CONSTRUCTION REPORT
ST. VRAIN CREEK REACH 3 RESTORATION

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Construction Report
St Vrain Creek Reach 3 Restoration
Boulder County, Colorado

Prepared for:

Boulder Country Parks and Open Space

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Longmont, Colorado 80503

Prepared for:

by

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Project No. 110666

June 2018

CERTIFICATE
ST VRAIN REACH 3

ENGINEER'S CERTIFICATION

I hereby certify that these Specifications for the **ST VRAIN REACH 3 STREAM RESTORATION PROJECT** for Boulder County Parks and Open Space Department were prepared by me, or under my direct supervision for the Owners thereof.

COLORADO REGISTERED
LESTER CLINTON BROWN
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PROFESSIONAL ENGINEER

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June 19, 2018
Date

EXECUTIVE SUMMARY

Construction for the St. Vrain Creek Reach 3 Restoration project began in October 2017. The scope of work included: 1) Removal of inorganic and organic debris; 2) Clearing, stripping, grubbing; 3) Breach repairs with clay core and riprap armoring; 4) Bank stabilization; 5) Stream restoration (riffles, glides, pools); 6) Grading of floodplain; 7) Revegetation.

Construction did not experience any significant delays and only minor field adjustments were needed. Work was substantially completed in May 2018.

Based on our observation and testing throughout the project, the work was conducted in accordance with the approved plans and specifications. Changes to the original plans and issues addressed during construction are described in this report and are shown on the "As-Constructed" drawings.

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1.0 INTRODUCTION

The project site is located along the St. Vrain Creek, approximately one-quarter mile east of the intersection of US Highway 36 East/N Foothills Highway and State Highway 66/Ute Highway, downstream to Crane Hollow Road in Boulder County, Colorado. The project area is within what is known as Reach 3 of the St. Vrain Creek, as defined in the St. Vrain Creek Coalition (SVCC) St. Vrain Creek Watershed Master Plan (Baker Team 2014).

This report summarizes the design changes, construction observations, and field testing results for the project.

1.1 Project Goals and Objective

The proposed scope of work included: 1) Removal of inorganic and organic debris; 2) Clearing, stripping, grubbing; 3) Breach repairs with clay core and riprap armoring; 4) Bank stabilization; 5) Stream restoration (riffles, glides, pools); 6) Grading of floodplain; 7) Revegetation.

2.0 DESIGN CHANGES

Memorandums of record were utilized to modify the unit cost for three pay item pricing: Erosion Control Fabric, the addition of Modified Type C Bank Stabilization, and Wood Straw, and a Revised Bid Tab. The purpose of the change order is defined by the following items:

> Erosion Control Fabric: Adjust contract price to account for change of material due to conflicting information in the Construction Specifications.
>
> Modified Type C Bank Stabilization: Add a pay item to accommodate new design for bank stabilization that addressed Quality Assurance Team concerns about Type D Bank Stabilization design and incorporated components of both the Type D and Type C bank stabilization plan designs.
>
> Wood Straw: The wood straw warranty between the contractor and the manufacturer holds for 60% cover with slopes flatter than 3:1. The project changed in percent coverage to maintain warranty from the vender but allow cost savings for the project at a time where the budget appeared insufficient to finish the project within budget.
>
> Revised Bid Tab: The Bid Tab was revised to portray final quantities of materials used, additional costs, and added line items.

No other significant changes were necessary. Minor changes were made periodically throughout the project as deemed necessary by the design team to math field conditions.

2.1 Formal Changes: Contract Amendments

There were the following amendments to the design:

- Amendment 1 – removal of the Bifurcation Structure Bid Tab from the project scope.
- Contract Amendments 2 and 3 discuss the extension of time from the funding agency.

Contract Amendments 1 through 3 and the Memorandums of Record from March invoice and final invoice are included in Appendix A.

2.2 Minor Changes

Minor changes of the project were documented in Work Change Directives (WCDs) and Field Directives (FDs). WCDs summarized a change in project scope, quantity, or cost. FDs summarized corrections or clarifications in the design that did not results in a change to project scope, quantity, or cost. The WCDs, FDs, and WCD Summary are included in Appendix B.

3.0 CONSTRUCTION AND FIELD ADJUSTMENTS

The contractor for this project was American Civil Constructors (ACC), Mountain West Division, out of Littleton, Colorado. Engineering Analytics, Inc. (EA), Ecological Resource Consultants, Inc. (ERC), and Ecosystems, LLC (ECOS), referred to in this report as the Design Team, provided construction oversight throughout the construction phase of the project. EA provided oversite testing for excavation limits, backfill, and riprap. ERC provided quality assurance on bank stabilization and stream restoration. ECOS provided construction oversight of the revegetation. Construction for St. Vrain Creek Reach 3 began in October 2017 and was completed in May 2018. Construction started slowly but overall had no major delays. there were several no-work days due to weather. The weather conditions, taken from a weather station located at the Longmont Airport, for the site during the construction phase are summarized in Appendix C.

Project-wide, a total of 1.48 miles of the St. Vrain Creek was restored, 2,835 linear feet (LF) of bank stabilization structure was installed, 21 riffle/pool sequences constructed, 4 breaches repaired, 113 boulder clusters placed, 43,181 plants installed (13,681 wetland plugs, 11,994 trees and shrubs, and 17,506 willows), 180 loads of organic and inorganic waste removed from the project site, and 19.3 acres (AC) of upper riparian seed and 12.2 AC of lower riparian seed installed.

The accomplishments of this project, as described in this report, is summarized by location. There are 5 areas referred to herein: Breach 1, Breach 2, Ramey, Hepp, and Crane Hollow. These location extents are shown in Figure 1.

The construction accomplishments are summarized in the following paragraphs. The construction photographs are presented in Appendix D. The Design Team's construction observation reports are in Appendix E, and daily reports by ACC are in Appendix F. Weekly construction meeting minutes are in Appendix G.

3.1 Breach 1

The Breach 1 area ranges between river stations 197+00 and 176+00. It is the work zone on the project that is furthest upstream. The start of stream work was determined by the property line of the Town of Lyons and the Vasquez property. The Breach 1 area includes the Breach 1 berm repair, 600 LF of bank stabilization (BS-14 and BS-15), 26 boulder clusters, 4 riffle/pool sequences (no. 23-26), and the revegetation of the Boulder County property (Boulder County conservation easement) on river right, Vasquez property on river left, and the Boulder County property adjacent to Burlington Northern Santa Fe (BNSF) railroad on river left and river right.

3.1.1 *Breach 1 Repair*

On river right of the Breach 1 area, the existing temporary berm was removed. Existing riprap, considered acceptable by the Engineer, was stockpiled for reuse. A new berm with a clay core was installed. Type M riprap, along with salvaged riprap from the existing berm, was placed on both sides of the clay core for erosion protection. The riprap was placed on top of nonwoven geotextile, and then filled with soil. The project extents of the Breach 1 berm were such that the structure would be sufficient in its hydraulic function while minimizing the footprint of disturbance. The Breach 1 repair construction occurred from mid-December to early February. Images A-01 and A-02 shows the dewatering of the clay core excavation. Images A-03 through A-05 show the clay core installation. Image A-06 shows the riprap placed against the clay core.

3.1.2 *Stream Channel Restoration*

Breach 1 included 4 riffle/pool sequences (no. 23-26). Boulder clusters were placed in the riffles and pools to create preferential flow paths occurring in a naturally sinuous pattern. In total, 20 imported boulders and 53 native boulders were strategically placed in the stream to form 26 boulder clusters in the Breach 1 area. Riffle/pool sequences no. 25-26 were constructed from mid-February to mid-March, and no. 23-24 were constructed during the first half of April. Images A-06 through A-13 show the riffle/pool sequences with boulder clusters.

3.1.3 *Bank Stabilization*

The Breach 1 area consists of 2 bank stabilizations: BS-15 which is a Type B bank stabilization on river right and BS-14 which is a Type A bank stabilization on river left. BS-15 was constructed from mid-February to mid-March. BS-14 was constructed during the first half of April.

3.1.4 *Vegetation*

The Boulder County and Vasquez properties were vegetated with lower and upper riparian seed and soil was amended with topsoil, compost, granular humate, granular inocula, fertilizer, and wood straw. Willows, wetland plugs, and trees and shrubs were planted in these areas. Erosion control blanket and willows were placed along the repaired banks at bankfull elevation according to plan sheets RD2 and RD3. Willows have the design spacing of 3 willows per LF. The executed spacing across the project ranged from 2.4 to 4.7 willows per LF. Some locations did not meet the minimum spacing requirement because of site-specific physical limitations. The topsoil, vegetation, and planting at Breach 1 occurred in the month of May. Images A-14 through A-16 show the vegetation efforts at Breach 1.

3.2 Breach 2

The Breach 2 area ranges between river stations 137+50 and 108+50. It extends from the Breach 2 repair to the work just downstream of the mining operations concrete crossing, south of the Martin Marietta property. The Breach 2 area includes the Breach 2 berm repair, 335 LF of bank stabilization (BS-10, BS-11 and BS-13), 25 boulder clusters, 4 riffle/pool sequences (no. 14, 15, 21, and 22), and the revegetation of the disturbed areas.

3.2.1 *Breach 2 Repair*

On river right of the Breach 2 area, the existing temporary berm was removed. The Breach 2 repair is located between St. Vrain Creek and Western Mobile Lake 2. Existing riprap, considered acceptable to the Engineer, was stockpiled for reuse. A new berm with a clay core was installed. Type M riprap, along with salvaged riprap from the existing berm, was placed on both sides of the clay core for erosion protection. The original plans called for Type H riprap. Type M with a greater thickness was determined as an equal replacement of Type H, as documented in Request for Information 11 (RFI-11) In Appendix H. The riprap was placed on top of nonwoven geotextile, and then filled with soil. The Breach 2 repair was under construction from mid-February to mid-April. Image B-01 shows the excavation for the clay core placement, and Image B-02 shows the riprap placed against the completed clay core.

3.2.2 *Stream Channel Restoration*

Breach 2 included 4 riffle/pool sequences (no. 14, 15, 21, and 22). As with the Breach 1 area, boulder clusters were placed in the riffles and pools to create preferential flow paths in a naturally sinuous pattern. In total, 64 imported boulders and 2 native boulders were strategically placed in the stream to form 25 boulder clusters in the Breach 2 area. Riffle/pool sequences no. 16-20 were not constructed per Amendment 1, as they were part of the bifurcation area and were removed from the project scope. The riffle/pool sequences for the Breach 2 area was constructed during the month of April. The boulder clusters were placed in April. Image B-03 shows some of the stream channel restoration at the Breach 2 area.

3.2.3 *Bank Stabilization*

The Breach 2 area consists of 3 bank stabilizations: BS-13 is a Type C bank stabilization on river left, BS-12 is a Type C bank stabilization on river right, and BS-10 is a Type C bank stabilization further downstream on river left. BS-13 was broken into two sections to construct around the existing large willow tree. BS-11 was not constructed per WCD14, since BS-11 was originally designed to raise the bank height as part of the bifurcation structure. The bank stabilization for the Breach 2 area was constructed in the month of April.

3.2.4 *Vegetation*

Disturbed areas were vegetated with lower and upper riparian seed, topsoil, compost, granular humate, granular inocula, fertilizer, and wood straw. Willows, wetland plugs, and trees and shrubs were planted in these areas. Erosion control blanket and willows were planted according to plan sheets RD2 and RD3. The Breach 2 area received topsoil, vegetation, and plants in the month of May. Image B-04 shows large woody debris used to create a wildlife corridor. Image B-05 shows the Breach 2 area with amended soil, seed, mulch and plants.

3.3 Ramey

The "Ramey" area covers multiple public and private properties and ranges between river stations 63+00 to 42+00. It extends from the stream work just south of 63rd Street Bridge to the end of pool glide number 10 at the Hepp property line. This area includes 690 LF of bank stabilization (BS-6, BS-7, and BS-8), 5 boulder clusters, 3 riffle/pool sequences (no. 11-13), and the revegetation of the disturbed areas.

3.3.1 *Stream Channel Restoration*

The Ramey area included 3 riffle/pool sequences (no. 11-13). In this area, some boulders were placed in the stream to disrupt flows, enhance oxygenation of the water, and create more habitat for stream organisms. In total, 15 native boulders were strategically placed in the stream to form 15 boulder clusters in the Ramey area. There was a desire to add more boulder clusters per the request from the Emergency Watershed Protection (EWP) Quality Assurance (QA) Team walkthrough on March 19, 2018. However, planting had begun in this area and stream access was difficult without damaging other progress made in the area. The Ramey stream channel restoration was under construction from February to the end of March. Image C-01 shows instream grading at Ramey. Image C-02 shows a completed riffle with vegetation and willows on the banks.

3.3.2 *Bank Stabilization*

The Ramey area consists of 3 bank stabilization structures: BS-8 is a Modified Type C bank stabilization structure on river left, BS-7 is a Modified Type C bank stabilization structure on river right, and BS-6 is a Type D bank stabilization structure further downstream on river left. BS-9a and BS-9b were determined no longer applicable to the project, due to future construction plans from a Federal Emergency Management Agency (FEMA)-funded project, and were not constructed per WCD7. The Ramey bank stabilization structures were constructed from February to the early March. Images C-03 and C-04 show BS-7 (Modified Type C).

3.3.3 *Vegetation*

The Ramey disturbed areas were vegetated with lower and upper riparian seed, topsoil, compost, granular humate, granular inocula, fertilizer, and wood straw. Willows, wetland plugs, and trees and shrubs were planted in these areas. Erosion control blanket and willows were planted according to plan sheets RD2 and RD 3. Ramey receive topsoil in starting in March. The Ramey area was vegetated and planted from mid-April to mid-May. Image C-05 shows willow planting with the use of a "stinger" – an excavator with a 3" diameter rod attached to the end. Images C-06 through C-08 show beaver and vole cage installation. Images C-09 and C-10 show some of the habitat created at Ramey. The Ramey access road did not incorporate topsoil due to the presence of a different pre-existing soil texture and at the request of the Agricultural Resources Section of BCPOS.

3.4 Hepp

The Hepp area ranges between river stations 42+00 to 21+00. It extends from the end of pool/glide no. 10 to Hygiene Road Bridge. The Hepp area includes 745 LF of bank stabilization (BS-2, BS-3, BS-4, and BS-5), 51 boulder clusters, 8 riffle/pool sequences (no. 3-10), and the revegetation of the disturbed areas. The slopes around Breaches 8 and 9 were armored with riprap for erosion protection, per the request of the City of Longmont (stakeholders).

3.4.1 *Stream Bank Armoring*

The stream banks just before and after Hygiene Road Bridge (stations 25+50 to 20+50) were armored with Type H riprap. The riprap was placed on nonwoven geotextile, and then buried with cobble then soil amendment. Erosion control blanket was placed on top of the soil buried riprap. The stream bank armoring was placed from January to early February. Image D-01 shows the banks being prepared for riprap placement. Images D-02 and D-03 show the armoring of the banks near Breaches 8 and 9. Images D-04 and D-05 shows the erosion control blanket that was placed on top of the soil filled riprap.

3.4.2 *Breach 6 Repair*

Breach 6 is located between stations 37+00 and 35+50. The repair berm was built with a clay core center and riprap on each side. The clay core and riprap were placed in the month of March. Images D-06 and D-07 show the construction of the clay core at the Breach 6 repair. Images D-08 and D-09 show the placement of riprap adjacent to the clay core.

3.4.3 *Breach 7 Repair*

Breach 7 was the largest breach repair and is located just north of the river on from station 36+00 to 30+00. The berm was built with a clay core center, per plan. The final contouring of the berm was field fit to optimize location, reduce material quantities, and save time. See the As-Constructed Drawings for the changes. The clay core and berm repair were under construction from November to the end of January. Images D-10 through D-12 show the construction of the clay core for the Breach 7 repair.

3.4.4 *Stream Channel Restoration*

The Hepp area included 8 riffle/pool sequences (no. 3-10). In this area, boulders were placed in the stream to disrupt flows and enhance stream habitat. In total, 133 imported boulders were placed in the stream to form 51 boulder clusters in the Hepp area. Most of these boulders were strategically placed as clusters. Some of them were scattered on the riffles to create additional flow irregularities. The Hepp stream channel restoration reach was constructed from late

November to late March. Boulders clusters were added in May. Image D-13 shows a pool transitioning to a run and riffle just downstream of the Breach 6 repair.

3.4.5 *Bank Stabilization*

The Hepp area consists of 4 bank stabilization structures: BS-5 is a Modified Type C bank stabilization structure on river left, BS-4 is a Type D bank stabilization structure on river right, BS-3 is a Type C bank stabilization structure on river left, and BS-2 is a Type C bank stabilization structure further downstream on river left. The Hepp bank stabilization structures were constructed from January to March.

3.4.6 *Vegetation*

The Hepp disturbed areas were vegetated with lower and upper riparian seed, topsoil, compost, granular humate, granular inocula, fertilizer, and wood straw. Willows, wetland plugs, and trees and shrubs were planted in these areas. Erosion control blanket, erosion control wattles and willows were planted according to plan sheets RD2 and RD3 and according to WCD19. Woody debris were buried in the graded upper riparian zones to create flow variability and diverse habitat. ACC started placing topsoil and seed starting in February. Planting occurred in the months of April and May. Images D-14 through D-18 show the buried large wood, container plants and willows, stakes, and installed beaver and vole cages.

3.5 Crane Hollow

The Crane Hollow (aka Gage) area extends from Hygiene Road Bridge at station 21+00 to the end of the project extents at station 12+50. This area consists of 465 LF of bank stabilization (BS-1), 6 boulder clusters, 2 riffle/pool sequences (no. 1-2), and the revegetation of the disturbed areas.

3.5.1 *Stream Channel Restoration*

The Crane Hollow area included 2 riffle/pool sequences (no. 1-2). As in the other locations, boulders were placed in the stream to disrupt flows and help create more natural flows. In total, 30 native boulders were strategically placed in the stream to form 6 boulder clusters in the Crane Hollow area. Image E-01 shows boulder placement at Crane Hollow.

3.5.2 *Bank Stabilization*

The Ramey area consists of a single bank stabilization structure, BS-1, which is a Type A bank stabilization on river right just downstream of the Hygiene Road Bridge. The Type A bank stabilization was installed from November to mid-December. Image E-02 shows the soil filled riprap lining the river left bank at the corner of the Hygiene Road Bridge.

3.5.3 *Vegetation*

The Crane Hollow disturbed areas were vegetated with lower and upper riparian seed, topsoil, compost, granular humate, granular inocula, fertilizer, and wood straw. Willows, wetland plugs, and trees and shrubs were planted in these areas. Erosion control blanket and willows were planted according to plan sheets RD2 and RD3. The first willow cuttings took place in December. Seeding at the Crane Hollow area started in March. Containerized plantings were installed in April and May. The Crane Hollow seeding, willows, and vegetation are shown in Images E-03 and E-04.

4.0 MATERIALS TESTING

Quality assurance testing was conducted on the project as work progressed. Appendix I of this report provides a summary of all testing conducted. The summary includes water quality test results, proctor density curves for the backfill, and moisture and density tests for the backfill. The tests indicate that the materials used during construction meet the project requirements.

5.0 NRCS SITE VISITS

Throughout the course of the project, the EWP QA Team came to the project for 3 official site visits to evaluate the progress being made and determine what could be improved. The site visits occurred on March 19, 2018; April 19, 2018; and May 16, 2018. The EWP QA Team provided Construction Observations and Photos as a report for each of the site visits. The construction observations, suggestions, and requests were taken into consideration by BCPOS and the Design Team and implemented as appropriate. The site visit reports and responses are included in Appendix J.

6.0 PUNCHLIST

From site walkthroughs, a punch list was developed and updated with items that needed completion to ensure the project was being constructed according to the Drawings, Specifications, and WCDs. Some of the items on the punch list were added in response to the NRCS suggestions that are discussed in their reports. The punch list items were completed by ACC, or the subcontractor CDI. An additional punch list was developed for the 1-year maintenance period. The construction punch list is in Appendix K.

7.0 FINAL QUANTITIES AND PROJECT COST

The final project cost was $4,719,084.81. Some final quantities differed from the original bid tab due to circumstantial and site-specific reasons. The final quantities, costs, changes to the original bid tab, and summary of WCDs are included in the May Memorandum of Record in Appendix A.

8.0 OPERATION, INSPECTION AND MAINTENANCE PLAN

An Operation, Inspection and Maintenance Plan was developed for this project. It includes general recommendations, specific recommendations, examples of when maintenance is required, and examples of when maintenance is not required. The Operation, Inspection and Maintenance Plan is located in Appendix L.

9.0 LESSONS LEARNED

Below are discussions of items observed by the Design Team during our field visits on Tuesday June 5th. This site visit occurred after higher flows (approximately 300 cfs) occurred. Dave Blauch, Troy Thompson and Kyle Medash of ERC conducted the site visit. Representatives from Boulder County, Engineering Analytics and ACC were also on the tour. The intent of the site visit was to evaluate initial responses of the restored project elements. Listed below are observations from the visit. Other lessons learned are from information gathered through the project, from EWP QA Team walk throughs, and from project meetings.

9.1 Bankfull Height

The stream performed well at higher flows. In a few areas water was out of its banks while in other areas flows were maintained within the channel.

Observed rack lines provided evidence that at some locations the channel started to extend beyond the constructed bankfull channel during the higher flow event.

9.2 Bankfull Height within Riffles

A couple of areas were observed where it appears bankfull heights within a riffle (between the riffle beginning and riffle end) were left a little high. In these areas shear stresses were highest and in some cases erosion was more significant. It is believed that this situation caused or contributed to erosion that lead to the initial formation of a mid channel bar. During construction bankfull elevations were surveyed at the beginning and end of riffles. A lesson learned is that it would have been helpful to confirm bankfull and overbank along the entire riffle length as well as along the entire channel.

9.3 Benefits of Root Wads

The root wads that were installed as part of the Type D and Modified Type C bank stabilization were observed to be providing a range of benefits including shading, backwater eddies, collection of biomass and instream habitat. Banks were observed to be generally stable where these approaches were used, but more adjustments were observed at these locations as compare to places where the more structural Type A and B stabilization was used.

Root wads in this modified (lowered 0.5 feet) Type D bank stabilization provided good channel complexity while helping to maintain a stable channel bank.

9.4 Challenges of Root Wads

Installed root wads also appear to be creating some flow irregularities that are causing some shifting of the channel. It appears that some of the root wads dampened flow along the outside bend so much in areas that they lead to upstream deposition which effectively narrowed the channel. The stream responded by eroding and widening the opposite bank and by shifting the thalweg away from the outside bend in other locations.

The photo shows deposition that occurred upstream of a root wad. Material deposited in the eddy that was created upstream of the root wad and the channel both jumped the bank on river left (right side of photo) and widened on river right. As a result of this sediment pattern the thalweg migrated from the left bank to the right bank.

9.5 Mobility of Sediment

The large flow event transported a notable amount of material. Portions of the channel that only had minor amounts of large gravel and cobbles had been generally covered with this material. It is likely that some of the material was transported in from upstream of the project site while others was derived from material in the project area. The influx of this material was beneficial to the overall stream function and appearance as it made the channel substrate appear and function more naturally than the initial conditions following construction.

9.6 Thalweg Shape

The higher flows that occurred helped to create a defined thalweg. The combination of the sediment flux through the system and the high flows effectively recreated the thalweg through the system. The lesson reinforced by this observation is that in a response type stream reach the thalweg is formed by natural processes and it doesn't make sense to spend much money in the construction phase the build an exact thalweg. We believe construction efforts are better spent ensuring the bankfull channel cross section and longitudinal profile of the stream are achieved; natural flow and sediment transport will help define low flow geometry.

9.7 Variable Stream Edges

After the higher flows, the channel edges took on a variable appearance which was much more natural than how banks looked immediately following construction. The lesson reinforced by this observation is that in a response type stream reach the natural processes of higher flows and sediment transport will alter stream edges so in locations where variability is desired, it is most economical to allow it to happen in response to higher flow conditions.

Higher flows caused the channel edges, which were constructed somewhat uniformly, to adjust. The result was a naturally appearing stream edge after the first flows.

9.8 Wetland Plugs

Wetland plugs that were installed in below bankfull had mixed success. Those that were on outside bends and will below bankfull did not withstand the higher flows. Those on inside bends and higher up closer to the bankfull elevation had better initial success. The lesson reinforced by this is that installing plugs within the active channel may not be appropriate. Particularly in locations such as the outside of a channel where scour occurs, this approach doesn't work. Wetland plugs that have had the most success after a single higher flow event are those that were installed in lower elevation depressions outside of the main channel and those that were on inside bends at higher elevations near bankfull.

Wetland plugs shown in the foreground above the current channel wetted perimeter on the inside bend appear to be mostly intact. Plugs on the outside bend (right side of the photo) appear to have all scoured out.

9.9 Protective Cages

Protective vegetation cages are a potential problem within the bankfull channel. In some cases where cages were installed within the active channel they washed out. In other areas such as where cages were below bankfull elevations but higher on the banks (particularly outside bends) the cages appeared to have caused some local bank erosion. Lessons learned are that the benefits of protection the cages provide needs to be weighed with the potential for erosion.

9.10 Imported Boulders for Clusters

The original boulders that were planned for habitat clusters and the additional boulders that were added late in the project were observed to be providing good channel diversity and habitat. In some places the placed boulders are providing additional, localized scour and in some places deposition adjacent to the boulders was observed. All boulders are providing complexity and overall they are a good improvement to the constructed system.

Habitat boulders such as those seen in this photo provide good channel diversity and habitat

9.11 Channel Substrate

The high flows and resulting sediment flux improved the stream bed appearance by sorting materials in a more natural manner than the construction itself. The lesson learned is that after a high flow the stream bed takes on a more natural appearance than after it is first constructed.

Higher flows brought in additional larger gravels and cobbles that helped the stream take on a natural appearance.

9.12 Pool Migration

We observed that in some of the pools the deepest point of the pool migrated a bit upstream or downstream and in other instances the pools scoured even deeper than they were constructed. In all cases the pool as modified by flows and sediment complimented the overall riffle/pool design concept. The lesson learned is that it can be expected in this type of a system to observe pool migration.

9.13 Type A and B Stabilization

The more structural Type A and B stabilization, which included riprap, have held as intended. Based on initial performance, these appeared to be good treatments in areas where the intent is to lock a bank in place.

9.14 Channel Cross Sections – Aggradation and Erosion

Following the higher flows and sediment loads deposition and aggradation were noted in different locations along the stream. As would be anticipated deposition was observed on inside bends. Deposition was also observed in locations where root wads disrupted natural flows. Erosion was observed along the thalweg and on some bends and banks.

Sand on the inside bend was deposited as a result of the higher flows. These same higher flows created a deeper thalweg at this cross section.

9.15 Channel Widening

The one location of pronounced channel widening was near station 47+00. In this location it appears that flows didn't get out of their banks and there was erosion from the riffle. This may have been aggravated by the root wads at about station 45+50 backing up flow. Eroded material appears to have deposited in the channel and the stream is overly wide. The worst result in this location is that the channel is wide and there isn't a well defined thalweg due to the deposition of new material. This location should be watched in the future for further evolution.

The mid channel formation shown in this photo at about Sta. 48+00 is likely the result of the higher flows not accessing their banks and higher shear stresses eroding the riffle banks. As the material deposited the channel widened and the feature shown in the photo was formed.

9.16 Overall Riffle/Pool Approach

Overall the constructed riffle/pool complexes behaved well in response to the first high flow. Deposition and erosion occurred based on the natural process in a response stream type. The overall bedform was retained. The lesson learned is that constructing the appropriate bedform for a given stream type results in a restored reach that works with the natural flow process.

The higher flows worked well with the constructed riffle/pool features and the meandering channel concept. The stream system appears and is functioning in a natural manner.

9.17 Vegetation

The lessons learned concerning vegetation are the following:

- Assure that all plants are available, contracted, acquired, and substitutions are selected and provided well in advance of delivery to the site.

- Obtain final plant delivery and schedules/manifests prior to issuing plant distribution field directives to the Contractor to avoid adjustments to plant schedules during the installation process.

- Avoid late additions of plants to the project and schedules that require recalculations of plant distribution and plant spacing requirements.

- Develop detailed specifications that dictate planting contractor qualifications, positive work history and references, provision of equipment capable of performing the work without delay, and that personnel assigned to the project have experience and can consistently maintain operational and quality control. Specifications should dictate that the project foreman is on site at all times performing quality control and provisioning their work-force adequately.

- Ensure that the planting contract period is reasonable and based on optimal planting seasons, the quantity of plants to be installed, and expected weather and run-off contingencies, avoiding arbitrary planting deadlines that may cause the contractor to install plants under sub-optimal weather or runoff conditions.

- Allow phased planting so that water-dependent species can be installed to take advantage of the weather and the climbing and receding runoff conditions.

- Require cold storage facilities capable of holding mass quantities of cuttings for as long as necessary until the site is ready for planting thereby avoiding sub-optimal storage conditions that may ultimately cause materials to be non-viable once installed.

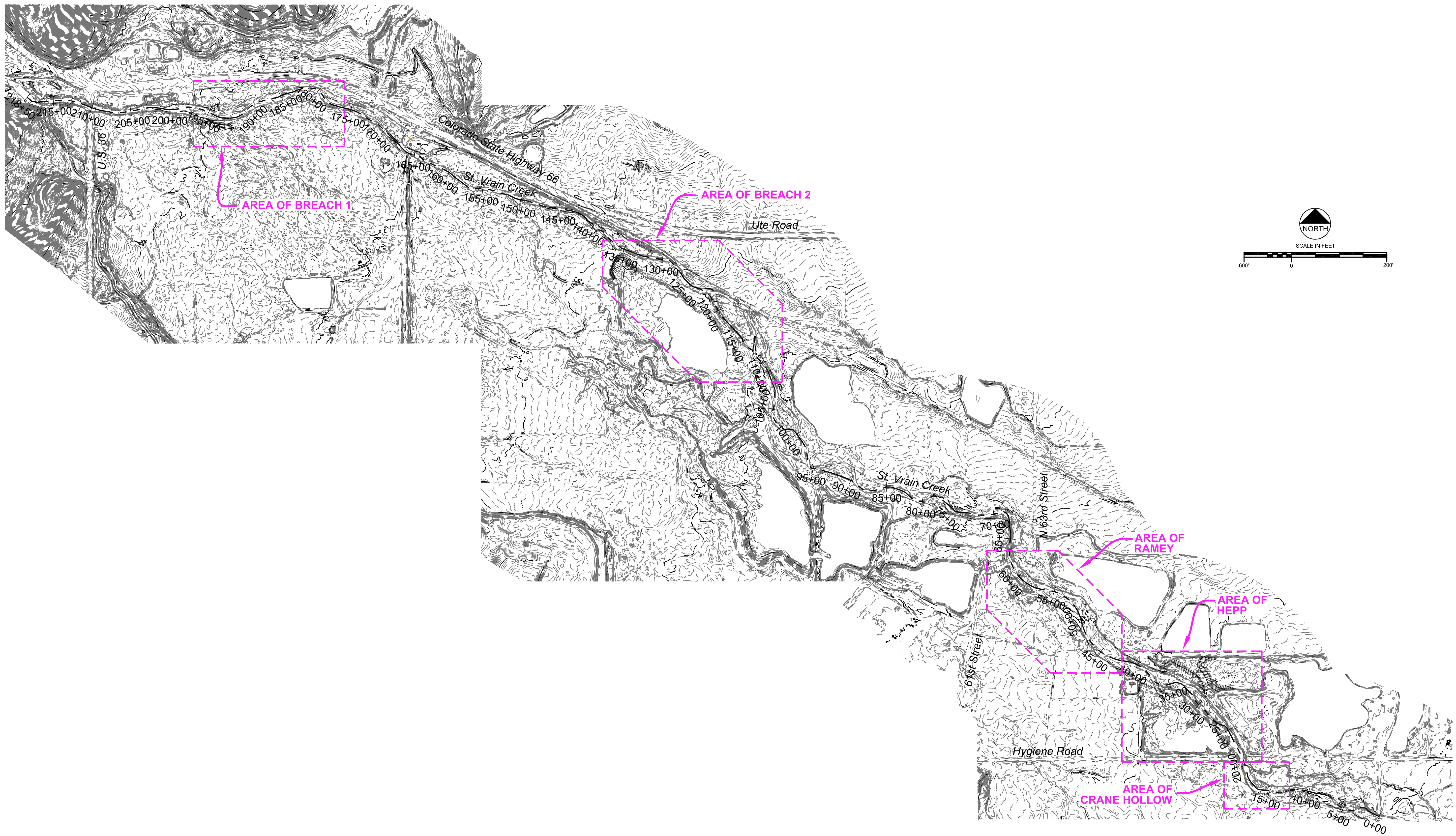
- Avoid harvesting willow cuttings after dormancy.

- Maintain all stationing stakes installed in the field so that they can be utilized for planting layout and reference for the planting contractor and long-term monitoring.

10.0 STANDARD OF CARE

The information contained in this report represents our findings at the time and location as indicated in this report. The methods utilized are in accordance with currently accepted engineering and testing procedures and other than this, no warranty, either expressed or implied, is intended.

FIGURES



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Project No. 110666

June 2018

Engineering Analytics, Inc.

FIGURE 1
PROJECT AREAS
ST. VRAIN BREACHES

Appendices available upon request