Cherry Creek at 12-Mile Park
Stream Reclamation Plan

Prepared For:

CHERRY CREEK
BASIN WATER
QUAILTY AUTHORITY

Prepared By:

CH2MHILL

February 2012

CH2M HILL
9193 South Jamaica St
Englewood, CO 80112
Tel 303-771-0900

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Project Number 407259

William P. Ruzzo, P.E.
Cherry Creek Basin Water Quality Authority
8390 East Crescent Parkway, Suite 500
Greenwood Village, Colorado 80111

Subject: Response to Comments on the Cherry Creek at 12-Mile Park Draft Stream Reclamation Plan

Dear Mr. Ruzzo
The purpose of this letter is to address the comments received on the Cherry Creek at 12-Mile Park Draft Stream Reclamation Plan from yourself and Tim Metzger/Cherry Creek State Park (CCSP). The following comments, with responses, were received:

Comments from Cherry Creek Basin Water Quality Authority (Bill Ruzzo)
Comment 1:
The reference list should include my analysis of water quality benefits, even though it is in the text and included as Appendix I. Also, the version in Appendix I was labeled "draft", which was subsequently accepted by the TAC and is, therefore, final. However, having it labeled as draft should not affect the report.

Response 1:
The analysis of water quality benefits has been included in the references list in the report.

Comment 2:
A detail of the creek access for Phase II was not provided, but a description is included in the text.

Response 2:
The creek access may be revised with final design; therefore a detail is not included in the Stream Reclamation Plan Report but will be included in the final design for Phase 2.

Comments from Cherry Creek State Parks (Tim Metzger):
Comment 3:
On sheet 11 on the site access detail it looks like they are all rock steps. I checked my notes and we never really talked about what the access point would look like. I always thought they would be treated timber framed steps similar to the ones at Tower Loop. We can discuss the pros and cons of each material.

Response 3:
Access materials, including boulders, timber, and other materials will be reviewed during the final design phase. The selected material will be included in final design detail drawings. For budgeting purposes rock steps were assumed in the Stream Reclamation Plan to be conservative.

Comment 4:
On the alternatives evaluation report the trail realignment along phase two was part of the Basin Authority project. In the stream reclamation report the trail realignment is shown as "done by others". Did we discuss this and determine the trail realignment that is needed because of the back sloping of the stream reclamation plan was Parks responsibility?

Response 4:

The Phase 2 Preliminary Construction Drawings and cost estimate have been revised to include the trail realignment as a part of the Cherry Creek Basin Water Quality Authority Stream Reclamation Plan.

Comment 5:
In several meetings we discussed the need for fence to be placed both on top near the trail to prevent dogs from shortcutting the access point and below to prevent dogs from going straight up the hill. In your plan there is a fence on top but not below. It is a tough balance of giving the vegetation enough protection to get started and having miles of fence everywhere. In the cross section where there are willows or boulders we might not need a bottom fence. In cross section B there are no willows to prevent dogs from just going uphill. This cross section does have soil riprap and an erosion control blanket so maybe a fence isn't needed here either. We can discuss.

Response 5:
Permanent and temporary fencing at the toe of the channel slope will be reviewed during the final design phase.

This letter responds to each of the comments received by the primary reviewers, Bill Ruzzo and Tim Metzger, for the Cherry Creek at 12-Mile Park Draft Stream Reclamation Plan. Each comment was either incorporated into the Final Stream Reclamation Plan or will be addressed during final design for Phase 2.

Sincerely,

CH2M HILL

Scott D Yanagihara

Scott Yanagihara
Project Manager

c: Tim Metzger/Cherry Creek State Park

Table of Contents

List of Appendices

List of Acronyms

ADA	Americans with Disabilities Act
CCBWQA	Cherry Creek Basin Water Quality Authority
CCSP	Cherry Creek State Park
DTM	Digital Terrain Model
DOLA	Dog Off Leash Area
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
HEC-RAS	Hydrologic Engineering Center – River Analysis System
MSE	Mechanically Stabilized Earth
TAC	Technical Advisory Committee
UDFCD	Urban Drainage and Flood Control District
ULTO	Ute Ladies'-Tresses Orchid
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

Exhibits and Figures

Tables

1. Purpose and Scope

The purpose of this Stream Reclamation Plan is to document and present alternatives for restoring a segment of Cherry Creek located at 12-Mile Park, at the upstream end of Cherry Creek State Park (CCSP). **Exhibit 1-1** shows the project area. The existing eastern or right bank of the channel has degraded in locations resulting in active erosion. The channel has also experienced a breakout or breach of the right bank of the low flow channel into the floodplain resulting in overbank erosion and additional environmental damage. Cherry Creek Basin Water Quality Authority (CCBWQA) contracted CH2M HILL to develop a recommended plan to stabilize the eroded banks and restore the channel to the historic alignment. The objectives for the project area are:

- Provide stream reclamation of Cherry Creek defined as enhancing water quality benefits through stream bank stabilization, by protecting and improving riparian vegetation, and providing more frequent connections between the main channel and the floodplain
- Stabilize the bed profile and outer channel banks to prevent bank erosion from migrating further upstream or downstream
- Identify bank restoration requirements for the breached area of the creek to allow for temporary or permanent repairs in a timely fashion that are consistent with the overall Stream Reclamation Plan and that restores the creek flow to the pre-breached alignment
- With the approval of the Authority Representatives, evaluate and assess pertinent information by others and acknowledge the information and source(s) in the Stream Reclamation Plan
- Minimize erosion, sediment transport, and bacterial contamination from the Dog Off Leash Area (DOLA) of 12-Mile Park and integrate the CCSP dog management plan into the Stream Reclamation Plan
- Minimize operation and maintenance requirements while preserving long term performance of the stream reclamation

The Alternatives Analysis report was presented at the June 2011 Technical Advisory Committee (TAC) meeting. The recommended alternatives were approved at that time. The selected alternatives are carried forward in this plan with the development of Construction Drawings and Preliminary Design Drawings presented in **Appendix A and B**, respectively. The engineer’s cost opinion is presented in Section 5.

EXHIBIT 1-1
Project Location Map
Cherry Creek Stream Reclamation at 12-Mile Park Project

2. Study Area

Cherry Creek is a major drainageway serving as the principal means of conveying runoff from south to north through Douglas, Arapahoe, and Denver Counties to the South Platte River. Cherry Creek Reservoir was constructed by the United States Army Corps of Engineers (USACE) as a flood control facility to protect downstream communities from catastrophic flooding. Since the construction of the reservoir, CCSP has become a premier recreational facility for the State of Colorado. The reservoir can experience significant nutrient loading from the contributing watershed that damages the health of the reservoir. The contributing area of the watershed from the upper reaches of Cherry Creek to the upstream limits of CCSP is approximately 361 square miles.

The project area is located at the 12-Mile DOLA located at the southern end of CCSP. The project includes approximately 3,000 feet of stream bank restoration adjacent to the DOLA. At the northern end of the project Cherry Creek has left its banks and established a new flow path, abandoning more than a mile of the historic flow path threatening the existing habitat. Due to the urgency of repair for the breakout of the channel, the project has been broken into two phases, with Phase 1 being the restoration of the channel alignment and repair of the bank where the Creek has left its banks. Construction Drawings for the Phase 1 area are included with **Appendix A**. Preliminary Design Drawings the remainder of the project are presented in **Appendix B**.

3. Site Assessment

This section provides a brief summary of the findings of the Site Assessment Report. Additional information can be found in the Cherry Creek at 12-Mile Park Site Assessment Report (CH2M HILL, 2010).

Park Use Characteristics

The 12-Mile Park DOLA was originally utilized as a sports dog training facility. As development around the park increased the park use changed to primarily an off leash dog park. Adjacent to the DOLA is an equestrian concessions area where horses are stabled and from which horse owners can access the CCSP trails.

As the park has seen an increase in usage there has been an increase in channel bank degradation as well as conflicts between dogs and horses. In an effort to improve the recreational experience at the park, Colorado State Parks is working to develop a plan for improving the DOLA. The plan, as of the date of this document, includes new dog waste stations, strategic fencing, improved trails, and new creek crossings. The plans for improvements to the DOLA are included as **Appendix C**.

Accessibility to the waters of Cherry Creek from the DOLA along much of the channel length is currently limited, in that any access must be made on foot over fairly steep and uneven terrain. Vertical or steep banks become more difficult or impossible to traverse when wet. There are no formal access points for users with limited mobility or who would qualify under the Americans with Disabilities Act (ADA). CCSP desires that any new facility make a good faith effort to include at least one ADA accessible access point. In the opinion of CCSP, one of the goals of the stream reclamation project is to provide access to the creek for park users and that one of the access points needs to be ADA accessible. The Phase 1 improvements provide this one ADA accessible access point.

Survey

To provide an accurate plan on which to develop comprehensive solutions, a field survey of the project area was performed in August of 2010. The survey limits include the 3,000 feet of Cherry Creek from the existing trail on the east side to the west channel bank as shown in Exhibit 1-1. Additional survey was collected in June of 2011 to provide more accurate detail of the breakout area. The additional survey was used to finalize the construction drawings for Phase 1 of the improvements, and to accurately determine the volume of material required to be removed from the site with the Phase 1 improvements.

Geotechnical Evaluation

CH2M HILL engaged the services of CTL Thompson Inc. to perform a geotechnical evaluation of the project area. CTL Thompson Inc. performed five borings along the eastern channel bank and took soil samples on the channel bank for material characterization and for total phosphorus testing. The geotechnical investigation determined that the borings contained 20 feet to more than 40 feet of silty to very clayey fine to medium grained sand with variable amounts of gravel. Sandstone bedrock was found in the southern most borings around 39 feet below the channel bank elevation.

ACZ Laboratories, Inc. performed phosphorus testing on the topsoil at each boring location. Using the EPA Method to calculate total phosphorus, the total phosphorus varies from 290 to 590 ppm (0.6 to 1.2 lbs/ton).

Recommendations and additional geotechnical detail can be found in the geotechnical report in the Cherry Creek at 12-Mile Park Site Assessment Report (2010). The geotechnical report is included as **Appendix D** to this report.

Site Review

Cherry Creek was observed for channel degradation, channel bank erosion and instability, and extreme degradation. There are no existing channel improvements or hydraulic structures within the project reach.

In general, Cherry Creek through the project area can be distinguished by three different channel reaches. The reaches were identified due to the similarities of channel characteristics through the channel reach. The east bank of Cherry Creek has experienced loss of vegetation and soil as a result of heavy traffic from park users through the entire project area. The project reaches are described below and shown on the recommended plan summary figure:

Reach 1: Upstream Reach – Characterized by a groundwater fed secondary channel that has a lower invert than the mainstem of Cherry Creek. The east bank is characterized by steep to near vertical banks that are 15 – 20 feet above the invert of the secondary channel with vegetation loss due to park use.

EXHIBIT 1-2
Reach 1: Upstream Reach (looking north, downstream)
Cherry Creek Stream Reclamation at 12-Mile Park Project

Reach 2: Downstream Reach – Downstream of Reach 1, the groundwater fed channel joins with the mainstem of Cherry Creek. The eastern bank decreases in height to between five and fifteen feet upstream of the breakout area and approximately three feet in height downstream of the breakout area. The lowered eastern bank provides easier access to the channel, and as a result there are numerous areas where the vegetation has been trampled and soil erosion has resulted.

EXHIBIT 1-3
Reach 2: Downstream Reach (looking south, upstream)
Cherry Creek Stream Reclamation at 12-Mile Park Project

Reach 3: Channel Breakout Reach – Within reach 2, Cherry Creek has experienced a breach of the eastern bank resulting in Cherry Creek leaving the historic flow path and flowing north rather than turning to the west as it has for the last 70 years. Based on discussion with CCSP staff and Park Concessionaires, it appears that the loss of vegetation in the area due to heavy park use resulted in the vulnerable east bank. The east bank overtopped during a large runoff event in 2009. The overtopping caused localized erosion washing out the east bank, creating a new channel with an invert lower than the historic flow path. This breakout of the channel is the most significant problem identified in the site assessment.

EXHIBIT 1-4
Reach 3: Channel Breakout Reach (looking north, downstream)
Cherry Creek Stream Reclamation at 12-Mile Park Project

Environmental Evaluation

Through and in the vicinity of the project reach, Cherry Creek consists of a very active stream system with several braided channels, areas of sand deposition, vertical cut banks, several well-developed wetlands, and densely forested riparian areas. The various elements of the stream system create a mosaic of diverse habitat types.

As previously described, the project area consists of three stream reaches. In Reach 1, wetlands extend across a broad, active floodplain. Wetlands in this reach are dominated by cattail (*Typhus latifolia*) and bulrush (*Schoenoplectus* spp.). Sandbar willow (*Salix exigua*), plains cottonwood (*Populus deltoides* subsp. *monilifera*) and peachleaf willow (*Salix amygdaloides*) create a dense overstory in places. Maps showing wetland areas within the project area are presented in **Appendix E**.

In Reach 2, wetlands on the northeast bank are more confined to narrow margins along the channel and are dominated by sandbar willow and reed canarygrass (*Phalaroides arundanaceae)*. Wider sandbar willow and plains cottonwood wetlands occur along the southwest bank and along the toe of the south bank of a groundwater-fed channel just upstream of Reach 2. West of the new breakout channel, surface water no longer consistently flows and shallow-rooted wetland vegetation along the historic channel will likely decrease. Deeper-rooted trees and shrubs will likely persist, but the number of new seedlings and saplings may decrease over time. Currently the damp sandy channel bottom provides an excellent growth medium for the establishment of willow and cottonwood seedlings.

The new channel in Reach 3 flows through an area that was previously a cattail/bulrush wetland and a small pond surrounded by a broad sandbar willow wetland. Sediment deposited by the new channel has buried wetland vegetation along its length and in a wetland at its northern extent. If sediment deposition is eliminated and the sediment is not too deep, wetland vegetation will reestablish in the deposition areas. A more detailed environmental discussion is provided in the Site Assessment Report (2010).

The Cherry Creek riparian corridor provides potential habitat for two species listed as threatened under the Endangered Species Act: Ute ladies'-tresses orchid (ULTO) (*Spiranthes diluvialis*) and Preble's meadow jumping mouse (*Zapus hudsonius preblei*). Although conditions along Cherry Creek in Douglas and Arapahoe counties appear to be suitable for ULTO, it is not known to be present. Along Colorado's Front Range, Preble's is found below 7,800 feet in elevation, generally in lowlands with medium to high moisture along permanent or intermittent streams. Preble's is known to occur along Cherry Creek in Douglas County and was captured on Cherry Creek about four miles south of the project area in 2000. Although known to be present on Cherry Creek in Douglas County, Preble's has not been captured on Cherry Creek in Arapahoe County.

Hydrologic Evaluation

No new hydrologic modeling was performed as part of this site assessment. Rather, existing hydrologic data was reviewed to determine the most appropriate flow rates on which to base the design. Documents reviewed as part of this study are listed below:

- Cherry Creek Corridor – Reservoir to Scott Road Major Drainageway Planning Preliminary Design Report by URS (2004).
- FEMA FIS (as reported by URS Cherry Creek Corridor Study)
- Channel Forming Discharge (Ruzzo, 2010)

Additional data from the sources is included in **Appendix F**. **Table 3-1** shows a comparison of the hydrology within the project area.

TABLE 3-1

Comparison of Existing Hydrologic Data for Cherry Creek at 12-Mile Park

Recurrence Interval	Cherry Creek Corridor Report[2]	FEMA FIS
2-Year Existing	2,142	-
2-Year Developed	4,429	-
5-Year Existing	5,892	-
5-Year Developed	9,537	-
10-Year Existing	10,071	10,300
10-Year Developed	14,655	-
25-Year Existing	20,200	-
25-Year Developed	25,821	-
50-Year Existing	31,217	31,000
50-Year Developed	36,946	-
100-Year Existing	49,021	51,000
100-Year Developed	54,285	-
500-Year Existing	-	150,000

[1] Peak flow rates presented in cubic feet per second (cfs).

[2] Peak flow rates from URS (2004) at UDSWM Design Point 286, at the Cherry Creek Reservoir.

In addition to the existing hydrologic data for Cherry Creek at 12-Mile Park, the mean annual flow, bank full flow, and base flow were determined for the project reach. The results of the mean annual flow analysis were presented in a Technical Memorandum by William P. Ruzzo, P.E. titled *Cherry Creek at 12-Mile Park – Channel Forming Discharge*. The results of this analysis suggest a range for the mean annual flow. The results are presented in **Table 3-2**.

TABLE 3-2
Mean Annual Flow for Cherry Creek at 12-Mile Park

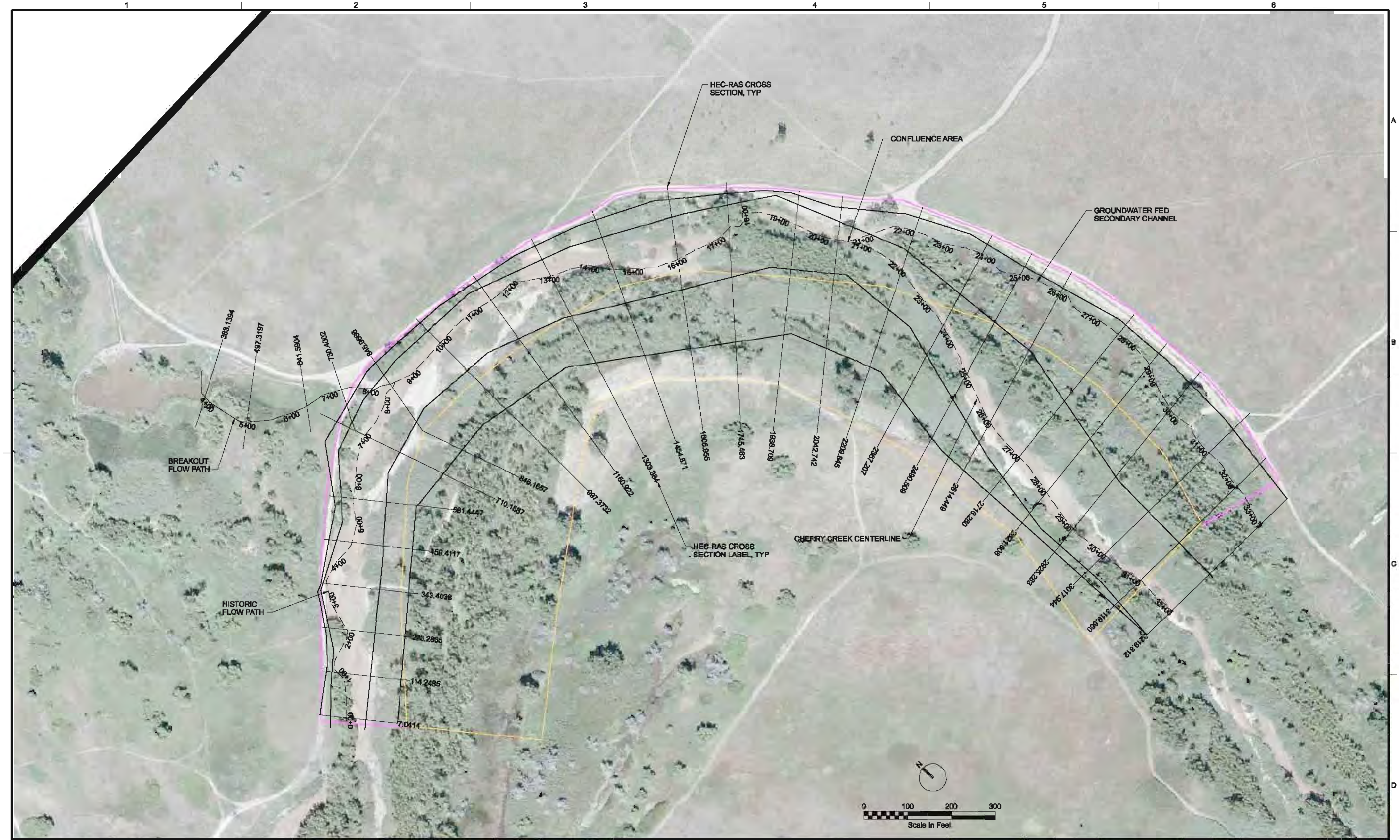
	Peak Flow (cfs)
Mean Annual Flow (min)	300
Mean Annual Flow (max)	800

The bank full flow is defined as the flow contained in the low flow channel from top of bank to top of bank and was determined for representative cross sections within the project reach using the Hydrologic Engineering Center River Analysis System (HEC-RAS). Where one bank is at a higher elevation than the other bank, the bank full flow extends to the top of the lower bank. The bank full flow rates are presented in **Table 3-3**. Cross section locations are shown in **Figure 3-1**.

TABLE 3-3
Bank Full Flow Analysis for Cherry Creek at 12-Mile Park

River Station	Model	Q Total (cfs)
3119.66	Historic/Breakout	505
2821.608	Historic/Breakout	570
2490.509	Historic/Breakout	345
2367.207	Historic/Breakout	335
2042.742	Historic/Breakout	405
1605.955	Historic/Breakout	385
1303.384	Historic/Breakout	585
1150.922	Historic/Breakout	810
459.4117	Historic	70
343.4038	Historic	20
730.4002	Breakout	520
497.3197	Breakout	255

The base flow for the project area varies from approximately 5 to 20 cfs. As shown in **Table 3-2**, the mean annual flow is in the range of 300 to 800 cfs. As shown in **Table 3-3**, the bank full flow varies from approximately 300 to 800 cfs upstream of the breakout area and is typically less downstream of the breakout.



DSGN A COOK						VERIFY SCALE		
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CH2MHILL

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK AT 12-MILE PARK
STREAM RECLAMATION

CHERRY CREEK AT 12-MILE PARK

FIGURE 3-1: HEC-RAS CROSS SECTIONS

SHEET	1
DWG	3-1
DATE	DECEMBER 2011
PROJ	407259

FILENAME: CC_Figure3-1.dgn PLOT DATE: 12/20/2011 PLOT TIME: 9:38:28 AM

Hydraulic Evaluation

Two HEC-RAS models were created for the project reach. The first HEC-RAS model is aligned with the historic flow path and the second model is aligned along the breakout flow path. Both models are the same upstream of the breakout area.

The values for flow depth and velocity from the hydraulic analysis are presented in **Table 3-4**. The values presented in **Table 3-4** represent a range of values since the flow characteristics change between cross sections. The cross sections downstream of the breakout area, both along the historic flow path and the breakout flow path, have more variability in the depths and velocities than the cross sections upstream of the breakout area. Additional HEC-RAS information is included in **Appendix G**.

TABLE 3-4
Typical Depth and Velocity Values from HEC-RAS Analysis

	2-Year Existing	2-Year Developed	Mean Annual Min	Mean Annual Max	Bank Full
Depth (ft)	2 - 4	4 - 5	1 - 3	2 - 4	2 - 3
Velocity (ft/s)	3 - 4	4 - 6	2 - 6	2 - 6	3 - 6

Stream Stability Analysis

The existing channel slope varies throughout the project reach from 0.015 ft/ft to 0.0015 ft/ft with an average channel slope through the project reach of approximately 0.003 ft/ft. A qualitative and quantitative analysis was performed to determine the sediment transport rate and stable sediment transport rate for Cherry Creek at 12-Mile Park. Based on a review of aerial photographs and an analysis to determine the stable slope based on a stable slope sediment transport rate, it has been determined that the project reach for Cherry Creek at 12-Mile Park is currently at a stable slope for the existing channel geometry and flow conditions. The average results of the stable slope analysis are presented in **Table 3-5**. The results are the average of the stable slope determined using the bank full, 2-year existing, and 2-year future peak flows.

TABLE 3-5
Average Stable Slope for Cross Section for Cherry Creek at 12-Mile Park

Cross Section	Average Stable Slope (%)
28+21	0.37%
27+18	0.28%
16+05	0.35%
13+03	0.47%
4+59	0.56%
4+97	0.90%
Average by Cross Section	***0.48%***
Average without 4+97	**0.41%**

The stable slope analysis using the stable sediment transport rate for Cherry Creek at 12-Mile Park suggests that the stable slope along the historic flow path is approximately 0.4%. It must be understood that the concepts used for the computation of sediment transport innately include a margin of error and in general the methods used in this analysis result in a slope that will reduce the degradation and aggradation of the main channel. Although the project reach as a whole has been determined to be at a stable condition, there may still be local areas of degradation and aggradation within the project reach caused by local changes in the main channel geometry and flow conditions. According to the *Cherry Creek Corridor – Reservoir to Scott Road Major Drainageway Planning Preliminary Design Report* (URS, 2004), the slope of this reach is 0.41% and the channel condition is aggrading to stable, which is consistent with the results of the stable slope analysis performed for this study.

Because the historic channel has been determined to be in a stable condition, the downcutting observed directly upstream of the breakout area can be attributed to the breakout flow path attempting to reach a stable slope. This is consistent with the aerial photography review which shows that the main channel has experienced little horizontal channel meandering over the last 20 years before the breakout occurred. The conclusion that the historic flow path is at a stable slope is also consistent with recent site visits in which the downcutting was not observed before the breakout occurred.

The stream stability geomorphic characteristics used for this analysis and the stable slope calculations are presented in **Appendix H**.

4. Alternatives Analysis

Alternatives were developed for the project area to address problems identified during the site assessment. The primary needs identified in the site assessment were repair of the breakout area, bank stabilization of the east bank, water quality enhancements, and providing specific creek access points along the east bank for park users. This section summarizes alternatives considered to address the problems identified. The complete alternatives analysis including a recommended plan can be found in the *Cherry Creek at 12-Mile Park Alternatives Evaluation Report* (CH2M HILL, 2011).

Bank Stabilization Alternatives

Bank stabilization techniques evaluated during the alternatives analysis phase included both structural and non-structural alternatives. Non-structural alternatives were defined as those alternatives that rely on measures such as re-vegetation to provide bank stabilization without the use of hardened structures. Non-structural bank stabilization alternatives likely impact a greater area due to grading the bank to a flatter slope to allow vegetation to establish. The following non-structural bank stabilization alternatives were considered:

Lay Back Slopes – lay back slopes to a 3:1 or 4:1 (H:V) slope with soil riprap and re-vegation for bank stabilization purposes.

Boardwalk Toe Protection – sandy beach area and boardwalk along the creek for pedestrian traffic and lay back slopes to a 3:1 or 4:1 (H:V) slope with soil riprap and re-vegetation.

Soil Wraps – combination of soil wraps at the toe of slope for 2.5 vertical feet with laying back the slopes to a 3:1 or 4:1 (H:V) slope with soil riprap and re-vegetation.

Terraced Slope – modification of the soil wraps alternative that includes soil wraps at the toe of slope for 2.5 vertical feet, laying back the slope to a 3:1 or 4:1 (H:V) slope up to the approximate midpoint of the slope, a 2.5 foot vertical boulder wall at the approximate midpoint of the slope, then laying back the slope to a 3:1 or 4:1 slope to catch grade.

Boulder Toe Protection – this alternative includes a vertical boulder wall at the toe of slope followed by laying back the slope to a 3:1 or 4:1 (H:V) slope with soil riprap and revegetation to catch existing grade.

Structural alternatives provide bank stabilization through the use of a hardened structure and generally impact less area because these alternatives can be placed at near vertical slopes. The following structural bank stabilization alternatives were considered during the alternatives evaluation phase:

Stacked Boulders – this alternative includes grouted boulders stacked near vertical with wetland plantings adjacent to the creek.

Sculpted Concrete – near vertical sculpted concrete colored and shaped to look natural with the surrounding area.

Soil Cement – soil cement lifts are stacked at a near vertical angle to provide bank stabilization

Mechanically Stabilized Earth (MSE) Walls – soil constructed with horizontal reinforcing elements and a facing to provide bank stabilization. The face of the MSE wall is typically vertical and the horizontal elements extend into backfilled soil to provide stability.

Unit costs per linear foot for each bank stabilization alternative were evaluated for two typical sections and are presented in **Table 4-1** and **4-2**. Unit costs for each of the bank stabilization alternatives were taken from the Urban Drainage and Flood Control District (UDFCD) bid tabs programs, past project, and various other sources.

TABLE 4-1

Unit Cost Per Linear Foot for 12 Foot High Bank with 1.5:1 Side Slopes

Alternative	$/LF
Lay Back Slopes	$200
Boardwalk Toe Protection	$420
Boulder Toe Protection	$190
Soil Wraps/Lay Back Slope	$220
Terraced Slope	$290
Stacked Boulders	$350
Sculpted Concrete	$1,720
Soil Cement	$650
Mechanically Stabilized Earth	$340

TABLE 4-2

Unit Cost Per Linear Foot for 5 Foot High Bank with 2:1 Side Slopes

Alternative	$/LF
Lay Back Slopes	$80
Boardwalk Toe Protection	$310
Boulder Toe Protection	$110
Soil Wraps/Lay Back Slope	$140
Terraced Slope	N/A
Stacked Boulders	$210
Sculpted Concrete	$570
Soil Cement	$210
Mechanically Stabilized Earth	$120

The data in **Table 4-1** and **4-2** suggest that the most cost effective bank stabilization alternatives for both typical sections are the alternatives where the bank is sloped back, including the lay back slopes alternative, the boulder toe protection alternative, the soil wraps alternative, and the terraced slope alternative. Although these alternatives are the most cost effective alternatives, they also cause the most disturbance to the park. In general, the structural bank stabilization alternatives are more costly for both typical sections, although the unit cost differential between the structural and non structural bank stabilization alternatives is less for the typical section with the lower bank height.

Water Quality Alternatives

Three water quality alternatives were identified in the Alternatives Analysis Report; constructed wetlands, upland ponds, and upland bio-swales. Each of the water quality alternatives is designed to address water quality at a different location in reference to the creek. See below for a description of the water quality alternatives for the Cherry Creek at 12-Mile Park project area. Unit costs for each of the water quality alternatives are presented in **Table 4-3**.

Constructed Wetlands

A constructed wetland is a new or restored wetland vegetative area that acts as a filter to remove sediments and soluble pollutants from water. Constructed wetlands occur within the creek and can also act as a physical barrier where it is unlikely that dogs or pedestrians would pass through the constructed wetland to access a different part of the creek due to the density of plants and the depth of water.

Upland Ponds

An upland pond is designed to capture stormwater runoff and detain it for many hours after storm runoff ends which allows time for sediment and other pollutants, such as dog waste, to settle out before the stormwater is discharged into Cherry Creek. An upland pond can include a small wetland area within the pond which enhances the removal of soluble pollutants. The upland pond would be located near the breakout area on the north side of the creek to capture stormwater runoff from the DOLA. The upland pond could be a sand infiltration basin where the water is allowed to infiltrate without a formal outlet structure, or an extended detention basin which has a formal outlet structure.

Upland Bio-Swales

Upland bio-swales are vegetated channels with a flat slope designed to convey runoff while removing sediment and other pollutants. The upland bio swales would be located adjacent to the trail along the east bank of Cherry Creek. Because of the flat side slopes, the water depth is shallow and the velocity is low, allowing for sedimentation and removal of pollutants while preventing erosion.

TABLE 4-3

Unit Cost for Water Quality Alternatives

Alternative	Unit	Unit Cost	Quantity Needed	Total Cost
Constructed Wetlands	SF	$25.00	8,900	$222,500
Upland Bio-Swale	LF	$15.00	2,400	$36,000
Upland Pond	Acre-ft	$47,000	2	$94,000

Access Alternatives

Throughout the Cherry Creek at 12-Mile Park project site, a number of different potential access points were identified as locations for a formal access point to the creek. Access alternatives were separated into Americans with Disabilities Act (ADA) accessible access points and non-ADA accessible access points.

ADA Accessible Creek Access Alternative

An ADA accessible creek access point meets the requirements of the Americans with Disabilities Act of 1990. To comply with ADA requirements for accessible routes, any ADA accessible creek access must have a longitudinal slope of 5% or flatter, a cross slope of 2% or flatter, a minimum width of 36 inches, and passing spaces at least every 200 feet if the width is less than 60 inches. The surface of any ADA accessible creek access must be stable, firm, and slip-resistant. If there are gratings along the surface, the maximum spacing between gratings in one direction is ½ inch. There are multiple materials that could be used to construct the ADA accessible creek access points including concrete, timber, porous pavers/articulated concrete blocks, or other materials.

Non-ADA Accessible Creek Access Alternative

A non-ADA accessible creek access point does not need to meet the requirements of the Americans with Disabilities Act of 1990 including the requirements for longitudinal slope, cross slope, access width, or surface material. Because there are no longitudinal slope requirements, any non-ADA compliant access point will likely have a steeper slope and may include a stepped surface to access the creek.

Comparison of Unit Costs for the Creek Access Material Alternatives

The typical unit costs for a number of materials considered for the access material are presented in **Table 4-4**. These costs are presented on a per square foot basis. Unit costs for alternative creek access materials were taken from the UDFCD bid tabs program, recent projects, and various other sources.

TABLE 4-4

Access Material Alternative Unit Cost

Access Material Alternative	Per SQ-FT
Concrete	$ 15.00
Concrete Porous Pavers	$ 4.25
Articulated Concrete Blocks	$ 7.50
Boulders	$ 25.00
Timber	$ 2.50
Landscape Stones	$ 4.00

5. Stream Reclamation Plan

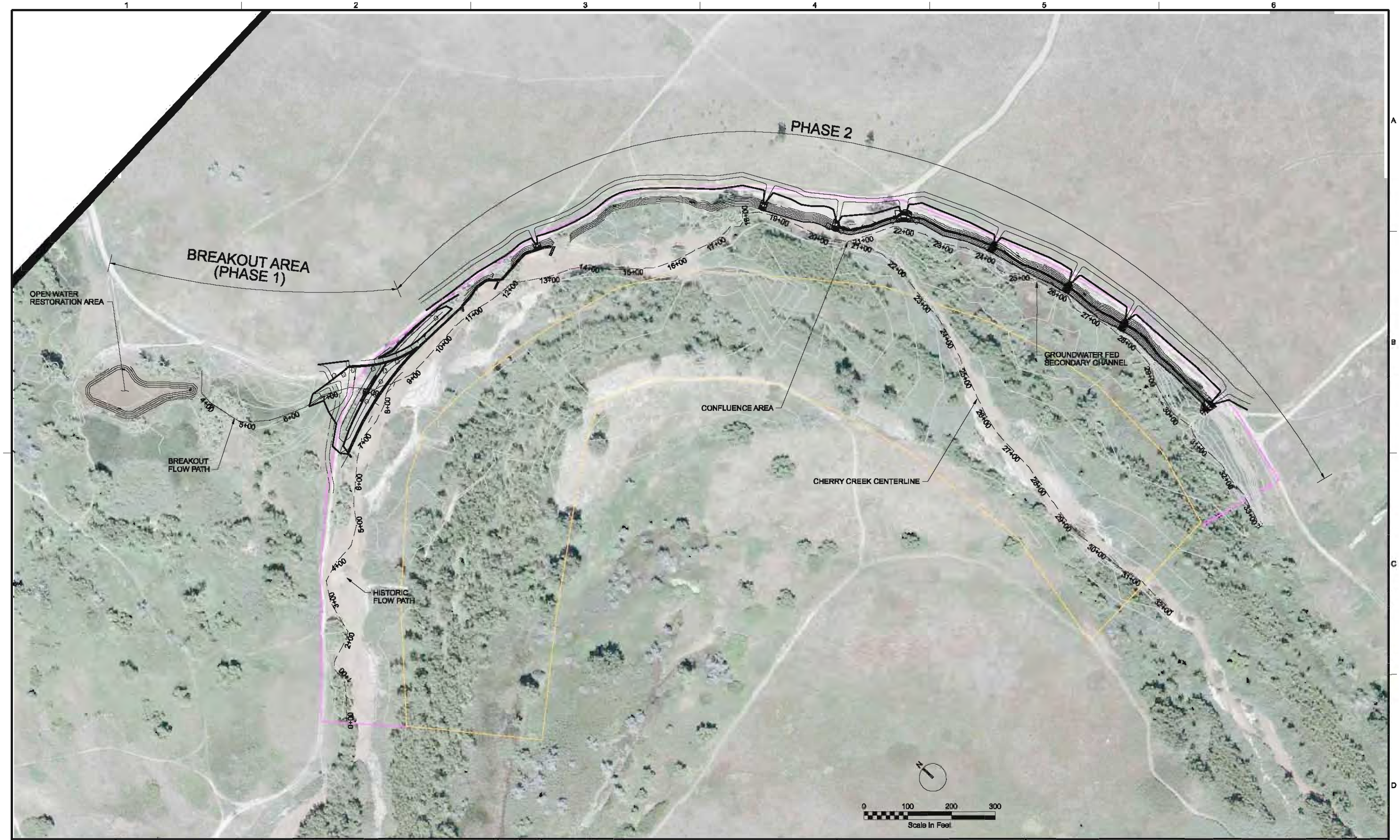
The stream reclamation plan was developed to address the primary needs within the Cherry Creek at 12-Mile Park project area. This section is organized from downstream to upstream within the project area and subdivided into bank stabilization improvements, water quality improvements, creek access improvements, and other improvements. The breakout area (Phase 1) was identified as a priority improvement area and was moved forward at an accelerated schedule separate from the rest of the of the Preliminary Design. For this reason, a separate construction drawings set was created for the repair of the breakout area. The Phase 1 construction drawings are included in **Appendix A**. The remainder of the project was designated as Phase 2. The preliminary construction drawings for Phase 2 are included in Appendix B. The Phase 1 and Phase 2 improvements and reach locations are shown in **Figure 5-1**.

Breakout Area (Phase 1) Improvements

The Phase 1 improvements consist of the repair of the breakout area to return the flow in Cherry Creek to the historic flow path, an ADA accessible creek access point, and an open water restoration area to meet the United States Army Corps of Engineers (USACE) onsite earthwork balancing requirements. The open water restoration area is along the breakout area flow path at a location where a pond existed prior to the flow path breakout.

Bank Stabilization – To return the flow in Cherry Creek to the historic flow path, the Phase 1 improvements include a berm across the breakout flow path at an elevation equal to the Cherry Creek bank elevation upstream of the breakout area. Boulders (36 inch) are placed at the toe of slope with the top 24 inches exposed and a 10:1 (H:V) slope extending from the top of the boulders to the top of the berm. The top of the berm is 5 feet in width and the back side of the berm is a 10:1 slope down to existing grade. Sheet pile is included in the center of the berm extending vertically from 1 foot below the top of berm down 13 feet and horizontally 10 feet past the breakout flow path banks on each side. The front side berm slope includes Type M (D_{50} = 12 inches) soil riprap, erosion control blanket, and upland seeding. Willow stakes are included at the interface of the boulders and the slope and cottonwood trees are included at strategic locations throughout the Phase 1 project area.

Creek Access Improvements – A concrete ADA access trail is included in the Phase 1 improvements. The trail is 10 feet wide and has a 4 inch vertical curb on the creek side of the trail that transitions near the creek to boulder edging. The maximum longitudinal slope along the trail is 5% to meet ADA requirements.



DSGN A COOK						VERIFY SCALE		CHERRY CREEK BASIN WATER QUALITY AUTHORITY CHERRY CREEK AT 12-MILE PARK STREAM RECLAMATION	CHERRY CREEK AT 12-MILE PARK FIGURE 5-1: ALTERNATIVES ANALYSIS RECOMMENDED PLAN SUMMARY	SHEET 1
DR A COOK						BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	CH2MHILL			DWG 5-1
CHK C HOOPER	NO	DATE	DESCRIPTION	APVR	N					DATE APRIL 2011
APVD S YANAGIHARA	NO.	DATE	REVISION	BY	APVD					PROJ 407259

FILENAME: CC_Figure5-1.dgn PLOT DATE: 12/20/2011 PLOT TIME: 9:39:22 AM

Other Improvements – An open water restoration area is required to meet the USACE onsite earthwork balancing requirements. The open water restoration area restores the pond that existed prior to the breakout occurring. The open water restoration area has 4:1 (H:V) side slopes extending approximately 3 – 4 vertical feet. Willow stakes are located at the toe of slope, wetland seeding is located along the bottom of the open water restoration area and extending up three vertical feet, and upland seeding overlaps the wetland seeding for 1 foot and extends to the top of slope.

Type 1 Fence is used at the top of slope to prevent dog park users from accessing the creek at non-designated locations. Type 1 Fence includes 6″ x 6 ½″ pressure treated posts at 24 foot intervals, intermediate steel tee fence posts at 8 foot intervals, a galvanized woven wire fence, and a high tensile fence wire. The Type 1 Fence ties into the future bullpen area, the interface between the DOLA and the rest of the park, which will be constructed as part of the DOLA plan. Type 1 Fence is also located on the creek side of the concrete ADA access trail from the bullpen area to the boulder toe.

Jetties, defined as structures that project into a body of water to direct flow to prevent erosion, are recommended at two locations within the Phase 1 project area. By directing the flow away from the bank at these locations, sandy beach areas are expected to form behind the jetties.

The breakout area repair also includes a future 10 foot wide equestrian trail to help separate horseback riders from the DOLA.

Phase 2 Improvements

The Phase 2 improvements are currently in the preliminary design phase and consist of bank stabilization, water quality improvements, creek access points, and other improvements from the breakout area to the upstream limit of the project area. The Phase 2 improvements are shown on the Preliminary Construction Drawings in **Appendix B**. The Phase 2 improvements are subdivided into improvements associated with Control Line 1 and improvements associated with Control Line 2. Control Line 1 begins immediately upstream of the Phase 1 improvements and extends upstream for 256 feet. There is then an approximate 40 foot gap before Control Line 2 begins. There are no proposed improvements within the 40 foot gap. Control Line 2 extends from the gap to the upstream limits of the project area.

Bank Stabilization from Control Line 1 Station 0+00 to Station 2+56 - The boulder toe protection bank stabilization alternative is included in the Stream Reclamation Plan from Control Line 1 Station 0+00 to Station 2+56. The boulder toe protection continues from the Phase I improvements. This bank stabilization technique includes 36 inch boulders at the toe of slope with the top 24 inches exposed, and a 3:1 (H:V) slope above the boulders to catch existing grade. The typical existing bank height through this section is approximately 5 to 7 feet with slopes ranging from steeper than 1:1 to 3:1. Willow stakes are placed at the interface between the boulder toe and the slope for added bank stability. The 3:1 slope includes Type M soil riprap, erosion control blanket, and upland seeding.

Bank Stabilization from Control Line 2 Station 0+00 to Station 4+75 - The lay back slopes bank stabilization alternative is included in the Stream Reclamation Plan between Control Line 2 Station 0+00 and Station 4+75. The typical existing bank height through this reach is approximately 5 to 7 feet with between 1:1 and 3:1 (H:V) side slopes. For this bank stabilization technique, the bank is graded to a 3:1 slope with Type M soil riprap, erosion control blanket, and upland seeding. The Type M soil riprap continues beneath the surface of the creek at a 2:1 slope for three vertical feet to provide additional protection if the toe of slope experiences localized erosion.

Bank Stabilization from Control Line 2 Station 4+75 to Station 6+50 - Between Control Line 2 Station 4+75 and Station 6+50, soil wraps combined with grading the bank to a 3:1 (H:V) slope is the bank stabilization included in the Stream Reclamation Plan. The typical existing bank height through this section is between 7 and 10 feet with side slopes ranging from steeper than 1:1 to approximately 2:1. Soil wraps staked with willows are placed at the toe of slope for 2.5 vertical feet at a 1:1 slope. Geotextile is used to wrap the soil. The height of each soil wrap is 1 foot and only the bottom soil wraps are staked with willows. The 4:1 slope includes Type M soil riprap, erosion control blanket, and upland seed.

Bank Stabilization from Control Line 2 Station 6+50 to Station 16+50 - Between Control Line 2 Station 6+50 and Station 16+50, the bank stabilization technique included in the stream reclamation plan is the terraced slope bank stabilization technique. The typical bank height between Station 6+50 and Station 16+50 is between 10 and 15 feet with side slopes varying from steeper than 1:1 (H:V) to approximately 2:1. The terraced slope bank stabilization has soil wraps with willow staking at the toe of slope, followed by a 3:1 slope to a 2.5 foot vertical grouted boulder wall approximately half way up the slope, and a 3:1 slope extending from the top of the top of the boulder wall to the top of slope. The 3:1 slopes include Type M soil riprap, erosion control blanket, and upland seeding.

Water Quality Improvements – A bioswale is recommended from Control Line 1 Station 0+00 to Station 2+56, from Control Line 2 Station 0+00 to 6+50, and from Control Line 2 Station 8+15 to Station 16+50. There is no bioswale between Control Line 2 Station 6+50 to Station 8+15. The bioswale is located at the top of slope between the top of slope and the Type 1 Fence and is designed to intercept stormwater from the upland area prior to entering Cherry Creek. The bioswale is a trapezoidal shaped channel with a 2 foot bottom width, 4:1 side slopes, and a depth of 1 foot. The top width of the bioswale is 10 feet. A mixture of 85% coarse sand and 15% compost growth media is used from the surface of the bioswale for a depth of 18 inches to allow stormwater to infiltrate.

Creek Access Improvements – Creek access locations and details are shown in **Table 5-1**. The stepped boulder access point is comprised of 36 inch diameter below grade anchor boulders at the toe of slope, 12 inch diameter boulders stepped along the slope, and horizontal boulders at the top of slope that tie into the crusher fines trail. The 12 inch diameter boulders along the slope must be placed on top of suitable subgrade material to prevent settling. The minimum and maximum step heights along the access are 6 inches and 8 inches, respectively. Cottonwood trees (2 inch caliper) are included in the Stream Reclamation plan on both sides of creek access #3 and creek access #4.

TABLE 5-1
Creek Access Locations and Details

Creek Access	Station[1]	Width (ft)	Height (ft)
1	Control Line 1 Station 2+25	6	4
2	Control Line 2 Station 4+75	6	7
3	Control Line 2 Station 6+50	6	9
4	Control Line 2 Station 8+15	6	12
5	Control Line 2 Station 10+25	6	13
6	Control Line 2 Station 12+20	6	13
7	Control Line 2 Station 13+75	6	14
8	Control Line 2 Station 16+40	6	10

Other Improvements – Jetties are recommended at Control Line 1 Station 10+10 and Control Line 1 Station 2+56. By directing the flow away from the bank at these locations, beach areas are expected to form behind the jetties.

Type 1 Fence is located between the crusher fine trail installed with the DOLA plan and the bioswale for the length of the project area to prevent park users from accessing the stabilized slopes. Gaps in the Type 1 Fence guide park users to the creek access locations. At the south end of the project, the Type 1 Fence ties into the future bullpen area which acts as an interface between the DOLA and the rest of the park. The bullpen will be constructed as part of the DOLA plan.

A 10 foot wide crusher fine trail is shown in the stream reclamation plan throughout the length of the project reach. The crusher fine trail is offset into the DOLA from the Type 1 fence by 20 feet except at locations where the trail guides park users to the formalized creek access locations. The crusher fine trail will be installed as part of the Cherry Creek DOLA plan. The DOLA plan is included as **Appendix C**.

Water Quality Benefits

The recommended improvements for Phase 1 and Phase 2 provide water quality benefits by restoring and protecting the bank to reduce the amount of sediment and other pollutant loads and concentrations, including phosphorus and nitrogen, in Cherry Creek. A detailed analysis of the water quality benefits and costs associated with the Cherry Creek Stream Reclamation at 12-Mile Park was performed by William P. Ruzzo, P.E. in May, 2011, and is presented in **Appendix I**.

Stream Reclamation Plan Summary

The final construction drawings for Phase 1 and the preliminary design drawings for Phase 2 are included in the appendices. The Phase 1 construction cost estimate is included as **Table 5-2** and the preliminary Phase 2 construction cost estimate is included as **Table 5-3**.

Phase 1 Contractor Bid

TABLE 5-2

Phase 1 Contractor Bid

ITEM NO.	DESCRIPTION OF BID ITEM	QUANTITY	PAY UNIT	UNIT PRICE	TOTAL COST
1	Mobilization	1	LS	$11,500.00	$11,500.00
2	Project Sign	2	EA	$350.00	$700.00
3	Stabilized Staging Area	1	EA	$1,100.00	$1,100.00
4	Vehicle Tracking Control	1	EA	$900.00	$900.00
5	Water Control and Dewatering	1	LS	$12,500.00	$12,500.00
6	Field Engineering/Survey	1	LS	$2,500.00	$2,500.00
7	Clearing, Grubbing, and Tree Removal	1	LS	$2,500.00	$2,500.00
8	Construction Fence (Green)	828	LF	$3.00	$2,484.00
9	Concrete Washout Area	1	EA	$900.00	$900.00
10	Sediment Control Log	185	LF	$3.00	$555.00
11	Sheet Pile, Steel	980	SF	$27.00	$24,570.00
12	Soil Riprap, Type L	293	CY	$40.00	$11,720.00
13	Soil Riprap, Type M	671	CY	$36.00	$24,156.00
14	Boulder Edging, 36"	431	LF	$52.00	$22,412.00
15	Excavation, Fill On-Site	102	CY	$14.00	$1,428.00
16	Excavation, Haul Off-Site	1,537	CY	$15.00	$23,055.00
17	Import Fill Material	810	CY	$23.00	$18,630.00
18	Jetty	2	EA	$750.00	$1,500.00
19	Trail/Path, Concrete, 6" Thick	302	SY	$45.00	$13,590.00
20	CDOT No. 57 Aggregate	49	CY	$75.00	$3,675.00
21	Type 1 Fence	636	LF	$11.00	$6,996.00
22	Topsoil, Import	623	CY	$24.00	$14,952.00
23	Mulch, Crimped Straw	0.3	AC	$3,000.00	$900.00
24	Seeding, Upland - Broadcast	1.0	AC	$1,500.00	$1,500.00
25	Seeding, Wetland - Broadcast	0.4	AC	$2,500.00	$1,000.00
26	Blanket, 100% Coconut (Coir)	3,735	SY	$4.00	$14,940.00
27	Tree, Cottonwood 2" Caliper	10	EA	$400.00	$4,000.00
28	Willow Staking	975	LF	$3.00	$2,925.00
	CONSTRUCTION TOTAL				**$227,588.00**

Phase 2 Preliminary Cost Estimate

TABLE 5-3

Phase 2 Preliminary Cost Estimate

ITEM NO.	DESCRIPTION OF BID ITEM	QUANTITY	PAY UNIT	UNIT PRICE	TOTAL COST
1	Mobilization	1	LS	$30,000	$30,000
2	Project Sign	2	EA	$650	$1,300
3	Stabilized Staging Area	1	EA	$2,500	$2,500
4	Vehicle Tracking Control	1	EA	$2,000	$2,000
5	Water Control and Dewatering	1	LS	$40,000	$40,000
6	Field Engineering/Survey	1	LS	$5,000	$5,000
7	Clearing, Grubbing, and Tree Removal	1	LS	$10,000	$10,000
8	Construction Fence (Green)	1,000	LF	$2	$2,000
9	Concrete Washout Area	1	EA	$1,000	$1,000
10	Sediment Control Log	200	LF	$5	$1,000
11	Soil Riprap, Type L	247	CY	$55	$13,585
12	Soil Riprap, Type M	3,245	CY	$55	$178,475
13	Boulder Edging, 36"	295	LF	$65	$19,175
14	Grouted Boulder, 12"	53	CY	$160	$8,480
15	Grouted Boulder, 36"	618	CY	$160	$98,880
16	Excavation, Fill On-Site	560	CY	$11	$6,160
17	Excavation, Haul Off-Site	5,201	CY	$18	$93,618
18	Compacted Soil Backfill	138	CY	$15	$2,070
19	Coarse Sand/Compost Mix	1,159	CY	$15	$17,385
20	Subgrade Material	53	CY	$42	$2,226
21	Geotextile	3,165	SY	$4	$12,660
22	Type 1 Fence	2,300	LF	$16	$36,800
23	Trail/Path, Crusher Fines	2,670	SY	$15	$40,050
24	Topsoil, Import	759	CY	$30	$22,770
25	Seeding, Upland - Broadcast	1.40	AC	$4,000	$5,600
26	Seeding, Wetland - Broadcast	0.10	AC	$5,000	$500
27	Blanket, 100% Coconut (Coir)	4,592	SY	$5	$22,960
28	Tree, Cottonwood 2" Caliper	4	EA	$500	$2,000
29	Willow Staking	1,447	LF	$5	$7,235
	CREEK IMPROVEMENT TOTAL COST				**$685,429**
30	Final Design and Permitting		20%		$137,086
31	Construction Observation		15%		$102,814
32	Administration		3%		$20,563
	SUBTOTAL COST				**$945,892**
	CONTINGENCY		10%		$94,589
	CONSTRUCTION TOTAL PLUS CONTINGENCY				**$1,040,481**

6. References

1. Brown and Caldwell (2009) "Annual Report on Activities" prepared for Cherry Creek Basin Water Quality Authority (CCBWQA), Greenwood Village, CO.
2. Business Research Division, Leeds School of Business, University of Colorado at Boulder (2008) "Off-Leash User Study: Cherry Creek State Park" conducted for Colorado State Parks.
3. CH2M HILL (2010) "Cherry Creek at 12-Mile Park Final Assessment Report" prepared for Cherry Creek Basin Water Quality Authority.
4. CH2M HILL (2011) "Cherry Creek at 12-Mile Park Alternatives Evaluation Report" prepared for Cherry Creek Basin Water Quality Authority.
5. Colorado State Parks (2009) "Public Feedback on Chatfield and Cherry Creek State Park Dog Training Areas".
6. Ensight Technical Services, Inc. (2008) "The Effects of Off-Leash Dog Areas on Birds and Small Mammals in Cherry Creek and Chatfield State Parks" submitted to Cherry Creek State Park, Aurora, CO.
7. GEI Consultants, Inc. (2008) "The Influence of Pet Recreation Areas on Soil and Water Quality at Cherry Creek State Park" submitted to Cherry Creek State Park, Aurora, CO.
8. Ruzzo, William P. (2010) "Cherry Creek at 12-Mile Park – Channel Forming Discharge" Cherry Creek Basin Water Quality Authority (CCBWQA), Greenwood Village, CO.
9. Ruzzo, William P. (2011) "Cherry Creek Stream Reclamation at 12-Mile Park – Water Quality Benefits and Costs" William P. Ruzzo, PE, LLC, Lakewood, CO.
10. Simons and Associates (1981) "Design Guidelines and Criteria for Channels and Hydraulic Structures on Sandy Soil" Written for Urban Drainage and Flood Control District (UDFCD), Denver, CO.
11. Spence, Edward M., Natural Resources Conservation Service (NRCS) (2008) "12-Mile Dog Park Erosion and Compaction Problems" submitted to Cherry Creek State Park, Aurora, CO.
12. United States Geological Survey (1985) "Determination of Roughness Coefficients for Streams in Colorado" Water Resources Investigations Report 85-4004, Lakewood, CO.
13. URS (2004) "Cherry Creek Corridor – Reservoir to Scott Road Major Drainageway Planning Preliminary Design Report" written for Urban Drainage and Flood Control District (UDFCD), Denver, CO.

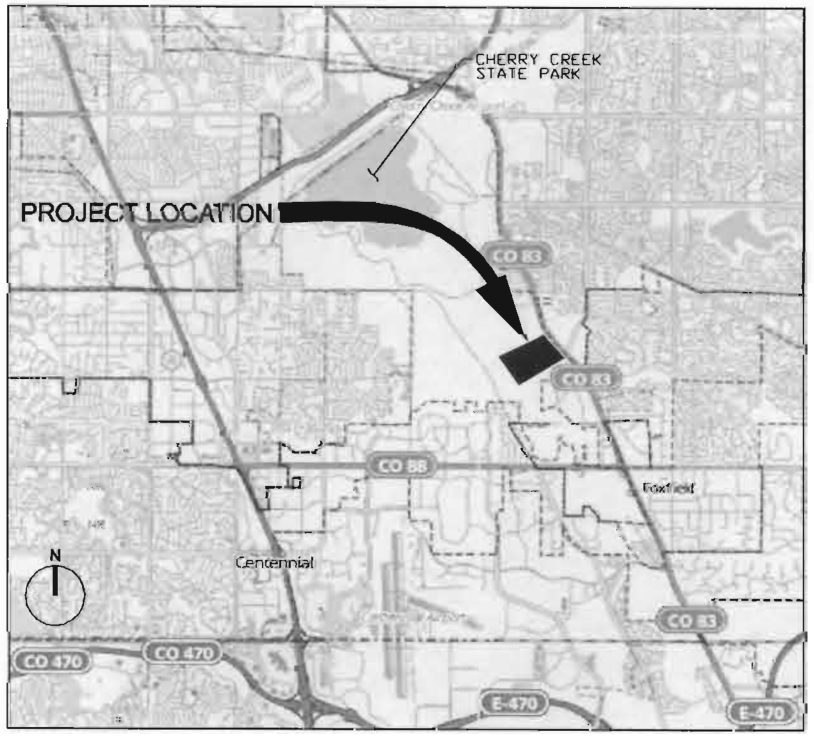
Appendix A – Phase 1 Construction Drawings

CONSTRUCTION DRAWINGS
CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
PHASE 1

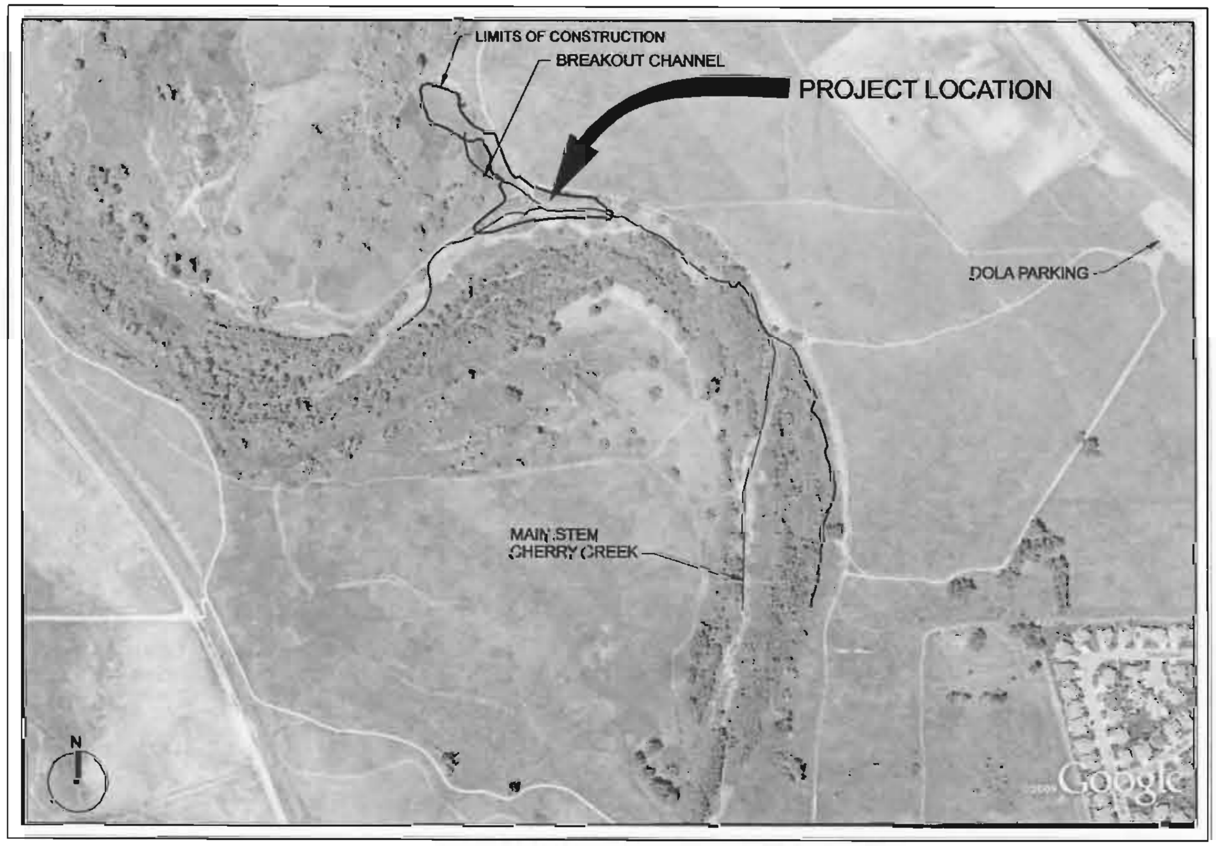
OCTOBER 2011

INDEX OF DRAWING

SHEET NO	DWG NO	SHEET TITLE
1	G-1	COVER
2	G-2	GENERAL NOTES
3	G-3	SURVEY CONTROL AND SITE PLAN
4	C-1	BREAKOUT AREA REPAIR PLAN
5	C-2	OPEN WATER RESTORATION AREA PLAN
6	C-3	BREAKOUT AREA REPAIR SECTIONS
7	C-4	OPEN WATER RESTORATION AREA SECTIONS
8	C-5	DETAILS
9	C-6	STANDARD DETAILS
10	C-7	STANDARD DETAILS



VICINITY MAP: ARAPAHOE COUNTY, CO
NTS
SOURCE: EXPERT GPS



LOCATION MAP: ARAPAHOE COUNTY, CO
NTS
SOURCE: GOOGLE EARTH

CHERRY CREEK BASIN WATER QUALITY AUTHORITY

William Ruzzo 10/06/2011
BILL RUZZO, TECHNICAL MANAGER
DATE

CH2M HILL

Scott D Yanagihara 10/7/2011
SCOTT YANAGIHARA, PROJECT MANAGER
DATE

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD
DSGN	DR	CHK	APVD	
A COOK	S KRAMER	C HOOPER	S YANAGIHARA	

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

CH2MHILL

COVER

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2011
PROJ	407259
DWG	G-1
SHEET	1

GENERAL NOTES

1. IT IS THE INTENT OF THESE PLANS TO SHOW ALL EXISTING UTILITIES, HOWEVER IT IS THE CONTRACTOR'S RESPONSIBILITY TO FIELD VERIFY ALL UTILITIES PRIOR TO CONSTRUCTION, WHETHER SHOWN ON THESE PLANS OR NOT. CONTACT THE UTILITY NOTIFICATION CENTER OF COLORADO (UNCC) AT 811, PRIOR TO DIGGING. THE ENGINEER AND CCBWQA SHALL BE NOTIFIED OF ANY POTENTIAL CONFLICTS.
2. EXISTING FACILITIES AND UTILITIES NOT INDICATED TO BE REMOVED SHALL BE PROTECTED IN PLACE OR REMOVED AND REPLACED IN KIND, AS APPROVED BY THE ENGINEER.
3. ALL MATERIALS AND WORKMANSHIP SHALL BE SUBJECT TO INSPECTION BY CCBWQA, CCSP AND/OR ITS AUTHORIZED REPRESENTATIVES. CCBWQA AND CCSP RESERVE THE RIGHT TO ACCEPT OR REJECT ANY SUCH MATERIALS AND WORKMANSHIP THAT DO NOT CONFORM TO ITS STANDARDS AND SPECIFICATIONS.
4. THE CONTRACTOR SHALL NOTIFY CCBWQA 48 HOURS PRIOR TO STARTING CONSTRUCTION.
5. THE CONTRACTOR SHALL HAVE ONE (1) SIGNED COPY OF THE PLANS (ACCEPTED BY CCBWQA), AND ONE (1) COPY OF ALL REQUIRED PERMITS AT THE JOB SITE AT ALL TIMES.
6. THE FINAL FILL AND EXCAVATION SLOPES, LINES AND GRADES SHOWN ON THE DRAWINGS ARE THE NEAT LINES FOR PAY PURPOSES AND ARE THE STEEPEST SLOPES PERMITTED UNLESS APPROVED BY THE ENGINEER. FLATTER SLOPES MAY BE NECESSARY, AS DETERMINED BY THE CONTRACTOR. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR PROVIDING STABLE EXCAVATIONS AND TEMPORARY SLOPES AND FOR SATISFYING ALL APPLICABLE FEDERAL, STATE, AND LOCAL REGULATIONS. TEMPORARY EXCAVATIONS SHALL PROVIDE AT MINIMUM, THE TRENCH DIMENSIONS AND CLEARANCES SHOWN OR SPECIFIED. TEMPORARY CONSTRUCTION SLOPES SHALL BE SLOPED, SHORED, SHEETED, AND/OR BRACED IN ACCORDANCE WITH STABILITY REQUIREMENTS AND APPLICABLE REGULATIONS, AND SHALL BE NO STEEPER THAN THE MINIMUM SLOPES SHOWN OR SPECIFIED WITHOUT THE APPROVAL OF THE ENGINEER. ANY SUCH APPROVALS BY THE ENGINEER WILL NOT RELIEVE THE CONTRACTOR FROM SOLE RESPONSIBILITY FOR PROVIDING STABLE EXCAVATIONS AND TEMPORARY SLOPES.
7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ACCEPTANCE AND CONTROL OF DRAINAGE WATER FROM AREAS ADJACENT TO THE CREEK AND FOR STREAM FLOW WITHIN THE CREEK. THE CONTRACTOR SHALL BE RESPONSIBLE FOR DETERMINING METHODS BY WHICH CHANNEL FLOW, SURFACE RUNOFF, AND SUBSURFACE SEEPAGE WILL BE TEMPORARILY DIVERTED, DETAINED OR OTHERWISE CONTROLLED. WATER CONTROL SHALL BE PERFORMED IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL REGULATIONS, AS WELL AS ALL APPLICABLE PERMIT CONDITIONS. TEMPORARY WATER CONTROL SYSTEMS SHALL NOT CAUSE INCREASED FLOODING OR AFFECT NORMAL FLOW CHARACTERISTICS DURING CONSTRUCTION. ANY DAMAGE TO THE WORK RESULTING FROM BASE FLOWS OR FLOOD FLOWS SHALL BE CORRECTED BY THE CONTRACTOR AT THE CONTRACTOR'S SOLE COST.
8. THE CONTRACTOR IS ADVISED THAT THE STOCKPILING AND USE OF MATERIAL AND/OR EQUIPMENT WITHIN THE CHANNEL CREATES POTENTIAL OBSTRUCTIONS TO THE FLOW OF THE STREAM. IT IS THE CONTRACTOR'S RESPONSIBILITY TO CONDUCT THE WORK IN A MANNER THAT MINIMIZES THE REDUCTION IN CHANNEL CAPACITY AT ALL TIMES. THE CONTRACTOR IS ADVISED THAT THE STORAGE OF FUELS, CHEMICALS, TRASH, DEBRIS, CONSTRUCTION MATERIAL, VEHICLES, AND EQUIPMENT SHALL BE PROHIBITED WITHIN THE CHANNEL AT ALL TIMES EXCEPT AS IS ESSENTIAL TO THE PROGRESS OF THE WORK. UNDER NO CIRCUMSTANCE SHALL ANY OF THE ABOVE MENTIONED MATERIALS BE STORED OVERNIGHT WITHIN THE CHANNEL.
9. CONTRACTOR SHALL PROVIDE PEDESTRIAN AND VEHICULAR SIGNAGE THAT CLEARLY IDENTIFIES THE CONSTRUCTION ZONE THROUGHOUT PROJECT. CONTRACTOR IS RESPONSIBLE FOR SITE SAFETY.
10. CONTRACTOR SHALL PROTECT ALL EXISTING CURB, GUTTER AND PAVEMENT AT ALL ACCESS POINTS FROM DAMAGE BY EQUIPMENT OR CONSTRUCTION OPERATIONS. ALL CURB, GUTTER AND PAVEMENT DAMAGED BY THE CONTRACTOR SHALL BE REMOVED AND REPLACED AT THE CONTRACTOR'S EXPENSE.
11. SOIL RIPRAP SHALL CONSIST OF 65% RIPRAP AND 35% SOIL, AND SHALL BE COMPACTED.
12. NATIVE FILL SHALL BE COMPACTED TO 95% STD PROCTOR.
13. CONSTRUCTION STAKING AND SURVEY SHALL BE PROVIDED BY THE CONTRACTOR.
14. CONTRACTOR SHALL OBTAIN ALL REQUIRED PERMITS FOR THIS PROJECT, EXCEPT FOR THE 404 PERMIT.
15. CONTRACTOR SHALL BE LICENSED TO PERFORM WORK IN ARAPAHOE COUNTY, AS REQUIRED.
16. NEW FILL SHOULD BE CONTINUOUSLY BENCHED INTO EXISTING SLOPES EXCEEDING 4 HORIZONTAL TO 1 VERTICAL. A BENCH HEIGHT BETWEEN 1 AND 2 FEET SHOULD BE USED. PROPER COMPACTION IS FREQUENTLY DIFFICULT TO ACHIEVE AT THE EDGES OF FILL SLOPES. FOR THIS REASON OVERBUILD FILL SLOPES 1 TO 2 FEET AND CUT THE SLOPE SURFACE BACK TO THE GRADES SHOWN. FILLS SHOULD BE PLACED IN UNIFORM LIFTS NOT EXCEEDING 8 INCHES LOOSE AND SHOULD BE COMPACTED TO THE MOISTURE AND DENSITY REQUIREMENTS PER CCBWQA SPECIFICATIONS.
17. VISITS TO THE JOB SITE BY THE ENGINEER TO OBSERVE THE CONSTRUCTION DO NOT IN ANY WAY MEAN THAT THE ENGINEER IS GUARANTOR OF CONTRACTOR'S WORK, NOR RESPONSIBLE FOR THE COMPREHENSIVE OR SPECIAL INSPECTIONS, COORDINATION, SUPERVISION, NOR THE SAFETY AT THE JOB SITE.
18. SITE ACCESS AND STAGING SHALL BE PER THE CONSTRUCTION DOCUMENTS, UNLESS ALTERNATIVE ACCESS AND STAGING ARE APPROVED BY CCBWQA AND/OR ITS AUTHORIZED REPRESENTATIVES.
19. CCBWQA STANDARD SPECIFICATIONS SHALL BE USED ON THIS PROJECT.
20. CONTRACTOR SHALL INSTALL TWO PROJECT SIGNS PER THE PROJECT SPECIFICATIONS.
21. SEE PROJECT SPECIFICATIONS FOR REQUIRED SUBMITTALS AND MEASUREMENT AND PAYMENTS REQUIREMENTS.

CULTURAL AND HISTORICAL FINDINGS

1. IF ANY SUSPECTED CULTURAL OR HISTORIC FINDINGS ARE UNCOVERED DURING CONSTRUCTION, STOP CONSTRUCTION IMMEDIATELY AND NOTIFY: MARY POWELL/ERO RESOURCES AT 303-830-1188.

SEEDING AND PLANTING NOTES

1. ADJUST SITE GRADING AS APPROPRIATE SO THAT IMPACTS TO WOODY VEGETATION AND TREES TO BE PROTECTED CAN BE AVOIDED.
2. AVOID CLEARING AND GRUBBING WOODY VEGETATION IN AREAS OF TEMPORARY IMPACTS. IF NECESSARY, PRUNE WOODY VEGETATION TO GROUND LEVEL SO THAT IT MAY GROW BACK FOLLOWING CONSTRUCTION.
3. AVOID THE UNNECESSARY REMOVAL OF TREES OR SHRUBS; FOR EXAMPLE, PRUNE THE AERIAL PORTIONS OF TREES AND SHRUBS THAT HANG OVER A PROJECT AREA AND INTERFERE WITH EQUIPMENT.
4. ALL DISTURBED AREAS SHALL BE SEEDED WITH EITHER THE UPLAND OR WETLAND SEED MIX LISTED BELOW. NO SUBSTITUTIONS SHALL BE ALLOWED, INCLUDING ADDITION OF A COVER CROP, WITHOUT WRITTEN PERMISSION OF CCBWQA REPRESENTATIVE. OVERLAP THE SEED MIXES A MINIMUM OF 1 FEET. THE CONTRACTOR SHALL LIMIT DISTURBANCE TO THE CONSTRUCTION LIMITS SHOWN ON THE PLAN. SEED TAGS MUST BE SUBMITTED TO THE CCBWQA REPRESENTATIVE.
5. NATIVE SEED MAY BE DRILLED OR BROADCAST. SEED WHICH IS BROADCAST SHALL BE HAND RAKED IMMEDIATELY FOLLOWING SEEDING TO COVER WITH 1/8" TO ½" OF TOPSOIL. SEEDING RATES SHOWN SHALL BE DOUBLED IF BROADCASTED.
6. LIVE SANDBAR WILLOW STAKES - WILLOWS SHALL BE CUT FROM THE EXISTING SANDBAR WILLOW WITHIN THE PROJECT AREA. THE EXISTING WILLOWS WILL BE CUT 8 TO 10 INCHES FROM THE GROUND WITH LOPPERS OR HANDSAWS. THE CUTS WILL BE AT A 45-DEGREE ANGLE. WILLOW STAKES WILL BE APPROXIMATELY 3 TO 4 FEET LONG AND GREATER THAN ½ INCH IN DIAMETER. ALL SIDE BRANCHES AND THE TERMINAL BUD SHALL BE TRIMMED OFF. IMMEDIATELY AFTER CUTTING, ALL LIVE STAKES WILL BE PLACED IN WATER SO THAT THE CUT ENDS ARE COVERED WITH WATER, AND THE CUTTINGS SHALL BE STORED IN A COOL LOCATION. TO STORE CUT WILLOWS STAKES GREATER THAN 3 DAYS, CUT STAKES WILL BE WRAPPED IN WET BURLAP AND STORED IN A COOL PLACE. BURLAP WILL REMAIN DAMP AT ALL TIMES DURING STORAGE. WILLOW STAKES SHALL BE PLANTED USING A PIECE OF REBAR TO CREATE A VERTICAL HOLE APPROXIMATELY 1 TO 2 FEET DEEP. APPROXIMATELY 2/3 OF THE STAKE SHALL BE INSERTED INTO THE HOLE SO THAT THE STAKE IS IN CONTACT WITH THE WATER TABLE. AFTER THE WILLOW CUTTING IS INSERTED, THE HOLE SHALL BE BACKFILLED WITH NATIVE SOILS AND LIGHTLY TAMPED TO PREVENT AIR POCKETS. THE STAKE SHALL THEN BE WATERED TO HELP FILL IN THE AIR POCKETS. WILLOW STAKES SHALL BE PLANTED 3 FEET ON CENTER IN TWO ROWS. IT IS IMPORTANT TO PLANT WILLOW STAKES DEEP ENOUGH SO THAT THE BOTTOM OF THE CUTTING REACHES SATURATED SOIL THROUGHOUT THE GROWING SEASON.
7. HARVEST AND PLANT WILLOW LIVE STAKES DURING DORMANT SEASON.
8. USE HEALTHY, STRAIGHT, AND LIVE WOOD AT 2 TO 3 YEARS OLD.
9. MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS DURING INSTALLATION.
10. SOAK CUTTINGS FOR 24 HOURS (MIN.) PRIOR TO INSTALLATION.
11. STORE CUT WILLOWS WITH LOWER ENDS IN WATER FOR NO LONGER THAN 7 DAYS BEFORE PLANTING.

WETLAND SEED MIX			
COMMON NAME	SCIENTIFIC NAME	VARIETY	LBS/ACRE
Woolly sedge	*Carex lanuginosa*	Native	0.25
Alkali sacaton	*Sporobolus airoides*	Native	3.00
Prairie cordgrass	*Spartina pectinata*	Native	6.00
Green needlegrass	*Nassella viridula*	Lodorm	15.00
Switchgrass	*Panicum virgatum*	Blackwell	15.00
Western wheatgrass	*Pascopyrum smithii*	Arriba	10.00
High Plains Wet Meadow Mix	*Western Native Seed CO.*		10.00
Louisiana sage	*Artemisia ludoviciana*	Native	0.25
Nuttall's sunflower	*Helianthus nuttallii*	Native	0.25
Blue vervain	*Verbena hastata*	Native	0.25
Yarrow	*Achillea lanulosa*	Native	0.25
Total pounds LBS/acre			60.25

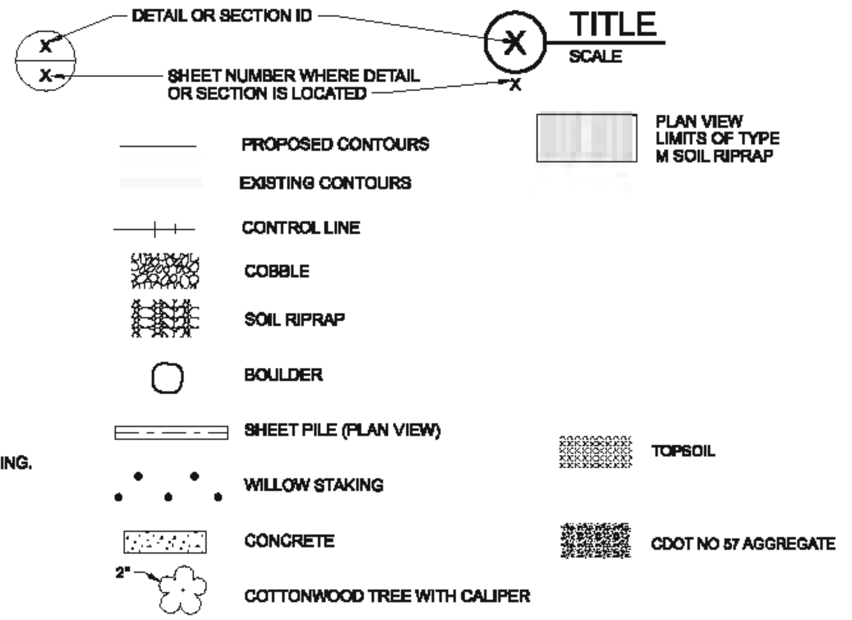
UPLAND SEED MIX FOR LOAMY TO CLAY-LOAM SOILS			
COMMON NAME	SCIENTIFIC NAME	VARIETY	LBS/ACRE
Sideoats grama	Bouteloua curtipendula	Butte	5
Blue grama	Chondrosum gracile	Lovington	3
Prairie sandreed	Calamovilfa longifolia	Native	6
Switchgrass	Panicum virgatum	Blackwell	5
Indian ricegrass	Oryzopsis hymenoides	Rimrock	1
Western wheatgrass	Pascopyrum smithii	Arriba	5
Sand bluestem	Andropogon hallii	Woodward	2
Sand dropseed	Sporobolus cryptandrus	Native	2
Fringed sage	Artemisia frigida	Native	0.05
Aster	Aster laevis	Native	0.01
Purple prairie clover	Dalea purpurea	Native	0.5
Blanket flower	Gaillardia aristata	Native	0.5
Tansy aster	Machaeranthera tanacetafolia	Native	0.1
Large-flowered penstemon	Penstemon grandiflorus	Native	0.1
Wand penstemon	Penstemon virgatus	Native	0.05
Prairie coneflower	Ratibida columnifera	Native	0.1
Showy goldeneye	Viguiera multiflora	Native	0.2
Total LBS/acre			30.6

SHEET PILE

1. SHEET PILE SHALL BE PZ-22.
2. USE MANUFACTURER INSTALLATION PROCESS FOR SOIL CONDITIONS PRESENTED IN THE GEOTECHNICAL REPORT TITLED "GEOTECHNICAL INVESTIGATION, 12-MILE PARK CHERRY CREEK STREAM RECLAMATION WEST OF SOUTH PARKER ROAD AND SOUTH CHAMBERS ROAD, ARAPAHOE COUNTY, COLORADO", CTL THOMPSON, AUGUST 30, 2010.
3. SHEET PILE PROFILE SHALL BE MANUFACTURED WITH AN INTERLOCKING FEATURE THAT ENSURES ADJACENT PANELS MAINTAIN ALIGNMENT.
4. SHEET PILE SHALL BE PAID FOR BY THE INSTALLED PLANAR SQUARE FEET, PER THE CONTRACT BID SCHEDULE.

LEGEND

TYPICAL SECTIONS AND DETAIL CALLOUTS FOLLOW THE GENERAL FORMAT SHOWN BELOW. DETAILS ARE IDENTIFIED WITH NUMBERS AND CROSS SECTION CUTS ARE IDENTIFIED BY LETTERS. SEE GESC SHEETS FOR ASSOCIATED SYMBOLOGY.



ABBREVIATIONS

CC	COMPOUND CURVE	H	HORIZONTAL
CCBWQA	CHERRY CREEK BASIN WATER QUALITY AUTHORITY	INV	INVERT
		LBS	POUNDS
CCSP	CHERRY CREEK STATE PARK	MAX	MAXIMUM
CDOT	COLORADO DEPARTMENT OF TRANSPORATION	MIN	MINIMUM
		N	NORTHING
CMP	CORRUGATED METAL PIPE	OC	ON CENTER
CLR	CLEAR	PC	POINT OF CURVATURE
CY	CUBIC YARD	PI	POINT OF INTERSECTION
DIA	DIAMETER	PJF	PREMOLDED JOINT FILLER
DOLA	DOG OFF LEASH AREA	POB	POINT OF BEGINNING
DWG	DRAWING	POE	POINT OF ENDING
E	EASTING	PT	POINT OF TANGENCY
EA	EACH	PVI	POINT OF VERTICAL INTERSECTION
EC	EROSION CONTROL	REINF	REINFORCING
EF	EACH FACE	S	SLOPE
ELEV	ELEVATION	SST	STAINLESS STEEL
EW	EACH WAY	STA	STATION
EWEF	EACH WAY EACH FACE	TYP	TYPICAL
EXST	EXISTING	UDFCD	URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
FES	FLARED END SECTION	V	VERTICAL
GESC	GRADING, EROSION, AND SEDIMENT CONTROL		

NO	DATE	DESCRIPTION	APVR	N
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A COOK	S KRAMER	C HOOPER	S YANAGIHARA	

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CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

GENERAL NOTES

VERIFY SCALE
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0 1"

DATE	OCTOBER 2011
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DWG	G-2
SHEET	2

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SURVEY CONTROL POINTS

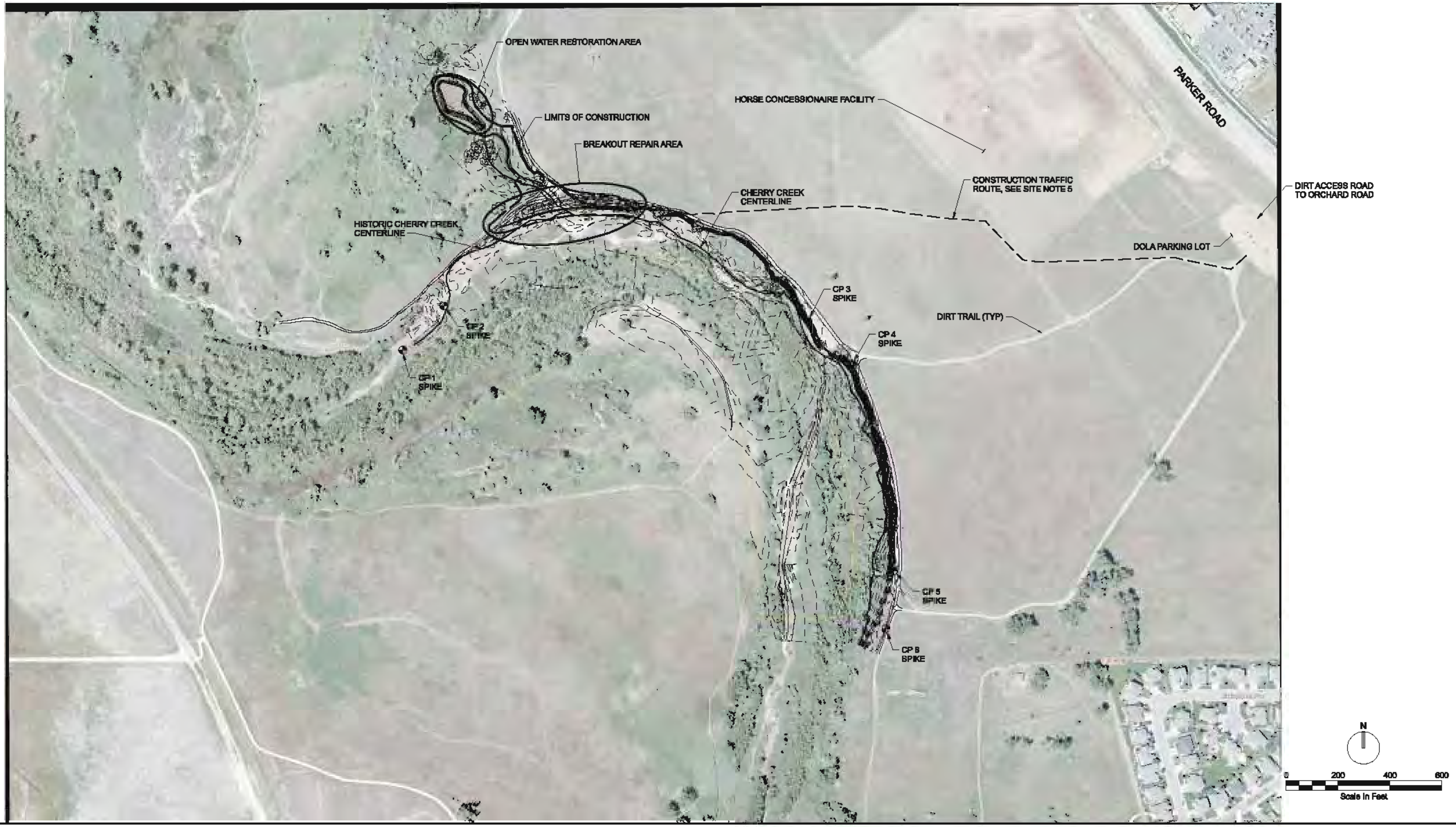
POINT NO	NORTHING	EASTING	ELEVATION	DESCRIPTION
CP 1	1649267.00	3190343.83	5597.07	SPIKE
CP 2	1649436.82	3190502.66	5597.77	SPIKE
CP 3	1649377.43	3191905.98	5610.48	SPIKE
CP 4	1649209.00	3192079.55	5612.93	SPIKE
CP 5	1648418.36	3192234.35	5617.6	SPIKE
CP 6	1648195.89	3192205.43	5616.45	SPIKE

SURVEY NOTES

1. HORIZONTAL DATUM: NORTH AMERICAN DATUM OF 1983, ADJUSTMENT OF 2007 (NSRS2007) ACQUIRED FROM VRS NETWORK
2. VERTICAL DATUM: NORTH AMERICAN VERTICAL DATUM OF 1988 ACQUIRED FROM VRS NETWORK. CONVERSION FROM NAVD 88 TO NGVD 29= NAVD 88 ELEV-2.97 FT=NGVD 29 ELEV.
3. PROJECTION: COLORADO COORDINATE SYSTEM OF 1983, CENTRAL ZONE
4. GEOID - 2009
5. COMBINED SCALE FACTOR (GRID TO GROUND) 1.000289002
6. UNITS: US SURVEY FEET
7. INITIAL SURVEY PERFORMED BY CRITIGEN, UPDATED BY CH2MHILL
8. DATE OF SURVEY: JULY 1, 2010 UPDATED FOR BORROW AREA JUNE 2, 2011

SITE NOTES:

1. SEE GESC PLANS FOR EROSION CONTROL MEASURES AND ACCESS REQUIREMENTS.
2. CONTRACTOR SHALL MAINTAIN PARK ACCESS AND TRAIL ACCESS DURING CONSTRUCTION.
3. CONTRACTOR SHALL COMPLY WITH STATE PARKS REQUIREMENTS FOR WORK HOURS AND SITE ACCESS.
4. CONTRACTOR SHALL REMOVE ALL WEEDS AND DIRT FROM CONSTRUCTION EQUIPMENT PRIOR TO ACCESSING SITE TO PREVENT THE SPREAD OF WEEDS.
5. CONSTRUCTION TRAFFIC SHALL UTILIZE IDENTIFIED ROUTE. IF ALTERNATE ROUTE IS REQUESTED IT MUST BE APPROVED BY CCSP PRIOR TO USE OF NEW ROUTE.



NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
A COOK	S KRAMER	C HOOPER	S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

CH2MHILL

SURVERY CONTROL AND SITE PLAN

VERIFY SCALE

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0 1"

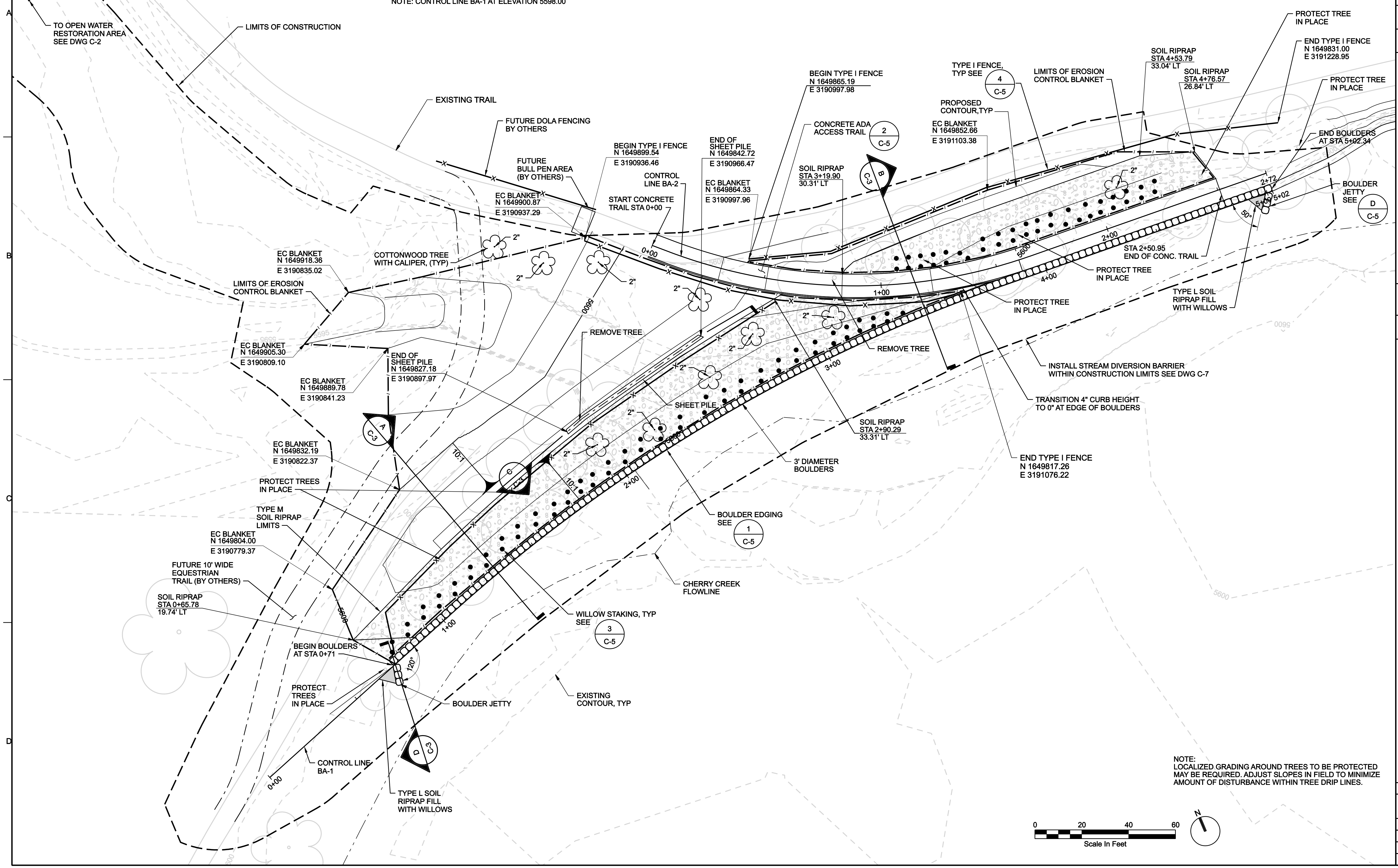
DATE	OCTOBER 2011
PROJ	407259
DWG	G-3
SHEET	3

CONTROL LINE BA-1								
POINT TYPE	POINT NUMBER	STATION	NORTHING	EASTING	RADIUS	LENGTH	DELTA/ THETA	ROTATION DIRECTION
POB		0+00.00	1649740.39	3190723.55				
PC		1+04.45	1649774.74	3190822.19				
PI		2+44.96	1649820.94	3190954.89	700	277.34	22°42'01"	RIGHT
CC			1649113.66	3191052.38				
PT		3+81.78	1649812.36	3191095.14				
POE		5+02.34	1649804.99	3191215.46				

NOTE: CONTROL LINE BA-1 AT ELEVATION 5598.00

CONTROL LINE BA-2								
POINT TYPE	POINT NUMBER	STATION	NORTHING	EASTING	RADIUS	LENGTH	DELTA/ THETA	ROATION DIRECTION
POB		0+00.00	1649886.48	3190962.37				
PC		0+07.81	1649881.10	3190968.03				
PI		0+89.82	1649824.60	3191027.46	225.00	157.29	40°03'10"	LEFT
CC			1650044.18	3191123.05				
PT		1+65.10	1649819.60	3191109.32				
POE		2+71.93	1649813.08	3191215.96				

CONTROL LINE BA-2 VERTICAL								
ELEMENT TYPE	BEGIN POINT TYPE	END POINT TYPE	BEGIN STATION	END STATION	BEGIN ELEVATION	END ELEVATION	TANGENT GRADE	TANGENT LENGTH
LINEAR	POB	PVI	0+00.00	0+07.81	5600.13	5600.14	0.22%	7.81
LINEAR	PVI	PVI	0+07.81	0+14.45	5600.14	5600.17	0.46%	6.65
LINEAR	PVI	PVI	0+14.45	0+59.00	5600.17	5602.4	5.00%	44.55
LINEAR	PVI	PVI	0+59.00	0+68.00	5602.4	5602.4	0.00%	9
LINEAR	PVI	PVI	0+68.00	1+60.00	5602.4	5600	-2.61%	92
LINEAR	PVI	POE	1+60.00	2+71.93	5600	5600	0.00%	111.93



NOTE:
LOCALIZED GRADING AROUND TREES TO BE PROTECTED MAY BE REQUIRED. ADJUST SLOPES IN FIELD TO MINIMIZE AMOUNT OF DISTURBANCE WITHIN TREE DRIP LINES.

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD
DSGN	DR	CHK	APVD	
A COOK	S KRAMER	C HOOPER	S YANAGIHARA	

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

CH2MHILL

BREAKOUT AREA REPAIR PLAN

VERIFY SCALE
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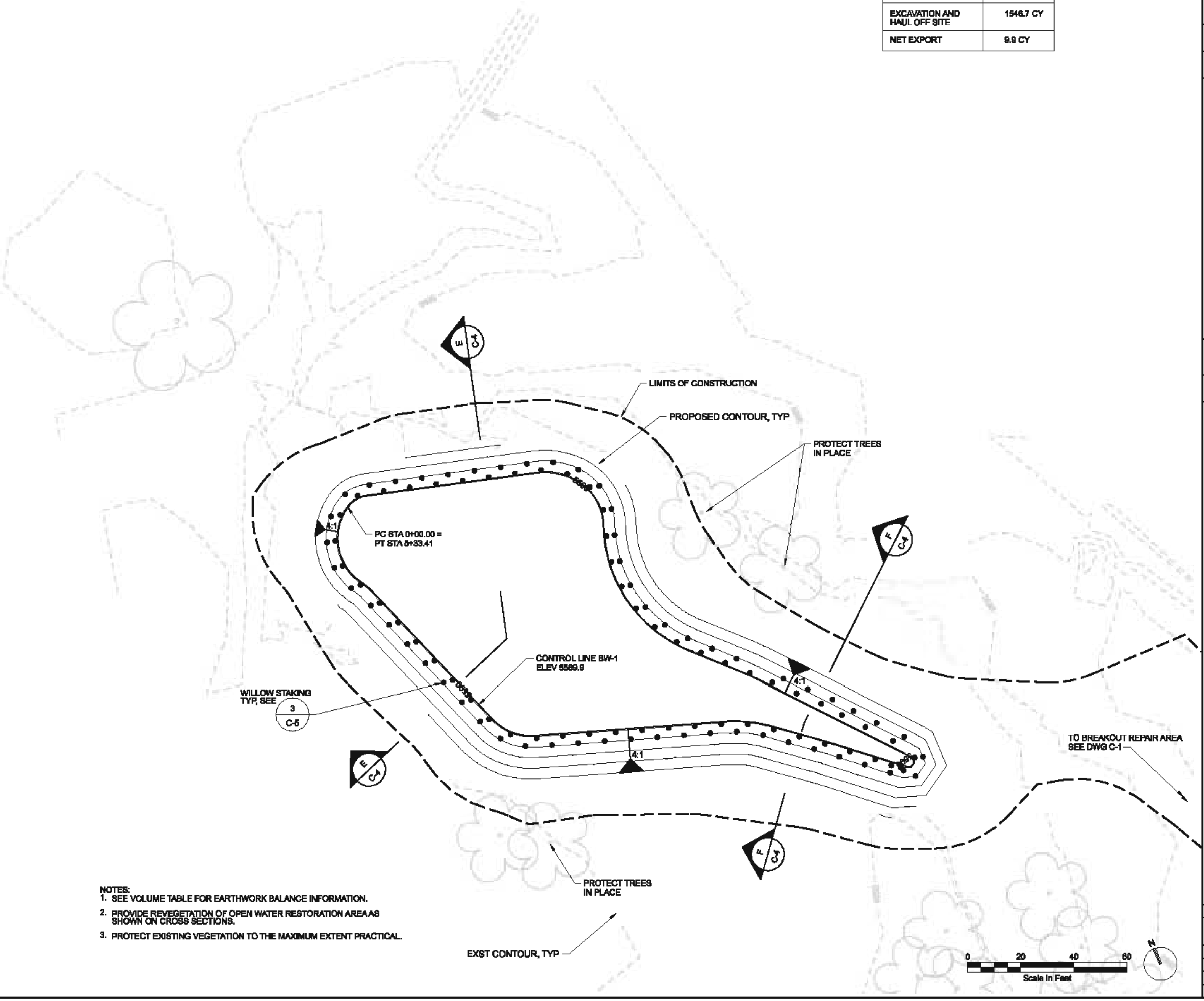
0 1"

DATE	OCTOBER 2011
PROJ	407259
DWG	C-1
SHEET	4

FILENAME: CC50nc003.dgn PLOT DATE: 10/7/2011 PLOT TIME: 4:45:17 PM

CONTROL LINE BW-1								
Point Type	Point Number	Station	Northing	Easting	Radius	Length	Delta / Theta	Rotation Direction
PC		0+00.00	1650298.18	3190493.83				
PI		0+19.94	1650287.83	3190476.79	20	31.36	89°49'48"	Left
CC			1650281.08	3190504.21				
PT		0+31.36	1650270.75	3190487.08				
PI		0+35.71	1650267.02	3190489.33				
PI		0+35.71	1650267.02	3190489.33				
PC		1+03.02	1650203.43	3190513.16				
PI		1+13.13	1650194.52	3190516.50	20	17.75	50°52'34"	Left
CC			1650210.45	3190531.89				
PT		1+21.38	1650191.48	3190525.51				
PC		1+93.30	1650168.57	3190593.69				
PI		2+02.03	1650165.79	3190601.96	50	17.28	19°48'09"	Right
CC			1650121.18	3190577.75				
PT		2+10.58	1650160.37	3190608.80				
PC		2+31.64	1650147.29	3190625.31				
PI		2+32.47	1650146.78	3190625.96	50	1.66	1°54'28"	Right
CC			1650108.10	3190594.26				
PT		2+33.30	1650146.24	3190626.59				
PC		2+64.45	1650126.09	3190650.35				
PI		2+89.29	1650110.03	3190669.30	2	5.96	170°47'36"	Left
CC			1650127.62	3190651.64				
PT		2+70.41	1650128.92	3190653.16				
PC		3+37.64	1650180.04	3190609.51				
PI		3+38.41	1650180.62	3190609.01	20	1.55	4°25'44"	Left
CC			1650167.05	3190594.30				
PT		3+39.18	1650181.17	3190608.46				
PC		3+63.25	1650198.21	3190591.46				
PI		3+96.38	1650221.67	3190588.06	52	59	65°00'30"	Right
CC			1650234.98	3190626.28				
PT		4+22.25	1650252.75	3190579.44				
PC		4+24.46	1650254.87	3190580.20				
PI		4+39.20	1650268.71	3190585.26	20	25.4	72°46'12"	Left
CC			1650261.73	3190561.42				
PT		4+49.86	1650277.64	3190573.54				
PC		4+51.71	1650278.76	3190572.07				
PI		4+55.62	1650281.13	3190568.96	20	7.72	22°06'28"	Left
CC			1650262.85	3190559.95				
PT		4+59.43	1650282.15	3190565.19				
PC		5+25.11	1650298.38	3190501.81				
PI		5+29.40	1650300.50	3190497.67	10	8.11	46°27'45"	Left
CC			1650289.73	3190499.19				
PT		5+33.22	1650298.38	3190494.00				
POE		5+33.41	1650298.18	3190493.83				

VOLUME TABLE	
ON-SITE FILL	1,499.8 CY
FILL AT TOWER LOOP ROAD SITE BY OTHERS	37 CY
EXCAVATION AND HAUL OFF SITE	1546.7 CY
NET EXPORT	9.9 CY



NOTES:
1. SEE VOLUME TABLE FOR EARTHWORK BALANCE INFORMATION.
2. PROVIDE REVEGETATION OF OPEN WATER RESTORATION AREA AS SHOWN ON CROSS SECTIONS.
3. PROTECT EXISTING VEGETATION TO THE MAXIMUM EXTENT PRACTICAL.

NO	DATE	DESCRIPTION		APVR	N
NO.	DATE	REVISION		BY	APVD
DSGN	DR	CHK	APVD		
A COOK	S KRAMER	C HOOPER	S YANAGIHARA		

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

CH2MHILL

OPEN WATER RESTORATION
AREA PLAN

VERIFY SCALE
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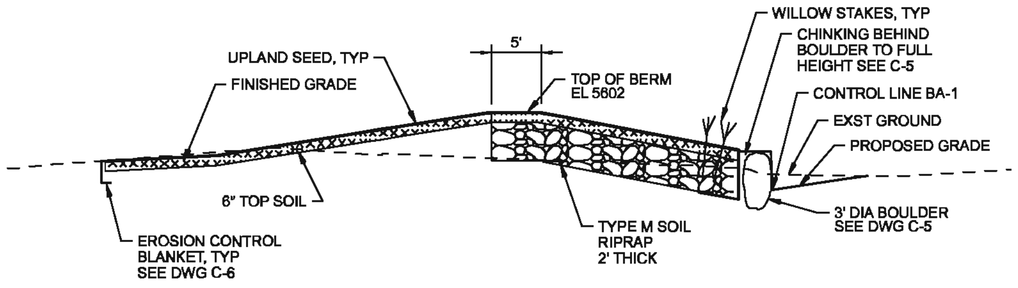
0 1"

DATE	OCTOBER 2011
PROJ	407259
DWG	C-2
SHEET	5

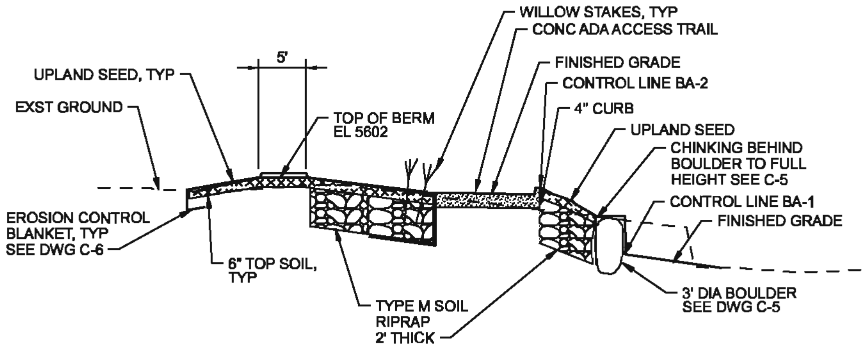
FILENAME: CC50nc005.dgn PLOT DATE: 9/29/2011 PLOT TIME: 10:31:11 AM



A BREAKOUT AREA CROSS SECTION

H:1"=10'-0" V: 1"=5'-0"

C-1



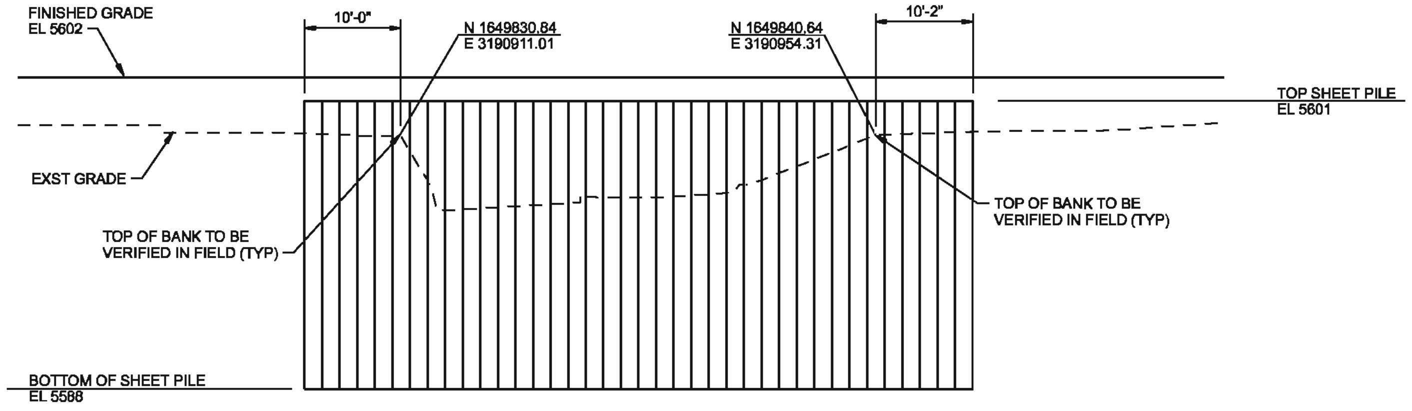
B BREAKOUT AREA CROSS SECTION

H:1"=10'-0" V: 1"=5'-0"

C-1

NOTES:

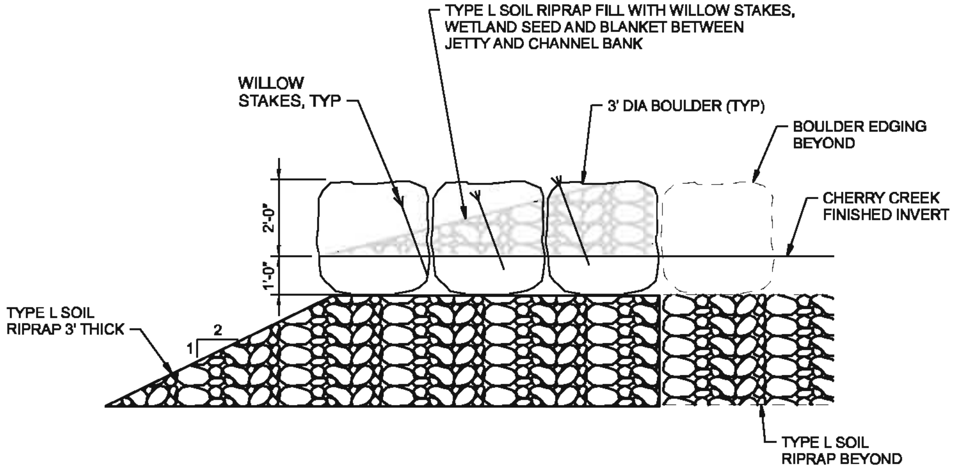
1. TYPE M SOIL RIPRAP PER CCBWQA STANDARDS.
2. LIMITS OF TYPE M SOIL RIPRAP SHOWN ON PLANS.



C BREAKOUT AREA SHEET PILE SECTION

H:1"=10'-0" V: 1"=5'-0"

C-1



D BOULDER JETTY SECTION

1"=5'

C-1

NO	DATE	DESCRIPTION	BY	APVR
		REVISION		

DSGN	DR	CHK	APVD
A COOK	S KRAMER	C HOOPER	S YANAGIHARA

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CHERRY CREEK BASIN
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ARAPAHOE COUNTY

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BREAKOUT AREA REPAIR SECTIONS

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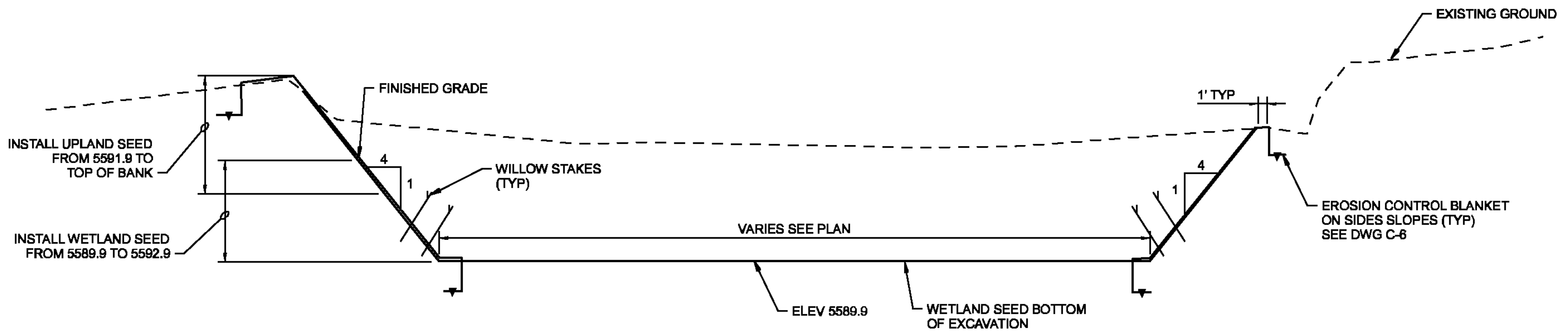
DATE	OCTOBER 2011
PROJ	407259
DWG	C-3
SHEET	6

FILENAME: CC50nc004.dgn PLOT DATE: 9/29/2011 PLOT TIME: 10:32:02 AM

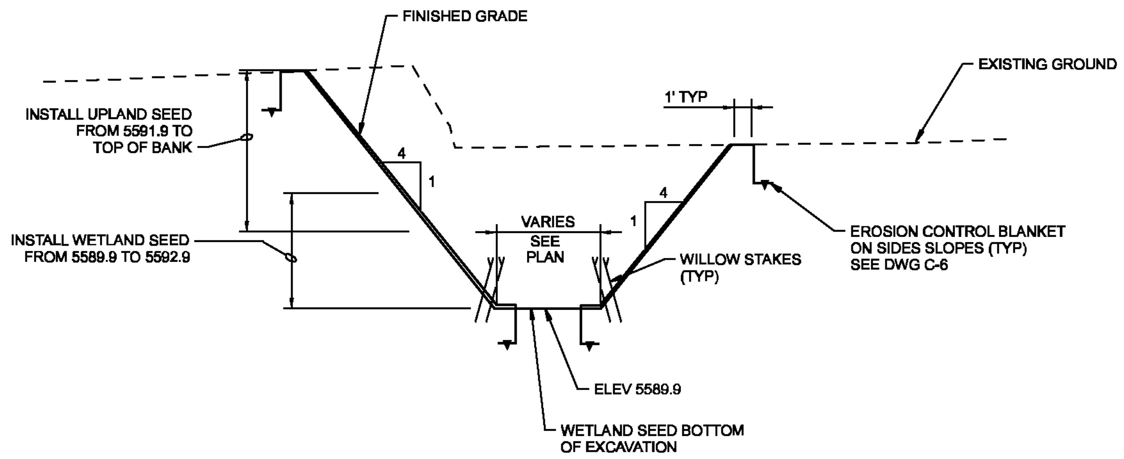


OPEN WATER RESTORATION AREA CROSS SECTION

E

C-2

H: 1"=10' V: 1"=2'



OPEN WATER RESTORATION AREA CROSS SECTION

F

C-2

H: 1"=10' V: 1"=2'

NOTES:
1. INSTALL 6" OF TOPSOIL AND SEED PRIOR TO INSTALLING EROSION CONTROL BLANKET.
2. THROUGHLY SATURATE SOILS PER SPECIFICATIONS PRIOR TO SEEDING.

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN A COOK | DR S KRAMER | CHK C HOOPER | APVD S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

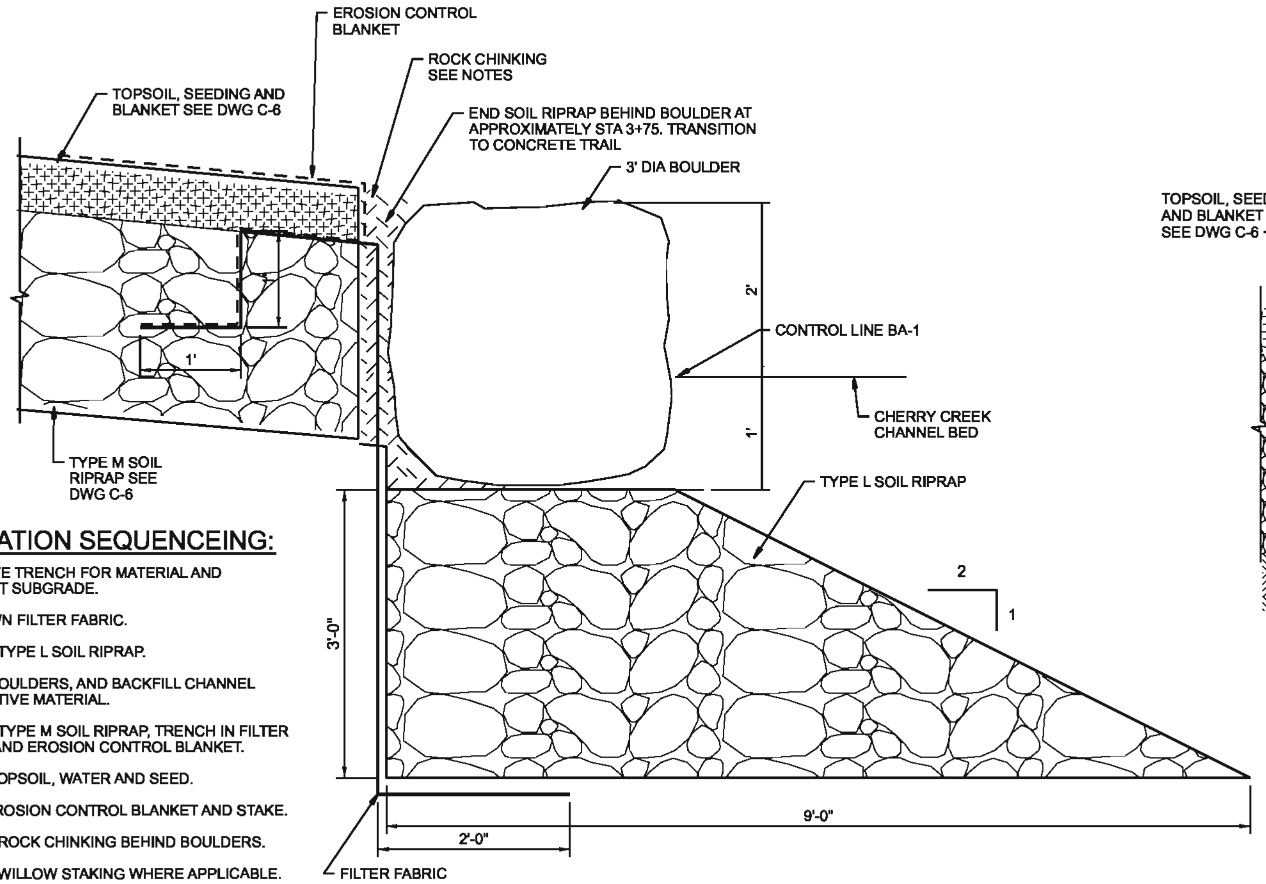
CH2MHILL

OPEN WATER RESTORATION
AREA SECTIONS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2011
PROJ	407259
DWG	C-4
SHEET	7

FILENAME: CC50nc006.dgn PLOT DATE: 9/29/2011 PLOT TIME: 10:33:56 AM



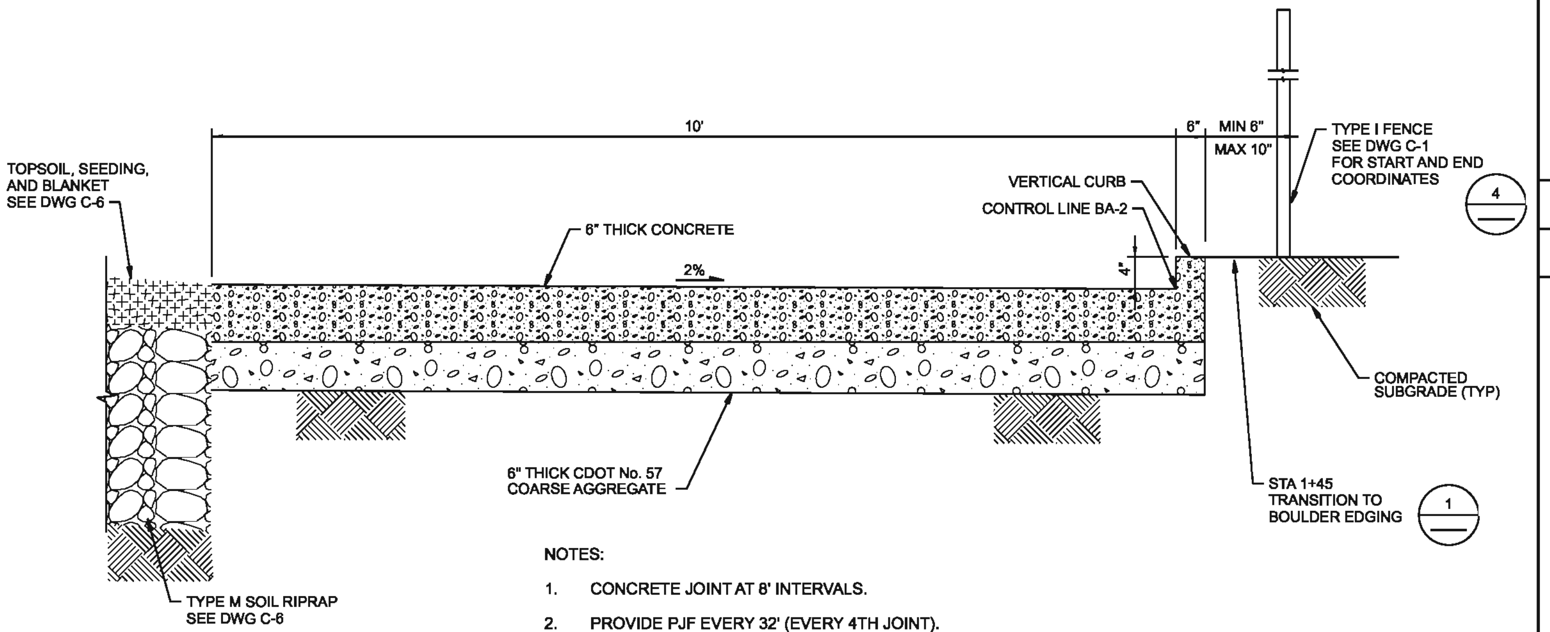
INSTALLATION SEQUENCEING:

1. EXCAVATE TRENCH FOR MATERIAL AND COMPACT SUBGRADE.
2. LAY DOWN FILTER FABRIC.
3. INSTALL TYPE L SOIL RIPRAP.
4. PLACE BOULDERS, AND BACKFILL CHANNEL WITH NATIVE MATERIAL.
5. INSTALL TYPE M SOIL RIPRAP, TRENCH IN FILTER FABRIC AND EROSION CONTROL BLANKET.
6. PLACE TOPSOIL, WATER AND SEED.
7. WRAP EROSION CONTROL BLANKET AND STAKE.
6. INSTALL ROCK CHINKING BEHIND BOULDERS.
9. INSTALL WILLOW STAKING WHERE APPLICABLE.

1 BOULDER EDGING DETAIL

1"=1'-0"

C-1



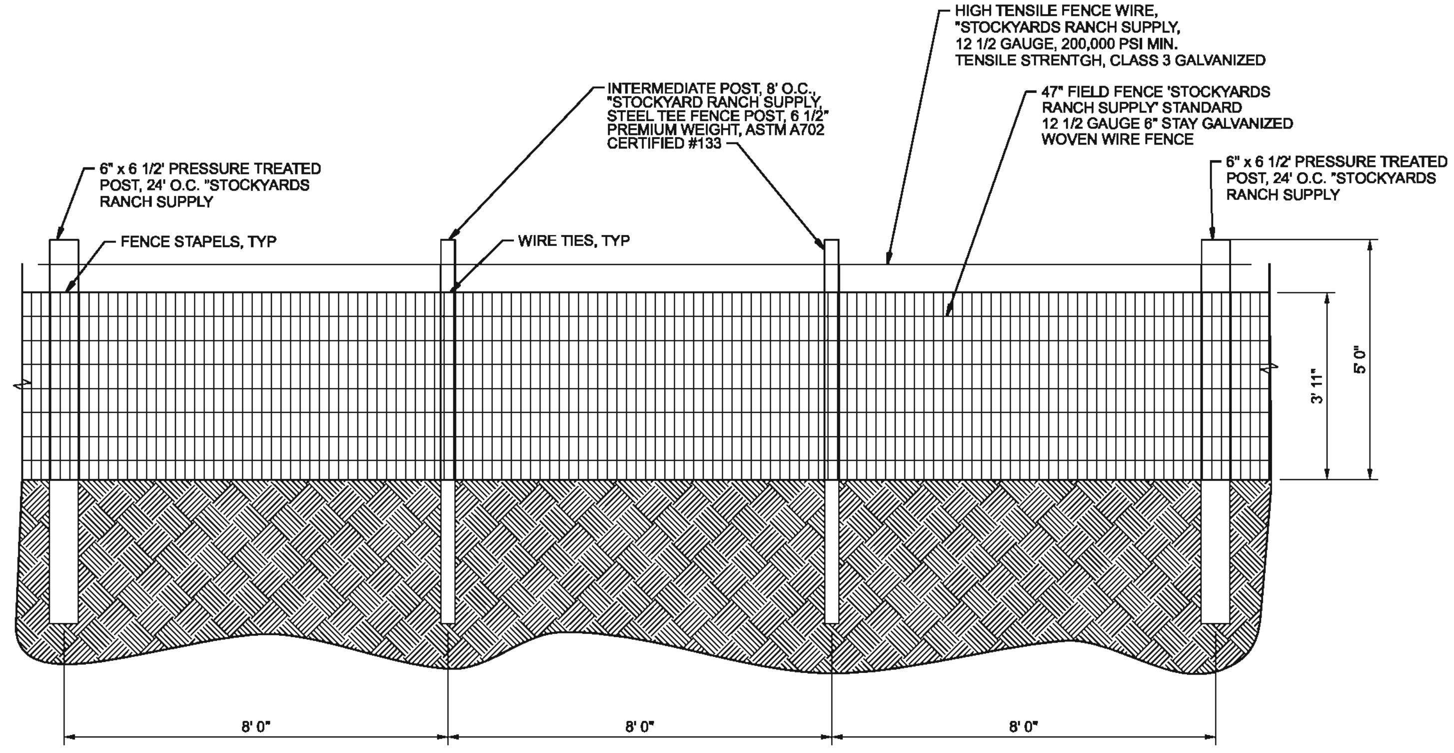
NOTES:

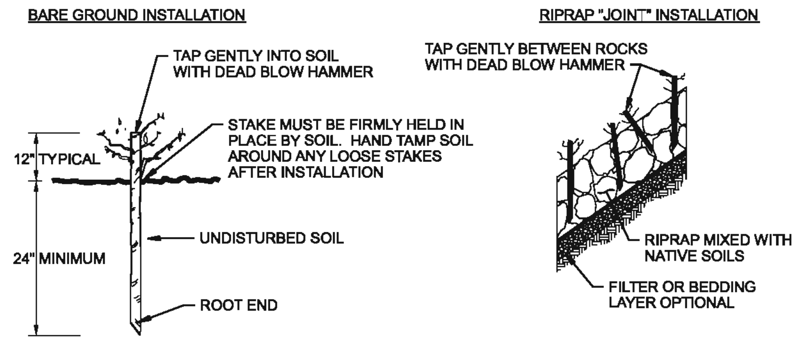
1. CONCRETE JOINT AT 8' INTERVALS.
2. PROVIDE PJF EVERY 32' (EVERY 4TH JOINT).
3. JOINTS SHALL BE SAW CUT NOT TOOLED JOINTS.
4. CONCRETE SHALL MEET REQUIREMENTS OF SPECIFICATION SECTIONS 3000.

2 CONCRETE TRAIL DETAIL

1"=1'-0"

C-1





NOTES:

1. THE STAKE SHALL BE INSERTED INTO THE HOLE SO STAKE IS IN CONTACT WITH WATER TABLE.
2. CUT STAKE AND INSTALL STAKES WITH A MINIMUM OF 4 BUDS ABOVE AND 4 BUDS BELOW FINISHED GRADE.

3 WILLOW STAKE DETAIL

NTS

C-1
C-2

4 DOG PARK FENCE, TYPE 1

NTS

C-1

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN A COOK
DR S KRAMER
CHK C HOOPER
APVD S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

CH2MHILL

DETAILS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2011
PROJ	407259
DWG	C-5
SHEET	8

FILENAME: CC95ndt01.dgn PLOT DATE: 10/7/2011 PLOT TIME: 4:50:25 PM

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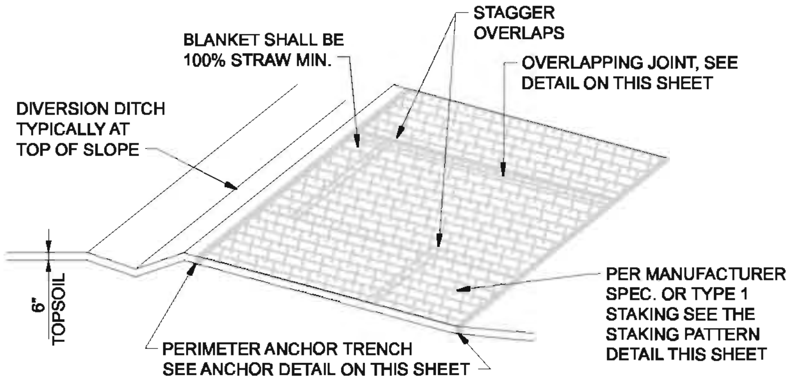
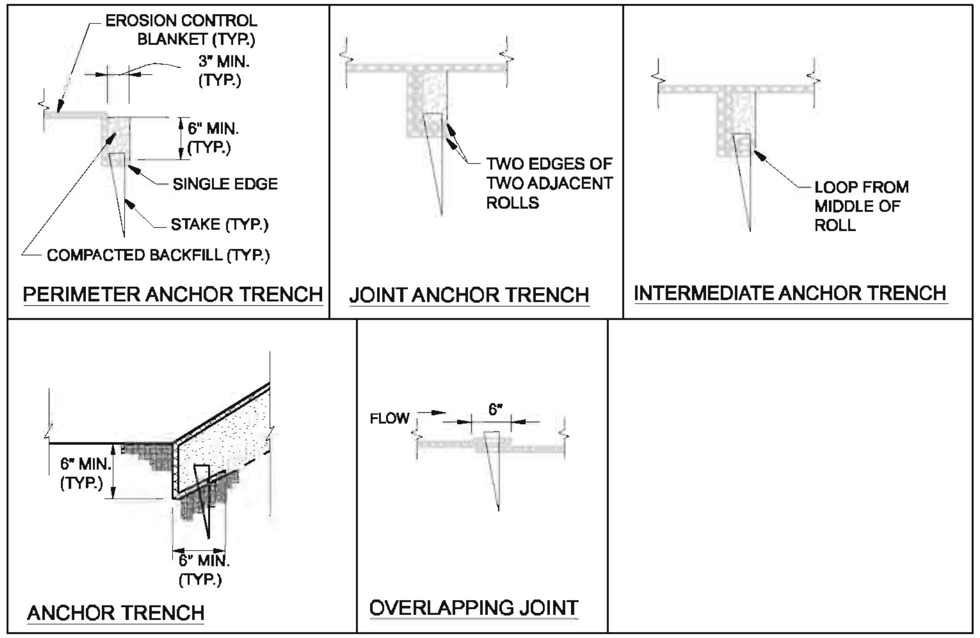
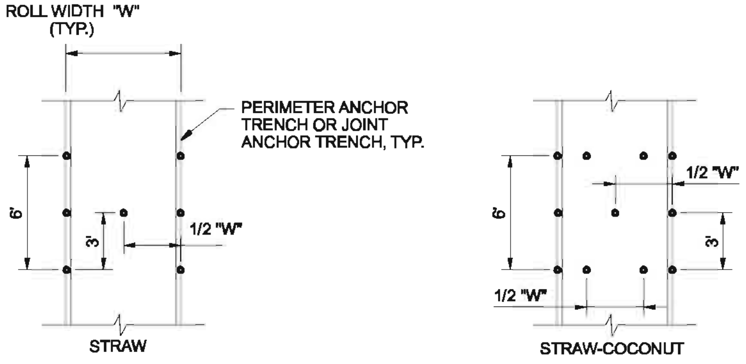


OUTSIDE OF STREAMS AND DRAINAGE CHANNELS

AT PIPE OUTLET AREAS OF STREAMS AND DRAINAGE CHANNELS - DETAIL A

ANCHOR DETAILS





STAKING PATTERNS

SHALL BE IN ACCORDANCE WITH MANUFACTURER'S SPECIFICATION. IF NO MANUFACTURER'S SPECIFICATION IS AVAILABLE USE THE ACCEPTABLE STAKING PATTERN (AS SHOWN ABOVE)

EROSION CONTROL BLANKET INSTALLATION NOTES

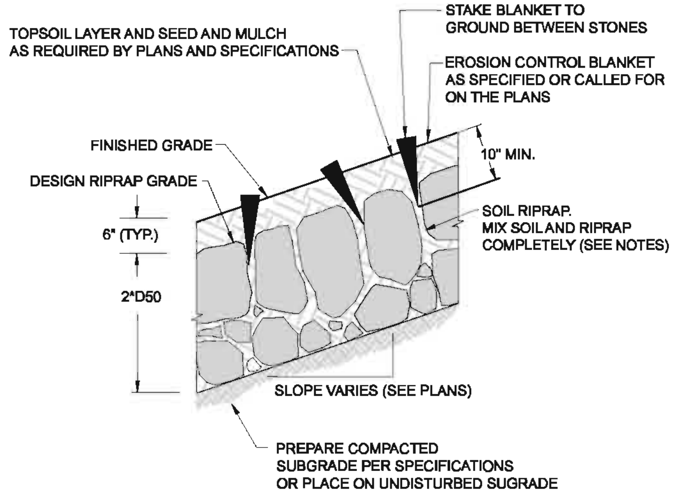
1. SEE PLAN VIEW FOR:
   - LOCATION OF PERIMETER OF EROSION CONTROL BLANKET.
   - TYPE OF BLANKET C125BN OR APPROVED EQUAL
   - AREA "A" IN SQUARE YARDS OF EACH TYPE OF BLANKET.
2. ALL EROSION CONTROL BLANKETS AND NETTING SHALL BE MADE OF 100% NATURAL AND BIODEGRADABLE MATERIAL (NOT INCLUDING COTTON) NO PLASTIC OR OTHER SYNTHETIC MATERIAL, EVEN IF PHOTO DEGRADABLE, SHALL BE ALLOWED.
3. IN AREAS WHERE EROSION CONTROL BLANKET IS SHOWN ON THE PLANS, THE PERMITEE SHALL PLACE TOPSOIL AND PERFORM FINAL GRADING, SURFACE PREPARATION, AND SEEDING BELOW THE SEEDING AND MULCHING. SUBGRADE SHALL BE SMOOTH AND MOIST PRIOR TO THE BLANKET INSTALLATION AND THE BLANKET SHALL BE IN FULL CONTACT WITH SUBGRADE, NO GAPS OF VOIDS SHALL EXIST UNDER THE BLANKET.
4. PERIMETER ANCHOR TRENCH SHALL BE USED AT OUTSIDE PERIMETER OF ALL BLANKET AREAS.
5. JOINT ANCHOR TRENCH SHALL BE USED TO JOIN ROLLS OF BLANKET TOGETHER (LONGITUDINALLY AND TRANSVERSELY) FOR ALL BLANKETS EXCEPT STRAW, WHICH MAY USE AND OVERLAPPING JOINT.
6. INTERMEDIATE ANCHOR TRENCH SHALL BE USED AT SPACING OF ONE-HALF THE ROLL LENGTH FOR COCONUT AND EXCELSIOR BLANKETS.
7. THE OVERLAPPING JOINT DETAIL SHALL BE USED TO JOIN ROLLS OF BLANKETS TOGETHER FOR BLANKETS ON SLOPES.
8. ANY AREAS OF SEEDING AND MULCHING DISTURBED IN THE PROCESS OF INSTALLING EROSION CONTROL BLANKET SHALL BE RESEEDED AND MULCHED.

EROSION CONTROL BLANKET MAINTENANCE NOTES

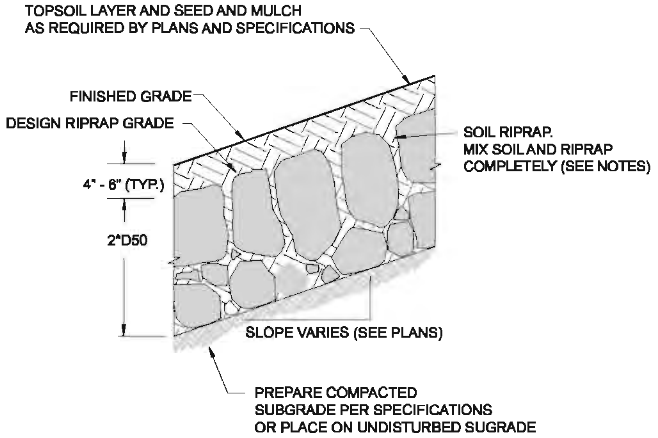
1. THE SWMP MANAGER SHALL INSPECT EROSION CONTROL BLANKETS WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS AS NECESSARY.
2. EROSION CONTROL BLANKET IS TO BE LEFT IN PLACE UNLESS REQUESTED TO BE REMOVED BY THE LOCAL JURISDICTION.
3. ANY EROSION CONTROL BLANKET PULLED OUT, TORN, OR OTHERWISE DAMAGED SHALL BE RE-INSTALLED. ANY SUBGRADE AREAS BELOW THE BLANKET THAT HAVE ERODED TO CREATE A VOID UNDER THE BLANKET, OR THAT REMAIN DEVOID OF GRASS SHALL BE REPAIRED, RESEEDED AND MULCHED AND THE EROSION CONTROL BLANKET REINSTALLED.

EROSION CONTROL BLANKET

NTS



TYPICAL SECTION - SOIL RIPRAP WITH EROSION CONTROL FABRIC



TYPICAL SECTION - SOIL RIPRAP WITH MUCLH

NOTES:
1. SOIL RIPRAP DETAILS ARE APPLICABLE TO SLOPED AREAS. REFER TO THE SITE PLAN ACTUAL LOCATION AND LIMITS.
2. MIX UNIFORMALLY 65% RIPRAP BY VOLUME WITH 35% OF APPROVED SOIL BY VOLUME PRIOR TO PLACEMENT.
3. PLACE STONE-SOIL MIX TO RESULT IN SECURELY INTERLOCKED ROCK AT THE DESIGN THICKNESS AND GRADE. COMPACT AND LEVEL TO ELIMINATE ALL VOIDS AND ROCKS PROJECTING ABOVE DESIGN RIPRAP TOP GRADE.
4. CRIMP OR TACKIFY MULCH OR USE APPROVED HYDROMULCH AS CALLED FOR IN THE PLANS AND SPECIFICATIONS.

SOIL RIPRAP

NTS

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
A COOK	S KRAMER	C HOOPER	S YANAGIHARA

CH2MHILL

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

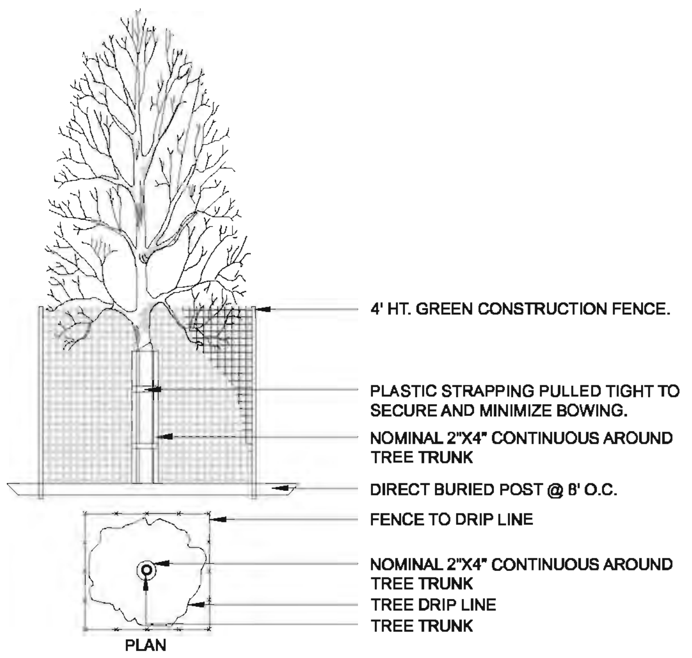
CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

STANDARD DETAILS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2011
PROJ	407259
DWG	C-6
SHEET	9

FILENAME: CC95ndt03.dgn PLOT DATE: 9/29/2011 PLOT TIME: 10:35:24 AM



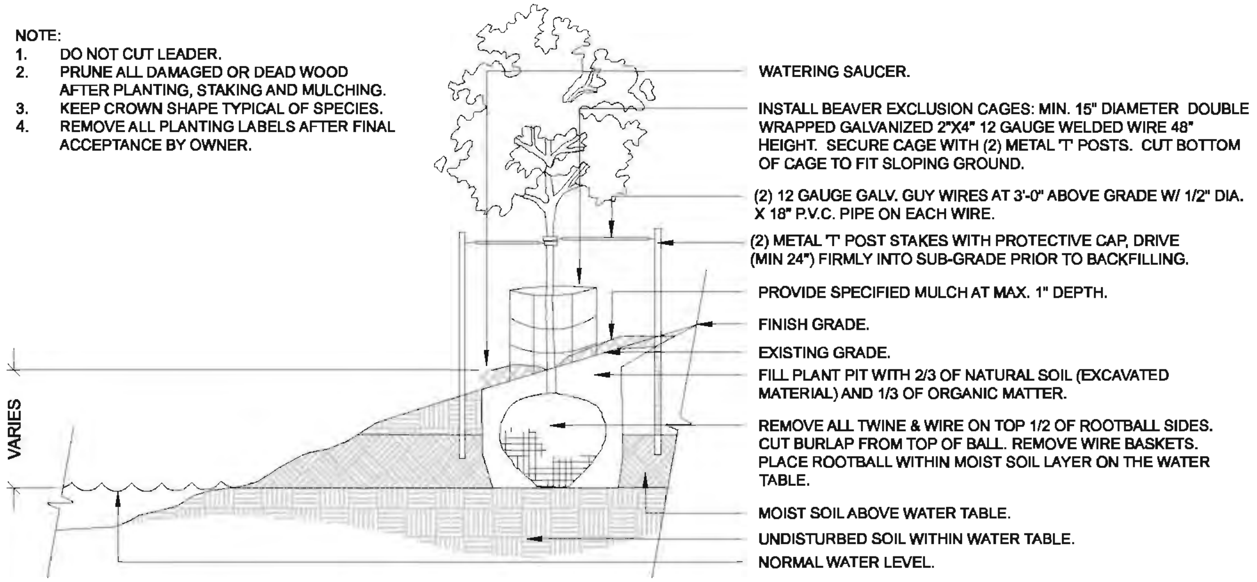
TREE PROTECTION

NTS

TREE PROTECTION NOTES:

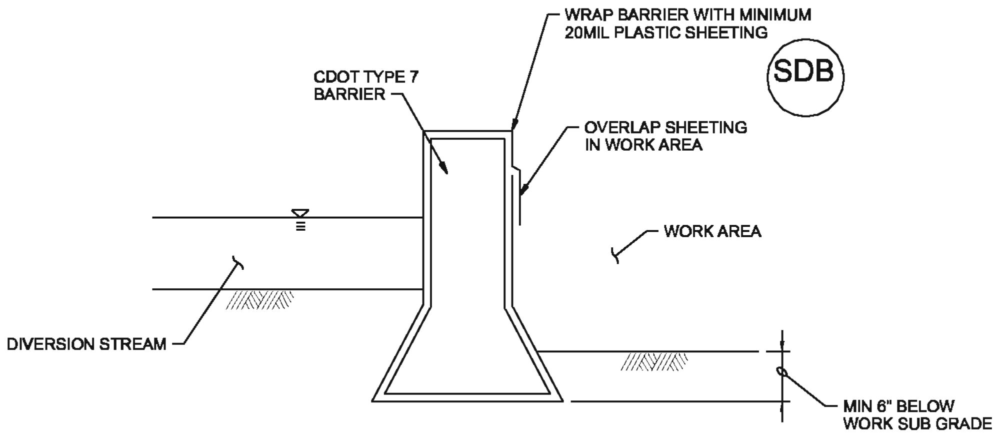
1. PRESERVATION MEASURES MUST BE IN PLACE BEFORE CONSTRUCTION, DEMOLITION AND/OR GRADING ACTIVITIES COMMENCE. CONSTRUCTION MAY BE HALTED IF TREE PRESERVATION MEASURES ARE NOT IN PLACE AND MAINTAINED THROUGHOUT THE CONSTRUCTION PERIOD.
2. TREES CALLED OUT FOR PRESERVATION SHALL BE FENCED AT THE DRIPLINE. FENCING MAY OCCUR AT THE COMBINED DRIPLINES OF GROVES OF TREES. PLACE 3 INCH BARK MULCH BENEATH DRIPLINES OF TREES TO BE PRESERVED. TREE PROTECTION ZONES SHALL HAVE A 6 FOOT MINIMUM DIAMETER.
3. FENCING SHALL BE 4 FEET TALL SNOW FENCING WITH STEEL POST EMBEDDED IN THE GROUND.
4. NO CONSTRUCTION MATERIALS OR CONSTRUCTION VEHICLES MAY BE STORED WITHIN THE DRIPLINES/FENCES AREA OF EXISTING TREES.
5. CONSTRUCTION VEHICLES OR MACHINERY MAY NOT PASS BETWEEN TWO OR MORE EXISTING TREES IDENTIFIED FOR PRESERVATION IF THEIR CANOPIES ARE WITHIN 10 FEET OF TOUCHING. ADDITIONAL FENCING MAY BE REQUIRED.
6. UNAUTHORIZED TREE REMOVAL OR DAMAGE IS SUBJECT TO REPLACEMENT EQUAL TO THE APPRAISED VALUE OF THE TREE LOST. CONTRACTOR IS RESPONSIBLE FOR DOCUMENTATION OF ALL EXISTING TREES TO REMAIN, PRIOR TO CONSTRUCTION.
7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ANY DAMAGE TO EXISTING IMPROVEMENTS AND UTILITIES AND SHALL REPAIR ANY DAMAGE AT HIS EXPENSE

NOTE:
1. DO NOT CUT LEADER.
2. PRUNE ALL DAMAGED OR DEAD WOOD AFTER PLANTING, STAKING AND MULCHING.
3. KEEP CROWN SHAPE TYPICAL OF SPECIES.
4. REMOVE ALL PLANTING LABELS AFTER FINAL ACCEPTANCE BY OWNER.



DEEP TREE PLANTING FOR B&B COTTONWOOD SPECIES

NTS



NOTES:
1. CONTRACTOR MAY SUBMIT AN ALTERNATIVE WATER DIVERSION SYSTEM, BUT IS SUBJECT TO APPROVAL BY ENGINEER.

STREAM DIVERSION BARRIER

NTS

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN A COOK
DR S KRAMER
CHK C HOOPER
APVD S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

CH2MHILL

STANDARD DETAILS

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2MHILL.

VERIFY SCALE
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0 1"

DATE	OCTOBER 2011
PROJ	407259
DWG	C-7
SHEET	10

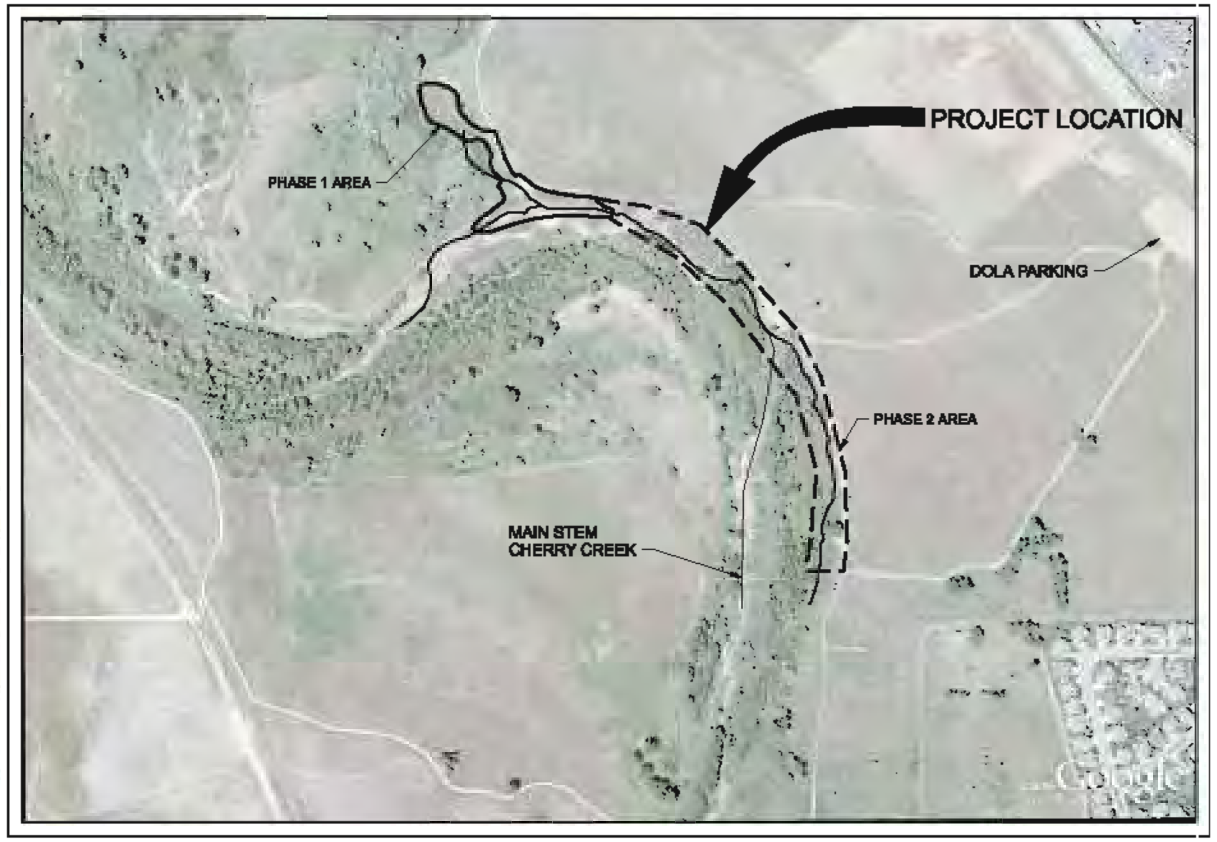
Appendix B – Phase 2 Preliminary Construction Drawings

PRELIMINARY CONSTRUCTION DRAWINGS
CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
PHASE 2

SEPTEMBER 2011

INDEX OF DRAWING

VICINITY MAP: ARAPAHOE COUNTY, CO
NTS
SOURCE: EXPERT GPS



LOCATION MAP: ARAPAHOE COUNTY, CO
NTS
SOURCE: GOOGLE EARTH

CHERRY CREEK BASIN WATER QUALITY AUTHORITY

BILL RUZZO, TECHNICAL MANAGER DATE

CH2M HILL

SCOTT YANAGIHARA, PROJECT MANAGER DATE

PRELIMINARY

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
A COOK	S KRAMER	C HOOPER	S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

CH2MHILL

COVER

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2011
PROJ	407259
DWG	G-1
SHEET	1

GENERAL NOTES

1. IT IS THE INTENT OF THESE PLANS TO SHOW ALL EXISTING UTILITIES, HOWEVER IT IS THE CONTRACTOR'S RESPONSIBILITY TO FIELD VERIFY ALL UTILITIES PRIOR TO CONSTRUCTION, WHETHER SHOWN ON THESE PLANS OR NOT. CONTACT THE UTILITY NOTIFICATION CENTER OF COLORADO (UNCC) AT 811, PRIOR TO DIGGING. THE ENGINEER AND CCBWQA SHALL BE NOTIFIED OF ANY POTENTIAL CONFLICTS.
2. EXISTING FACILITIES AND UTILITIES NOT INDICATED TO BE REMOVED SHALL BE PROTECTED IN PLACE OR REMOVED AND REPLACED IN KIND, AS APPROVED BY THE ENGINEER.
3. ALL MATERIALS AND WORKMANSHIP SHALL BE SUBJECT TO INSPECTION BY CCBWQA, CCSP AND/OR ITS AUTHORIZED REPRESENTATIVES. CCBWQA AND CCSP RESERVE THE RIGHT TO ACCEPT OR REJECT ANY SUCH MATERIALS AND WORKMANSHIP THAT DO NOT CONFORM TO ITS STANDARDS AND SPECIFICATIONS.
4. THE CONTRACTOR SHALL NOTIFY CCBWQA 48 HOURS PRIOR TO STARTING CONSTRUCTION.
5. THE CONTRACTOR SHALL HAVE ONE (1) SIGNED COPY OF THE PLANS (ACCEPTED BY CCBWQA), AND ONE (1) COPY OF ALL REQUIRED PERMITS AT THE JOB SITE AT ALL TIMES.
6. THE FINAL FILL AND EXCAVATION SLOPES, LINES AND GRADES SHOWN ON THE DRAWINGS ARE THE NEAT LINES FOR PAY PURPOSES AND ARE THE STEEPEST SLOPES PERMITTED UNLESS APPROVED BY THE ENGINEER. FLATTER SLOPES MAY BE NECESSARY, AS DETERMINED BY THE CONTRACTOR. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR PROVIDING STABLE EXCAVATIONS AND TEMPORARY SLOPES AND FOR SATISFYING ALL APPLICABLE FEDERAL, STATE, AND LOCAL REGULATIONS. TEMPORARY EXCAVATIONS SHALL PROVIDE AT MINIMUM, THE TRENCH DIMENSIONS AND CLEARANCES SHOWN OR SPECIFIED. TEMPORARY CONSTRUCTION SLOPES SHALL BE SLOPED, SHORED, SHEETED, AND/OR BRACED IN ACCORDANCE WITH STABILITY REQUIREMENTS AND APPLICABLE REGULATIONS, AND SHALL BE NO STEEPER THAN THE MINIMUM SLOPES SHOWN OR SPECIFIED WITHOUT THE APPROVAL OF THE ENGINEER. ANY SUCH APPROVALS BY THE ENGINEER WILL NOT RELIEVE THE CONTRACTOR FROM SOLE RESPONSIBILITY FOR PROVIDING STABLE EXCAVATIONS AND TEMPORARY SLOPES.
7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ACCEPTANCE AND CONTROL OF DRAINAGE WATER FROM AREAS ADJACENT TO THE CREEK AND FOR STREAM FLOW WITHIN THE CREEK. THE CONTRACTOR SHALL BE RESPONSIBLE FOR DETERMINING METHODS BY WHICH CHANNEL FLOW, SURFACE RUNOFF, AND SUBSURFACE SEEPAGE WILL BE TEMPORARILY DIVERTED, DETAINED OR OTHERWISE CONTROLLED. WATER CONTROL SHALL BE PERFORMED IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL REGULATIONS, AS WELL AS ALL APPLICABLE PERMIT CONDITIONS. TEMPORARY WATER CONTROL SYSTEMS SHALL NOT CAUSE INCREASED FLOODING OR AFFECT NORMAL FLOW CHARACTERISTICS DURING CONSTRUCTION. ANY DAMAGE TO THE WORK RESULTING FROM BASE FLOWS OR FLOOD FLOWS SHALL BE CORRECTED BY THE CONTRACTOR AT THE CONTRACTOR'S SOLE COST.
8. THE CONTRACTOR IS ADVISED THAT THE STOCKPILING AND USE OF MATERIAL AND/OR EQUIPMENT WITHIN THE CHANNEL CREATES POTENTIAL OBSTRUCTIONS TO THE FLOW OF THE STREAM. IT IS THE CONTRACTOR'S RESPONSIBILITY TO CONDUCT THE WORK IN A MANNER THAT MINIMIZES THE REDUCTION IN CHANNEL CAPACITY AT ALL TIMES. THE CONTRACTOR IS ADVISED THAT THE STORAGE OF FUELS, CHEMICALS, TRASH, DEBRIS, CONSTRUCTION MATERIAL, VEHICLES, AND EQUIPMENT SHALL BE PROHIBITED WITHIN THE CHANNEL AT ALL TIMES EXCEPT AS IS ESSENTIAL TO THE PROGRESS OF THE WORK. UNDER NO CIRCUMSTANCE SHALL ANY OF THE ABOVE MENTIONED MATERIALS BE STORED OVERNIGHT WITHIN THE CHANNEL.
9. CONTRACTOR SHALL PROVIDE PEDESTRIAN AND VEHICULAR SIGNAGE THAT CLEARLY IDENTIFIES THE CONSTRUCTION ZONE THROUGHOUT PROJECT. CONTRACTOR IS RESPONSIBLE FOR SITE SAFETY.
10. CONTRACTOR SHALL PROTECT ALL EXISTING CURB, GUTTER AND PAVEMENT AT ALL ACCESS POINTS FROM DAMAGE BY EQUIPMENT OR CONSTRUCTION OPERATIONS. ALL CURB, GUTTER AND PAVEMENT DAMAGED BY THE CONTRACTOR SHALL BE REMOVED AND REPLACED AT THE CONTRACTOR'S EXPENSE.
11. SOIL RIPRAP SHALL CONSIST OF 65% RIPRAP AND 35% SOIL, AND SHALL BE COMPACTED.
12. NATIVE FILL SHALL BE COMPACTED TO 95% STD PROCTOR.
13. CONSTRUCTION STAKING AND SURVEY SHALL BE PROVIDED BY THE CONTRACTOR.
14. CONTRACTOR SHALL OBTAIN ALL REQUIRED PERMITS FOR THIS PROJECT, EXCEPT FOR THE 404 PERMIT.
15. CONTRACTOR SHALL BE LICENSED TO PERFORM WORK IN ARAPAHOE COUNTY, AS REQUIRED.
16. NEW FILL SHOULD BE CONTINUOUSLY BENCHED INTO EXISTING SLOPES EXCEEDING 4 HORIZONTAL TO 1 VERTICAL. A BENCH HEIGHT BETWEEN 1 AND 2 FEET SHOULD BE USED. PROPER COMPACTION IS FREQUENTLY DIFFICULT TO ACHIEVE AT THE EDGES OF FILL SLOPES. FOR THIS REASON OVERBUILD FILL SLOPES 1 TO 2 FEET AND CUT THE SLOPE SURFACE BACK TO THE GRADES SHOWN. FILLS SHOULD BE PLACED IN UNIFORM LIFTS NOT EXCEEDING 8 INCHES LOOSE AND SHOULD BE COMPACTED TO THE MOISTURE AND DENSITY REQUIREMENTS PER CCBWQA SPECIFICATIONS.
17. VISITS TO THE JOB SITE BY THE ENGINEER TO OBSERVE THE CONSTRUCTION DO NOT IN ANY WAY MEAN THAT THE ENGINEER IS GUARANTOR OF CONTRACTOR'S WORK, NOR RESPONSIBLE FOR THE COMPREHENSIVE OR SPECIAL INSPECTIONS, COORDINATION, SUPERVISION, NOR THE SAFETY AT THE JOB SITE.
18. SITE ACCESS AND STAGING SHALL BE PER THE CONSTRUCTION DOCUMENTS, UNLESS ALTERNATIVE ACCESS AND STAGING ARE APPROVED BY CCBWQA AND/OR ITS AUTHORIZED REPRESANTITIVES.
19. CCBWQA STANDARD SPECIFICATIONS SHALL BE USED ON THIS PROJECT.
20. CONTRACTOR SHALL INSTALL TWO PROJECT SIGNS PER THE PROJECT SPECIFICATIONS.
21. SEE PROJECT SPECIFICATIONS FOR REQUIRED SUBMITTALS AND MEASUREMENT AND PAYMENTS REQUIREMENTS.

CULTURAL AND HISTORICAL FINDINGS

1. IF ANY SUSPECTED CULTURAL OR HISTORIC FINDINGS ARE UNCOVERED DURING CONSTRUCTION, STOP CONSTRUCTION IMMEDIATELY AND NOTIFY: MARY POWELL/ERO RESOURCES AT 303-830-1188.

SEEDING AND PLANTING NOTES

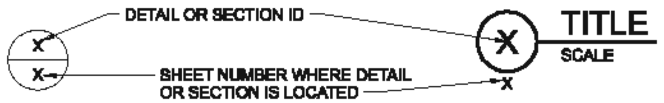
1. ADJUST SITE GRADING AS APPROPRIATE SO THAT IMPACTS TO WOODY VEGETATION AND TREES TO BE PROTECTED CAN BE AVOIDED.
2. AVOID CLEARING AND GRUBBING WOODY VEGETATION IN AREAS OF TEMPORARY IMPACTS. IF NECESSARY, PRUNE WOODY VEGETATION TO GROUND LEVEL SO THAT IT MAY GROW BACK FOLLOWING CONSTRUCTION.
3. AVOID THE UNNECESSARY REMOVAL OF TREES OR SHRUBS; FOR EXAMPLE, PRUNE THE AERIAL PORTIONS OF TREES AND SHRUBS THAT HANG OVER A PROJECT AREA AND INTERFERE WITH EQUIPMENT.
4. ALL DISTURBED AREAS SHALL BE SEEDED WITH EITHER THE UPLAND OR WETLAND SEED MIX LISTED BELOW. NO SUBSTITUTIONS SHALL BE ALLOWED, INCLUDING ADDITION OF A COVER CROP, WITHOUT WRITTEN PERMISSION OF CCBWQA REPRESENTATIVE. OVERLAP THE SEED MIXES A MINIMUM OF 1 FEET. THE CONTRACTOR SHALL LIMIT DISTURBANCE TO THE CONSTRUCTION LIMITS SHOWN ON THE PLAN. SEED TAGS MUST BE SUBMITTED TO THE CCBWQA REPRESENTATIVE.
5. NATIVE SEED MAY BE DRILLED OR BROADCAST. SEED WHICH IS BROADCAST SHALL BE HAND RAKED IMMEDIATELY FOLLOWING SEEDING TO COVER WITH 1/8" TO ½" OF TOPSOIL. SEEDING RATES SHOWN SHALL BE DOUBLED IF BROADCASTED.
6. LIVE SANDBAR WILLOW STAKES - WILLOWS SHALL BE CUT FROM THE EXISTING SANDBAR WILLOW WITHIN THE PROJECT AREA. THE EXISTING WILLOWS WILL BE CUT 8 TO 10 INCHES FROM THE GROUND WITH LOPPERS OR HANDSAWS. THE CUTS WILL BE AT A 45-DEGREE ANGLE. WILLOW STAKES WILL BE APPROXIMATELY 3 TO 4 FEET LONG AND GREATER THAN ½ INCH IN DIAMETER. ALL SIDE BRANCHES AND THE TERMINAL BUD SHALL BE TRIMMED OFF. IMMEDIATELY AFTER CUTTING, ALL LIVE STAKES WILL BE PLACED IN WATER SO THAT THE CUT ENDS ARE COVERED WITH WATER, AND THE CUTTINGS SHALL BE STORED IN A COOL LOCATION. TO STORE CUT WILLOWS STAKES GREATER THAN 3 DAYS, CUT STAKES WILL BE WRAPPED IN WET BURLAP AND STORED IN A COOL PLACE. BURLAP WILL REMAIN DAMP AT ALL TIMES DURING STORAGE. WILLOW STAKES SHALL BE PLANTED USING A PIECE OF REBAR TO CREATE A VERTICAL HOLE APPROXIMATELY 1 TO 2 FEET DEEP. APPROXIMATELY 2/3 OF THE STAKE SHALL BE INSERTED INTO THE HOLE SO THAT THE STAKE IS IN CONTACT WITH THE WATER TABLE. AFTER THE WILLOW CUTTING IS INSERTED, THE HOLE SHALL BE BACKFILLED WITH NATIVE SOILS AND LIGHTLY TAMPED TO PREVENT AIR POCKETS. THE STAKE SHALL THEN BE WATERED TO HELP FILL IN THE AIR POCKETS. WILLOW STAKES SHALL BE PLANTED 3 FEET ON CENTER IN TWO ROWS. IT IS IMPORTANT TO PLANT WILLOW STAKES DEEP ENOUGH SO THAT THE BOTTOM OF THE CUTTING REACHES SATURATED SOIL THROUGHOUT THE GROWING SEASON.
7. HARVEST AND PLANT WILLOW LIVE STAKES DURING DORMANT SEASON.
8. USE HEALTHY, STRAIGHT, AND LIVE WOOD AT 2 TO 3 YEARS OLD.
9. MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS DURING INSTALLATION.
10. SOAK CUTTINGS FOR 24 HOURS (MIN.) PRIOR TO INSTALLATION.
11. STORE CUT WILLOWS WITH LOWER ENDS IN WAER FOR NO LONGER THAN 7 DAYS BEFORE PLANTING.

WETLAND SEED MIX			
COMMON NAME	SCIENTIFIC NAME	VARIETY	LBS/ACRE
Woolly sedge	*Carex lanuginosa*	Native	0.25
Alkali sacaton	*Sporobolus airoides*	Native	3.00
Prairie cordgrass	*Spartina pectinata*	Native	6.00
Green needlegrass	*Nassella viridula*	Lodorm	15.00
Switchgrass	*Panicum virgatum*	Blackwell	15.00
Western wheatgrass	*Pascopyrum smithii*	Arriba	10.00
High Plains Wet Meadow Mix	*Western Native Seed CO.*		10.00
Louisiana sage	*Artemisia ludoviciana*	Native	0.25
Nuttall's sunflower	*Helianthus nuttallii*	Native	0.25
Blue vervain	*Verbena hastata*	Native	0.25
Yarrow	*Achillea lanulosa*	Native	0.25
Total pounds LBS/acre			60.25

UPLAND SEED MIX FOR LOAMY TO CLAY-LOAM SOILS			
COMMON NAME	SCIENTIFIC NAME	VARIETY	LBS/ACRE
Sideoats grama	Bouteloua curtipendula	Butte	5
Blue grama	Chondrosum gracile	Lovington	3
Prairie sandreed	Calamovilfa longifolia	Native	6
Switchgrass	Panicum virgatum	Blackwell	5
Indian ricegrass	Oryzopsis hymenoides	Rimrock	1
Western wheatgrass	Pascopyrum smithii	Arriba	5
Sand bluestem	Andropogon hallii	Woodward	2
Sand dropseed	Sporobolus cryptandrus	Native	2
Fringed sage	Artemisia frigida	Native	0.05
Aster	Aster laevis	Native	0.01
Purple prairie clover	Dalea purpurea	Native	0.5
Blanket flower	Gaillardia aristata	Native	0.5
Tansy aster	Machaeranthera tanacetafolia	Native	0.1
Large-flowered penstemon	Penstemon grandiflorus	Native	0.1
Wand penstemon	Penstemon virgatus	Native	0.05
Prairie coneflower	Ratibida columnifera	Native	0.1
Showy goldeneye	Viguiera multiflora	Native	0.2
Total LBS/acre			30.6

LEGEND

TYPICAL SECTIONS AND DETAIL CALLOUTS FOLLOW THE GENERAL FORMAT SHOWN BELOW. DETAILS ARE IDENTIFIED WITH NUMBERS AND CROSS SECTION CUTS ARE IDENTIFIED BY LETTERS. SEE GESC SHEETS FOR ASSOCIATED SYMBOLOGY.



———	PROPOSED CONTOURS
- - -	EXISTING CONTOURS
—+—+—	CONTROL LINE
▨	TOPSOIL
▨	SOIL RIPRAP
○	BOULDER
• • •	WILLOW STAKING
2"	COTTONWOOD TREE WITH CALIPER
—X—	TYPE 1 FENCE
▨	10' WIDE TRAIL BY OTHERS
▨	PLAN VIEW LIMITS OF TYPE M SOIL RIPRAP
▨	BIO-SWALE

ABBREVIATIONS

CCBWQA	CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CCSP	CHERRY CREEK STATE PARK
CDOT	COLORADO DEPARTMENT OF TRANSPORATION
CMP	CORRUGATED METAL PIPE
CLR	CLEAR
DIA	DIAMETER
DOLA	DOG OFF LEASH AREA
DWG	DRAWING
E	EASTING
EA	EACH
EC	EROSION CONTROL
EF	EACH FACE
ELEV	ELEVATION
EW	EACH WAY
EWEF	EACH WAY EACH FACE
EXST	EXISTING
FES	FLARED END SECTION
GESC	GRADING, EROSION, AND SEDIMENT CONTROL
H	HORIZONTAL
INV	INVERT
LBS	POUNDS
MAX	MAXIMUM
MIN	MINIMUM
N	NORTHING
OC	ON CENTER
PJF	PREMOLDED JOINT FILLER
REINF	REINFORCING
S	SLOPE
SST	STAINLESS STEEL
STA	STATION
TYP	TYPICAL
UDFCD	URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
V	VERTICAL
VPI	VERTICAL POINT OF INTERSECTION

PRELIMINARY

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN A COOK
DR S KRAMER
CHK C HOOPER
APVD S YANAGIHARA

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CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CH2MHILL

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

GENERAL NOTES

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 ▬ 1"

DATE	SEPTEMBER 2011
PROJ	407259
DWG	G-2
SHEET	2

SURVEY CONTROL POINTS

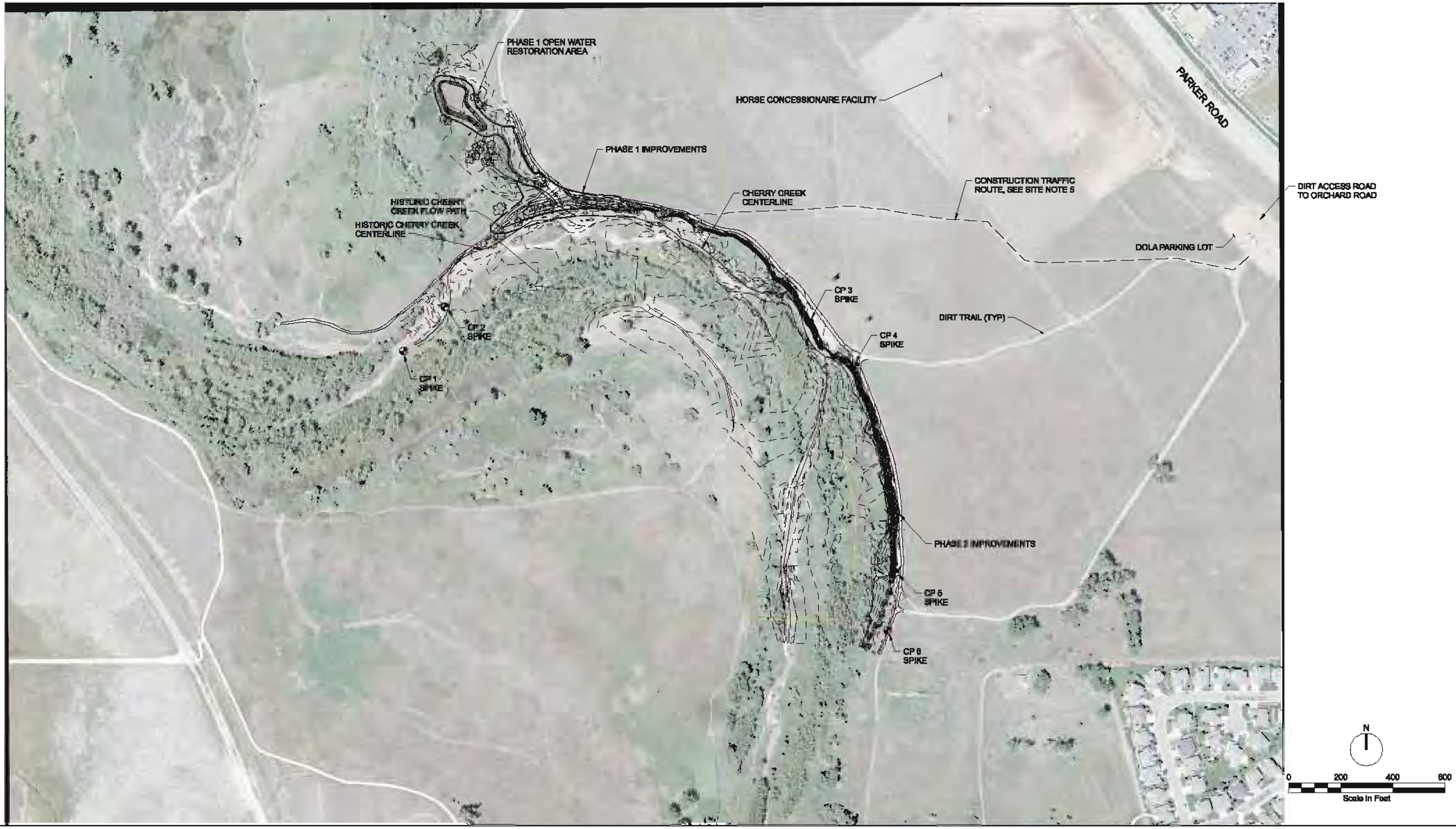
POINT NO	NORTHING	EASTING	ELEVATION	DESCRIPTION
CP 1	1649267.00	3190343.83	5597.07	SPIKE
CP 2	1649436.82	3190502.66	5597.77	SPIKE
CP 3	1649377.43	3191905.98	5610.48	SPIKE
CP 4	1649209.00	3192079.55	5612.93	SPIKE
CP 5	1648418.36	3192234.35	5617.6	SPIKE
CP 6	1648195.89	3192205.43	5616.45	SPIKE

SURVEY NOTES

1. HORIZONTAL DATUM: NORTH AMERICAN DATUM OF 1983, ADJUSTMENT OF 2007 (NSRS2007) ACQUIRED FROM VRS NETWORK
2. VERTICAL DATUM: NORTH AMERICAN VERTICAL DATUM OF 1988 ACQUIRED FROM VRS NETWORK. CONVERSION FROM NAVD 88 TO NGVD 29: NAVD 88 ELEV -2.97 FT = NGVD 29 ELEV.
3. PROJECTION: COLORADO COORDINATE SYSTEM OF 1983, CENTRAL ZONE
4. GEOID - 2009
5. COMBINED SCALE FACTOR (GRID TO GROUND) 1.000289002
6. UNITS: US SURVEY FEET
7. INITIAL SURVEY PERFORMED BY CRITIGEN, UPDATED BY CH2MHILL
8. DATE OF SURVEY: JULY 1, 2010 UPDATED FOR BORROW AREA JUNE 2, 2011

SITE NOTES:

1. SEE GESC PLANS FOR EROSION CONTROL MEASURES AND ACCESS REQUIREMENTS.
2. CONTRACTOR SHALL MAINTAIN PARK ACCESS AND TRAIL ACCESS DURING CONSTRUCTION.
3. CONTRACTOR SHALL COMPLY WITH STATE PARKS REQUIREMENTS FOR WORK HOURS AND SITE ACCESS.
4. CONTRACTOR SHALL REMOVE ALL WEEDS AND DIRT FROM CONSTRUCTION EQUIPMENT PRIOR TO ACCESSING SITE TO PREVENT THE SPREAD OF WEEDS.
5. CONSTRUCTION TRAFFIC SHALL UTILIZE IDENTIFIED ROUTE. IF ALTERNATE ROUTE IS REQUESTED IT MUST BE APPROVED BY CCSP PRIOR TO USE OF NEW ROUTE.



PRELIMINARY

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
A COOK	S KRAMER	C HOOPER	S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

CH2MHILL

SURVERY CONTROL AND
SITE PLAN

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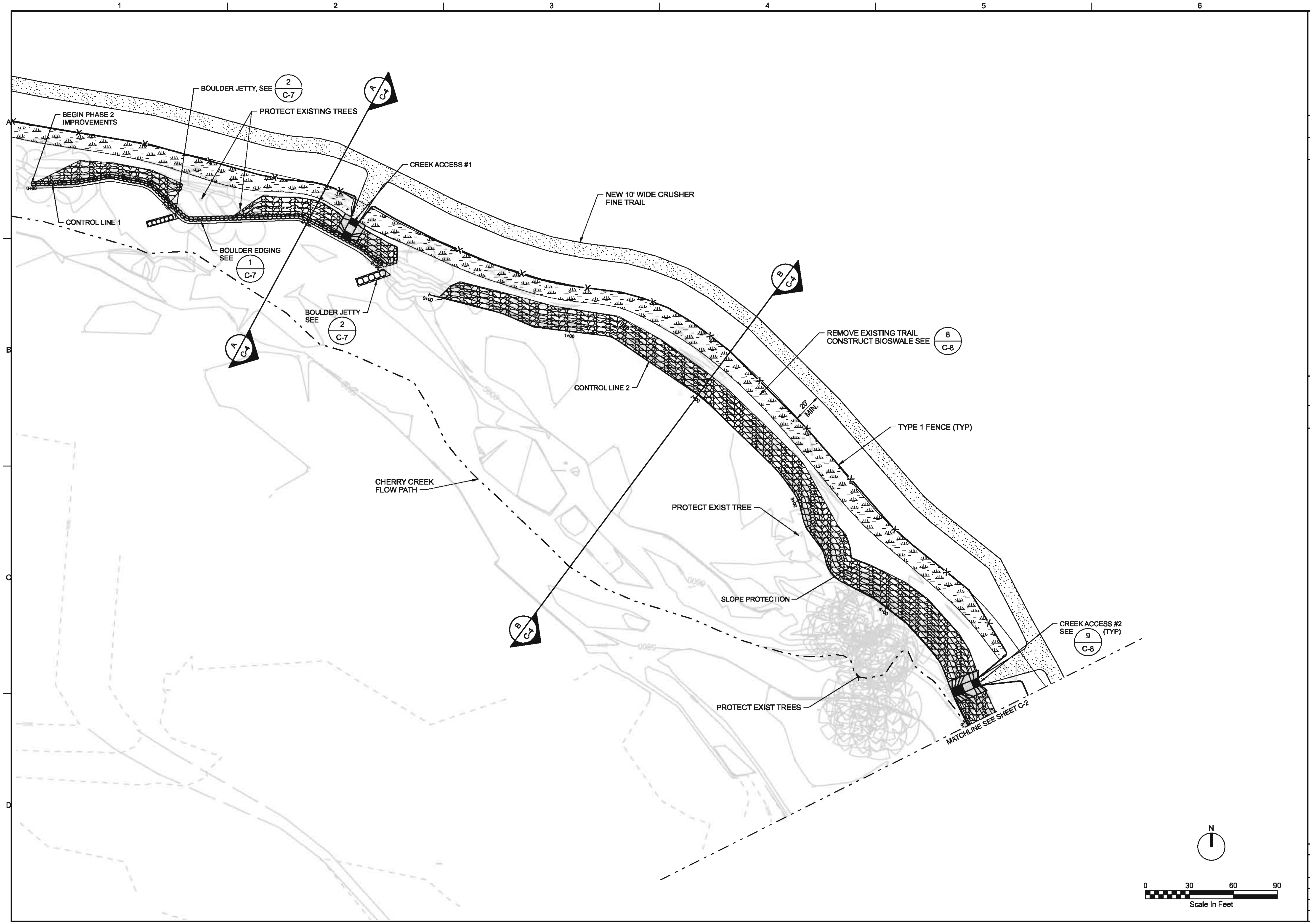
VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2011
PROJ	407259
DWG	G-3
SHEET	3

FILENAME: 005-C-2301.dgn PLOT DATE: 9/7/2011 PLOT TIME: 8:57:22 AM



NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
A COOK	S KRAMER	C HOOPER	S YANAGIHARA

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CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CH2MHILL

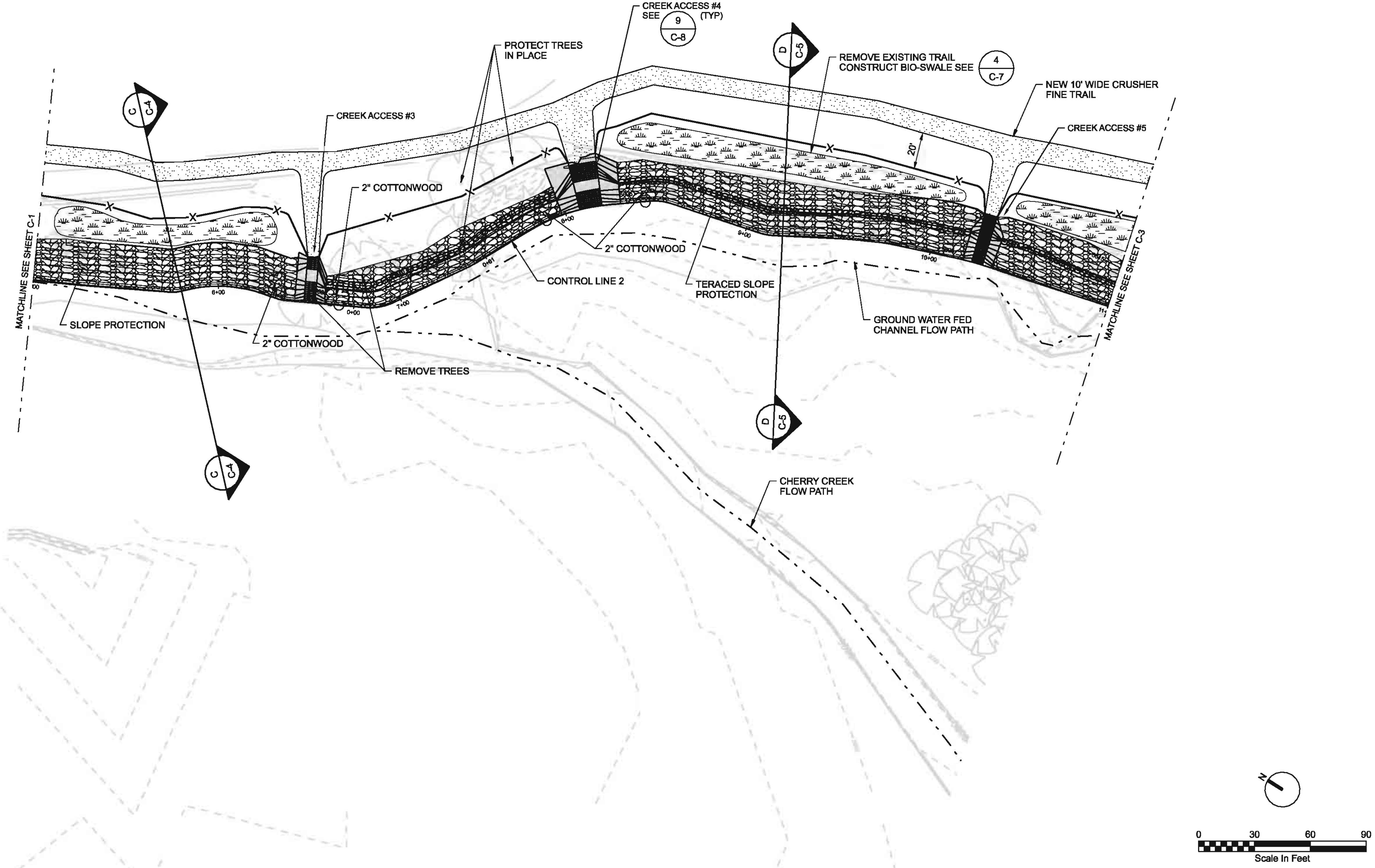
REACH 1 PLAN

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2011
PROJ	407259
DWG	C-1
SHEET	4

FILENAME: 005-C-2302.dgn PLOT DATE: 2/6/2012 PLOT TIME: 1:59:33 PM



CH2MHILL

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

REACH 2 PLAN

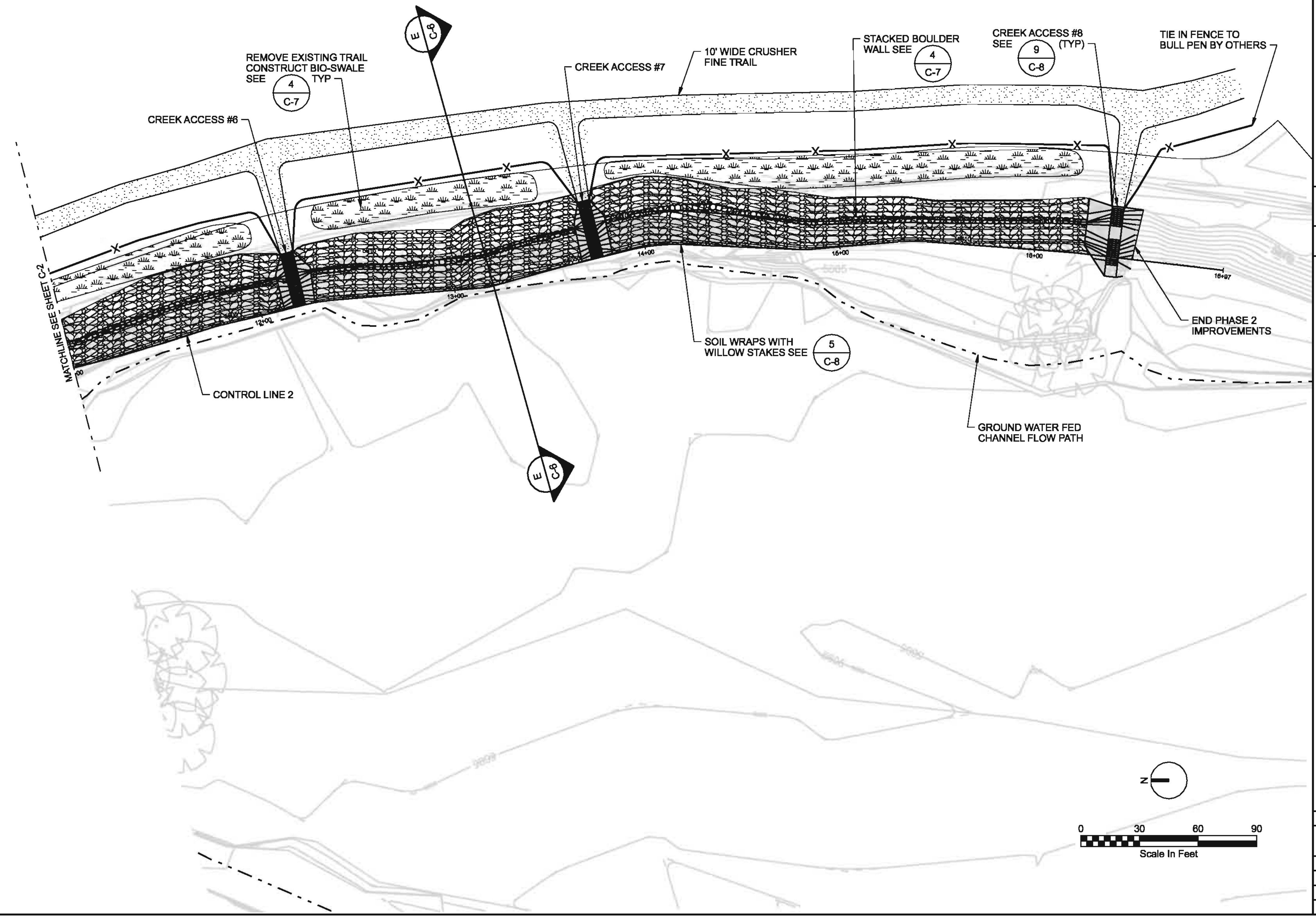
NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
A COOK	S KRAMER	C HOOPER	S YANAGIHARA

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2011
PROJ	407259
DWG	C-2
SHEET	5

FILENAME: 005-C-2303.dgn PLOT DATE: 2/8/2012 PLOT TIME: 1:59:00 PM



CH2MHILL

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

REACH 3 PLAN

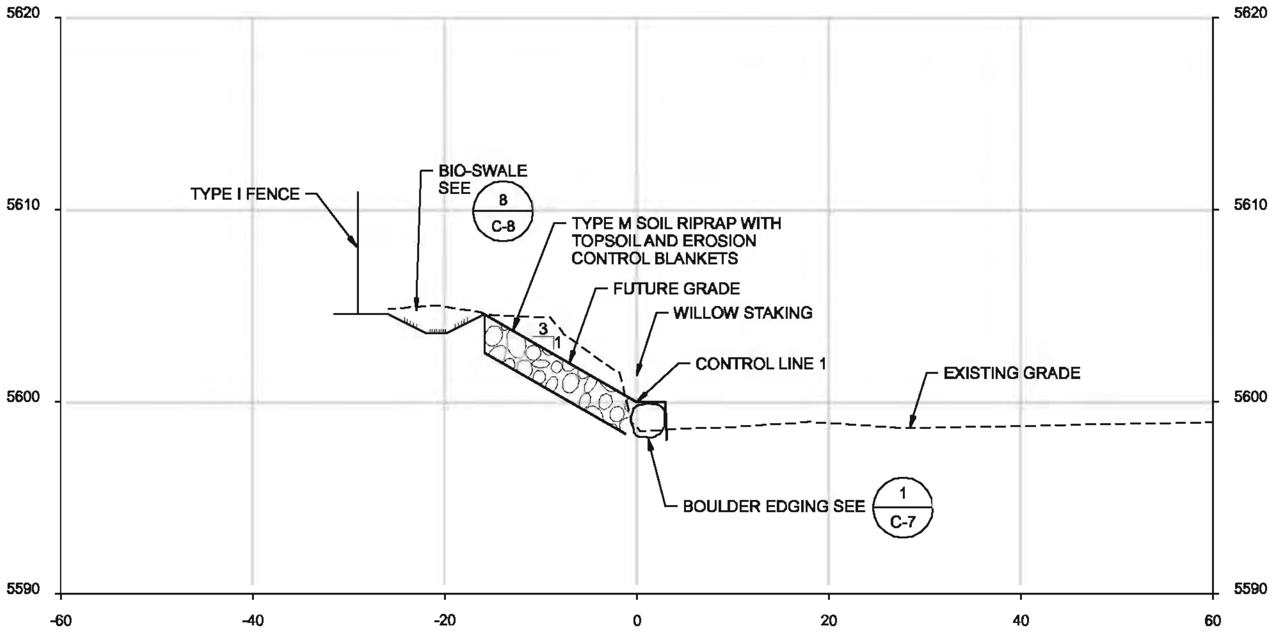
NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
A COOK	S KRAMER	C HOOPER	S YANAGIHARA

VERIFY SCALE

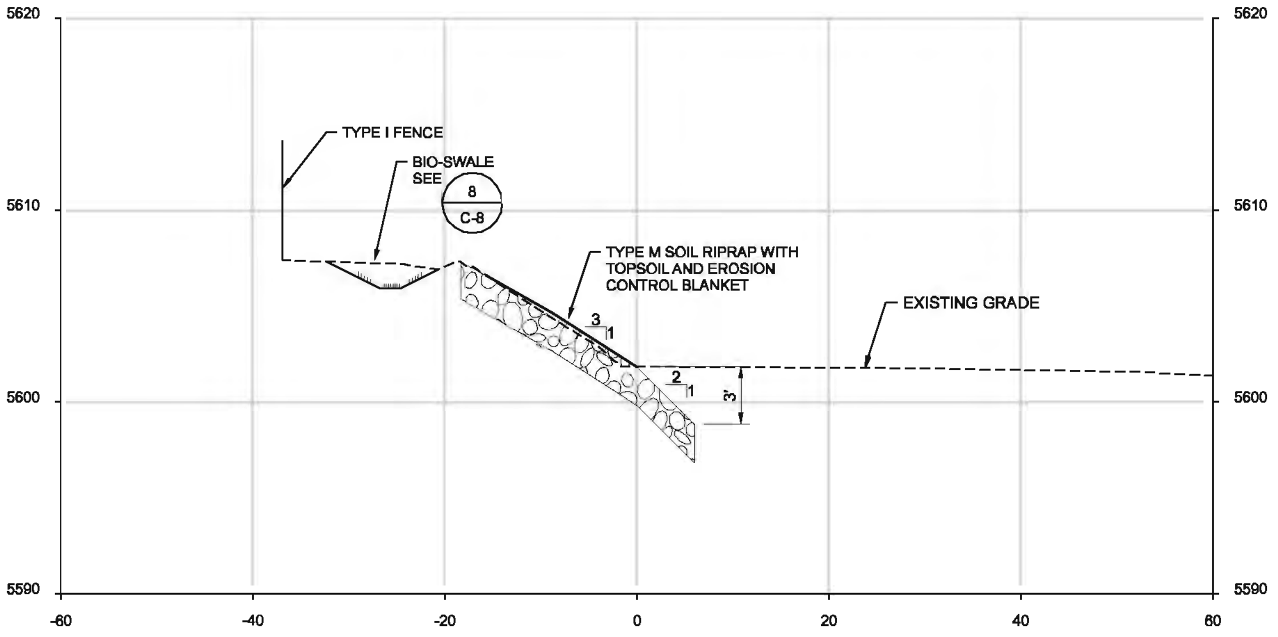
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2011
PROJ	407259
DWG	C-3
SHEET	6



CROSS SECTION - CONTROL LINE 1 STA 0+00 TO STA 2+56 +/-

A
C-1
H: 1"=10' V: 1"=5'



CROSS SECTION - CONTROL LINE 2 STA 0+00 TO STA 4+60 +/-

B
C-1
H: 1"=10' V: 1"=5'

ARAPAHOE COUNTY CASE #E11-031

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
A COOK	S KRAMER	C HOOPER	S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

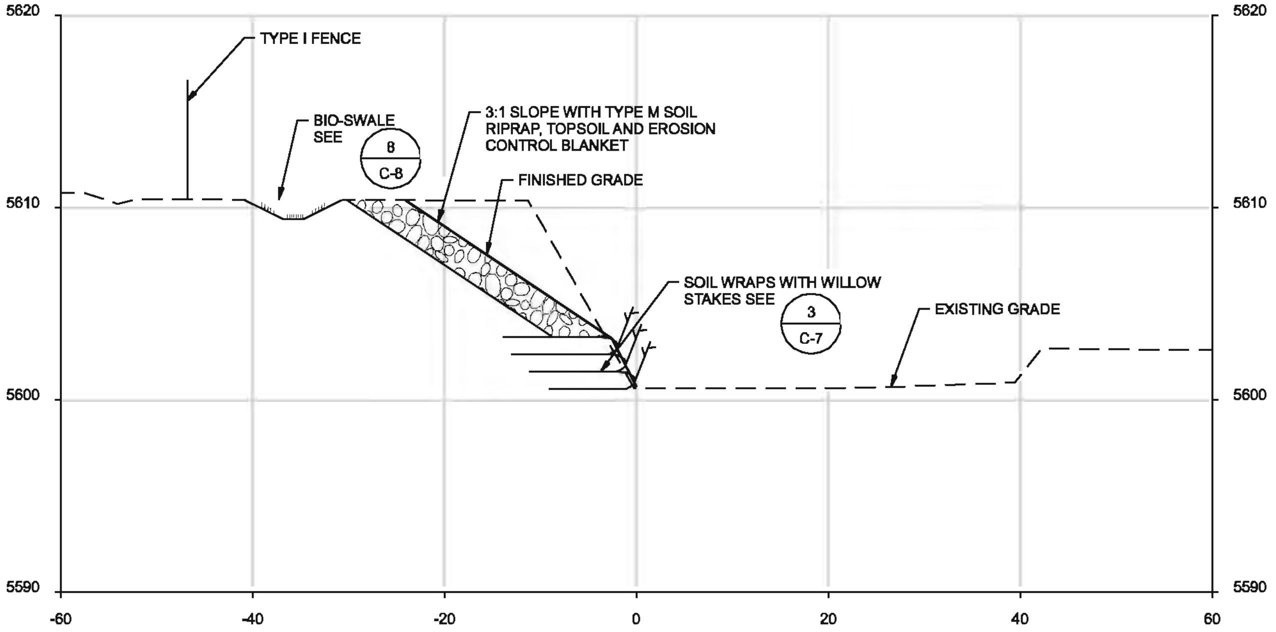
CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CH2MHILL

CROSS SECTIONS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

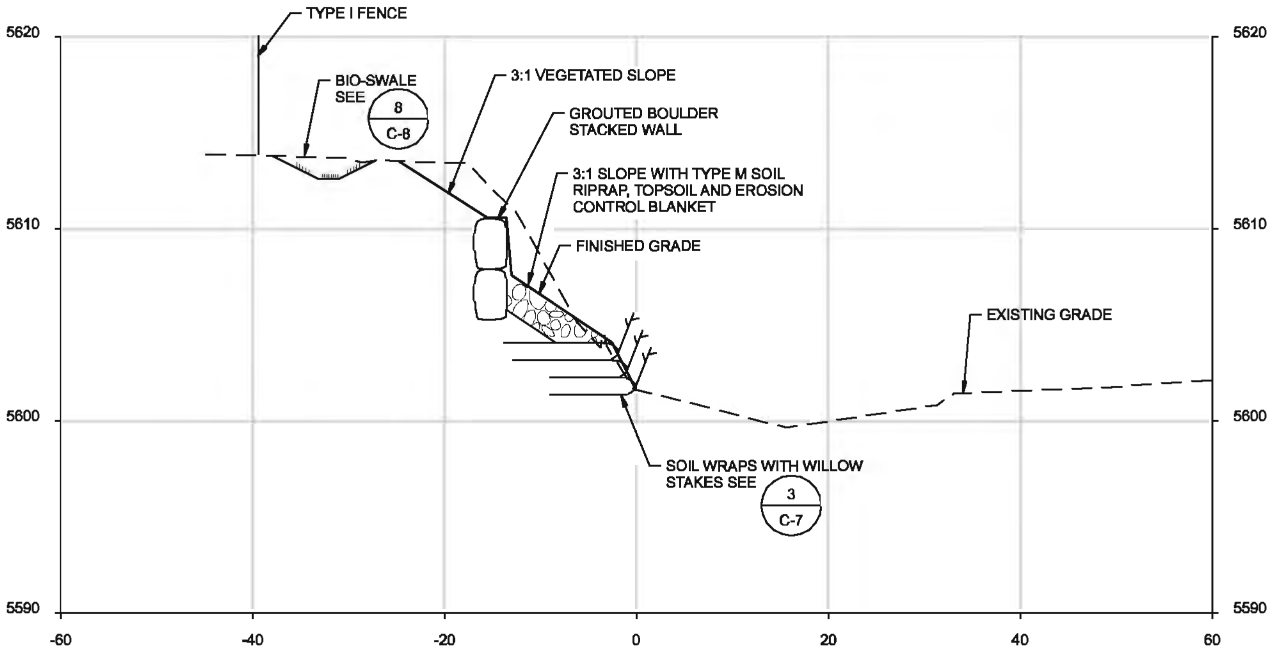
DATE SEPTEMBER 2011
PROJ 407259
DWG C-4
SHEET 7



C CROSS SECTION - CONTROL LINE 2 STA 4+80 TO STA 6+45 +/-

C-2

H: 1"=10' V: 1"=5'



D CROSS SECTION - CONTROL LINE 2 STA 6+60 TO STA 8+00 +/-

C-2

H: 1"=10' V: 1"=5'

ARAPAHOE COUNTY CASE #E11-031

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN A COOK
DR S KRAMER
CHK C HOOOPER
APVD S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CH2MHILL

CROSS SECTIONS

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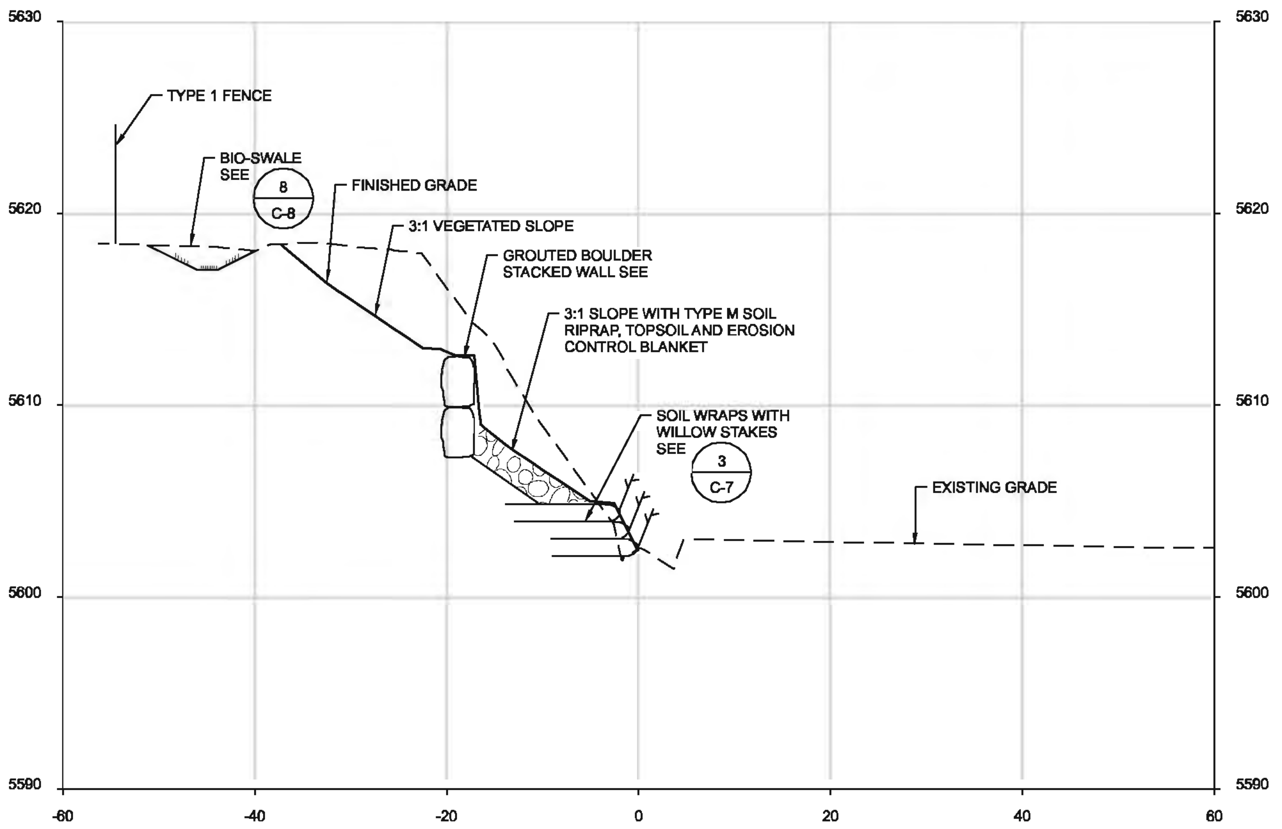
0 1"

DATE	SEPTEMBER 2011
PROJ	407259
DWG	C-5
SHEET	8

FILENAME: 005-C-3302.dgn PLOT DATE: 12/20/2011 PLOT TIME: 10:54:11 AM



E CROSS SECTION - CONTROL LINE 2 STA 8+40 +/- TO STA 16+20 +/-

C-2

H: 1"=10' V: 1"=5'

ARAPAHOE COUNTY CASE #E11-031

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
A COOK	S KRAMER	C HOOPER	S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

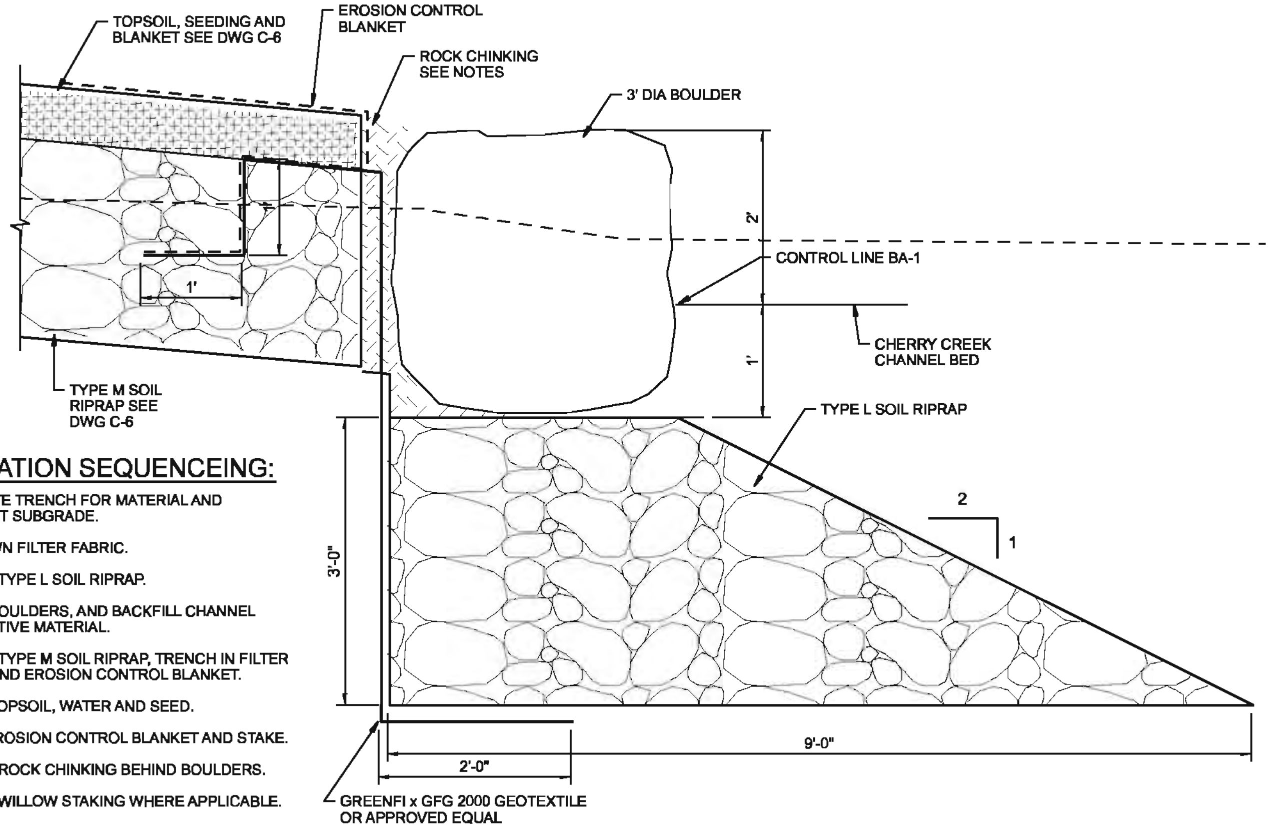
CH2MHILL

CROSS SECTIONS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2011
PROJ	407259
DWG	C-6
SHEET	9

FILENAME: 005-C-3304.dgn PLOT DATE: 12/20/2011 PLOT TIME: 10:56:26 AM

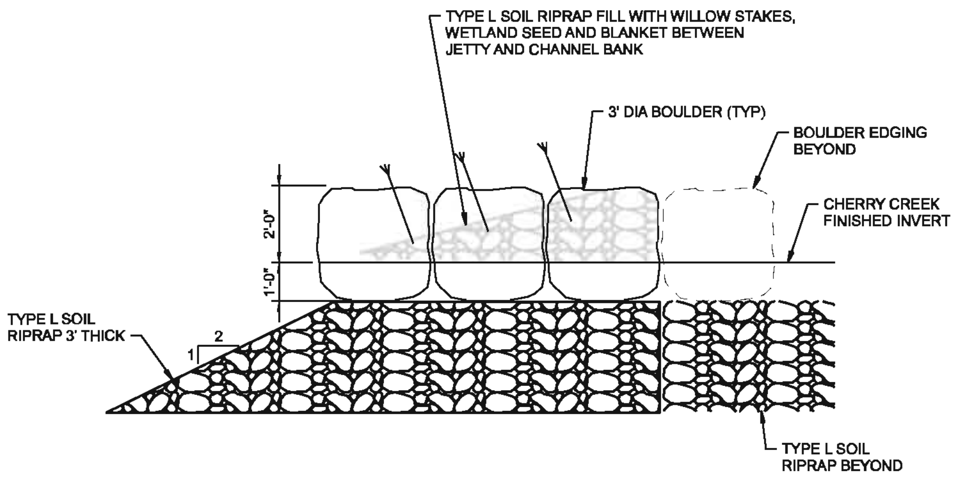


INSTALLATION SEQUENCEING:

1. EXCAVATE TRENCH FOR MATERIAL AND COMPACT SUBGRADE.
2. LAY DOWN FILTER FABRIC.
3. INSTALL TYPE L SOIL RIPRAP.
4. PLACE BOULDERS, AND BACKFILL CHANNEL WITH NATIVE MATERIAL.
5. INSTALL TYPE M SOIL RIPRAP, TRENCH IN FILTER FABRICAND EROSION CONTROL BLANKET.
6. PLACE TOPSOIL, WATER AND SEED.
7. WRAP EROSION CONTROL BLANKET AND STAKE.
8. INSTALL ROCK CHINKING BEHIND BOULDERS.
9. INSTALL WILLOW STAKING WHERE APPLICABLE.

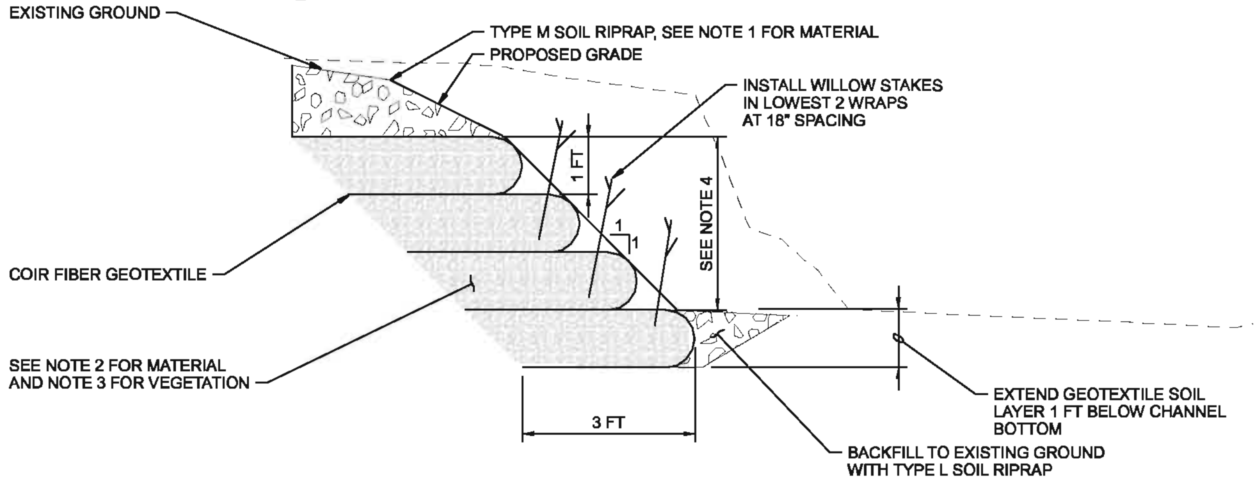
① BOULDER EDGING DETAIL

1"=1'-0"



② BOULDER JETTY DETAIL

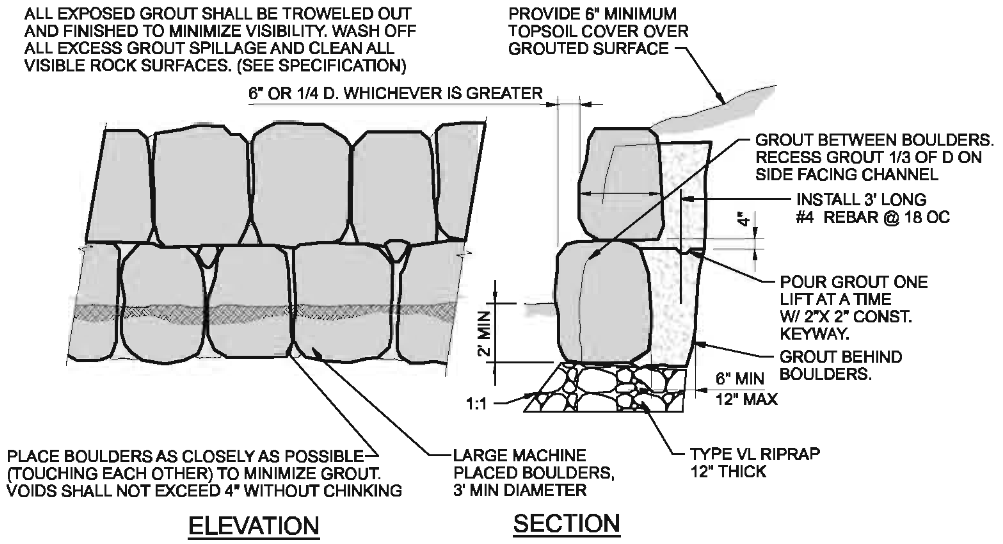
1"=5'



1. ALL RIPRAP EXPOSED ABOVE THE WATERLINE SHALL BE BURIED WITH INSITU SOIL. THE SOIL RIPRAP SHALL CONSIST OF 35% BY VOLUME OF NATIVE SOIL, TAKEN FROM BANKS OF CHANNEL, THAT IS MIXED IN WITH 65% BY VOLUME OF RIPRAP ON SITE, BEFORE PLACEMENT AS CHANNEL LINER.
2. COMPACTED SOIL BACKFILL SHALL CONSIST OF 40% BY VOLUME OF SOIL, TAKEN FROM BANKS OF CHANNEL, THAT IS MIXED IN WITH 60% BY VOLUME OF TYPE L RIPRAP ON SITE, BEFORE PLACEMENT AS SCHANNEL LINER.
3. GEOTEXTILE SHALL BE GREENFIX TYPE CFG2000 OR APPROVED EQUAL.
4. BUILD GEOTEXTILE SOIL LAYERS APPROXIMATELY 3 FT ABOVE TOE OF SLOPE.

③ GEOTEXTILE SOIL LAYER DETAIL

NTS



④ GROUTED BOULDER WALL DETAIL

NTS

PRELIMINARY

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN A COOK
DR S KRAMER
CHK C HOOPER
APVD S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CH2MHILL

DETAILS

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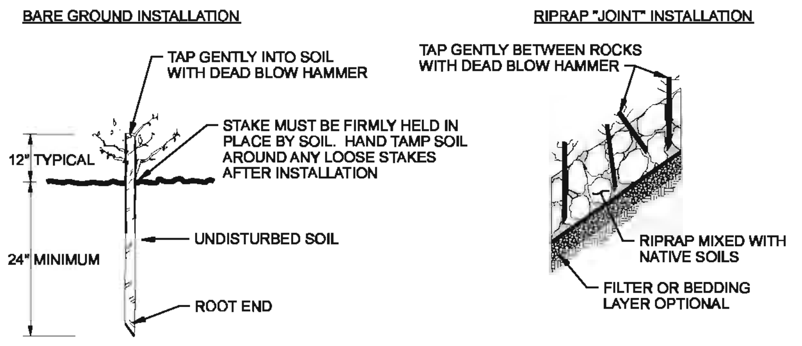
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE SEPTEMBER 2011
PROJ 407259
DWG C-7
SHEET 10

FILENAME: 005-C-3303.dgn PLOT DATE: 9/7/2011 PLOT TIME: 9:03:37 AM



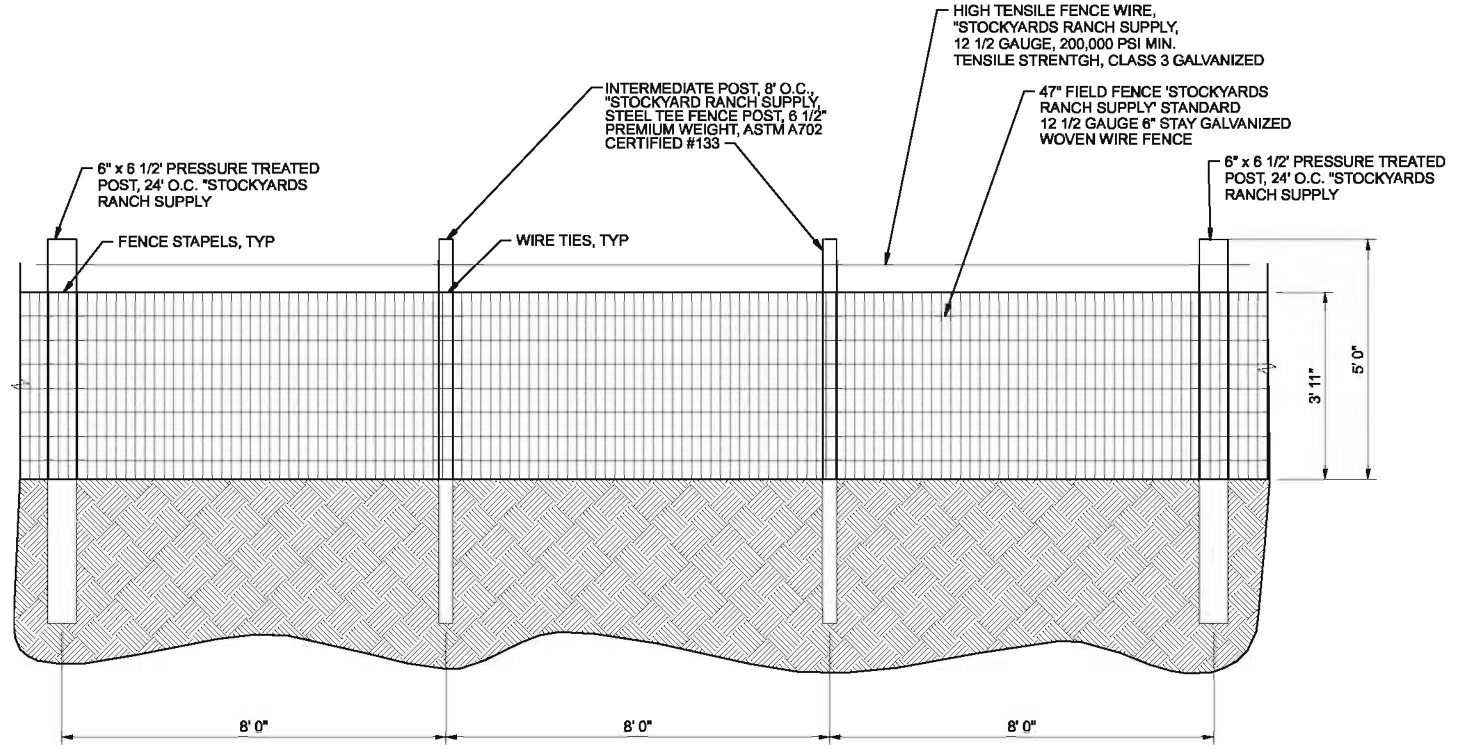
NOTES:

1. THE STAKE SHALL BE INSERTED INTO THE HOLE SO STAKE IS IN CONTACT WITH WATER TABLE.
2. CUT STAKE AND INSTALL STAKES WITH A MINIMUM OF 4 BUDS ABOVE AND 4 BUDS BELOW FINISHED GRADE.

5 WILLOW STAKE DETAIL

NTS

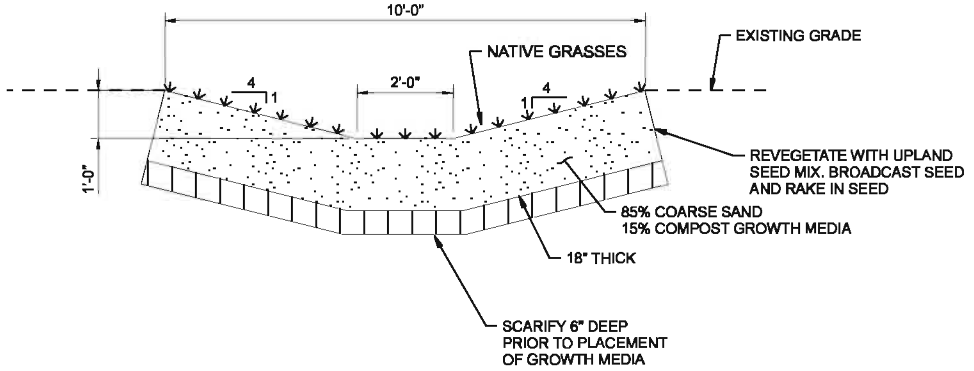
C-1



6 DOG PARK FENCE, TYPE 1

NTS

C-1



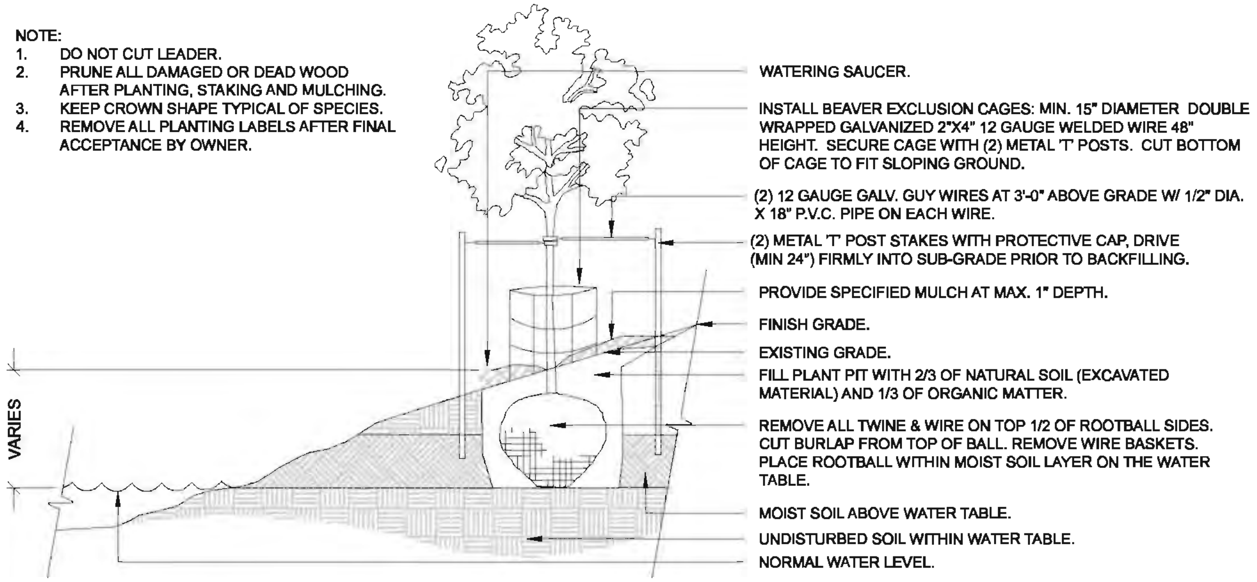
8 BIO-SWALE DETAIL

NTS

C-1

NOTE:

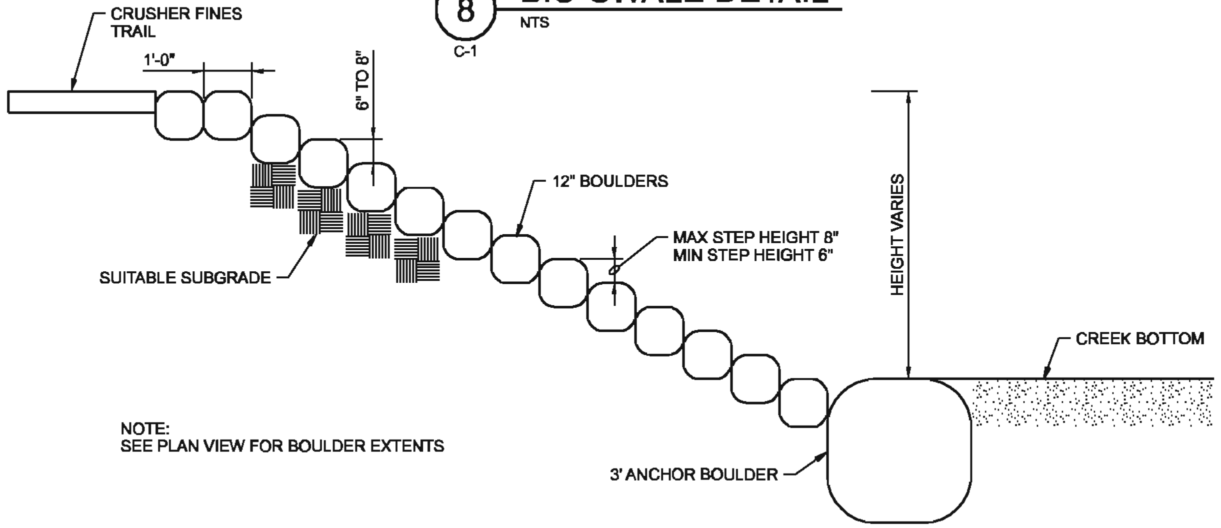
1. DO NOT CUT LEADER.
2. PRUNE ALL DAMAGED OR DEAD WOOD AFTER PLANTING, STAKING AND MULCHING.
3. KEEP CROWN SHAPE TYPICAL OF SPECIES.
4. REMOVE ALL PLANTING LABELS AFTER FINAL ACCEPTANCE BY OWNER.



7 DEEP TREE PLANTING FOR B&B COTTONWOOD SPECIES

NTS

C-1



NOTE:
SEE PLAN VIEW FOR BOULDER EXTENTS

9 SITE ACCESS DETAIL

NTS

C-1

PRELIMINARY

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD
DSGN	A COOK	DR S KRAMER	CHK C HOOPER	APVD S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK STATE PARK
ARAPAHOE COUNTY

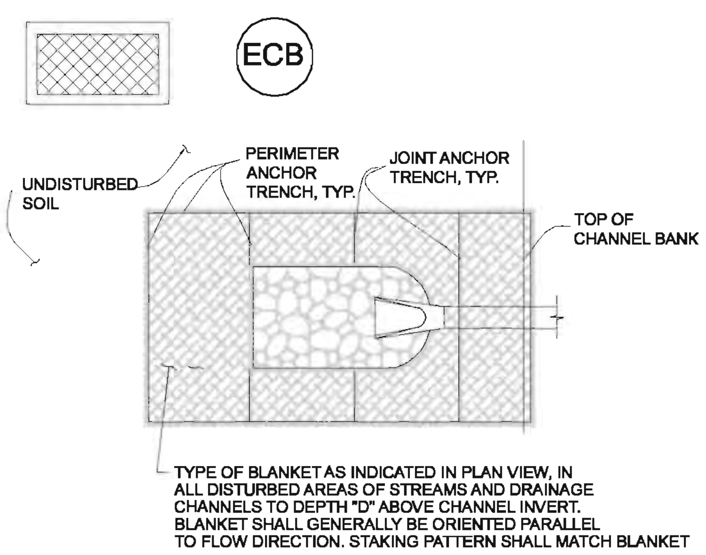
CH2MHILL

DETAILS

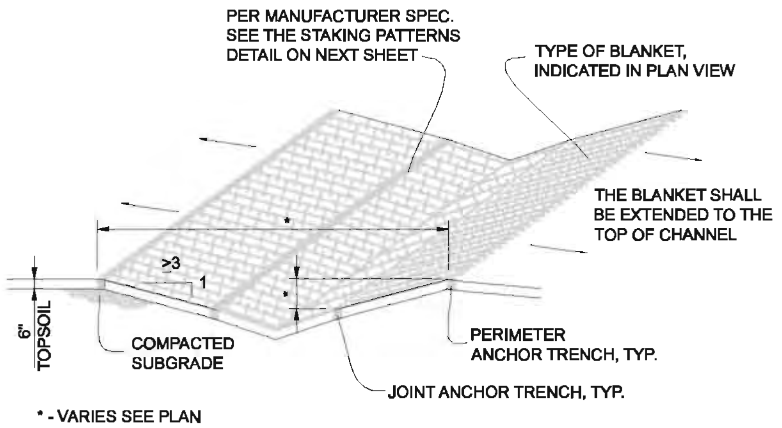
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2011
PROJ	407259
DWG	C-8
SHEET	11

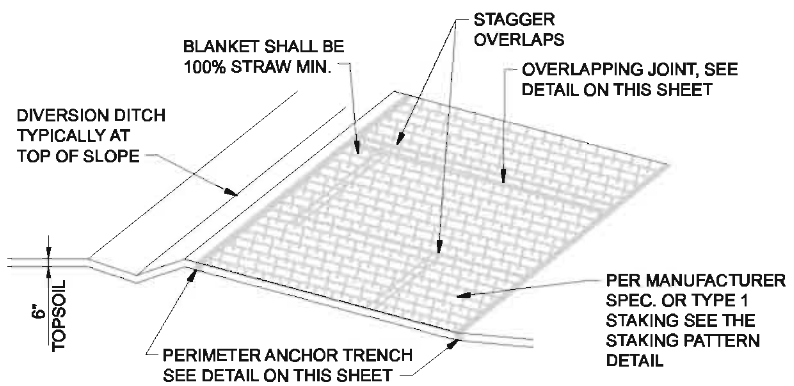
FILENAME: 005-C-5001.dgn PLOT DATE: 9/19/2011 PLOT TIME: 10:06:02 AM



AT PIPE OUTLET AREAS OF STREAMS AND DRAINAGE CHANNELS - DETAIL A

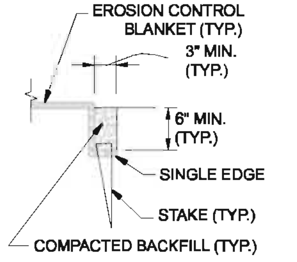


IN DIVERSION DITCH OR SMALL DITCH DRAINAGE WAY - DETAIL B

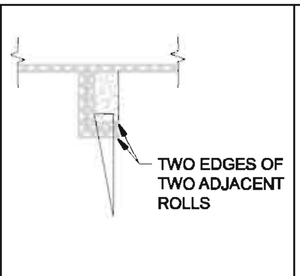


OUTSIDE OF STREAMS AND DRAINAGE CHANNELS - DETAIL C

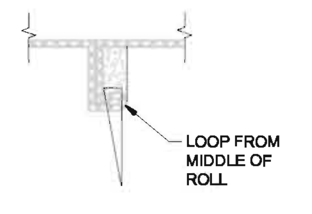
ANCHOR DETAILS



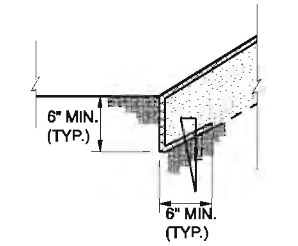
PERIMETER ANCHOR TRENCH



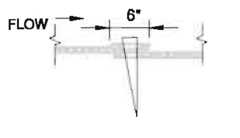
JOINT ANCHOR TRENCH



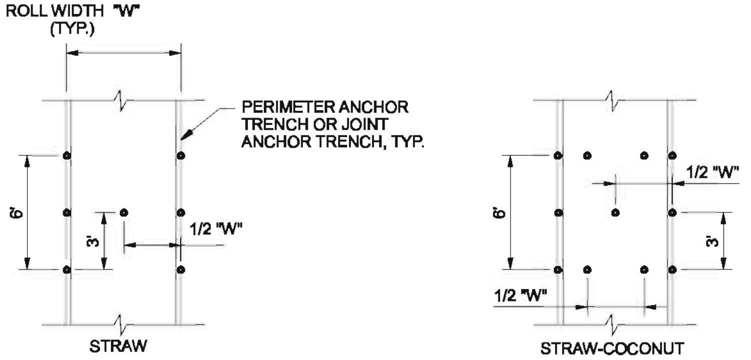
INTERMEDIATE ANCHOR TRENCH



ANCHOR TRENCH



OVERLAPPING JOINT



STRAW

STRAW-COCONUT

STAKING PATTERNS

SHALL BE IN ACCORDANCE WITH MANUFACTURER'S SPECIFICATION. IF NO MANUFACTURER'S SPECIFICATION IS AVAILABLE USE THE ACCEPTABLE STAKING PATTERN (AS SHOWN ABOVE)

EROSION CONTROL BLANKET INSTALLATION NOTES

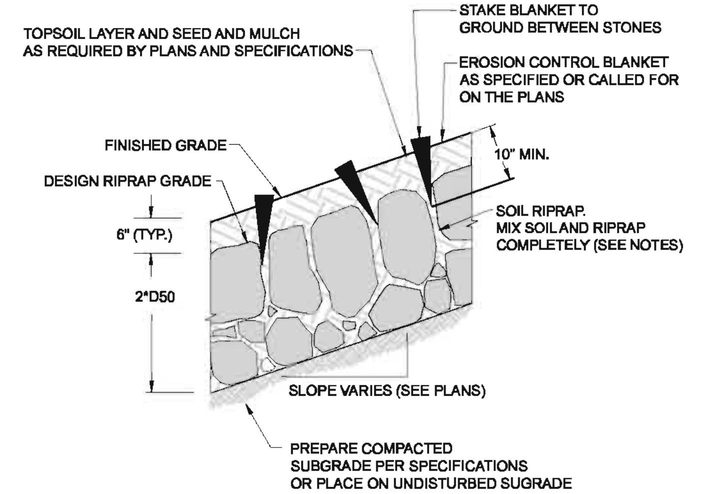
1. SEE PLAN VIEW FOR:
   - LOCATION OF PERIMETER OF EROSION CONTROL BLANKET.
   - TYPE OF BLANKET C125BN OR APPROVED EQUAL
   - AREA "A" IN SQUARE YARDS OF EACH TYPE OF BLANKET.
2. ALL EROSION CONTROL BLANKETS AND NETTING SHALL BE MADE OF 100% NATURAL AND BIODEGRADABLE MATERIAL NO PLASTIC OR OTHER SYNTHETIC MATERIAL, EVEN IF PHOTO DEGRADABLE, SHALL BE ALLOWED.
3. IN AREAS WHERE EROSION CONTROL BLANKET IS SHOWN ON THE PLANS, THE PERMITEE SHALL PLACE TOPSOIL AND PERFORM FINAL GRADING, SURFACE PREPARATION, AND SEEDING BELOW THE SEEDING AND MULCHING. SUBGRADE SHALL BE SMOOTH AND MOIST PRIOR TO THE BLANKET INSTALLATION AND THE BLANKET SHALL BE IN FULL CONTACT WITH SUBGRADE, NO GAPS OF VOIDS SHALL EXIST UNDER THE BLANKET.
4. PERIMETER ANCHOR TRENCH SHALL BE USED AT OUTSIDE PERIMETER OF ALL BLANKET AREAS.
5. JOINT ANCHOR TRENCH SHALL BE USED TO JOIN ROLLS OF BLANKET TOGETHER (LONGITUDINALLY AND TRANSVERSELY) FOR ALL BLANKETS EXCEPT STRAW, WHICH MAY USE AND OVERLAPPING JOINT.
6. INTERMEDIATE ANCHOR TRENCH SHALL BE USED AT SPACING OF ONE-HALF THE ROLL LENGTH FOR COCONUT AND EXCELSIOR BLANKETS.
7. THE OVERLAPPING JOINT DETAIL SHALL BE USED TO JOIN ROLLS OF BLANKETS TOGETHER FOR BLANKETS ON SLOPES.
8. ANY AREAS OF SEEDING AND MULCHING DISTURBED IN THE PROCESS OF INSTALLING EROSION CONTROL BLANKET SHALL BE RESEEDED AND MULCHED.

EROSION CONTROL BLANKET MAINTENANCE NOTES

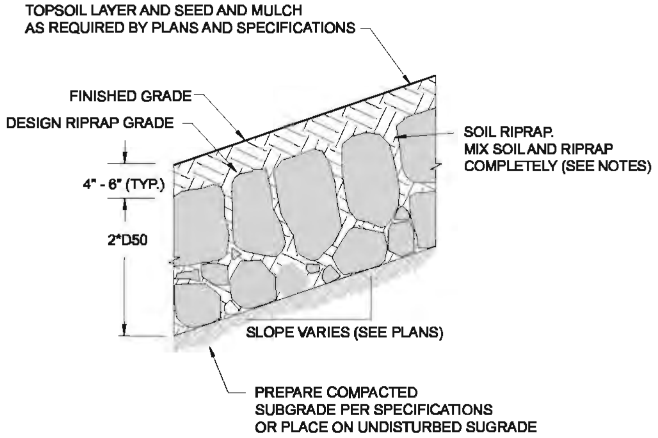
1. THE SWMP MANAGER SHALL INSPECT EROSION CONTROL BLANKETS WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS AS NECESSARY.
2. EROSION CONTROL BLANKET IS TO BE LEFT IN PLACE UNLESS REQUESTED TO BE REMOVED BY THE LOCAL JURISDICTION.
3. ANY EROSION CONTROL BLANKET PULLED OUT, TORN, OR OTHERWISE DAMAGED SHALL BE RE-INSTALLED. ANY SUBGRADE AREAS BELOW THE BLANKET THAT HAVE ERODED TO CREATE A VOID UNDER THE BLANKET, OR THAT REMAIN DEVOID OF GRASS SHALL BE REPAIRED, RESEEDED AND MULCHED AND THE EROSION CONTROL BLANKET REINSTALLED.

EROSION CONTROL BLANKET

NTS



TYPICAL SECTION -
SOIL RIPRAP WITH EROSION CONTROL FABRIC



TYPICAL SECTION -
SOIL RIPRAP WITH MUCLH

NOTES:
1. SOIL RIPRAP DETAILS ARE APPLICABLE TO SLOPED AREAS. REFER TO THE SITE PLAN ACTUAL LOCATION AND LIMITS.
2. MIX UNIFORMALLY 65% RIPRAP BY VOLUME WITH 35% OF APPROVED SOIL BY VOLUME PRIOR TO PLACEMENT.
3. PLACE STONE-SOIL MIX TO RESULT IN SECURELY INTERLOCKED ROCK AT THE DESIGN THICKNESS AND GRADE. COMPACT AND LEVEL TO ELIMINATE ALL VOIDS AND ROCKS PROJECTING ABOVE DESIGN RIPRAP TOP GRADE.
4. CRIMP OR TACKIFY MULCH OR USE APPROVED HYDROMULCH AS CALLED FOR IN THE PLANS AND SPECIFICATIONS.

SOIL RIPRAP

NTS

PRELIMINARY

NO	DATE	DESCRIPTION	APVR	N
NO.	DATE	REVISION	BY	APVD

DSGN A COOK
DR S KRAMER
CHK C HOOPER
APVD S YANAGIHARA

CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CHERRY CREEK STREAM RECLAMATION
AT 12-MILE PARK
CHERRY CREEK BASIN
WATER QUALITY AUTHORITY

CH2MHILL

DETAILS

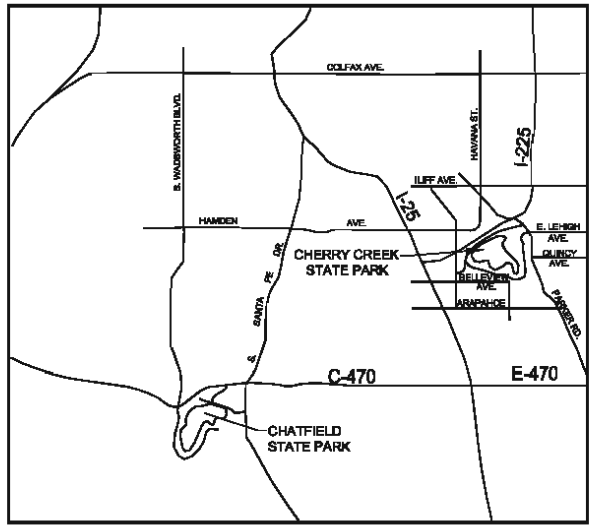
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2011
PROJ	407259
DWG	C-9
SHEET	12

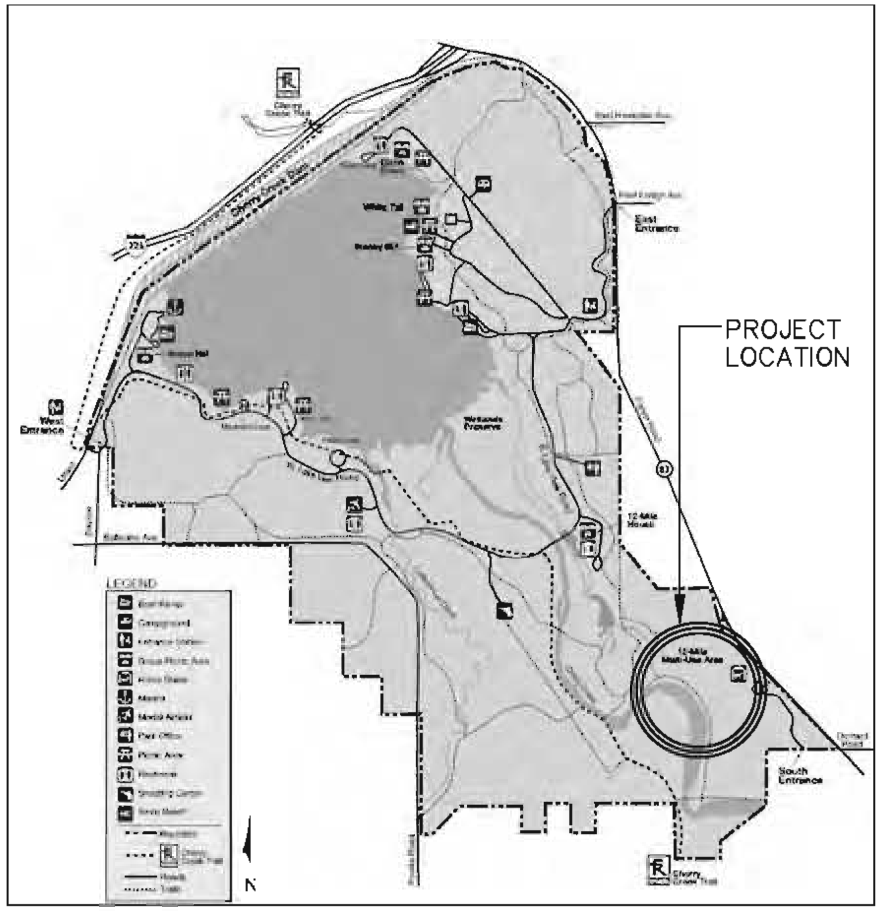
Appendix C – DOLA Improvement Plans

CHERRY CREEK STATE PARK
DOG OFF-LEASH AREA

ARAPAHOE COUNTY, COLORADO
FOR
COLORADO DIVISION OF PARKS AND OUTDOOR RECREATION



VICINITY MAP
NO SCALE



CHERRY CREEK STATE PARK
PROJECT LOCATION MAP
NO SCALE

CHERRY CREEK STATE PARK
DOG OFF-LEASH AREA – EXISTING AERIAL MAP
NO SCALE

SHEET INDEX
SHEET 1 – COVER SHEET
SHEET 2 – DOG OFF-LEASH AREA SITE PLAN
SHEET 3 – DOG OFF-LEASH AREA, ENLARGED PLAN
SHEET 4 – 12 MILE NORTH, ENLARGED PLAN
SHEET 5 – DETAILS
SHEET 6 – DETAILS

IMPORT/EXPORT CALCULTATIONS

AREA OF DISTURBANCE	IMPORT	EXPORT	ADDITIONAL EXPORT MATERIAL REQUIRED
ITEM #1 Excavation	0 CY	4590 CY	
ITEM #2 Concrete Footer	12 CY	0 CY	
ITEM #3 Sub-base	9 CY	0 CY	
ITEM #4 Flatwork	4569 CY	0 CY	
TOTALS	4590 CY	4590 CY	0 CY

OWNER REP. TO IDENTIFY ADDITIONAL EXPORT MATERIAL DURING CONSTRUCTION IF REQUIRED
PROJECT MANAGER WILL COORDINATE EXPORT SITE.

APPROVAL:
REGIONAL MANAGER:______________________________
CAPITAL DEVELOPMENT MANAGER:_______________________

COLORADO DIVISION OF PARKS & OUTDOOR RECREATION

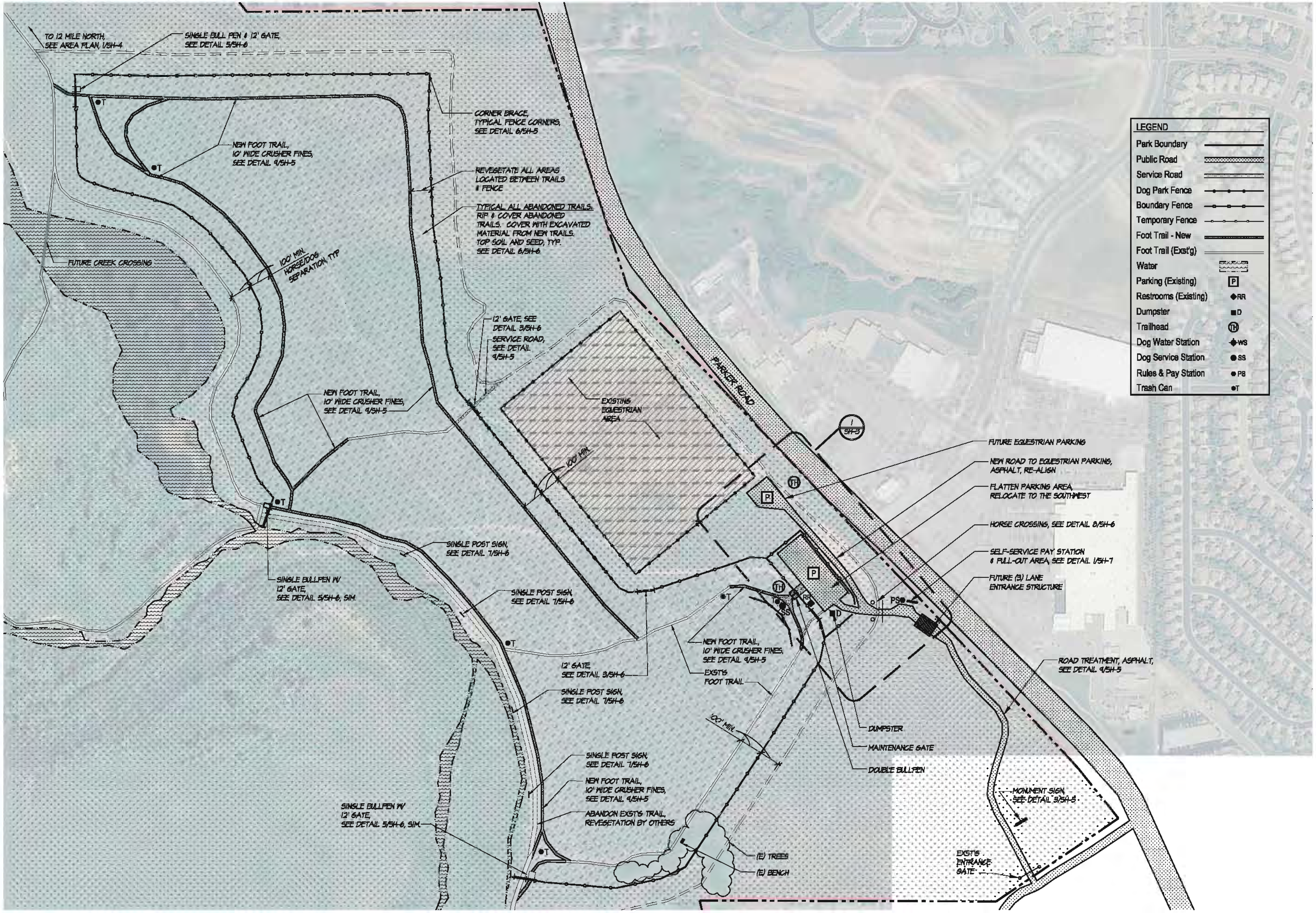
Colorado State Parks

STUART WATADA
PROJECT MANAGER
HEATHER DUGAN
REGIONAL MANAGER

DESIGNED: PM
DRAWN: E.H.S.
FILE: ____
DATE: 030911

SHEET 1 OF 7 SHEETS

CHERRY CREEK STATE PARK
DOG OF-LEASH AREA
COVER SHEET



① DOG OFF-LEASH AREA - SITE PLAN

SCALE: 1" = 200'-0"

COLORADO DIVISION OF PARKS & OUTDOOR RECREATION

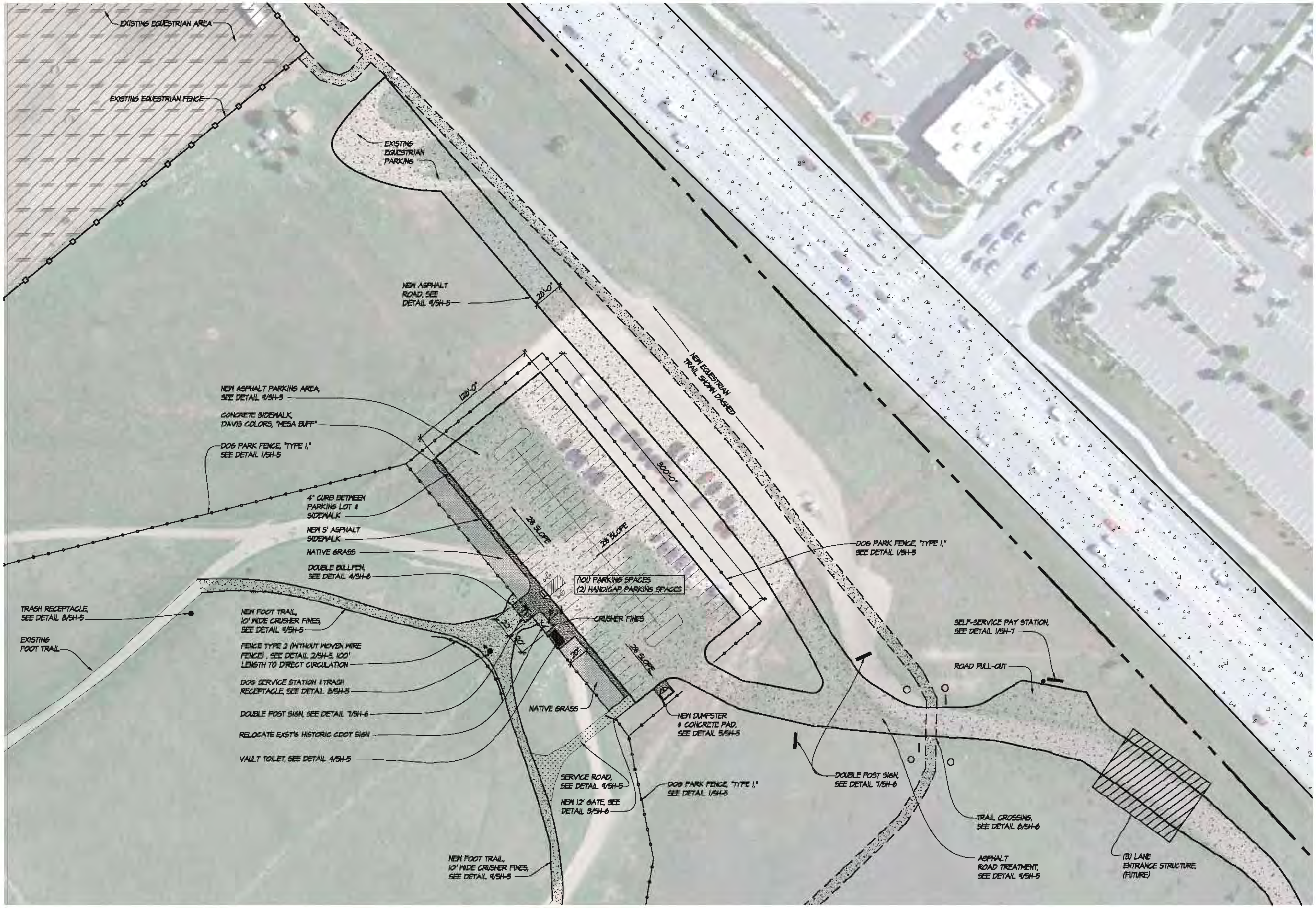
Colorado State Parks

HEATHER DUGAN
PROJECT MANAGER
HEATHER DUGAN
REGIONAL MANAGER

DESIGNED: PM
DRAWN: E.H.S.
FILE:
DATE: 030911

SHEET 2 OF 7 SHEETS

CHERRY CREEK STATE PARK
DOG OFF-LEASH AREA PROJECT
SITE PLAN



1 **DOG OFF-LEASH AREA - ENLARGED PLAN**

SCALE: 1" = 40'-0"

COLORADO DIVISION OF PARKS & OUTDOOR RECREATION

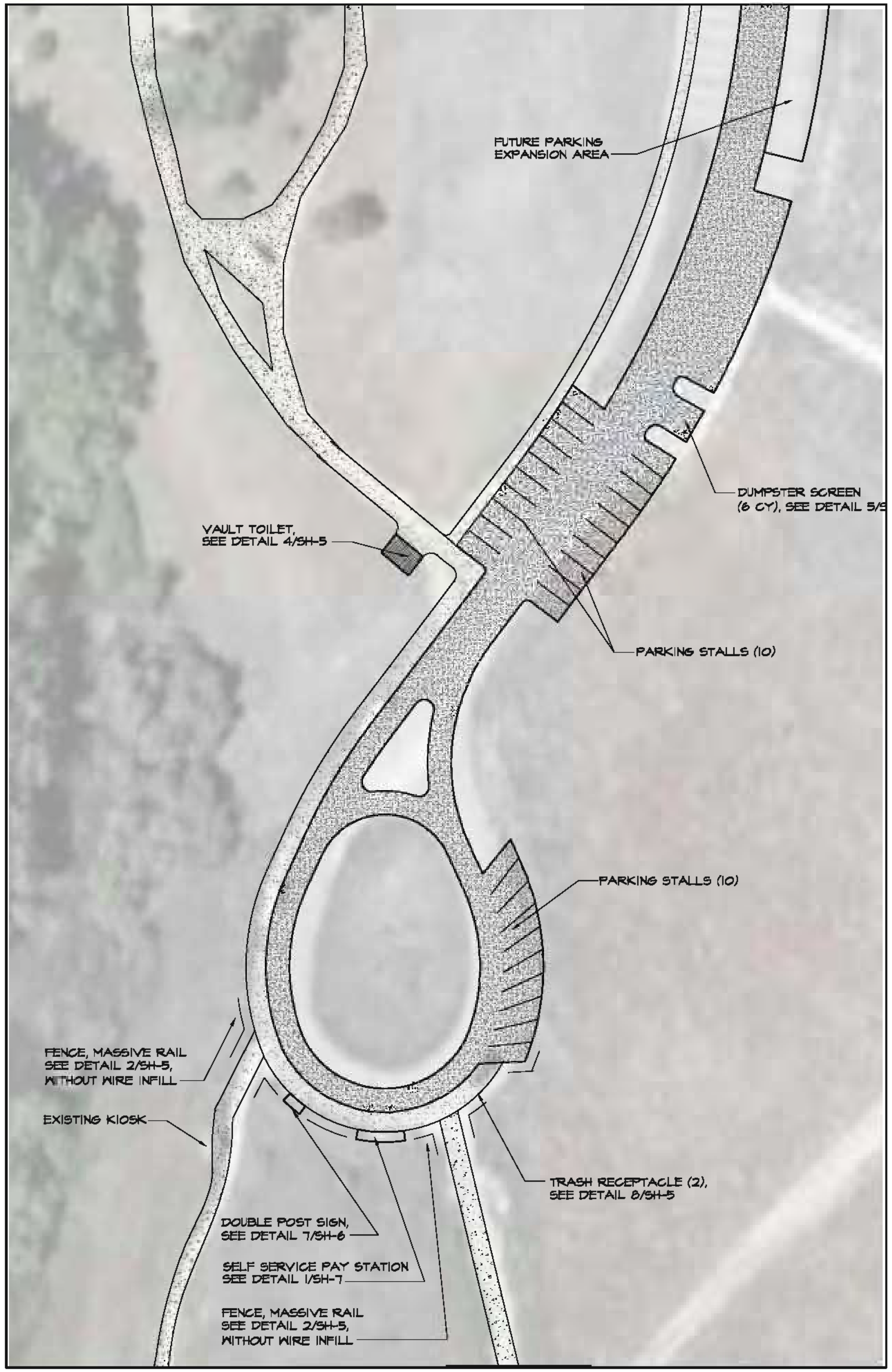
Colorado State Parks

HEATHER DUGAN
PROJECT MANAGER
HEATHER DUGAN
REGIONAL MANAGER

DESIGNED: PM
DRAWN: E.H.S.
FILE:
DATE: 030911

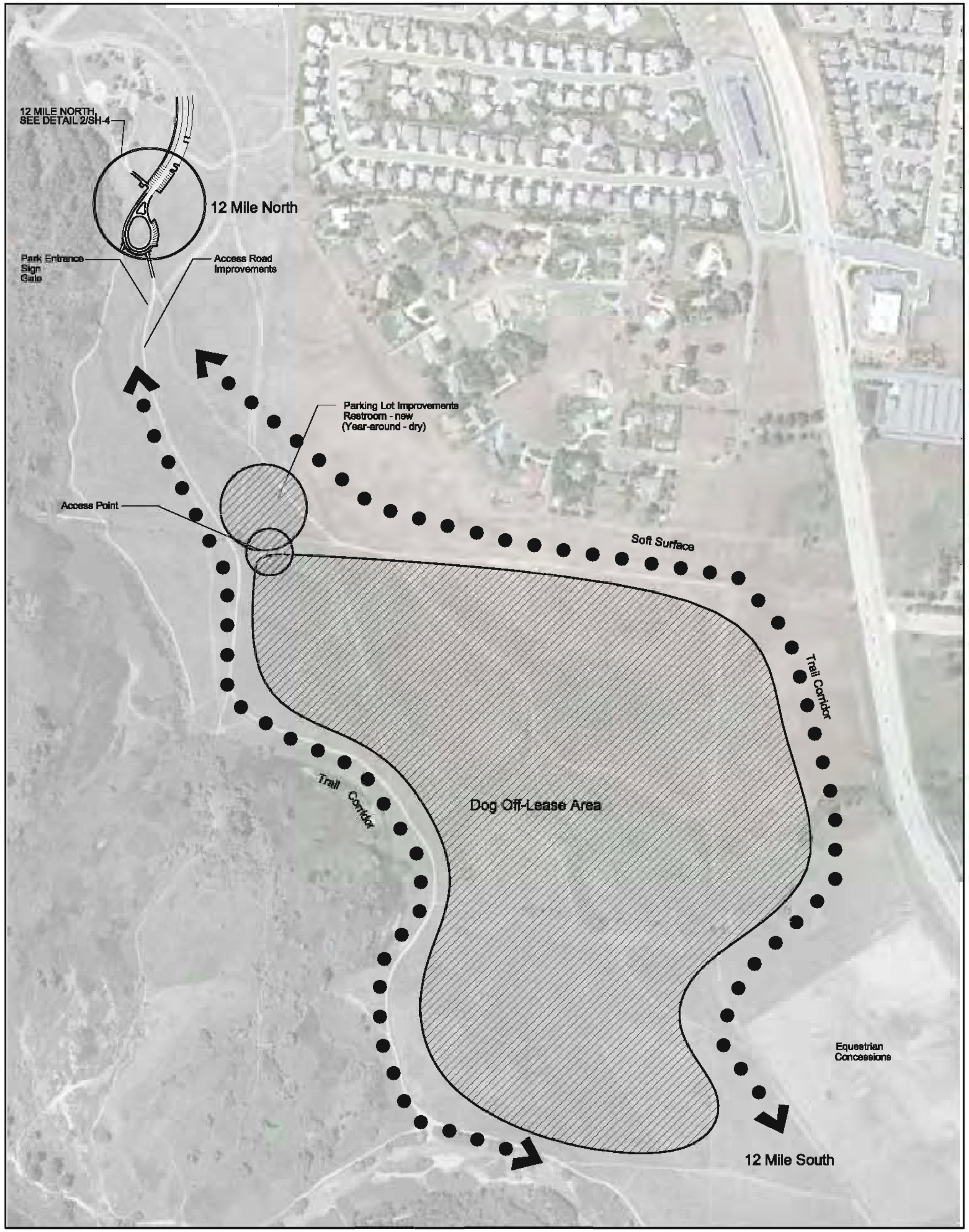
SHEET 3 OF 7 SHEETS

CHERRY CREEK STATE PARK
DOG OFF-LEASH AREA PROJECT
ENLARGED SITE PLAN



② 12 MILE NORTH - ENLARGED PLAN

SCALE: NO SCALE



① 12 MILE NORTH - VICINITY PLAN

SCALE: NO SCALE

COLORADO DIVISION OF
PARKS
& OUTDOOR RECREATION

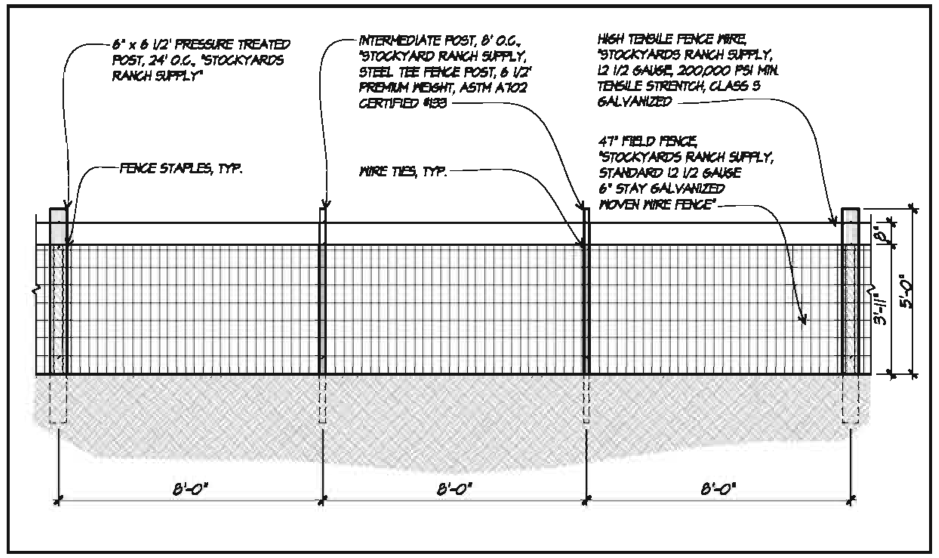
Colorado State Parks

HEATHER DUGAN
PROJECT MANAGER
HEATHER DUGAN
REGIONAL MANAGER

DESIGNED: PM
DRAWN: E.H.S.
FILE: ___
DATE: 030911

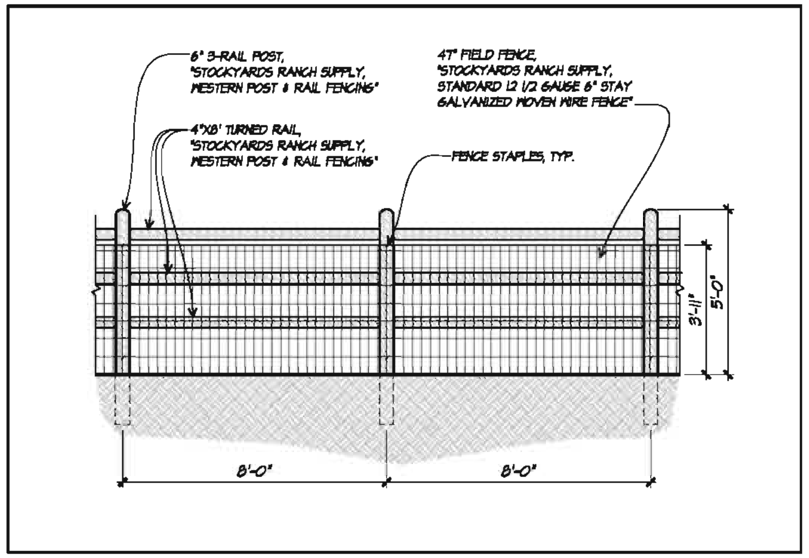
SHEET 4 OF 7 SHEETS

CHERRY CREEK STATE PARK
DOG OFF-LEASH AREA PROJECT
12 MILE NORTH



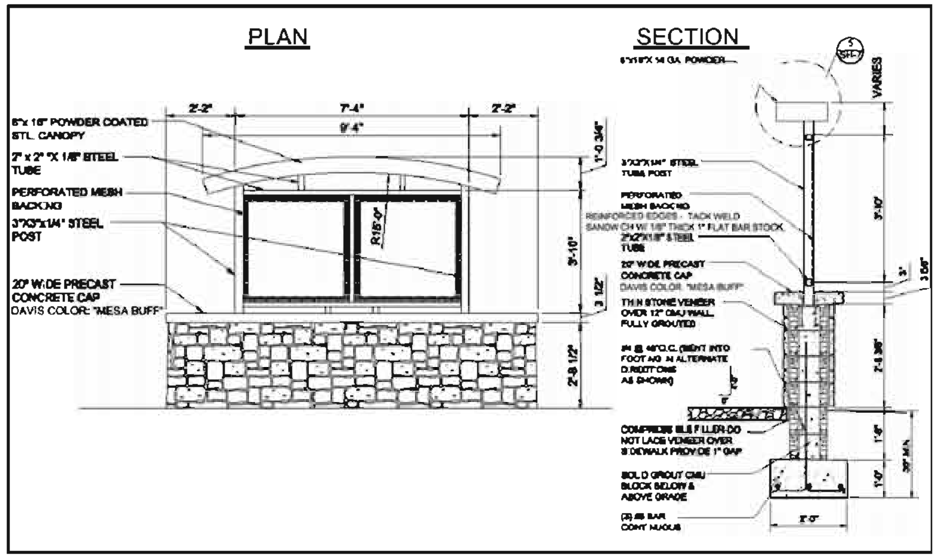
① **DOG PARK FENCE, TYPE 1**

SCALE: 3/8" = 1'-0"



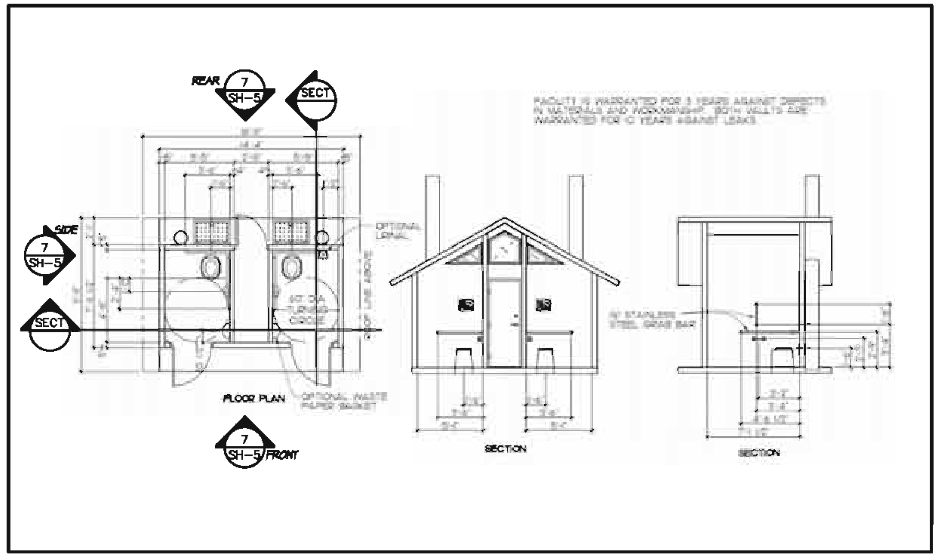
② **BULL PEN FENCE, TYPE 2**

SCALE: 3/8" = 1'-0"



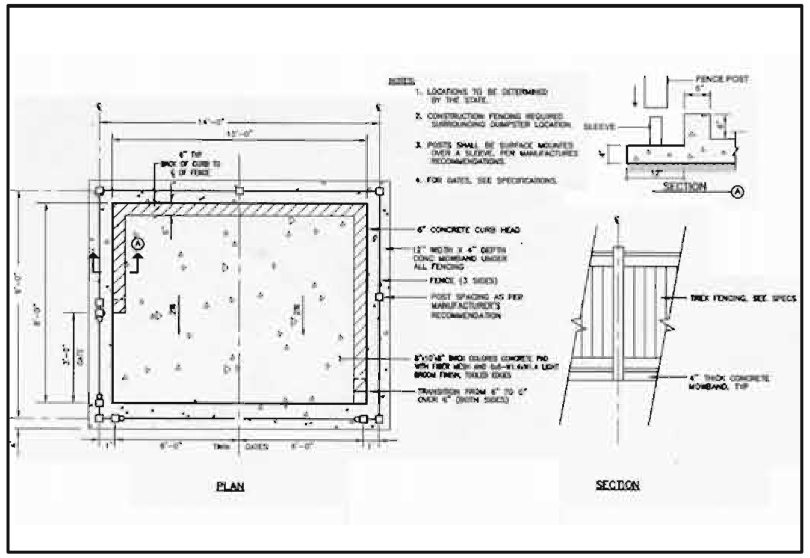
③ **MONUMENT SIGN**

SCALE: NO SCALE



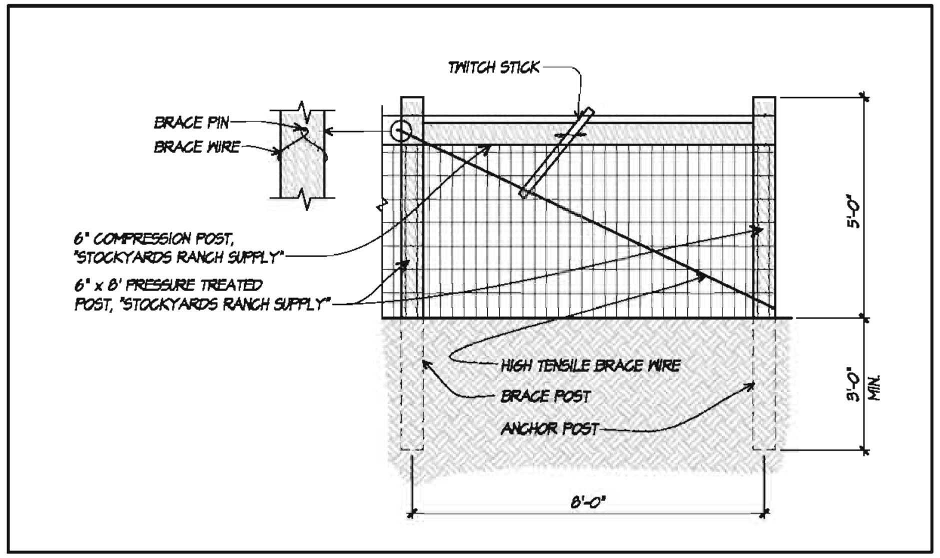
④ **VAULT TOILET - PLAN & SECTIONS**

SCALE: NO SCALE



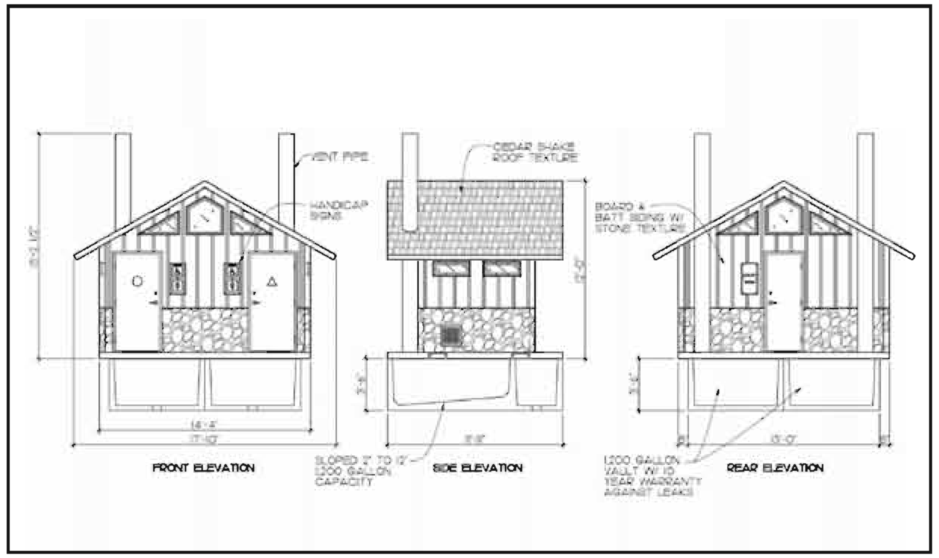
⑤ **DUMPSTER PAD & SCREEN**

SCALE: 1/2" = 1'-0"



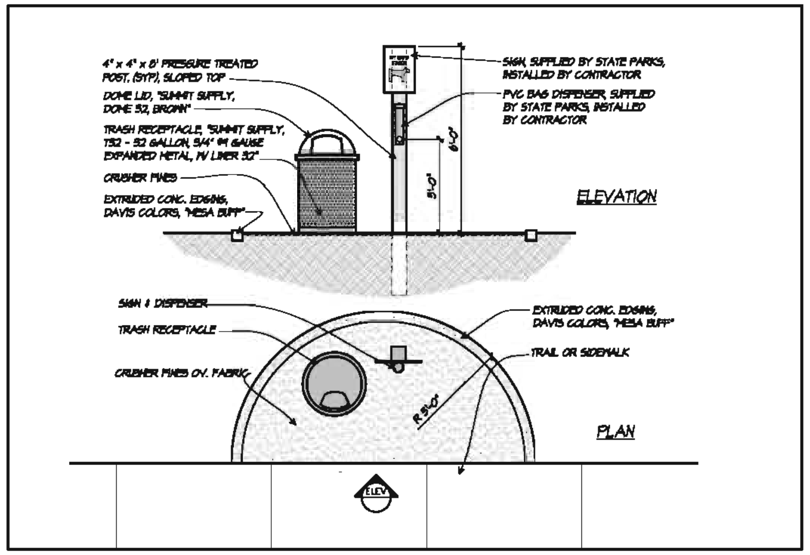
⑥ **FENCE CORNER BRACE DETAIL**

SCALE: 1/2" = 1'-0"



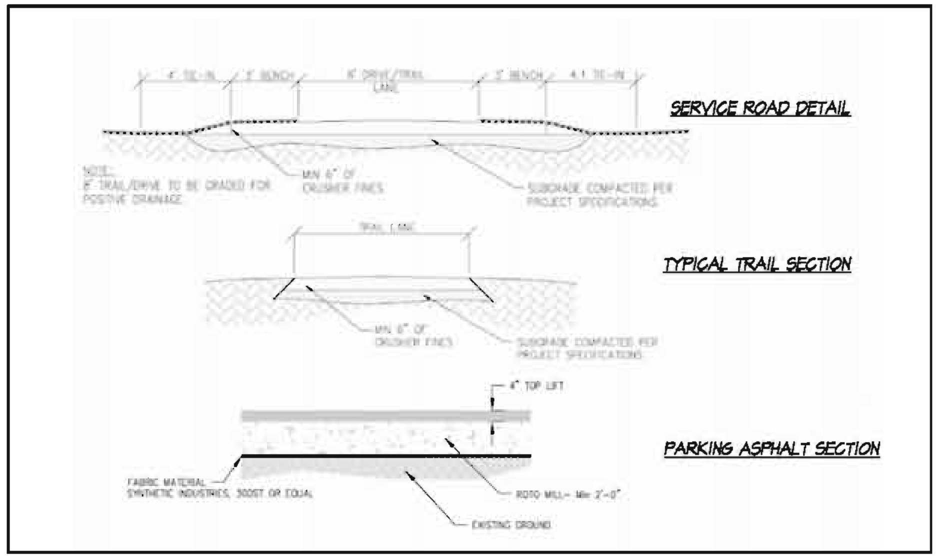
⑦ **VAULT TOILET - ELEVATIONS**

SCALE: NO SCALE



⑧ **DOG SERVICE STATION & WASTE RECEPTACLE DETAIL**

SCALE: 1/2" = 1'-0"



⑨ **SERVICE ROAD, TYPICAL TRAIL SECTION, & ASPHALT SECTION**

SCALE: NO SCALE

COLORADO DIVISION OF
PARKS
& OUTDOOR RECREATION

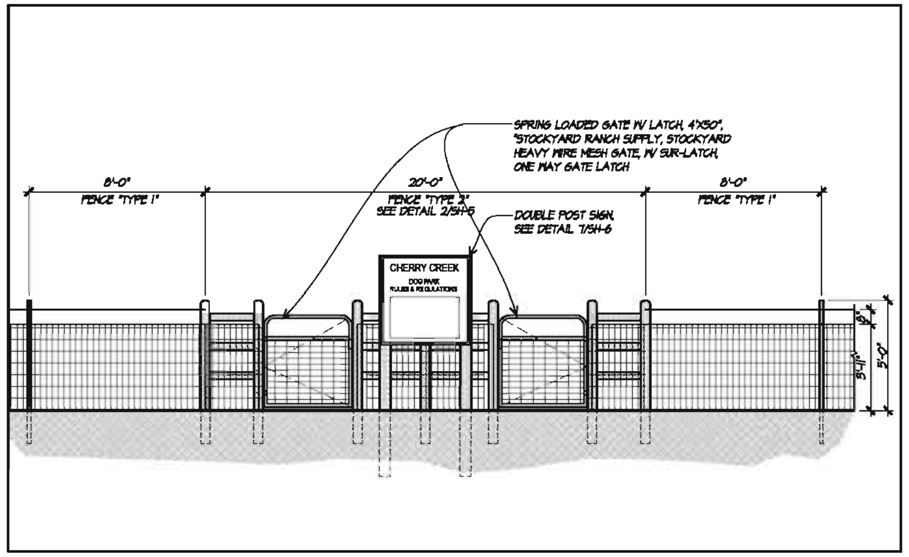
Colorado State Parks

HEATHER DUGAN
PROJECT MANAGER
HEATHER DUGAN
REGIONAL MANAGER

DESIGNED: PM
DRAWN: E.H.S.
FILE: ____
DATE: 030911

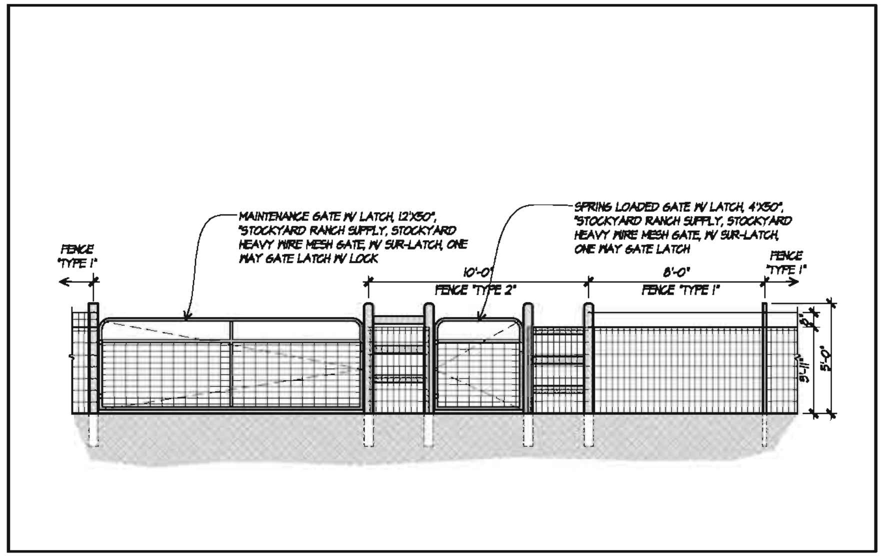
SHEET
5
OF
7
SHEETS

CHERRY CREEK STATE PARK
DOG OFF-LEASH AREA
DETAILS



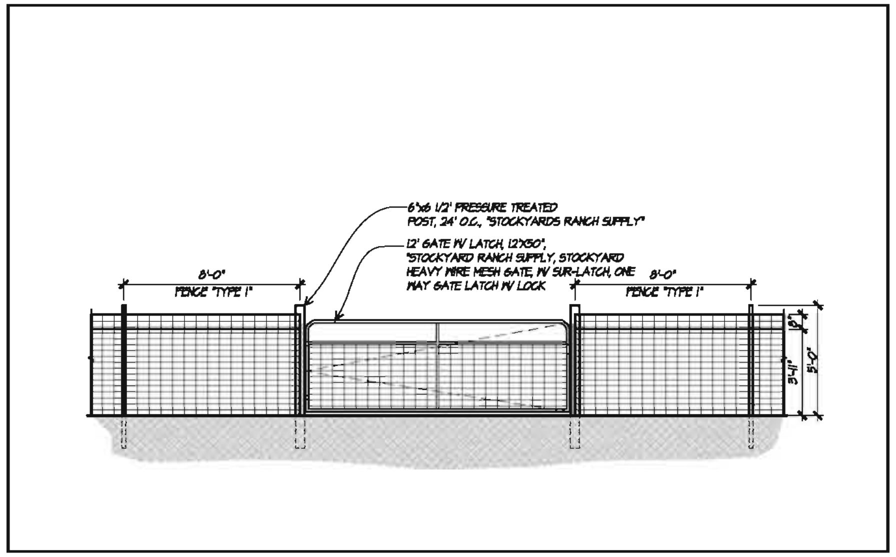
1 DOUBLE BULL PEN ELEVATION

SCALE: 1/4" = 1'-0"



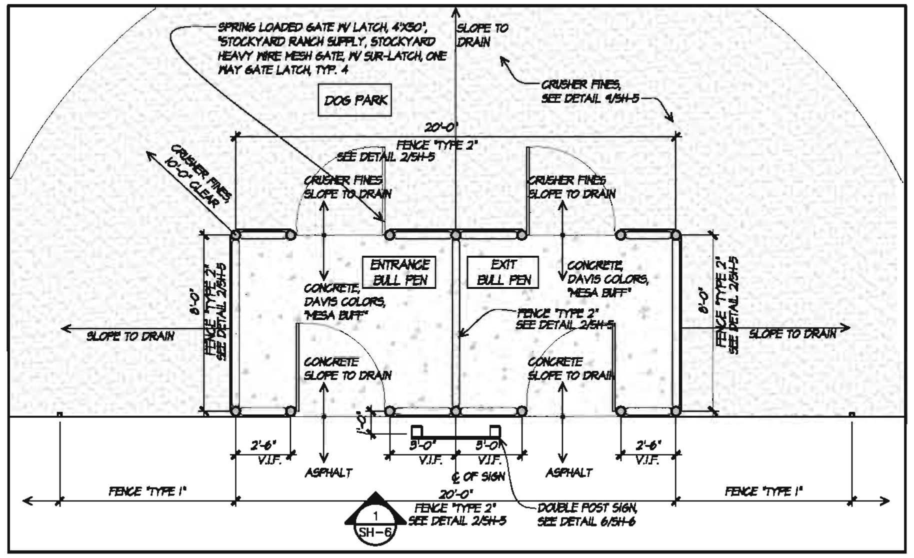
2 SINGLE BULL PEN W/ 12' GATE ELEVATION

SCALE: 1/4" = 1'-0"



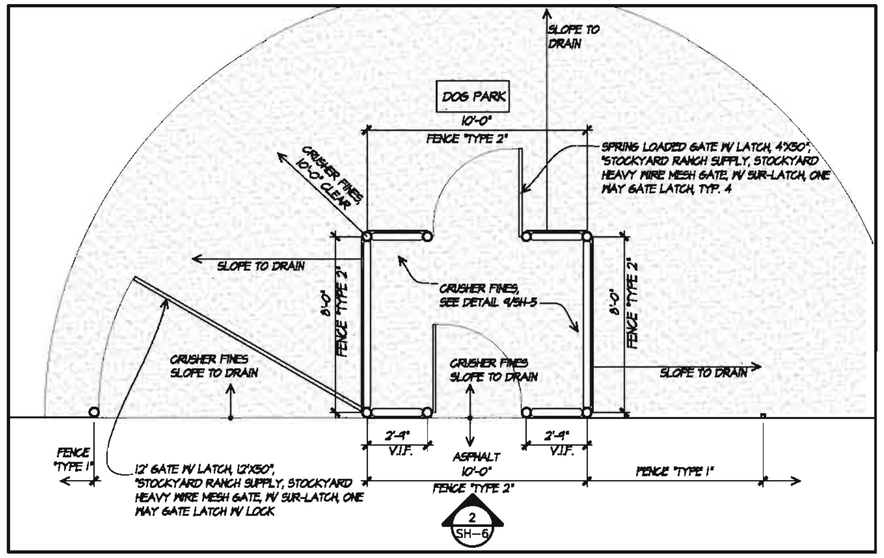
3 12' GATE ELEVATION

SCALE: 1/4" = 1'-0"



4 DOUBLE BULL PEN PLAN

SCALE: 1/4" = 1'-0"

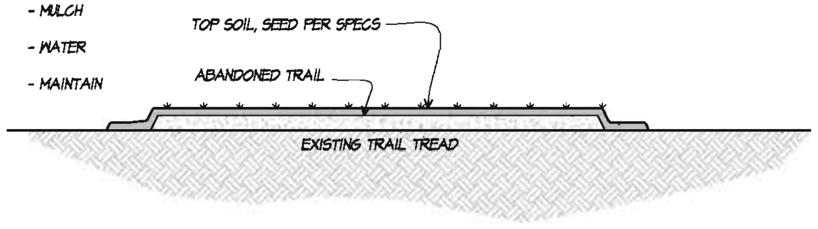


5 SINGLE BULL PEN W/ MAINTENANCE GATE PLAN

SCALE: 1/4" = 1'-0"

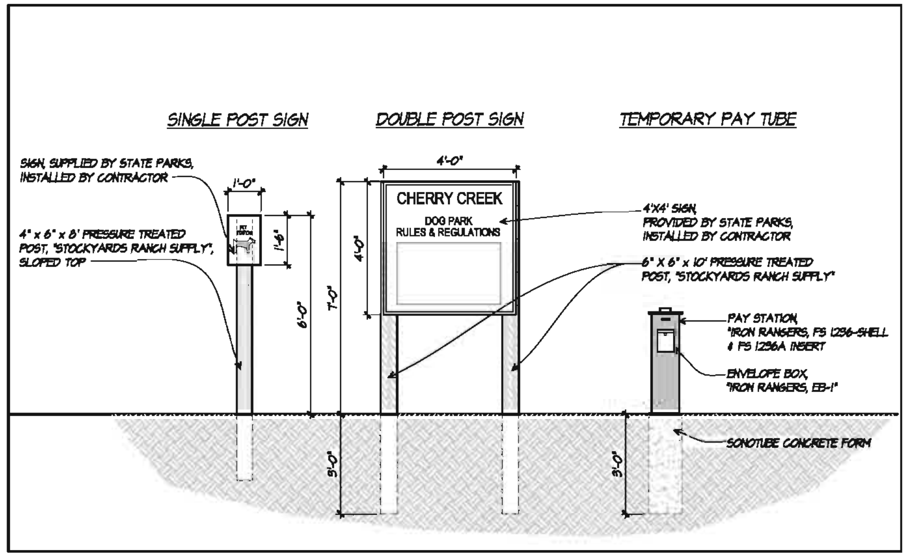
TRAIL REVEGETATION PROCEDURE:

- SCRAPE, & REMOVE EXISTING TRAIL MATERIAL
- RIP COMPACTED TRAIL TREAD, MIN. 4"
- ADD 2" TOP SOIL, AND TILL MIN. 6"
- COMPACT 95%
- SEED PER SPECIFICATIONS
- MULCH
- WATER
- MAINTAIN



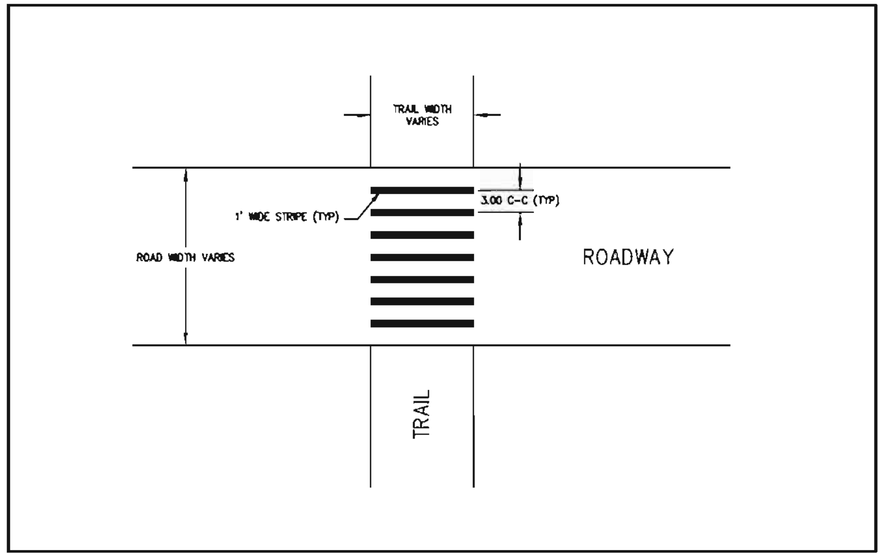
6 ABANDONED TRAIL REVEGETATION

SCALE: 1/2" = 1'-0"



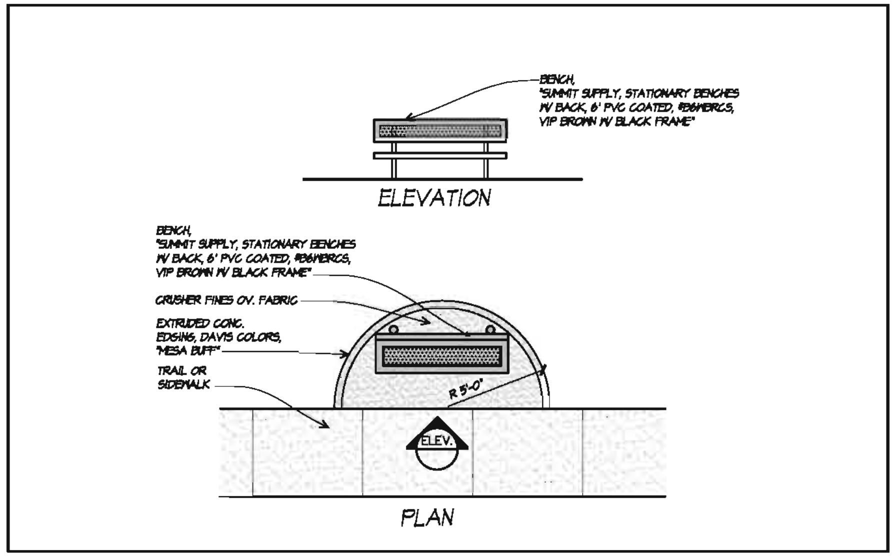
7 SINGLE POST, DOUBLE POST SIGN, & TEMPORARY PAY TUBE

SCALE: 1/2" = 1'-0"



8 STANDARD TRAIL CROSSING

SCALE: NO SCALE



9 BENCH DETAIL

SCALE: 1/4" = 1'-0"

COLORADO DIVISION OF
PARKS
& OUTDOOR RECREATION

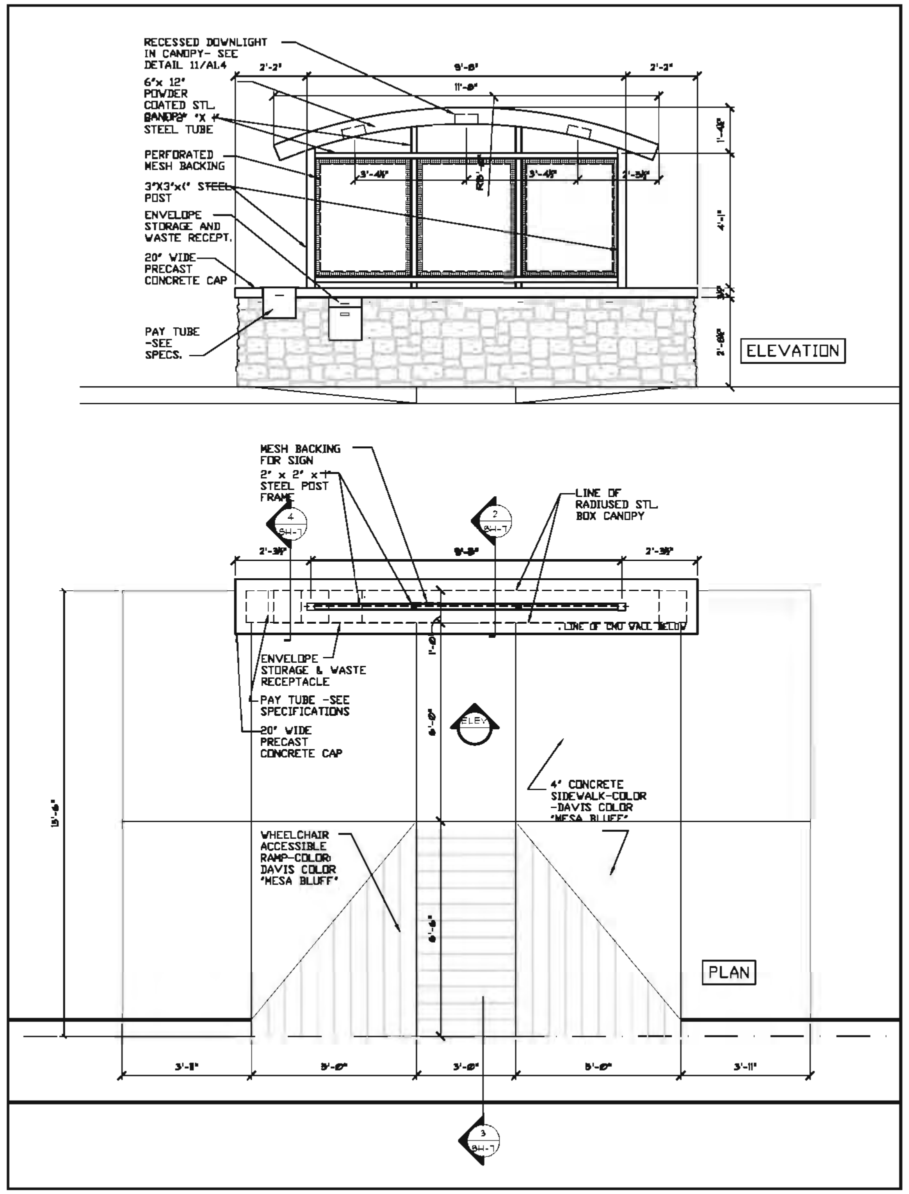
Colorado State Parks

HEATHER DUGAN
PROJECT MANAGER
HEATHER DUGAN
REGIONAL MANAGER

DESIGNED: PM
DRAWN: E.H.S.
FILE: ____
DATE: 030911

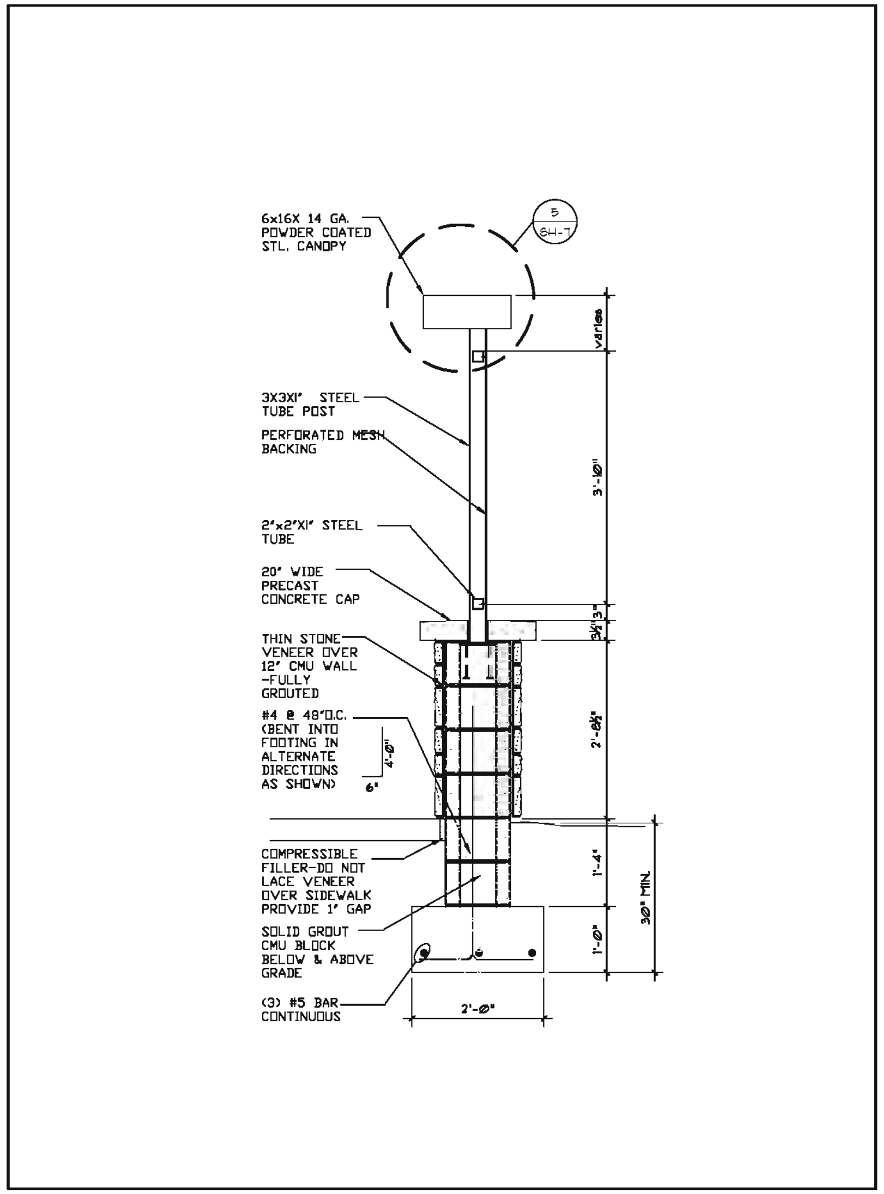
SHEET
6
OF
7
SHEETS

CHERRY CREEK STATE PARK
DOG OFF-LEASH AREA
DETAILS



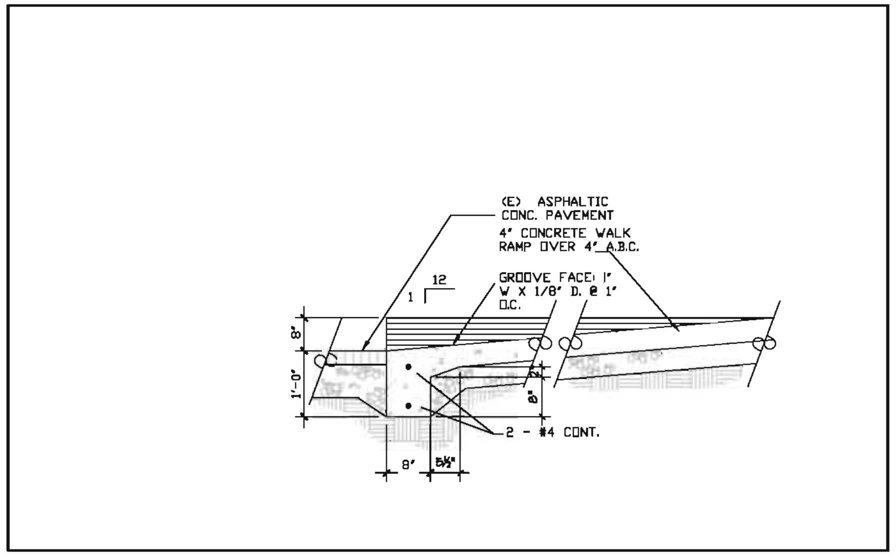
① SELF-SERVICE PAY STATION - PLAN & ELEVATION

SCALE: 3/8" = 1'-0"



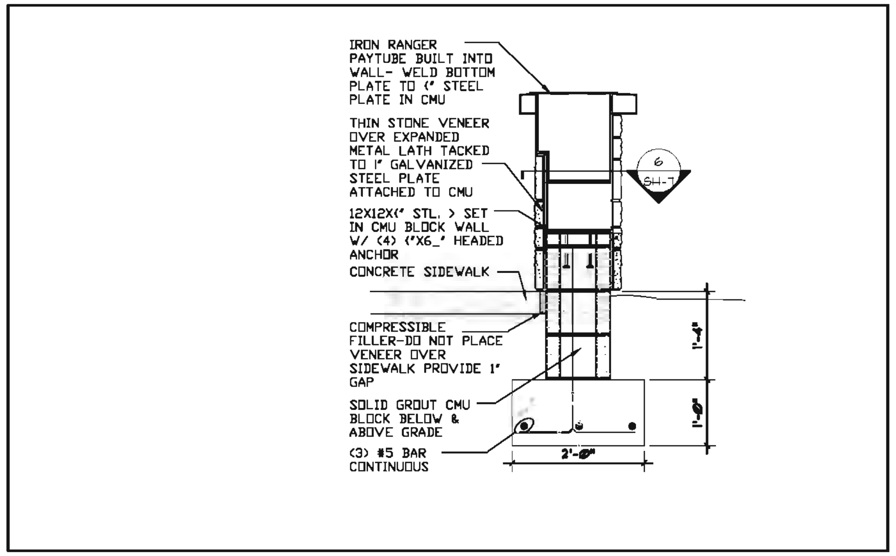
② SELF-SERVICE PAY STATION - SECTION

SCALE: 3/4" = 1'-0"



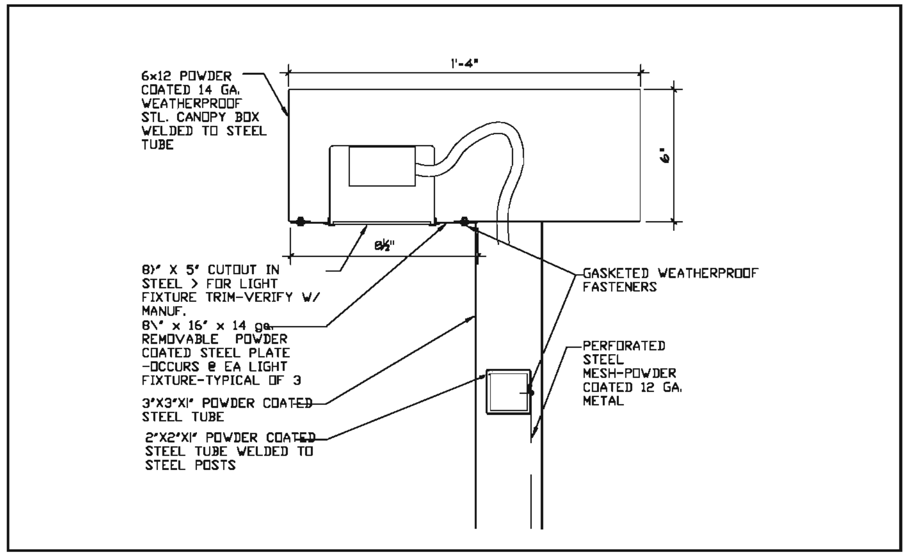
③ DETAIL AT RAMP

SCALE: 3/4" = 1'-0"



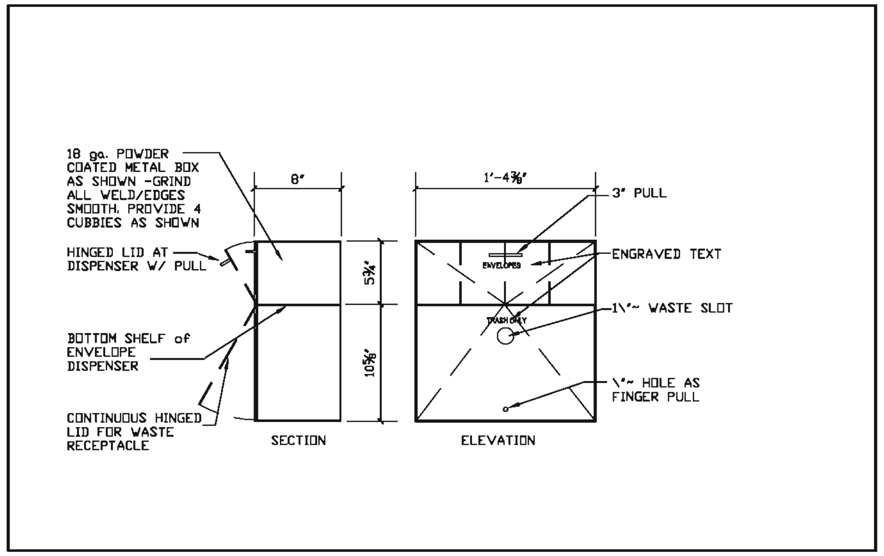
④ DETAIL AT PAY TUBE

SCALE: 3/4" = 1'-0"



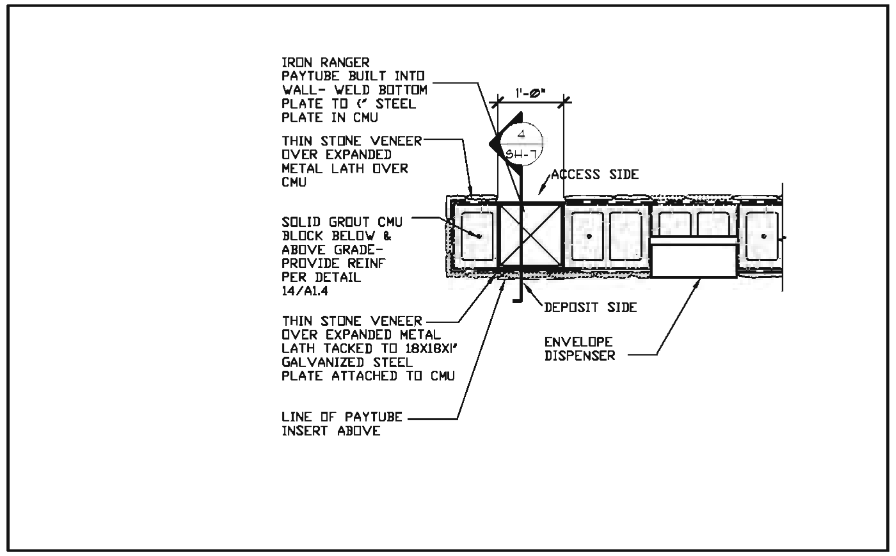
⑤ DETAIL AT CANOPY

SCALE: 3" = 1'-0"



⑥ ENVELOPE DISPENSER

SCALE: 1 1/2" = 1'-0"



⑦ PAY TUBE DETAIL

SCALE: 3/4" = 1'-0"

COLORADO DIVISION OF
PARKS
& OUTDOOR RECREATION

Colorado State Parks

HEATHER DUGAN
PROJECT MANAGER
HEATHER DUGAN
REGIONAL MANAGER

DESIGNED: PM
DRAWN: E.H.S.
FILE: ____
DATE: 030911

SHEET 7 OF 7 SHEETS

CHERRY CREEK STATE PARK
DOG OFF-LEASH AREA
DETAILS

Appendix D – Geotechnical Report

CTL | THOMPSON
INCORPORATED

GEOTECHNICAL INVESTIGATION
12-MILE PARK
CHERRY CREEK STREAM RECLAMATION
WEST OF SOUTH PARKER ROAD
AND SOUTH CHAMBERS ROAD
ARAPAHOE COUNTY, COLORADO

Prepared For:

CH2M HILL
9193 South Jamaica Street
Englewood, Colorado 80112

Attention: Mr. Scott Yanagihara, P.E.

Project No. DN45,052-125

August 30, 2010

TABLE OF CONTENTS

SCOPE

This report presents the results of our Geotechnical Investigation for the planned restoration of a 3,000-foot reach of Cherry Creek stream bed in the southeast portion of Cherry Creek State Park adjacent to the dog park area and west of the intersection of South Parker Road and South Chambers Road in Arapahoe County, Colorado (Fig. 1). The purpose of our investigation was to evaluate subsurface conditions at the site and provide geotechnical design and construction criteria for the project. The scope was described in our Service Agreement (No. DN 10-0068) dated January 26, 2010.

This report was prepared from data developed during field exploration, laboratory testing, and our engineering analysis and experience with similar conditions and projects. The report includes our description of the subsurface conditions found in our exploratory borings and discussions on design and construction of the proposed improvements as influenced by geotechnical considerations. The recommendations presented in this report are based upon construction as currently planned. If plans change, we should be contacted to review our recommendations and determine if revisions are necessary. A brief summary of our conclusions and recommendations follows, with more detailed discussion and design criteria provided within the report. Environmental assessment was not part of the scope.

SUMMARY OF CONCLUSIONS

1. Subsoils encountered in our borings consisted of grained 39 to 40 feet of silty to very clayey fine to medium sand with variable amounts of gravel. A persistent layer of a sandy clay about 6 to 12 feet thick occurs at depths between 1 and 8 feet. Sandstone bedrock was encountered in TH-1 and TH-2 only. Ground water was found in all 5 borings at depths of 9 to 15 feet during drilling. Water levels were measured at depths between about 4 and 13.5 feet several days later.

2. The silty to clayey sand is expected to have high erosion potential. The sandy clay is more resistant to erosion. The clay layer is believed to be persistent enough that it may be used to anchor seepage cutoff such as sheet pile or clay core embankments.

3. **We believe the soils penetrated by our exploratory borings can generally be excavated with typical heavy-duty construction equipment. On-site soils are suitable for re-use in new fills provided they are substantially free of debris and organic material, moisture conditioned, and compacted as discussed in SITE DEVELOPMENT.**

4. **The banks along Cherry Creek can be stabilized by flattening and re-vegetation. Benched slopes can also be utilized to reduce sheet flow velocity and erosion.**

5. **On-site clay can be used as fill for the embankment which will be constructed to reestablish the original stream path of Cherry Creek. Re-vegetation of the embankment slopes or rip-rap can be used to help control erosion. A sheet pile cutoff wall can be utilized to provide additional seepage control. Design and construction criteria for embankment construction are presented in the report.**

6. **The proposed boardwalk can be constructed on helical piles or push piles. Foundations should be protected from scour and undermining during flood stage events. Design and construction criteria for foundations are presented in the report.**

SITE CONDITIONS

The site is located in the southeast portion of Cherry Creek State Park adjacent to the dog park area and west of the intersection of South Parker Road and South Chambers Road in Arapahoe County, Colorado (Fig. 1). The project involves about 3,000 feet of Cherry Creek along existing trails within the dog park area. Many areas along the outer stream bank adjacent to the dog park area are experiencing active erosion. The banks are relatively steep and range from about 2:1 (horizontal:vertical) to nearly vertical and undercut. The bank height ranges from about 10 to 15 feet near the upstream end of the project to less than 3 feet near the downstream end. Ground cover consists of grasses, shrubs, weeds, bushes, and mature trees.

Beginning at the upstream end of the project, Cherry Creek flows to the north and northwest for about 1,800 feet, turns west for about 500 feet, and continues north toward Cherry Creek Reservoir. Review of Google Earth historical aerial images dating back to 1937 indicated Cherry Creek has meandered from the north to the northwest, then west, and finally bending down to the southwest. The location

where Cherry Creek curved from the west to the southwest has progressively moved farther north. High water levels caused by heavy runoff this spring caused the stream bank to break at the location where Cherry Creek has historically bent to the southwest. As a result, the creek now flows to the north. Conversation with Scott Yanagihara, P.E. also indicates Cherry Creek is actively cutting the creek bottom. We understand the stream bottom has been lowered about 2 feet since the bank broke.

PROPOSED CONSTRUCTION

Based on information provided to us and conversation with Scott Yanagihara, P.E., the main intent of the project is to stabilize the outer stream banks. In general, the toe of the bank will remain and the bank slope will be flattened. We understand a fence may be installed near the top of the new bank and the existing path will be moved further east. The new path will likely consist of gravel.

Near the location where Cherry Creek begins to curve to the west and the embankment height is comparatively less, we understand a boardwalk is being considered for the proposed improvements. The project also includes reestablishing the original stream path of Cherry Creek by constructing an embankment at the location of the broken bank.

INVESTIGATION

Subsurface conditions were investigated by drilling five exploratory borings at the approximate locations shown on Fig. 1. The boring locations were selected by a representative of our firm and a representative of CH2M HILL. The borings were drilled to depths of 20 to 40 feet using 4-inch diameter, continuous-flight auger and a CME-45 truck-mounted drill rig. Samples were generally obtained at 5-foot intervals using 2.5-inch diameter (O.D.) modified California samplers driven by blows of a 140-pound hammer falling 30 inches. Borings TH-1 through TH-3 were drilled to 40 feet and samples were not obtained below 15 feet, until we reached

bedrock near the bottom of the boring. We also collected topsoil and streambed samples from and adjacent to each boring, respectively. The drilling operations were observed by our field representative who logged the soils and bedrock encountered in the borings and obtained samples for laboratory testing. Summary logs of the borings, field penetration resistance test results, and a portion of the laboratory data are presented on Fig. 3.

The samples were returned to our laboratory where they were examined by our engineers and tests were assigned. Laboratory tests included moisture content, dry density, Atterberg limits, percent fines (silt and clay-sized particles passing the No. 200 sieve), gradation analysis, and unconfined compressive strength. As requested by Bill Ruzzo with Cherry Creek Basin Water Quality Authority, total phosphorus tests were performed by ACZ Laboratories, Inc. on topsoil samples. Laboratory test results are presented on Figs. 5 through 8 and summarized in Table I. The report and test results from ACZ Laboratories, Inc. are provided in Appendix A.

SUBSURFACE CONDITIONS

The subsoils encountered in our exploratory borings generally consisted of at least 20 to more than 40 feet of silty to very clayey fine to medium grained sand with variable amounts of gravel. A persistent layer of sandy clay layer occurs at depths between about 1 and 8 feet. The sandy clay layer was about 6 to 12 feet thick. Sandstone bedrock was found in TH-1 and TH-2 at depths of 39 and 39.5 feet, respectively. Ground water was measured at depths between about 9 and 15 feet during drilling (elevations 5590.6 to 5603.2). When the borings were checked several days after drilling on July 15, 2010, ground water levels were between about 4 and 13.5 feet below the ground surface (elevations 5595.6 to 5604.3). Boring elevations were provided to us by CH2M HILL.

Based on field penetration resistance tests, the sand was very loose to dense, the clay was very soft to very stiff, and the bedrock was hard. Samples of sand had between 13 and 49 percent fines and exhibited low to moderate plasticity

with liquid limits of 24 to 43 percent and plasticity indices of 3 to 28 percent. Two samples of silty sand contained 2 and 10 percent gravel (retained by the No. 4 sieve). Two samples of clayey sand had unconfined compressive strengths of 1,800 and 2,200 psf. Two sandy clay samples had 87 and 90 percent fines and exhibited high plasticity with liquid limits of 81 and 85 percent and a plasticity index of 57 percent for each sample. Unconfined compressive strengths of 2,500 and 9,000 were measured on two samples of sandy clay. In general, we expect site soils to have high erosion potential.

Streambed samples obtained adjacent to each boring had between 1 and 12 percent fines and between 1 and 8 percent gravel. Total phosphorus concentrations between 0.029 and 0.059 percent were measured by ACZ Laboratories, Inc. on topsoil samples obtained from each boring.

The silty to clayed sand is expected to have high erosion potential. The sandy clay is more resistant to erosion. The clay layer is believed to be persistent enough that it may be used to anchor seepage cutoff such as sheet pile of clay core embankments.

SITE DEVELOPMENT

Excavations

We believe the soils penetrated by our exploratory borings can generally be excavated with typical heavy-duty construction equipment. We recommend the owner and the contractor become familiar with applicable local, state, and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) Excavation and Trench Safety Standards. Based on our investigation and OSHA standards, we anticipate the clay will classify as Type B soil and the sand as Type C. Based on OSHA regulations, maximum slope inclinations of 1:1 (horizontal to vertical) for Type B soil and 1.5:1 for Type C are required for temporary excavations in dry conditions. Flatter slopes will be required below ground water or where seepage is present. Excavation slopes specified by OSHA

are dependent upon soil types and ground water conditions encountered. The contractor's "competent person" should identify the soils in the excavations and refer to OSHA standards to determine appropriate slopes. Stockpiles of soil and construction equipment should not be placed within a horizontal distance equal to one-half the excavation depth, from the edge of the excavation. A professional engineer should design excavations deeper than 20 feet.

If soft, wet soils are exposed in excavations, the bottom can be stabilized by crowding crushed rock into the excavation bottom such that when compactive effort is applied it does not deform more than 1 inch. Acceptable rock materials include, but are not limited to, No. 2 and No. 57 rock, or 1 to 3 inch recycled concrete. Crushed rock on a layer of geosynthetic grid or woven fabric can also be used and will likely allow less rock to be used.

The proposed construction will include excavation of soils along the stream bank to flatten the banks and placement of fill for new embankment construction. We were informed that cuts and fills on the order of 10 to 15 feet are possible. Soils to be excavated generally consist of silty to very clayey sand with variable amounts of gravel and/or sandy clay and can be re-used as fill and/or backfill. Very moist or saturated soils should not be used as fill. The fill should be placed according to the criteria discussed below.

Fill Placement

On-site soils are suitable for re-use as fill provided debris, vegetation, organics, and other deleterious materials are substantially removed prior to placement. Soil particles larger than 3 inches or cobbles larger than 6 inches should be broken down or removed prior to fill placement. If imported fill material is required, it should ideally be similar to on-site materials. A sample of import material should be submitted to our office for approval prior to placement.

Prior to fill placement, debris, organics, and deleterious matter should be substantially removed from areas to receive fill. Areas to receive fill should be scarified to a depth of about 8 inches prior to fill placement, moisture conditioned to within 2 percent of optimum moisture content for sand and between optimum and 3 percent above optimum for clay, and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698). All fill and backfill should be compacted and moisture conditioned as described above. Placement and compaction of fill and backfill should be observed and tested by a representative of our firm during construction.

Our experience indicates fill and backfill can settle, even if properly compacted to the criteria provided above. Factors that influence the amount of settlement are depth of fill, soil type, degree of compaction, and time. The length of time for the compression to occur can be a few weeks to several years. The degree of compression of fill under its own weight will likely range from low for granular soils (1 percent or less) to moderate for clay/sand mixtures (1 to 2 percent). Any improvements placed over backfill should be designed to accommodate movement.

Bank Stabilization

We anticipate most of the banks along Cherry Creek will be flattened by cutting back the existing bank. If new fill is required, the bank should be benched prior to placing fill as shown on Fig. 2. The benching will allow a platform for keying new fill into existing bank soils.

Permanent slopes should be stable at inclinations of 2.5:1 (horizontal: vertical). Inclinations of 3:1 or flatter are better to reduce erosion and re-vegetation problems. We also recommend re-vegetation and/or mechanical protection of the slopes to increase resistance to erosion. Shallower slopes and/or benched slopes at about mid-height can further decrease erosion from run-off and sheet-flow.

We understand a fence may be installed near the top of the new bank to help create isolated areas where the creek can be accessed by park users. At these locations, the current alternatives being considered for bank stabilization include soil cement, articulated porous concrete pavers, and sculpted concrete. Each alternative can provide increased resistance to erosion. The detrimental properties can include difficulty of re-vegetation, high cost, and, in the case of soil cement, chemical leaching. Should the owner wish to consider chemical stabilization of a portion of the bank soils, we should perform tests to determine the most appropriate additive and amount.

DEWATERING

Water levels were measured between about 4 and 13.5 feet (elevations 5595.6 and 5604.3 feet) when the holes were checked on July 15, 2010. Ground water elevations will vary seasonally, fluctuate with water levels in Cherry Creek, and may rise in response to precipitation. Temporary construction dewatering systems may be needed.

Excavations may require temporary dewatering during construction. Several methods (or combinations) of dewatering can be considered to temporarily dewater excavations. Well points or cased wells outside the excavation are alternatives commonly used to lower ground water levels. We believe dewatering the sandy clay layer will require closely-spaced wells or sumps. Excavations that extend only a foot or two into ground water can often be dewatered using sumps about 3 feet below grade, where the water is pumped down through the soils before being discharged.

The Colorado Department of Public Health and Environment may require dewatering permits. Our experience indicates periodic environmental testing is usually required with these permits, with reporting. Permitting requirements may also influence the construction schedule. We recommend researching these requirements and permit processing times well before dewatering begins.

EMBANKMENT CONSTRUCTION

We understand it is desired to reestablish the original stream path of Cherry Creek by constructing an embankment at the location where the bank has broken. The on-site clay soil can be used for embankment fill. We recommend clay fill be placed at relatively high moisture content to reduce potential seepage. Clay with at least 70 percent fines and a plasticity index of at least 20 percent is suitable for this purpose. Fill should be placed in accordance with the criteria provided in Fill Placement. The placement and compaction of embankment fill should be observed and tested by a representative of our firm during construction.

The embankment should be designed with a maximum slope of 3:1. Slopes can likely be steepened to 2.5:1 if site constraints do not permit construction with a 3:1 slope. Once construction of the new embankment is complete, the slope should be re-vegetated as soon as practical to help control erosion. Planting shrubs and trees on the embankment is not recommended as the root systems can create cavities and voids which can provide a pathway for water and reduce stability. Alternatively, rip-rap can be used as the embankment “shell” and will provide greater strength and erosion resistance. We recommend a filter composed of on-site soils or a geotextile fabric be placed between the rip-rap “shell” and the clay embankment soils. We can provide filter design and construction criteria if this option is pursued.

We understand that a sheet pile cutoff wall may be used as additional seepage control. Design and construction criteria for the sheet pile are presented below. These criteria were developed from analysis of field and laboratory data and our experience.

1. The sheet pile can be designed for a lateral bearing pressure of 200 psf per foot for the section of the pile embedded within the embankment, provided the fill is well compacted and remains in place. A lateral bearing pressure of 100 psf per foot below the streambed can be used in design.

2. We recommend a minimum depth below the streambed of 6 feet. Ideally, the sheet pile should bottom in the sandy clay.

3. The interlocking connection between sheet pile sections can be a source of inefficiency. To promote greater seepage control efficiency, the interlocks can be sealed.

FOUNDATIONS – BOARDWALK

We understand a boardwalk may be constructed along the northern third of the east channel bank. Subsoils found at anticipated foundation level consist of relatively moist, loose sand and soft clay. We have considered several foundation types for the construction of the boardwalk. Due to loose and soft material and shallow groundwater, installation of footings or concrete drilled piers may be impractical due to caving soil and water accumulation in foundation excavations and pier holes. In our opinion, helical piles or push piles will provide a more constructible foundation system. However, push piles will require equipment large enough to serve as a reaction point for the piles to push against. Helical piles can be installed with Bobcat type equipment. Potential differential movement between foundation elements is expected to be insignificant with piles. Design and construction criteria for helical piles and push piles are presented below. These criteria were developed from analysis of field and laboratory data and our experience.

Helical Piles

1. Helical piles should have a minimum pile length of 12 feet. Required minimum length should be measured from the proposed ground surface to the top helical plate. The piles should be installed as close to vertical as possible.

2. The ultimate capacity of helical piles should be calculated based on the manufacturer's recommendations. We recommend calculation of the installation torque using a factor of safety of at least 2 when converting ultimate values to working (allowable) capacity. The allowable pressure on the helical plate area should not exceed 10,000 psf. Helical pile capacity should be verified in the field using load tests and/or manufacturer recommended capacity torque ratios. Contractors should use the number and size of helicies required to achieve depth, torque, and capacity.

3. We recommend contacting the manufacturer or the manufacturer's representative concerning corrosion protection of the steel. Manufacturer's recommendations should be followed.

4. **Soft and loose subsoils will likely pose difficulties in achieving the recommended installation torque. We recommend the helical plate have a minimum diameter of 12 inches and/or multiple helices be utilized in the design.**

5. **Twisting of the shaft can occur during the installation process. We recommend steel pipe piles be used because they generally have higher flexure rigidity and load carrying capacity than square-shaft type piles. The structural engineer should evaluate the effect(s) twisting of the shaft may have on the capacity of the helical pile as well as corrosion protection (such as the "flaking-off" of the galvanizing material) of the helical piles. The structural engineer should specify the maximum torque which should be applied to avoid over-stressing the piles.**

6. **The helical pile can be designed for a lateral bearing pressure of 100 psf per foot below grade. Lateral bearing should be neglected for the upper 2 feet of the pile.**

7. **The pile caps and the connection between the piles and the boardwalk should be able to resist both tension and compression and be designed to resist lateral earth pressure. The structural engineer should evaluate the lateral load stability at the connection and design this connection.**

8. **Foundations should be protected from scour and undermining during flood stage events.**

9. **Installation of helical piles should be observed by a representative of our firm to confirm the depth and installation torque of helical piles are adequate. The helical pile contractor should provide the correlation data between torque or pressure gauge reading (if used) and the pile capacity for review prior to helical pile installation and observation.**

Push Piles

1. **Push piles should have a minimum length of 12 feet below the proposed ground surface and be closed ended.**

2. **The location and spacing of push piles should be determined by a structural engineer to span between piles. Due to constraints of typical brackets and group effects, the minimum spacing of push piles is 2 feet.**

3. **Pile depth and installation pressure shall be observed and recorded at a minimum of 3-foot intervals.**

4. The design load (dead + live) at each pile location should be determined by a structural engineer. All push piles shall be installed to support at least 1.5 times the design load.

5. Push pile installation should be observed and documented by a representative of CTL | Thompson, Inc. or the structural engineer for quality assurance purposes.

6. After installation, the piles should be reinforced full length with at least one No. 6 reinforcing bar continuous. Following reinforcement, the piles should be grouted solid with 1,500 psi sand-cement.

7. The connection of the piles to the boardwalk should be capable of resisting tensile and compressive loads. The connection should be designed by the structural engineer considering the effects of eccentricity. Alternatively, the pile brackets and connections can be load tested in the field.

8. Foundations should be protected from scour and undermining during flood stage events.

CONCRETE

Concrete in contact with soil can be subject to sulfate attack. Based on our experience, water-soluble sulfate concentrations at this site are likely less than 0.1 percent. Sulfate concentrations less than 0.1 percent indicate Class 0 exposure to sulfate attack for concrete in contact with the subsoils, according to the American Concrete Institute (ACI). For this level of sulfate concentration, ACI indicates any type of cement can be used for concrete in contact with the subsoils. In our experience, superficial damage may occur to the exposed surfaces of highly permeable concrete, even though sulfate levels are relatively low. To control this risk and to resist freeze-thaw deterioration, the water-to-cementitious material ratio should not exceed 0.50 for concrete in contact with soils that are likely to stay moist due to surface drainage or high water tables. Concrete should be air entrained. To reduce risk of sulfate attack or hydration distress, damp-proofing of walls or grade beams in contact with the soil can be considered.

LIMITATIONS

Our borings were spaced to obtain a reasonably accurate picture of subsurface conditions along the east bank of Cherry Creek. Variations in the subsurface conditions not indicated by our borings are always possible. A representative of our firm should observe excavations, fill placement, and installation of foundations and other improvements.

We believe this investigation was conducted with that level of skill and care normally used by geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or in the analysis of the influence of the subsurface conditions on the proposed project, please call.

CTL | THOMPSON, INC.

Justin S. Crummett, E.I.T.
Staff Engineer

Reviewed by:

David A. Glater, P.E., C.P.G.
Principal Geological Engineer

COLORADO LICENSED
DAVID A. GLATER
8/30/10
20204
PROFESSIONAL ENGINEER

JSC:DAG/jsc/nt
(3 copies)

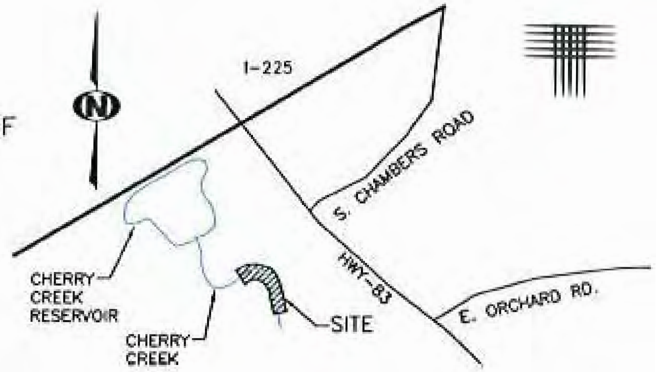
via e-mail: Scott.Yanagihara@CH2M.com

LEGEND:

TH-1 ● APPROXIMATE LOCATION OF EXPLORATORY BORING

0 150 300

SCALE: 1" = 300'

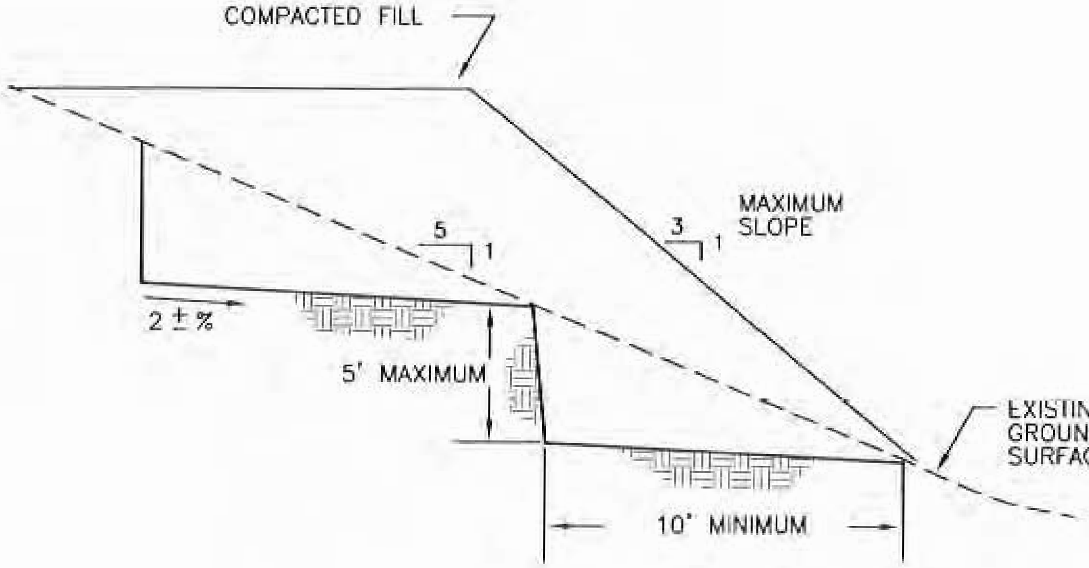


VICINITY MAP
NOT TO SCALE

CH2M HILL, INC.
12-MILE PARK CHERRY CREEK STREAM RECLAMATION
Project No. DN45,052-125

Locations of Exploratory Borings

Fig. 1



NOTES:

1) NATURAL SLOPES OF 20 PERCENT OR STEEPER ARE TO BE BENCHED PRIOR TO FILL PLACEMENT.

2) SLOPE BENCHES TO OUTSLOPE AT 2± PERCENT.

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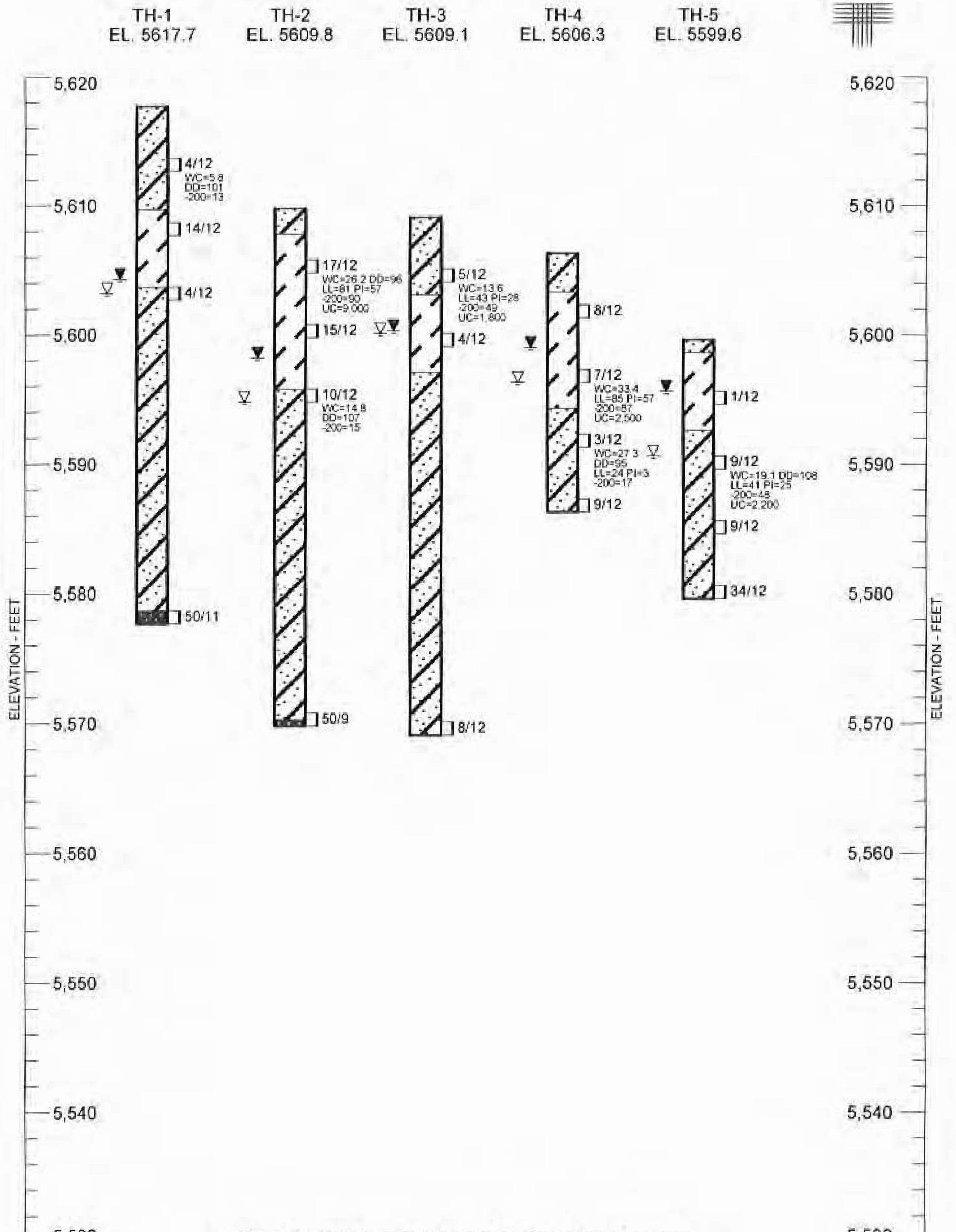
Project No. DN45,052-125

Conceptual Benched Fill Detail

Fig. 2



SUMMARY LOGS OF EXPLORATORY BORINGS

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12-MILE PARK CHERRY CREEK STREAM RECLAMATION
PROJECT NO. DN45,052-125

FIG. 3

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LEGEND:

▨ CLAY, SLIGHTLY SANDY TO SANDY, VERY SOFT TO VERY STIFF, MOIST TO WET, BROWN, GRAY, RUST, CALCAREOUS (CL OR CH).

▧ SAND, FINE TO MEDIUM GRAINED, SILTY TO VERY CLAYEY, VARIABLE AMOUNTS OF GRAVEL, VERY LOOSE TO DENSE, MOIST TO WET, BROWN, GRAY (SP, SM, SC).

▓ BEDROCK, SANDSTONE, HARD, MOIST, BROWN, RUST.

▯ DRIVE SAMPLE. THE SYMBOL 4/12 INDICATES 4 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.

∇ WATER LEVEL MEASURED AT TIME OF DRILLING.

▼ WATER LEVEL MEASURED 3 DAYS AFTER DRILLING ON JULY 15, 2010.

NOTES:

1. THE BORINGS WERE DRILLED ON JULY 12, 2010 USING 4-INCH DIAMETER, CONTINUOUS-FLIGHT AUGER AND A TRUCK-MOUNTED CME-45 DRILL RIG.
2. BORING LOCATIONS WERE DETERMINED BY A REPRESENTATIVE OF OUR FIRM AND A REPRESENTATIVE OF CH2M HILL. BORING ELEVATIONS WERE PROVIDED TO US BY CH2M HILL.
3. WC - INDICATES MOISTURE CONTENT (%).
   DD - INDICATES DRY DENSITY (PCF).
   LL - INDICATES LIQUID LIMIT (%).
   PI - INDICATES PLASTICITY INDEX (%).
   -200 - INDICATES PASSING NO. 200 SIEVE (%).
   UC - INDICATES UNCONFINED COMPRESSIVE STRENGTH (psf).
4. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS AND CONCLUSIONS CONTAINED IN THIS REPORT.

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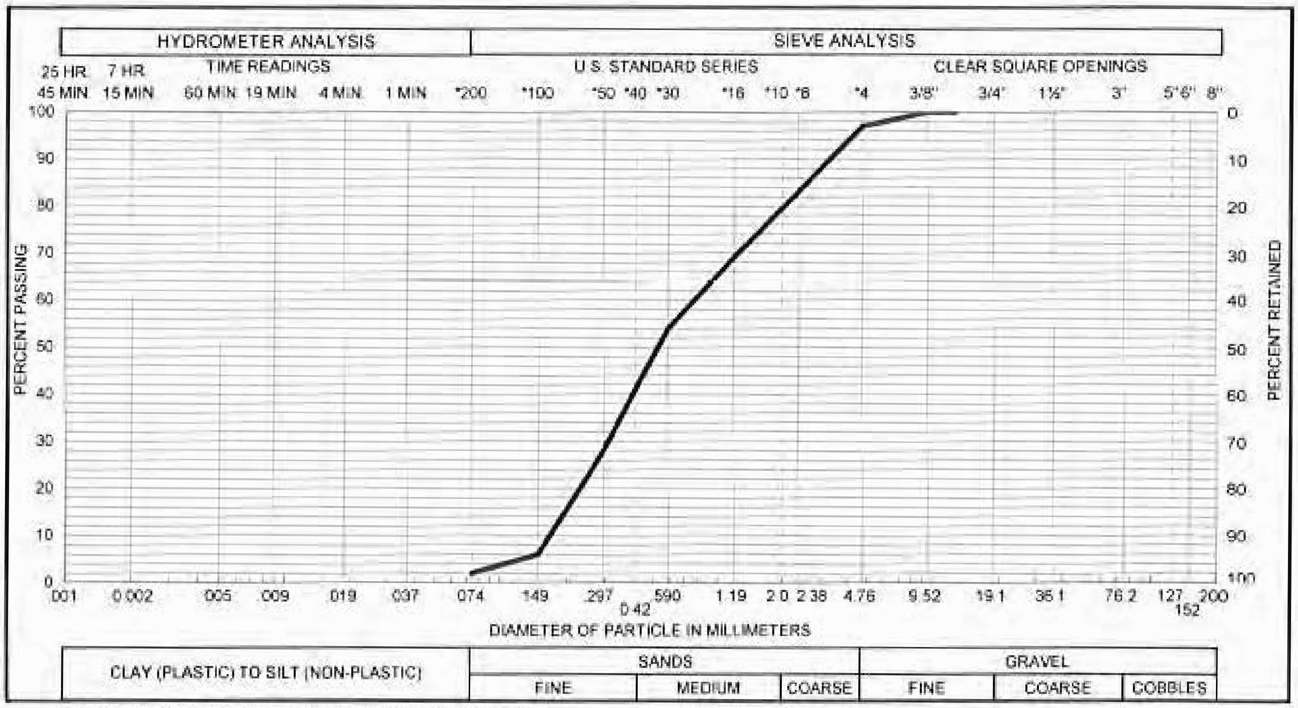
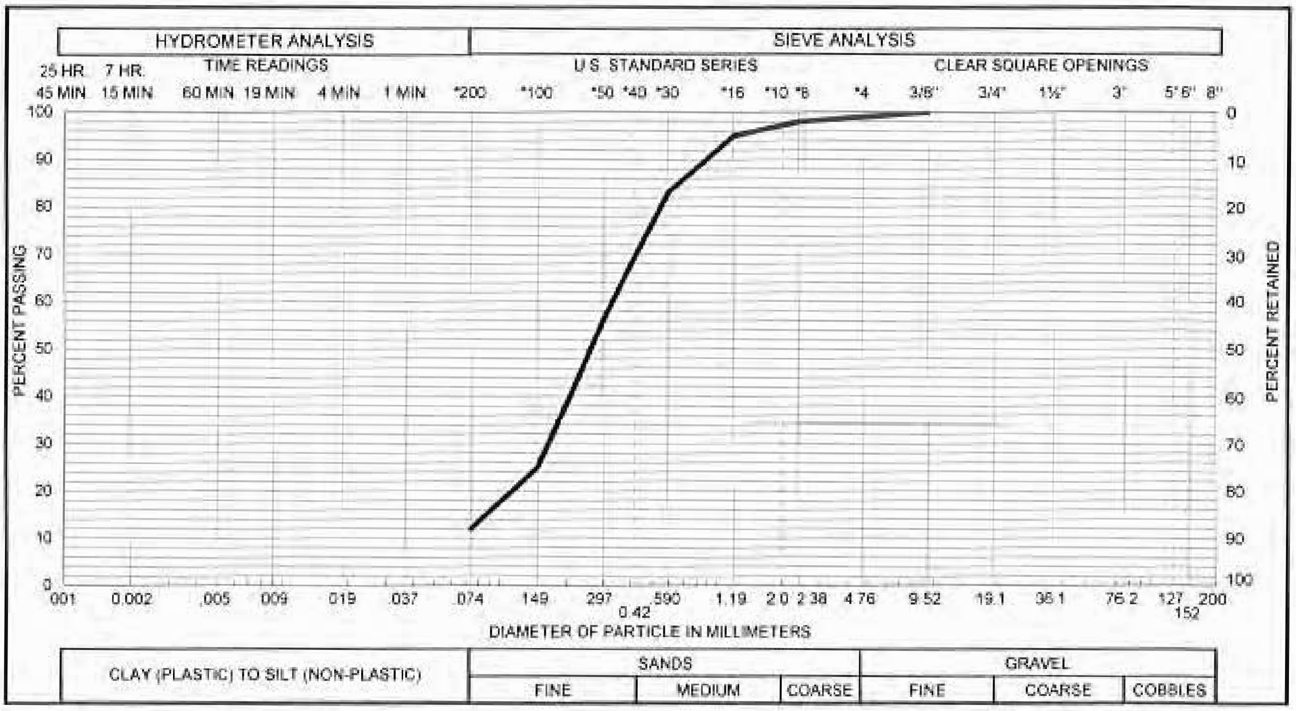
SUMMARY LEGEND OF EXPLORATORY BORINGS



Sample of SAND, SLIGHTLY SILTY (SP)
From STREAMBED SAMPLE ADJACENT TO TH-1

GRAVEL 3 % SAND 95 %
SILT & CLAY 2 % LIQUID LIMIT - %
PLASTICITY INDEX - %



Sample of SAND, SILTY (SM)
From STREAMBED SAMPLE ADJACENT TO TH-2

GRAVEL 1 % SAND 87 %
SILT & CLAY 12 % LIQUID LIMIT - %
PLASTICITY INDEX - %

Gradation Test Results

FIG. 5

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PROJECT NO. DN45,052-125
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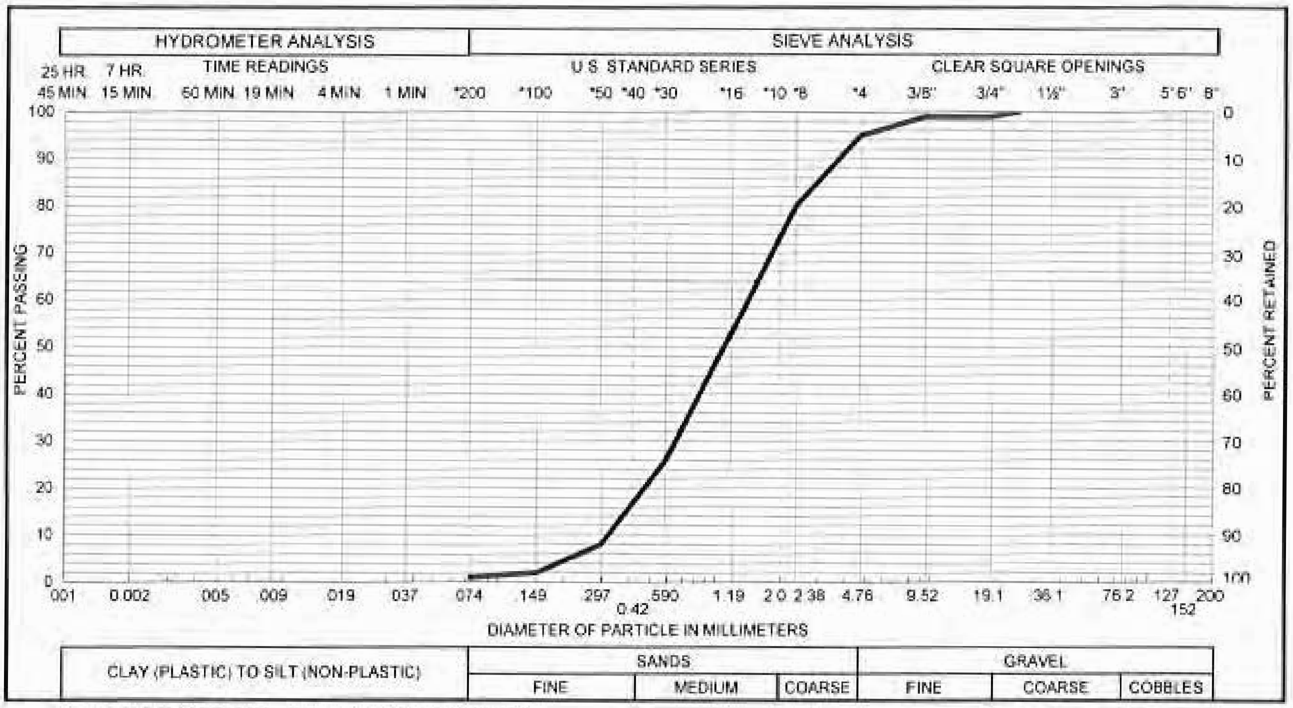
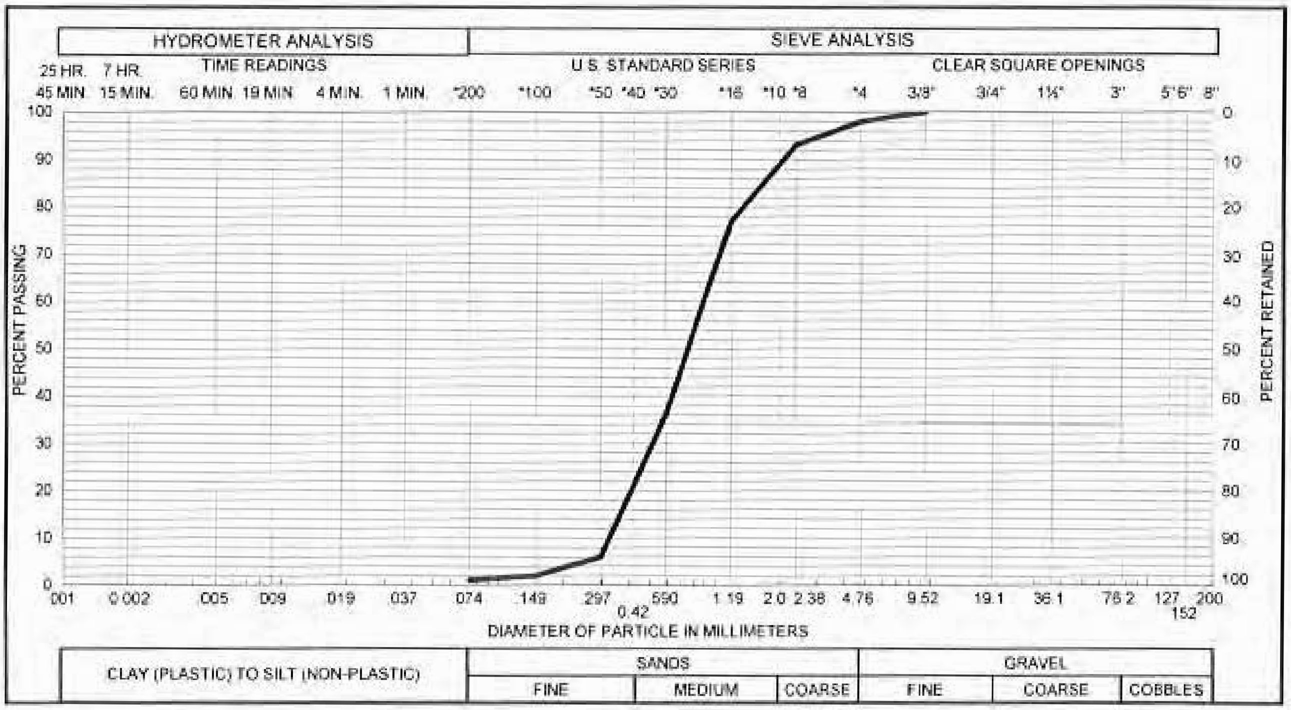


Sample of SAND, SLIGHTLY SILTY (SP)
From STREAMBED SAMPLE ADJACENT TO TH-3

GRAVEL 5 %
SAND 94 %
SILT & CLAY 1 %
LIQUID LIMIT - %
PLASTICITY INDEX - %



Sample of SAND, SLIGHTLY SILTY (SP)
From STREAMBED SAMPLE ADJACENT TO TH-4

GRAVEL 2 %
SAND 97 %
SILT & CLAY 1 %
LIQUID LIMIT - %
PLASTICITY INDEX - %

Gradation Test Results

FIG. 6

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PROJECT NO. DN45.052-125
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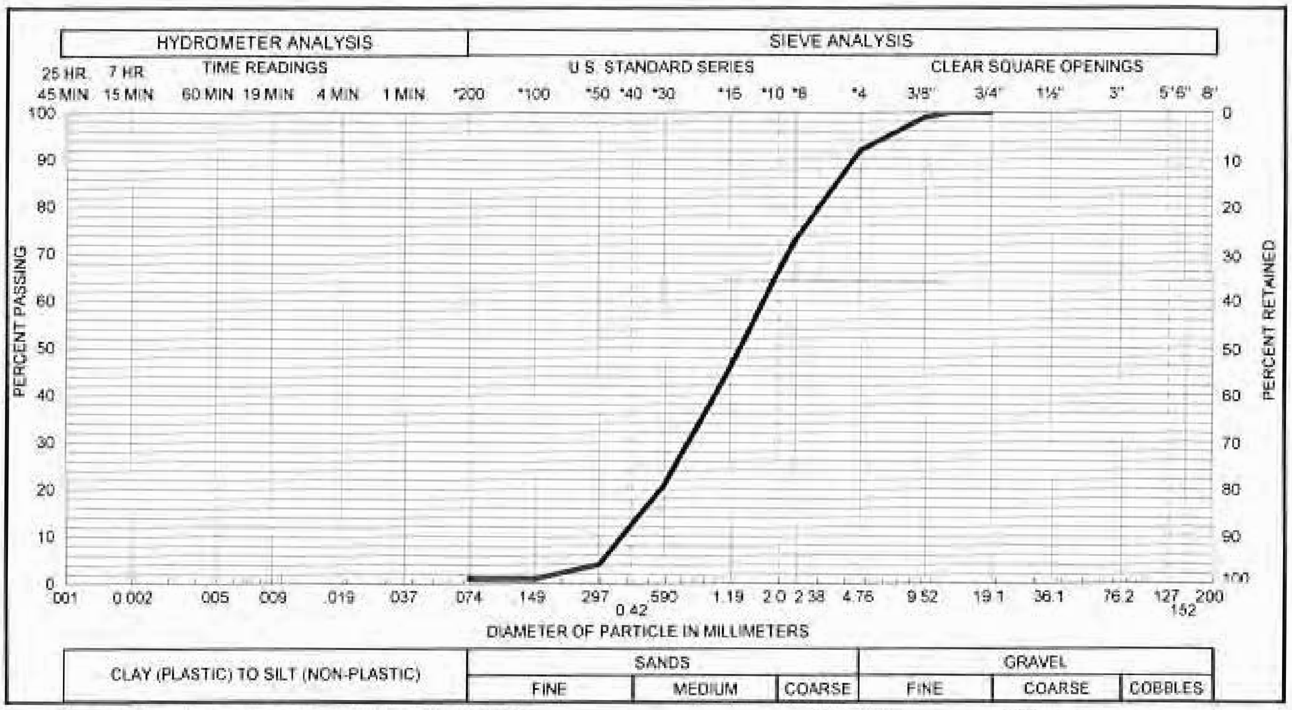
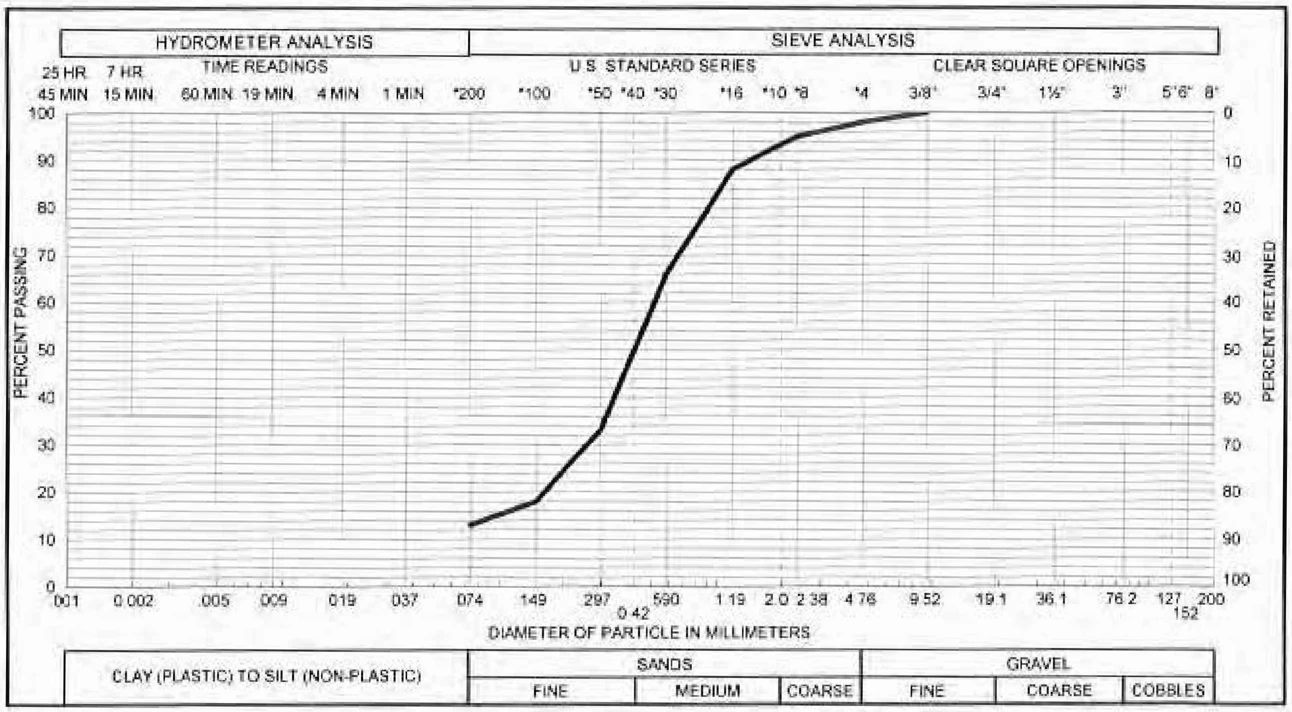


Sample of SAND, SLIGHTLY SILTY (SP)
From STREAMBED SAMPLE ADJACENT TO TH-5

GRAVEL 8 % SAND 91 %
SILT & CLAY 1 % LIQUID LIMIT - %
PLASTICITY INDEX - %



Sample of SAND, SILTY (SM)
From TH - 1 AT 4 FEET

GRAVEL 2 % SAND 85 %
SILT & CLAY 13 % LIQUID LIMIT - %
PLASTICITY INDEX - %

Gradation Test Results

FIG. 7

CH2M HILL, INC.
12-MILE PARK CHERRY CREEK STREAM RECLAMATION
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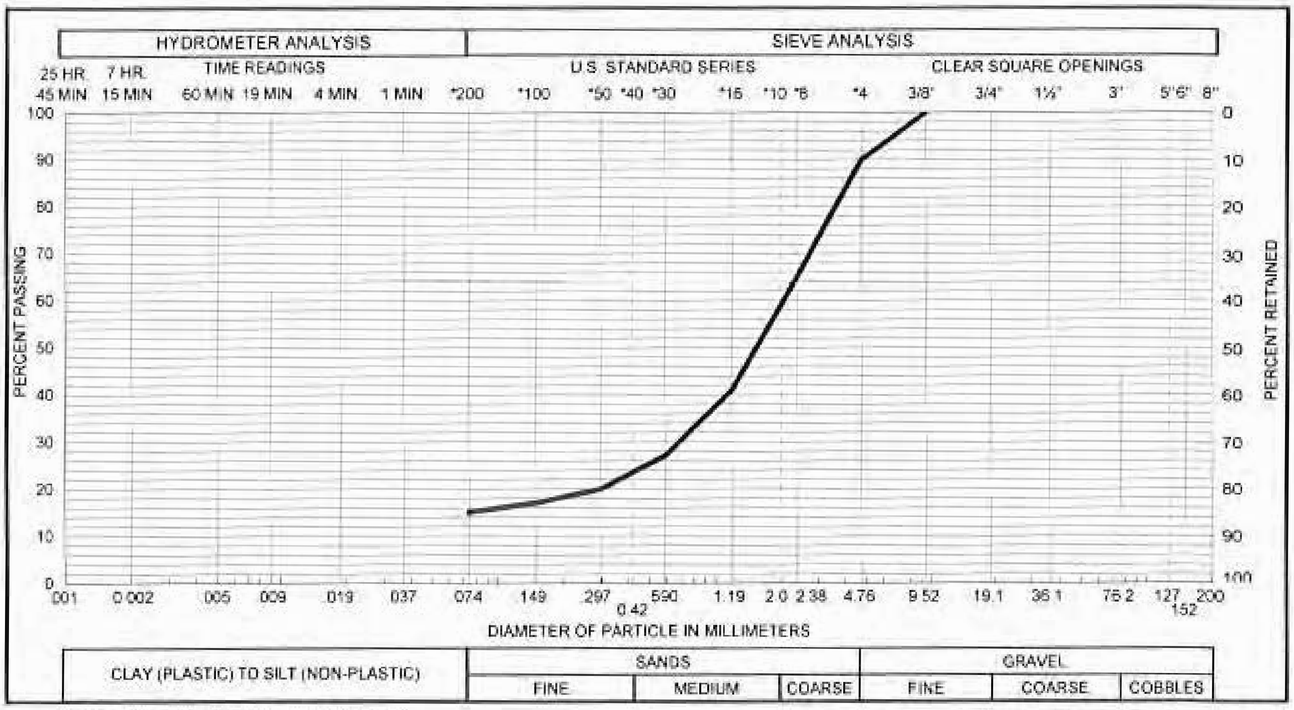
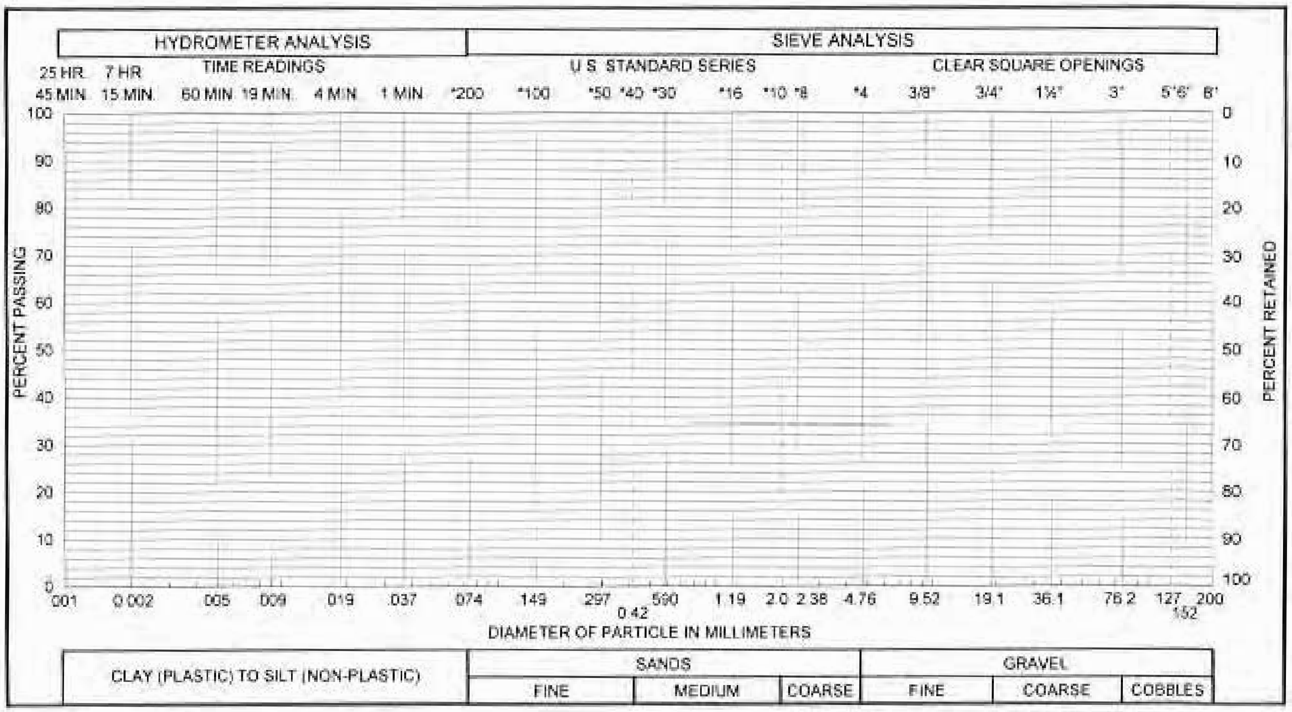


Sample of SAND, SILTY (SM)
From TH - 2 AT 14 FEET

GRAVEL 10 % SAND 75 %
SILT & CLAY 15 % LIQUID LIMIT - %
PLASTICITY INDEX - %



Sample of
From

GRAVEL % SAND %
SILT & CLAY % LIQUID LIMIT %
PLASTICITY INDEX %

Gradation Test Results

FIG. 8

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

BORING	DEPTH (ft)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	ATTERBERG LIMITS LIQUID LIMIT (%)	ATTERBERG LIMITS PLASTICITY INDEX (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)	PASSING NO. 200 SIEVE (%)	SOIL TYPE
TH-1	4	5.8	101				13	SAND, SILTY (SM)
TH-2	4	26.2	96	81	57	9,000	90	CLAY, SANDY (CL)
TH-2	14	14.8	107				15	SAND, SILTY (SM)
TH-3	4	13.6		43	28	1,800	49	SAND, CLAYEY (SC)
TH-4	9	33.4		85	57	2,500	87	CLAY, SANDY (CL)
TH-4	14	27.3	95	24	3		17	SAND, SILTY (SM)
TH-5	9	19.1	108	41	25	2,200	48	SAND, CLAYEY (SC)
TH-1	Streambead						2	SAND (SP)
TH-2	Streambead						12	SAND, SILTY (SM)
TH-3	Streambead						1	SAND (SP)
TH-4	Streambead						1	SAND (SP)
TH-5	Streambead						1	SAND (SP)

CH2M HILL, INC.
12-MILE PARK CHERRY CREEK STREAM RECLAMATION
PROJECT NO. DN45,052-125
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APPENDIX A

REPORT AND LABORATORY TEST RESULTS BY ACZ LABORATORIES, INC.

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Analytical Report

August 11, 2010

Report to:
Justin Crummett
CTL Thompson, Inc.
1971 West 12th Avenue
Denver, CO 80204

Bill to:
Bill Ruzzo
Cherry Creek Basin Water Quality Authority
6641 W. Hamilton
Lakewood, CO 80227

Project ID: DN45052-125
ACZ Project ID: L83444

Justin Crummett:

Enclosed are the analytical results for sample(s) submitted to ACZ Laboratories, Inc. (ACZ) on July 26, 2010. This project has been assigned to ACZ's project number, L83444. Please reference this number in all future inquiries.

All analyses were performed according to ACZ's Quality Assurance Plan. The enclosed results relate only to the samples received under L83444. Each section of this report has been reviewed and approved by the appropriate Laboratory Supervisor, or a qualified substitute.

Except as noted, the test results for the methods and parameters listed on ACZ's current NELAC certificate letter (#ACZ) meet all requirements of NELAC.

This report shall be used or copied only in its entirety. ACZ is not responsible for the consequences arising from the use of a partial report.

All samples and sub-samples associated with this project will be disposed of after September 11, 2010. If the samples are determined to be hazardous, additional charges apply for disposal (typically less than $10/sample). If you would like the samples to be held longer than ACZ's stated policy or to be returned, please contact your Project Manager or Customer Service Representative for further details and associated costs. ACZ retains analytical reports for five years.

If you have any questions or other needs, please contact your Project Manager.

Tony Antalek has reviewed and
approved this report

Cherry Creek Basin Water Quality Authority
Project ID: DN45052-125
Sample ID: TH-1 TOPSOIL SAMPLE

ACZ Sample ID: ***L83444-01***
Date Sampled: *07/12/10 11:00*
Date Received: *07/26/10*
Sample Matrix: *Soil*

Inorganic Prep

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Phosphorus, total	M365.1 - Auto Ascorbic Acid Digestion							08/09/10 12:40	mpb

Soil Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Solids, Percent	CLPSOW390, PART F, D-98	94.3		*	%	0.1	0.5	08/05/10 16:03	meg

Wet Chemistry

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)	0.03	B	*	%	0.01	0.05	08/09/10 19:13	llk

* Please refer to Qualifier Reports for details.

Cherry Creek Basin Water Quality Authority

Project ID: DN45052-125
Sample ID: TH-2 TOPSOIL SAMPLE

ACZ Sample ID: ***L83444-02***
Date Sampled: *07/12/10 11:15*
Date Received: *07/26/10*
Sample Matrix: *Soil*

Inorganic Prep

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Phosphorus, total	M365.1 - Auto Ascorbic Acid Digestion							08/09/10 14:20	mpb

Soil Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Solids, Percent	CLPSOW390, PART F, D-98	94.8		*	%	0.1	0.5	08/05/10 19:41	meg

Wet Chemistry

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)	0.029	B	*	%	0.009	0.04	08/09/10 19:15	itk

** Please refer to Qualifier Reports for details.*

Inorganic Analytical Results

Cherry Creek Basin Water Quality Authority

Project ID: DN45052-125
Sample ID: TH-3 TOPSOIL SAMPLE

ACZ Sample ID: ***L83444-03***
Date Sampled: *07/12/10 11:30*
Date Received: *07/26/10*
Sample Matrix: *Soil*

Inorganic Prep

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Phosphorus, total	M365.1 - Auto Ascorbic Acid Digestion							08/09/10 16:00	mpb

Soil Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Solids, Percent	CLPSOW390, PART F, D-98	89.5		*	%	0.1	0.5	08/05/10 21:30	meg

Wet Chemistry

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)	0.059		*	%	0.008	0.04	08/09/10 19:17	itk

* Please refer to Qualifier Reports for details.

Inorganic Analytical Results

Cherry Creek Basin Water Quality Authority
Project ID: DN45052-125
Sample ID: TH-4 TOPSOIL SAMPLE

ACZ Sample ID: ***L83444-04***
Date Sampled: *07/12/10 11:45*
Date Received: *07/26/10*
Sample Matrix: *Soil*

Inorganic Prep

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Phosphorus, total	M365.1 - Auto Ascorbic Acid Digestion							08/09/10 16:50	mpb

Soil Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Solids, Percent	CLPSOW390, PART F, D-98	95.1		*	%	0.1	0.5	08/05/10 23:18	meg

Wet Chemistry

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)	0.04	B	*	%	0.01	0.05	08/09/10 19:18	itk

** Please refer to Qualifier Reports for details.*

Cherry Creek Basin Water Quality Authority

Project ID:	DN45052-125	ACZ Sample ID:	***L83444-05***
Sample ID:	TH-5 TOPSOIL SAMPLE	Date Sampled:	*07/12/10 12:00*
		Date Received:	*07/26/10*
		Sample Matrix:	*Soil*

Inorganic Prep

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Phosphorus, total	M365.1 - Auto Ascorbic Acid Digestion							08/09/10 17:40	mpb

Soil Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Solids, Percent	CLPSOW390, PART F, D-98	86.6		*	%	0.1	0.5	08/06/10 1:07	meg

Wet Chemistry

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)	0.045		*	%	0.009	0.04	08/09/10 19:20	itk

** Please refer to Qualifier Reports for details.*

Report Header Explanations

Batch	A distinct set of samples analyzed at a specific time
Found	Value of the QC Type of interest
Limit	Upper limit for RPD, in %.
Lower	Lower Recovery Limit, in % (except for LCSS, mg/Kg)
MDL	Method Detection Limit. Same as Minimum Reporting Limit. Allows for instrument and annual fluctuations.
PCN/SCN	A number assigned to reagents/standards to trace to the manufacturer's certificate of analysis
PQL	Practical Quantitation Limit, typically 5 times the MDL.
QC	True Value of the Control Sample or the amount added to the Spike
Rec	Amount of the true value or spike added recovered, in % (except for LCSS, mg/Kg)
RPD	Relative Percent Difference, calculation used for Duplicate QC Types
Upper	Upper Recovery Limit, in % (except for LCSS, mg/Kg)
Sample	Value of the Sample of interest

QC Sample Types

AS	Analytical Spike (Post Digestion)	LCSWD	Laboratory Control Sample - Water Duplicate
ASD	Analytical Spike (Post Digestion) Duplicate	LFB	Laboratory Fortified Blank
CCB	Continuing Calibration Blank	LFM	Laboratory Fortified Matrix
CCV	Continuing Calibration Verification standard	LFMD	Laboratory Fortified Matrix Duplicate
DUP	Sample Duplicate	LRB	Laboratory Reagent Blank
ICB	Initial Calibration Blank	MS	Matrix Spike
ICV	Initial Calibration Verification standard	MSD	Matrix Spike Duplicate
ICSAB	Inter-element Correction Standard - A plus B solutions	PBS	Prep Blank - Soil
LCSS	Laboratory Control Sample - Soil	PBW	Prep Blank - Water
LCSSD	Laboratory Control Sample - Soil Duplicate	PQV	Practical Quantitation Verification standard
LCSW	Laboratory Control Sample - Water	SDL	Serial Dilution

QC Sample Type Explanations

Blanks	Verifies that there is no or minimal contamination in the prep method or calibration procedure.
Control Samples	Verifies the accuracy of the method, including the prep procedure.
Duplicates	Verifies the precision of the instrument and/or method.
Spikes/Fortified Matrix	Determines sample matrix interferences, if any.
Standard	Verifies the validity of the calibration.

ACZ Qualifiers (Qual)

B	Analyte concentration detected at a value between MDL and PQL. The associated value is an estimated quantity.
H	Analysis exceeded method hold time. pH is a field test with an immediate hold time.
U	The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

Method References

(1) EPA 600/4-83-020. Methods for Chemical Analysis of Water and Wastes, March 1983.
(2) EPA 600/R-93-100. Methods for the Determination of Inorganic Substances in Environmental Samples, August 1993.
(3) EPA 600/R-94-111. Methods for the Determination of Metals in Environmental Samples - Supplement I, May 1994.
(5) EPA SW-846. Test Methods for Evaluating Solid Waste, Third Edition with Update III, December 1996.
(6) Standard Methods for the Examination of Water and Wastewater, 19th edition, 1995 & 20th edition (1998).

Comments

(1) QC results calculated from raw data. Results may vary slightly if the rounded values are used in the calculations.
(2) Soil, Sludge, and Plant matrices for Inorganic analyses are reported on a dry weight basis.
(3) Animal matrices for Inorganic analyses are reported on an "as received" basis.
(4) An asterisk in the "XQ" column indicates there is an extended qualifier and/or certification qualifier associated with the result.

For a complete list of ACZ's Extended Qualifiers, please click: http://www.acz.com/public/extquallist.pdf

ACZ ID	WORKNUM	PARAMETER	METHOD	QUAL	DESCRIPTION
L83444-01	WG287561	Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)	DD	Sample required dilution due to matrix color or odor.
			M365.1 - Auto Ascorbic Acid (digest)	RA	Relative Percent Difference (RPD) was not used for data validation because the sample concentration is too low for accurate evaluation (< 10x MDL).
L83444-02	WG287561	Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)	DD	Sample required dilution due to matrix color or odor.
			M365.1 - Auto Ascorbic Acid (digest)	RA	Relative Percent Difference (RPD) was not used for data validation because the sample concentration is too low for accurate evaluation (< 10x MDL).
L83444-03	WG287561	Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)	DD	Sample required dilution due to matrix color or odor.
			M365.1 - Auto Ascorbic Acid (digest)	RA	Relative Percent Difference (RPD) was not used for data validation because the sample concentration is too low for accurate evaluation (< 10x MDL).
L83444-04	WG287561	Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)	DD	Sample required dilution due to matrix color or odor.
			M365.1 - Auto Ascorbic Acid (digest)	RA	Relative Percent Difference (RPD) was not used for data validation because the sample concentration is too low for accurate evaluation (< 10x MDL).
L83444-05	WG287561	Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)	DD	Sample required dilution due to matrix color or odor.
			M365.1 - Auto Ascorbic Acid (digest)	RA	Relative Percent Difference (RPD) was not used for data validation because the sample concentration is too low for accurate evaluation (< 10x MDL).

Soil Analysis

The following parameters are not offered for certification or are not covered by NELAC certificate #ACZ.

Solids, Percent	CLPSOW390, PART F, D-98

Wet Chemistry

The following parameters are not offered for certification or are not covered by NELAC certificate #ACZ.

Phosphorus, total	M365.1 - Auto Ascorbic Acid (digest)

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Sample Receipt

Cherry Creek Basin Water Quality Authority
DN45052-125

ACZ Project ID: L83444
Date Received: 07/26/2010 10:37
Received By: gac
Date Printed: 7/26/2010

Receipt Verification

	YES	NO	NA
1) Does this project require special handling procedures such as CLP protocol?			X
2) Are the custody seals on the cooler intact?			X
3) Are the custody seals on the sample containers intact?			X
4) Is there a Chain of Custody or other directive shipping papers present?	X		
5) Is the Chain of Custody complete?	X		
6) Is the Chain of Custody in agreement with the samples received?	X		
7) Is there enough sample for all requested analyses?	X		
8) Are all samples within holding times for requested analyses?	X		
9) Were all sample containers received intact?	X		
10) Are the temperature blanks present?			X
11) Are the trip blanks (VOA and/or Cyanide) present?			X
12) Are samples requiring no headspace, headspace free?			X
13) Do the samples that require a Foreign Soils Permit have one?			X

Exceptions: If you answered no to any of the above questions, please describe

N/A

Contact (For any discrepancies, the client must be contacted)

N/A

Shipping Containers

Cooler Id		Temp (°C)	Rad (µR/hr)
Na11299		17.3	14

Client must contact ACZ Project Manager if analysis should not proceed for samples received outside of thermal preservation acceptance criteria.

Notes

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Sample Receipt

Cherry Creek Basin Water Quality Authority
DN45052-125

ACZ Project ID: L83444
Date Received: 07/26/2010 10:37
Received By: gac
Date Printed: 7/26/2010

Sample Container Preservation

SAMPLE	CLIENT ID	R < 2	G < 2	BK < 2	Y< 2	YG< 2	B< 2	O < 2	T >12	N/A	RAD	ID
L83444-01	TH-1 TOPSOIL SAMPLE									X		☑
L83444-02	TH-2 TOPSOIL SAMPLE									X		☑
L83444-03	TH-3 TOPSOIL SAMPLE									X		☑
L83444-04	TH-4 TOPSOIL SAMPLE									X		☑
L83444-05	TH-5 TOPSOIL SAMPLE									X		☑

Sample Container Preservation Legend

Abbreviation	Description	Container Type	Preservative/Limits
R	Raw/Nitric	RED	pH must be < 2
B	Filtered/Sulfuric	BLUE	pH must be < 2
BK	Filtered/Nitric	BLACK	pH must be < 2
G	Filtered/Nitric	GREEN	pH must be < 2
O	Raw/Sulfuric	ORANGE	pH must be < 2
P	Raw/NaOH	PURPLE	pH must be > 12 *
T	Raw/NaOH Zinc Acetate	TAN	pH must be > 12
Y	Raw/Sulfuric	YELLOW	pH must be < 2
YG	Raw/Sulfuric	YELLOW GLASS	pH must be < 2
N/A	No preservative needed	Not applicable	
RAD	Gamma/Beta dose rate	Not applicable	must be < 250 µR/hr

* pH check performed by analyst prior to sample preparation

Sample IDs Reviewed By: gac

ACZ Laboratories, Inc. L83444

2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

CHAIN of CUSTODY

Report to:

Name: Justin Crummett

Company: CTL | Thompson, Inc.

E-mail: jcrummett@ctlthompson.com

Address: 1971 West 12th Avenue
Denver, CO 80204

Telephone: 303-825-0777

Copy of Report to:

Name:

Company:

E-mail:

Telephone:

Invoice to:

Name: Bill Ruzzo

Company: Cherry Creek (Account #CCB)

E-mail: bill.ruzzo@comcast.net

Address:

Telephone:

If sample(s) received past holding time (HT), or if insufficient HT remains to complete analysis before expiration, shall ACZ proceed with requested short HT analyses? YES ☒ NO ☐
If "NO" then ACZ will contact client for further instruction. If neither "YES" nor "NO" is indicated, ACZ will proceed with the requested analyses, even if HT is expired, and data will be qualified.

Are samples for CO DW Compliance Monitoring? YES ☐ NO ☒
If yes, please include state forms. Results will be reported to PQL.

PROJECT INFORMATION

Quote #:

Project/PO #: DN45052-125

Reporting state for compliance testing:

Sampler's Name: Jeremy Knakmuhs

Are any samples NRC licensable material? Yes [✓ No]

ANALYSES REQUESTED *(attach list or use quote number)*

SAMPLE IDENTIFICATION	DATE TIME	Matrix	# of Containers	Total Phosphorus
TH-1 Topsoil Sample	07/12/2010: 11:00 am	SO	1 bag	×
TH-2 Topsoil Sample	07/12/2010: 11:15 am	SO	1 bag	×
TH-3 Topsoil Sample	07/12/2010: 11:30 am	SO	1 bag	×
TH-4 Topsoil Sample	07/12/2010: 11:45 am	SO	1 bag	×
TH-5 Topsoil Sample	07/12/2010: 12:00 pm	SO	1 bag	×

Matrix SW (Surface Water) · GW (Ground Water) · WW (Waste Water) · DW (Drinking Water) · SL (Sludge) · SO (Soil) · OL (Oil) · Other (Specify)

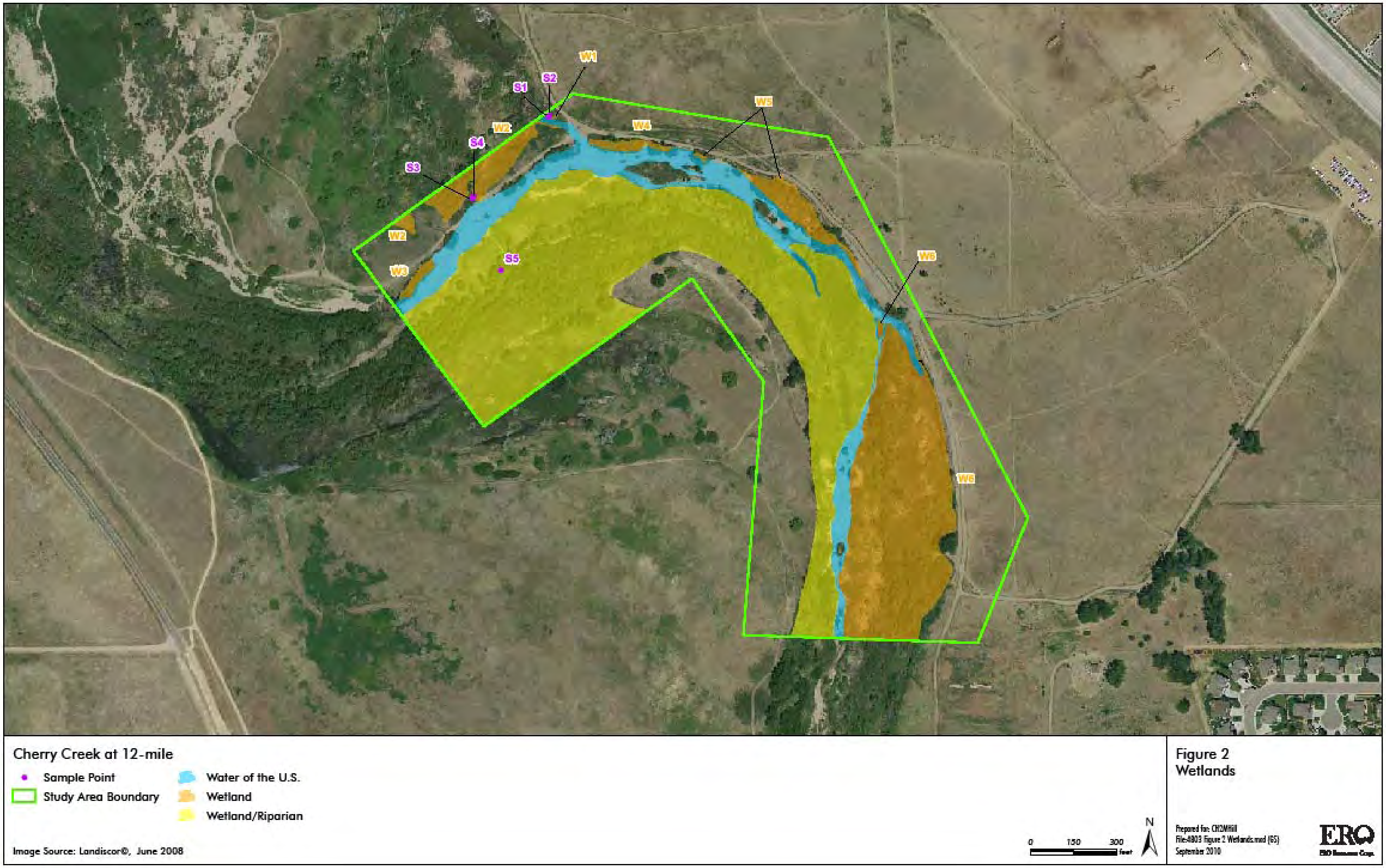
REMARKS

Please refer to ACZ's terms & conditions located on the reverse side of this COC.

RELINQUISHED BY:	DATE TIME	RECEIVED BY:	DATE TIME
	7/22/10 - 3:15pm	LEB	7-26-10 10:20

FRMAD050.01.15.09 White - Return with sample. Yellow - Retain for your records.

Appendix E – Wetland Maps



Wetland Delineation

Appendix F – Hydrologic Analysis

Hydrology

Information Presented in Cherry Creek Master Plan

TABLE F-1

FEMA FIS Discharge Summary, Existing Conditions

Flooding Source and Location	UDSWMM Design Point	10-Year	50-Year	100-Year	500-Year
At Reservoir	286	10,300	31,000	51,000	150,000
At Douglas/ Arapahoe Co. Limits	280	8,950	26,800	43,710	133,200
At Cottonwood Drive	337	8,670	25,940	42,200	129,700
At E-470	276	8,480	25,360	41,200	127,380
at Lincoln Avenue	274	8,100	24,200	39,190	122,740
At West Parker Road	266	7,730	23,040	37,180	118,100
At Stroh Avenue	262	6,610	19,570	31,510	104,200
at Scott Road	250	6,000	17,500	27,120	100,000
At State Highway 86	247	5,500	12,600	19,080	79,000

TABLE F-2

100-Year Discharge Comparison Summary, Existing Conditions

Flooding Source and Location	UDSWMM Design Point	Drainage Area (sq. mi.)	Simulated 100-Year Discharge (cfs)	FEMA FIS 100-Year Discharge (cfs)	Percent Difference
At Reservoir	286	361	49,021	51,000	-3.9
At Douglas/ Arapahoe Co. Limits	280	338	43,706	43,710	1.0
At Cottonwood Drive	337	333	39,895	42,200	-5.4
At E-470	276	310	39,887	41,200	-3.2
at Lincoln Avenue	274	305	39,628	39,190	1.1
At West Parker Road	266	288	35,000	37,180	-5.9
At Stroh Avenue	262	267	32,585	31,510	3.4
at Scott Road	250	241	29,442	27,120	8.6
At State Highway 86	247	204	19,941	19,080	4.5

TABLE F-3

10-Year Discharge Comparison Summary

Flooding Source and Location	UDSWMM Design Point	Drainage Area (sq. mi.)	Simulated 10-Year Discharge (cfs)	FEMA FIS 10-Year Discharge (cfs)	Percent Difference
At Reservoir	286	361	10,071	10,300	-2.2
At Douglas/ Arapahoe Co. Limits	280	338	8,125	8,950	-9.2
At Cottonwood Drive	337	333	8,966	8,670	3.4
At E-470	276	310	8,109	8,480	-4.4
at Lincoln Avenue	274	305	8,033	8,100	-0.8
At West Parker Road	266	288	7,112	7,730	-8.0
At Stroh Avenue	262	267	6,689	6,610	1.2
at Scott Road	250	241	6,051	6,000	0.9
At State Highway 86	247	204	4,995	5,500	-9.2

TABLE F-4

UDSWM Modeling Results Summary Table, Existing Condtions

Flooding Source and Location	UDSWMM Design Point	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
At Reservoir	286	2,142	5,892	10,071	20,200	31,217	49,021
At Douglas/ Arapahoe Co. Limits	280	1,798	5,035	8,125	17,330	27,105	43,706
At Cottonwood Drive	337	1,567	4,463	8,966	16,980	26,818	39,895
At E-470	276	1,558	4,451	8,109	16,650	24,063	39,887
at Lincoln Avenue	274	1,544	4,403	8,033	15,675	23,772	39,628
At West Parker Road	266	1,302	3,723	7,112	15,000	20,374	35,000
At Stroh Avenue	262	1,170	3,406	6,689	12,580	18,600	32,585
at Scott Road	250	972	2,964	6,051	11,500	16,257	29,442
At State Highway 86	247	664	1,785	4,995	9,050	10,365	19,941

TABLE F-5

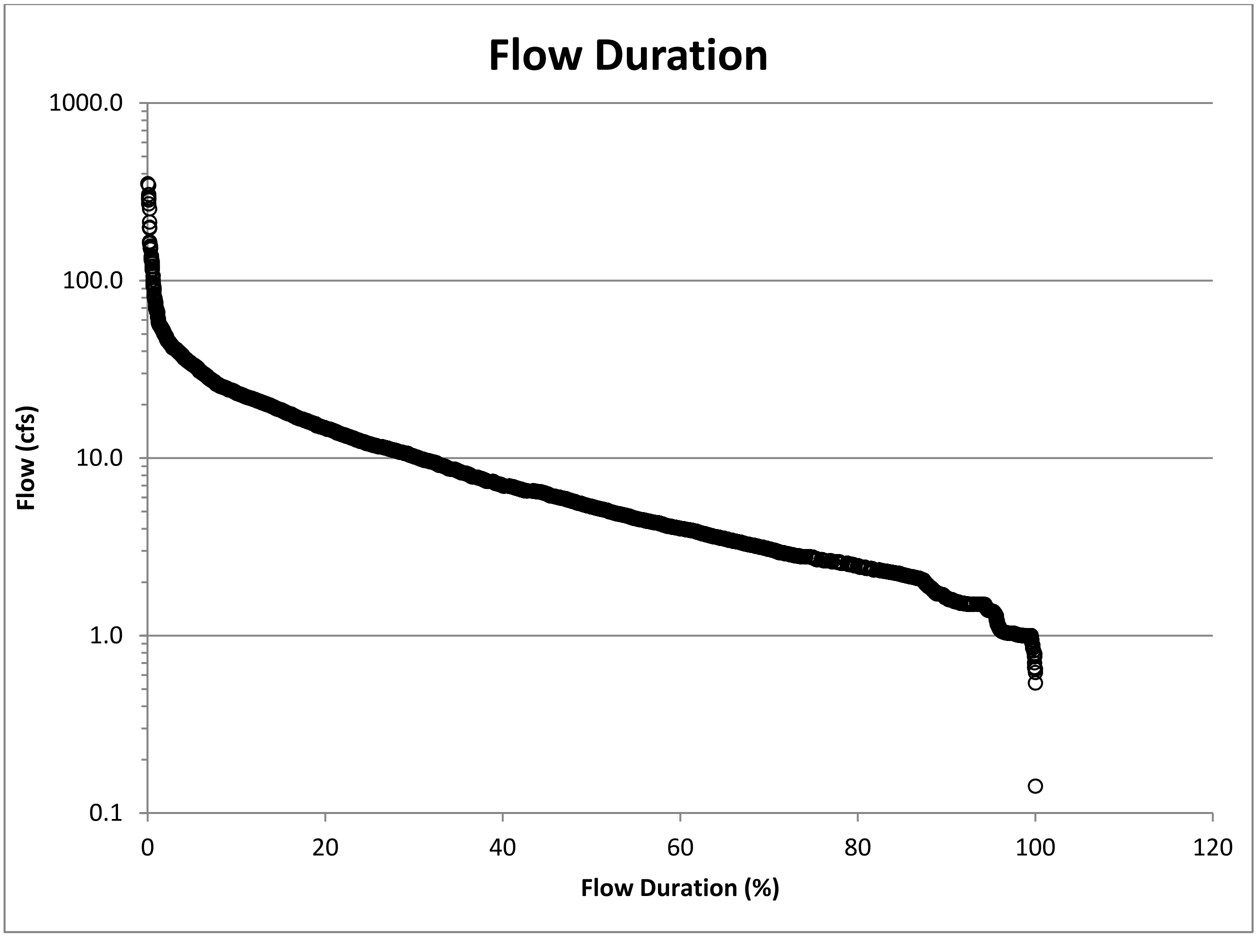
UDSWM Modeling Results Summary Table, Developed Conditions

Flooding Source and Location	UDSWMM Design Point	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
At Reservoir	286	4,429	9,537	14,655	25,821	36,946	54,285
At Douglas/ Arapahoe Co. Limits	280	3,968	8,432	12,852	22,625	32,435	48,378
At Cottonwood Drive	337	3,384	7,172	11,096	19,819	28,438	43,471
At E-470	276	3,303	7,009	10,950	19,624	28,222	43,299
at Lincoln Avenue	274	3,291	6,894	10,782	19,363	27,806	42,870
At West Parker Road	266	2,843	5,887	9,269	16,637	23,671	37,548
At Stroh Avenue	262	2,450	5,204	8,345	14,952	21,086	34,452
at Scott Road	250	1,605	3,797	6,615	12,305	17,262	30,188
At State Highway 86	247	784	1,765	4,945	7,990	10,237	19,813

Base Flow Analysis

TABLE F-6
Base Flow Analysis

	Mean		Median	
	cfs	**af/d**	**cfs**	**af/d**
1992	5.937	11.776	3.869	7.674
1993	4.945	9.808	3.869	7.674
1994	3.902	7.739	2.556	5.070
1995	5.401	10.713	3.404	6.752
1996	4.846	9.612	4.735	9.392
1997	3.973	7.881	3.446	6.836
1998	12.977	25.740	9.403	18.650
1999	16.707	33.138	14.886	29.526
2000	10.969	21.756	2.239	4.440
2001	7.287	14.453	2.575	5.108
2002	2.746	5.447	1.037	2.057
2003	9.367	18.578	6.371	12.637
2004	11.492	22.794	7.786	15.445
2005	14.256	28.276	7.720	15.313
2006	7.580	15.034	6.437	12.768
2007	25.648	50.873	13.090	25.964
2008	15.283	30.313	10.610	21.045
2009	24.279	48.156	17.741	35.189


Flow Duration
1000.0
100.0
10.0
1.0
0.1
Flow (cfs)
0
20
40
60
80
100
120
Flow Duration (%)

Cherry Creek Basin Water Quality Authority
8390 East Crescent Parkway, Suite 500
Greenwood Village, Colorado 80111
(P) 303.779.4525
(F) 303.773.2050

Memorandum

To: Scott Yanagihara, CH2M Hill

From: William P. Ruzzo, P.E.

Date: September 8, 2010

Re: Cherry Creek at 12-Mile Park – Channel Forming Discharge

On behalf of the Authority, I prepared an analysis to define the channel forming discharge in Cherry Creek at 12-Mile Park area for the purpose of providing design guidance for the above reference project. This information is being provided to CH2M Hill in accordance with the Agreement with the Authority to prepare a Stream Reclamation Report for this segment of Cherry Creek.

Background

One hydrologic parameter of importance in the design of a stable channel system is the channel forming or dominant discharge. The channel forming discharge is defined as a theoretical discharge that if constantly maintained over a long period of time would produce the same channel geometry that is produced by the long-term natural hydrograph[1].

Channel forming discharges have been related to bank full discharge, a specific recurrence interval discharge, effective discharge, and mean annual flow. For this analysis, a combination of the specific recurrence interval discharge and mean annual flow were used as “surrogates” to estimate channel forming discharge.

The literature cites several studies to determine a specific recurrence interval for channel forming discharges and mean annual flow[2], with typical ranges from 1.0 to

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[1] The Federal Interagency Stream Restoration Working Group October 1998. *Stream Corridor Restoration Principles, Processes, and Practices.* p7-8.

[2] Ibid, p 7-12.

2-years. For this analysis, it is recommended to use a frequency range of 1.1- to 1.5-years. Bankfull discharge was not used because the channel in this reach is characterized by a high right bank, but low left bank, making bank full determination more problematic. In addition, the effective discharge requires a sediment transport analysis, which is beyond the scope of the project.

Approach

Assuming the mean annual flow is a reasonable surrogate for the channel forming, the regional regression analysis by Dunne and Leopold as shown on Figure 7.6 from the FISRWG report[3] resulted in flow rate from 300- to 500-cfs for a drainage area of 361-square miles. Since the Upper Green River Basin Wyoming is more representative of the Colorado Front Range area, 300-cfs was used for comparison purposes.

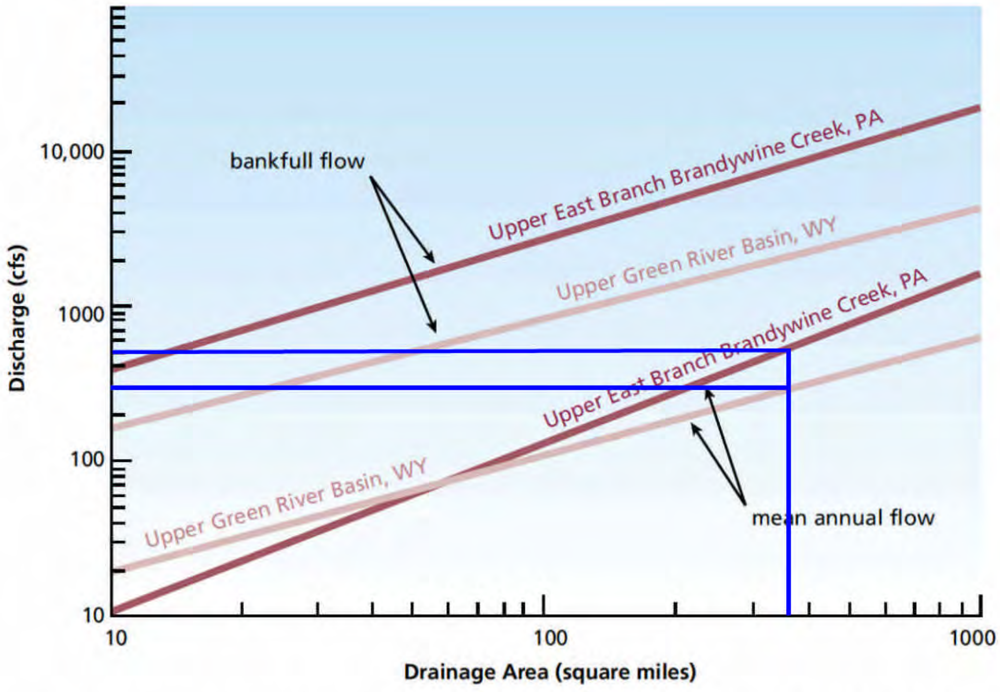

Figure 7.6: Regional relationships for bankfull and mean annual discharge as a function of drainage area. *The mean annual flow is normally less than the bankfull flow.*
Source: Dunne and Leopold 1978.

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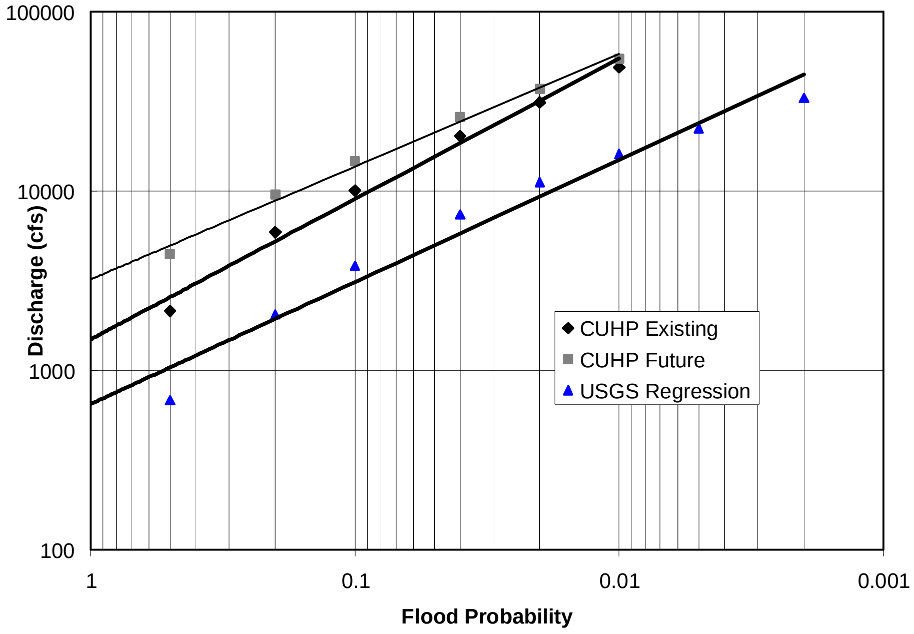
[3] Ibid, p7-16.

The next approach was to use the specific recurrence interval range of 1.1 to 1.5-years using two flood frequency data sets, the URS study[4] of Cherry Creek and the USGS regression analysis[5]. The URS study provided peak flows for the 2- through the 100-year for both existing and projected future development conditions based on the CUHP hydrologic model[6]. Flood peaks were plotted in a log-log format versus the flood probability (i.e.: 1/frequency) and a power equation was fit to the data (see Figure 2). The equation was then used to estimate the 1.1- and 1.5-year peaks, which are assumed to represent the likely range of mean annual flood peaks.

The USGS regression analysis for the "Plains Region," which included data from Cherry Creek gages at Melvin (#06712000) and Franktown (#06712500), resulted in a power form of equation where the only independent variable was area (square miles). Regression equations were presented for flood frequencies from the 2-year through the 500-year. Flood peaks were then calculated using the equations and plotted in a log-log format versus the flood probability, as for the URS study results. A power equation was also fit to the data and used to estimate the 1.1- and 1.5-year flood peaks (see Figure 2).

Figure 2 - Cherry Creek Flood Frequency Analysis



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[4] URS 2002. *Cherry Creek Corridor – Reservoir to Scott Road Major Drainageway Planning Study Alternative Evaluation Report.*

[5] USGS 2000. *Analysis of the Magnitude and Frequency of Floods in Colorado.* WRI 99-4190

[6] UDSWM2000 Version 4. Urban Drainage & Flood Control District.

Evaluation of Results

Presented in the table below is a summary of calculation results for both sets of data and for the 1.1- and 1.5-year flood frequency.

Table 1 – Comparison of Predicted Mean Annual Flows

Frequency		**CUHP Existing**	**CUHP Future**	**USGS**
Years	**Probability**	**Qp**	**Qp**	**Qp**
1.1	0.91	1605	3415	692
1.5	0.67	2046	4150	855

It is clear from both the table and the attached figure that the predicted flood peaks for the 1.1- and 1.5-year frequencies are significantly higher using the URS hydrologic model data than the USGS regression analysis that included actual flow data from two Cherry Creek gages. Also, the Dunne and Leopold regression analysis suggested mean annual flow rates of around 300-cfs, which is even lower than the USGS regression analysis.

It is believed that the best estimate of channel forming discharge lies between 300- to 800-cfs, based on comparison of these results. Therefore, in the absence of better information, both of these flow rates should be used in the HECRAS analysis and for preliminary design of the channel.

Enclosure: Calculations

Cherry Creek Basin Water Quality Authority
Flood Frequency Analysis - Cherry Creek at the Reservoir

Ref:
1. URS December 2002. *Cherry Creek Corridor - Reservoir to Scott Road Major Drainageway Planning Study Alternative Evaluation Report* Tables 3-5 and 3-6
2. USGS 2000. *Analysis of the Magnitude and Frequency of Floods in Colorado.* WRI 99-4190

Hydrologic Model (CUHP)

Frequency		**Existing**	**Future**
Years	**Probability**	**Qp**	**Qp**
2	0.5	2142	4429
5	0.2	5892	9537
10	0.1	10071	14655
25	0.04	20200	25821
50	0.02	31217	36946
100	0.01	49021	54285

USGS Regression Analysis

A = 361 sq mi. Equation Form: Qp = K A^^{P}

Frequency		**Equation**		**Qp**
Years	**Probability**	K	P	
2	0.5	39	0.486	682
5	0.2	195.8	0.399	2052
10	0.1	364.6	0.400	3844
25	0.04	725.3	0.395	7426
50	0.02	1116	0.392	11226
100	0.01	1640	0.388	16112
200	0.005	2324	0.385	22432
500	0.002	3534	0.380	33122

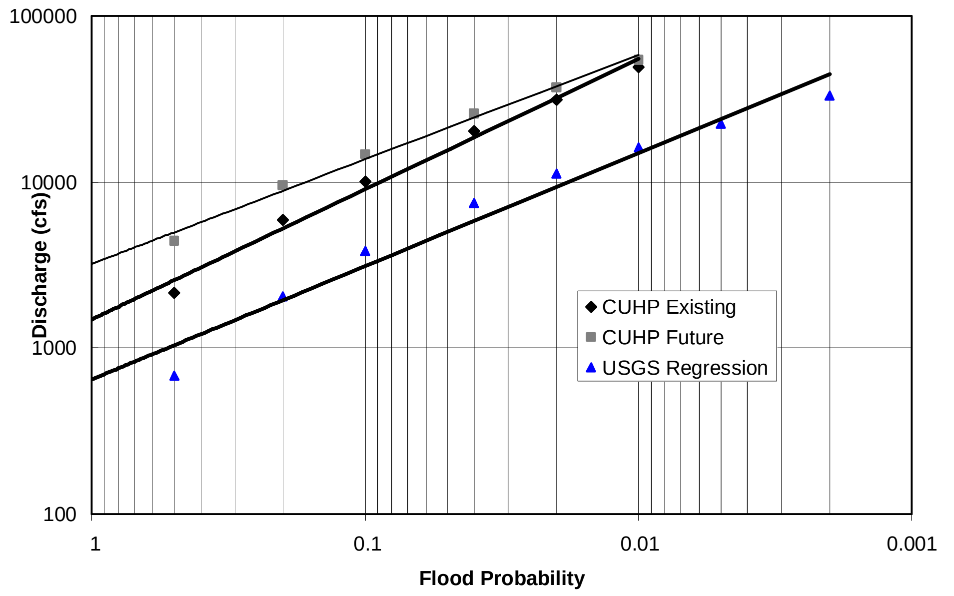
Calculated Mean Annual

Power Equation: Qp = K*Probability^Power ("Plains Region")

Condition	**Equation**	
	K	Power
CUHP Exist	1489.6	-0.7828
CUHP Future	3216.4	-0.6287
USGS	649.0	-0.6805

Frequency		**CUHP Existing**	**CUHP Future**	**USGS**
Years	**Probability**	**Qp**	**Qp**	**Qp**
1.1	0.91	1605	3415	692
1.5	0.67	2046	4150	855

Figure 2 - Cherry Creek Flood Frequency Analysis



Appendix G – Hydraulic Analysis

Hydraulics

Manning’s n Value Calculations

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)m$$

Where:

n_0 = base value for straight uniform channels

n_1 = correction for variations in the size and shape of the channel

n_2 = correction for surface irregularities

n_3 = correction for obstructions

n_4 = corrections for vegetation and flow conditions

m = correction factor for channel meandering

Main Channel

n_0 = 0.026 for sand channels (use 0.026 assuming sand with a mean diameter of 1 mm)

n_1 = 0 (gradual channel variations)

n_2 = 0.005 (minor irregularities, slightly eroded)

n_3 = 0 (minor obstructions)

n_3 = 0.01 (braided channels)

n_4 = 0 (no channel vegetation)

m = 1 (meandering picked up in HEC-RAS model)

Typical values for main channel:

TABLE G-1
Typical Manning’s n values for Low Flow Channel for Cherry Creek at 12-Mile Park

Description	n_0	n_1	n_2	n_3	n_4	m	n
Typical Channel	0.026	0	0.005	0	0	1	0.031
Braided Channel	0.026	0	0.005	0	0.01	1	0.041

Overbanks/Floodplain

n_0 = 0.026 for sand channels (use 0.026 assuming sand with a mean diameter of 1 mm)

n_1 = 0 (gradual channel variations)

n_2 = 0.005 (minor irregularities)

n_3 = 0 (minor obstructions)

n_4 = 0 (no channel vegetation)

n_4 = 0.007 (short weeds and grasses)

n_4 = 0.018 (medium weeds and grasses)

n_4 = 0.05 (natural brush with willows)

n_4 = 0.075 (moderate brush with willows)

n_4 = 0.10 (dense brush with willows)

m = 1 (meandering picked up in HEC-RAS model)

Typical values for overbanks/floodplains:

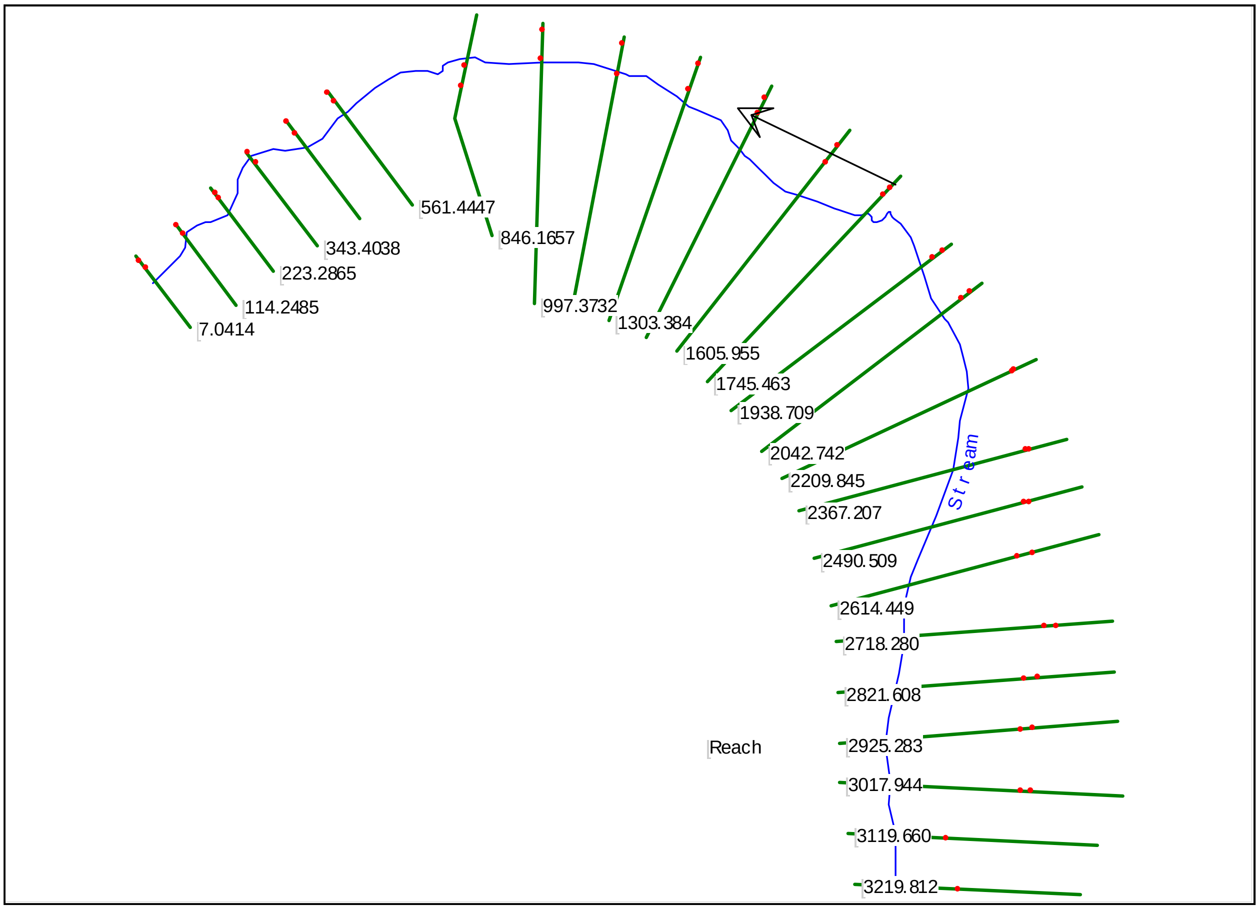
TABLE G-2

Typical Manning's n values for overbanks/floodplains for Cherry Creek at 12-Mile Park

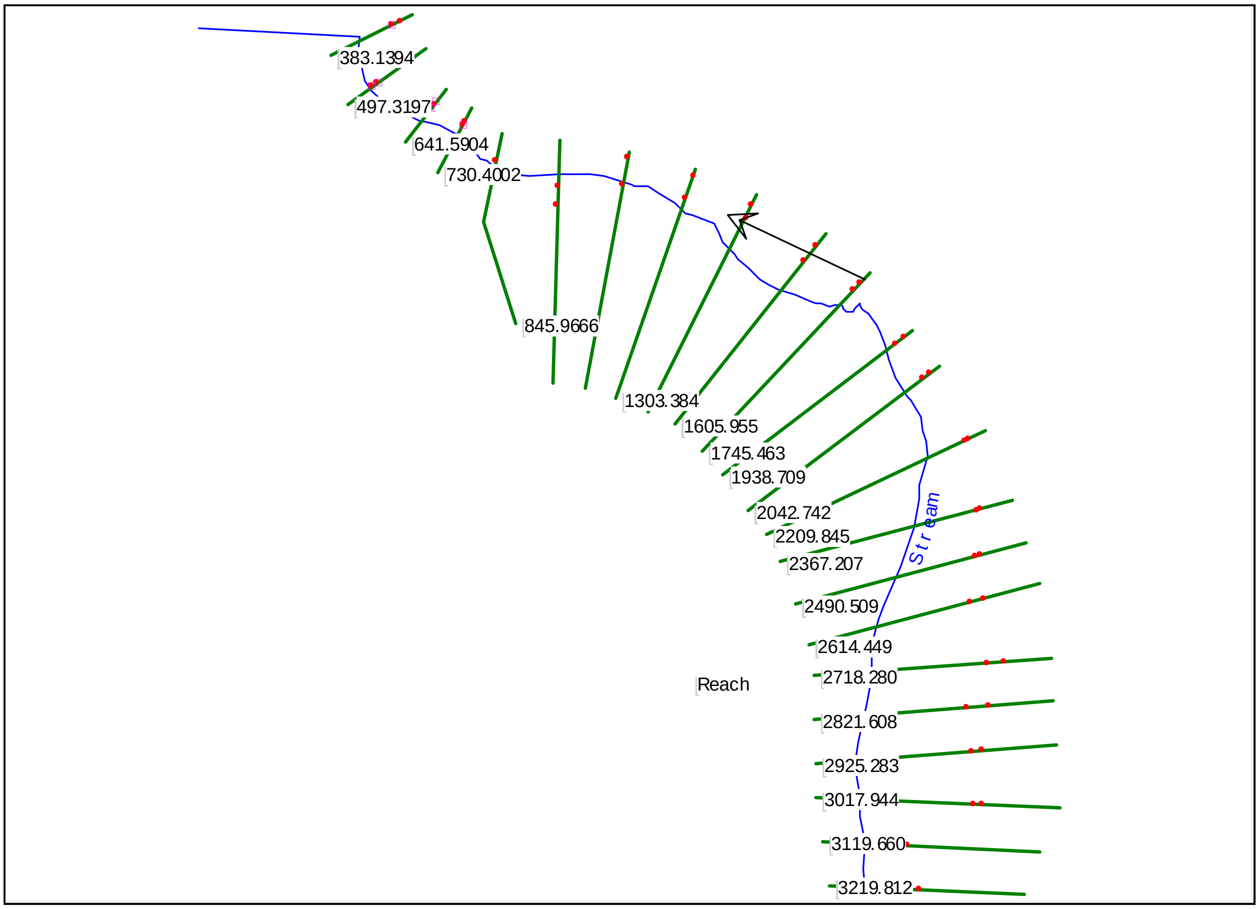
Description	**n_0**	**n_1**	**n_2**	**n_3**	**n_4**	**m**	**n**
Short Weeds and Grasses	0.026	0	0.005	0	0.007	1	0.038
Medium Weeds and Grasses	0.026	0	0.005	0	0.018	1	0.049
Natural Brush with Willows	0.026	0	0.005	0	0.05	1	0.081
Moderate Brush with Willows	0.026	0	0.005	0	0.075	1	0.106
Dense Brush with Willows	0.026	0	0.005	0	0.1	1	0.131

Existing Conditions HEC-RAS

Plan View of Historic Flow Path

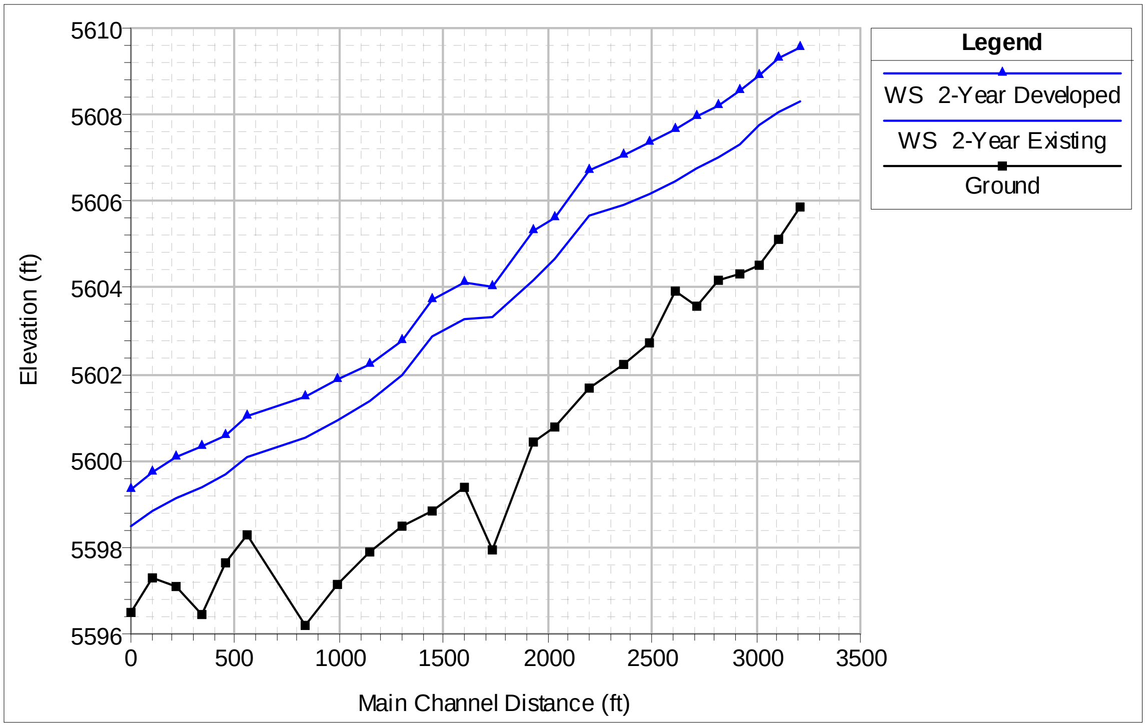


Plan View of Breakout Flow Path

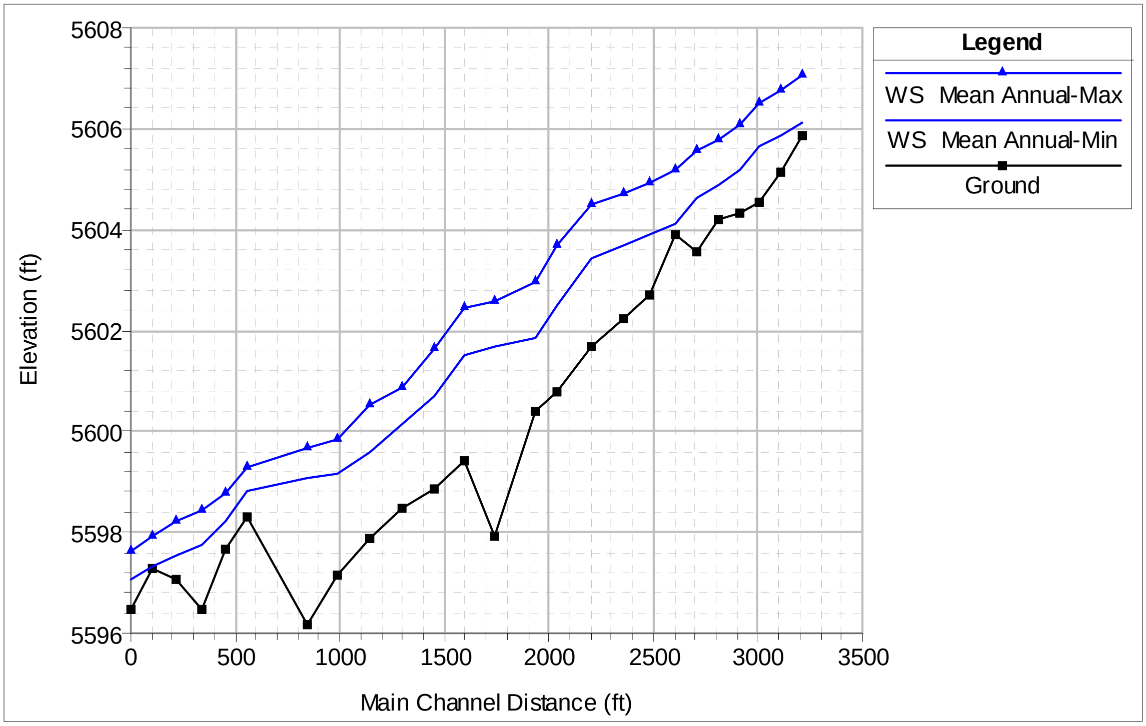


HEC-RAS Profiles

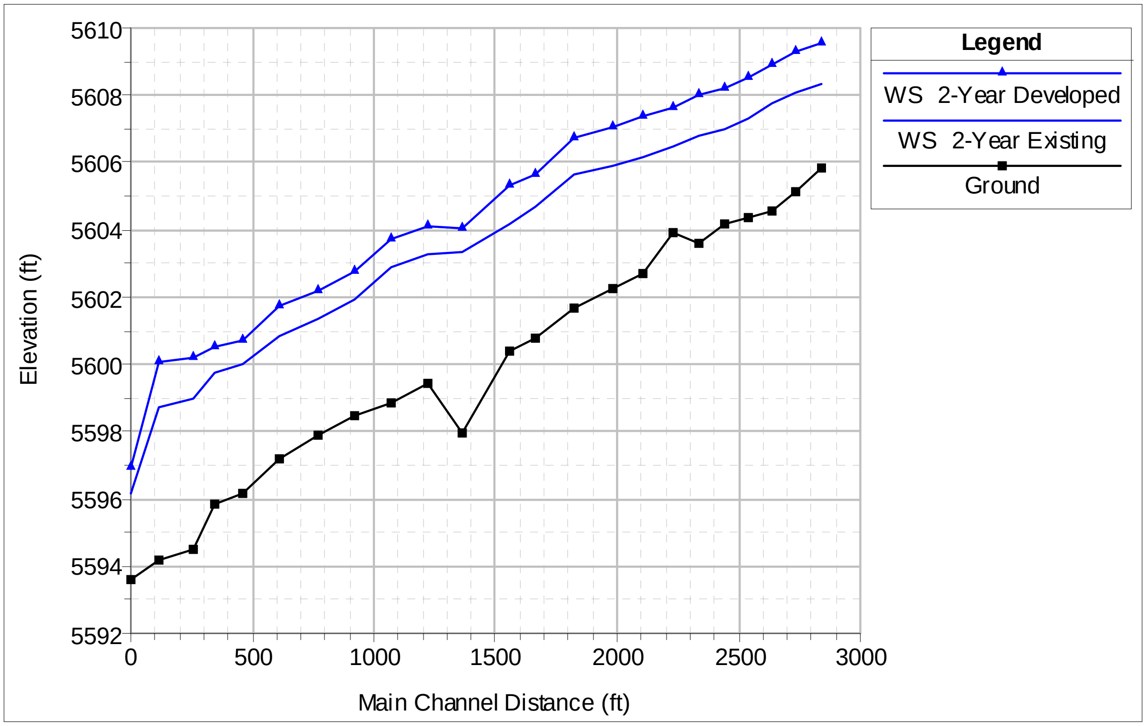
2-Year Existing and 2-Year Developed Flows for Historic Flow Path



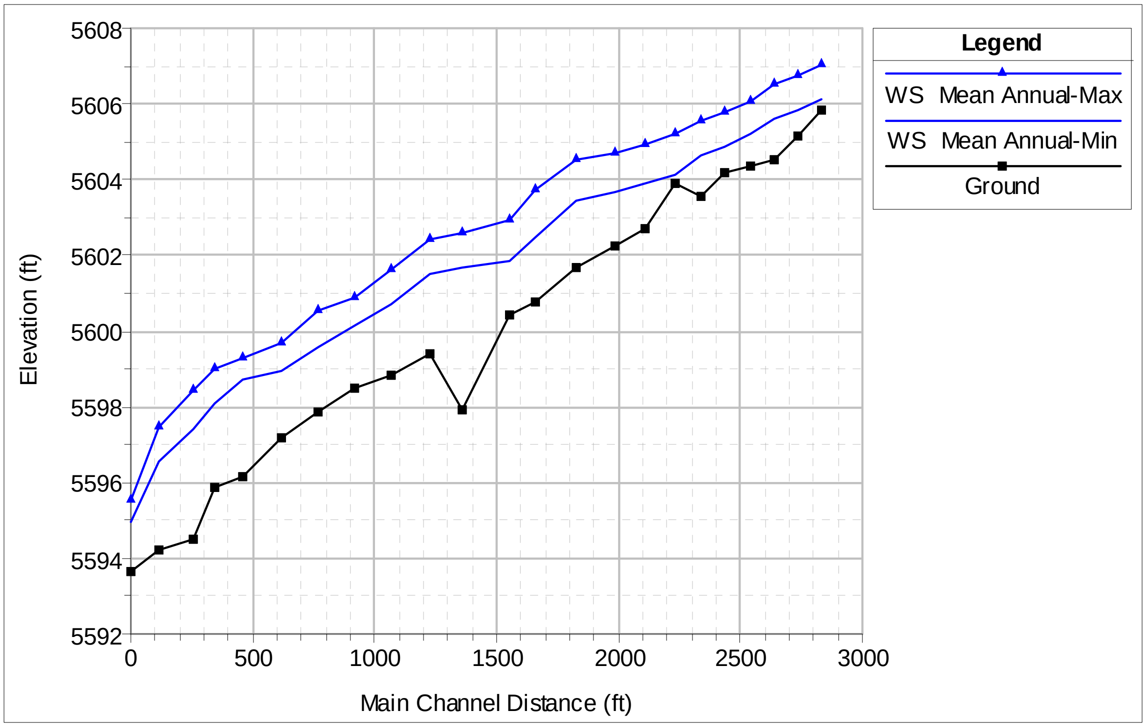
Minimum and Maximum Mean Annual Flows for Historic Flow Path



2-Year Existing and 2-Year Developed Flows for Breakout Flow Path



Minimum and Maximum Mean Annual Flows for Breakout Flow Path



HEC-RAS Output

2-YR Exst = 2-Year Existing

2-YR Dev = 2-Year Developed

MA-Min = Minimum Mean Annual

MA-Max = Maximum Mean Annual

TABLE G-3

Historic Flow Path HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
3219.812	2-YR Exst	2142	5605.9	5608.3	5608.5	0.0030	3.9	942.2	487.1	0.51
3219.812	2-YR Dev	4429	5605.9	5609.6	5609.8	0.0027	5.3	1551.5	497.8	0.53
3219.812	MA - Min	300	5605.9	5606.1	5606.2	0.0050	0.9	199.4	177.0	0.43
3219.812	MA - Max	800	5605.9	5607.1	5607.1	0.0044	2.3	432.5	333.3	0.52
3119.66	2-YR Exst	2142	5605.1	5608.1	5608.2	0.0023	4.3	911.1	492.4	0.46
3119.66	2-YR Dev	4429	5605.1	5609.3	5609.5	0.0027	5.9	1547.0	531.0	0.53
3119.66	MA - Min	300	5605.1	5605.9	5605.9	0.0016	1.3	187.8	237.5	0.3
3119.66	MA - Max	800	5605.1	5606.8	5606.8	0.0019	2.6	423.0	282.7	0.38
3119.66	31+19 BF	505	5605.1	5607.6	5608.0	0.0042	5.1	98.6	43.1	0.6
3017.944	2-YR Exst	2142	5604.5	5607.7	5607.9	0.0035	5.0	967.0	477.6	0.56
3017.944	2-YR Dev	4429	5604.5	5608.9	5609.2	0.0037	6.7	1627.9	636.0	0.62
3017.944	MA - Min	300	5604.5	5605.6	5605.7	0.0032	2.0	219.2	242.7	0.43
3017.944	MA - Max	800	5604.5	5606.5	5606.6	0.0033	3.1	464.5	332.3	0.48
2925.283	2-YR Exst	2142	5604.3	5607.3	5607.4	0.0033	3.6	918.4	494.2	0.51
2925.283	2-YR Dev	4429	5604.3	5608.5	5608.7	0.0032	5.2	1666.7	801.2	0.55
2925.283	MA - Min	300	5604.3	5605.2	5605.2	0.0029	1.8	162.5	235.8	0.41
2925.283	MA - Max	800	5604.3	5606.1	5606.1	0.0033	2.9	405.3	329.4	0.47
2821.608	2-YR Exst	2142	5604.2	5607.0	5607.1	0.0026	3.9	1018.9	498.8	0.47
2821.608	2-YR Dev	4429	5604.2	5608.2	5608.4	0.0028	5.5	1642.4	614.0	0.54
2821.608	MA - Min	300	5604.2	5604.9	5604.9	0.0035	1.6	200.6	235.4	0.43
2821.608	MA - Max	800	5604.2	5605.8	5605.8	0.0027	2.6	498.6	375.6	0.44
2821.608	28+21 BF	570	5604.2	5606.6	5606.9	0.0043	4.3	132.6	93.9	0.64

TABLE G-3

Historic Flow Path HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
2718.28	2-YR Exst	2142	5603.6	5606.8	5606.9	0.0021	3.7	1077.1	574.4	0.44
2718.28	2-YR Dev	4429	5603.6	5608.0	5608.1	0.0021	5.0	1960.8	967.5	0.47
2718.28	MA - Min	300	5603.6	5604.6	5604.7	0.0020	1.4	256.2	264.3	0.34
2718.28	MA - Max	800	5603.6	5605.6	5605.6	0.0019	2.3	530.5	346.6	0.38
2614.449	2-YR Exst	2142	5603.9	5606.5	5606.6	0.0025	3.8	1045.8	529.4	0.47
2614.449	2-YR Dev	4429	5603.9	5607.6	5607.8	0.0025	5.2	1827.4	798.8	0.51
2614.449	MA - Min	300	5603.9	5604.1	5604.2	0.0051	0.8	196.7	254.7	0.41
2614.449	MA - Max	800	5603.9	5605.2	5605.2	0.0027	2.2	515.1	352.7	0.42
2490.509	2-YR Exst	2142	5602.7	5606.2	5606.3	0.0021	4.3	915.4	549.3	0.45
2490.509	2-YR Dev	4429	5602.7	5607.3	5607.5	0.0025	5.8	1716.0	959.2	0.51
2490.509	MA - Min	300	5602.7	5603.9	5603.9	0.0013	1.4	172.2	150.6	0.28
2490.509	MA - Max	800	5602.7	5605.0	5605.0	0.0016	2.6	380.7	251.2	0.35
2490.509	24+90 BF	345	5602.7	5604.9	5605.5	0.0084	6.0	57.3	33.6	0.81
2367.207	2-YR Exst	2142	5602.2	5605.9	5606.0	0.0025	5.0	1049.1	539.6	0.48
2367.207	2-YR Dev	4429	5602.2	5607.1	5607.2	0.0029	6.5	1835.2	987.2	0.53
2367.207	MA - Min	300	5602.2	5603.7	5603.7	0.0025	2.7	144.2	126.2	0.42
2367.207	MA - Max	800	5602.2	5604.7	5604.8	0.0025	3.8	438.0	433.7	0.44
2367.207	23+67 BF	225	5602.2	5604.9	5605.1	0.0025	3.9	57.2	24.3	0.45
2209.845	2-YR Exst	2142	5601.7	5605.7	5605.7	0.0012	3.6	1354.3	593.2	0.32
2209.845	2-YR Dev	4429	5601.7	5606.7	5606.8	0.0017	5.1	2110.8	977.6	0.41
2209.845	MA - Min	300	5601.7	5603.4	5603.5	0.0010	1.9	253.2	348.6	0.27
2209.845	MA - Max	800	5601.7	5604.5	5604.6	0.0009	2.4	716.2	513.8	0.26
2042.742	2-YR Exst	2142	5600.8	5604.7	5605.3	0.0070	8.4	735.2	534.3	0.83
2042.742	2-YR Dev	4429	5600.8	5605.6	5606.3	0.0069	9.8	1443.0	1047.2	0.85
2042.742	MA - Min	300	5600.8	5602.5	5603.0	0.0097	5.9	50.5	34.6	0.87
2042.742	MA - Max	800	5600.8	5603.7	5604.2	0.0061	6.3	303.8	370.2	0.74
2042.742	20+42 BF	405	5600.8	5603.1	5603.6	0.0072	5.7	71.7	42.4	0.77
1938.709	2-YR Exst	2142	5600.4	5604.2	5604.4	0.0032	5.6	999.2	750.4	0.57

TABLE G-3

Historic Flow Path HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
1938.709	2-YR Dev	4429	5600.4	5605.3	5605.5	0.0025	6.1	1989.9	1057.1	0.53
1938.709	MA - Min	300	5600.4	5601.8	5602.1	0.0075	4.3	121.6	136.3	0.73
1938.709	MA - Max	800	5600.4	5603.0	5603.2	0.0038	4.4	402.3	351.9	0.57
1745.463	2-YR Exst	2142	5597.9	5603.3	5603.8	0.0034	6.8	714.3	529.1	0.6
1745.463	2-YR Dev	4429	5597.9	5604.0	5604.9	0.0055	9.7	1128.0	616.6	0.79
1745.463	MA - Min	300	5597.9	5601.7	5601.7	0.0006	2.1	180.5	94.2	0.24
1745.463	MA - Max	800	5597.9	5602.6	5602.8	0.0014	3.8	386.9	352.8	0.37
1605.955	2-YR Exst	2142	5599.4	5603.3	5603.4	0.0020	3.3	1135.2	897.2	0.34
1605.955	2-YR Dev	4429	5599.4	5604.1	5604.3	0.0022	4.1	1929.6	999.3	0.37
1605.955	MA - Min	300	5599.4	5601.5	5601.6	0.0020	2.1	141.0	91.8	0.3
1605.955	MA - Max	800	5599.4	5602.4	5602.5	0.0020	2.6	464.8	666.4	0.32
1605.955	16+05 BF	385	5599.4	5601.8	5601.9	0.0023	2.2	171.7	113.9	0.32
1454.871	2-YR Exst	2142	5598.9	5602.9	5603.1	0.0021	4.4	1080.3	884.8	0.46
1454.871	2-YR Dev	4429	5598.9	5603.7	5603.9	0.0023	5.4	1816.8	940.0	0.5
1454.871	MA - Min	300	5598.9	5600.7	5601.0	0.0086	4.5	66.5	62.6	0.77
1454.871	MA - Max	800	5598.9	5601.6	5602.0	0.0064	5.1	222.7	400.5	0.71
1303.384	2-YR Exst	2142	5598.5	5602.0	5602.6	0.0049	6.8	609.5	691.5	0.69
1303.384	2-YR Dev	4429	5598.5	5602.8	5603.4	0.0051	8.1	1258.7	852.3	0.73
1303.384	MA - Min	300	5598.5	5600.1	5600.3	0.0028	2.9	104.2	85.0	0.46
1303.384	MA - Max	800	5598.5	5600.9	5601.2	0.0042	4.8	179.4	138.6	0.6
1303.384	13+03 BF	585	5598.5	5601.0	5601.1	0.0020	3.3	175.0	85.5	0.41
1150.922	2-YR Exst	2142	5597.9	5601.4	5601.5	0.0027	4.1	1109.1	811.9	0.49
1150.922	2-YR Dev	4429	5597.9	5602.3	5602.4	0.0027	5.0	1857.8	921.6	0.51
1150.922	MA - Min	300	5597.9	5599.6	5599.8	0.0037	3.5	91.3	109.8	0.53
1150.922	MA - Max	800	5597.9	5600.5	5600.7	0.0026	3.7	476.1	643.4	0.46
1150.922	11+50 BF	810	5597.9	5601.1	5601.4	0.0033	4.1	197.7	103.2	0.52
997.3732	2-YR Exst	2142	5597.2	5600.9	5601.1	0.0032	4.6	1081.9	823.2	0.53
997.3732	2-YR Dev	4429	5597.2	5601.9	5602.0	0.0027	5.1	1906.0	897.4	0.49

TABLE G-3

Historic Flow Path HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
997.3732	MA - Min	300	5597.2	5599.2	5599.3	0.0024	3.3	153.1	178.0	0.44
997.3732	MA - Max	800	5597.2	5599.9	5600.2	0.0048	4.9	328.3	358.9	0.7
846.1657	2-YR Exst	2142	5596.2	5600.5	5600.7	0.0018	4.1	1257.6	887.3	0.42
846.1657	2-YR Dev	4429	5596.2	5601.5	5601.7	0.0019	5.1	2127.4	1016.9	0.46
846.1657	MA - Min	300	5596.2	5599.1	5599.1	0.0006	1.6	340.3	326.3	0.22
846.1657	MA - Max	800	5596.2	5599.7	5599.8	0.0012	2.7	611.0	502.6	0.33
561.4447	2-YR Exst	2142	5598.3	5600.1	5600.2	0.0032	3.5	1317.4	779.9	0.51
561.4447	2-YR Dev	4429	5598.3	5601.0	5601.1	0.0030	4.7	2042.4	798.8	0.54
561.4447	MA - Min	300	5598.3	5598.8	5598.9	0.0025	1.3	428.7	603.4	0.36
561.4447	MA - Max	800	5598.3	5599.3	5599.3	0.0032	2.3	722.5	673.0	0.46
459.4117	2-YR Exst	2142	5597.7	5599.7	5599.8	0.0047	4.3	1117.3	729.4	0.62
459.4117	2-YR Dev	4429	5597.7	5600.6	5600.8	0.0039	5.4	1839.0	776.3	0.61
459.4117	MA - Min	300	5597.7	5598.2	5598.3	0.0221	3.0	197.3	529.0	1.01
459.4117	MA - Max	800	5597.7	5598.8	5598.8	0.0079	3.3	518.2	627.8	0.7
459.4117	4+59 BF	70	5597.7	5598.4	5598.5	0.0112	2.5	28.1	81.6	0.75
343.4038	2-YR Exst	2142	5596.5	5599.4	5599.4	0.0020	3.1	1430.6	750.7	0.41
343.4038	2-YR Dev	4429	5596.5	5600.4	5600.5	0.0021	4.2	2209.2	834.3	0.46
343.4038	MA - Min	300	5596.5	5597.7	5597.7	0.0022	1.3	388.3	448.0	0.35
343.4038	MA - Max	800	5596.5	5598.4	5598.5	0.0021	1.8	773.0	618.1	0.37
343.4038	3+43 BF	20	5596.5	5598.0	5598.0	0.0007	0.7	30.3	75.8	0.18
223.2865	2-YR Exst	2142	5597.1	5599.1	5599.2	0.0025	3.4	1392.2	704.7	0.46
223.2865	2-YR Dev	4429	5597.1	5600.1	5600.2	0.0031	5.0	2098.2	805.4	0.55
223.2865	MA - Min	300	5597.1	5597.5	5597.5	0.0015	0.7	472.4	461.1	0.26
223.2865	MA - Max	800	5597.1	5598.2	5598.2	0.0020	1.7	810.7	545.2	0.35
114.2485	2-YR Exst	2142	5597.3	5598.8	5598.9	0.0035	2.4	1296.1	724.8	0.48
114.2485	2-YR Dev	4429	5597.3	5599.7	5599.8	0.0037	3.9	1979.8	777.3	0.55
114.2485	MA - Min	300	5597.3	5597.3	5597.3	0.0025	0.1	400.4	428.7	0.21
114.2485	MA - Max	800	5597.3	5597.9	5598.0	0.0034	1.4	687.0	505.5	0.41

TABLE G-3

Historic Flow Path HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
7.0414	2-YR Exst	2142	5596.5	5598.5	5598.6	0.0028	3.4	1233.7	763.9	0.48
7.0414	2-YR Dev	4429	5596.5	5599.4	5599.5	0.0028	4.6	1919.5	793.0	0.52
7.0414	MA - Min	300	5596.5	5597.1	5597.1	0.0028	0.9	338.4	480.4	0.34
7.0414	MA - Max	800	5596.5	5597.6	5597.6	0.0028	2.0	639.3	571.7	0.42

TABLE G-4

Breakout Flow Path HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
3219.812	2-YR Exst	2142	5605.9	5608.3	5608.5	0.0030	3.9	942.0	487.1	0.51
3219.812	2-YR Dev	4429	5605.9	5609.6	5609.8	0.0027	5.3	1548.8	497.7	0.53
3219.812	MA - Min	300	5605.9	5606.1	5606.2	0.0050	0.9	199.4	177.0	0.43
3219.812	MA - Max	800	5605.9	5607.1	5607.1	0.0044	2.3	432.5	333.3	0.52
3119.66	2-YR Exst	2142	5605.1	5608.1	5608.2	0.0023	4.3	910.6	492.3	0.46
3119.66	2-YR Dev	4429	5605.1	5609.3	5609.5	0.0027	5.9	1543.4	530.8	0.53
3119.66	MA - Min	300	5605.1	5605.9	5605.9	0.0016	1.3	187.8	237.5	0.3
3119.66	MA - Max	800	5605.1	5606.8	5606.8	0.0019	2.6	423.0	282.7	0.38
3119.66	31+19 BF	505	5605.1	5607.6	5608.0	0.0042	5.1	98.6	43.1	0.6
3017.944	2-YR Exst	2142	5604.5	5607.7	5607.9	0.0035	5.0	966.3	477.5	0.56
3017.944	2-YR Dev	4429	5604.5	5608.9	5609.2	0.0038	6.7	1621.1	634.6	0.62
3017.944	MA - Min	300	5604.5	5605.6	5605.7	0.0032	2.0	219.2	242.7	0.43
3017.944	MA - Max	800	5604.5	5606.5	5606.6	0.0033	3.1	464.5	332.3	0.48
2925.283	2-YR Exst	2142	5604.3	5607.3	5607.4	0.0034	3.6	917.0	494.0	0.51
2925.283	2-YR Dev	4429	5604.3	5608.5	5608.7	0.0032	5.2	1651.9	794.0	0.55
2925.283	MA - Min	300	5604.3	5605.2	5605.2	0.0029	1.8	162.5	235.8	0.41
2925.283	MA - Max	800	5604.3	5606.1	5606.1	0.0033	2.9	405.3	329.4	0.47
2821.608	2-YR Exst	2142	5604.2	5607.0	5607.1	0.0025	3.6	1022.3	499.8	0.52
2821.608	2-YR Dev	4429	5604.2	5608.2	5608.4	0.0027	4.5	1662.8	628.1	0.49
2821.608	MA - Min	300	5604.2	5604.9	5604.9	0.0035	1.6	200.6	235.4	0.43
2821.608	MA - Max	800	5604.2	5605.8	5605.8	0.0027	2.6	498.6	375.6	0.44
2821.608	28+21 BF	570	5604.2	5606.6	5606.9	0.0043	4.3	132.6	93.9	0.64
2718.28	2-YR Exst	2142	5603.6	5606.8	5606.9	0.0020	3.2	1085.8	578.3	0.44
2718.28	2-YR Dev	4429	5603.6	5608.0	5608.1	0.0020	3.9	2001.3	986.6	0.41
2718.28	MA - Min	300	5603.6	5604.6	5604.7	0.0020	1.4	256.2	264.3	0.34
2718.28	MA - Max	800	5603.6	5605.6	5605.6	0.0019	2.3	530.5	346.6	0.38
2614.449	2-YR Exst	2142	5603.9	5606.5	5606.6	0.0025	3.8	1046.1	529.5	0.47

TABLE G-4

Breakout Flow Path HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
2614.449	2-YR Dev	4429	5603.9	5607.6	5607.8	0.0025	5.2	1828.6	799.2	0.51
2614.449	MA - Min	300	5603.9	5604.1	5604.2	0.0051	0.8	196.7	254.7	0.41
2614.449	MA - Max	800	5603.9	5605.2	5605.2	0.0027	2.2	515.1	352.7	0.42
2490.509	2-YR Exst	2142	5602.7	5606.2	5606.3	0.0021	4.3	915.4	549.3	0.45
2490.509	2-YR Dev	4429	5602.7	5607.3	5607.5	0.0025	5.8	1716.0	959.2	0.51
2490.509	MA - Min	300	5602.7	5603.9	5603.9	0.0013	1.4	172.2	150.6	0.28
2490.509	MA - Max	800	5602.7	5605.0	5605.0	0.0016	2.6	380.7	251.2	0.35
2490.509	24+90 BF	345	5602.7	5604.9	5605.5	0.0084	6.0	57.3	33.6	0.81
2367.207	2-YR Exst	2142	5602.2	5605.9	5606.0	0.0025	5.0	1049.1	539.6	0.48
2367.207	2-YR Dev	4429	5602.2	5607.1	5607.2	0.0029	6.5	1835.2	987.2	0.53
2367.207	MA - Min	300	5602.2	5603.7	5603.7	0.0025	2.7	144.2	126.2	0.42
2367.207	MA - Max	800	5602.2	5604.7	5604.8	0.0025	3.8	438.0	433.7	0.44
2367.207	23+67 BF	225	5602.2	5604.9	5605.1	0.0025	3.9	57.2	24.3	0.45
2209.845	2-YR Exst	2142	5601.7	5605.7	5605.7	0.0012	3.6	1354.3	593.2	0.32
2209.845	2-YR Dev	4429	5601.7	5606.7	5606.8	0.0017	5.1	2110.8	977.6	0.41
2209.845	MA - Min	300	5601.7	5603.4	5603.5	0.0010	1.9	253.2	348.6	0.27
2209.845	MA - Max	800	5601.7	5604.5	5604.6	0.0009	2.4	716.2	513.8	0.26
2042.742	2-YR Exst	2142	5600.8	5604.7	5605.3	0.0070	8.4	735.2	534.3	0.83
2042.742	2-YR Dev	4429	5600.8	5605.6	5606.3	0.0069	9.8	1443.0	1047.2	0.85
2042.742	MA - Min	300	5600.8	5602.5	5603.0	0.0097	5.9	50.5	34.6	0.87
2042.742	MA - Max	800	5600.8	5603.7	5604.2	0.0061	6.3	303.8	370.2	0.74
2042.742	20+42 BF	405	5600.8	5603.1	5603.6	0.0072	5.7	71.7	42.4	0.77
1938.709	2-YR Exst	2142	5600.4	5604.2	5604.4	0.0032	5.6	999.2	750.4	0.57
1938.709	2-YR Dev	4429	5600.4	5605.3	5605.5	0.0025	6.1	1989.9	1057.1	0.53
1938.709	MA - Min	300	5600.4	5601.8	5602.1	0.0075	4.3	121.6	136.3	0.73
1938.709	MA - Max	800	5600.4	5603.0	5603.2	0.0038	4.4	402.2	351.9	0.57
1745.463	2-YR Exst	2142	5597.9	5603.3	5603.8	0.0034	6.8	714.9	529.3	0.6
1745.463	2-YR Dev	4429	5597.9	5604.1	5604.9	0.0055	9.7	1130.4	618.2	0.78

TABLE G-4

Breakout Flow Path HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
1745.463	MA - Min	300	5597.9	5601.7	5601.7	0.0006	2.1	180.5	94.2	0.24
1745.463	MA - Max	800	5597.9	5602.6	5602.8	0.0014	3.8	386.7	352.7	0.37
1605.955	2-YR Exst	2142	5599.4	5603.3	5603.4	0.0020	3.3	1136.5	897.5	0.34
1605.955	2-YR Dev	4429	5599.4	5604.1	5604.3	0.0022	4.0	1933.5	1000.3	0.37
1605.955	MA - Min	300	5599.4	5601.5	5601.6	0.0020	2.1	141.0	91.8	0.3
1605.955	MA - Max	800	5599.4	5602.4	5602.5	0.0020	2.6	464.5	666.2	0.32
1605.955	16+05 BF	385	5599.4	5601.8	5601.9	0.0023	2.2	171.7	113.9	0.32
1454.871	2-YR Exst	2142	5598.9	5602.9	5603.1	0.0021	4.4	1084.2	886.4	0.45
1454.871	2-YR Dev	4429	5598.9	5603.7	5603.9	0.0023	5.4	1824.2	940.5	0.49
1454.871	MA - Min	300	5598.9	5600.7	5601.0	0.0086	4.5	66.5	62.7	0.77
1454.871	MA - Max	800	5598.9	5601.6	5602.0	0.0064	5.1	222.7	400.5	0.71
1303.384	2-YR Exst	2142	5598.5	5602.0	5602.6	0.0050	6.9	600.4	683.4	0.7
1303.384	2-YR Dev	4429	5598.5	5602.7	5603.4	0.0052	8.2	1243.4	851.8	0.74
1303.384	MA - Min	300	5598.5	5600.1	5600.3	0.0028	2.9	104.1	85.0	0.46
1303.384	MA - Max	800	5598.5	5600.9	5601.2	0.0042	4.8	179.4	138.7	0.6
1303.384	13+03 BF	585	5598.5	5601.0	5601.1	0.0020	3.3	175.0	85.5	0.41
1150.922	2-YR Exst	2142	5597.9	5601.4	5601.5	0.0028	4.1	1101.9	810.7	0.49
1150.922	2-YR Dev	4429	5597.9	5602.2	5602.4	0.0029	5.1	1811.0	917.4	0.53
1150.922	MA - Min	300	5597.9	5599.6	5599.8	0.0039	3.5	89.4	103.1	0.54
1150.922	MA - Max	800	5597.9	5600.5	5600.7	0.0025	3.6	484.3	646.9	0.45
1150.922	11+50 BF	810	5597.9	5601.1	5601.4	0.0033	4.1	197.7	103.2	0.52
997.3732	2-YR Exst	2142	5597.2	5600.9	5601.0	0.0036	4.9	1033.1	816.5	0.56
997.3732	2-YR Dev	4429	5597.2	5601.7	5601.9	0.0032	5.5	1794.2	891.1	0.54
997.3732	MA - Min	300	5597.2	5599.0	5599.2	0.0038	3.9	120.1	155.8	0.54
997.3732	MA - Max	800	5597.2	5599.7	5600.1	0.0059	5.8	273.9	282.1	0.82
845.9666	2-YR Exst	2142	5596.2	5600.0	5600.4	0.0047	5.9	789.6	872.6	0.66
845.9666	2-YR Dev	4429	5596.2	5600.7	5601.2	0.0059	7.8	1384.6	893.0	0.78
845.9666	MA - Min	300	5596.2	5598.7	5598.8	0.0013	2.1	242.1	281.7	0.32

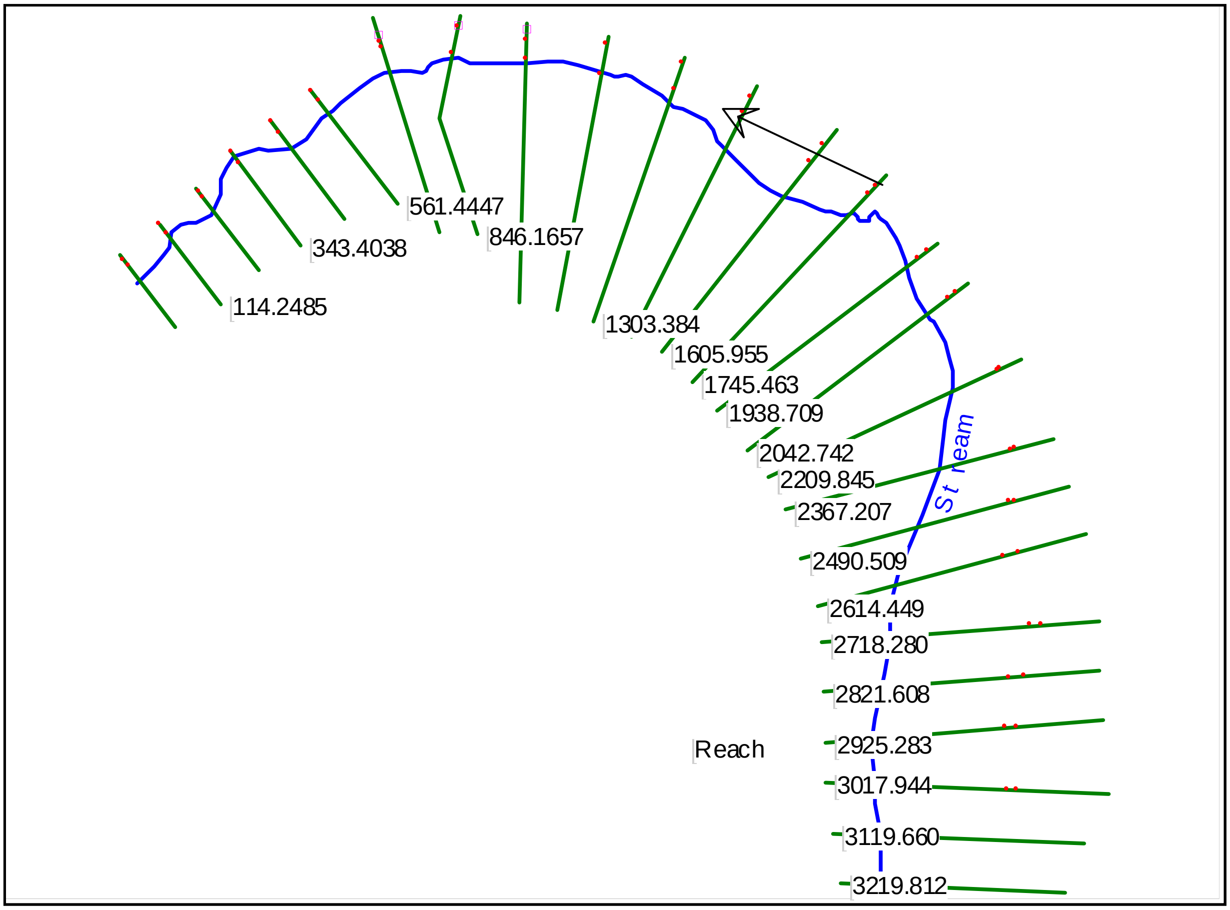
TABLE G-4

Breakout Flow Path HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
845.9666	MA - Max	800	5596.2	5599.3	5599.5	0.0025	3.5	438.9	455.4	0.46
730.4002	2-YR Exst	2142	5595.9	5599.8	5599.9	0.0028	3.7	1056.8	882.1	0.48
730.4002	2-YR Dev	4429	5595.9	5600.5	5600.7	0.0025	4.2	1789.9	1020.2	0.48
730.4002	MA - Min	300	5595.9	5598.1	5598.5	0.0051	5.2	78.1	267.6	0.65
730.4002	MA - Max	800	5595.9	5599.0	5599.1	0.0030	3.6	466.8	652.2	0.49
730.4002	7+30 BF	520	5595.9	5598.5	5599.4	0.0107	7.6	68.8	34.6	0.95
641.5904	2-YR Exst	2142	5594.5	5599.0	5599.4	0.0064	8.5	701.0	730.6	0.81
641.5904	2-YR Dev	4429	5594.5	5600.2	5600.4	0.0025	6.6	1865.9	1149.7	0.54
641.5904	MA - Min	300	5594.5	5597.4	5597.9	0.0073	6.0	64.8	83.4	0.78
641.5904	MA - Max	800	5594.5	5598.4	5598.8	0.0041	6.1	335.2	560.0	0.63
497.3197	2-YR Exst	2142	5594.2	5598.8	5598.8	0.0006	2.9	1287.8	500.5	0.25
497.3197	2-YR Dev	4429	5594.2	5600.1	5600.2	0.0007	3.9	2042.3	640.8	0.3
497.3197	MA - Min	300	5594.2	5596.6	5596.6	0.0005	1.5	342.3	381.6	0.21
497.3197	MA - Max	800	5594.2	5597.4	5597.5	0.0005	2.0	699.4	419.4	0.22
497.3197	4+97 BF	255	5594.2	5595.9	5596.1	0.0048	3.7	69.8	60.4	0.6
383.1394	2-YR Exst	2142	5593.6	5596.2	5596.5	0.0075	6.3	595.8	495.4	0.81
383.1394	2-YR Dev	4429	5593.6	5596.9	5597.4	0.0075	7.9	987.8	556.5	0.86
383.1394	MA - Min	300	5593.6	5594.9	5595.1	0.0075	3.8	122.8	215.0	0.72
383.1394	MA - Max	800	5593.6	5595.5	5595.7	0.0075	4.7	287.3	386.1	0.75

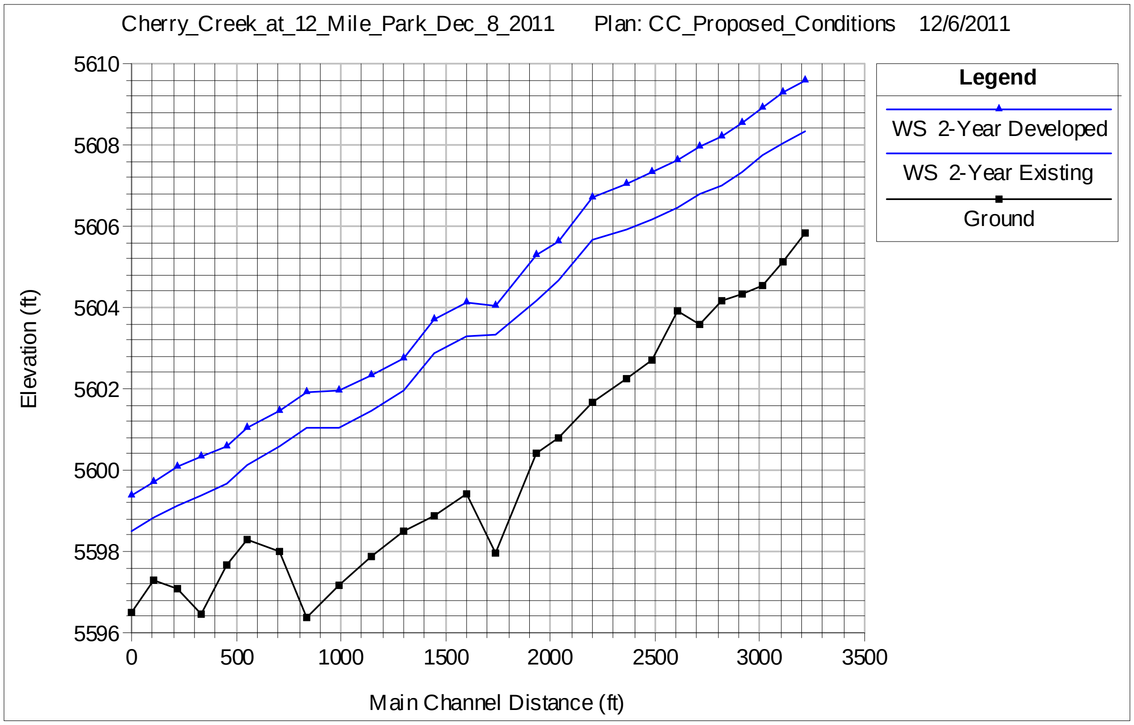
Proposed Conditions HEC-RAS

Plan View of Proposed Conditions

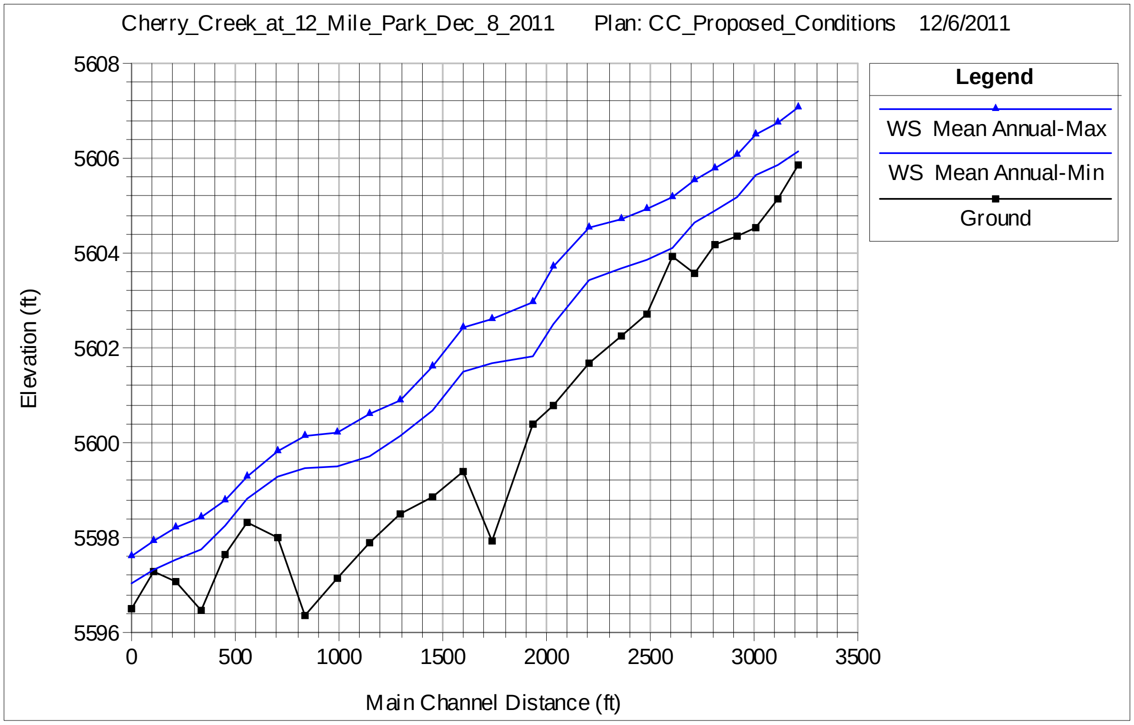


Proposed Conditions HEC-RAS Profiles

2-Year Existing and 2-Year Developed Flows for Proposed Conditions



Minimum and Maximum Mean Annual Flows for Proposed Conditions



HEC-RAS Output

2-YR Exst = 2-Year Existing

2-YR Dev = 2-Year Developed

MA-Min = Minimum Mean Annual

MA-Max = Maximum Mean Annual

TABLE G-5

Proposed Conditions HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
3219.812	2-YR Exst	2142	5605.9	5608.3	5608.5	0.0030	3.9	942.2	487.1	0.51
3219.812	2-YR Dev	4429	5605.9	5609.6	5609.8	0.0027	5.3	1551.5	497.8	0.53
3219.812	MA - Min	300	5605.9	5606.1	5606.2	0.0050	0.9	199.4	177.0	0.43
3219.812	MA - Max	800	5605.9	5607.1	5607.1	0.0044	2.3	432.5	333.3	0.52
3119.66	2-YR Exst	2142	5605.1	5608.1	5608.2	0.0023	4.3	911.1	492.4	0.46
3119.66	2-YR Dev	4429	5605.1	5609.3	5609.5	0.0027	5.9	1547.0	531.0	0.53
3119.66	MA - Min	300	5605.1	5605.9	5605.9	0.0016	1.3	187.8	237.5	0.3
3119.66	MA - Max	800	5605.1	5606.8	5606.8	0.0019	2.6	423.0	282.7	0.38
3119.66	31+19 BF	505	5605.1	5607.6	5608.0	0.0042	5.1	98.6	43.1	0.6
3017.944	2-YR Exst	2142	5604.5	5607.7	5607.9	0.0035	5.0	967.0	477.6	0.56
3017.944	2-YR Dev	4429	5604.5	5608.9	5609.2	0.0037	6.7	1627.9	636.0	0.62
3017.944	MA - Min	300	5604.5	5605.6	5605.7	0.0032	2.0	219.2	242.7	0.43
3017.944	MA - Max	800	5604.5	5606.5	5606.6	0.0033	3.1	464.5	332.3	0.48
2925.283	2-YR Exst	2142	5604.3	5607.3	5607.4	0.0033	3.6	918.4	494.2	0.51
2925.283	2-YR Dev	4429	5604.3	5608.5	5608.7	0.0032	5.2	1666.7	801.2	0.55
2925.283	MA - Min	300	5604.3	5605.2	5605.2	0.0029	1.8	162.5	235.8	0.41
2925.283	MA - Max	800	5604.3	5606.1	5606.1	0.0033	2.9	405.3	329.4	0.47
2821.608	2-YR Exst	2142	5604.2	5607.0	5607.1	0.0026	3.9	1018.9	498.8	0.47
2821.608	2-YR Dev	4429	5604.2	5608.2	5608.4	0.0028	5.5	1642.4	614.0	0.54
2821.608	MA - Min	300	5604.2	5604.9	5604.9	0.0035	1.6	200.6	235.4	0.43
2821.608	MA - Max	800	5604.2	5605.8	5605.8	0.0027	2.6	498.6	375.6	0.44
2821.608	28+21 BF	570	5604.2	5606.6	5606.9	0.0043	4.3	132.6	93.9	0.64
2718.28	2-YR Exst	2142	5603.6	5606.8	5606.9	0.0021	3.7	1077.1	574.4	0.44
2718.28	2-YR Dev	4429	5603.6	5608.0	5608.1	0.0021	5.0	1960.8	967.5	0.47
2718.28	MA - Min	300	5603.6	5604.6	5604.7	0.0020	1.4	256.2	264.3	0.34

TABLE G-5

Proposed Conditions HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
2718.28	MA - Max	800	5603.6	5605.6	5605.6	0.0019	2.3	530.5	346.6	0.38
2614.449	2-YR Exst	2142	5603.9	5606.5	5606.6	0.0025	3.8	1045.8	529.4	0.47
2614.449	2-YR Dev	4429	5603.9	5607.6	5607.8	0.0025	5.2	1827.4	798.8	0.51
2614.449	MA - Min	300	5603.9	5604.1	5604.2	0.0051	0.8	196.7	254.7	0.41
2614.449	MA - Max	800	5603.9	5605.2	5605.2	0.0027	2.2	515.1	352.7	0.42
2490.509	2-YR Exst	2142	5602.7	5606.2	5606.3	0.0021	4.3	915.4	549.3	0.45
2490.509	2-YR Dev	4429	5602.7	5607.3	5607.5	0.0025	5.8	1716.0	959.2	0.51
2490.509	MA - Min	300	5602.7	5603.9	5603.9	0.0013	1.4	172.2	150.6	0.28
2490.509	MA - Max	800	5602.7	5605.0	5605.0	0.0016	2.6	380.7	251.2	0.35
2490.509	24+90 BF	345	5602.7	5604.9	5605.5	0.0084	6.0	57.3	33.6	0.81
2367.207	2-YR Exst	2142	5602.2	5605.9	5606.0	0.0025	5.0	1049.1	539.6	0.48
2367.207	2-YR Dev	4429	5602.2	5607.1	5607.2	0.0029	6.5	1835.2	987.2	0.53
2367.207	MA - Min	300	5602.2	5603.7	5603.7	0.0025	2.7	144.2	126.2	0.42
2367.207	MA - Max	800	5602.2	5604.7	5604.8	0.0025	3.8	438.0	433.7	0.44
2367.207	23+67 BF	225	5602.2	5604.9	5605.1	0.0025	3.9	57.2	24.3	0.45
2209.845	2-YR Exst	2142	5601.7	5605.7	5605.7	0.0012	3.6	1354.3	593.2	0.32
2209.845	2-YR Dev	4429	5601.7	5606.7	5606.8	0.0017	5.1	2110.8	977.6	0.41
2209.845	MA - Min	300	5601.7	5603.4	5603.5	0.0010	1.9	253.2	348.6	0.27
2209.845	MA - Max	800	5601.7	5604.5	5604.6	0.0009	2.4	716.2	513.8	0.26
2042.742	2-YR Exst	2142	5600.8	5604.7	5605.3	0.0070	8.4	735.2	534.3	0.83
2042.742	2-YR Dev	4429	5600.8	5605.6	5606.3	0.0069	9.8	1443.0	1047.2	0.85
2042.742	MA - Min	300	5600.8	5602.5	5603.0	0.0097	5.9	50.5	34.6	0.87
2042.742	MA - Max	800	5600.8	5603.7	5604.2	0.0061	6.3	303.8	370.2	0.74
2042.742	20+42 BF	405	5600.8	5603.1	5603.6	0.0072	5.7	71.7	42.4	0.77
1938.709	2-YR Exst	2142	5600.4	5604.2	5604.4	0.0032	5.6	999.2	750.4	0.57
1938.709	2-YR Dev	4429	5600.4	5605.3	5605.5	0.0025	6.1	1989.9	1057.1	0.53
1938.709	MA - Min	300	5600.4	5601.8	5602.1	0.0075	4.3	121.6	136.3	0.73
1938.709	MA - Max	800	5600.4	5603.0	5603.2	0.0038	4.4	402.3	351.9	0.57
1745.463	2-YR Exst	2142	5597.9	5603.3	5603.8	0.0034	6.8	714.3	529.1	0.6
1745.463	2-YR Dev	4429	5597.9	5604.0	5604.9	0.0055	9.7	1128.0	616.6	0.79
1745.463	MA - Min	300	5597.9	5601.7	5601.7	0.0006	2.1	180.5	94.2	0.24
1745.463	MA - Max	800	5597.9	5602.6	5602.8	0.0014	3.8	386.9	352.8	0.37

TABLE G-5

Proposed Conditions HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
1605.955	2-YR Exst	2142	5599.4	5603.3	5603.4	0.0020	3.3	1135.2	897.2	0.34
1605.955	2-YR Dev	4429	5599.4	5604.1	5604.3	0.0022	4.1	1929.6	999.3	0.37
1605.955	MA - Min	300	5599.4	5601.5	5601.6	0.0020	2.1	141.0	91.8	0.3
1605.955	MA - Max	800	5599.4	5602.4	5602.5	0.0020	2.6	464.8	666.4	0.32
1605.955	16+05 BF	385	5599.4	5601.8	5601.9	0.0023	2.2	171.7	113.9	0.32
1454.871	2-YR Exst	2142	5598.9	5602.9	5603.1	0.0021	4.4	1080.3	884.8	0.46
1454.871	2-YR Dev	4429	5598.9	5603.7	5603.9	0.0023	5.4	1816.8	940.0	0.5
1454.871	MA - Min	300	5598.9	5600.7	5601.0	0.0086	4.5	66.5	62.6	0.77
1454.871	MA - Max	800	5598.9	5601.6	5602.0	0.0064	5.1	222.7	400.5	0.71
1303.384	2-YR Exst	2142	5598.5	5602.0	5602.6	0.0049	6.8	609.5	691.5	0.69
1303.384	2-YR Dev	4429	5598.5	5602.8	5603.4	0.0051	8.1	1258.7	852.3	0.73
1303.384	MA - Min	300	5598.5	5600.1	5600.3	0.0028	2.9	104.2	85.0	0.46
1303.384	MA - Max	800	5598.5	5600.9	5601.2	0.0042	4.8	179.4	138.6	0.6
1303.384	13+03 BF	585	5598.5	5601.0	5601.1	0.0020	3.3	175.0	85.5	0.41
1150.922	2-YR Exst	2142	5597.9	5601.4	5601.5	0.0027	4.1	1109.1	811.9	0.49
1150.922	2-YR Dev	4429	5597.9	5602.3	5602.4	0.0027	5.0	1857.8	921.6	0.51
1150.922	MA - Min	300	5597.9	5599.6	5599.8	0.0037	3.5	91.3	109.8	0.53
1150.922	MA - Max	800	5597.9	5600.5	5600.7	0.0026	3.7	476.1	643.4	0.46
1150.922	11+50 BF	810	5597.9	5601.1	5601.4	0.0033	4.1	197.7	103.2	0.52
997.3732	2-YR Exst	2142	5597.2	5600.9	5601.1	0.0032	4.6	1081.9	823.2	0.53
997.3732	2-YR Dev	4429	5597.2	5601.9	5602.0	0.0027	5.1	1906.0	897.4	0.49
997.3732	MA - Min	300	5597.2	5599.2	5599.3	0.0024	3.3	153.1	178.0	0.44
997.3732	MA - Max	800	5597.2	5599.9	5600.2	0.0048	4.9	328.3	358.9	0.7
846.1657	2-YR Exst	2142	5596.2	5600.5	5600.7	0.0018	4.1	1257.6	887.3	0.42
846.1657	2-YR Dev	4429	5596.2	5601.5	5601.7	0.0019	5.1	2127.4	1016.9	0.46
846.1657	MA - Min	300	5596.2	5599.1	5599.1	0.0006	1.6	340.3	326.3	0.22
846.1657	MA - Max	800	5596.2	5599.7	5599.8	0.0012	2.7	611.0	502.6	0.33
561.4447	2-YR Exst	2142	5598.3	5600.1	5600.2	0.0032	3.5	1317.4	779.9	0.51
561.4447	2-YR Dev	4429	5598.3	5601.0	5601.1	0.0030	4.7	2042.4	798.8	0.54
561.4447	MA - Min	300	5598.3	5598.8	5598.9	0.0025	1.3	428.7	603.4	0.36
561.4447	MA - Max	800	5598.3	5599.3	5599.3	0.0032	2.3	722.5	673.0	0.46

TABLE G-5

Proposed Conditions HEC-RAS Output File

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
459.4117	2-YR Exst	2142	5597.7	5599.7	5599.8	0.0047	4.3	1117.3	729.4	0.62
459.4117	2-YR Dev	4429	5597.7	5600.6	5600.8	0.0039	5.4	1839.0	776.3	0.61
459.4117	MA - Min	300	5597.7	5598.2	5598.3	0.0221	3.0	197.3	529.0	1.01
459.4117	MA - Max	800	5597.7	5598.8	5598.8	0.0079	3.3	518.2	627.8	0.7
459.4117	4+59 BF	70	5597.7	5598.4	5598.5	0.0112	2.5	28.1	81.6	0.75
343.4038	2-YR Exst	2142	5596.5	5599.4	5599.4	0.0020	3.1	1430.6	750.7	0.41
343.4038	2-YR Dev	4429	5596.5	5600.4	5600.5	0.0021	4.2	2209.2	834.3	0.46
343.4038	MA - Min	300	5596.5	5597.7	5597.7	0.0022	1.3	388.3	448.0	0.35
343.4038	MA - Max	800	5596.5	5598.4	5598.5	0.0021	1.8	773.0	618.1	0.37
343.4038	3+43 BF	20	5596.5	5598.0	5598.0	0.0007	0.7	30.3	75.8	0.18
223.2865	2-YR Exst	2142	5597.1	5599.1	5599.2	0.0025	3.4	1392.2	704.7	0.46
223.2865	2-YR Dev	4429	5597.1	5600.1	5600.2	0.0031	5.0	2098.2	805.4	0.55
223.2865	MA - Min	300	5597.1	5597.5	5597.5	0.0015	0.7	472.4	461.1	0.26
223.2865	MA - Max	800	5597.1	5598.2	5598.2	0.0020	1.7	810.7	545.2	0.35
114.2485	2-YR Exst	2142	5597.3	5598.8	5598.9	0.0035	2.4	1296.1	724.8	0.48
114.2485	2-YR Dev	4429	5597.3	5599.7	5599.8	0.0037	3.9	1979.8	777.3	0.55
114.2485	MA - Min	300	5597.3	5597.3	5597.3	0.0025	0.1	400.4	428.7	0.21
114.2485	MA - Max	800	5597.3	5597.9	5598.0	0.0034	1.4	687.0	505.5	0.41
7.0414	2-YR Exst	2142	5596.5	5598.5	5598.6	0.0028	3.4	1233.7	763.9	0.48
7.0414	2-YR Dev	4429	5596.5	5599.4	5599.5	0.0028	4.6	1919.5	793.0	0.52
7.0414	MA - Min	300	5596.5	5597.1	5597.1	0.0028	0.9	338.4	480.4	0.34
7.0414	MA - Max	800	5596.5	5597.6	5597.6	0.0028	2.0	639.3	571.7	0.42

Appendix H – Stream Stability Analysis

Stream Stability

Geomorphic Conditions from Cherry Creek Master Plan (URS, 2004)

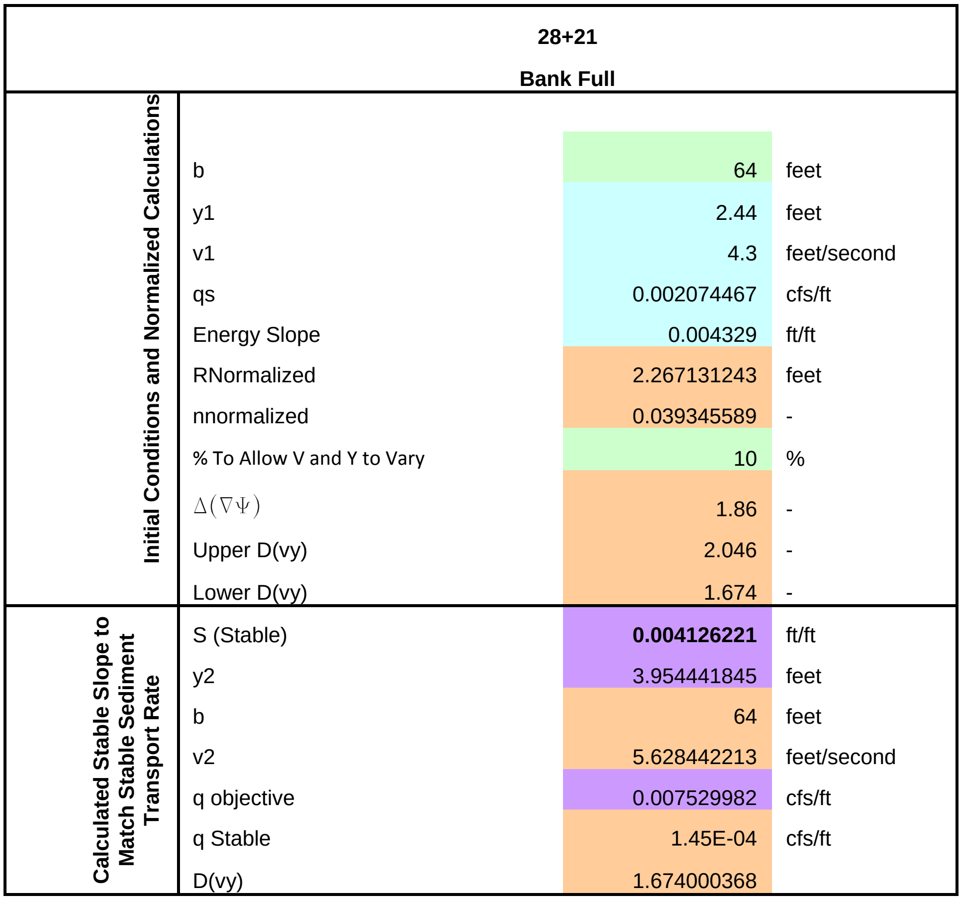
TABLE H-1

Geomorphic Characteristics by Reach from Cherry Creek Master Plan (URS, 2004)

Reach	Reach Grade (%)	Channel Condition	Bank Erosion	Dominant Stream Form	Rosgen Classification
1*	**0.41**	**Aggrading to Stable**	**None**	**Braided**	**D5**
2	0.39	Aggrading - Degrading Stable	None to Minor	Braided-Meandering	D5
3	0.37	Entrenched Segments, Degrading to Stable	Minor to Severe	Meandering	C5
4	0.37	Entrenched Segments, Degrading to Stable	Minor with Healing Banks to Severe	Meandering	C5, C5 change to F5, F5
5	0.41	Entrenched Segments, Degrading to Stable	Minor with Healing Banks to Severe	Meandering, Short Braided Segment	C5, D5, C5 change to F5, F5
6	0.37	Entrenched Segments, Degrading to Stable	Minor with Healing Banks to Severe	Meandering, Short Braided Segment	C5, D5, F5
7	0.41	Entrenched Segments, Mostly Stable	Minor	Meandering, Short Braided Segment	C5, D5, F5
8	0.39	Entrenched Segments, Mostly Stable	Minor	Meandering, Short Braided Segment	C5, D5, F5

*Cherry Creek at 12-Mile Park is within Reach 1

Stable Slope Spreadsheets



28+21

Bank Full

Initial Conditions and Normalized Calculations	b	64	feet
	y1	2.44	feet
	v1	4.3	feet/second
	qs	0.002074467	cfs/ft
	Energy Slope	0.004329	ft/ft
	RNormalized	2.267131243	feet
	nnormalized	0.039345589	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	1.86	-
	Upper D(vy)	2.046	-
	Lower D(vy)	1.674	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.004126221**	ft/ft
	y2	3.954441845	feet
	b	64	feet
	v2	5.628442213	feet/second
	q objective	0.007529982	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	1.674000368	

Color Key	
🟩	User Input
🟦	User Changes by Reach and Flow
🟧	User Does Not Change Internal Calculation
🟪	Fluctuates within Constraints of Optimization Model

(Typical for all spreadsheets)

28+21

2-Year Existing

Initial Conditions and Normalized Calculations	b	64	feet
	y1	2.83	feet
	v1	3.86	feet/second
	qs	0.001342442	cfs/ft
	Energy Slope	0.002548	ft/ft
	RNormalized	2.600057422	feet
	nnormalized	0.036842914	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	1.03	-
	Upper D(vy)	1.133	-
	Lower D(vy)	0.927	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.002936559**	ft/ft
	y2	4.651572498	feet
	b	64	feet
	v2	5.578573059	feet/second
	q objective	0.007530003	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	0.927000561	

28+21

2-Year Developed

Initial Conditions and Normalized Calculations	b	64	feet
	y1	4.02	feet
	v1	5.47	feet/second
	qs	0.006674716	cfs/ft
	Energy Slope	0.00274	ft/ft
	RNormalized	3.57134925	feet
	nnormalized	0.033314178	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	1.45	-
	Upper D(vy)	1.595	-
	Lower D(vy)	1.305	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.002777233**	ft/ft
	y2	4.152163925	feet
	b	64	feet
	v2	5.613366834	feet/second
	q objective	0.007529736	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	1.461202909	

27+18

Bank Full

Initial Conditions and Normalized Calculations	b	71	feet
	y1	2.72	feet
	v1	3.73	feet/second
	qs	0.001145277	cfs/ft
	Energy Slope	0.003216	ft/ft
	RNormalized	2.526425955	feet
	nnormalized	0.042021657	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	1.01	-
	Upper D(vy)	1.111	-
	Lower D(vy)	0.909	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.003739017**	ft/ft
	y2	4.66845402	feet
	b	71	feet
	v2	5.577454448	feet/second
	q objective	0.007529939	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	0.909000427	

27+18

2-Year Existing

Initial Conditions and Normalized Calculations	b	71	feet
	y1	4.41	feet
	v1	3.71	feet/second
	qs	0.001255709	cfs/ft
	Energy Slope	0.002056	ft/ft
	RNormalized	3.922701077	feet
	nnormalized	0.0452947	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	0.7	-
	Upper D(vy)	0.77	-
	Lower D(vy)	0.63	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.002997153**	ft/ft
	y2	6.258721753	feet
	b	71	feet
	v2	5.488721757	feet/second
	q objective	0.007530999	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	0.769999996	

27+18 **2-Year Developed**			
Initial Conditions and Normalized Calculations	b	71	feet
	y1	3.22	feet
	v1	4.98	feet/second
	qs	0.004204317	cfs/ft
	Energy Slope	0.0021	ft/ft
	RNormalized	2.952221074	feet
	nnormalized	0.028216241	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	1.76	-
	Upper D(vy)	1.936	-
	Lower D(vy)	1.584	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.002035014**	ft/ft
	y2	4.037996723	feet
	b	71	feet
	v2	5.621996841	feet/second
	q objective	0.007529995	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	1.584000117	

20+42

Bank Full

Initial Conditions and Normalized Calculations	b	36	feet
	y1	2.26	feet
	v1	5.65	feet/second
	qs	0.006698247	cfs/ft
	Energy Slope	0.007227	ft/ft
	RNormalized	2.007897335	feet
	nnormalized	0.035681616	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	3.39	-
	Upper D(vy)	3.729	-
	Lower D(vy)	3.051	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.008397206**	ft/ft
	y2	2.09838812	feet
	b	36	feet
	v2	5.827387452	feet/second
	q objective	0.007529998	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	3.728999332	

20+42

2-Year Existing

Initial Conditions and Normalized Calculations	b	36	feet
	y1	3.87	feet
	v1	8.39	feet/second
	qs	0.04270346	cfs/ft
	Energy Slope	0.00696	ft/ft
	RNormalized	3.185185185	feet
	nnormalized	0.032073921	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	4.52	-
	Upper D(vy)	4.972	-
	Lower D(vy)	4.068	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.016644804**	ft/ft
	y2	1.073477535	feet
	b	36	feet
	v2	6.045477542	feet/second
	q objective	0.00753	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	4.972000008	

20+42

2-Year Developed

Initial Conditions and Normalized Calculations	b	36	feet
	y1	4.84	feet
	v1	9.75	feet/second
	qs	0.086723374	cfs/ft
	Energy Slope	0.00685	ft/ft
	RNormalized	3.814360771	feet
	nnormalized	0.030877452	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	4.91	-
	Upper D(vy)	5.401	-
	Lower D(vy)	4.419	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.009685566**	ft/ft
	y2	1.513666864	feet
	b	36	feet
	v2	5.932666375	feet/second
	q objective	0.007529999	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	4.418999511	

16+05

Bank Full

Initial Conditions and Normalized Calculations	b	110	feet
	y1	2.51	feet
	v1	2.24	feet/second
	qs	0.000121619	cfs/ft
	Energy Slope	0.002283	ft/ft
	RNormalized	2.400452095	feet
	nnormalized	0.056979666	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	0.27	-
	Upper D(vy)	0.297	-
	Lower D(vy)	0.243	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.005565161**	ft/ft
	y2	5.244887018	feet
	b	110	feet
	v2	5.541886749	feet/second
	q objective	0.007529433	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	0.296999731	

16+05

2-Year Existing

Initial Conditions and Normalized Calculations	b	110	feet
	y1	3.86	feet
	v1	3.29	feet/second
	qs	0.000720388	cfs/ft
	Energy Slope	0.002011	ft/ft
	RNormalized	3.606863744	feet
	nnormalized	0.047765709	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	0.57	-
	Upper D(vy)	0.627	-
	Lower D(vy)	0.513	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.003189532**	ft/ft
	y2	6.122134128	feet
	b	110	feet
	v2	5.495133175	feet/second
	q objective	0.007529616	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	0.627000953	

16+05

2-Year Developed

Initial Conditions and Normalized Calculations	b	110	feet
	y1	4.7	feet
	v1	4.05	feet/second
	qs	0.001868673	cfs/ft
	Energy Slope	0.002166	ft/ft
	RNormalized	4.32998325	feet
	nnormalized	0.045486719	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	0.65	-
	Upper D(vy)	0.715	-
	Lower D(vy)	0.585	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.003935288**	ft/ft
	y2	4.850789742	feet
	b	110	feet
	v2	5.565789305	feet/second
	q objective	0.007530154	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	0.714999564	

		13+03 Bank Full	
Initial Conditions and Normalized Calculations	b	91	feet
	y1	2.47	feet
	v1	3.34	feet/second
	qs	0.000691492	cfs/ft
	Energy Slope	0.001961	ft/ft
	RNormalized	2.342818428	feet
	nnormalized	0.034847451	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	0.87	-
	Upper D(vy)	0.957	-
	Lower D(vy)	0.783	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.002431167**	ft/ft
	y2	4.745330186	feet
	b	91	feet
	v2	5.572423121	feet/second
	q objective	0.007529704	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	0.827092935	

13+03

2-Year Existing

Initial Conditions and Normalized Calculations	b	91	feet
	y1	3.47	feet
	v1	6.83	feet/second
	qs	0.016967232	cfs/ft
	Energy Slope	0.004886	ft/ft
	RNormalized	3.224116806	feet
	nnormalized	0.033279961	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	3.36	-
	Upper D(vy)	3.696	-
	Lower D(vy)	3.024	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.004683485**	ft/ft
	y2	2.720979882	feet
	b	91	feet
	v2	5.744979698	feet/second
	q objective	0.007530004	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	3.023999816	

13+03

2-Year Developed

Initial Conditions and Normalized Calculations	b	91	feet
	y1	4.27	feet
	v1	8.08	feet/second
	qs	0.037100844	cfs/ft
	Energy Slope	0.005077	ft/ft
	RNormalized	3.903656821	feet
	nnormalized	0.032575636	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	3.81	-
	Upper D(vy)	4.191	-
	Lower D(vy)	3.429	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.005452735**	ft/ft
	y2	2.360861545	feet
	b	91	feet
	v2	5.789861497	feet/second
	q objective	0.007530002	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	3.428999952	

4+97

Bank Full

Initial Conditions and Normalized Calculations	b	61	feet
	y1	1.73	feet
	v1	3.65	feet/second
	qs	0.000935164	cfs/ft
	Energy Slope	0.004829	ft/ft
	RNormalized	1.637139311	feet
	nnormalized	0.039404495	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	1.92	-
	Upper D(vy)	2.112	-
	Lower D(vy)	1.728	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.004454312**	ft/ft
	y2	3.756719744	feet
	b	61	feet
	v2	5.64424762	feet/second
	q objective	0.007529735	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	1.887527876	

4+97

2-Year Existing

Initial Conditions and Normalized Calculations	b	61	feet
	y1	4.55	feet
	v1	2.86	feet/second
	qs	0.000406835	cfs/ft
	Energy Slope	0.00582	ft/ft
	RNormalized	3.959343795	feet
	nnormalized	0.099471165	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	1.69	-
	Upper D(vy)	1.859	-
	Lower D(vy)	1.521	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.01309658**	ft/ft
	y2	6.976914659	feet
	b	61	feet
	v2	5.455915479	feet/second
	q objective	0.007529679	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	1.52099918	

4+97

2-Year Developed

Initial Conditions and Normalized Calculations	b	61	feet
	y1	5.88	feet
	v1	3.86	feet/second
	qs	0.001598821	cfs/ft
	Energy Slope	0.0072	ft/ft
	RNormalized	4.929631666	feet
	nnormalized	0.094872758	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	2.02	-
	Upper D(vy)	2.222	-
	Lower D(vy)	1.818	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.011359121**	ft/ft
	y2	7.261993574	feet
	b	61	feet
	v2	5.443993799	feet/second
	q objective	0.007529934	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	1.817999775	

4+59

Bank Full

Initial Conditions and Normalized Calculations	b	83	feet
	y1	0.76	feet
	v1	2.49	feet/second
	qs	0.000144991	cfs/ft
	Energy Slope	0.011188	ft/ft
	RNormalized	0.746332229	feet
	nnormalized	0.052077638	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	1.73	-
	Upper D(vy)	1.903	-
	Lower D(vy)	1.557	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.007171425**	ft/ft
	y2	3.87762711	feet
	b	83	feet
	v2	5.634464266	feet/second
	q objective	0.007529788	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	1.756837156	

4+59 **2-Year Existing**			
Initial Conditions and Normalized Calculations	b	83	feet
	y1	2	feet
	v1	4.33	feet/second
	qs	0.002387526	cfs/ft
	Energy Slope	0.004679	ft/ft
	RNormalized	1.908045977	feet
	nnormalized	0.036210466	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	2.33	-
	Upper D(vy)	2.563	-
	Lower D(vy)	2.097	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.003880366**	ft/ft
	y2	3.56363847	feet
	b	83	feet
	v2	5.660639302	feet/second
	q objective	0.007529984	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	2.097000832	

4+97

2-Year Developed

Initial Conditions and Normalized Calculations	b	83	feet
	y1	2.94	feet
	v1	5.44	feet/second
	qs	0.006047059	cfs/ft
	Energy Slope	0.003886	ft/ft
	RNormalized	2.74549955	feet
	nnormalized	0.0334775	-
	% To Allow V and Y to Vary	10	%
	$\Delta(\nabla\Psi)$	2.5	-
	Upper D(vy)	2.75	-
	Lower D(vy)	2.25	-
Calculated Stable Slope to Match Stable Sediment Transport Rate	S (Stable)	**0.003500341**	ft/ft
	y2	3.423136829	feet
	b	83	feet
	v2	5.673137135	feet/second
	q objective	0.007529999	cfs/ft
	q Stable	1.45E-04	cfs/ft
	D(vy)	2.250000306	

Appendix I – Phosphorus Removal Memo

William P. Ruzzo, PE, LLC
6641 West Hamilton Drive,
Lakewood, Colorado 80227
(303) 985-1091
(303) 989-6561 fax
bill.ruzzo@comcast.net

Memorandum

To: Rick Goncalves, Chairman, CCBWQA TAC

CC: Chuck Reid, Manager, CCBWQA

From: William P. Ruzzo, P.E.

Date: May 25, 2011

Re: Cherry Creek Stream Reclamation at 12-Mile Park – Water Quality Benefits and Costs

Presented in this memorandum is a more detailed evaluation of the water quality benefits and costs for the Cherry Creek Stream Reclamation at 12-Mile Park project (12-Mile Park). The 12-Mile Park project consists of approximately 3,000 feet along the outside bend of Cherry Creek adjacent to the existing dog park (see Figure 1).

BACKGROUND

Water quality benefits and costs for the 12-Mile Project were first evaluated for the 2008 5-year capital improvement program (CIP) based on master planning level estimates for projects costs. Since then, the Authority initiated alternative investigations and preliminary design for the 12-Mile Project resulting in updated information on stream reclamation needs and cost projections[1]. Also, a breach in the right bank of Cherry Creek resulted in stream flows being diverted away from the main channel resulting in sediment deposition in the wetlands and other environmental damages that were not considered in the 2008 water quality evaluation.

In addition, Cherry Creek State Park (CCSP) has been developing a plan to upgrade the off-leash dog area (DOLA) adjacent to and part of the 12-Mile Park project. CCSP projections conservatively estimated the number of dog visits per year to be 450,000. Because the CCSP and the Authority project are overlapping in area, water quality impact, and benefits, the two projects are integral. This updated information provides the basis for preparing a more detailed evaluation of water quality costs and benefits for the 12-Mile Park project.

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[1] CH2MHill April 2011. *Cherry Creek at 12-Mile Park Draft Alternatives Evaluation Report.*

OVERVIEW OF WATER QUALITY BENEFITS

Water quality benefits from the combined 12-Mile Park and DOLA projects (combined projects) fall into one of two categories, stream reclamation or recreation management.

Stream Reclamation. Stream reclamation benefits and evaluation procedures have been documented in the Authority's Stream Reclamation Interim Report[2]. Benefits include reductions in sediment and other pollutant loads and concentrations, including phosphorus and nitrogen. These benefits are supported by Authority data, literature research, and quantitative analysis. Procedures used by the Authority to quantify phosphorus reduction benefits are also provided in the Interim Report and were used herein to quantify benefits of the 12-Mile Park project.

The CH2M Hill stream reclamation plan also addresses the dispersed runoff from the DOLA by including a bioswale along the top of the east bank of Cherry Creek. This BMP is intended to capture minor storm events from the DOLA and provide filtration and infiltration treatment of the runoff.

Because of the breach that occurred in the right bank of Cherry Creek, the 12-Mile Park project also includes repairs and restoration of Cherry Creek and the damaged wetland area. The primary benefit of the breach repair that's not included in overall stream reclamation is the removal of deposited sediment and vegetative restoration of the damaged area. The benefits of sediment removal have been quantified in this memo using procedures documented in the Interim Report.

Recreation Management. The CCSP DOLA project includes extensive improvements, relative to water quality, such as perimeter fencing, controlled access to Cherry Creek, and waste management practices. Quantification of water quality benefits for perimeter fencing and controlled access to Cherry Creek is assumed to be part of the overall stream reclamation benefits. Benefits of waste management practices, however, have been quantified in this memorandum.

In addition to management of the dog use area, the overall CCSP project includes modifications to the horse boarding area, which is adjacent to the DOLA area on the west and south. The principal modification to the horse area, relative to water quality, will be an updated manure management plan, whose benefits have been quantified in this memorandum.

QUANTIFICATION OF WATER QUALITY BENEFITS

Calculations were performed to quantify the water quality benefits associated with stream reclamation and recreation management activities discussed above. The

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[2] CCBWQA Technical Advisory Committee, April 12, 2011 (final draft). *Stream Reclamation, Water Quality Benefit Evaluation – Interim Report.*

calculations, assumptions, and variables used in the analysis are provided within the appendix to this memorandum. A summary of the calculations is presented below.

Stream Reclamation. Calculations (sheet 1) were made following the guidelines in the Interim Report, except that the interest rate used for this analysis was 4%[3]. The results show that over the life of the project, the phosphorus reduction for stream stabilization alone is 51-lbs per year and the life-time unit cost is $1,520 per pound of phosphorus.

Calculations for the breach area benefits (sheet 2) were based solely on the phosphorus content of eroded sediment from the wetlands area using data gathered as part of the reclamation project design. The benefits (i.e.: phosphorus load in the sediment) was spread out over the assumed project life of 35-years, resulting in an additional 37 lbs per year of phosphorus reduction.

Calculations for the bio-swale benefits are discussed under the Dog Use Area Improvements and the Waste Management Plan for Horse Boarding Area, but are considered part of the stream reclamation benefits because the 12-Mile Park project includes a bioswale. The reported[4] effectiveness of bio-swales to immobilize phosphorus varies widely (i.e.: 30 to 80%). For conservatism, bio-swale effectiveness was assumed to be 30% for phosphorus immobilization.

Dog Use Area Improvements. Calculations (sheet 3) of benefits associated with management of the dog wastes are based on values generated by CCSP using traffic counts, visitor surveys, and DOLA pass sales. Their analysis of the DOLA area use shows that about 450,000 dog-visits per year occur generating four cubic yards of waste per week. Since dog waste contain around 10% of phosphates per pound, the DOLA generates over 25,000 pounds of phosphorus per year which could reach Cherry Creek if not managed properly[5]. The CCSP dog waste management plan is anticipated to be 90% efficient in removal of waste and phosphorus, resulting in a net water quality by reducing almost 23,000 pounds of phosphorus per year.

For the stream reclamation component (sheet 3), it is conservatively estimated that 10% of the dog wastes will not be removed through waste management, but would still be treated before discharging into Cherry Creek by including bioswale in the stream reclamation plan along the creek bank adjacent to the DOLA. The assumed efficiency of the bio-swale is 30%, which is conservatively low. This BMP can

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[3] At the Boards request, the Authority is investigating the appropriate discount rates to be used in evaluation of Authority CIP projects. The value used has not been approved by the Board but is believed to be a reasonable rate for this analysis.

[4] Oregon Department of Environmental Quality January 2003. *Biofilters (Bioswales, Vegetative buffers, & Constructed Wetlands for Storm Water Discharge Pollution Removal.*

[5] The amount of phosphorus in dog waste used in this analysis is approximately 0.6 lbs/year/dog. Lake Tahoe investigation (http://www.4swep.org/resources/LakeTahoeReport/064.html) suggest the value could be as high as 2 lbs/year/dog.

effectively prevent about 780 lbs/year of phosphates from dog wastes from entering Cherry Creek.

Waste Management Plan for Horse Boarding Area. Calculations (sheet 4) of benefits associated with an effective horse manure management plan are based on the pending renewal of the concessionaire lease for the facility. Based on an internet literature search, the amount of manure waste per 1,000-pound horse and the phosphorus content were determined. The number of horses and the rental season were approximated from discussions with CCSP staff. The horse boarding area is estimated to generate over 232,000 pounds of phosphorus per year.

For the stream reclamation component, it is conservatively estimated that 10% of the manure wastes will not be removed through waste management, but would still be treated before discharging into Cherry Creek by including bio-swale in the stream reclamation plan along the creek bank adjacent to the DOLA. The assumed efficiency of the bio-swale is 30%, which is conservatively low. This BMP can effectively prevent about 21 pounds/year of phosphates from manure wastes from entering Cherry Creek.

The potential impacts of storm runoff from dog waste and horse manure on phosphorus concentrations in Cherry Creek were also estimated for the loads that are not otherwise removed through waste management practices (sheet 5). The estimated annual phosphorus load from these sources is 2,670 pounds and the mean annual flow in Cherry Creek at 12-Mile Park project is estimated to be 15,000 acre feet. This converts to a concentration of 0.065 mg/l. When compared to the mean annual phosphorus concentration in Cherry Creek (i.e.: 0.210 mg/l), the potential impacts are apparent. Phosphorus from dog waste and horse manure could contribute to the degradation of water quality in Cherry Creek Reservoir.

WATER QUALITY COST/BENEFITS

The final step in the analysis was a comparison of project costs and benefits, as measured by the reduction in phosphorus through project construction. Cost and benefits are compared separately for the Authority's stream reclamation work and the CCSP recreation management work.

Stream Reclamation. Table 1 below shows the benefits of stream reclamation individual components and Table 2 compares the cost and benefits for the total stream reclamation work that also includes benefits of breach repairs and sediment removal, and the bio-swale to treat storm runoff from dog waste and manure wastes.

Table 1 – Average Annual Phosphorus Reduction Benefits for Components of Stream Reclamation

Reclamation Component	Phosphorus Reduction	Units
Bed/Bank stabilization annual P load Reduction	51	lbs P/year
Breach Repair average annual P load reduction	37	lbs P/year
Bioswale treatment of Dog Wastes	780	lbs P/year
Bioswale treatment of Manure Wastes	21	lbs P/year
Total	889	lbs P/year

Table 2 – Stream Reclamation Benefit Cost Analysis – Complete Project

Item	Cherry Creek Stream Reclamation @ 12-Mile Park
Project Length (mi) =	0.57
Project Capital Costs[1] =	$ 1,451,000
Project Cost per mile =	$ 2,554,000
Stream Reclamation Water Quality Benefits (lbs/mi/yr) =	90
Total Phosphorus reduction benefits (lbs/yr)[3] =	889
Capital Recovery Factor (4% 35-years) =	0.0538
Annualized Capital Cost =	$ 78,100
Annual O&M Cost(2.5%)[2] =	$ 36,275
Project Annual Unit Cost ($/lb) =	$ 129
Baseline Project Life (yr) =	35
Project Life Time Costs =	$ 2,720,625
Project Life Time Water Quality Benefits (lb) =	31118
Project Life Time Unit Costs ($/lb) =	$ 87

NOTES:

1. CH2M Hill February 2011. Draft Alternatives Evaluation Report
2. Ruzzo August 25, 2004. *CCBWQA - Long-Term Capital Budget Projections*
3. Includes benefits of sediment removal and of bio-swale treatment of dog and horse manure wastes.

Without the repairs to the breach area, sediment removal, and bio-swales to treat dog and horse manure wastes, the Project Life Time Unit Costs would be $1,520/pound of phosphorus (see appendix sheet 1). Adding the benefits of repairing the breach area to the benefits of stream reclamation, the results show that over the life of the project, the phosphorus reduction is 889-lbs per year and the life-time unit cost is $87 per pound of phosphorus. These additional benefits represent over a ten-fold reduction in cost per pound of phosphorus.

Recreation Management. Table 3 below shows the costs and benefits, as measured by the reduction in phosphates, associated with the recreational modifications for the DOLA and the horse concession. The analysis suggests that the waste management practices for the DOLA and horse concession could be as low as two dollars per pound of phosphorus removed.

Table 3 – Recreation Management Cost and Benefits.

Item	Recreation Management
Project Capital Costs[1] =	$ 1,100,000
Capital Recovery Factor (4% 35-years) =	0.0538
Annualized Capital Cost =	$ 59,200
Annual O&M Cost(2.5%)[2] =	$ 27,500
Baseline Project Life (yr) =	35
Project Life Time Costs =	$ 2,062,500
DOLA Dog waste management benefits (lbs P/year)=	22950
Horse manure waste management benefits (lbs P/year) =	628
Project Annual Water Quality Benefits (lbs/yr) =	23578
Project Life Time Water Quality Benefits (lb) =	825221
Project Annual Unit Cost ($/lb) =	$ 4
Project Life Time Unit Costs ($/lb) =	$ 2

NOTES:

1. Cost estimate by CCSP
2. Ruzzo August 25, 2004. *CCBWQA - Long-Term Capital Budget Projections*

CONCLUSIONS

The Authority uses the cost per pound of phosphorus immobilized as a metric to compare capital projects and to assess the water quality benefits. The Authority's contribution to projects is sometimes limited to a cost of $600 per pound of phosphorus when partnering with other agencies or local government.

The analysis presented herein suggests that when concentrated nutrient (phosphorus) sources are addressed, along with stream reclamation, the water quality benefits are significantly increased, and can reduce cost per pound to values below $100 per pound. This supports the Authority's approach of also addressing local sources of nutrients, when partnering with others on stream reclamation projects.

Figure 2. Cherry Creek State Park Preferred Alternative

Cherry Creek State Park
Dog Off-Leash Area Project

Colorado State Parks

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK STREAM RECLAMATION AT 12-MILE PARK
EVALUATION OF COST AND BENEFITS

PHOSPHORUS LOADS FROM STREAM RECLAMATION
AND ESTIMATED WATER QUALITY BENEFITS

Item	Cherry Creek Stream Reclamation @ 12-mile Park
Project Length (mi) =	0.57
Project Capital Costs[1] =	$ 1,451,000
Project Cost per mile =	$ 2,554,000
Stream Reclamation Water Quality Benefits (lbs/mi/yr) =	90
Project Annual Water Quality Benefits (lbs/yr) =	51
Capital Recovery Factor (4% 35-years) =	0.0538
Annualized Capital Cost =	$ 78,100
Annual O&M Cost(2.5%)[2] =	$ 36,275
Project Annual Unit Cost ($/lb) =	$ 2,237
Baseline Project Life (yr) =	35
Project Life Time Costs =	$ 2,720,625
Project Life Time Water Quality Benefits (lb) =	1790
Project Life Time Unit Costs ($/lb) =	$ 1,520

NOTES:

1. CH2M Hill February 2011. Draft Alternatives Evaluation Report
2. Ruzzo August 25, 2004. *CCBWQA - Long-Term Capital Budget Projections*

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK STREAM RECLAMATION AT 12-MILE PARK
EVALUATION OF COST AND BENEFITS

PHOSPHORUS LOADS FROM BREACH AREA DAMAGE AND ESTIMATED REPAIR BENEFITS

ASSUMPTIONS:

Volume of material deposited in wetland pond[1] = 2000 cy
Volume of other sediment deposits = unknown cy
Phosphorus content in sediment[1] = 0.6 lbs/ton
Sediment density = 80 pcf

LOAD CALCULATIONS

Single event load = 1296 lbs P

PHOSPHORUS REDUCTION BENEFIT

Since the sediment in the wetland pond will be removed from CCSP to balance imported mateials then the phosphorus load reduction is a one-time benefit spread over the life of the project.

Project life assumption = 35 years
Average annual P load reduction = 37 lbs P/year

Add this amount to the estimated amount for stream reclamation to identify benefits of breach repair

NOTES:

1. CH2M Hill February 2011. Draft Alternatives Evaluation Report
2. Ruzzo August 25, 2004. *CCBWQA - Long-Term Capital Budjet Projections*

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK STREAM RECLAMATION AT 12-MILE PARK
EVALUATION OF COST AND BENEFITS
PHOSPHATE LOADS FROM DOLA AND ESTIMATED BMP BENEFITS

DOG USE INFORMATION

	Quantitity	Unit	Source
Dogs use at DOLA areas =	450,000	#dogs/year	CCSP[1]
Waste produced =	4	cy/week	CCSP[1]

ASSUMPTIONS:

Dog waste, Phosphate =	10%	% Phosphate/lb	http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-18/
Waste production =	0.2	lbs/dog/day	http://www.poopbutler.com/pooper-scooper-health.htm
Waste density =	45.0	pcf	Assumed similar to horses, dry
Season =	365	days/year	CCSP Manager

LOAD CALCULATIONS

Waste production =	4900	lbs/week
Waste production =	254800	lbs/year
Phosphates produced =	25500	lbs/year

NOTES: 1. Values generated using traffic counters, visitor surveys and DOLA pass sales.

CCSP WASTE MANAGEMENT PLAN BENEFITS

Dog waste management effectiveness =	90%	percent reduction per year	Assumption vetted by CCSP personnel
Average annual P load reduction =	22950	lbs/year	

AUTHORITY STREAM RECLAMATION PLAN

Phosphates in storm runoff =	2600	lbs/year	
Effectiveness of bio-swale areas =	30%	percent reduction per year	http://www.deq.state.or.us/wq/stormwater/docs/nwr/biofilters.pdf
Water Quality Benefits =	780	lbs P/year reduction	

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK STREAM RECLAMATION AT 12-MILE PARK
EVALUATION OF COST AND BENEFITS

PHOSPHATE LOADS FROM HORSE CONCESSION AND ESTIMATED BMP BENEFITS

HORSE USE INFORMATION

	Quantitity	Unit	Source
Horses boarded/rented =	50		Estimate, CCSP Manager

ASSUMPTIONS:

Horse waste, Phosphate =	6	lbs Phosphate/ton	http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-18/
Waste production =	31.0	lbs/day/1000lb horse	http://pubs.cas.psu.edu/freepubs/pdfs/ub035.pdf
Waste density =	63.0	pcf	http://pubs.cas.psu.edu/freepubs/pdfs/ub035.pdf
Season =	150	days/year	CCSP manager

LOAD CALCULATIONS

Waste production =	1550	lbs waste/day
Waste production =	232500	lbs waste/year
Phosphates produced =	698	lbs/year

NOTES: 1. Values generated using traffic counters, visitor surveys and DOLA pass sales.

CCSP WASTE MANAGEMENT PLAN BENEFITS

Waste management effectiveness =	90%	percent reduction per year	Assumption vetted by CCSP personnel
Average annual P load reduction =	628	lbs/year	

AUTHORITY STREAM RECLAMATION PLAN

Phosphates in storm runoff =	70	lbs/year	
Effectiveness of bio-swale areas =	30%	percent reduction per year	http://www.deq.state.or.us/wq/stormwater/docs/nwr/biofilters.pdf
Water Quality Benefits =	21	lbs P/year reduction	

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK STREAM RECLAMATION AT 12-MILE PARK
EVALUATION OF COST AND BENEFITS
PHOSPHATE CONCENTRATION DUE TO DOG AND HORSE WASTE

ITEM	QUANTITY	UNITS
Loads		
Annual Dog Waste P loads (not otherwise removed in dumpsters)	2600	lbs/year
Horse manue Waste P loads (not otherwise removed by concessionaire)	70	lbs/year
Total Phosphorus loads from recreation areas	2670	lbs/year
Runoff Volume		
Mean annual inflow to Reservoir[1]	16080	af
Watershed area at dam	386	sq.mi
Watershed area at 12-Mile Park	360	sq.mi
Adjusted mean annual inflow to Reservoir	15000	af
Unit load from dog and horse waste	0.18	lbs/af
Unit load from dog and horse waste	0.065	mg/l
Flow weighted mean annual phosphorus conc[1].	0.210	mg/l

NOTES:

1. CCBWQA 2011. *2010 Annual Report on Activities*