ICON ENGINEERING, INC.

Memorandum

TO: City of Boulder Public Works, Katie Knapp, P.E., CFM

FROM: ICON Engineering, Brian LeDoux, PE, CFM

DATE: February 22nd, 2019

RE: Upper Goose Creek and Twomile Canyon Creek – Flood Mitigation Plan – Alternative Selection Memorandum

Background and Purpose

ICON Engineering Inc. (ICON) has been placed under contract by the City of Boulder to develop, select, analyze, and recommend flood mitigation alternatives for Upper Goose Creek and Twomile Canyon Creek. This effort follows the previously completed Letter of Map Revision (LOMR) for Upper Goose Creek and Twomile Canyon Creek (Case No. 16-08-0026P) that became effective on August 18, 2016. The LOMR provided updated hydrologic and hydraulic analysis for flooding from Upper Goose Creek and Twomile Canyon Creek.

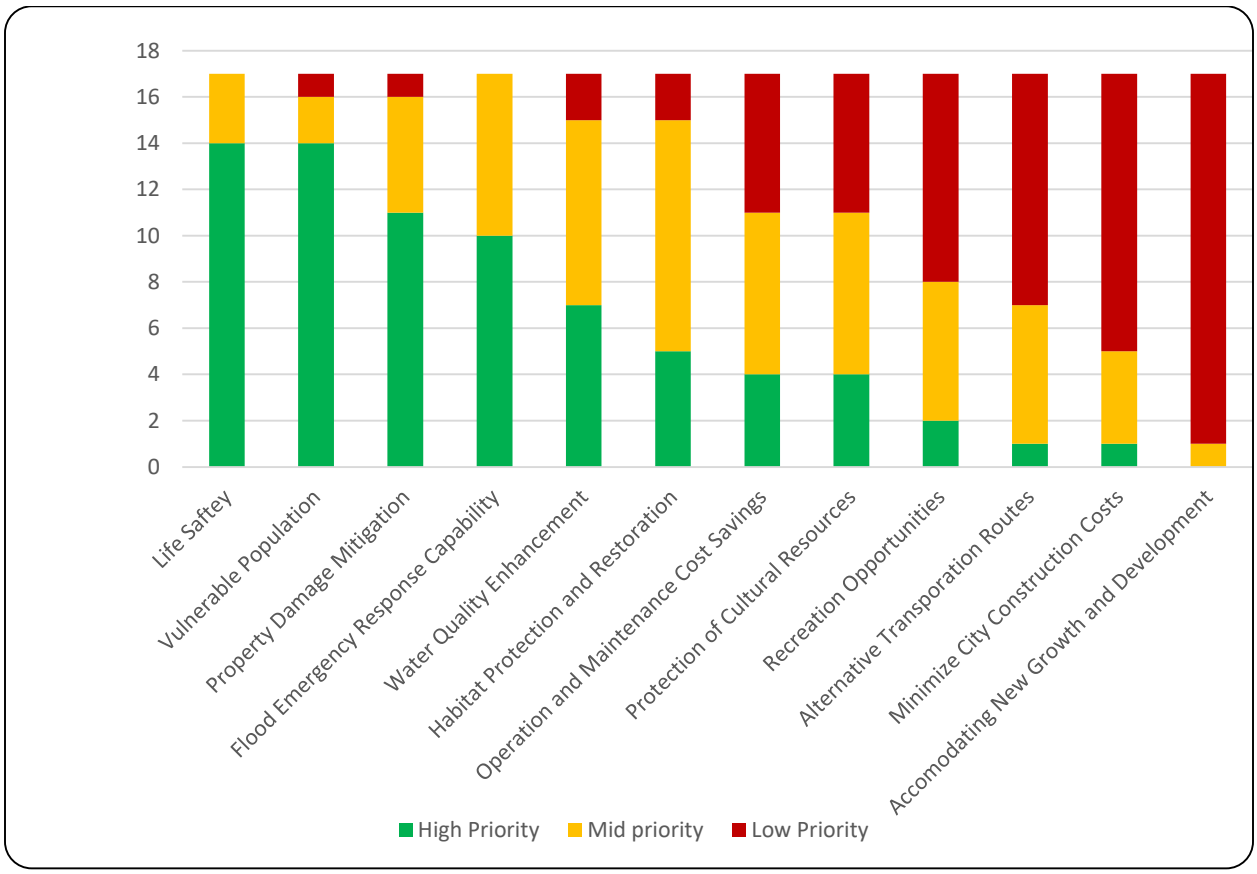
This memorandum summarizes the initial public process and alternative development that was completed in 2017 and 2018 and describes an additional screening process for the previously developed alternatives as part of this alternative selection effort. The remaining alternatives as recommended by this memorandum, will ultimately undergo further evaluation including a scoring process, benefit/cost analysis, and additional public coordination. Following these efforts, a recommended approach to flood mitigation will be developed. The recommended approach will then undergo conceptual design and inclusion into the final Upper Goose Creek and Twomile Canyon Creek Flood Mitigation Plan.

Public Process

A city wide flood planning and mitigation open house was held on April 12th, 2017. This open house served as the official "kick-off" for the Upper Goose Creek and Twomile Canyon Creek Flood Mitigation Plan project. This open house provided the public with an opportunity to discuss flooding problem areas and to provide input on flood mitigation approaches.

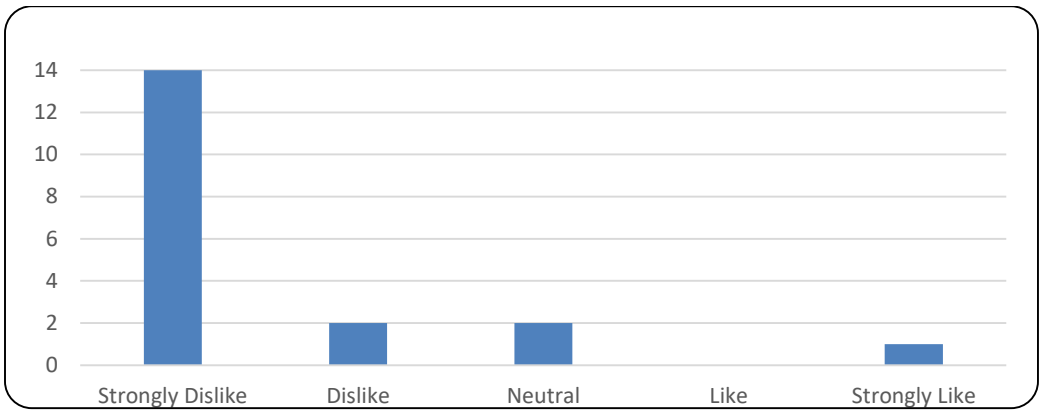
On July 20th, 2017, a public workshop was held at the North Boulder Recreation Center. This public workshop covered a spectrum of potential mitigation strategies to gain initial input on the preferred flood mitigation strategies and to rank the flood mitigation priorities. Of the attendees, 22 people provided written input on both table top maps

and in a written questionnaire. The data from the public input was compiled by the City of Boulder and used to help refine flood mitigation alternatives along Upper Goose Creek and Twomile Canyon Creek. The public attendees ranked the flood and greenways objectives as follows:

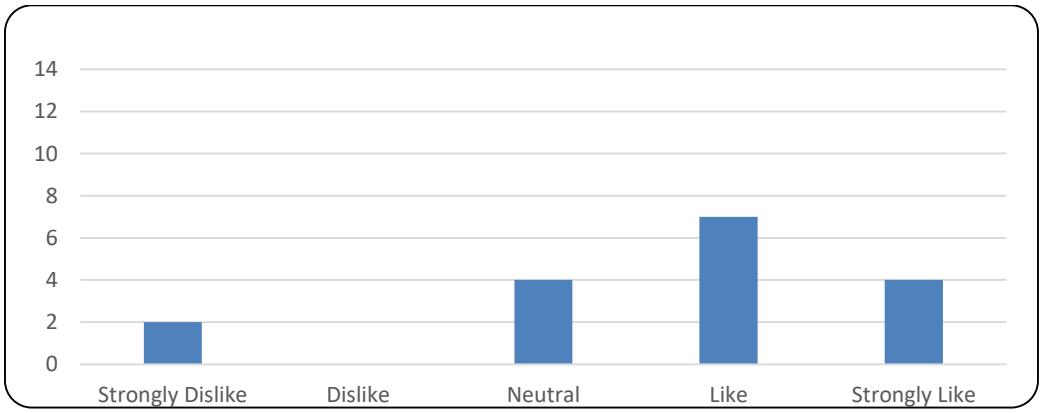


The public attendees also provided opinions on different mitigation strategies. The ratings for each mitigation strategies are illustrated by the graphs below.

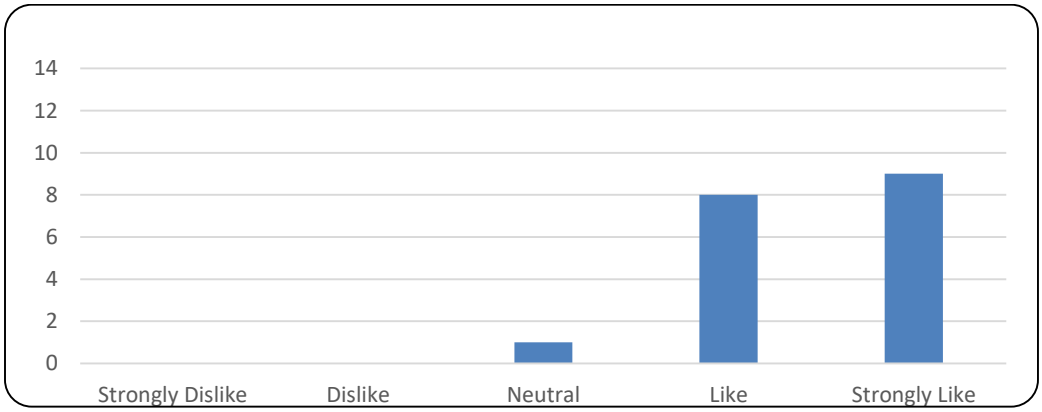
No Action:



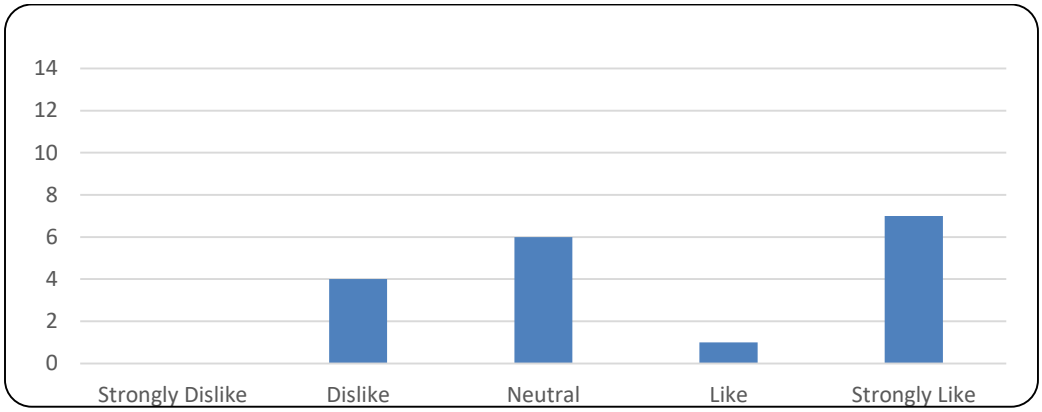
Detention and/or sediment control facilities:



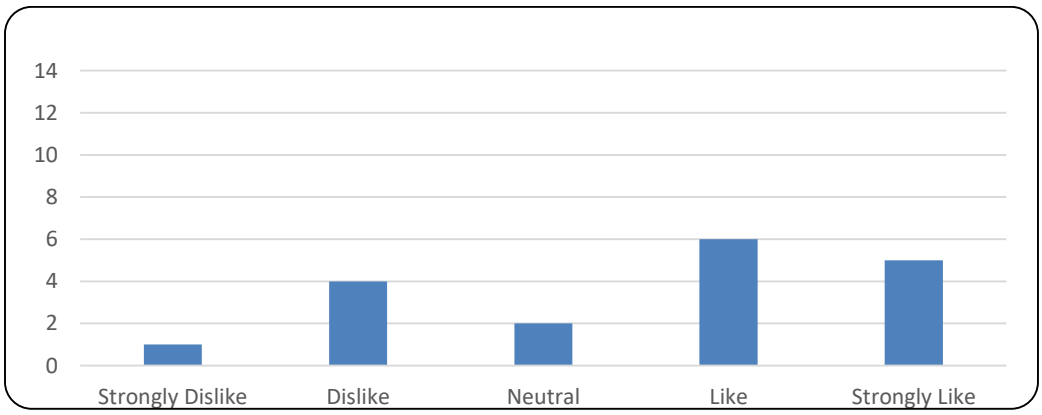
Open channel and culvert improvements:



Storm drain system:



Roadway Conveyance:



Feedback Incorporation

Following the July 20th, 2017 public workshop, the mitigation strategies were refined based on the public feedback and city staff input. This refinement generally focused on an open channel mitigation strategy where applicable, which was also the public's highest ranked strategy. Less popular than open channels - detention, storm drains, and roadway conveyance were all three generally favored on the same level by the public. For areas that would be more challenging to incorporate an open channel, storm drains and detention pond solutions were also incorporated into project alternatives. These two options were also generally supported by the public responses for the watershed. Roadway conveyance was not included west of Broadway due to the existence of an open channel west of Broadway, and the concern that roadway conveyance could potentially bring additional flood risk to areas that currently have low

risk. The alternatives developed following the July 20th, 2017 public workshop are included in **Appendix A**.

These alternatives were then presented at a public open house and to the Water Resources Advisory Board (WRAB) meeting on March 19th, 2018. Following this meeting, revisions to the alternatives were completed based on further public and WRAB input, which included the following dominant comments:

- Many comments were made with respect to the potential use of the Long's Garden area as a potential detention site or for an open channel. Comments related to the historic use of the site and the incompatibility of garden soils with stormwater applications.
- Many comments were made regarding the potential removal of the Alpine Condominiums for mitigation. Comments related to the importance of this housing stock and the ramifications if current residents were to be displaced.
- Comments also included a desire to look at moving the detention from the Long's Garden area upstream and into Boulder County and/or to the Boulder County complex at the north east corner of Broadway and Iris Avenue.
- Comments also included a desire to utilize roadway conveyance west of Broadway as a way to reduce or eliminate the need to enlarge the existing Twomile Canyon Creek Channel.
- Unlike the initial workshop, public opinion was no longer in favor of an enlarged 100-Year open channel west of Broadway, rather maintenance of the existing channel was preferred.

The feedback from the March 19th, 2018 public open house was gathered through an online survey. A total of 477 individual responses were logged by the survey, with 191 individuals completing the full survey. The survey asked responders to rank the flood and greenways objectives. The results of this ranking were very similar to the same ranking exercise completed at the July 20th, 2017 workshop (see graph on page 2). It should be noted that the life safety objective was inadvertently not included in the questionnaire.

The survey also asked for opinions on the presented alternatives. The corresponding survey results are included as pie-charts on the applicable sheets located in **Appendix A**. Additional comment summary tables are included in **Appendix A**. The feedback from the online survey was taken into consideration and utilized in the initial screening process as discussed below.

Full results from this survey can be found on the project website at:

https://bouldercolorado.gov/pages/skunk-creek-bluebell-canyon-creek-kings-gulch-upper-goose-and-twomile-flood-mitigation-studies

Initial Alternative Screening

Flood mitigation alternatives at the following areas have been adjusted based on initial screening that reviewed feasibility, public support, level of mitigation, and the greenways objectives.

Long's Garden Property along Twomile Canyon Creek

Due to a lack of public support, all alternatives that would have the potential to impact the Long's Garden area have been removed from consideration. Additional storm drain alternatives have now been developed east of Broadway in order to include a drainage route south of Iris Avenue.

Alpine Condominiums Property along Upper Goose Creek

Due to a lack of public support, all alternatives that would require removal of the condominium structures have been removed from consideration. Current alternatives consider an underground storm drain across the property. However, should the Alpine Condominium area undergo a significant redevelopment in the future, the option to daylight flood mitigation measures should be considered if other mitigation is not yet complete.

100-Year Open Channel

Due to a lack of public support and the excessive cost, several reaches of 100-year channel conveyance have been removed where acquisition and removal of a large number of privately held residential structures would be required.

Detention in Boulder County

Detention alternatives within Boulder County and at the Boulder County complex near Iris and Broadway were reviewed and presented to Boulder County staff during a meeting on June 25th, 2018. As discussed, new flood water detention upstream of the City of Boulder limits would require approximately five new dam/detention facilities in order to provide storage for the 100-year event down to the capacity of the downstream drainageway. Due to steep topography in this area, all five dams would be expected to range in size from 3 to 19.3 acre-feet, with all five likely to fall under state jurisdictional high hazard status. In addition,

impacts to private property, transportation and roadways, and viewscapes would be considerable. To date, a formal response from Boulder County regarding their assessment and thoughts behind these alternatives has not been received. However, based on land use impacts and high costs, new detention upstream of the City of Boulder limits was chosen to not be pursued further.

The flood storage that exists within the Pine Brook Reservoir was reviewed as a detention alternative. However, the discharge rates out of the service and emergency spillways at the elevations within the flood storage pool are relatively high resulting in a lack of peak flood discharge attenuation. Based on this lack of mitigation impact, detention within Pine Brook Reservoir was chosen to not be pursued further.

The area along Twomile Canyon Creek just upstream of Linden Avenue and Spring Valley Drive is owned by the City of Boulder. The site does not provide for significant storage volume for a detention facility, but the location is ideal for a sediment capture facility. The sediment capture facility would function similar to the current sediment capture facility in this location, but would be expanded including a second embankment upstream of Spring Valley Drive.

Detention in Boulder County Complex (NE corner of Iris & Broadway)

The original detention concept for the Boulder County Complex at the north east corner of Iris Avenue and Broadway included detention options for both the ballfields on the east side of the property and where the current Boulder County offices are located. The project team discussed the likelihood of any redevelopment of the county offices and potential for vacating that portion of the parcel. This was found to be unlikely due to property values and therefore, detention on the County's building site itself was removed from consideration. Should the portion of the parcel that includes the County offices be redeveloped in the future, the option to include detention could be reconsidered if other mitigation measures are not yet complete. The ballfields on the east side of the property have been retained as an alternative for detention consideration. The detention alternative will reduce the footprint available for ballfields, but the area could still function as fields. The City is currently leading efforts to discuss this use and impacts with the management for Iris Field and local little league.

Community Plaza and Ideal Market Commercial Area

The City of Boulder met with representatives of the Community Plaza and Ideal Market commercial area to discuss major redevelopment efforts of the commercial area. Extent and timing of any redevelopment of the area is

unknown at this time. Furthermore, the alternative of an open channel, while being a potential focus point of a redevelopment, would also likely reduce the developable footprint of the area. For this reason, the open channel alternatives between Broadway and 13th Street along Upper Goose Creek have been removed from consideration. Should the Community Plaza and Ideal Market commercial area redevelop in the future, the option to daylight flood mitigation could be reconsidered if other mitigation measures are not yet complete.

Roadway Conveyance on Twomile Canyon Creek west of Broadway

While a roadway conveyance mitigation approach west of Broadway had originally not been moved forward based on public input from the July 20th, 2017 public workshop (open channel favored over roadway conveyance), this alternative has now been incorporated into the alternatives for further evaluation. This inclusion is based on comments received in the 2018 questionnaire which requested that roadway conveyance be investigated further in place of major changes to the existing Twomile Canyon Creek channel.

Alternatives for Further Evaluation

Following the public process, feedback incorporation, and initial screening, the alternatives for additional analysis for the Upper Goose Creek and Twomile Canyon Creek Flood Mitigation Plan are summarized in **Table 1** (Twomile Canyon Creek) **Table 2** (Upper Goose Creek), and **Figures 1** through **11** below.

Attachments:

- *Table 1:* Twomile Canyon Creek Alternatives Summary
- *Table 2:* Upper Goose Creek Alternatives Summary
- *Figure 1:* Reach Overview
- *Figure 2:* Twomile Canyon Creek Reach 1
- *Figure 3:* Twomile Canyon Creek Reach 2
- *Figure 4:* Twomile Canyon Creek Reach 3
- *Figure 5:* Twomile Canyon Creek Reach 4
- *Figure 6:* Upper Goose Creek Reach 1
- *Figure 7:* Upper Goose Creek Reach 2
- *Figure 8:* Upper Goose Creek Reach 3
- *Figure 9:* Upper Goose Creek Reach 4
- *Figure 10:* Upper Goose Creek Reach 5
- *Figure 11:* Upper Goose Creek Reach 6

Appendices:

- *Appendix A:* WRAB Figures (from March 19th, 2018 meeting)
- *Appendix B:* Detention Alternatives Figure

Upper Goose Creek and Twomile Canyon Creek – Flood Mitigation Plan – Alternative Selection Memorandum

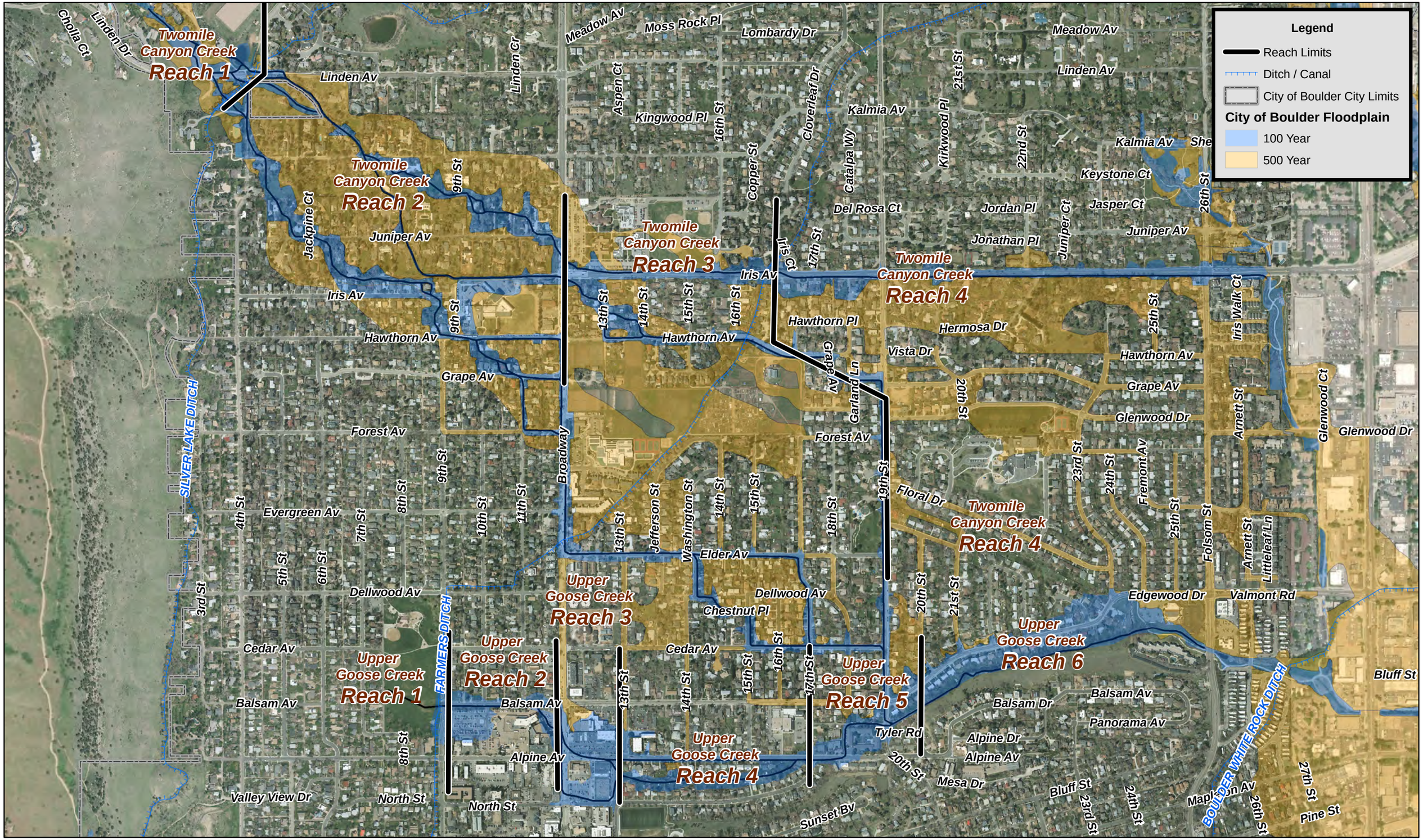
Table 1: Twomile Canyon Creek Alternatives for Further Evaluation Summary

Reach	Reach Description	Alt	Mitigation Measure	Project Benefits (pro)	Project Issues (con)
Twomile-01	City Limits to Linden Avenue	A	100-Year channel improvements; new Spring Valley Drive and Linden Avenue culverts	• Reduces spill flow out of Twomile Canyon Creek • Reduces overtopping of roadways	• May require removal of mature trees • Does not address sediment capture • Channel work requires drainage easements
Twomile-01	City Limits to Linden Avenue	B	<100-Year channel improvements; new Spring Valley Drive and Linden Avenue culverts	• Reduces spill flow out of Twomile Canyon Creek • Reduces overtopping of roadways	• May require removal of mature trees • Does not address sediment capture • Channel work requires drainage easements • Does not contain 100-year event
Twomile-01	City Limits to Linden Avenue	C	Enlarge existing sediment capture facility	• Reduces sedimentation impact downstream • Existing City ownership of sediment capture facility footprint • Can be constructed independent of other improvements	• Change in natural sediment transport • May require removal of mature trees • Embankment may impact viewscape • Impacts Open Space Mountain Parks land • No significant reduction in flood risk
Twomile-02	Linden Avenue to Broadway	A	<100-Year channel improvements; new Kalmia Avenue, Juniper Avenue, and Broadway culverts; channel to Broadway and Iris	• Reduces spill flow out of Twomile Canyon Creek • Reduces overtopping of roadways • Follows existing channel alignment • Opportunity for underpass at Broadway	• Requires some structure acquisition • Requires extensive drainage easements • Requires Iris or 13th Street alternatives
Twomile-02	Linden Avenue to Broadway	B	<100-Year channel improvements; new Kalmia Avenue, Juniper Avenue, and Broadway/Hawthorn Avenue culverts; channel to Broadway and Hawthorn	• Reduces spill flow out of Twomile Canyon Creek • Reduces overtopping of roadways • More efficient connection to downstream channel • Opportunity for underpass at Broadway	• Not as feasible for Broadway underpass • Requires some structure acquisition • Requires extensive drainage easements • Requires downstream improvements
Twomile-02	Linden Avenue to Broadway	C	Roadway conveyance along Linden, Kalmia and/or Juniper to Broadway	• Captures spill flow out of Twomile Canyon Creek • Utilizes existing roadway corridors	• Conveys flood risk into areas without previous risk • Possible utility conflicts • Increases surface flow within Broadway • Life safety and emergency access concerns with street flooding
Twomile-03	Broadway to 19th Street	A	100-Year channel improvements; new 13th Street, 14th Street culverts, culvert from 16th Street through Farmer's Ditch; Iris Avenue Roadway Improvements for surface flow	• Conveys flood flows to Elmer's Twomile • Less property acquisition than southern alignments	• Major impact to Iris Avenue
Twomile-03	Broadway to 19th Street	B	<100-Year channel improvements; new 13th Street, 14th Street culverts, culvert from 16th Street through Farmer's Ditch; Iris Avenue Roadway Improvements for surface flow	• Conveys flood flows to Elmer's Twomile • Less property acquisition than southern alignments	• Major impact to Iris Avenue • Does not contain 100-year event
Twomile-03	Broadway to 19th Street	C	100-Year storm drain outfall system	• Utilizes existing City Right-of-Way • Provides for local drainage along 13th Street	• Requires downstream improvements • Does not impact Iris Avenue • Susceptible to clogging
Twomile-03	Broadway to 19th Street	D	<100-Year storm drain outfall system	• Utilizes existing City Right-of-Way • Provides for local drainage along 13th Street	• Requires downstream improvements • Does not impact Iris Avenue • Susceptible to clogging
Twomile-03	Broadway to 19th Street	E	Detention facility within the Boulder County Complex at Broadway and Iris (ballfields only)	• Reduces downstream discharges • Utilizes publicly owned property • Retain or re-purpose park uses	• Impact to existing park uses • May require removal of mature trees • Embankment may impact viewscape
Twomile-04	19th Street to Elmer's Twomile Creek	A	Iris Avenue Roadway Improvements for surface flow	• Conveys flood flows to Elmer's Twomile	• Major impact to Iris Avenue • Life safety and emergency access concerns with street flooding
Twomile-04	19th Street to Upper Goose Creek	B	<100-Year Iris Avenue Roadway Improvements for surface flow	• Conveys flood flows to Elmer's Twomile	• Major impact to Iris Avenue • Life safety and emergency access concerns with street flooding • Does not contain 100-year event
Twomile-04	19th Street to Upper Goose Creek	C	100-Year storm drain outfall system	• Utilizes the 19th Street Right-of-Way • Does not require open channel construction	• Does not remove Twomile Canyon Creek discharge from Goose Creek between 19th and historical confluence • Susceptible to clogging
Twomile-04	19th Street to Upper Goose Creek	D	<100-Year storm drain outfall system	• Utilizes the 19th Street Right-of-Way • Does not require open channel construction	• Does not remove Twomile Canyon Creek discharge from Goose Creek between 19th and historical confluence • Susceptible to clogging • Does not contain 100-year event
Twomile-04	19th Street to Upper Goose Creek	E	100-Year channel improvements; new 21st Street and Edgewood Drive culverts	• Provides open channel connectivity to Goose Creek • May reduce groundwater issues in local area	• Requires significant land acquisition • May require removal of mature trees • Places channel in backyards
Twomile-04	19th Street to Upper Goose Creek	F	<100-Year channel improvements; new 21st Street and Edgewood Drive culverts	• Provides open channel connectivity to Goose Creek • May reduce groundwater issues in local area	• Requires significant land acquisition • May require removal of mature trees • Places channel in backyards

Upper Goose Creek and Twomile Canyon Creek – Flood Mitigation Plan – Alternative Selection Memorandum

Table 2: Upper Goose Creek Alternatives for Further Evaluation Summary

Reach	Reach Description	Alt	Mitigation Measure	Project Benefits (pro)	Project Issues (con)
Goose-01	North Boulder Park to 9th Street	A	Detention facility within North Boulder Park; new 9th Street culvert	• Reduces downstream discharges • Reduces overtopping of 9th Street • Retain or re-purpose park uses	• Impact to existing park uses • May require removal of mature trees • Embankment may impact viewscape
Goose-01	North Boulder Park to 9th Street	B	No detention; Roadway collection to deliver flows to Alpine-Balsam site	• Provides flooding protection for the Alpine-Balsam site • Does not impact North Boulder Park • Reduces flooding on Balsam Avenue	• No reduction in discharges • Concentrates discharges onto the Alpine-Balsam site • May require roadway reconfiguration
Goose-02	9th Street to Broadway	A	100-Year open channel through Alpine-Balsam site	• Provides flooding protection for the Alpine-Balsam site • Reduces flooding on Balsam Street • Aligns with the Alpine-Balsam Master Plan • Provides open channel habitat / green infrastructure	• Final configuration of Alpine-Balsam site unknown • Requires more room than storm drain system
Goose-02	9th Street to Broadway	B	<100-Year open channel through Alpine-Balsam site	• Provides flooding protection for the Alpine-Balsam site • Reduces flooding on Balsam Street • Aligns with the Alpine-Balsam Master Plan • Provides open channel habitat / green infrastructure	• Final configuration of Alpine-Balsam site unknown • Requires more room than storm drain system • Does not contain 100-year event
Goose-02	9th Street to Broadway	C	100-Year storm drain through Alpine-Balsam site (detained flow)	• Provides flooding protection for the Alpine-Balsam site • Reduces flooding on Balsam Street • Aligns with the Alpine-Balsam Master Plan	• Final configuration of Alpine-Balsam site unknown • Susceptible to clogging
Goose-02	9th Street to Broadway	D	100-Year storm drain through Alpine-Balsam site (full flow)	• Provides flooding protection for the Alpine-Balsam site • Reduces flooding on Balsam Street	• Final configuration of Alpine-Balsam site unknown • Susceptible to clogging
Goose-02	9th Street to Broadway	E	<100-Year storm drain through Alpine-Balsam site (full flow)	• Provides flooding protection for the Alpine-Balsam site • Reduces flooding on Balsam Street	• Final configuration of Alpine-Balsam site unknown • Susceptible to clogging • Does not contain 100-year event
Goose-03	Broadway to 13th Street	A	100-Year storm drain system	• Utilizes existing Right-of-Way • Does not require property acquisition • Provides local drainage along Broadway and Alpine Avenue	• Construction disruption to busy business corridor • Susceptible to clogging
Goose-03	Broadway to 13th Street	B	<100-Year storm drain system	• Utilizes existing Right-of-Way • Does not require property acquisition • Provides local drainage along Broadway and Alpine Avenue	• Construction disruption to busy business corridor • Susceptible to clogging
Goose-04	13th Street to 17th Street	A	100-Year open channel	• Provides additional open channel habitat • Enhances existing drainage path • Green infrastructure	• Requires extensive drainage easement acquisition • Disruptive to residential back-yards
Goose-04	13th Street to 17th Street	B	<100-Year open channel	• Provides additional open channel habitat • Enhances existing drainage path • Green infrastructure	• Requires extensive drainage easement acquisition • Disruptive to residential back-yards • Does not contain 100-year event
Goose-04	13th Street to 17th Street	C	100-Year storm drain system	• Utilizes existing Right-of-Way • Does not require property acquisition • Provides local drainage along Alpine Avenue	• Does not address overland flow in existing flow path • Susceptible to clogging
Goose-04	13th Street to 17th Street	D	<100-Year storm drain system	• Utilizes existing Right-of-Way • Does not require property acquisition • Provides local drainage along Alpine Avenue	• Does not address overland flow in existing flow path • Susceptible to clogging • Does not contain 100-year event
Goose-05	17th Street to 20th Street	A	100-Year storm drain system from Alpine/17th through 20th	• Utilizes some existing Right-of-Way • Does not require Alpine Condos removal • Provides local drainage adjacent to Alpine Condos	• Requires drainage easement acquisition • Disruptive to Alpine Condo property (construction) • Susceptible to clogging
Goose-05	17th Street to 20th Street	B	<100-Year storm drain system from Alpine/17th through 19th	• Utilizes some existing Right-of-Way • Does not require Alpine Condos removal • Provides local drainage adjacent to Alpine Condos	• Requires drainage easement acquisition • Disruptive to Alpine Condo property (construction) • Susceptible to clogging • Does not contain 100-year event
Goose-06	20th Street to 24th Street	A	100-Year Open channel	• Provides additional open channel habitat • Enhances existing drainage path • Green infrastructure	• Requires extensive drainage easement acquisition • Disruptive to residential back-yards • Requires tall retaining walls on south bank
Goose-06	20th Street to 24th Street	B	Open channel (sizing per previous study recommending a "5-Year" improvement; exceeds 5-Year with detained flow and/or Twomile improvements)	• Provides additional open channel habitat • Enhances existing drainage path • Green infrastructure	• Requires extensive drainage easement acquisition • Disruptive to residential back-yards • Requires tall retaining walls on south bank • Does not contain 100-year event



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Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 1: Reach Overview

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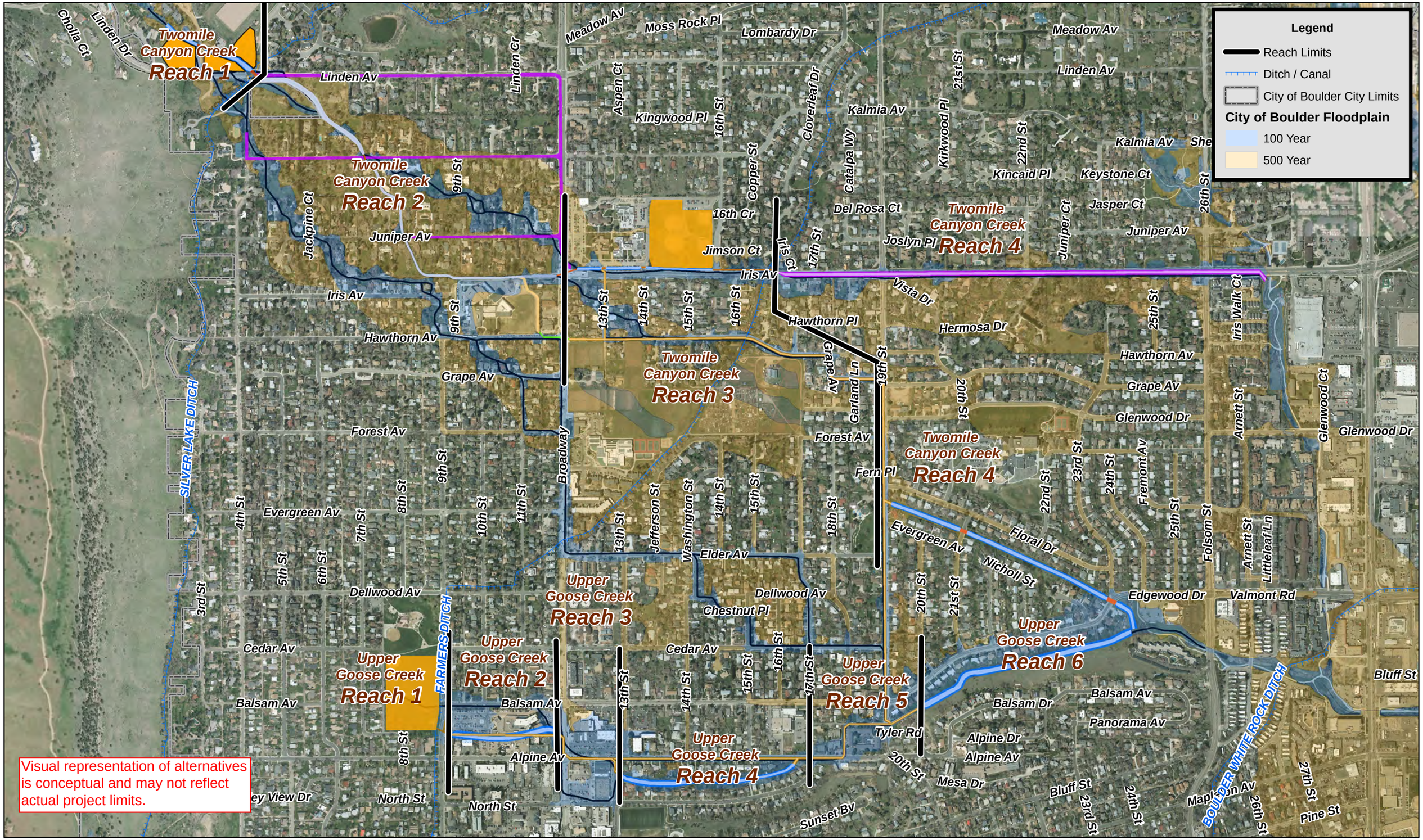

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Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 1: Reach Overview

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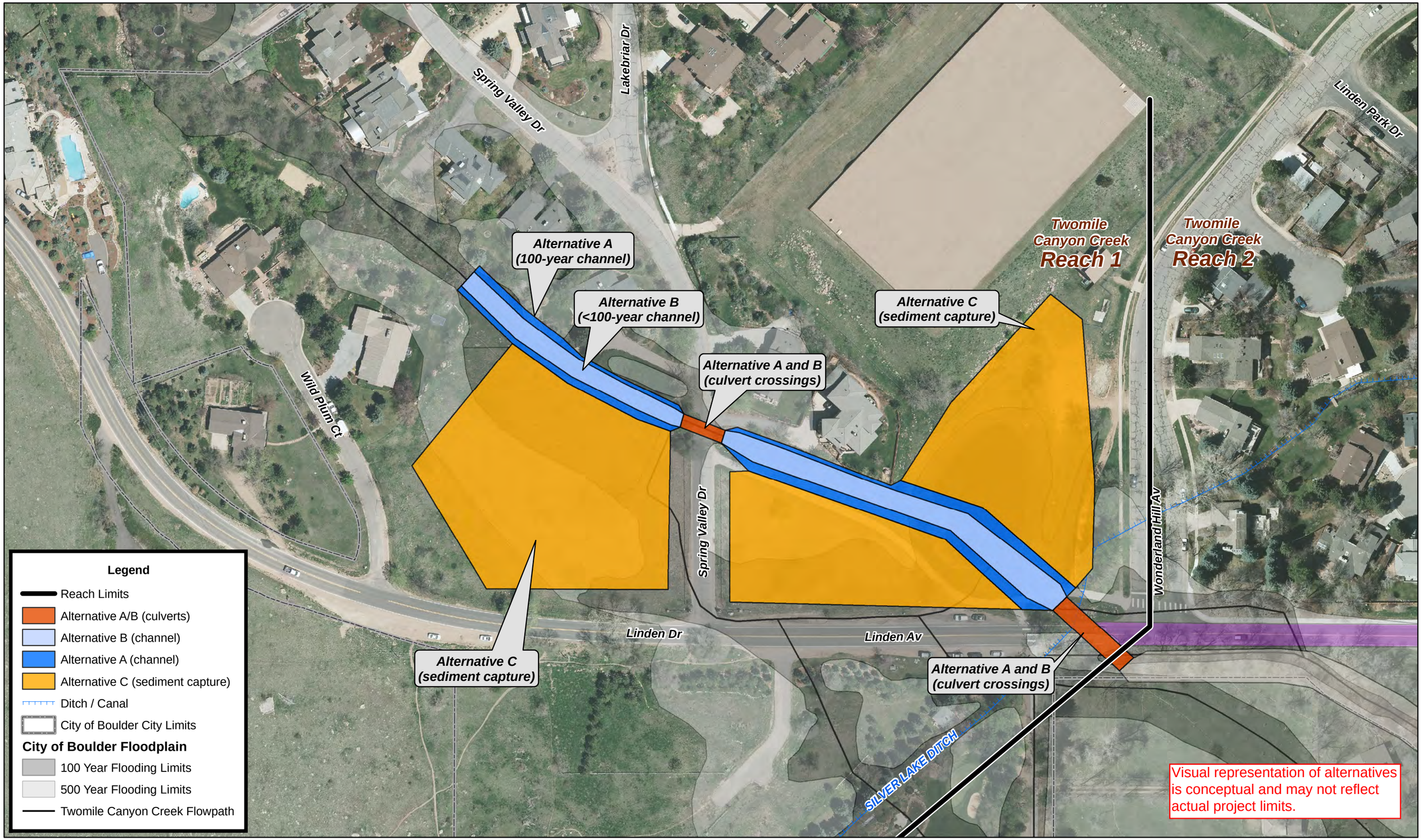

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Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 2: Twomile Canyon Creek - Reach 1

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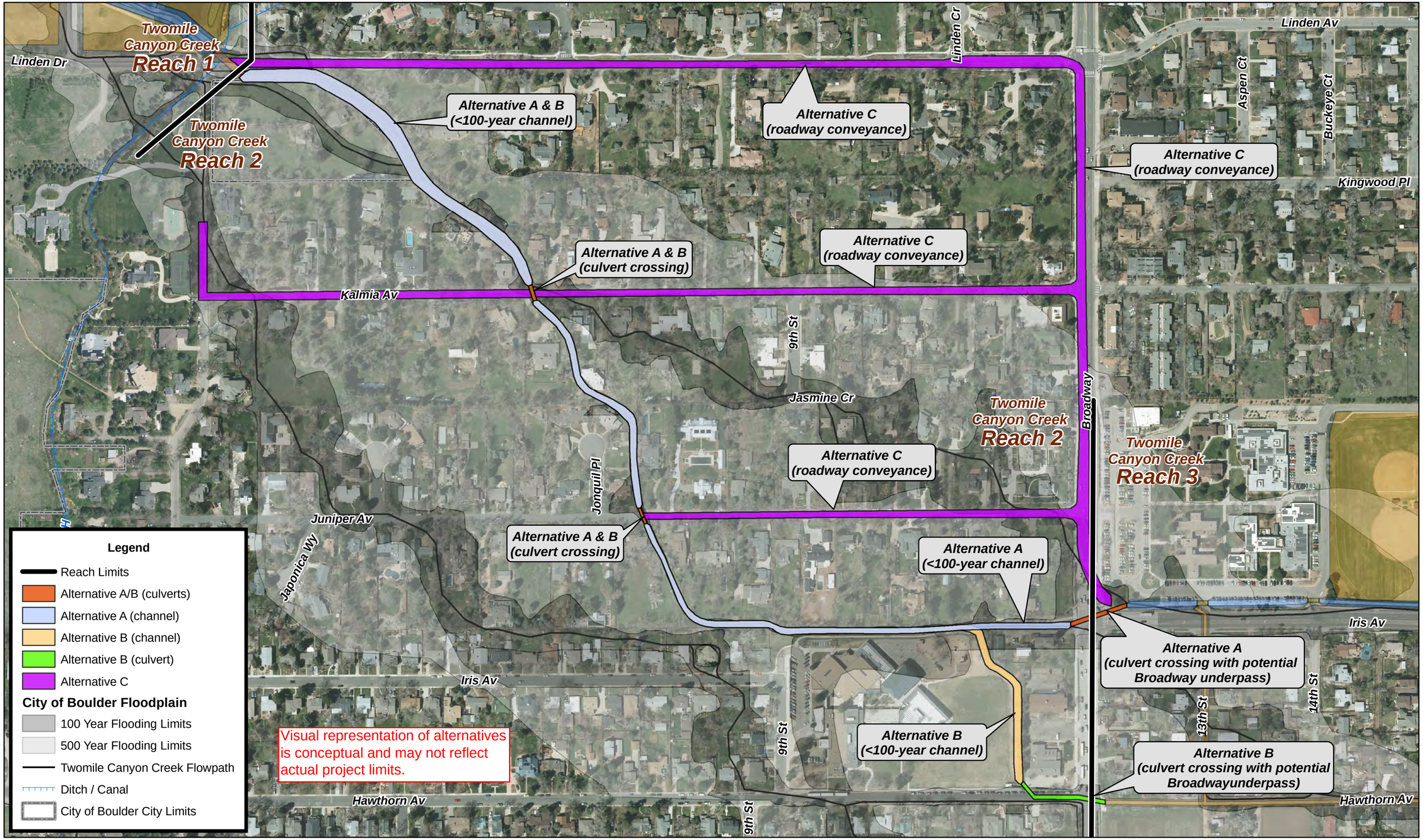

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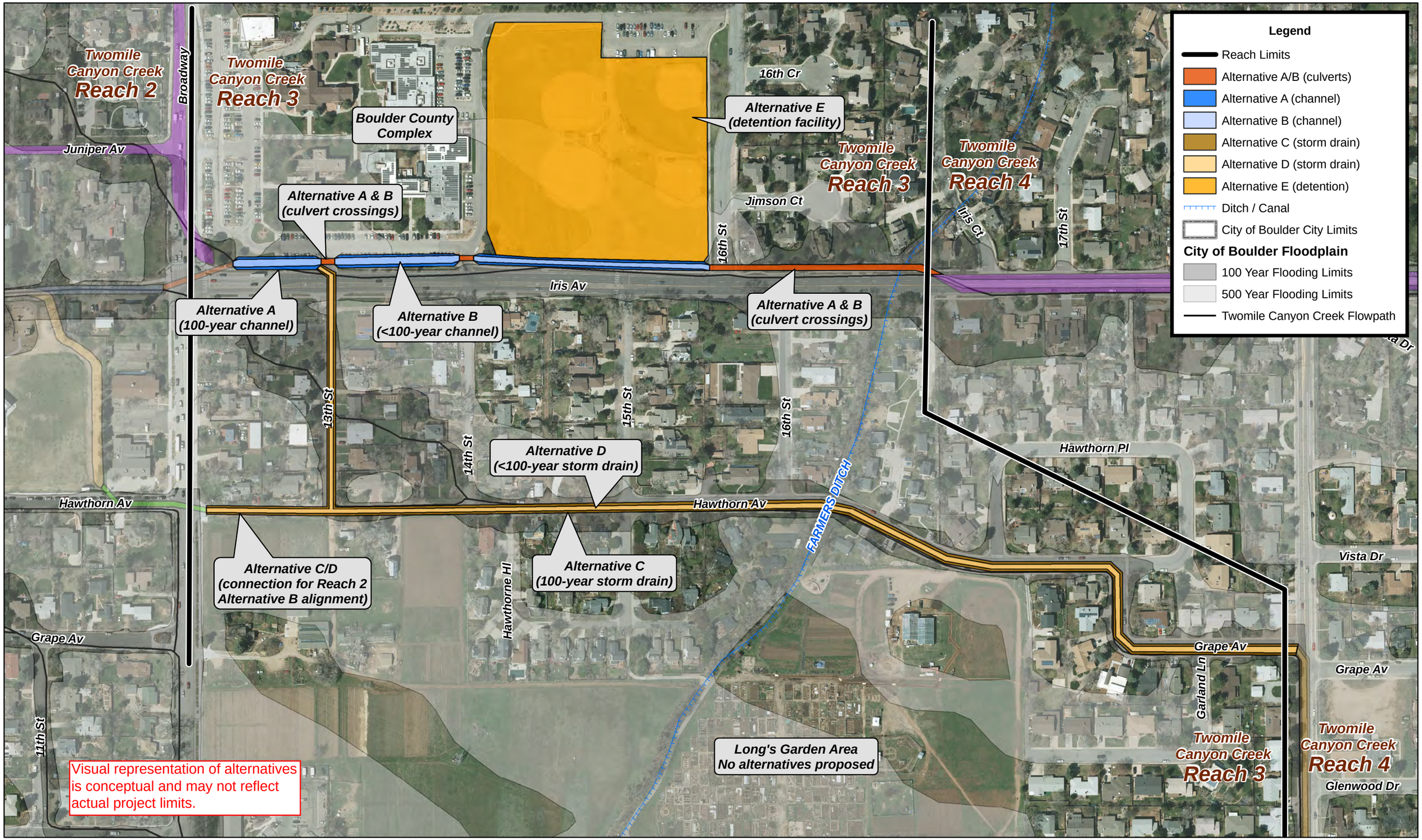
Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 3: Twomile Canyon Creek - Reach 2



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Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 4: Twomile Canyon Creek - Reach 3

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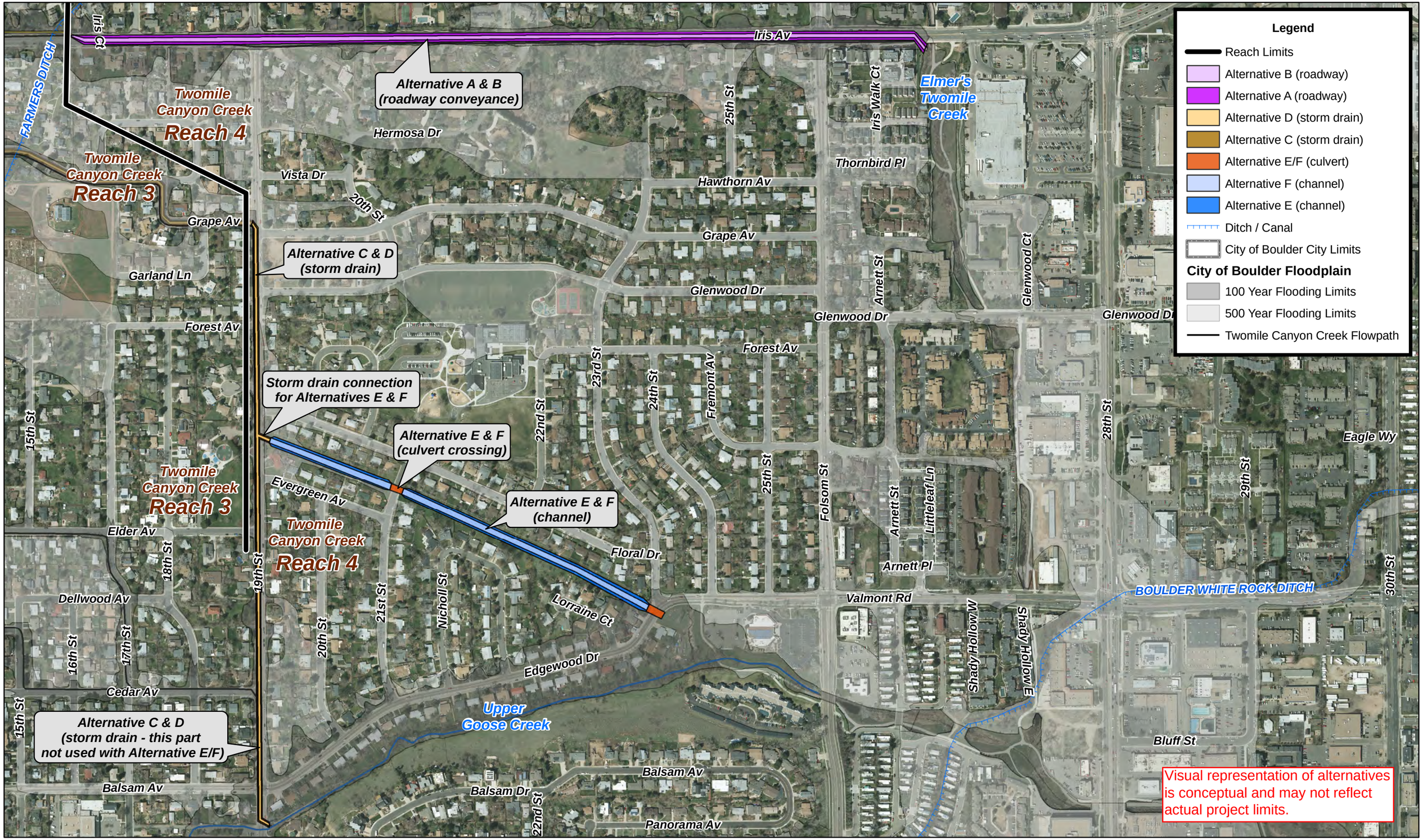

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Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 5: Twomile Canyon Creek - Reach 4

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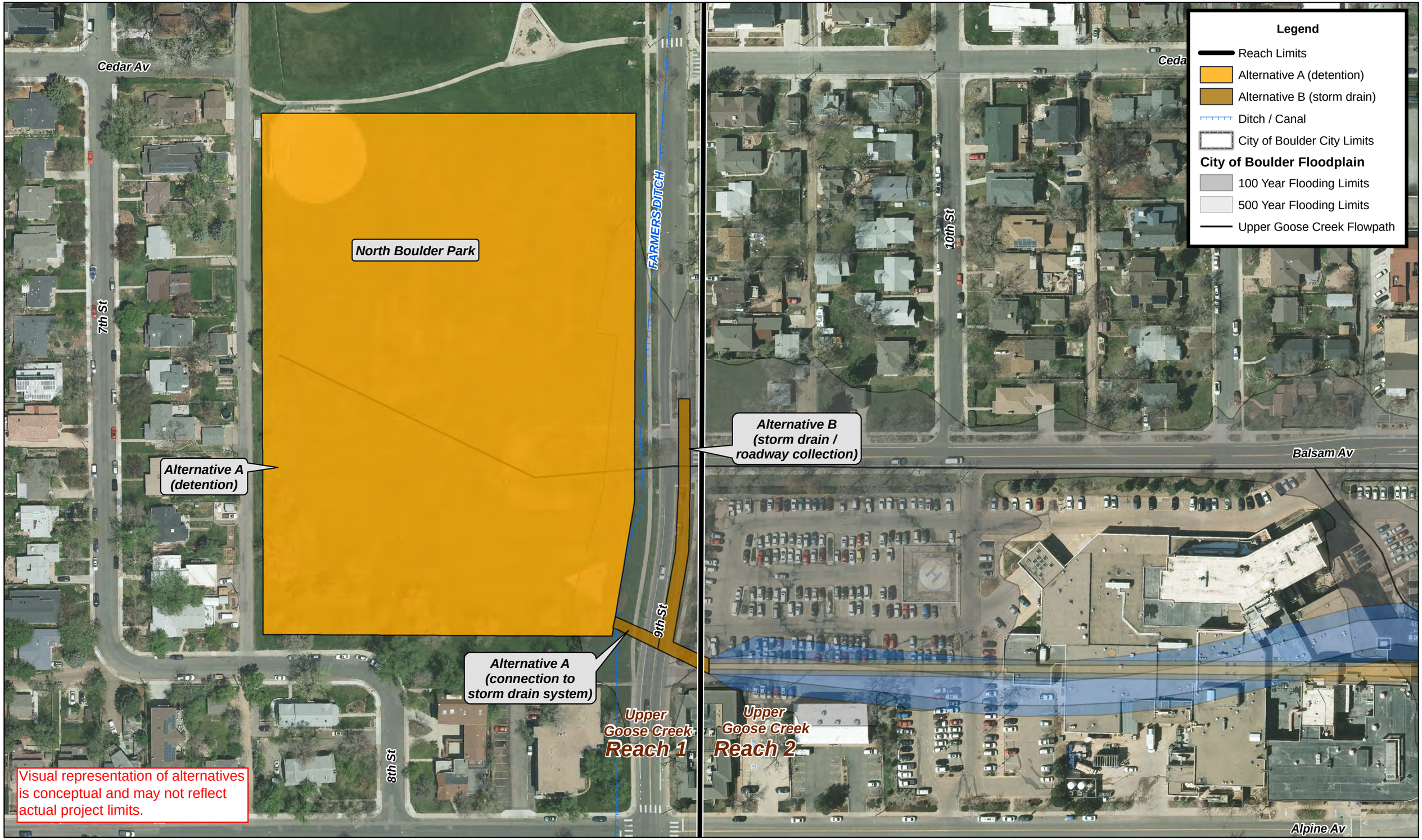

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Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 6: Upper Goose Creek - Reach 1

N

100 Feet

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Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 7: Upper Goose Creek - Reach 2

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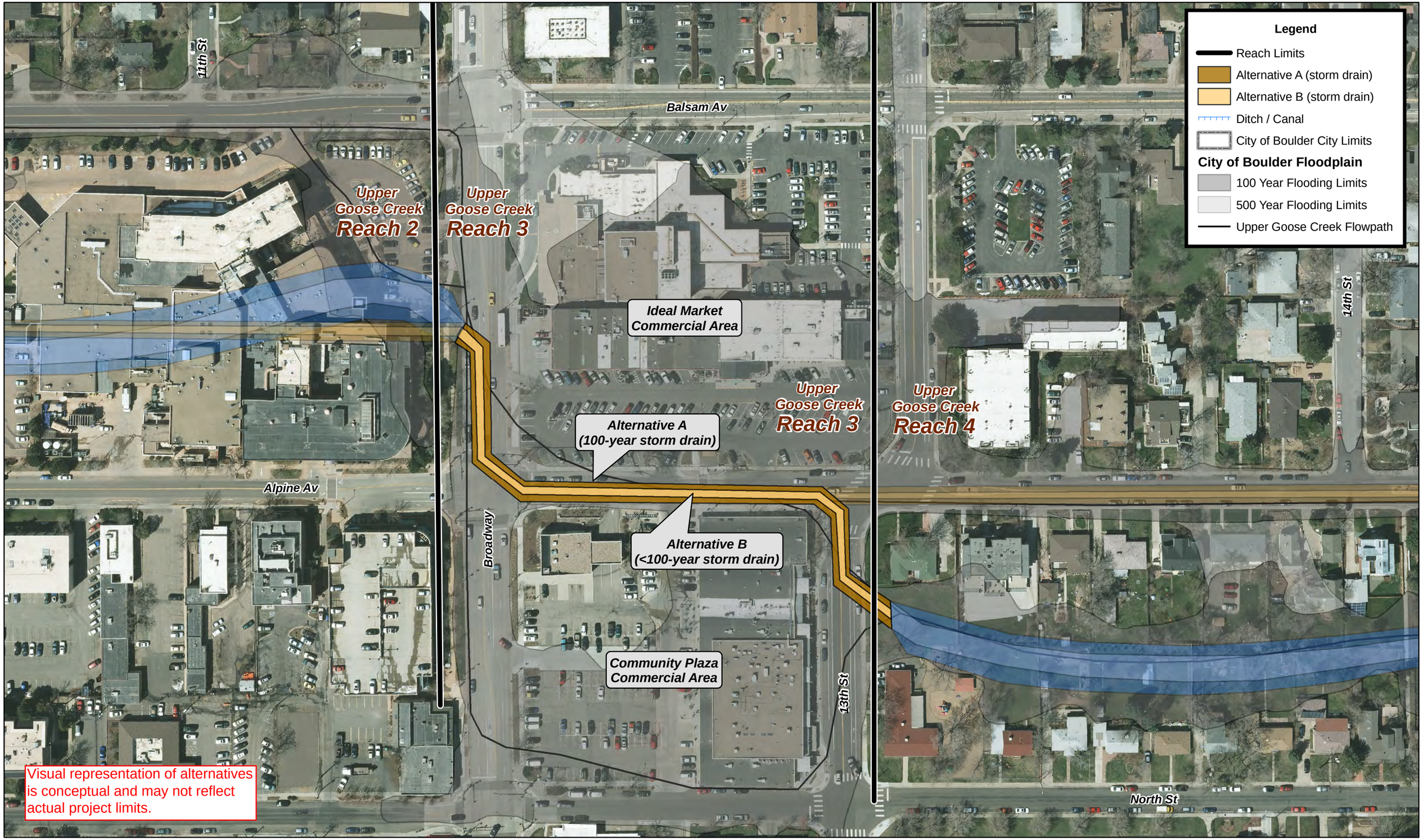

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Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 8: Upper Goose Creek - Reach 3

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100 Feet

ICON ENGINEERING, INC.

Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 9: Upper Goose Creek - Reach 4

N
150 Feet

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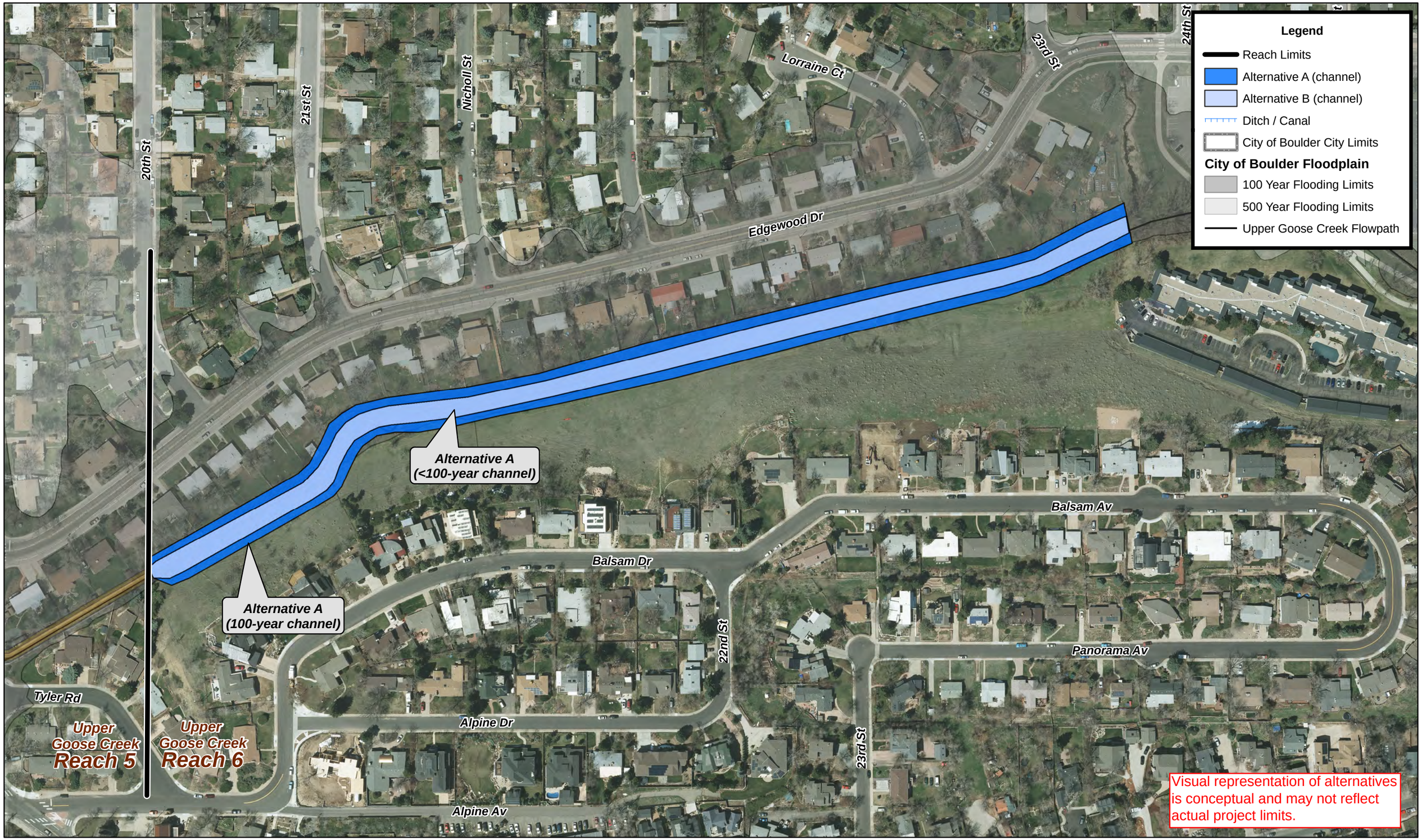
Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 10: Upper Goose Creek - Reach 5

N
150 Feet



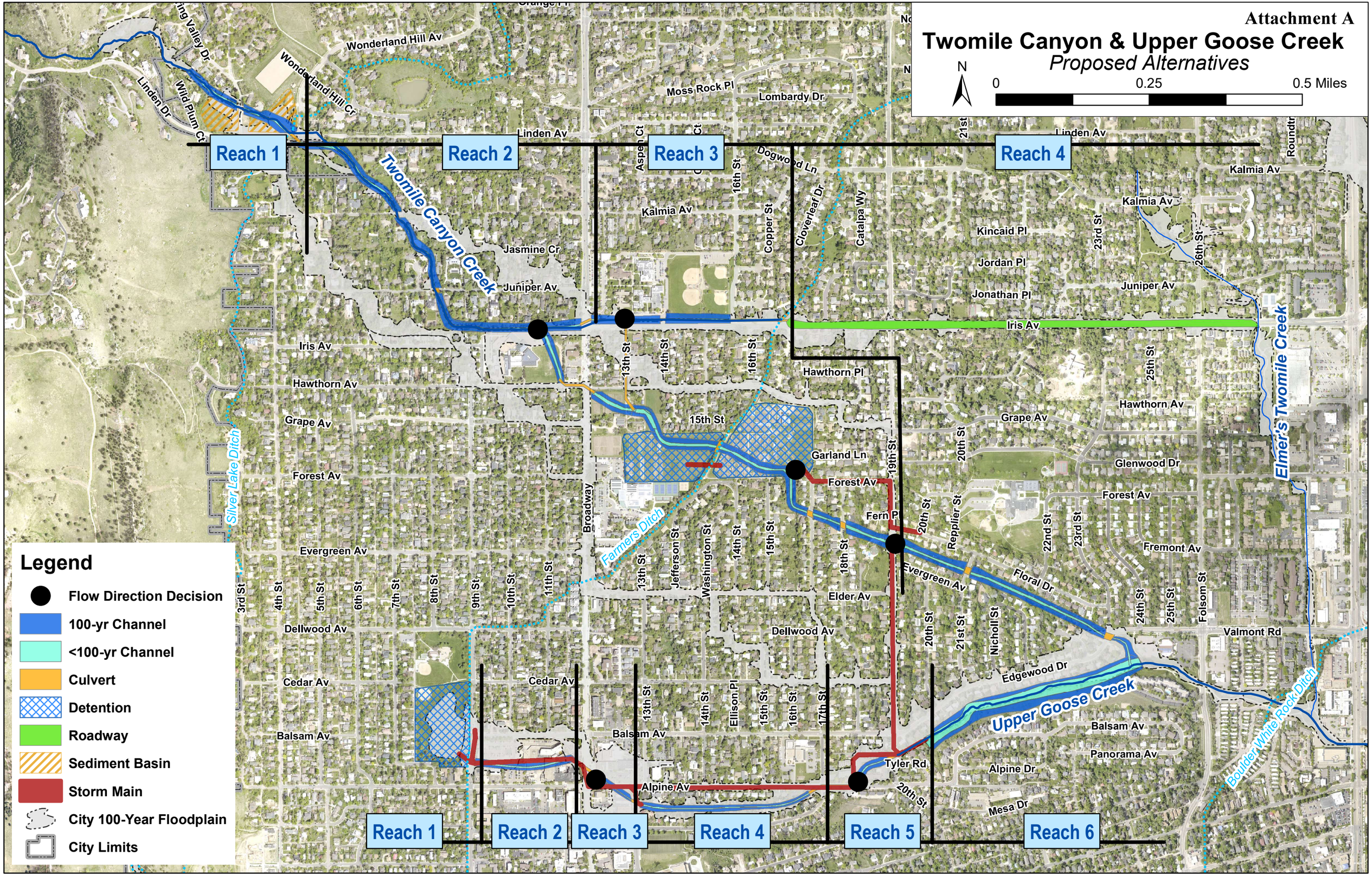
ICON ENGINEERING, INC.

Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure 11: Upper Goose Creek - Reach 6

N

150 Feet

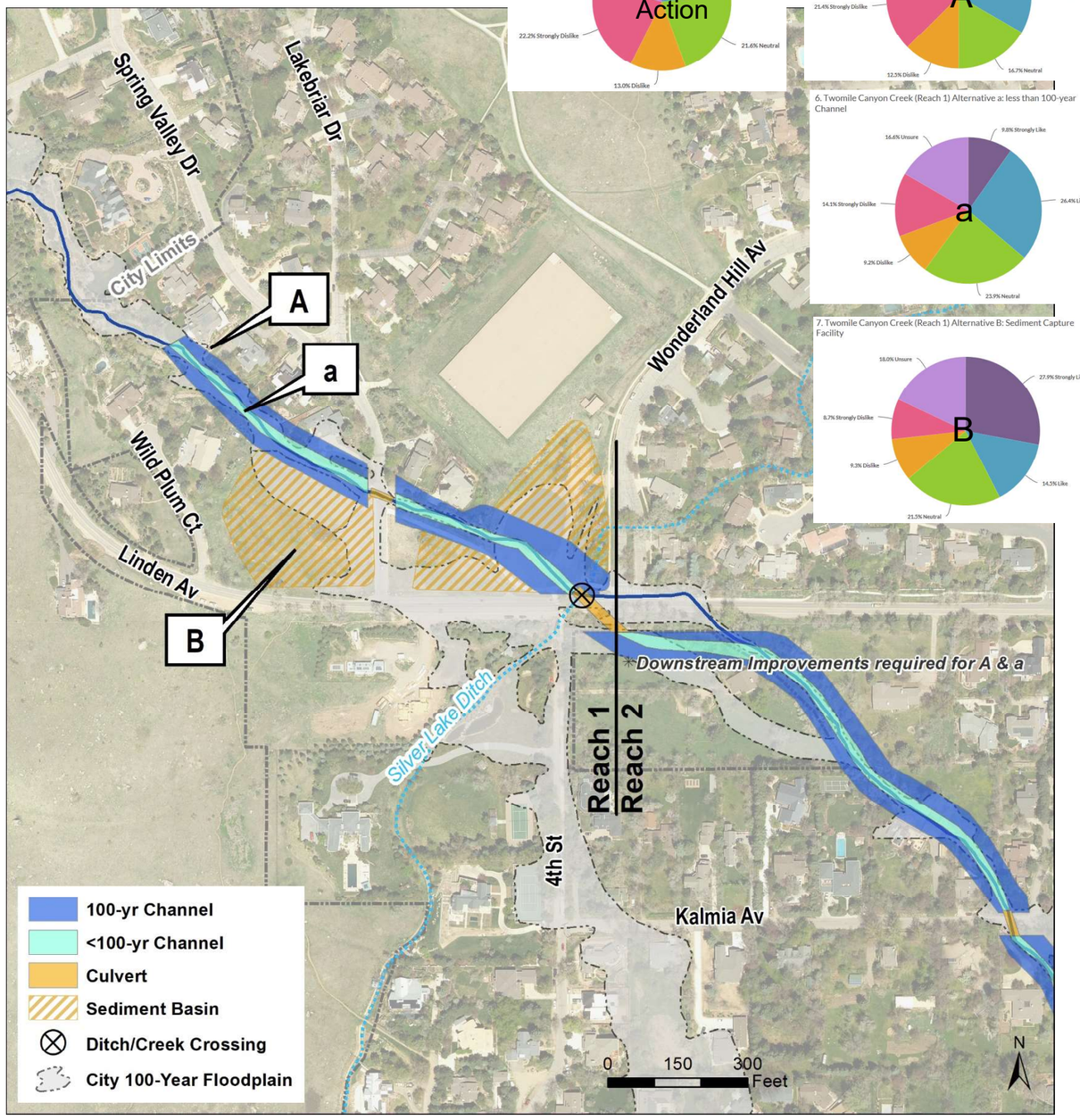
Appendix A: WRAB Figures (from March 19th, 2018 meeting)

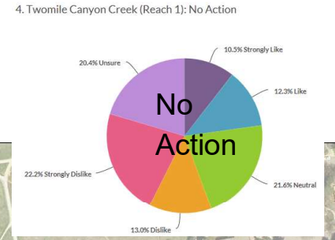

Attachment A
Twomile Canyon & Upper Goose Creek
Proposed Alternatives
N
0
0.25
0.5 Miles
Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Twomile Canyon Creek
Upper Goose Creek
Elmer's Twomile Creek
Silver Lake Ditch
Farmers Ditch
Boulder White Rock Ditch
Wonderland Hill Av
Wonderland Hill Cr
Linden Dr
Wild Plum Ct
Moss Rock Pl
Lombardy Dr
Linden Av
Aspen Ct
16th St
Dogwood Ln
Cloverleaf Dr
Catalpa Wy
Kalmia Av
Copper St
Jasmine Cr
Juniper Av
Kincaid Pl
Jordan Pl
Jonathan Pl
23rd St
26th St
Roundtr
Iris Av
Hawthorn Av
Grape Av
13th St
14th St
15th St
Hawthorn Pl
Garland Ln
Forest Av
Fern Pl
19th St
20th St
Reppler St
25th St
Glenwood Dr
Fremont Av
22nd St
23rd St
Evergreen Av
Floral Dr
Elder Av
Dellwood Av
Broadway
Jefferson St
Washington St
18th St
21st St
Nicholl St
24th St
Folsom St
Valmont Rd
Edgewood Dr
Cedar Av
Ellison Pl
17th St
Balsam Av
Panorama Av
Alpine Dr
Tyler Rd
Alpine Av
Mesa Dr
3rd St
4th St
5th St
6th St
7th St
8th St
9th St
10th St
11th St
Legend
Flow Direction Decision
100-yr Channel
<100-yr Channel
Culvert
Detention
Roadway
Sediment Basin
Storm Main
City 100-Year Floodplain
City Limits

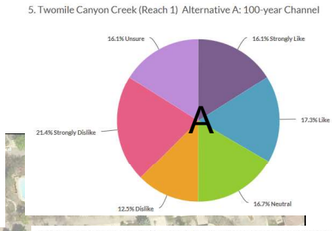
Attachment B

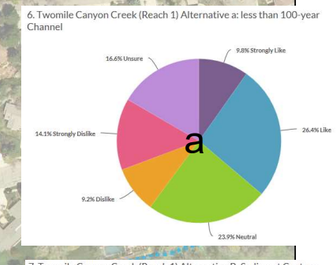
Twomile Canyon Creek

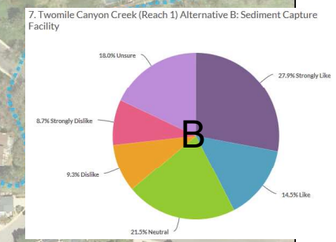
Reach 1: Wild Plum Ct to Linden Av





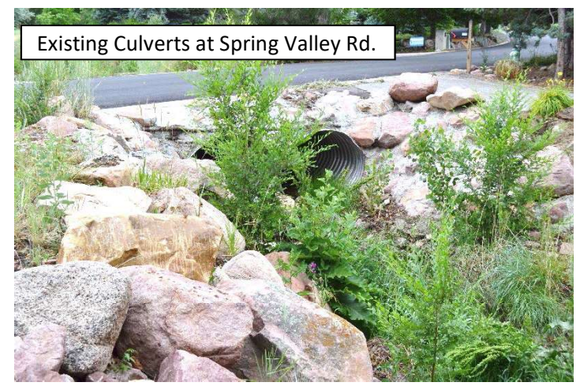






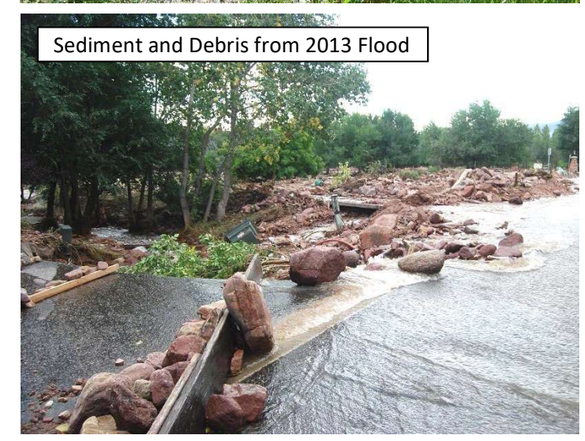
Information about the Alternatives

Alt	Description	Cost	Benefits	Issues
A	100-year open channel improvements; new culverts at Spring Valley Dr. and Linden Av	$2.5M	• Eliminates 100-year spill flows • Eliminates overtopping of roadways during 100-year storm	• May require mature tree removal • Does not address sediment capture • Extensive property impacts • Requires downstream improvements
a	<100-year open channel (smaller version of Alt A)	$1.6M	• Similar to Alt A • Reduced cost and property impacts	• Similar to Alt A • Does not contain 100-year flood
B	Enlarge existing sediment capture facility	$1.0M	• Reduces sedimentation impact downstream • Existing City ownership of facility footprint • Can be constructed independent of other improvements	• Change in natural sediment transport • May require mature tree removal • Embankment may impact viewscape • Impacts Open Space Mountain Parks land • No significant reduction in flood risk


Existing Culverts at Spring Valley Rd.

Example Culvert Improvement

Existing Sediment Capture Facility


Sediment and Debris from 2013 Flood

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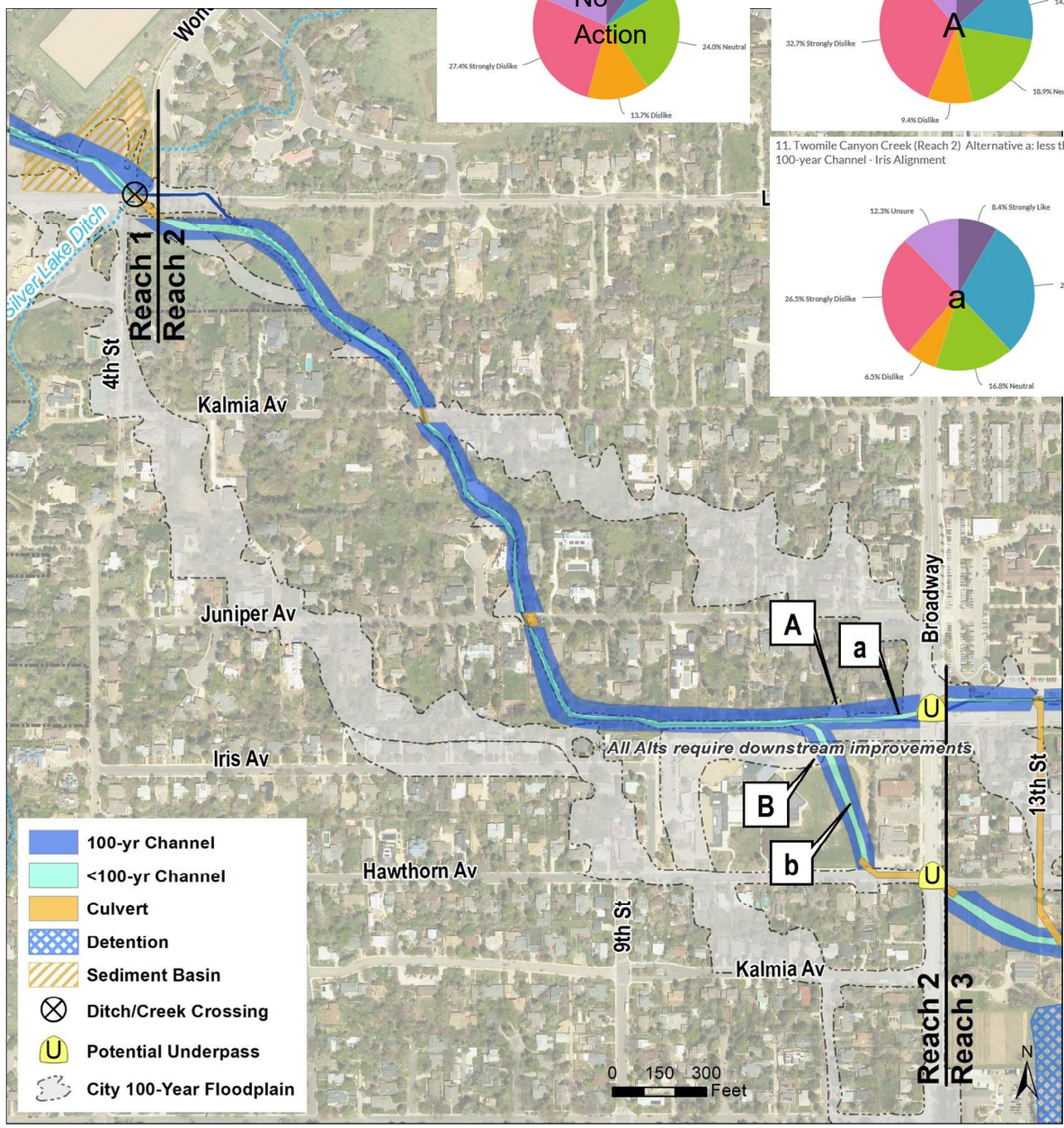
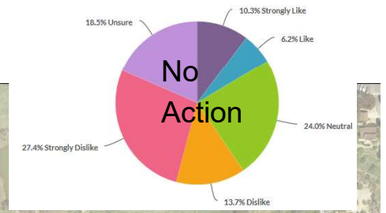
Twomile Canyon Creek

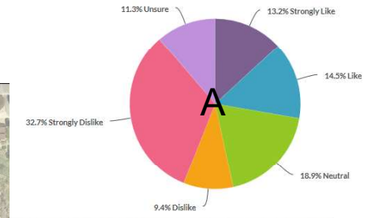
Reach 2: Linden Av to Broadway



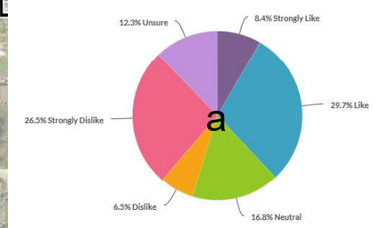
9. Twomile Canyon Creek (Reach 2): No Action



10. Twomile Canyon Creek (Reach 2) Alternative A: 100-year Channel - Iris Alignment



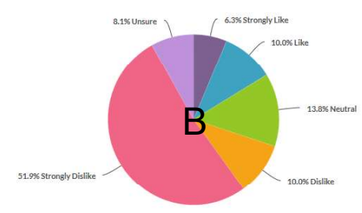
11. Twomile Canyon Creek (Reach 2) Alternative a: less than 100-year Channel - Iris Alignment



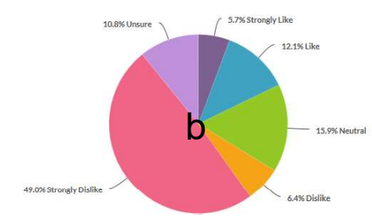
Information about the Alternatives

Alt	Description	Cost	Benefits	Issues
A	100-year open channel improvements; new culverts at Kalmia Av, Juniper Av, and Broadway; channel to Broadway and Iris	$27M	• Reduces spill flows • Reduces overtopping of roadways • Follows existing channel alignment • Opportunity for underpass at Broadway	• Requires structure acquisition • Extensive property impacts • Requires Iris or 13th St alternatives • Requires downstream improvements
a	<100-year open channel (smaller version of Alt A)	$10M	• Similar to Alt A • Reduced cost and property impacts	• Similar to Alt A • Does not contain 100-year flood
B	100-year open channel improvements; new culverts at Kalmia Av, Juniper Av, Broadway; channel to Broadway and Hawthorn	$32M	• Reduces spill flow • Reduces overtopping of roadways • More efficient connection to downstream channel • Opportunity for underpass at Broadway	• Not as feasible for Broadway underpass • Requires structure acquisition • Extensive property impacts • Requires downstream improvements
b	<100-year open channel (smaller version of Alt B)	$14M	• Similar to Alt B • Reduced cost and property impacts	• Similar to Alt B • Does not contain 100-year flood

12. Twomile Canyon Creek (Reach 2) Alternative B: 100-year Channel - Hawthorn Alignment



13. Twomile Canyon Creek (Reach 2) Alternative b: less than 100-year Channel - Hawthorn Alignment



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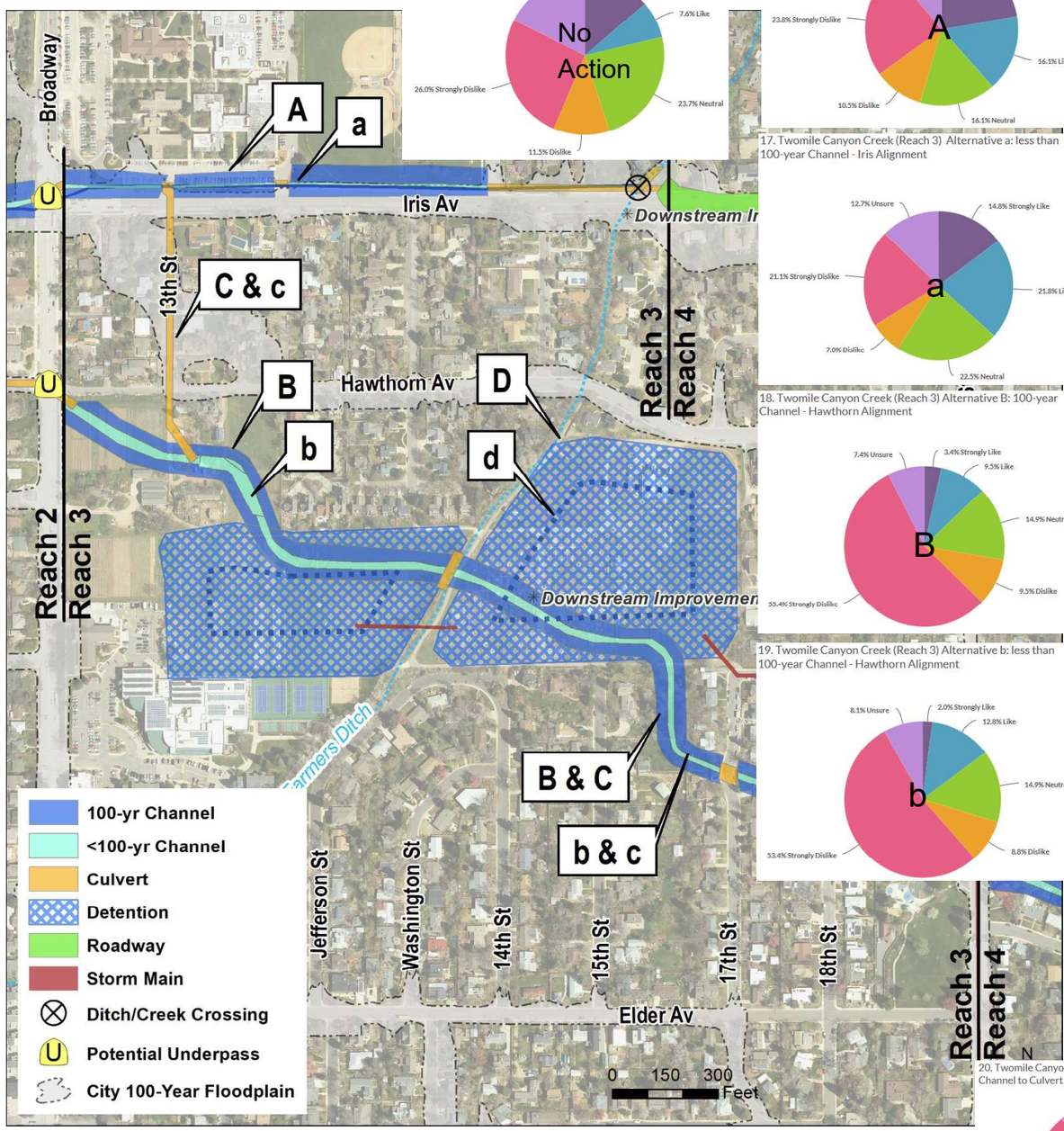
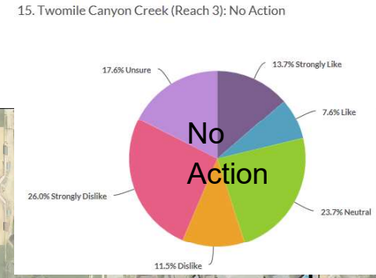
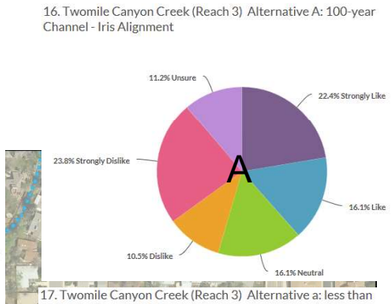
Twomile Canyon Creek

Reach 3: Broadway to 19th St







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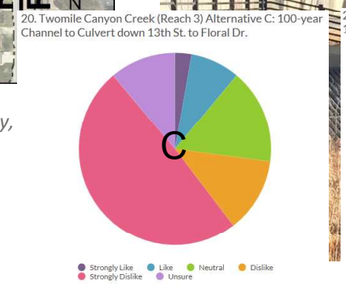
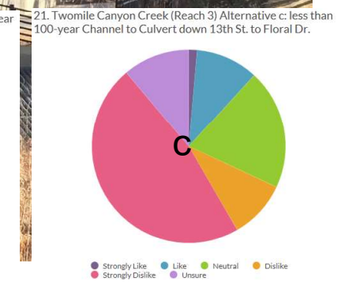
Information about the Alternatives

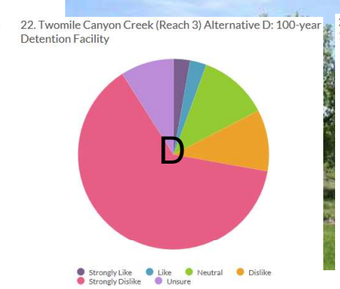
Alt	Description	Cost	Benefits	Issues
A	100-year open channel improvements; new culverts at 13th, 14th and from 16th St through Farmer's Ditch; Iris Av Roadway Improvements for surface flow	$8.4M	• Conveys flood flows to Elmer's Twomile Creek • Less property impacts and acquisition than southern alignments	• Major impact to Iris Av • Requires downstream improvements
a	<100-year open channel (smaller version of Alt A)	$5.7M	• Similar to Alt A • Reduced cost and property impacts	• Similar to Alt A • Does not contain 100-year flood
B	100-year open channel improvements; new culverts at Farmer's Ditch, 17th, 18th and 19th St	$9.5M	• Utilizes southern alignments	• Significant property impacts • Requires downstream improvements
b	<100-year open channel (smaller version of Alt B)	$3.3M	• Similar to Alt B • Reduced cost and property impacts	• Similar to Alt B • Does not contain 100-year flood
C	100-year open channel improvements; new culvert south on 13th St, Farmer's Ditch, 17th, 18th and 19th St	$9.0M	• Utilizes southern alignments • Provides for local drainage along 13th St	• Significant property impacts • Requires downstream improvements
c	<100-year open channel (smaller version of Alt C)	$4.9M	• Similar to Alt C • Reduced cost and property impacts	• Similar to Alt C • Does not contain 100-year flood
D	100-year detention facility; new culvert south on 13th St; outfall to existing storm drain system	$44M	• Reduces downstream discharges • Reduces sedimentation impact downstream • Ability to retain existing use of gardens or re-purpose area • Can be constructed independent from other improvements	• Significant property impacts • May require removal of mature trees • Embankment may impact viewscape
d	<100-year detention facility (smaller version of Alt D)	$35M	• Similar to Alt D • Reduced cost and property impacts	• Similar to Alt D • Does not detain the full 100-year flood

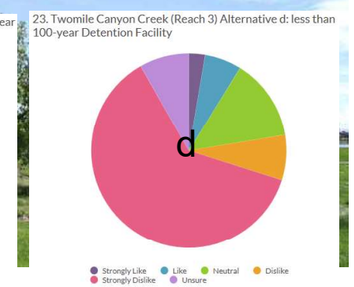
Example Culvert





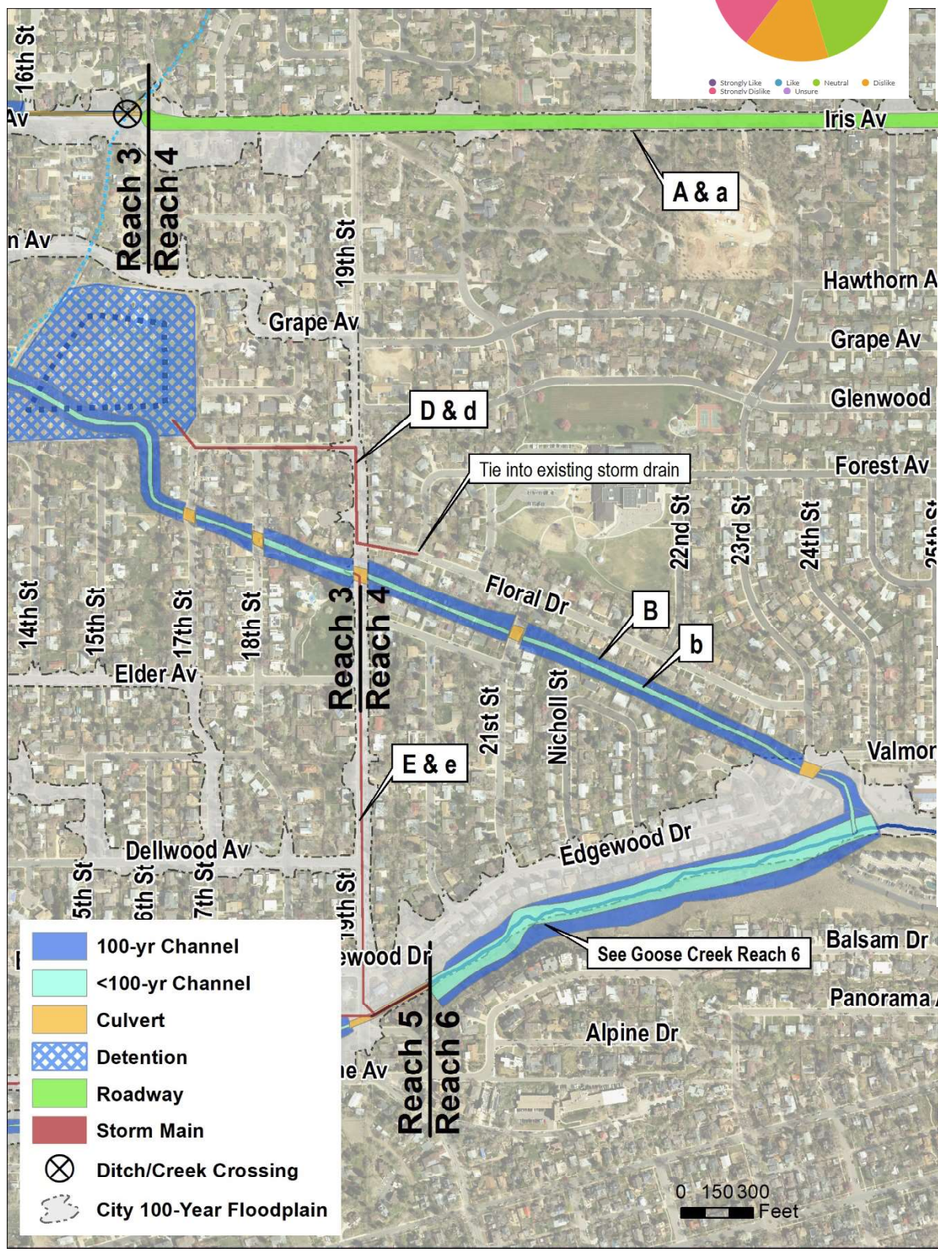
Example Detention Facility





Twomile Canyon Creek

Reach 4: 19th St to 24th St



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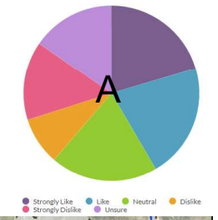
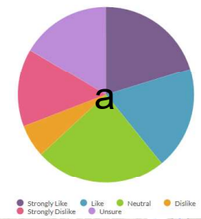
25. Twomile Canyon Creek (Reach 4): No Action

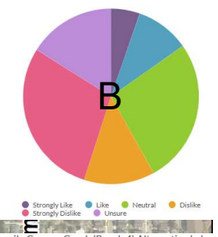
26. Twomile Canyon Creek (Reach 4) Alternative A: Iris Ave. Roadway Improvements (100-year)



27. Twomile Canyon Creek (Reach 4) Alternative a: Iris Ave. Roadway Improvements (less than 100-year)

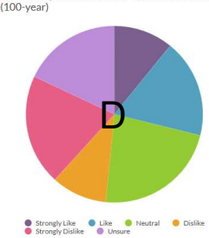


28. Twomile Canyon Creek (Reach 4) Alternative B: 100-year Channel

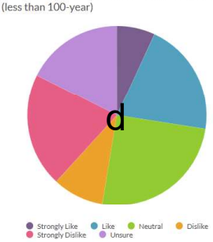


29. Twomile Canyon Creek (Reach 4) Alternative b: less than 100-year Channel

30. Twomile Canyon Creek (Reach 4) Alternative D: Storm Drain (100-year)



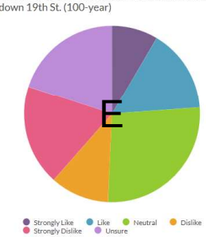
31. Twomile Canyon Creek (Reach 4) Alternative d: Storm Drain (less than 100-year)



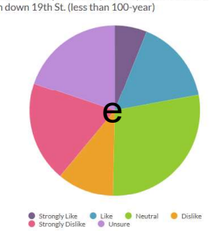
Information about the Alternatives

Alt	Description	Cost	Benefits	Issues
A	Iris Av roadway improvements for surface flow	$3.1M	• Conveys flood flows to Elmer's Twomile • Less property acquisition than southern alignments	• Major impact to Iris Av • Life safety and emergency access concerns with street flooding
a	<100-year roadway improvements (smaller version of Alt A)	$1.6M	• Similar to Alt A • Reduced cost and property impacts	• Similar to Alt A • Does not contain 100-year flood
B	100-year open channel improvements; new culverts at 21st St and Edgewood Dr.	$2.8M	• Provides open channel connectivity to Goose Creek • May reduce groundwater issues in local area	• Significant property impacts • May require mature tree removal • Places channel in backyards
b	<100-year open channel (smaller version of Alt B)	$2.0M	• Similar to Alt B • Reduced cost and property impacts	• Similar to Alt B • Does not contain 100-year flood
D	Storm drain outfall system (detained flow)	$0.5M	• Utilizes existing storm drain infrastructure • Does not require open channel construction	• Relies on existing infrastructure • Susceptible to clogging
d	<100-year storm system (smaller version of Alt D)	$0.3M	• Similar to Alt D • Reduced cost and property impacts	• Similar to Alt D • Does not contain 100-year flood
E	Storm drain outfall system (full flow)	$3.0M	• Utilizes the 19th St Right-of-Way • Does not require open channel construction	• Does not remove Twomile Canyon Creek discharge from Goose Creek between 19th and historical confluence • Susceptible to clogging
e	<100-year storm system (smaller version of Alt E)	$2.0M	• Similar to Alt E • Reduced cost and property impacts	• Similar to Alt E • Does not contain 100-year flood

32. Twomile Canyon Creek (Reach 4) Alternative E: Storm Drain down 19th St. (100-year)

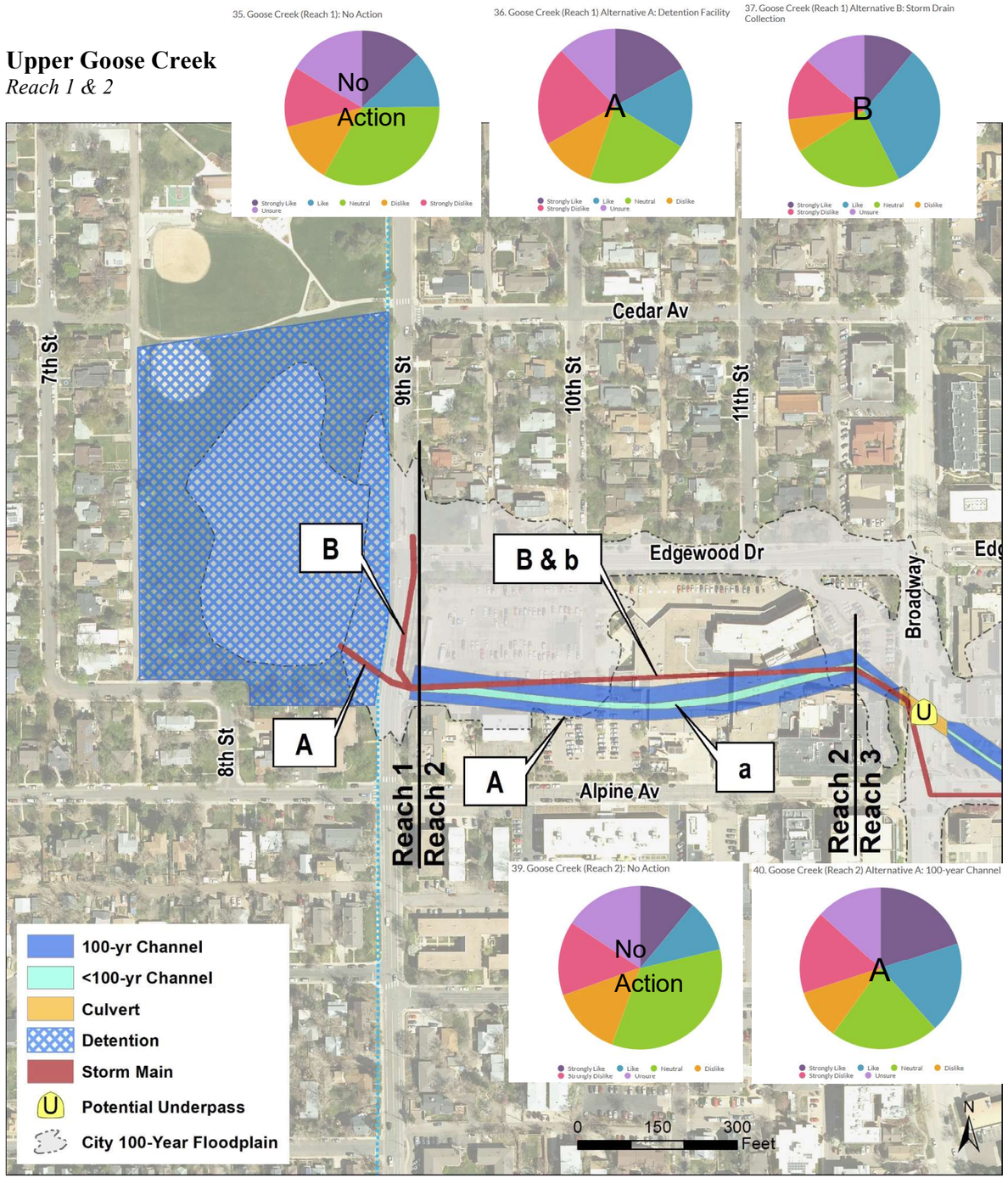


33. Twomile Canyon Creek (Reach 4) Alternative e: Storm Drain down 19th St. (less than 100-year)



Upper Goose Creek

Reach 1 & 2



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Information about the Alternatives

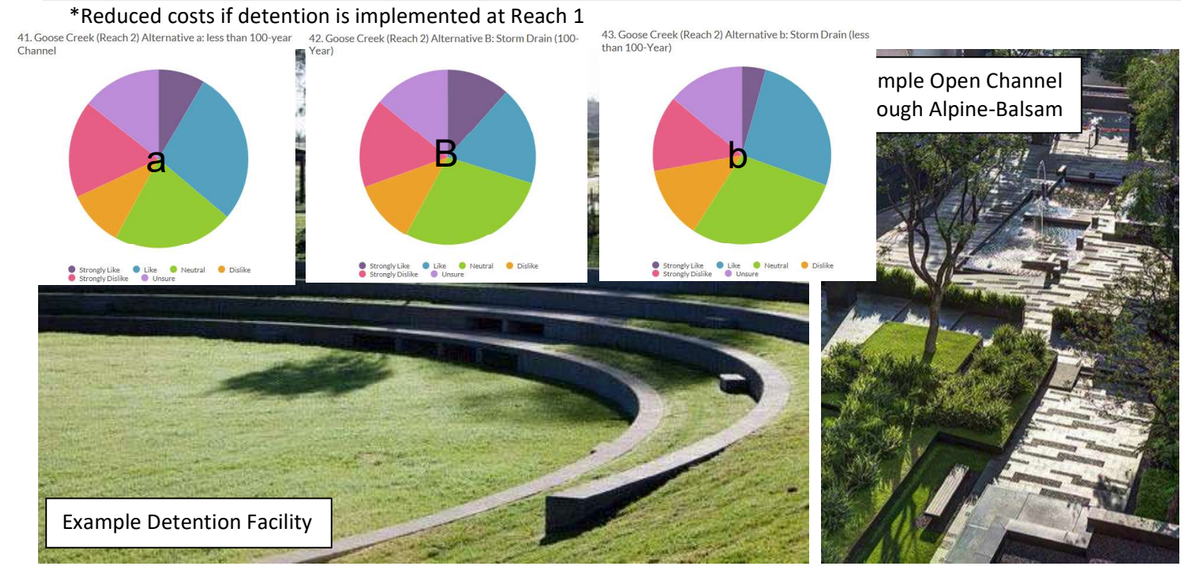
Reach 1: North Boulder Park to 9th St

Alt	Description	Cost	Benefits	Issues
A	Detention facility within North Boulder Park; new 9th St culvert.	$3.0M	• Reduces downstream flows • Reduces overtopping of 9th St • Retain or re-purpose park uses	• Impact to existing park uses • May require mature tree removal • Embankment may impact viewscape
B	No detention; Storm drainage collection to deliver flows to Alpine-Balsam site	$0.5M	• Provides flooding protection for the Alpine-Balsam site • Does not impact North Boulder Park • Reduces flooding on Balsam St	• No reduction in discharges • Concentrates discharges onto the Alpine-Balsam site • May require roadway reconfiguration

Reach 2: 9th St to Broadway

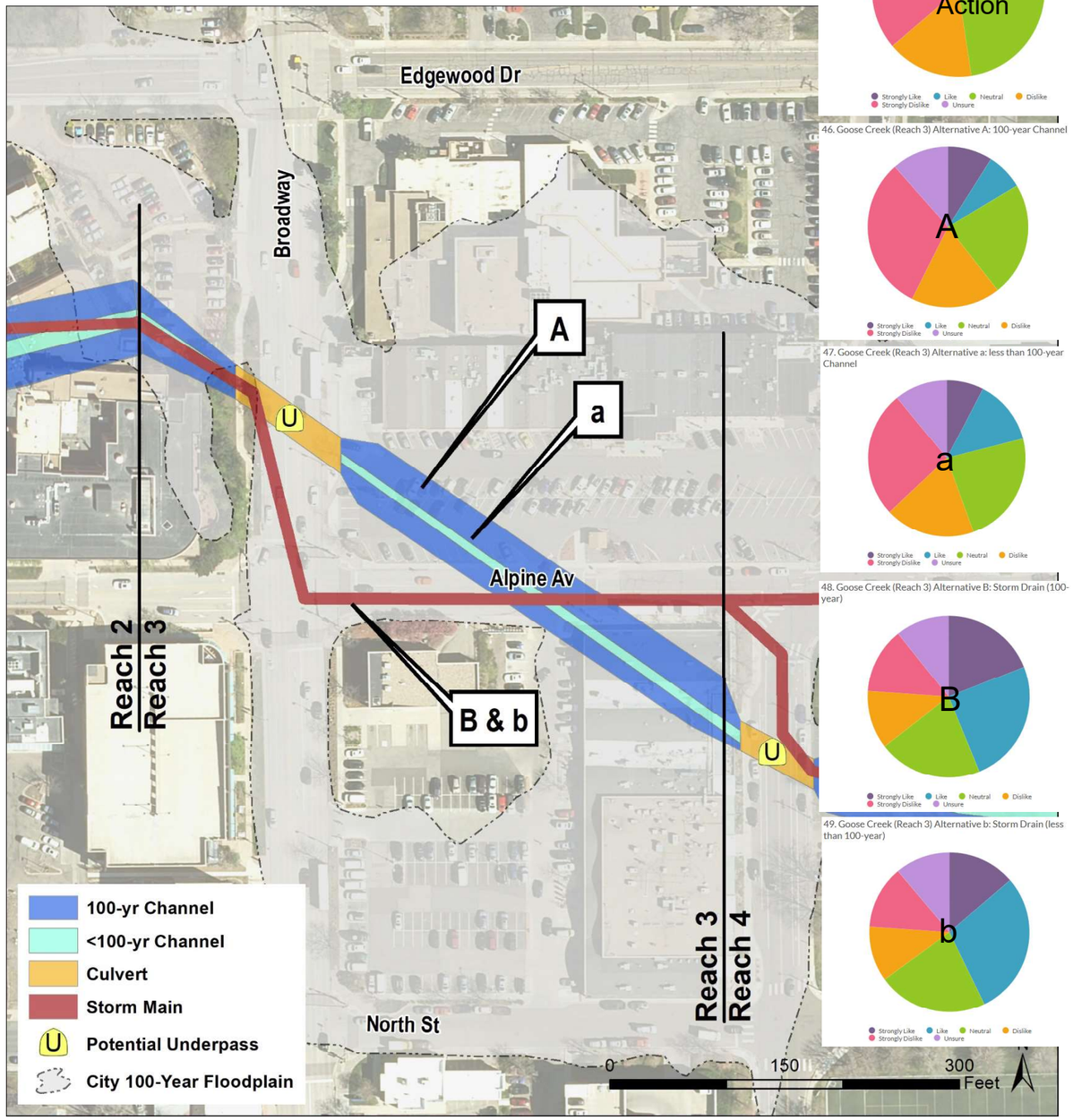
Alt	Description	Cost	Benefits	Issues
A	100-year open channel	$0.5M	• Provides additional open channel habitat • Green infrastructure • Aligns with the Alpine-Balsam Vision Plan	• Final configuration of Alpine-Balsam site unknown • Could require more room than piped system
a	<100-year open channel (smaller version of Alt A)	$0.3M	• Similar to Alt A • Reduced cost and property impacts	• Similar to Alt A • Does not contain 100-year flood
B	100-year storm system	$0.6M $0.2M*	• Could require less room than open channel	• Final configuration of Alpine-Balsam site unknown • Susceptible to clogging
b	<100-year storm system (smaller version of Alt B)	$0.4M	• Similar to Alt B • Reduced cost and property impacts	• Similar to Alt B • Does not contain 100-year flood

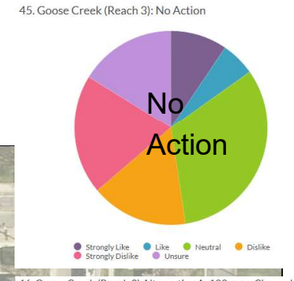
*Reduced costs if detention is implemented at Reach 1



Upper Goose Creek

Reach 3: Broadway to 13th St





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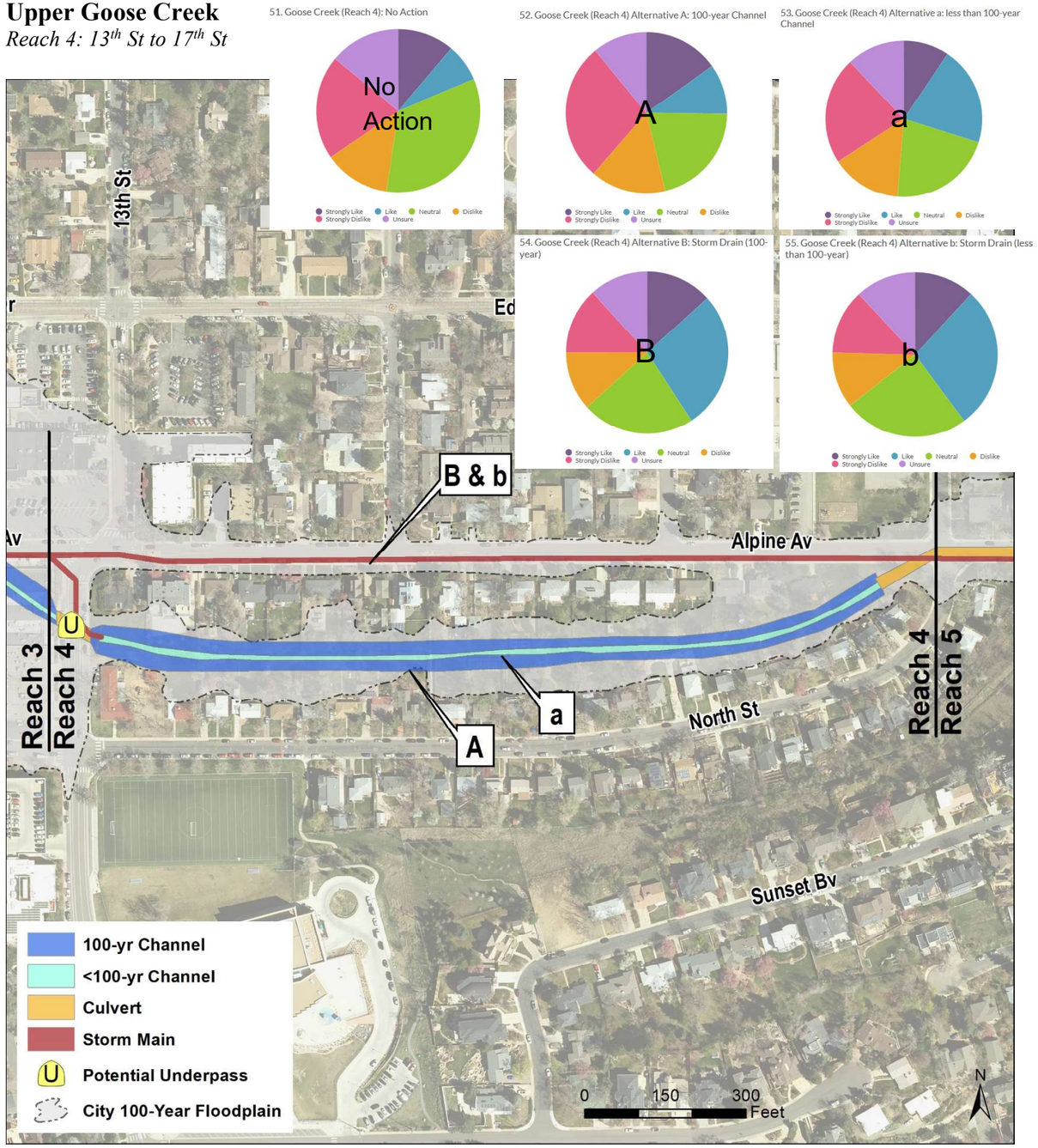
Information about the Alternatives

Alt	Description	Cost	Benefits	Issues
A	100-year open channel	$1.8M $1.3M*	• Provides additional open channel habitat • Green infrastructure • Opportunity for underpasses	• Extensive property impacts • Disruptive to existing businesses
a	<100-year open channel (smaller version of Alt A)	$0.8M	• Similar to Alt A • Reduced cost and property impacts	• Similar to Alt A • Does not contain 100-year flood
B	100-year storm drain system	$1.2M $1.0M*	• Utilizes existing Right-of-Way • Does not require property acquisition • Provides local drainage along Broadway and Alpine Av	• Construction disruption to busy business corridor • Susceptible to clogging
b	<100-year storm system (smaller version of Alt B)	$0.9M $0.8M*	• Similar to Alt B • Reduced cost and property impacts	• Similar to Alt B • Does not contain 100-year flood

*Reduced costs if detention is implemented at Reach 1

Upper Goose Creek

Reach 4: 13th St to 17th St



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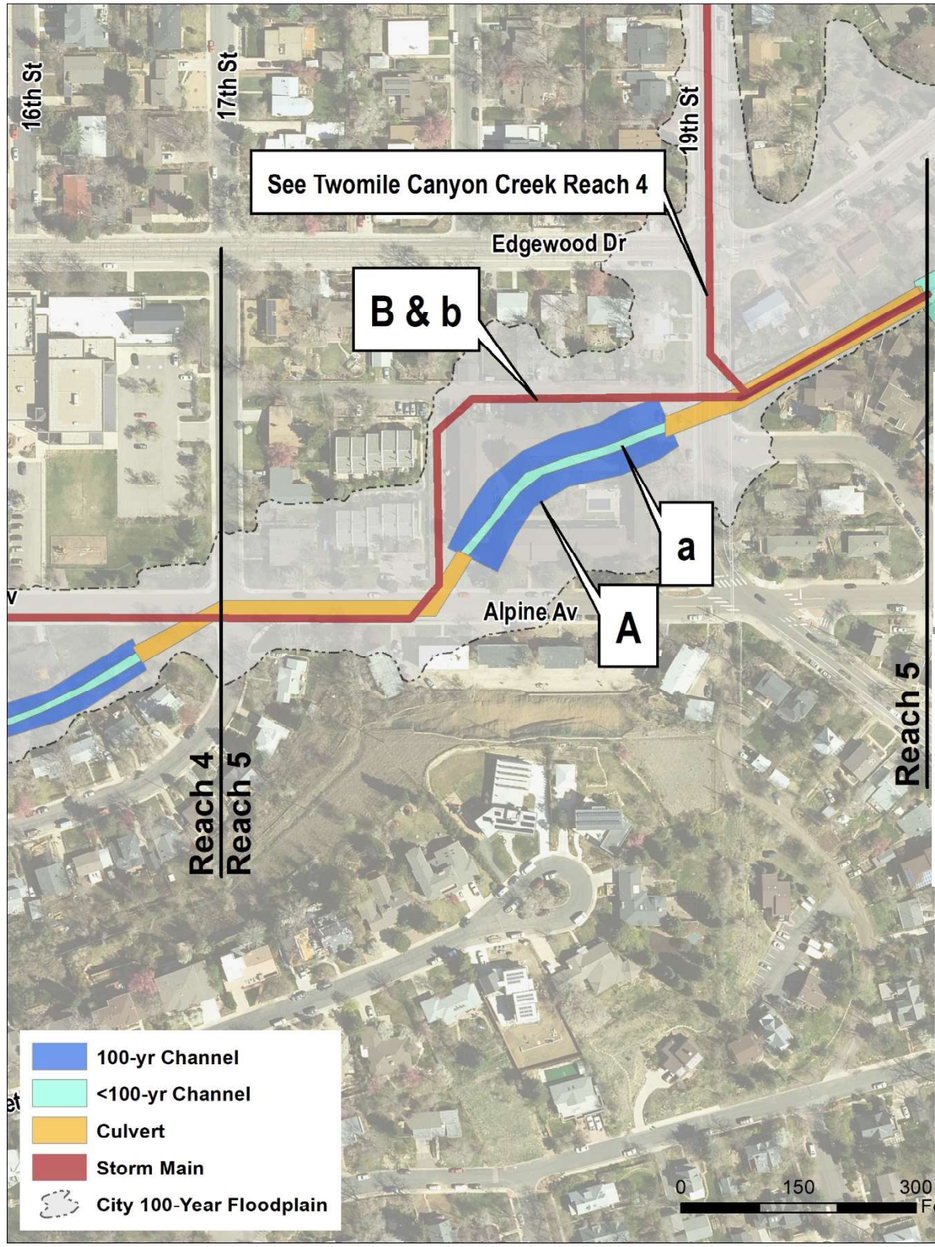
Information about the Alternatives

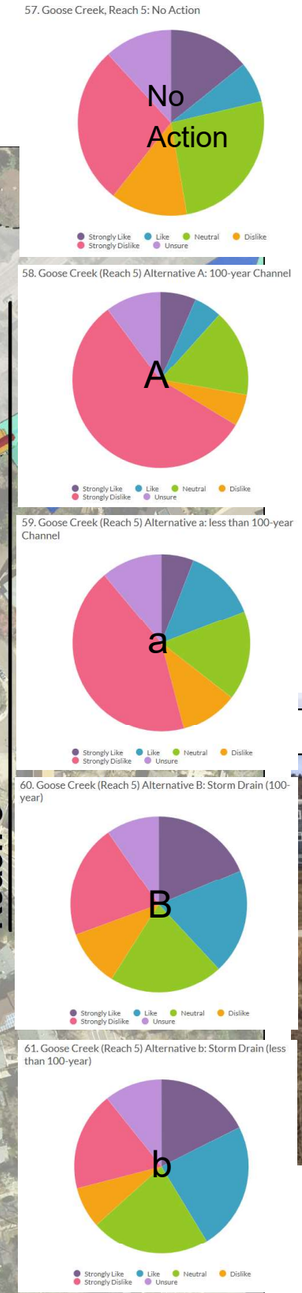
Alt	Description	Cost	Benefits	Issues
A	100-year open channel	$2.4M	• Provides additional open channel habitat • Enhances existing drainage path • Green infrastructure	• Extensive property impacts • Disruptive to residential back-yards
a	<100-year open channel (smaller version of Alt A)	$1.2M	• Similar to Alt A • Reduced cost and property impacts	• Similar to Alt A • Does not contain 100-year flood
B	100-year storm drain system	$3.1M $2.9M*	• Utilizes existing Right-of-Way • Does not require property acquisition • Provides local drainage along Alpine Av	• Does not address overland flow in existing flow path • Susceptible to clogging
b	<100-year storm drain system (smaller version of Alt B)	$2.0M $1.9M*	• Similar to Alt B • Reduced cost and property impacts	• Similar to Alt B • Does not contain 100-year flood

*Reduced costs if detention is implemented at Reach 1

Upper Goose Creek

Reach 5: 17th St to 20th St





Information about the Alternatives

Alt	Description	Cost	Benefits	Issues
A	100-year open channel	$26M	• Provides additional open channel habitat • Green infrastructure • Removes high hazard structures from floodplain	• Requires Alpine Condo acquisition • Reduces residential units within City
a	<100-year improvements (smaller version of Alt A)	$2.9M	• Similar to Alt C • Reduced cost and property impacts	• Similar to Alt C • Does not contain 100-year flood
B	100-year storm drain system	$2.2M $2.0M*	• Utilizes some existing Right-of-Way • Does not require Alpine Condos removal • Provides local drainage adjacent to Alpine Condos	• Requires drainage easement acquisition • Disruptive to Alpine Condo property (construction) • Susceptible to clogging
b	<100-year improvements (smaller version of Alt B)	$1.6M $1.5M*	• Similar to Alt B • Reduced cost and property impacts	• Similar to Alt B • Does not contain 100-year flood

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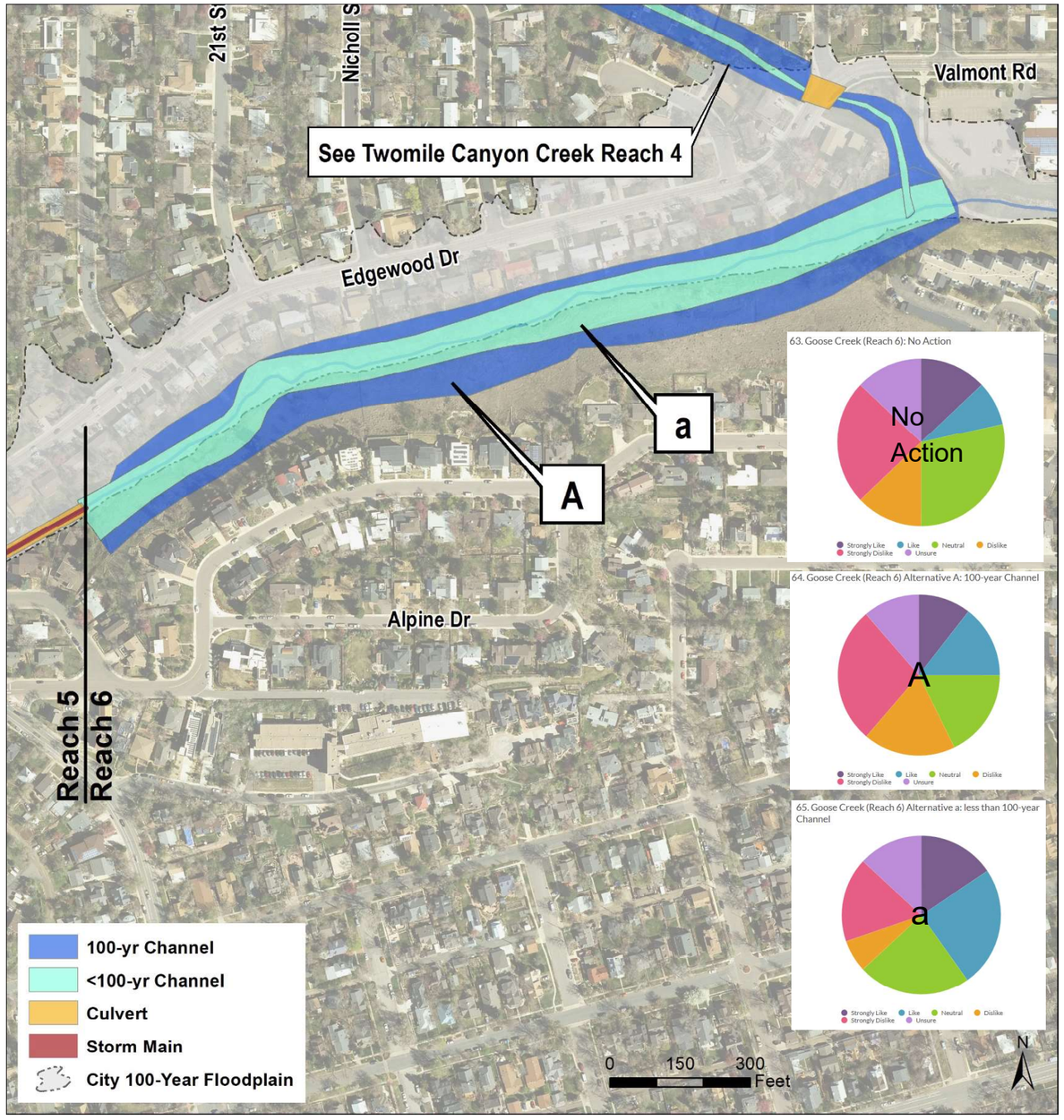
Upper Goose Creek

Reach 6: 17th St to 24th St



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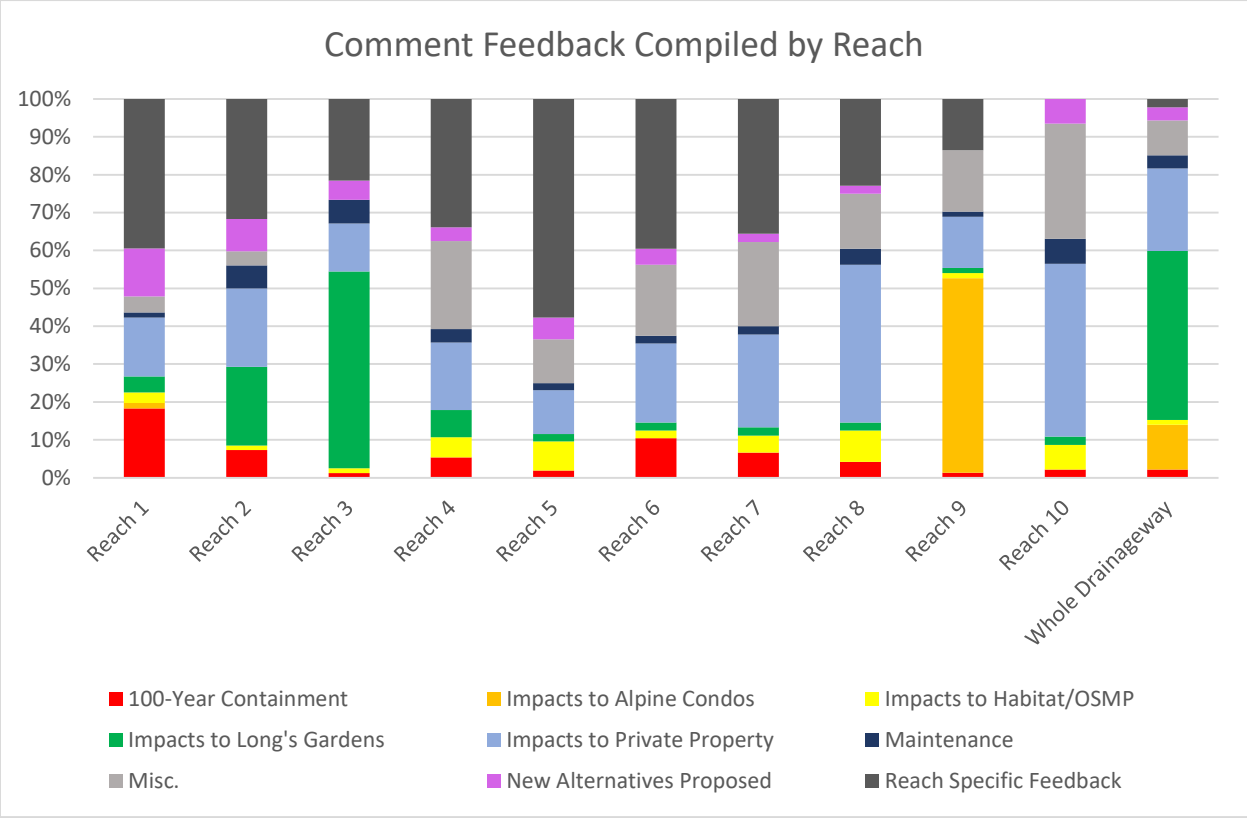
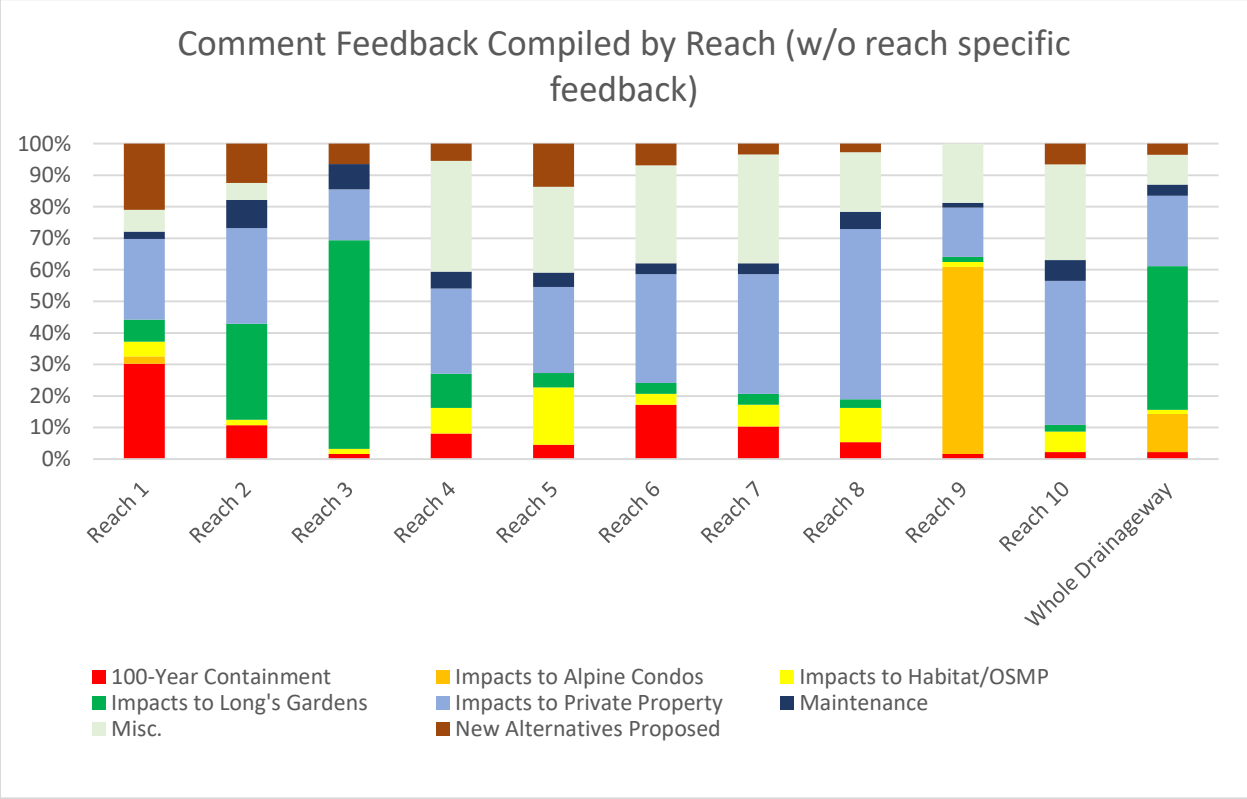
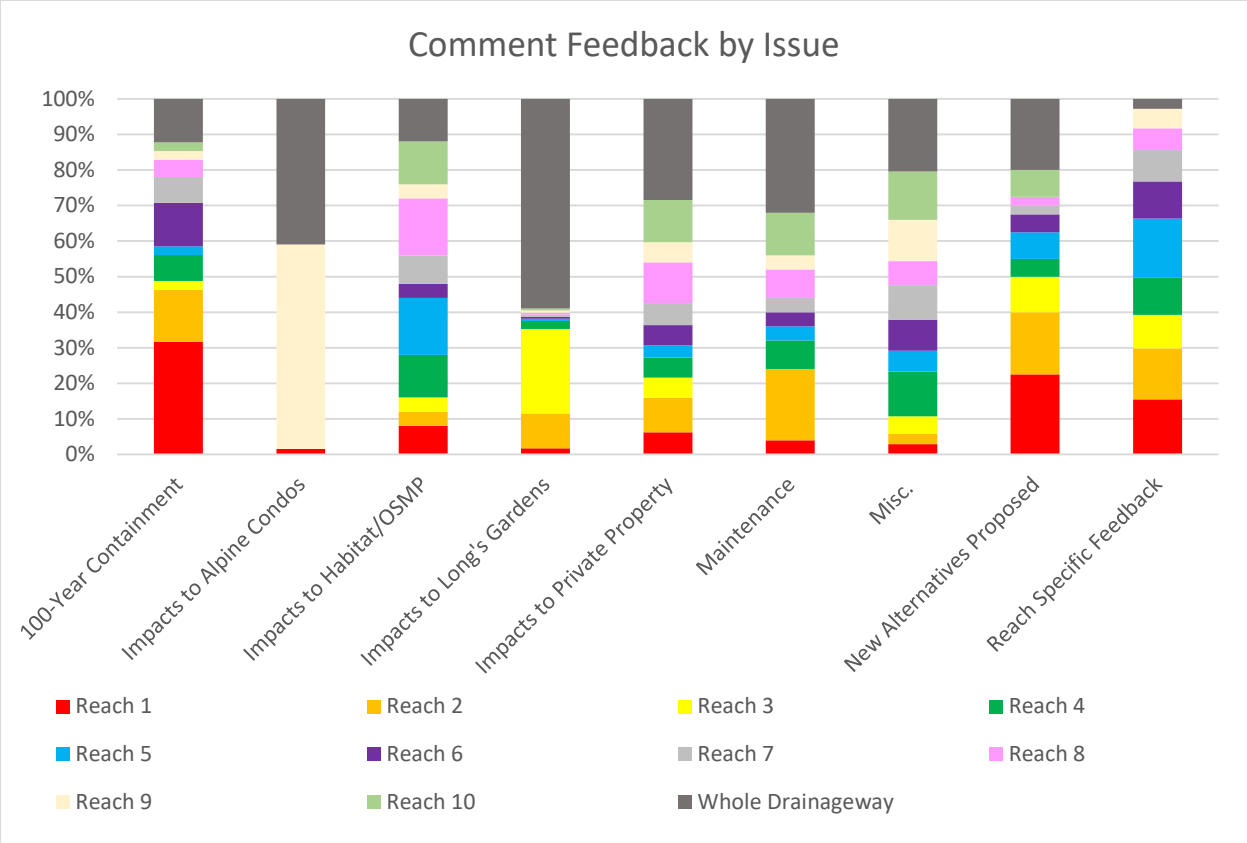
Information about the Alternatives

Alt	Description	Cost	Benefits	Issues
A	100-year open channel	$12M	• Provides additional open channel habitat • Enhances existing drainage path • Green infrastructure	• Extensive property impacts • Disruptive to residential back-yards • Requires tall retaining walls on south bank
a	<100-year channel (sizing per previous study recommending a "5-year" improvement; exceeds 5-year with detained flow and/or Twomile improvements)	$5.7M	• Similar to Alt A • Reduced cost and property impacts	• Similar to Alt A • Does not contain 100-year flow

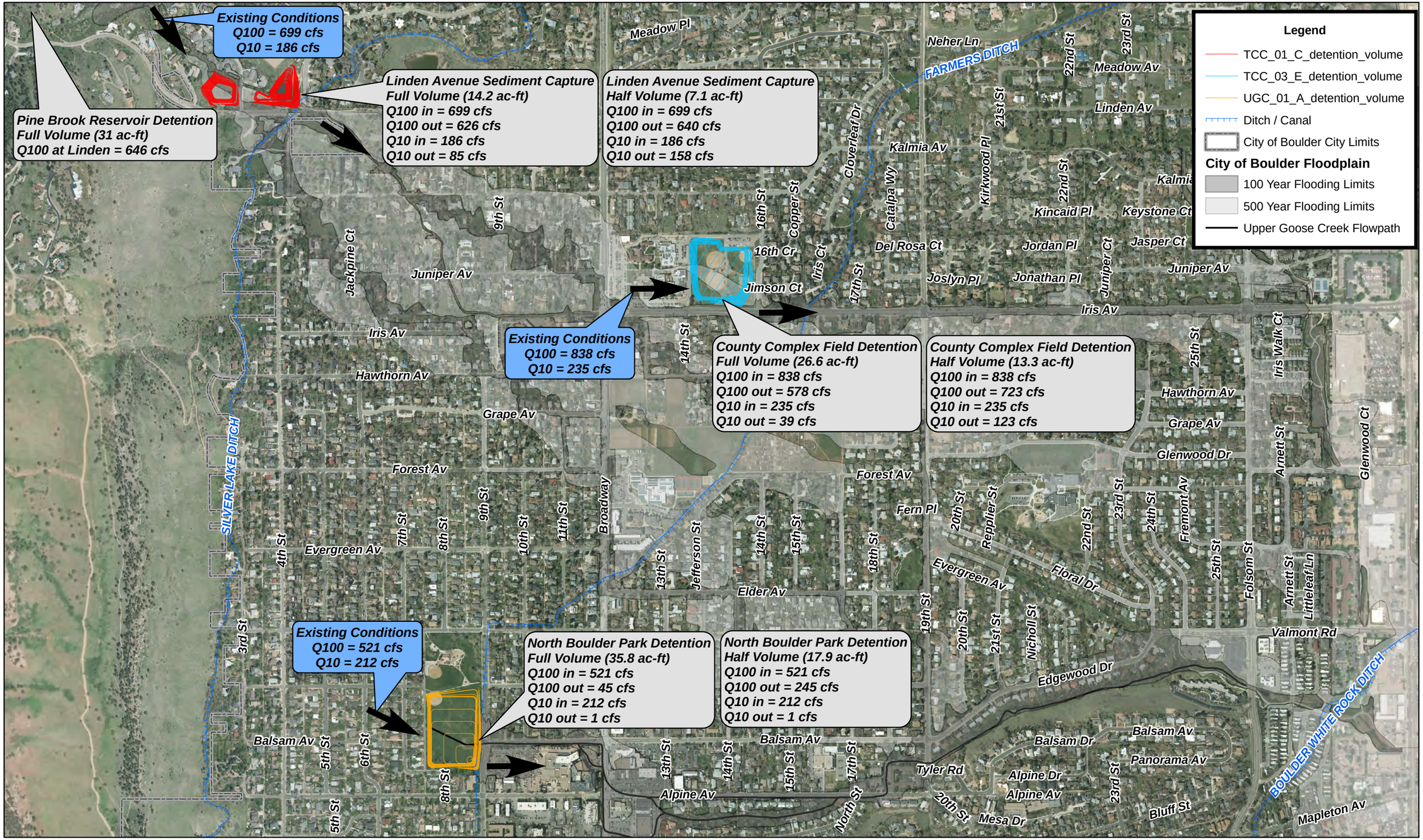
Feedback from the March 19th, 2018 public open house:






Comment Feedback by Issue
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
100-Year Containment
Impacts to Alpine Condos
Impacts to Habitat/OSMP
Impacts to Long's Gardens
Impacts to Private Property
Maintenance
Misc.
New Alternatives Proposed
Reach Specific Feedback
Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Reach 7
Reach 8
Reach 9
Reach 10
Whole Drainageway

Appendix B: Detention Alternatives Figure



ICON ENGINEERING, INC.

Upper Goose Creek and Twomile Canyon Creek - Flood Mitigation Plan
Alternative Selection Memorandum
Figure B1: Upper Goose Creek and Twomile Canyon Creek - Detention

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700 Feet