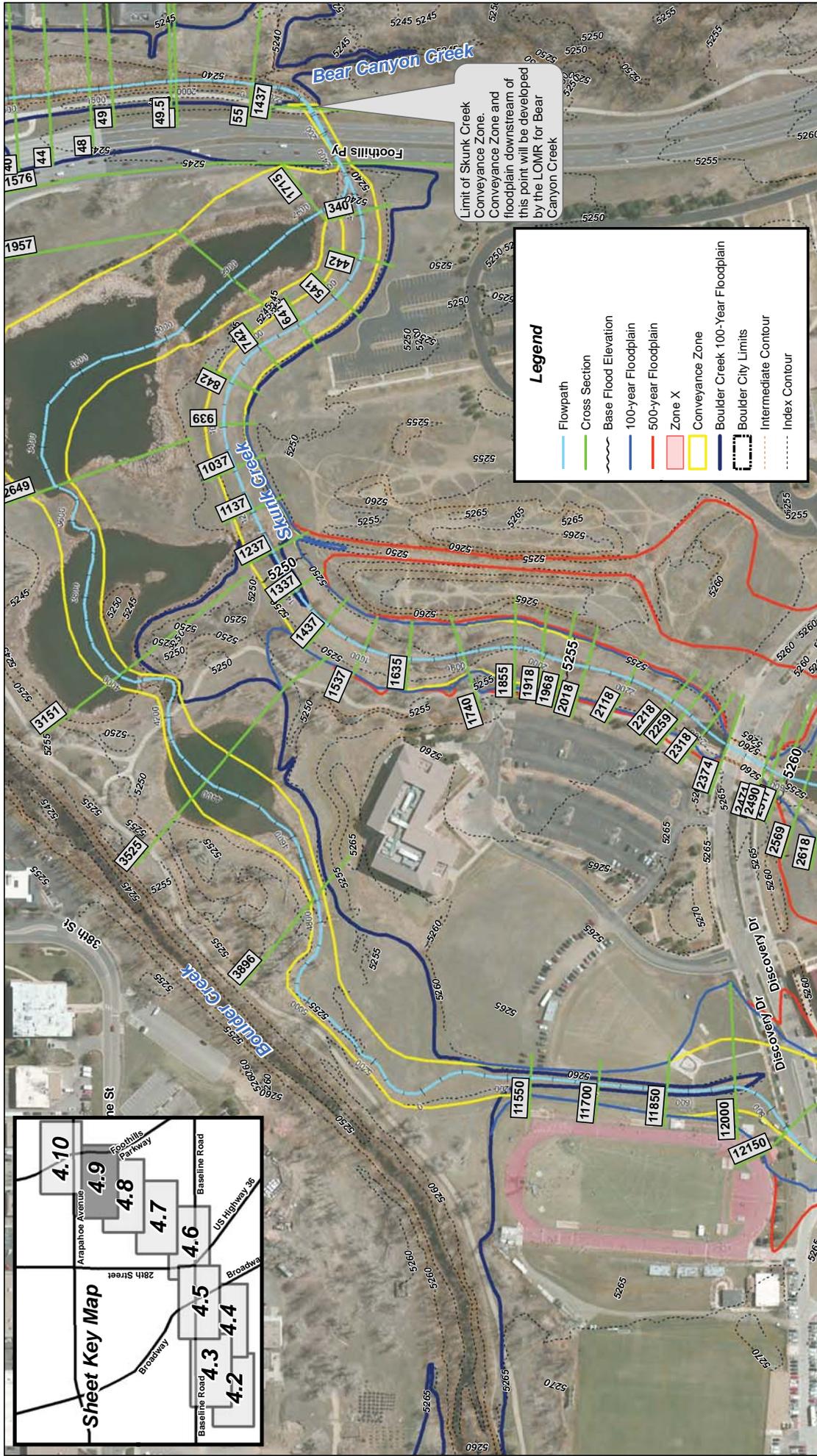
ICON
 ENGINEERING, INC.





Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
 Figure 4.8: Floodplain Workmap





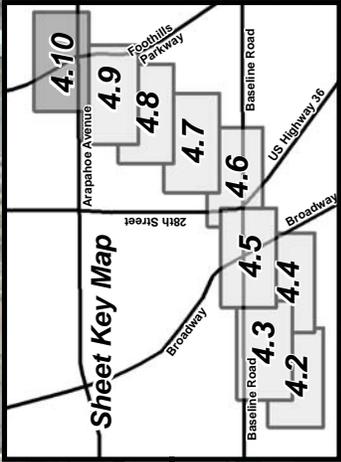
Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
 Figure 4.9: Floodplain Workmap





Note: Conveyance Zone and floodplain downstream of Foothills Parkway and Arapahoe Avenue will be developed by the separate LOMR for Bear Canyon Creek and PMR for Boulder Creek.

- Legend**
- Flowpath
 - Cross Section
 - Base Flood Elevation
 - 100-year Floodplain
 - 500-year Floodplain
 - Zone X
 - Conveyance Zone
 - Boulder Creek 100-Year Floodplain
 - Boulder City Limits
 - Intermediate Contour
 - Index Contour



Skunk Creek, Bluebell Canyon Creek, King's Gulch
 Request for Physical Map Revision (PMR)
 Figure 4.10: Floodplain Workmap

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Skunk Creek, Bluebell Canyon Creek and King's Gulch Remapping Study Public Comment Summary

Open House Date: Aug. 18, 2014

Open House Meeting Location: Municipal Building Lobby

Number of attendees that signed-in: 23

Staff in Attendance:

Robert Harberg

Katie Knapp

Kristin Dean

Laurel Olsen-Horen

Douglas Sullivan

Public Comments:

1. **Location:** 2042 Baseline

Commenter: Property owner (Ben Chancellor; Christina Jurgens)

Comment: Did not see flooding in September 2013 and do not feel that the high hazard designation is warranted; question split values for Mariposa vs. Columbine

Response: The high hazard zone delineations have been refined based on a review of adjacent grades. Adjacent to the structure at 2042 baseline, the delineation was revised such that the structure sits just outside of the high hazard zone. Split flow values for Mariposa and Columbine are being re-evaluated using 2D modeling to see if the September flood event can be more closely replicated in the modeling. It should be noted that the September 2013 flooding reflected a lower intensity and longer duration storm compared to the regulatory 100-year design storm that is a significantly higher intensity but shorter duration storm. This difference in storms can result in significant differences between the regulatory 100-year floodplain mapping and what was experienced in the September flood event.

2. **Location:** Area south of Baseline Road between 20th and Broadway

Commenter: Several property owners

Comment: Flooding in September 2013 was confined to streets; no flow behind homes; water did not appear to be originating from Bluebell Canyon Creek proper.

Response: Split flow values for Mariposa and Columbine are being re-evaluated using 2D modeling to see if the September flood event can be more closely replicated in the modeling. It should be noted that the September 2013 flooding reflected a lower intensity and longer duration storm compared to the regulatory 100-year design storm that is a significantly higher intensity but shorter duration storm. This difference in storms can result

in significant differences between the regulatory 100-year floodplain mapping and what was experienced in the September flood event.

3. **Location:** 22nd and Mariposa Avenue
Commenter: Several property owners
Comment: Flows traveling east on Mariposa turned north on 22nd Street and continued to Columbine Avenue; this is not shown as 100-year flooding.
Response: This flow path has been added to the documentation of the September flood event. The portion of 22nd Street between Mariposa and Columbine is shown as shallow flooding (Zone X) for the proposed floodplain. The proposed floodplain mapping in this area is being re-evaluated.
4. **Location:** 19th and Mariposa Avenue
Commenter: Property owner
Comment: structure at south east corner is shown in the 100-year floodplain but did not experience damage during the September 2013 event; please review assumptions here.
Response: Split flow values for Mariposa and Columbine are being re-evaluated using 2D modeling to see if the September flood event can be more closely replicated in the modeling. It should be noted that the September 2013 flooding reflected a lower intensity and longer duration storm compared to the regulatory 100-year design storm that is a significantly higher intensity but shorter duration storm. This difference in storms can result in significant differences between the regulatory 100-year floodplain mapping and what was experienced in the September flood event.
5. **Location:** 955 Quinn Street
Commenter: Property owner (Lee Payne)
Comment: Structure does not show as impacted on floodplain maps (tree cover issue?); how was floodplain delineated at corner of Denton Avenue and Quinn Street.
Response: Due to the large amount of tree cover, the structure was inadvertently excluded from the proposed floodplain map exhibit. The maps have been corrected to show the principal structure located outside of the proposed 100-year floodplain.
6. **Location:** 3130 Aurora
Commenter: Property Owner
Comment: It seems like the HHZ could be the result of a small depression that we may not want to include in the mapping.
Response:
7. **Location:** 1700 Bluebell
Commenter: Property Owner (Bill Mooz)
Comment: Structure is shown as in proposed floodplain but was not impacted by September 2013 event; wants to know why actual data was disregarded.

Response: The September 2013 flooding reflected a lower intensity and longer duration storm compared to the regulatory 100-year design storm that is a significantly higher intensity but shorter duration storm. This difference in storms can result in significant differences between the regulatory 100-year floodplain mapping and what was experienced in the September flood event. Split flow values for Mariposa and Columbine are being re-evaluated using 2D modeling to see if the September flood event can be more closely replicated in the modeling.

8. **Location:** 1849 Mariposa Ave,

Commenter: Property Owner (Steve Brown, Guen Simons)

Comment: Water from Bluebell creek did not flow to Mariposa. It flowed down the Bluebell drainage but primarily to the north along 19th Street and down Columbine.

Response: Split flow values for Mariposa and Columbine are being re-evaluated using 2D modeling to see if the September flood event can be more closely replicated in the modeling. It should be noted that the September 2013 flooding reflected a lower intensity and longer duration storm compared to the regulatory 100-year design storm that is a significantly higher intensity but shorter duration storm. This difference in storms can result in significant differences between the regulatory 100-year floodplain mapping and what was experienced in the September flood event.

9. **Location:** 2100 Baseline

Commenter: Property Owner (Jamie Karpohl)

Comment: a) There were no eastbound flows observed on Columbine west of 20th Street. b) The flooding at 20th and Columbine originated from the Anderson ditch on the north side of Columbine. This water flowed through properties to the north-east and down the Columbine North alley towards 21st. At 21st the flows split - continuing down the alley and heading north towards Baseline. c) During the flood, there was no flow observed coming down Columbine west of 20th. The only flows observed in Columbine were from Anderson ditch on the north side of the street. When I visited the location of Bluebell Canyon Creek at 15th St. on the morning of September 14th, I observed all of the flow heading down Mariposa. I did not observe any man-made diversions at this location.

Response: a) The city has received conflicting information about the flooding observed along Columbine between 19th and 20th Streets. At this time the flood extent documentation shows this area as having flows that came north from Mariposa along 19th Street and then continuing east on Columbine. The documentation of the September 2013 flood extents will continue to be refined as additional information is received.

b) Split flow values for Mariposa and Columbine are being re-evaluated using 2D modeling to see if the September flood event can be more closely replicated in the modeling. It should be noted that the September 2013 flooding reflected a lower intensity and longer duration storm compared to the regulatory 100-year design storm that is a significantly higher intensity but shorter duration storm. This difference in storms can result in significant differences between the regulatory 100-year floodplain mapping and what was experienced in the September flood event.

Public Hearing: WRAB Meeting, Aug. 18, 2014

Meeting Location: Council Chambers

Public Comments:

1. Steve Brown, Guen Simons - Water from Bluebell creek did not flow to Mariposa. It flowed down the Bluebell drainage but primarily to the north along 19th Street and down Columbine.
2. Lee Payne - My home does not show up as either added, removed or remaining in the 100 year floodplain on the "structures affected proposed 100 year floodplain". I believe this is due to the dense tree cover on my lot. The buildings on this lot look to be un-included in the 100 year flood zone, but it is unclear. The grading and slopes on my lot are high from the street and I believe the new mapping to be close to reality in that the homes are excluded. Can you please contact me to clarify if the structures are excluded and what the base flood elevation is in this area? There is also no information on sections or elevations for this lot on the city's website. Thank you!

Public Hearing: WRAB Meeting, Sept. 15, 2014

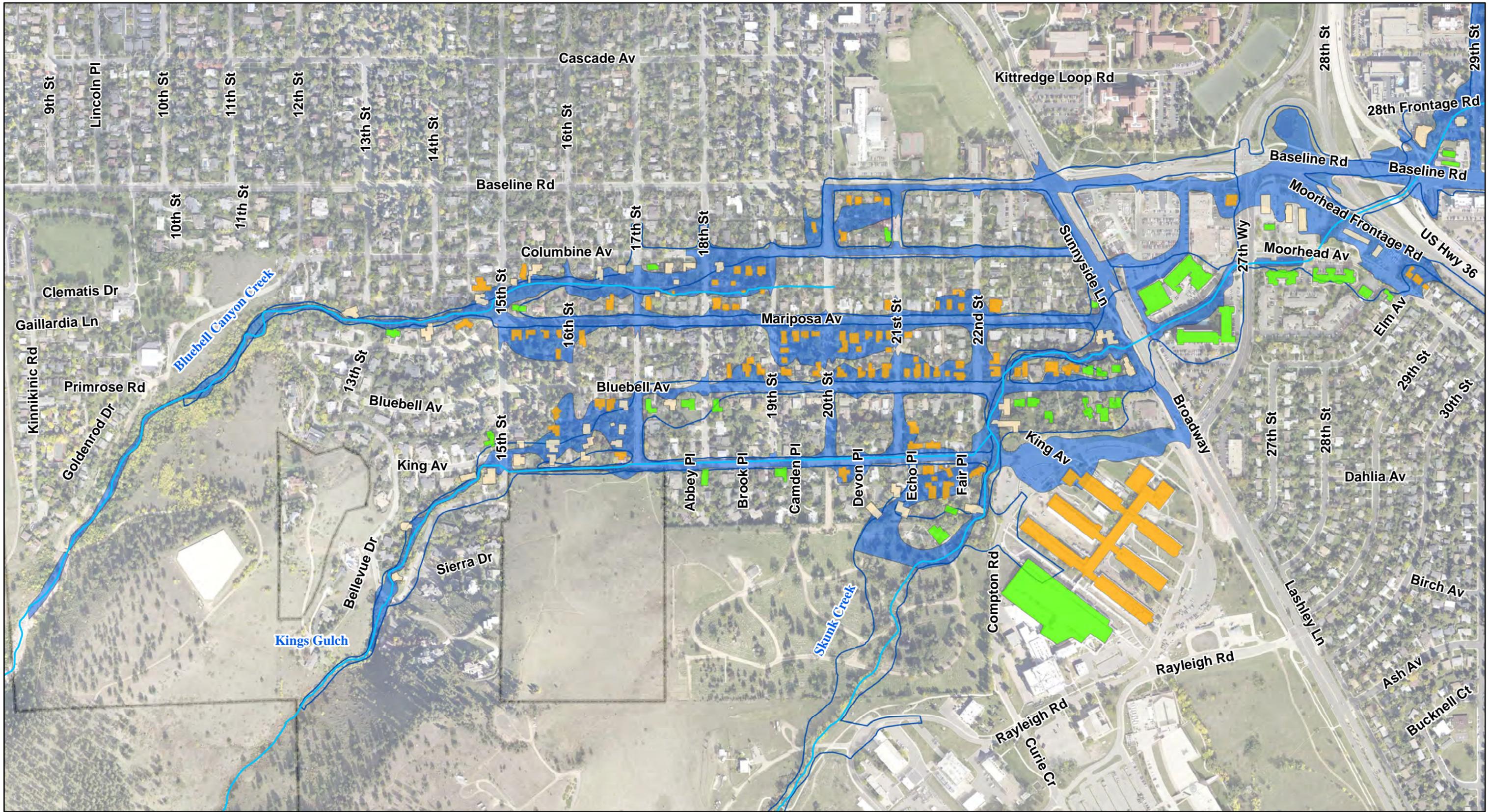
Meeting Location: Council Chambers

Public Comments:

1. Christina Jurgens – Concerns are with the Bluebell and that there were no diversions, which isn't reflected accurately in the mapping presented. Question is if a lot of water falls in the area, water will not flow uphill to 19th street and over Columbine if it's natural direction is downhill. She would like for this to be considered when moving forward with the amendment.
2. Bryan Boots – Owns a home at 20th and Columbine, which is in a newly designated hazard zone. He was completely unaware of the changes in zoning and is feeling like he is coming to the conversation late. Questions the assumptions that are going into this decision making and having a hard time reconciling the recent studies with what he actually experienced last September. He would like to better understand the next steps in the process regarding what is decided. It doesn't seem reasonable to put the burden on residents. He is requesting better, more effective outreach to citizens.
3. Tim Fuller-Rowell – Lives on Columbine Avenue, which is affected by the new floodplain, which now makes up half of his property. Increase in the water table flooded the basement. Flow down Mariposa didn't affect us. Rock dam broke causing a flash flood and persistent rainfall and wonders if that was factored into the analysis, but didn't see any major flow on

Columbine. Wants to understand the actual impact of flood to his property and physical reasons why it is now included on the floodplain. What is the process for deciding how the new boundaries are drawn and decided? Premature to start approving a new floodplain before the previous event is fully understood and would like the city to have more interaction with the people who are actually affected.

4. Jamie Krapohl – Property owner affected by the proposed flow split changes at 15th is his major concern. He didn't observe what is being shown on the maps and feels there is a lack of correlation in how the split affects these three blocks. On the Saturday of the flood, he was at 15th and Mariposa and didn't observe any diversions that were put into place by residents. The flooding on his corner was due to the Anderson Ditch overflowing, which is not represented in the changes. Since the open house, he has reached out to neighbors, but there are many renters around his property. He contacted three other property owners and informed them of the recent flood mapping changes. Feels that neighbors were not aware of these new changes. Concerned with the accuracy of the models, based on observations from walking around the neighborhood and what is being reflected in the updated maps. He feels this just doesn't make sense.



Legend

	FEMA Effective 100 Year Floodplain		Buildings Newly Affected by 100 Year Floodplain (104)		Creek
	Proposed Skunk Creek 100 Year Floodplain		Buildings Remaining in the 100 Year Floodplain (113)		City Limits
	Revised Boulder Creek 100 Year Floodplain		Buildings No Longer Affected by 100 Year Floodplain (66)		




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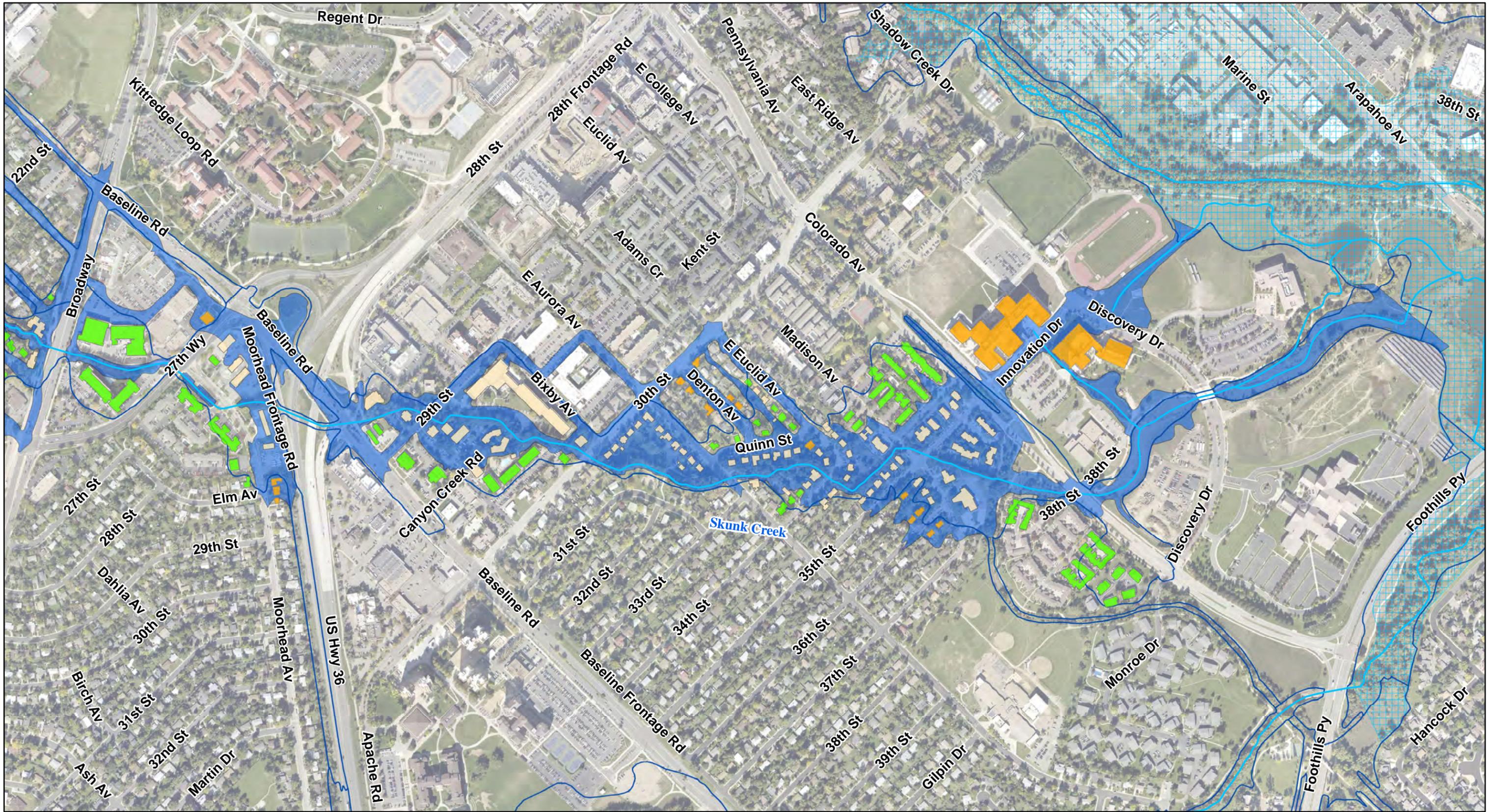
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Skunk Creek

Proposed 100 Year Floodplain
 Compared to FEMA Effective
 Map 1 of 2



CITY OF BOULDER
Utilities Division
Rev. 4/28/2015



Legend

	FEMA Effective 100 Year Floodplain		Buildings Newly Affected by 100 Year Floodplain (104)		Creek
	Proposed Skunk Creek 100 Year Floodplain		Buildings Remaining in the 100 Year Floodplain (113)		City Limits
	Revised Boulder Creek 100 Year Floodplain		Buildings No Longer Affected by 100 Year Floodplain (66)		

  1:6,000

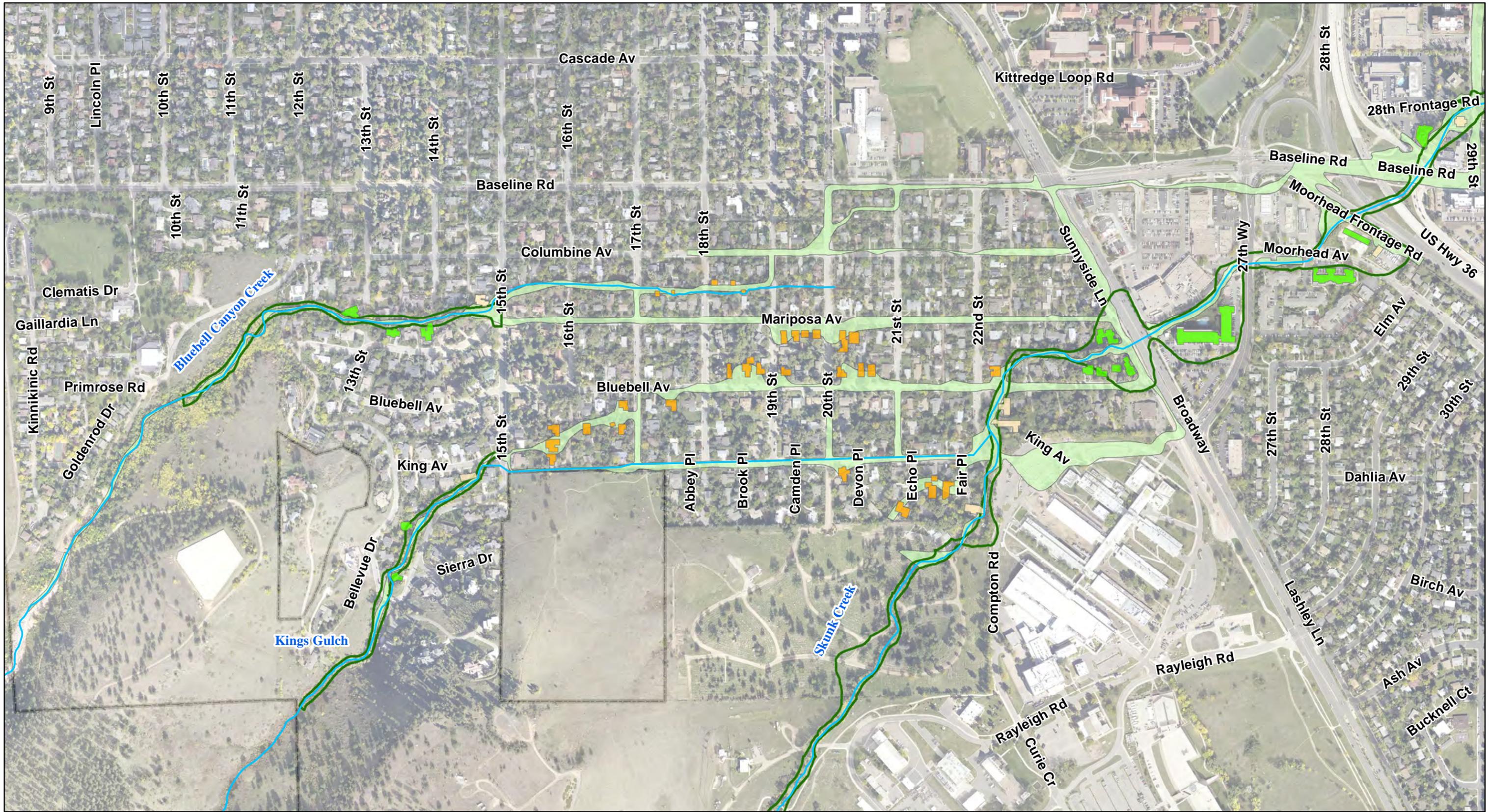
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Skunk Creek

Proposed 100 Year Floodplain Compared to FEMA Effective

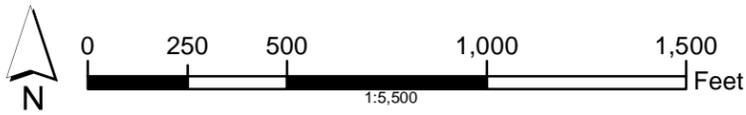
Map 2 of 2


 CITY OF BOULDER
 Utilities Division
 Rev. 4/28/2015



Legend

- Effective Conveyance Zone
- Proposed Skunk Creek Conveyance Zone
- Revised Boulder Creek Conveyance Zone
- Buildings Newly Affected by Conveyance Zone (33)
- Buildings Remaining in the Conveyance Zone (28)
- Buildings No Longer Affected by Conveyance Zone (55)
- Creek
- City Limits

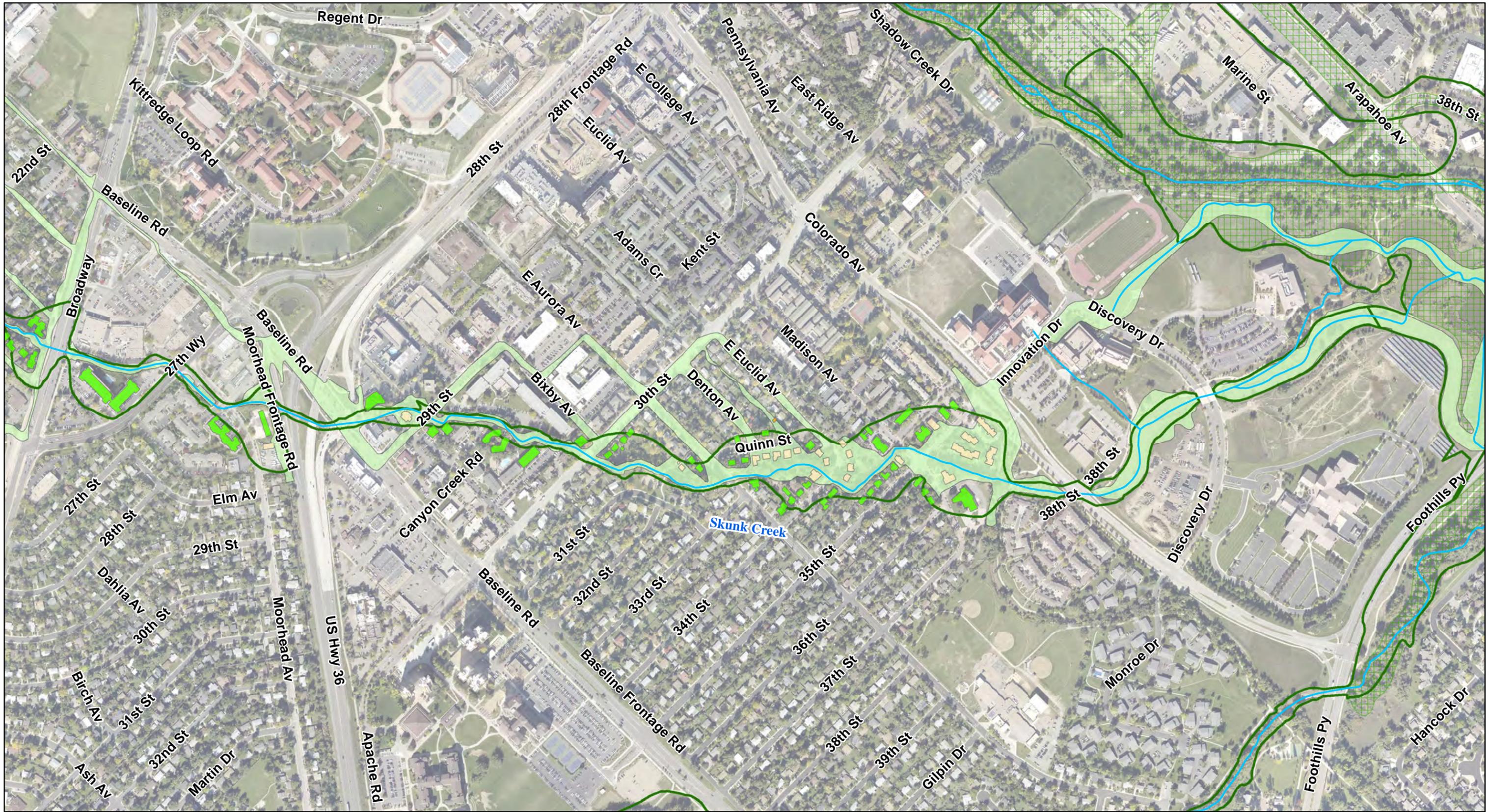


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Skunk Creek

Proposed Conveyance Zone
Compared to FEMA Effective
Map 1 of 2





Legend

- Effective Conveyance Zone
- Proposed Skunk Creek Conveyance Zone
- Revised Boulder Creek Conveyance Zone
- Buildings Newly Affected by Conveyance Zone (33)
- Buildings Remaining in the Conveyance Zone (28)
- Buildings No Longer Affected by Conveyance Zone (55)
- Creek
- City Limits

0 250 500 1,000 1,500 Feet
1:6,000

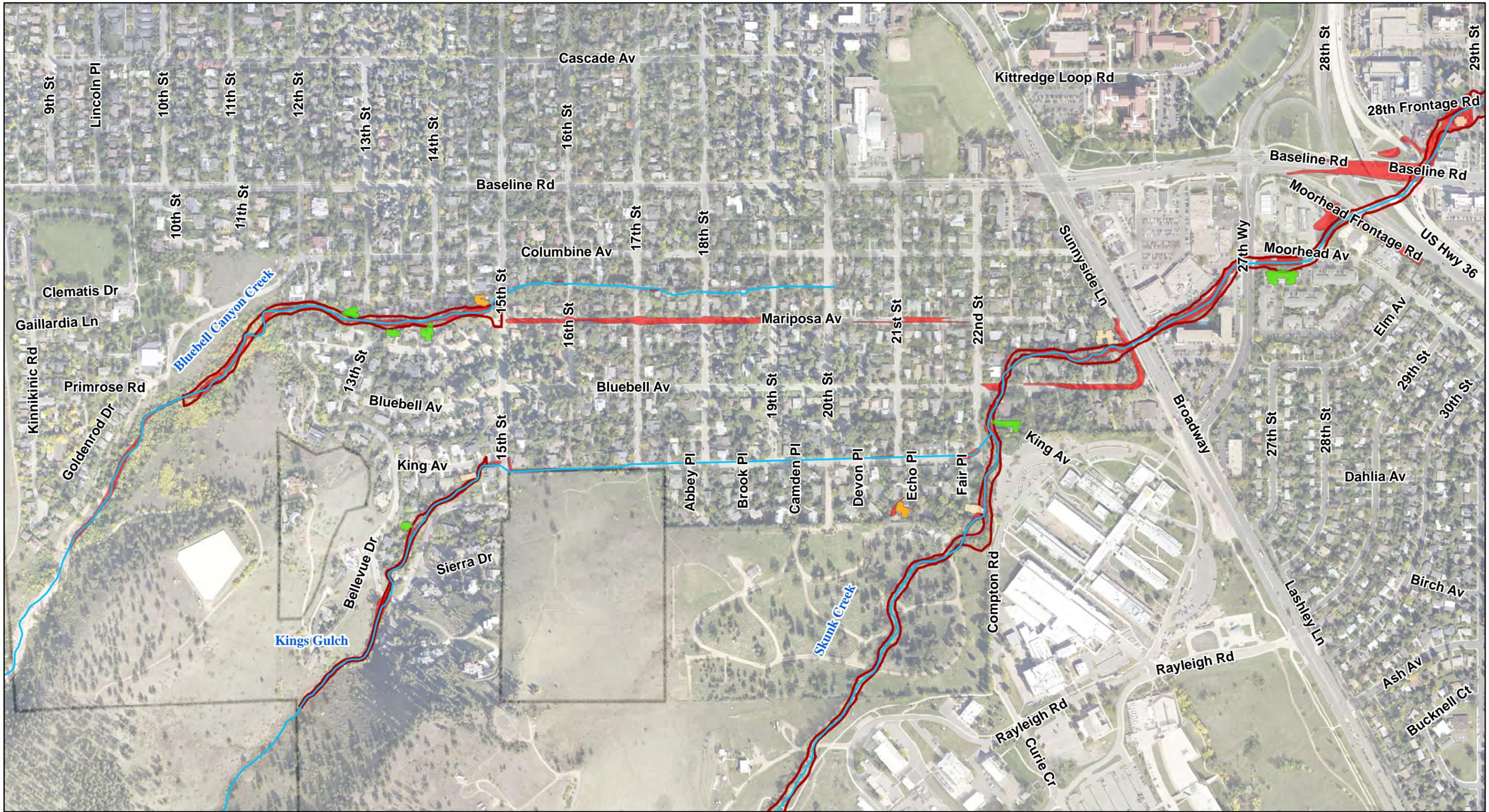
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Skunk Creek

*Proposed Conveyance Zone
Compared to FEMA Effective*

Map 2 of 2

CITY OF BOULDER
Utilities Division
Rev. 4/28/2015



Legend

- Effective High Hazard Zone
- Proposed Skunk Creek High Hazard Zone
- Revised Boulder Creek High Hazard Zone
- Buildings Newly Affected by High Hazard Zone (3)
- Buildings Remaining in the High Hazard Zone (7)
- Buildings No Longer Affected by High Hazard Zone (22)
- Creek
- City Limits

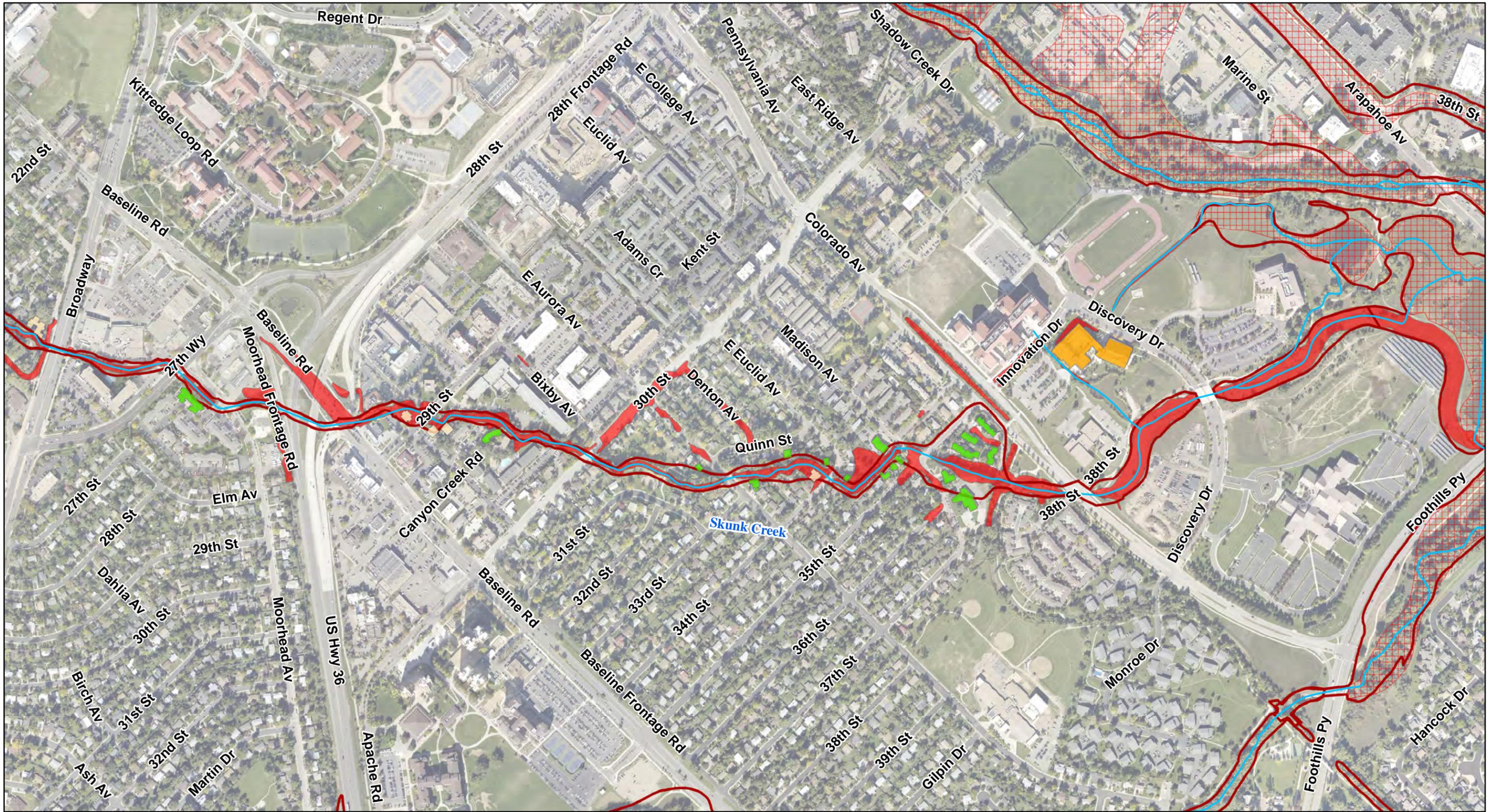


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Skunk Creek

Proposed High Hazard Zone
Compared to FEMA Effective
Map 1 of 2





Legend

- Effective High Hazard Zone
- Proposed Skunk Creek High Hazard Zone
- Revised Boulder Creek High Hazard Zone
- Buildings Newly Affected by High Hazard Zone (3)
- Buildings Remaining in the High Hazard Zone (7)
- Buildings No Longer Affected by High Hazard Zone (22)
- Creek
- City Limits

0 250 500 1,000 1,500 Feet

1:6,000

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Skunk Creek

Proposed High Hazard Zone Compared to FEMA Effective

Map 2 of 2

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