Conceptual Design Memorandum

PREPARED FOR:	City of Boulder
COPY TO:	Urban Drainage and Flood Control District
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The purpose of this Conceptual Design Memorandum for the *Gregory Canyon Creek Major Drainageway Plan* (Study) is to document design criteria and hydraulic results for the City of Boulder's (City's) Recommended Plan that was presented to and approved by the City's Water Resources Advisory Board (WRAB) on April 27, 2015.

Design Criteria

The design of the conceptual alternative was based on the criteria contained in the Urban Drainage and Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual* (USDCM), the *City of Boulder Design and Construction Standards*, and as directed by the City where applicable. Gregory Canyon Creek is designated as a major drainageway by the City of Boulder and, due to right-of-way constraints, was classified as a Lined Artificial Channel as defined by City criterion. Relevant criteria are shown in **Table 1**.

Table 1. Criteria for Sizing Storm Drainage Facilities

	Author	Criteria
Culvert Crossing	City of Boulder	Assume culverts are 20 percent blocked with debris during storm events. Convey the 10-year storm capacity with no roadway overtopping. Minimum culvert velocity of 2 feet per second (fps).
Channel Improvements	City of Boulder	Convey the 10-year storm event without adverse impacts to existing structures. Channels to include a reinforced channel bottom consisting of soil riprap and grouted boulder drops. Channel banks will be protected with boulder walls and soil riprap. Velocities of 7 fps or less with a Froude number of 0.8 or less for unlined artificial drainageways, unless greater velocities given under existing conditions. Manning's N values represent unmaintained channel conditions for capacity. 1-foot minimum depth of freeboard.
	UDFCD	Manning's N values for lined or built-up channels, minimum 0.03 for velocity calculations / maximum 0.04 for freeboard capacity. Minimum 2.5:1 reinforced side slopes. Maximum height of 3 feet for boulder drop structures. Less than 1% slope for reinforced channels. Unless additional analysis is complete.
	Natural Resources Conservation Service	Allowable shear stress for 36-inch boulders - 9.3 lb/sq ft. Allowable shear stress for Type M Riprap - 4.7 lb/sq ft; vegetated coir mat - 6 lb/sq ft.
Inlets	City of Boulder	Type R inlets are permitted on all street types for continuous grade.

As part of the conceptual design process, project stakeholders were consulted to refine the design criteria based on the constraints in the basin that would impact the conceptual design, as identified in the following list.

- Due to the horizontal constraints to private structures and property, reinforced vertical, 1H: 1V or 2H: 1V side slopes were considered appropriate for design to minimize impacts to structures and property. Freeboard may be less than 1 foot.
- Steeper channel slopes are permissible with technical documentation supporting the design slope.
- For soil riprap-lined channels, Froude number and velocities can be increased due to the greater resistance of the bed material to erosion.
- Structural improvements, such as boulder walls, were preferred over impacting adjacent properties.
- Drop structures may be closely spaced together to achieve the 1.5 percent stable slope.
- A 10-foot maintenance access will be identified where feasible. The access is intended to be a natural surface to blend into the existing landscaping. No hardened surfaces are being proposed. Routes to access the channel will be identified but will need to be formalized, including discussions with property owners during design. The access is necessary for UDFCD to maintain the improvements through their useful life.

Plan Development Overview

The U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Centers River Analysis System (HEC-RAS) hydraulic model completed as part of the Alternative Analysis in March 2015 was updated with the improvements presented to and approved by WRAB on April 27, 2015. The conceptual improvements adhered to the design criteria outlined in **Table 1** and are further described in the subsequent sections. Design was based on City of Boulder 2013 LiDAR contours; in areas where survey data were available from the development of the effective model, the existing profile was updated to reflect the survey information. These areas are documented in **Appendix A**.

Changes from City's Recommended Plan

The City's Recommended Plan was modified per residential comments and site limitations. The culvert improvements at Willowbrook Court and Willowbrook Road were omitted. At Willowbrook Road, low-priority inlet and storm sewer improvements are suggested. The inlets would be designed for the 63-cubic-feet-per-second (cfs) flow that would overtop Willowbrook Road during a 10-year storm event. UD-INLET® was used to determine the inlets necessary along Willowbrook Road to capture the flow that will result in the undersized culvert during the 10-year storm event. It was determined that 30 linear feet of Type R inlets would be necessary to capture the 63 cfs. These low-priority improvements are not included in the benefit-cost ratio.

The City of Boulder included two inline sediment traps in the City's Recommended Plan to help remove sediment from Gregory Canyon Creek during storm events. The traps are located near 637 Pennsylvania Avenue and upstream of Willowbrook Road. A third sediment trap was to be located near Smith Park per the City's Recommended Plan. During conceptual design, the channel improvements at Smith Park were eliminated due to feasibility. As a result, the sediment trap at this location was omitted from the conceptual design. Street improvements were identified in the City's Recommended Plan to convey spill from Gregory Canyon Creek in larger storm events. The conceptual design focused on culvert and channel improvements only, and no other analysis of street improvements will be performed as part of this Master Plan. All other elements identified in the City's Recommended Plan for culvert and channel improvements are included in the conceptual design.

Channel Improvements

Channel improvements downstream of University Avenue were incorporated into the HEC-RAS model to stabilize the existing channel. The alternatives for channel improvements were limited in this area due to the horizontal proximity of adjacent structures. Based on the 2013 LiDAR information, the existing channel has an approximate bottom width between 5 and 10 feet in most locations with side slopes steeper than 2.5H: 1V. The proposed typical section for the channel improvements downstream of University Avenue consists of a 10-foot bottom width with vertical side slopes. The larger bottom width will allow for slower channel velocities and maximize conveyance area. In addition, to protect the foundation of adjacent structures, vertical walls are proposed in the lower portion of Gregory Canyon Creek, north of University Avenue. The vertical side slopes shall be armored with boulder walls or edging. At most culvert / bridge crossings, the boulder edge will tie in directly to the proposed wingwalls. At Euclid Avenue, the proposed channel bottom has a 5-foot bottom width; however, side slopes were determined based on existing side slopes of 2H: 1V. In these areas where the side slopes are not vertical and where shear stresses allow, soil lifts may be an option to protect against erosion and scour, in lieu of boulders. Examples of these materials are shown in **Picture 1** and **Picture 2**. It was determined in the Alternative Analysis that the culverts were undersized for the 10-year storm event and negatively impacting channel capacity during larger storm events. The culvert improvements are seen as critical to the conveyance of the entire system; therefore, the necessary size and inverts identified in the Alternative Analysis served as the tie-in locations for the channel improvements. At some locations, the culvert invert had to be lowered to accommodate the larger culvert size.

Picture 1: Stacked Boulder Wall

Picture 2: Soil Lifts

Sediment Traps

As part of the City's Recommended Plan, two sediment traps were identified, one between Pennsylvania Avenue and 7th Street, and one upstream of Willowbrook Road. Downstream of Pennsylvania Avenue, adjacent to 637 South Pennsylvania Avenue, a step-pool sediment trap is proposed offline to split larger flows and capture sediment from the watershed as well as to serve as a water amenity for the private residence (see **Picture 3**). During final design of any facilities, it is recommended that current property owners be consulted regarding the desired materials and finishes to complete the channel and sediment basin improvements and that a landscape architect be employed to blend improvements into the private residential properties. Boulder edging and boulder drop structures are recommended in the Master Plan and are included in the hydraulic model.

The second sediment trap location is upstream of Willowbrook Road culvert. To minimize the disturbance to adjacent property, an inline sediment trap is proposed. The sediment trap will consist of a concrete Colorado Department of Transportation (CDOT) Type D inlet structure with a 4-foot-deep sump. The grate of the inlet will be set at the channel flowline, with a drain and infiltration layer installed at the bottom of the inlet. Boulders may be used to transition grades around the inlet. As water and sediment are conveyed by Gregory Canyon Creek, the flow will enter the sediment trap through the grate (see **Picture 4**). If the amount of runoff exceeds the volume of the inlet, the water will fill the inlet and continue to flow towards Willowbrook Road. Once the runoff has receded, the water in the sediment trap will infiltrate the ground via the drain. It is recommended that the City of Boulder remove the sediment from the trap after each major flow event, estimated at two to four times annually.

Picture 3: Inline Sediment Trap

Stable Slope Analysis

Gregory Canyon Creek is a steep mountain channel at the headwaters near Flagstaff Road; the creek flows towards the City of Boulder and the slope flattens out to the confluence with Boulder Creek. Due to the nature of the existing channel and soil types in the area, a permissible velocity approach was used to determine the stable slope for Gregory Canyon Creek. This approach reviews the underlying geology of the channel based in the Natural Resources Conservation Services (NRCS) soil classification and determines the maximum velocity that these materials can withstand prior to erosion occurring in the channel. The published permissible velocity values vary both with depth and soil type. The soil data were obtained from NRCS and are included in **Appendix A**. **Table 2** below presents the permissible velocity values for the soil types found within the study area.

Picture 4: Example Inline Sediment Trap

Table 2. Permissible Velocities for Soil Types within the Study Area

	Soil Types within Study Area		Permissible Velocities (fps)					
Soil Description by Fortier and Scobey (1926)	**NRCS Soil Type Applied**	**NRCS Soil Description**	**Clear Water[a]**	**Water Transporting Colloidal Silt[a]**	**Flow Depth = 3 to 5 feet[b]**	**Flow Depth = 5 to 8 feet[b]**	**Flow Depth = 8 to 10 feet[b]**	**Grass Lined or Vegetated[c]**
Alluvial Silt			2.0 - 3.8	3.5 - 5	3.9	4.6	4.9	6.8
Sandy Loam	BaF, Nh	Baller Stony Sandy Loam, Niwot	1.75 - 2.0	2.5 - 3.5	3.9	4.6	4.9	6.8
Graded Loam to Cobbles (noncolloidal)	Cu, NdD, Ro, Te	Colluvial Land, Nederland Cobbly Sandy Loam, Rock Outcrop, Terrace Escarpments	3.8	5.0	5.3	5.5	6.0	6.8

[a] Fortier and Scobey (1926).

[b] Keown et al. (1977).

[c] SCS (1954) and UDFCD (2006).

Typical cross-sections from HEC-RAS were selected from each reach, Lower, Middle, and Upper, to compute the normal depth and velocity using Manning's Equation. Because Manning's Equation presents velocity as a function of channel slope, a stable velocity was reached by adjusting the slope of the channel. Stable slopes were calculated using flow rates for the 2-, 5-, 10-, and 100-year storm events, and the results were averaged to determine the final stable slope for Gregory Canyon Creek. Cross-sections directly upstream or downstream of culverts were not used due to the accelerating and decelerating nature of velocities around culverts. On the basis of this analysis, it was determined that a stable slope of 1.5 percent would be conservative based on the various soil conditions found for Gregory Canyon Creek, as shown in **Table 3**.

Table 3. Calculated Stable Slopes by Reach and Cross-Section

Reach #	Cross-Section #	2-Yr Flow (cfs) Calculated Stable Slope (ft/ft)	5-Yr Flow (cfs) Calculated Stable Slope (ft/ft)	10-Yr Flow (cfs) Calculated Stable Slope (ft/ft)	100-Yr Flow (cfs) Calculated Stable Slope (ft/ft)
Upper	530	0.023	0.019	0.015	0.012
Upper	508	0.035	0.034	0.032	0.023[a]
Middle	385	0.039	0.031	0.036	0.073
Middle	360	0.041	0.033	0.020	0.020
Lower	173	0.031	0.024	0.024[b]	0.084[a]
Lower	110	0.031	0.029	0.033[b]	0.069[a]

[a] Does not meet minimum freeboard requirement.

[b] Less than 1 foot of freeboard.

To achieve this stable slope, grouted boulder drop structures are proposed throughout the project area. The desired maximum height for each drop structure is 3 feet. At Euclid Avenue, a 4-foot drop structure is proposed to minimize the impact to the upstream property owner and tie into existing grade. In some areas, drop structures will need to be constructed in sequence to achieve the stable slope and maintain the 3-foot maximum drop. Examples of these drops are shown in **Picture 5** and **Picture 6**.

Picture 5: Grouted Boulder Drop Structure

Picture 6: Multiple Drop Structure

Hydraulic Modeling

The HEC-RAS model delivered with the Alternative Analysis, dated April 2015, was updated with the channel improvements described in previous sections. Proposed culverts were updated to match the City's Recommended Plan. At the alley way between Arapahoe Avenue and Marine Street, C-11, the culvert was extended to protect access to the adjacent property. The majority of the channel improvements are being proposed in the lower portion of the Gregory Canyon Creek Watershed, downstream of University Avenue. Approximately 20 drop structures are needed to achieve the stable slope of 1.5 percent. To define these improvements, a cross-section was added at the crest and toe of each drop structure. Cross-sections at roadways were modified on an as-needed basis, to accurately model any change in alignment or location. The cross-sections were defined based on proposed grading within the channel and supplemented with the City of Boulder's 2013 LiDAR along the overbanks. It should be noted that the existing conditions model was not updated with this Master Plan and was based on a different topography dataset. In areas where no changes were being proposed, the cross-section reflected the existing conditions model. In addition, the proposed Manning's roughness coefficient was adjusted to 0.03 within the channel, to better represent the proposed conditions of a rock-lined channel section that has been cleared of brush and obstructions

Results of Hydraulic Analyses

The goal of the conceptual design was to safely convey the 10-year storm event within Gregory Canyon Creek. The proposed culvert and channel improvements convey the 10-year storm event and stabilize the channel in lower storm events. In areas where the drop structures are spaced to allow the flow regime in the channel to stabilize, the velocities are less than 7 fps and subcritical. Additional erosion and scour protection will be required at the proposed culverts to accommodate the increase in velocity at these locations. The channel bottom should be lined with Type M soil riprap to allow for vegetation to reestablish in the channel bottom. The riprap will protect against shear forces along the channel bottom.

A split flow condition exists downstream of Marine Street. With the conceptual design, additional capacity is added to Gregory Canyon Creek, reducing the amount of flow diverted at this split location. As a result, additional flow stays in the Gregory Creek channel downstream of Marine Street, resulting in minor increases in the 100-year water surface elevation. However, due to the channel and culvert improvements at these locations there is no adverse impacts to adjacent structures. The impacts to the 100-year water surface elevation should be evaluated during final design. A master-planned 100-year floodplain delineation is shown in **Figure 1** included in **Appendix B**. The hydraulic results for the 10- and 100-year storm events are presented in **Appendix B**.

Water Quality Improvements

The Gregory Canyon Creek Watershed is predominately built out, which provides limited opportunities to enhance water quality. However, two inline sediment basins are being proposed along Gregory Canyon Creek. These facilities will assist in removing sediment from the channel, thereby helping to improve the health of the corridor.

Throughout the watershed, opportunities exist to retrofit the storm sewer manholes and inlets to help improve water quality. We advise that these retrofits are included as funds and storm drain improvements are completed by the City. Various products are on the market to enhance water quality through the interception of floatable debris at inlets to oil and sand separators for manholes. In addition, the inverts of each manhole can be lowered to allow for trash and debris to separate from the water in the system. These retrofits will benefit water quality along Gregory Canyon Creek.

Prioritization and Phasing of Improvements

The items included in the Conceptual Design are required to convey the 10-year storm event and meet the City of Boulder's drainage criteria. The conceptual design contains improvements to alleviate flooding issues identified by the City and residents during the flooding event in September 2013. These improvements include culvert/ bridge improvements as well as channel improvements. The identified culvert and channel improvements are considered high priority, with inlet and sediment trap construction regarded as a low priority. The high-priority improvements are considered to be interrelated and necessary for the cohesive conveyance of Gregory Canyon Creek. Therefore, the culvert improvements and channel work necessary to construct the culvert were divided into reaches. In all, 11 reaches are being proposed, R-1 to R-11, and are represented in **Figure 2** in **Appendix A**.

To minimize adverse impacts to downstream property owners, the improvements shall be constructed from downstream, R-1, to upstream, R-11. The proposed piping of Anderson Ditch will occur with the construction of the Culvert C6 at 7th Street, R-8. The low-priority improvements are considered independent of the overall system conveyance. However, the sediment trap proposed at 637 Pennsylvania Avenue is included with the costs for Reach 8, R-8. The proposed improvements are identified in **Table 4**.

Table 4. Gregory Canyon Creek Alternatives

	High Priority		Low Priority	
	Culvert / Bridge Improvements	**Additional Channel Improvements Required**	**Sediment Trap**	**Inlet Improvements**
Construction Phasing				
Downstream	**R-1 – Private Drive**			
	R-2– Arapahoe Avenue	x		
	R-3 – Alley Way	x		
	R-4 – Marine Street	x		
	R-5 – 8th Street	x		
	R-6 – University Avenue	x		
	R-7 – Pleasant Street			
	R-8 – Anderson Ditch	(Construct with 7th Street Improvements)		
	R-8 – 7th Street	x	x	
	R-9 – Pennsylvania Avenue	x		
	R-10 – College Avenue	x		
Upstream	**R-11 – Euclid Avenue**	x		
	Willowbrook Road		x	x

Updated Cost Estimate

The associated costs were presented by reach as described in previous sections. During the conceptual design, it became clear that a more structured channel would be required to meet the horizontal constraints and convey the 10-year flow at the existing roadways. Additionally, multiple drop structures would be needed to allow for a stable slope of 1.5 percent. The addition of boulder walls, boulder drop structures, and soil riprap necessary to stabilize the channel will impact the cost for each reach of channel improvements. For proposed improvements that will impact existing landscaped areas, a line item has been added to restore extensive landscaping. Additional line items to protect/ relocate overhead electric and relocate utilities have also been included in the cost where appropriate. These updated costs are provided in **Appendix C**.

The same methodology utilized in the alternative analysis to determine the benefit-cost ratio (BCR) was updated for the conceptual design. Basement types and classification of structures were reviewed per the recommendations received and updated per FEMA's guidance. Damage curves were also verified and updated as necessary. By increasing the overall channel capacity, the flooding risk associated with more frequent storm events was reduced with the conceptual design. The overall cost of the channel and culvert improvements was approximately $9,924,308.39 with a BCR of 2.82.

Appendix A
Technical Appendix

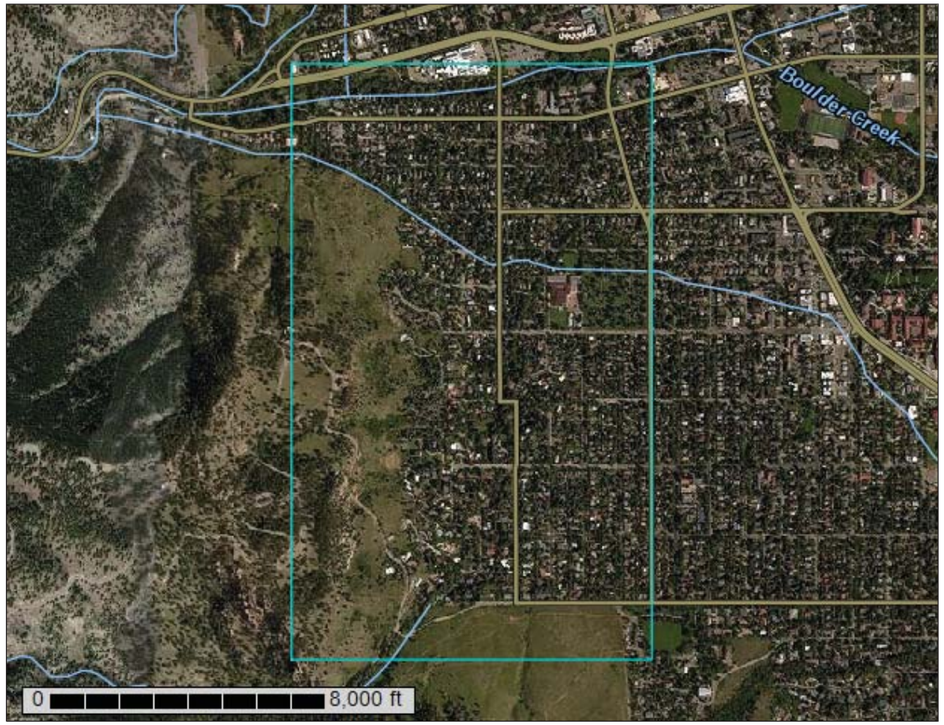
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Boulder County Area, Colorado



July 6, 2015

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Cu—Colluvial land....13
NdD—Nederland very cobbly sandy loam, 1 to 12 percent slopes....14
Nh—Niwot soils....15
Ro—Rock outcrop....16
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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the

individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

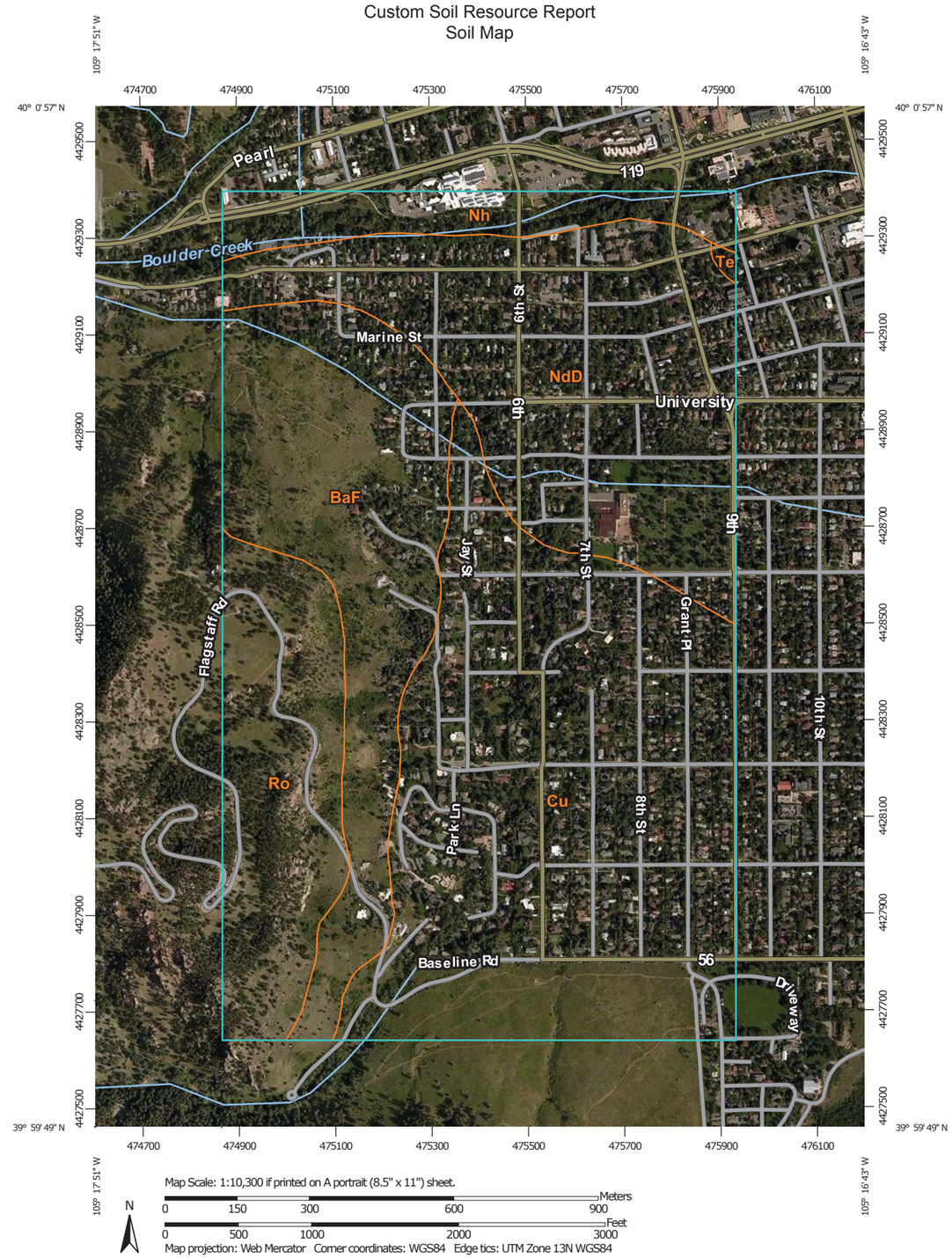
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Boulder County Area, Colorado
Survey Area Data: Version 11, Sep 22, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 28, 2012—Sep 18, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Boulder County Area, Colorado (CO643)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
BaF	Baller stony sandy loam, 9 to 35 percent slopes	89.1	19.2%
Cu	Colluvial land	179.1	38.6%
NdD	Nederland very cobbly sandy loam, 1 to 12 percent slopes	113.3	24.4%
Nh	Niwot soils	24.5	5.3%
Ro	Rock outcrop	57.6	12.4%
Te	Terrace escarpments	0.6	0.1%
Totals for Area of Interest		**464.3**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Boulder County Area, Colorado

BaF—Baller stony sandy loam, 9 to 35 percent slopes

Map Unit Setting

National map unit symbol: jpr9
Elevation: 5,500 to 6,500 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 47 to 51 degrees F
Frost-free period: 140 to 155 days
Farmland classification: Not prime farmland

Map Unit Composition

Baller and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Baller

Setting

Landform: Ridges
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy residuum weathered from sandstone

Typical profile

H1 - 0 to 10 inches: very stony sandy loam
H2 - 10 to 15 inches: very stony fine sandy loam, very stony sandy loam
H2 - 10 to 15 inches: unweathered bedrock
H3 - 15 to 19 inches:

Properties and qualities

Slope: 9 to 35 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: Shallow Foothill (R049BY204CO)

Cu—Colluvial land

Map Unit Setting
National map unit symbol: jprk
Elevation: 7,500 to 9,000 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 39 to 43 degrees F
Frost-free period: 80 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition
Colluvial land: 80 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Colluvial Land

Setting
Landform: Valleys
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Colluvium

Typical profile
H1 - 0 to 3 inches: gravelly sandy loam
H2 - 3 to 60 inches: gravelly sand, very gravelly sand, gravelly loamy sand
H2 - 3 to 60 inches:
H2 - 3 to 60 inches:

Properties and qualities
Slope: 9 to 25 percent
Depth to restrictive feature: 2 to 60 inches to lithic bedrock
Natural drainage class: Excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Calcium carbonate, maximum in profile: 10 percent
Available water storage in profile: Very low (about 0.3 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A

NdD—Nederland very cobbly sandy loam, 1 to 12 percent slopes

Map Unit Setting
National map unit symbol: jps7
Elevation: 5,500 to 6,500 feet
Mean annual precipitation: 15 to 20 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 140 to 155 days
Farmland classification: Not prime farmland

Map Unit Composition
Nederland and similar soils: 80 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Nederland

Setting
Landform: Terraces, alluvial fans
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Cobbly loamy alluvium

Typical profile
H1 - 0 to 7 inches: very cobbly sandy loam
H2 - 7 to 20 inches: very cobbly sandy clay loam
H3 - 20 to 60 inches: very cobbly sandy loam

Properties and qualities
Slope: 1 to 12 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.9 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: Cobbly Foothills (R048AY346CO)

Nh—Niwot soils

Map Unit Setting
National map unit symbol: jps8
Elevation: 4,900 to 5,500 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 140 to 155 days
Farmland classification: Not prime farmland

Map Unit Composition
Niwot and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Niwot

Setting
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy over sandy and gravelly alluvium

Typical profile
H1 - 0 to 14 inches: loam
H2 - 14 to 60 inches: gravelly sand

Properties and qualities
Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water storage in profile: Low (about 4.4 inches)

Interpretive groups
Land capability classification (irrigated): 4w
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B
Ecological site: Wet Meadow (R067XB038CO)

Ro—Rock outcrop

Map Unit Composition
Rock outcrop: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rock Outcrop

Setting
Landform: Mountain slopes, cliffs
Landform position (three-dimensional): Mountaintop, free face
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Mixed

Typical profile
H1 - 0 to 60 inches: unweathered bedrock

Properties and qualities
Slope: 20 to 95 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: D

Te—Terrace escarpments

Map Unit Setting
National map unit symbol: jpsv
Elevation: 4,400 to 5,500 feet
Mean annual precipitation: 10 to 16 inches
Mean annual air temperature: 46 to 54 degrees F
Frost-free period: 120 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition
Terrace escarpments: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Terrace Escarpments

Setting
Landform: Paleoterraces, fan remnants

Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Base slope, riser
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Cobbly and stony colluvium over sandstone and shale

Typical profile
H1 - 0 to 6 inches: gravelly sand
H2 - 6 to 60 inches: gravelly sand, very gravelly sand, gravelly coarse sand
H2 - 6 to 60 inches:
H2 - 6 to 60 inches:

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A

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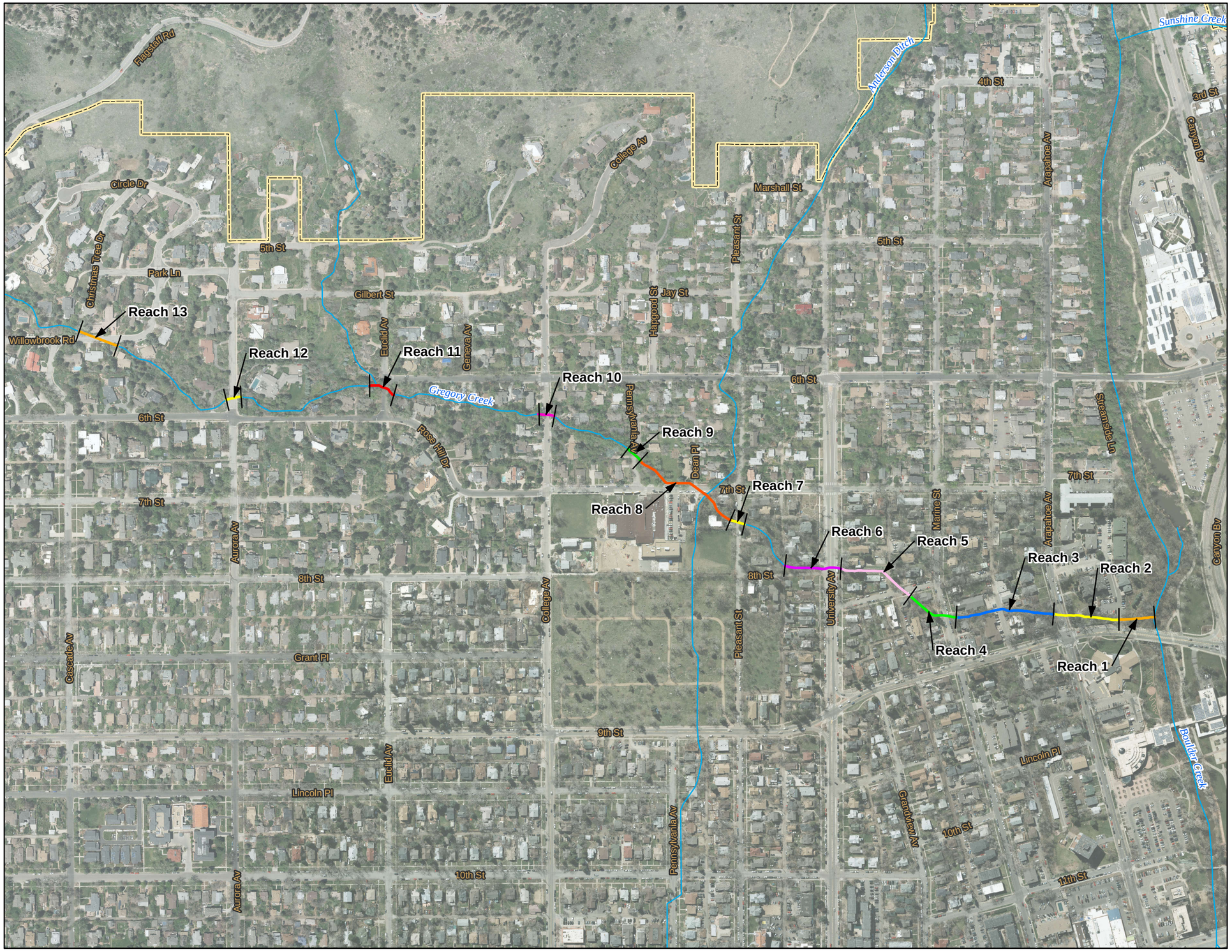
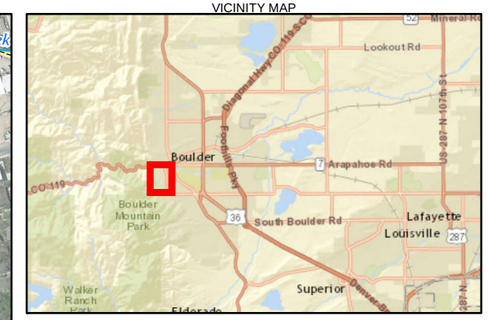
Existing Ground Vertical Adjustments

Station		
From	To	Source
4+80	3+61	Survey from 2009 Belt Collins Update
7+30	6+30	Survey from 2009 Belt Collins Update
12+50	9+05	Survey from 2009 Belt Collins Update
14+91	13+75	Survey from 2009 Belt Collins Update
19+75	18+50	Survey from 2009 Belt Collins Update
25+00	23+55	Survey from 2009 Belt Collins Update
28+55	27+80	Survey from 2009 Belt Collins Update
35+33	35+57	Survey from 997 Euclid Avenue
42+75	41+47	Survey from 2009 Belt Collins Update
50+00	47+50	Survey from 2009 Belt Collins Update
54+75	53+60	Survey from 2009 Belt Collins Update

* All other elevations are from 2013 LiDAR



VICINITY MAP



LEGEND

- Project Reach
- Creeks and Streams
- City Limits

N

0 200 400
Feet

FIGURE X
Project Reaches
Gregory Canyon Creek Flood Mitigation

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Appendix B
Hydraulic Results

HEC-RAS Plan: PR10.15 River: RIVER-1 Reach: Reach-1 Profile: 10-year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	600	10-year	400.00	5750.20	5753.68	5753.68	5754.79	0.072296	8.48	48.02	24.17	0.97
Reach-1	590	10-year	400.00	5718.23	5733.09	5723.36	5733.10	0.000209	1.09	591.85	103.66	0.05
Reach-1	585		Culvert									
Reach-1	580	10-year	400.00	5717.80	5722.94	5722.94	5725.47	0.053059	12.75	31.38	23.86	0.99
Reach-1	560	10-year	400.00	5684.47	5692.49	5689.18	5692.65	0.006768	3.66	175.47	106.85	0.26
Reach-1	555		Culvert									
Reach-1	550	10-year	400.00	5683.10	5687.61	5687.61	5688.79	0.008159	9.12	59.63	31.70	0.85
Reach-1	540	10-year	400.00	5660.98	5665.75	5665.75	5666.71	0.027321	8.57	56.81	30.30	1.00
Reach-1	530	10-year	400.00	5652.10	5657.05	5657.05	5658.19	0.027142	8.57	46.67	20.54	1.00
Reach-1	520	10-year	400.00	5645.52	5656.89	5652.30	5657.07	0.001264	3.77	221.72	134.61	0.21
Reach-1	515		Culvert									
Reach-1	510	10-year	400.00	5643.57	5650.39	5650.39	5653.73	0.027158	14.67	27.26	39.62	0.99
Reach-1	508	10-year	400.00	5640.03	5644.43	5644.43	5645.27	0.050904	7.35	54.39	32.40	1.00
Reach-1	507	10-year	400.00	5639.21	5642.99	5642.99	5643.84	0.048378	7.41	54.01	33.53	1.01
Reach-1	505	10-year	400.00	5638.27	5642.03	5642.03	5642.78	0.042710	7.03	61.26	46.95	0.95
Reach-1	500	10-year	400.00	5625.60	5634.33	5629.30	5634.51	0.003737	3.71	168.13	76.26	0.22
Reach-1	495		Bridge									
Reach-1	490	10-year	400.00	5624.40	5628.10	5628.10	5629.92	0.069729	10.81	36.99	10.00	0.99
Reach-1	470	10-year	400.00	5607.68	5619.14	5611.66	5619.20	0.000731	2.05	220.79	58.95	0.11
Reach-1	465		Culvert									
Reach-1	460	10-year	400.00	5603.33	5607.30	5607.30	5609.25	0.027243	11.19	35.76	14.56	0.99
Reach-1	455	10-year	495.00	5596.39	5601.20	5601.20	5602.43	0.036666	8.91	55.56	22.58	1.00
Reach-1	450	10-year	495.00	5590.81	5595.98	5595.98	5597.24	0.036236	9.02	54.87	21.23	0.99
Reach-1	440	10-year	495.00	5587.69	5591.62	5591.62	5592.64	0.036979	8.12	60.93	30.12	1.01
Reach-1	436	10-year	495.00	5578.63	5581.71	5581.71	5582.52	0.032149	8.12	90.76	68.33	0.95
Reach-1	431	10-year	495.00	5571.70	5576.47	5574.81	5577.12	0.007200	6.49	76.25	19.33	0.52
Reach-1	425		Culvert									
Reach-1	420	10-year	495.00	5571.10	5574.21	5574.21	5575.75	0.029776	9.94	49.80	20.45	0.99
Reach-1	410	10-year	495.00	5565.61	5569.39	5567.95	5569.83	0.006518	5.29	93.55	33.18	0.48
Reach-1	405		Culvert									
Reach-1	400	10-year	495.00	5563.35	5566.12	5565.18	5566.40	0.007466	4.25	116.47	54.94	0.48
Reach-1	398	10-year	495.00	5563.39	5564.94	5564.91	5565.63	0.094408	8.33	82.10	67.05	1.46
Reach-1	395	10-year	495.00	5555.00	5558.75	5558.73	5559.65	0.045916	7.65	64.72	36.03	1.01
Reach-1	390	10-year	495.00	5551.40	5555.11	5555.11	5555.75	0.034076	7.02	100.24	85.25	0.88
Reach-1	389	10-year	495.00	5550.00	5553.05	5553.00	5553.83	0.049733	7.79	90.92	84.99	1.05
Reach-1	385	10-year	495.00	5537.75	5540.73	5540.73	5541.19	0.070682	8.03	114.50	110.19	1.16
Reach-1	383	10-year	495.00	5532.68	5535.07	5535.07	5536.11	0.010908	8.17	60.63	38.63	0.99
Reach-1	382	10-year	495.00	5529.15	5533.45	5533.45	5534.82	0.011142	9.40	52.65	19.47	1.01
Reach-1	381	10-year	495.00	5529.15	5533.13	5533.13	5534.44	0.010871	9.17	53.99	20.85	1.00
Reach-1	380	10-year	495.00	5527.28	5531.27	5531.27	5532.53	0.010565	9.00	55.00	21.40	0.99
Reach-1	375		Culvert									
Reach-1	370	10-year	495.00	5527.21	5529.88	5529.88	5531.07	0.009957	8.75	56.56	50.16	0.99
Reach-1	360	10-year	495.00	5511.80	5515.88	5515.88	5517.01	0.046086	8.54	57.99	25.76	1.00
Reach-1	352	10-year	495.00	5507.30	5511.34	5511.28	5512.43	0.031847	8.63	68.27	33.26	0.87
Reach-1	351	10-year	495.00	5506.80	5510.54	5510.54	5511.58	0.043604	8.16	60.63	29.33	1.00
Reach-1	350	10-year	495.00	5503.40	5507.38	5507.38	5508.55	0.042998	8.71	56.85	24.20	1.00
Reach-1	342	10-year	495.00	5494.95	5499.43	5499.43	5500.51	0.035572	8.73	68.70	33.41	0.92
Reach-1	340	10-year	495.00	5493.14	5497.17	5497.17	5498.40	0.047114	8.90	55.62	22.70	1.00
Reach-1	334	10-year	495.00	5488.11	5492.20	5492.20	5493.46	0.044410	9.02	54.89	22.22	1.01
Reach-1	330	10-year	495.00	5485.84	5490.99	5489.16	5491.66	0.007866	6.55	75.54	28.74	0.51
Reach-1	325		Culvert									
Reach-1	318	10-year	600.00	5485.27	5489.04	5489.04	5490.89	0.033469	10.90	55.07	40.10	0.99
Reach-1	304	10-year	600.00	5484.40	5489.61	5487.32	5489.74	0.002484	2.91	219.98	75.75	0.26
Reach-1	303		Bridge									
Reach-1	302	10-year	600.00	5483.05	5486.07	5486.07	5486.90	0.033333	7.55	97.77	71.83	0.88
Reach-1	301	10-year	600.00	5479.08	5482.02	5482.02	5483.13	0.043268	8.44	71.10	32.46	1.00
Reach-1	300	10-year	600.00	5475.10	5478.44	5478.44	5479.10	0.033229	6.62	105.83	111.08	0.87
Reach-1	295	10-year	600.00	5470.26	5473.62	5473.62	5474.21	0.035730	6.40	114.14	109.08	0.89
Reach-1	291	10-year	600.00	5468.09	5470.94	5470.94	5471.54	0.031183	6.98	132.14	118.87	0.86
Reach-1	290.5	10-year	600.00	5463.82	5469.36	5469.36	5470.25	0.005885	8.32	166.44	136.53	0.72
Reach-1	287	10-year	600.00	5460.82	5469.03	5466.57	5469.39	0.007520	5.24	199.53	162.11	0.40
Reach-1	285		Bridge									
Reach-1	283	10-year	600.00	5460.46	5465.28	5465.28	5466.43	0.009916	8.78	85.71	50.16	0.94
Reach-1	282	10-year	600.00	5457.67	5461.87	5461.87	5463.55	0.012693	10.40	57.68	17.35	1.01
Reach-1	278	10-year	600.00	5456.63	5459.28	5459.28	5460.11	0.011932	7.30	82.16	50.48	1.01
Reach-1	276	10-year	600.00	5453.91	5457.72	5457.24	5458.42	0.006393	6.74	89.03	35.75	0.75
Reach-1	274	10-year	600.00	5454.04	5457.00	5457.00	5458.12	0.011773	8.50	70.57	31.93	1.01
Reach-1	272	10-year	600.00	5449.36	5454.50		5455.07	0.002918	6.07	98.83	20.11	0.48
Reach-1	271	10-year	600.00	5449.36	5454.21	5452.77	5455.00	0.004191	7.14	84.04	17.97	0.58
Reach-1	265		Culvert									
Reach-1	250	10-year	600.00	5435.21	5440.23	5439.62	5441.62	0.008570	9.46	63.45	20.49	0.80
Reach-1	231	10-year	600.00	5434.26	5438.68	5438.68	5440.59	0.013180	11.07	54.21	14.34	1.00
Reach-1	230	10-year	600.00	5433.44	5438.05	5436.57	5438.75	0.003918	6.72	89.24	20.20	0.56
Reach-1	225		Culvert									
Reach-1	220	10-year	600.00	5432.65	5436.00	5436.00	5437.64	0.012988	10.26	58.48	17.75	1.00

HEC-RAS Plan: PR10.15 River: RIVER-1 Reach: Reach-1 Profile: 10-year (Continued)

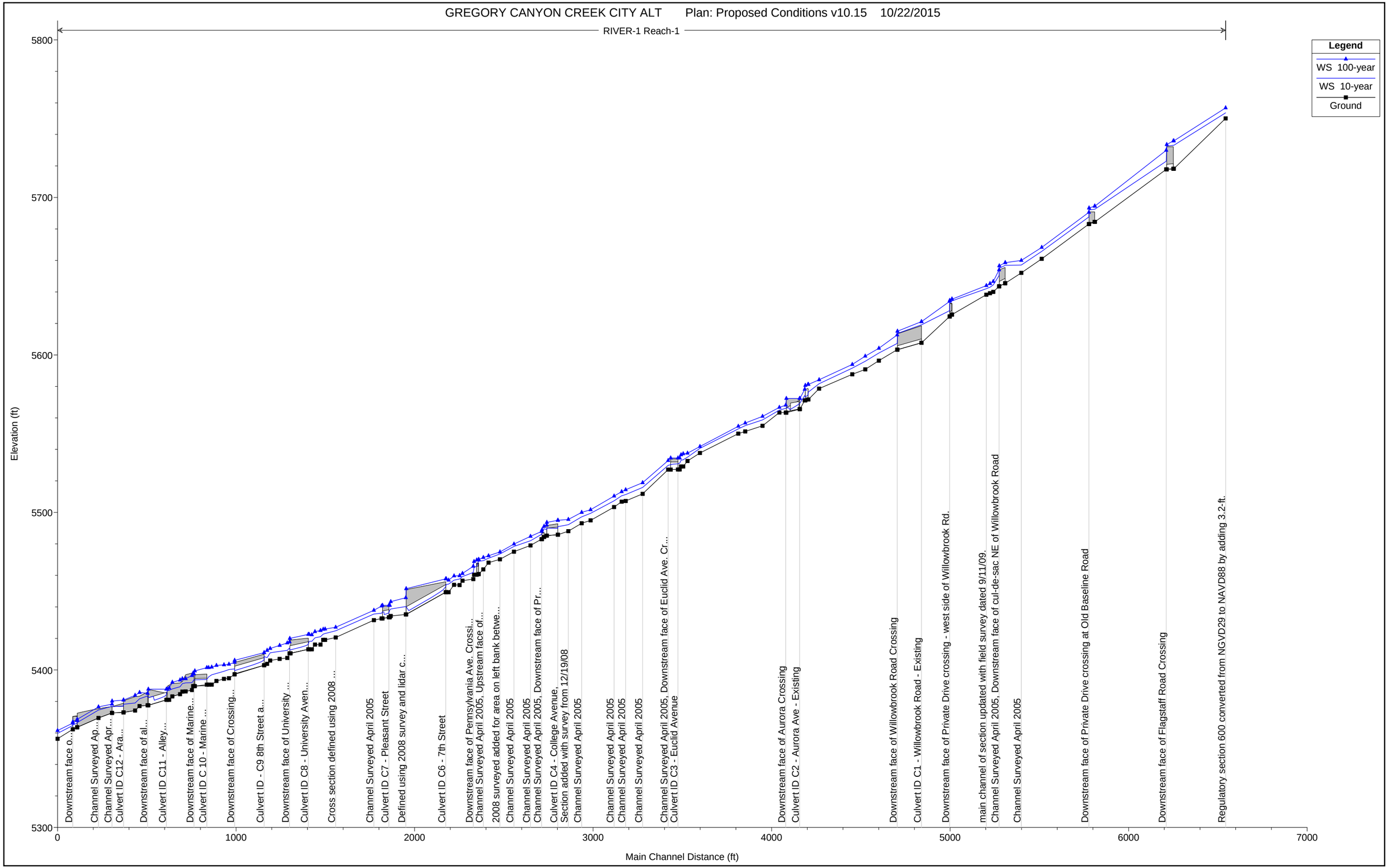
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	219	10-year	600.00	5431.60	5435.50	5435.50	5436.71	0.009614	8.85	74.49	57.35	0.94
Reach-1	200	10-year	600.00	5420.59	5424.84	5424.84	5425.88	0.012072	8.17	73.44	35.69	1.00
Reach-1	197	10-year	600.00	5419.10	5423.12	5423.12	5424.38	0.011133	9.01	66.61	26.56	1.00
Reach-1	195	10-year	600.00	5419.10	5422.75	5422.75	5424.18	0.011043	9.61	62.42	22.07	1.01
Reach-1	194	10-year	600.00	5416.10	5421.11	5420.47	5422.38	0.007689	9.02	66.53	16.62	0.79
Reach-1	193	10-year	600.00	5416.10	5420.36	5420.36	5422.04	0.011810	10.41	57.64	17.40	1.01
Reach-1	191	10-year	600.00	5413.10	5418.17		5418.88	0.003711	6.77	88.68	19.42	0.56
Reach-1	190.5	10-year	600.00	5413.10	5418.19	5416.33	5418.80	0.003580	6.27	95.75	19.57	0.50
Reach-1	185		Culvert									
Reach-1	180	10-year	673.00	5410.57	5413.97	5413.97	5415.65	0.010667	10.42	64.60	19.81	1.00
Reach-1	177	10-year	673.00	5407.62	5412.38	5412.38	5414.41	0.013257	11.44	58.82	14.61	1.01
Reach-1	175	10-year	673.00	5407.01	5411.78	5411.78	5413.80	0.013122	11.42	58.94	14.73	1.01
Reach-1	173	10-year	673.00	5405.97	5410.90	5410.90	5412.69	0.011408	10.81	70.70	32.51	0.94
Reach-1	172	10-year	673.00	5403.83	5407.80	5407.80	5409.59	0.012147	10.73	62.74	17.78	1.01
Reach-1	171	10-year	673.00	5402.97	5408.48	5406.39	5409.12	0.001733	6.43	104.65	25.18	0.48
Reach-1	165		Culvert									
Reach-1	161	10-year	673.00	5397.22	5400.65	5400.65	5402.31	0.008490	10.36	64.97	22.73	0.99
Reach-1	155	10-year	673.00	5394.73	5400.22	5399.32	5401.51	0.007588	9.11	73.91	17.30	0.78
Reach-1	152	10-year	673.00	5394.34	5399.12	5399.12	5401.16	0.013247	11.46	58.73	14.55	1.01
Reach-1	151	10-year	673.00	5392.99	5397.76	5397.76	5399.80	0.013255	11.46	58.71	14.58	1.01
Reach-1	150	10-year	673.00	5390.64	5396.90	5395.53	5398.07	0.006280	8.67	77.63	15.25	0.68
Reach-1	130	10-year	673.00	5390.64	5395.58	5395.58	5397.64	0.013552	11.53	58.37	13.87	0.99
Reach-1	125		Culvert									
Reach-1	120	10-year	673.00	5389.74	5393.70	5392.94	5394.73	0.005345	8.13	82.73	22.03	0.73
Reach-1	119.9		Lat Struct									
Reach-1	117	10-year	673.00	5389.74	5393.03	5393.03	5394.54	0.011224	9.88	68.10	22.58	1.00
Reach-1	113	10-year	673.00	5387.24	5391.95	5391.95	5393.92	0.012762	11.27	59.70	15.19	1.00
Reach-1	110	10-year	673.00	5386.36	5391.81	5391.56	5392.78	0.008654	8.03	97.89	44.75	0.86
Reach-1	108	10-year	673.00	5386.25	5391.27	5391.27	5392.59	0.007662	9.48	107.09	72.44	0.82
Reach-1	106	10-year	673.00	5384.61	5389.34	5389.34	5391.32	0.012710	11.27	59.69	15.23	1.00
Reach-1	104	10-year	673.00	5383.20	5387.96	5387.96	5389.96	0.012865	11.32	59.43	15.00	1.00
Reach-1	102	10-year	673.00	5381.00	5386.99		5387.41	0.001798	5.23	128.62	22.27	0.38
Reach-1	100	10-year	673.00	5381.00	5386.94	5384.26	5387.39	0.001952	5.39	124.95	22.07	0.40
Reach-1	95		Culvert									
Reach-1	91	10-year	673.00	5377.55	5383.47	5381.03	5384.02	0.002484	5.95	113.06	19.99	0.44
Reach-1	89.9		Lat Struct									
Reach-1	70	10-year	673.00	5377.04	5381.69	5381.69	5383.45	0.011796	10.63	63.28	18.20	1.01
Reach-1	65	10-year	673.00	5374.19	5379.00	5379.00	5381.04	0.013251	11.46	58.72	14.41	1.00
Reach-1	60	10-year	673.00	5373.01	5378.21	5376.03	5378.71	0.001476	5.71	117.89	25.61	0.44
Reach-1	55		Culvert									
Reach-1	51	10-year	673.00	5372.70	5376.91	5375.72	5377.68	0.011928	7.05	95.47	56.39	0.61
Reach-1	49.9		Lat Struct									
Reach-1	45	10-year	672.32	5369.49	5374.52	5374.52	5375.93	0.043677	9.51	70.70	26.16	1.02
Reach-1	40	10-year	672.32	5363.57	5366.58	5366.05	5367.41	0.025220	7.32	91.81	31.02	0.75
Reach-1	35		Bridge									
Reach-1	30	10-year	672.32	5362.31	5364.69	5364.69	5365.78	0.044045	8.38	80.22	37.46	1.01
Reach-1	10	10-year	672.32	5356.30	5359.72	5359.72	5360.97	0.038709	9.00	76.00	32.82	0.99

HEC-RAS Plan: PR10.15 River: RIVER-1 Reach: Reach-1 Profile: 100-year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	600	100-year	1450.00	5750.20	5756.85	5756.85	5758.45	0.038880	10.98	175.50	60.17	0.82
Reach-1	590	100-year	1450.00	5718.23	5735.89	5730.31	5735.94	0.000868	2.52	977.51	161.26	0.11
Reach-1	585		Culvert									
Reach-1	580	100-year	1450.00	5717.80	5729.90	5729.90	5735.89	0.040251	19.64	73.82	88.34	1.00
Reach-1	560	100-year	1450.00	5684.47	5694.47	5693.18	5694.75	0.011242	5.70	419.85	133.66	0.36
Reach-1	555		Culvert									
Reach-1	550	100-year	1450.00	5683.10	5690.54	5690.54	5693.07	0.009615	14.71	169.00	48.60	1.01
Reach-1	540	100-year	1450.00	5660.98	5668.23	5668.23	5669.92	0.024603	11.70	156.41	46.95	1.04
Reach-1	530	100-year	1450.00	5652.10	5660.01	5660.01	5661.83	0.018610	10.92	141.60	46.25	0.94
Reach-1	520	100-year	1450.00	5645.52	5658.56	5657.67	5658.90	0.002927	5.91	537.13	145.29	0.31
Reach-1	515		Culvert									
Reach-1	510	100-year	1450.00	5643.57	5654.01	5654.01	5654.54	0.003470	6.31	339.48	80.69	0.36
Reach-1	508	100-year	1450.00	5640.03	5646.63	5646.63	5648.30	0.037599	10.49	146.36	49.63	0.98
Reach-1	507	100-year	1450.00	5639.21	5645.29	5645.29	5646.87	0.033293	10.36	158.87	54.52	0.95
Reach-1	505	100-year	1450.00	5638.27	5644.00	5644.00	5645.40	0.032446	10.18	185.67	75.13	0.94
Reach-1	500	100-year	1450.00	5625.60	5635.37	5634.97	5636.39	0.022426	9.78	276.75	125.14	0.55
Reach-1	495		Bridge									
Reach-1	490	100-year	1450.00	5624.40	5634.00	5634.00	5635.06	0.026436	9.96	264.01	125.71	0.57
Reach-1	470	100-year	1450.00	5607.68	5621.13	5614.06	5621.46	0.003722	5.16	446.07	129.13	0.25
Reach-1	465		Culvert									
Reach-1	460	100-year	1450.00	5603.33	5612.65	5612.65	5617.29	0.020842	17.28	83.92	96.84	1.00
Reach-1	455	100-year	1700.00	5596.39	5604.21	5604.21	5606.38	0.028330	11.85	148.27	39.91	0.98
Reach-1	450	100-year	1700.00	5590.81	5599.19	5599.19	5600.78	0.026792	10.27	182.25	106.22	0.93
Reach-1	440	100-year	1700.00	5587.69	5593.98	5593.98	5595.25	0.023797	9.75	254.63	136.18	0.89
Reach-1	436	100-year	1700.00	5578.63	5584.23	5584.23	5585.08	0.016562	9.62	410.40	224.64	0.78
Reach-1	431	100-year	1700.00	5571.70	5581.24	5578.80	5581.77	0.006021	6.76	494.41	217.07	0.40
Reach-1	425		Culvert									
Reach-1	420	100-year	1700.00	5571.10	5578.20	5578.20	5581.68	0.022498	14.97	113.58	124.36	0.99
Reach-1	410	100-year	1700.00	5565.61	5572.37	5570.92	5573.31	0.010388	7.76	219.09	40.34	0.59
Reach-1	405		Culvert									
Reach-1	400	100-year	1700.00	5563.35	5568.13	5566.97	5569.13	0.012078	8.04	211.36	59.64	0.67
Reach-1	398	100-year	1700.00	5563.39	5566.67	5566.67	5568.18	0.055920	12.44	216.26	89.81	1.33
Reach-1	395	100-year	1700.00	5555.00	5560.98	5560.98	5562.73	0.037266	10.61	161.08	48.30	1.01
Reach-1	390	100-year	1700.00	5551.40	5556.74	5556.74	5557.87	0.035761	10.19	257.78	108.53	0.98
Reach-1	389	100-year	1700.00	5550.00	5554.69	5554.69	5555.84	0.040472	10.35	249.04	105.65	1.04
Reach-1	385	100-year	1700.00	5537.75	5541.87	5541.87	5542.85	0.079806	11.69	243.31	115.69	1.32
Reach-1	383	100-year	1700.00	5532.68	5537.60	5537.60	5538.68	0.005375	9.42	326.05	157.32	0.79
Reach-1	382	100-year	1700.00	5529.15	5537.25	5536.82	5538.36	0.003989	9.52	354.54	125.69	0.69
Reach-1	381	100-year	1700.00	5529.15	5536.61	5536.61	5538.24	0.005977	10.69	241.86	104.79	0.83
Reach-1	380	100-year	1700.00	5527.28	5534.55	5534.55	5536.81	0.009459	12.07	140.86	31.36	1.00
Reach-1	375		Culvert									
Reach-1	370	100-year	1700.00	5527.21	5532.94	5532.94	5535.39	0.007933	12.57	137.02	176.13	0.98
Reach-1	360	100-year	1700.00	5511.80	5518.90	5518.90	5520.81	0.034722	11.20	162.13	49.18	0.95
Reach-1	352	100-year	1700.00	5507.30	5514.42	5514.42	5516.19	0.025142	11.95	210.93	100.66	0.86
Reach-1	351	100-year	1700.00	5506.80	5513.16	5513.16	5515.01	0.033116	10.99	163.09	50.58	0.97
Reach-1	350	100-year	1700.00	5503.40	5510.37	5510.37	5512.43	0.037198	11.52	147.56	36.46	1.01
Reach-1	342	100-year	1700.00	5494.95	5501.69	5501.69	5503.95	0.039860	13.71	182.40	53.93	1.08
Reach-1	340	100-year	1700.00	5493.14	5500.02	5500.02	5500.92	0.021195	8.74	340.88	219.44	0.75
Reach-1	334	100-year	1700.00	5488.11	5495.56	5495.56	5497.29	0.025662	10.85	194.47	76.92	0.85
Reach-1	330	100-year	1700.00	5485.84	5494.98	5493.18	5495.49	0.005647	5.97	392.74	170.04	0.38
Reach-1	325		Culvert									
Reach-1	318	100-year	1900.00	5485.27	5491.90	5491.90	5492.81	0.023021	9.76	395.24	216.83	0.69
Reach-1	304	100-year	1900.00	5484.40	5491.10	5489.24	5491.69	0.007855	6.33	357.30	178.40	0.48
Reach-1	303		Bridge									
Reach-1	302	100-year	1900.00	5483.05	5487.91	5487.91	5489.29	0.033327	10.62	250.54	90.55	0.95
Reach-1	301	100-year	1900.00	5479.08	5484.81	5484.81	5486.17	0.022682	9.81	258.27	121.67	0.82
Reach-1	300	100-year	1900.00	5475.10	5479.93	5479.93	5480.86	0.031059	8.66	318.58	168.21	0.90
Reach-1	295	100-year	1900.00	5470.26	5474.88	5474.88	5475.76	0.039266	8.31	314.26	211.21	0.98
Reach-1	291	100-year	1900.00	5468.09	5472.49	5472.49	5473.33	0.026948	9.37	394.76	222.72	0.87
Reach-1	290.5	100-year	1900.00	5463.82	5471.37	5471.37	5472.38	0.006200	11.10	633.36	310.57	0.79
Reach-1	287	100-year	1900.00	5460.82	5470.21	5470.21	5471.04	0.018395	9.39	443.34	240.83	0.65
Reach-1	285		Bridge									
Reach-1	283	100-year	1900.00	5460.46	5468.83	5468.83	5469.85	0.003822	9.27	607.43	373.04	0.66
Reach-1	282	100-year	1900.00	5457.67	5465.80	5465.80	5467.83	0.008209	12.10	246.43	77.54	0.88
Reach-1	278	100-year	1900.00	5456.63	5461.24	5461.24	5462.65	0.009655	9.56	201.19	81.56	1.00
Reach-1	276	100-year	1900.00	5453.91	5459.82	5459.73	5461.55	0.009269	10.55	180.43	53.19	0.97
Reach-1	274	100-year	1900.00	5454.04	5459.67	5459.67	5461.21	0.008723	10.06	217.87	91.78	0.95
Reach-1	272	100-year	1900.00	5449.36	5457.02	5456.16	5459.46	0.008981	12.54	152.79	33.79	0.84
Reach-1	271	100-year	1900.00	5449.36	5457.82	5457.82	5458.97	0.005786	9.72	435.02	226.52	0.64
Reach-1	265		Culvert									
Reach-1	250	100-year	1900.00	5435.21	5445.85	5443.60	5446.32	0.001851	5.54	398.15	136.91	0.44
Reach-1	231	100-year	1900.00	5434.26	5443.33	5443.33	5445.52	0.007911	12.21	219.31	83.05	0.86
Reach-1	230	100-year	1900.00	5433.44	5441.02	5440.16	5443.49	0.008603	12.62	153.54	38.39	0.83
Reach-1	225		Culvert									
Reach-1	220	100-year	1900.00	5432.65	5440.54	5440.54	5442.00	0.005661	10.80	401.59	174.63	0.69

HEC-RAS Plan: PR10.15 River: RIVER-1 Reach: Reach-1 Profile: 100-year (Continued)

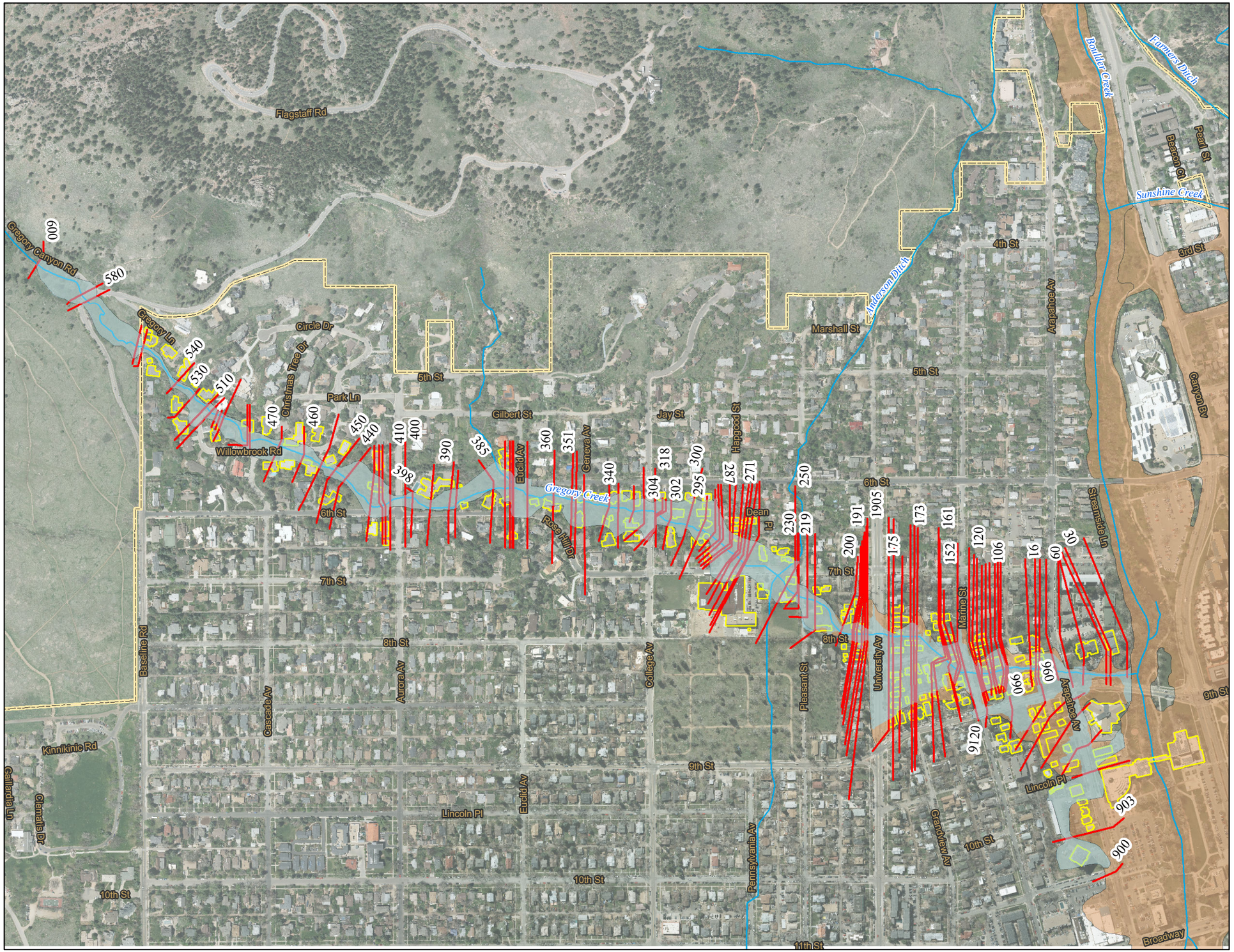
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	219	100-year	1900.00	5431.60	5437.88	5437.88	5439.07	0.008434	9.89	372.60	185.56	0.94
Reach-1	200	100-year	1900.00	5420.59	5427.11	5427.11	5428.64	0.010287	9.94	191.79	65.73	1.01
Reach-1	197	100-year	1900.00	5419.10	5425.97	5425.97	5427.63	0.008277	10.54	226.03	95.44	0.95
Reach-1	195	100-year	1900.00	5419.10	5425.81	5425.81	5427.17	0.009218	9.50	231.23	102.62	0.97
Reach-1	194	100-year	1900.00	5416.10	5425.02	5425.02	5426.43	0.010802	9.60	220.55	100.49	1.01
Reach-1	193	100-year	1900.00	5416.10	5424.32	5424.32	5425.75	0.009477	9.62	212.01	118.00	0.97
Reach-1	191	100-year	1900.00	5413.10	5422.32	5420.34	5423.98	0.008925	10.36	183.36	43.21	0.89
Reach-1	190.5	100-year	1900.00	5413.10	5422.57	5420.01	5423.70	0.007757	8.53	222.80	61.64	0.79
Reach-1	185		Culvert									
Reach-1	180	100-year	2092.00	5410.57	5417.80	5417.80	5421.27	0.010595	14.94	139.99	115.90	0.99
Reach-1	177	100-year	2092.00	5407.62	5417.11	5417.11	5418.61	0.009096	9.85	233.41	180.07	0.93
Reach-1	175	100-year	2092.00	5407.01	5415.58	5415.58	5416.45	0.008278	7.93	448.20	352.76	0.88
Reach-1	173	100-year	2092.00	5405.97	5413.64	5413.64	5414.40	0.005475	9.79	859.62	507.53	0.69
Reach-1	172	100-year	2092.00	5403.83	5412.41	5412.41	5413.34	0.004440	9.19	716.99	445.31	0.64
Reach-1	171	100-year	2092.00	5402.97	5410.95	5410.95	5412.16	0.004092	9.37	496.81	373.06	0.60
Reach-1	165		Culvert									
Reach-1	161	100-year	2092.00	5397.22	5404.79	5404.46	5405.63	0.006978	7.37	283.83	111.73	0.81
Reach-1	155	100-year	2092.00	5394.73	5403.64	5403.64	5405.17	0.009117	10.04	247.12	124.43	0.94
Reach-1	152	100-year	2092.00	5394.34	5403.26	5403.26	5404.47	0.006661	9.24	385.05	249.69	0.81
Reach-1	151	100-year	2092.00	5392.99	5402.83		5403.48	0.002831	7.01	550.33	227.35	0.55
Reach-1	150	100-year	2092.00	5390.64	5401.79	5401.79	5403.30	0.004744	10.82	454.03	217.63	0.63
Reach-1	130	100-year	2092.00	5390.64	5401.48	5401.48	5402.36	0.003637	9.04	817.90	557.72	0.56
Reach-1	125		Culvert									
Reach-1	120	100-year	2092.00	5389.74	5397.45	5396.60	5399.65	0.007967	11.97	212.83	126.07	0.84
Reach-1	119.9		Lat Struct									
Reach-1	117	100-year	2092.00	5389.74	5397.96	5396.96	5399.08	0.004276	8.65	334.33	168.68	0.68
Reach-1	113	100-year	2092.00	5387.24	5396.45	5396.45	5398.91	0.008361	12.75	209.99	86.89	0.91
Reach-1	110	100-year	2092.00	5386.36	5394.45	5394.45	5395.96	0.006606	10.80	390.61	168.30	0.83
Reach-1	108	100-year	2083.72	5386.25	5394.37	5394.37	5395.48	0.004925	10.75	646.16	327.82	0.71
Reach-1	106	100-year	2043.72	5384.61	5393.55	5393.55	5394.75	0.004946	10.58	592.68	300.27	0.69
Reach-1	104	100-year	1954.02	5383.20	5392.15	5392.15	5393.42	0.005048	10.56	536.27	266.25	0.69
Reach-1	102	100-year	1952.06	5381.00	5388.50	5387.41	5390.74	0.007680	11.99	163.85	28.97	0.79
Reach-1	100	100-year	1952.06	5381.00	5387.78	5387.78	5390.59	0.010566	13.49	156.74	39.91	0.93
Reach-1	95		Culvert									
Reach-1	91	100-year	1952.06	5377.55	5385.12	5384.52	5387.88	0.010140	13.31	146.61	20.68	0.88
Reach-1	89.9		Lat Struct									
Reach-1	70	100-year	1850.92	5377.04	5385.67	5385.67	5386.79	0.003888	9.70	546.87	347.43	0.65
Reach-1	65	100-year	1752.34	5374.19	5383.84	5383.84	5385.74	0.005858	11.66	272.99	115.94	0.71
Reach-1	60	100-year	1679.33	5373.01	5380.88	5378.51	5381.90	0.003104	8.22	270.89	100.28	0.53
Reach-1	55		Culvert									
Reach-1	51	100-year	1679.33	5372.70	5378.28	5378.28	5381.01	0.029065	13.28	126.50	100.21	0.99
Reach-1	49.9		Lat Struct									
Reach-1	45	100-year	1510.80	5369.49	5376.54	5376.54	5377.87	0.023963	10.03	217.20	93.11	0.82
Reach-1	40	100-year	1482.98	5363.57	5368.66	5367.76	5370.04	0.023774	9.44	157.02	31.72	0.75
Reach-1	35		Bridge									
Reach-1	30	100-year	1482.98	5362.31	5366.24	5366.24	5367.93	0.038683	10.45	141.90	42.31	1.01
Reach-1	10	100-year	1482.98	5356.30	5361.52	5361.52	5363.45	0.029831	11.29	145.87	44.68	0.95


GREGORY CANYON CREEK CITY ALT Plan: Proposed Conditions v10.15 10/22/2015
RIVER-1 Reach-1
Legend
WS 100-year
WS 10-year
Ground
Elevation (ft)
5800
5700
5600
5500
5400
5300
0
1000
2000
3000
4000
5000
6000
7000
Main Channel Distance (ft)
Downstream face o...
Channel Surveyed Ap...
Channel Surveyed Apr...
Culvert ID C12 - Ara...
Downstream face of al...
Culvert ID C11 - Alley...
Downstream face of Marine...
Culvert ID C 10 - Marine ...
Downstream face of Crossing...
Culvert ID - C9 8th Street a...
Downstream face of University ...
Culvert ID C8 - University Aven...
Cross section defined using 2008 ...
Channel Surveyed April 2005
Culvert ID C7 - Pleasant Street
Defined using 2008 survey and lidar c...
Culvert ID C6 - 7th Street
Downstream face of Pennsylvania Ave. Crossi...
Channel Surveyed April 2005, Upstream face of...
2008 surveyed added for area on left bank betwe...
Channel Surveyed April 2005
Channel Surveyed April 2005
Channel Surveyed April 2005, Downstream face of Pr...
Culvert ID C4 - College Avenue,
Section added with survey from 12/19/08
Channel Surveyed April 2005
Channel Surveyed April 2005
Channel Surveyed April 2005
Channel Surveyed April 2005
Channel Surveyed April 2005, Downstream face of Euclid Ave. Cr...
Culvert ID C3 - Euclid Avenue
Downstream face of Aurora Crossing
Culvert ID C2 - Aurora Ave - Existing
Downstream face of Willowbrook Road Crossing
Culvert ID C1 - Willowbrook Road - Existing
Downstream face of Private Drive crossing - west side of Willowbrook Rd.
main channel of section updated with field survey dated 9/11/09.
Channel Surveyed April 2005, Downstream face of cul-de-sac NE of Willowbrook Road
Channel Surveyed April 2005
Downstream face of Private Drive crossing at Old Baseline Road
Downstream face of Flagstaff Road Crossing
Regulatory section 600 converted from NGVD29 to NAVD88 by adding 3.2-ft.

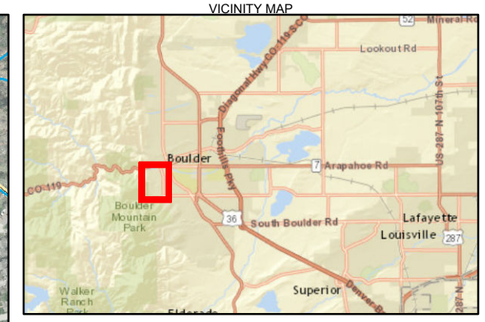
Riprap Sizing

UDFCD (Sections 4.4.2.3 and 4.1.6.1 Pg MD-63 and MD-47, Eqns MD-13 and MD-10 and Table MD-10)

																UDFCD Results				
																INSIDE BEND		OUTSIDE BEND		
	Required Input											UDFCD Calculations				V Not Adjusted		V Adjusted If Applic		
Location	River Station	Q Total	Channel Slope	Depth	Channel Velocity	Froude Number [1]	Channel Top Width	Bank Slope	Spec Gravity (2.5 min)	Riprap Angle of Repose [2]	Bend Radius (0 if N/A)	R_c/T	Channel Velocity	Adjusted Velocity (MD-10)	Velocity Used [3]	UDFCD D50 (MD-13)	Riprap Type	UDFCD D50 (MD-13)	Riprap Type	RIPRAP TO USE
		(cfs)	%	(ft)	(ft/s)		(ft)	XH:1V		(deg)	(ft)		(ft/s)	(ft/s)	(ft/s)	(ft)		(ft)		
Existing	600	400	11%	3.48	8.48	0.97	24.17	1	2.5	39.5	0	0.00	8.48	18.45	8.48	0.98	M	0.98	M	
Existing	590	400	1%	14.86	1.09	0.05	103.66	1	2.5	39.5	0	0.00	1.09	2.37	1.09	0.01	VL	0.01	VL	
Existing	580	400	8%	5.14	12.75	0.99	23.86	1	2.5	39.5	0	0.00	12.75	27.74	12.75	2.02	Grouted	2.02	Grouted	
Existing	560	400	4%	8.02	3.66	0.26	106.85	1	2.5	39.5	0	0.00	3.66	7.96	3.66	0.13	VL	0.13	VL	
Existing	550	400	8%	4.51	9.12	0.85	31.7	1	2.5	39.5	0	0.00	9.12	19.85	9.12	1.03	H	1.03	H	
Existing	540	400	8%	4.77	8.57	1	30.3	1	2.5	39.5	0	0.00	8.57	18.65	8.57	0.89	M	0.89	M	
Existing	530	400	7%	4.95	8.57	1	20.54	1	2.5	39.5	0	0.00	8.57	18.65	8.57	0.87	M	0.87	M	
Existing	520	400	6%	11.37	3.77	0.21	134.61	1	2.5	39.5	0	0.00	3.77	8.20	3.77	0.15	VL	0.15	VL	
Existing	510	400	11%	6.82	14.67	0.99	39.62	1	2.5	39.5	0	0.00	14.67	31.92	14.67	2.93	Grouted	2.93	Grouted	
Existing	508	400	5%	4.4	7.35	1	32.4	1	2.5	39.5	0	0.00	7.35	15.99	7.35	0.54	L	0.54	L	
Existing	507	400	5%	3.78	7.41	1.01	33.53	1	2.5	39.5	0	0.00	7.41	16.12	7.41	0.56	L	0.56	L	
Existing	505	400	7%	3.76	7.03	0.95	46.95	1	2.5	39.5	0	0.00	7.03	15.30	7.03	0.57	L	0.57	L	
Existing	500	400	0%	8.73	3.71	0.22	76.26	1	2.5	39.5	0	0.00	3.71	8.07	3.71	0.00	VL	0.00	VL	
Existing	490	400	11%	3.7	10.81	0.99	10	1	2.5	39.5	0	0.00	10.81	23.52	10.81	1.58	VH	1.58	VH	
Existing	470	400	3%	11.46	2.05	0.11	58.95	1	2.5	39.5	0	0.00	2.05	4.46	2.05	0.04	VL	0.04	VL	
Existing	460	400	7%	3.97	11.19	0.99	14.56	1	2.5	39.5	0	0.00	11.19	24.35	11.19	1.45	H	1.45	H	
Existing	455	495	7%	4.81	8.91	1	22.58	1	2.5	39.5	0	0.00	8.91	19.39	8.91	0.94	M	0.94	M	
Existing	450	495	4%	5.17	9.02	0.99	21.23	1	2.5	39.5	0	0.00	9.02	19.63	9.02	0.81	M	0.81	M	
Existing	440	495	5%	3.93	8.12	1.01	30.12	1	2.5	39.5	0	0.00	8.12	17.67	8.12	0.68	L	0.68	L	
Existing	436	495	12%	3.08	8.12	0.95	68.33	1	2.5	39.5	0	0.00	8.12	17.67	8.12	0.92	M	0.92	M	
Existing	431	495	3%	4.77	6.49	0.52	19.33	1	2.5	39.5	0	0.00	6.49	14.12	6.49	0.37	VL	0.37	VL	
Existing	420	495	20%	3.11	9.94	0.99	20.45	1	2.5	39.5	0	0.00	9.94	21.63	9.94	1.66	VH	1.66	VH	
Existing	410	495	3%	3.78	5.29	0.48	33.18	1	2.5	39.5	0	0.00	5.29	11.51	5.29	0.24	VL	0.24	VL	
Existing	400	495	0%	2.77	4.25	0.48	54.94	1	2.5	39.5	0	0.00	4.25	9.25	4.25	0.05	VL	0.05	VL	
Existing	398	495	9%	1.55	8.33	1.46	67.05	1	2.5	39.5	0	0.00	8.33	18.13	8.33	0.88	M	0.88	M	
Existing	395	495	4%	3.75	7.65	1.01	36.03	1	2.5	39.5	0	0.00	7.65	16.65	7.65	0.55	L	0.55	L	
Existing	390	495	4%	3.71	7.02	0.88	85.25	1	2.5	39.5	0	0.00	7.02	15.28	7.02	0.46	VL	0.46	VL	
Existing	389	495	6%	3.05	7.79	1.05	84.99	1	2.5	39.5	0	0.00	7.79	16.95	7.79	0.66	L	0.66	L	
Existing	385	495	7%	2.98	8.03	1.16	110.19	1	2.5	39.5	0	0.00	8.03	17.47	8.03	0.77	M	0.77	M	M
	383	495	15%	2.39	8.17	0.99	38.63	1	2.5	39.5	0	0.00	8.17	17.78	8.17	1.00	H	1.00	H	Drop
	382	495	0%	4.3	9.4	1.01	19.47	1	2.5	39.5	0	0.00	9.40	20.45	9.40	0.00	VL	0.00	VL	Drop
	381	495	26%	3.98	9.17	1	20.85	1	2.5	39.5	0	0.00	9.17	19.95	9.17	1.53	VH	1.53	VH	Drop
	380	495	0%	3.99	9	0.99	21.4	1	2.5	39.5	0	0.00	9.00	19.58	9.00	0.23	VL	0.23	VL	Culvert
	370	495	11%	2.67	8.75	0.99	50.16	1	2.5	39.5	0	0.00	8.75	19.04	8.75	1.04	H	1.04	H	H
Existing	360	495	5%	4.08	8.54	1	25.76	1	2.5	39.5	0	0.00	8.54	18.58	8.54	0.75	L	0.75	L	
Existing	352	495	2%	4.04	8.63	0.87	33.26	1	2.5	39.5	0	0.00	8.63	18.78	8.63	0.59	L	0.59	L	
Existing	351	495	8%	3.74	8.16	1	29.33	1	2.5	39.5	0	0.00	8.16	17.76	8.16	0.82	M	0.82	M	
Existing	350	495	6%	3.98	8.71	1	24.2	1	2.5	39.5	0	0.00	8.71	18.95	8.71	0.86	M	0.86	M	
Existing	342	495	4%	4.48	8.73	0.92	33.41	1	2.5	39.5	0	0.00	8.73	19.00	8.73	0.71	L	0.71	L	
Existing	340	495	7%	4.03	8.9	1	22.7	1	2.5	39.5	0	0.00	8.90	19.37	8.90	0.92	M	0.92	M	
Existing	334	495	4%	4.09	9.02	1.01	22.22	1	2.5	39.5	0	0.00	9.02	19.63	9.02	0.78	M	0.78	M	
Existing	330	495	1%	5.15	6.55	0.51	28.74	1	2.5	39.5	0	0.00	6.55	14.25	6.55	0.25	VL	0.25	VL	
Existing	318	600	6%	3.77	10.9	0.99	40.1	1	2.5	39.5	0	0.00	10.90	23.72	10.90	1.32	H	1.32	H	
Existing	304	600	0%	5.21	2.91	0.26	75.75	1	2.5	39.5	0	0.00	2.91	6.33	2.91	0.00	VL	0.00	VL	
Existing	302	600	6%	3.02	7.55	0.88	71.83	1	2.5	39.5	0	0.00	7.55	16.43	7.55	0.65	L	0.65	L	
Existing	301	600	4%	2.94	8.44	1	32.46	1	2.5	39.5	0	0.00	8.44	18.37	8.44	0.71	L	0.71	L	
Existing	300	600	6%	3.34	6.62	0.87	111.08	1	2.5	39.5	0	0.00	6.62	14.41	6.62	0.49	VL	0.49	VL	
Existing	295	600	3%	3.36	6.4	0.89	109.08	1	2.5	39.5	0	0.00	6.40	13.93	6.40	0.37	VL	0.37	VL	
Existing	291	600	15%	2.85	6.98	0.86	118.87	1	2.5	39.5	0	0.00	6.98	15.19	6.98	0.73	L	0.73	L	Drop
	290.5	600	12%	5.54	8.32	0.72	136.53	1	2.5	39.5	0	0.00	8.32	18.10	8.32	0.96	M	0.96	M	M
	287	600	0%	8.21	5.24	0.4	162.11	1	2.5	39.5	0	0.00	5.24	11.40	5.24	0.00	VL	0.00	VL	M
	283	600	59%	4.82	8.78	0.94	50.16	1	2.5	39.5	0	0.00	8.78	19.11	8.78	1.86	VH	1.86	VH	Drop
	282	600	2%	4.2	10.4	1.01	17.35	1	2.5	39.5	0	0.00	10.40	22.63	10.40	0.79	M	0.79	M	M
	278	600	17%	2.65	7.3	1.01	50.48	1	2.5	39.5	0	0.00	7.30	15.88	7.30	0.84	M	0.84	M	Drop
	276	600	0%	3.81	6.74	0.75	35.75	1	2.5	39.5	0	0.00	6.74	14.67	6.74	0.00	VL	0.00	VL	M
	274	600	15%	2.96	8.5	1.01	31.93	1	2.5	39.5	0	0.00	8.50	18.50	8.50	1.10	H	1.10	H	Drop
	272	600	0%	5.14	6.07	0.48	20.11	1	2.5	39.5	0	0.00	6.07	13.21	6.07	0.00	VL	0.00	VL	M
	271	600	6%	4.85	7.14	0.58	17.97	1	2.5	39.5	0	0.00	7.14	15.54	7.14	0.57	L	0.57	L	Culvert
	250	600	1%	5.02	9.46	0.8	20.49	1	2.5	39.5	0	0.00	9.46	20.58	9.46	0.56	L	0.56	L	M
	231	600	15%	4.42	11.07	1	14.34	1	2.5	39.5	0	0.00	11.07	24.09	11.07	1.87	VH	1.87	VH	Drop
	230	600	2%	4.61	6.72	0.56	20.2	1	2.5	39.5	0	0.00	6.72	14.62	6.72	0.33	VL	0.33	VL	Culvert
	220	600	2%	3.35	10.26	1	17.75	1	2.5	39.5	0	0.00	10.26	22.33	10.26	0.86	M	0.86	M	M
	219	600	5%	3.9	8.85	0.94	57.35	1	2.5	39.5	0	0.00	8.85	19.26	8.85	0.83	M	0.83	M	M
Existing	200	600	3%	4.25	8.17	1	35.69	1	2.5	39.5	0	0.00	8.17	17.78	8.17	0.55	L	0.55	L	
	197	600	0%	4.02	9.01	1	26.56	1	2.5	39.5	0	0.00	9.01	19.61	9.01	0.00	VL	0.00	VL	Drop
	195	600	20%	3.65	9.61	1.01	22.07	1	2.5	39.5	0	0.00	9.61	20.91	9.61	1.54	VH	1.54	VH	Drop
	194	600	0%	5.01	9.02	0.79	16.62	1	2.5	39.5	0	0.00	9.02	19.63	9.02	0.00	VL	0.00	VL	Drop
	193	600	17%	4.26	10.41	1.01	17.4	1	2.5	39.5	0	0.00	10.41	22.65	10.41	1.72	VH	1.72	VH	Drop
	191	600	0%	5.07	6.77	0.56	19.42	1	2.5	39.5	0	0.00	6.77	14.73	6.77	0.00	VL	0.00	VL	Drop
	190.5	600	2%	5.09	6.27	0.5	19.57	1	2.5	39.5	0	0.00	6.27	13.64	6.27	0.32	VL	0.32	VL	Culvert
	180	673	23%	3.4	10.42	1	19.81	1	2.5	39.5	0	0.00	10.42	22.67	10.42	1.91	VH	1.91	VH	H
	177	673	1%	4.76	11.44	1.01	14.61	1	2.5	39.5	0	0.00	11.44	24.89	11.44	0.89	M	0.89	M	M
	175	673	2%	4.77	11.42	1.01	14.73	1	2.5	39.5	0	0.00	11.42	24.85	11.42	0.99	M	0.99	M	Drop
	173	673	13%	4.93	10.81	0.94	32.51	1	2.5	39.5	0	0.00	10.81	23.52	10.81	1.67	VH	1.67	VH	Drop
	172	673	5%	3.97	10.73	1.01	17.78	1	2.5	39.5	0	0.00	10.73	23.35	10.73	1.21	H	1.21	H	H
	171	673	3%	5.51	6.43	0.48	25.18	1	2.5	39.5	0	0.00	6.43	13.99	6.43	0.38	VL	0.38	VL	Culvert
	161	673	8%	3.43	10.36	0.99	22.73	1	2.5	39.5	0	0.00	10.36	22.54	10.36	1.31	H	1.31	H	Drop
	155	673	1%	5.49	9.11	0.78	17.3	1	2.5	39.5	0	0.00	9.11	19.82	9.11	0.56	L	0.56	L	M
	152	673	3%	4.78	11.46	1.01	14.55	1	2.5	39.5	0	0.00	11.46	24.94	11.46	1.17	H	1.17	H	H
	151	673	9%	4.77	11.46	1.01	14.58	1	2.5	39.5	0	0.00	11.46	24.94	11.46	1.67	VH	1.67	VH	Drop
	150	673	0%	6.26	8.67	0.68	15.25	1	2.5	39.5	0	0.00	8.67	18.87	8.67	0.00	VL	0.00	VL	Drop
	130	673	1%	4.94	11.53	0.99	13.87	1	2.5	39.5	0	0.00	11.53	25.09	11.53	0.83	M	0.83	M	Culvert
	120	673	0%	3.96	8.13	0.73	22.03	1	2.5	39.5	0	0.00	8.13	17.69	8.13	0.00	VL	0.00	VL	M
	117	673	39%	3.29	9.88	1	22.58	1	2.5	39.5	0	0.00	9.88	21.50	9.88	2.05	Grouted	2.05	Grouted	Drop
	113	673	2%	4.71	11.27	1	15.19	1	2.5	39.5	0	0.00	11.27	24.52	11.27	1.04	H	1.04	H	Drop
	110	673	1%	5.45	8.03	0.86	44.75	1	2.5	39.5	0	0.00	8.03	17.47	8.03	0.33	VL	0.33	VL	M
	108	673	13%	5.02	9.48	0.82	72.44	1	2.5	39.5	0	0.00	9.48	20.63	9.48	1.29	H	1.29	H	Drop
	106	673	3%	4.73	11.27	1	15.23	1	2.5	39.5	0	0.00	11.27	24.52	11.27	1.15	H	1.15	H	Drop
	104	673	13%	4.76	11.32	1	15	1	2.5	39.5	0	0.00	11.32	24.63	11.32	1.83	VH	1.83	VH	Drop
	102	673	0%	5.99	5.23	0.38	22.27	1	2.5	39.5	0	0.00	5.23	11.38	5.23	0.00	VL	0.00	VL	Drop
	100	673	3%	5.94	5.39	0.4	22.07	1	2.5	39.5	0	0.00	5.39	11.73	5.39	0.26	VL	0.26	VL	Culvert
	91	673	1%	5.92	5.95	0.44	19.99	1	2.5	39.5	0	0.00	5.95	12.95	5.95	0.22	VL	0.22	VL	M
	70	673	11%	4.65	10.63	1.01	18.2	1	2.5	39.5	0	0.00	10.63	23.13	10.63	1.56	VH	1.56	VH	Drop
	65	673	2%	4.81	11.46	1	14.41	1	2.5	39.5	0	0.00	11.46	24.94	11.46	0.97	M	0.97	M	M
	60	673	0%	5.2	5.71	0.44	25.61	1	2.5	39.5	0	0.00	5.71	12.42	5.71	0.15	VL	0.15	VL	Culvert
	51	673	4%	4.21	7.05	0.61	56.39	1	2.5	39.5	0	0.00	7.05	15.34	7.05	0.49	VL	0.49	VL	M
	45	672.32	5%	5.03	9.51	1.02	26.16	1	2.5	39.5	0	0.00	9.51	20.69	9.51	0.94	M	0.94	M	M
	40	672.32	0%	3.01	7.32	0.75	31.02	1	2.5	39.5	0	0.00	7.32	15.93	7.32	0.00	VL	0.00	VL	Culvert
	30	672.32	7%	2.38	8.38	1.01	37.46	1	2.5	39.5	0	0.00	8.38	18.23	8.38	0.82	M	0.82	M	M
	10	672.32	2%	3.42	9	0.99	32.82	1	2.5	39.5	0	0.00	9.00	19.58	9.00	0.56	L	0.56	L	M



VICINITY MAP



LEGEND

- Proposed Masterplan 100-year Floodplain
- City 100 Year Floodplain
- Structures Adjacent to the Floodplain
- Cross Section
- Creeks and Streams
- City Limits

N

0 300 600 Feet

FIGURE 1
Proposed Master Plan100-YR Floodplain
Gregory Canyon Creek Flood Mitigation

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Appendix C
Updated Cost

Reach	Description	Culvert / Bridge Improvements	Channel Improvements	Utility Relocation	Landscaping	Engineering / Contingency	Total
R - 1	Install private bridge	$ 96,525.00	Included with Bridge Cost	$ 6,176.25	$ 27,000.00	$ 119,201.25	$ 248,902.50
R - 2	Culvert improvements at Arapahoe Avenue and associated channel improvements	$ 180,933.50	Included with Culvert Cost	$ 11,691.25	$ 52,890.65	$ 225,641.25	$ 471,156.65
R - 3	Culvert improvements at Alley Way and upstream and downstream drop structures / channel improvements	$ 616,969.00	$ 190,461.00	$ 52,811.50	$ 38,800.00	$ 826,264.50	$ 1,725,306.00
R - 4	Culvert improvements at Marine Street and upstream drop structures / channel improvements	$ 183,903.20	$ 319,960.98	$ 26,438.20	$ 24,900.00	$ 510,256.40	$ 1,065,458.78
R - 5	Culvert improvements at 8th Street and upstream channel improvements	$ 374,322.20	$ 331,133.00	$ 47,557.75	$ 35,700.00	$ 724,864.75	$ 1,513,577.70
R - 6	University Channel Improvements and upstream drop structures / channel improvements	$ 257,765.20	$ 209,548.00	$ 40,275.00	$ 57,100.00	$ 584,309.00	$ 1,148,997.20
R - 7	Culvert improvements at Pleasant Street and associated channel improvements	$ 131,316.00	$ 89,446.00	$ 22,105.60	$ 11,350.00	$ 233,639.00	$ 487,856.60
R - 8	Culvert improvements at 7th Street, upstream drop structures and downstream channel improvements	$ 447,235.40	$ 341,546.96	$ 51,849.00	$ 38,200.00	$ 807,687.20	$ 1,686,518.56
R - 9	Pedestrian bridge crossing and drop structure improvements	$ 125,654.20	$ 88,052.00	$ 11,215.30	$ 10,600.00	$ 216,455.50	$ 451,977.00
R - 10	Culvert improvements at College Avenue and upstream drop structure	$ 148,010.50	$ 80,711.00	$ 22,546.00	$ 12,150.00	$ 242,092.80	$ 505,510.30
R - 11	Culvert improvements at Euclid Avenue and upstream drop structures	$ 116,804.40	$ 165,915.00	$ 25,360.95	$ 14,500.00	$ 296,466.75	$ 619,047.10
Other	Pipe Anderson Ditch to the east of 7th Street		$ 23,450.00		$ 1,172.50	$ 18,760.00	$ 43,382.50
Other	Sediment Traps Upstream of Willowbrook Road (C-1)		$ 46,527.00		$ 2,326.35	$ 37,221.60	$ 86,074.95

Total: $ 9,924,308.39