Unnamed Tributary 3 Post-Fire Restoration Project

Final Report

Prepared for: **Colorado Watershed Restoration Grant Program**

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Attn: Chris Sturm

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Coalition for the Poudre River Watershed

Grant Amount: $75,000

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Introduction

The 2012 High Park Fire burned over 87,000 acres in the Cache La Poudre (Poudre) watershed. Approximately half the burn area saw severe to moderate severity burns. One drainage that was moderately to severely burned was the drainage known as Unnamed 3 (UT3). The fire burned over 50% of the site at high severity, resulting in an estimated 531% increase in expected post-fire peak flows (BAER Report, 2012) It is a small, steep drainage (210 acres) that forms a narrow canyon before flowing into CO-14 & the Poudre River. Approximately 500 feet downstream from UT3 is the Munroe Gravity Tunnel, an integral drinking and irrigation water supply tunnel for downstream municipalities. Landownership in the sub-drainage is a mixture of private (3 private landowners) & public (City of Ft Collins & USFS). After the High Park Fire, debris flows, increased runoff events, & erosion occurred with each storm. Some of these storms caused the Munroe Gravity Tunnel to become blocked with debris & sediment & overtopped CO-14.

Since the fire, and during the 2013 flood and subsequent high flow events, debris flows from this watershed caused the blockage of Munroe Tunnel. Debris flow risks from this tributary continued to threaten the primary access road for the private landowners and CO HWY 14. Landowners at the site attempted to control the post-fire hydrology by installing cobble/boulder check dams (some just upstream of CO-14), one impoundment, & additional crossings/culverts. Unfortunately, these structures were not installed correctly or were undersized, posing a threat to channel stability and downstream sediment loading. It was estimated that with discharges of 200-300 cfs, there could be major damage to the culverts, roadway, sediment traps and grade control structures (e.g., check dams) that could result in 300-350 TNs of sediment transported downstream, and ultimately to the Poudre River. Because of this, the Coalition for the Poudre River Watershed (CPRW) prioritized this site for a post-fire restoration project.

Background

In the fall of 2015, CPRW conducted a rapid field assessment to confirm whether there was ongoing need for recovery/restoration work. Results from this assessment prompted a more detailed geomorphic assessment. The assessment identified 7 significant problem areas along a 966 ft reach of the drainage. Over the winter of 2015/2016 a 30% design for the reach was completed by AloTerra Restoration Services for resiliency improvements at UT3. Analyses included initial geomorphic surveys, ecological assessments, hydrological and hydraulic modeling and stakeholder engagement were completed as a part of the 30% design.

AloTerra was contracted by CPRW in summer 2016 to advance the design to a 60% level of completion. The 60% design refined the description of existing conditions, and goals. Using an MCDA analysis, multiple design alternatives were ranked, and a preferred alternative was chosen that we felt best achieved our goals. This alternative formed the basis for the 60% design. This design identified 7 problem areas along the reach where further field assessments were completed prior to construction. After CPRW received the CWCB Watershed Restoration Grant, AloTerra was contracted again to complete the final design & implementation of the project. The following project goals were developed collaboratively among staff and stakeholders of CPRW and staff of AloTerra and Five Smooth Stones River Restoration (5SSR).

Roadway Improvements and Stabilization Goal:

- **Improved Sustainability and Robustness**: The design should be sustainable with the current and expected future flow regimes as well as feasible with respect to implementation.
- **Improved Accessibility and Vertical Grades**: The existing roadway has a steep grade and
- problems with access. This project should decrease the vertical grades in turns and
- improve access.
- **Roadway Width and Turnouts**: The roadway should provide areas for turnouts to assist with vehicle passing and emergency access

Ecosystem Enhancements Goal:

- **Short Term Revegetation**: Native herbaceous revegetation that will be noticed in years 1-5 after treatment, providing approximately 30% vegetation cover and 70% total ground cover
- (vegetation and litter).
- **Long Term Vegetation Enhancements**: Successful native shrub and tree establishment will
- be most noticeable five years after treatment, providing increased woody root biomass on
- treated slopes.
- **Ecological Sustainability:** The restored vegetation community should not require significant
- maintenance given the existing and expected future hydrology.
- **Ecological Resiliency**: The project should be resilient enough to recover from design flows
- (25-year flood).
- **Restoration and Connectivity:** Restoration and connectivity of the channel and riparian zone
- with the surrounding plant communities and geomorphic conditions.

Sediment Reduction, Stabilization, and Channel Enhancement Goal:

- **Reduction of Bank Erosion and Lateral Bank Migration**: Reduce bank erosion and lateral
- bank migration to pre-fire levels, within the limitations of the current roadway conditions.
- **Sediment Trapping Efficiency**: The potential for additional sediment trapping should be
- increased in the main channel and in contributing gullies.
- **Sustainable Sediment Transport Balance**: Promote sustainable sediment transport
- balance without aggrading or degrading the channel.
- **Multi-stage Channel**: Promote channel and bed diversity through a multi-stage design
- approach.
- **Large Flood Sediment Pulses from Dam, Embankment and Fill Slope Failure**: The risk of
- entrained sediment sources from structural failures should be reduced

Risk Reduction Goal:

- **No Increase in Liability to Funders**: The funders of this project should not pay for a design
- that increases or transfers liability.
- **Flood Reduction Risk to Roadway**: Currently the roadway experiences overtopping/flooding
- at 200 cfs due to poor structural design and undersized culverts.
- **Reduced risk to Power Poles**: The power pole on the left bank at Lat 40°41'23.04"N Long
- 105°15'27.25"W should not be negatively impacted by the final design.
- **Ease of Permitting and Approval**: There is a scheduling risk related to permitting and the approval process.

The long-term objective for this project is to stabilize potential erosion and water quality degradation & to reduce downstream risk to watershed values like instream habitat and water supply.

The project is located within a small 210 ac sub-watershed located directly above HWY 14 and the Munroe Gravity canal. See Photo 1 for the location of the UT3 sub-watershed within the watershed. The specific project reach for restoration was 966 ft of the main stream channel along the private road (Photo 2). The seven priority areas were the primary focus areas for construction to achieve the project goals (Photo 3).

Photo 1. Location of UT3 Sub-Watershed

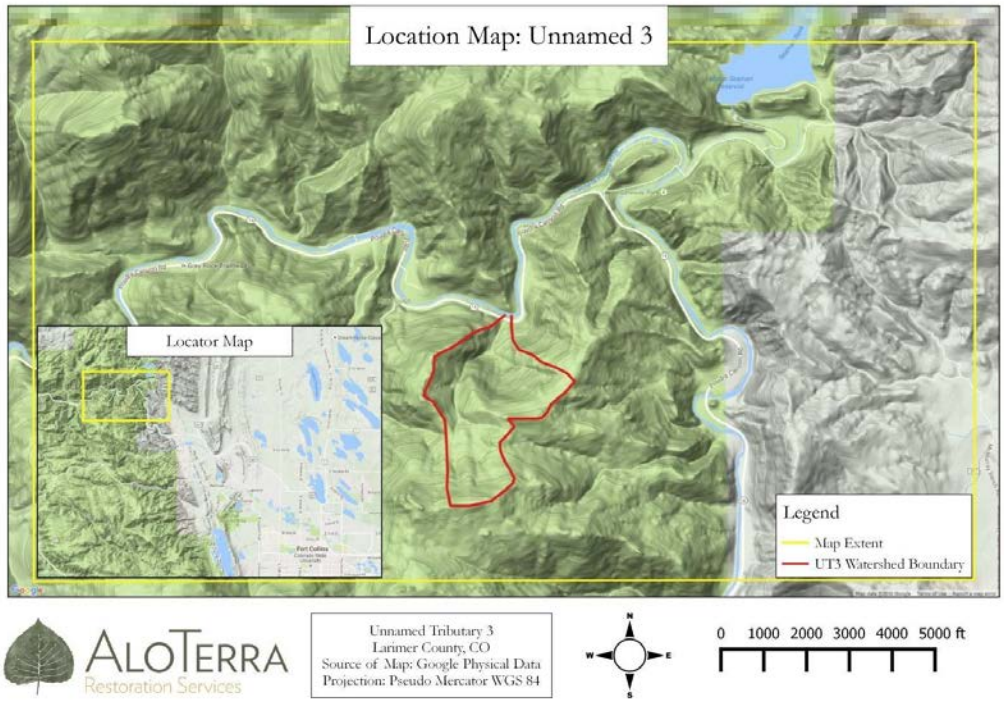
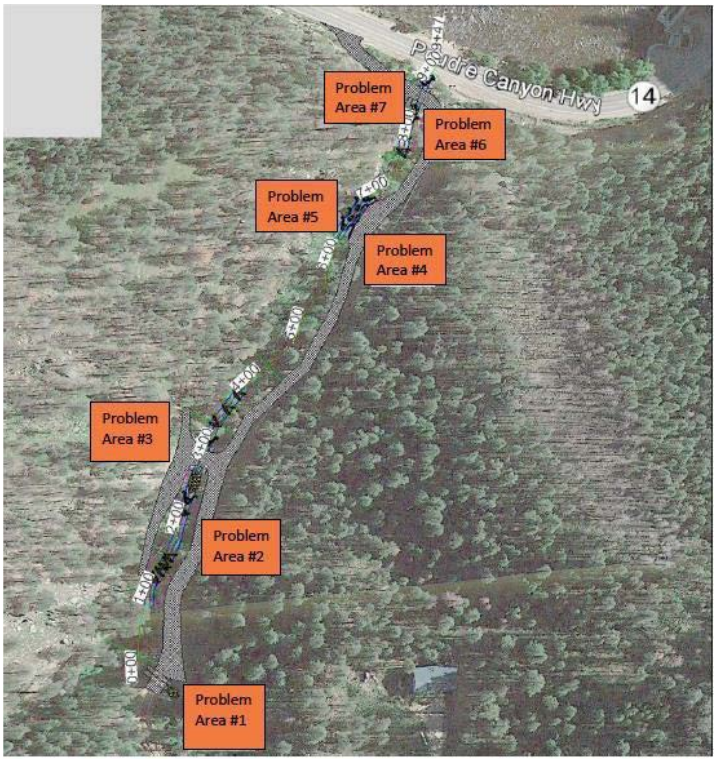


Photo 2. Project Reach (indicated by the blue line)

Photo 3. Identified Problem Areas



Methods

The final design was completed in spring 2018 and construction began in October 2018. AloTerra completed the construction starting from the upper end of the reach and finished at the bottom. Construction was completed in 4 weeks from the start date. AloTerra used a skid loader and excavator to complete most of the in-stream construction, including the log-drop structures, rock vanes/cross vanes, boulder walls, grading, and culvert installation. A hammer was also used to break up the bedrock at the bottom of the project reach to replace the 18" culvert with a 60" culvert. Field crews worked alongside the heavy equipment to install erosion control structures like vegetated soil lifts, retaining walls and erosion fabric/coir matting, native vegetation and spread native seed. In addition, we also held one 8-hour volunteer project where volunteers helped finish planting, seeding and installing erosion control (coir mats and mulch) on the first 500ft of the project reach.

The total project budget was $193,961 including cash and in-kind contributions. CWCB covered $75,000 of the project costs which included the completion of the final design, project coordination and management by CPRW staff, mobilization and demobilization, installation of the culverts and construction some of the in-stream structures including rock vanes, log-drop structures and boulder retaining walls.

The remaining project budget was matched with the following: $7,086 from another CWCB Watershed Restoration grant, $32,106.98 from a CDPHE grant, a $45,000 donation from the City of Fort Collins, a $1,841 donation from the City of Greeley, a $5,000 donation from Northern Water and a 72" culvert donation from North Poudre Irrigation (valued at $1,950), and $2,500 from Rocky Mountain Flycasters. The volunteer project contributed $4,478.10 (23 volunteers, 7.5 hours at $25.96/hr) of in-kind value to the project. All log-rock material was donated by the landowners and obtained on site (in-kind donation valued at $18,500), and we received an additional $500 in cash match from one of the landowners to purchase vegetation.

Work items that were completed to meet project objectives included:

- Three culvert crossings were added, four 72" pipes replaced four 32" pipes, and a 60" pipe replaced an 18" pipe
- 100 feet of vegetated soil lifts were constructed to improve steep slopes adjacent to the driveway to reduce risk of bank sloughing;
- 440 feet of bank grading and stabilization;
- 400 feet of channel realignment;
- Six rock cross-vanes installed;
- 200 tons of toe rock installed;
- 10 Log drop structures installed;
- Four rock steps installed;
- Two constructed rock ramps installed;
- 36 feet of stacked boulder walls installed to fortify road and culverts;
- 1400 square yards of erosion control fabric installed;
- 0.8 acres seeded and mulched; (1lb wetland, 7.8 lbs of riparian, and 55 lbs of erosion control)
- 385 riparian and upland plants installed;
- 1000 wetland plants installed;

- 800 live willow stakes installed; and
- 45 tons of road base installed to repair damaged roads from construction

Specifically, construction was focused on the 7 problem areas identified from the 60% design. In the final UT3 Project Report from AloTerra, a description of the construction completed within each problem area is described (Appendix A)

Results

The UT3 Project increased the floodplain capacity, reduced potential bank erosion and channel incision, increased channel complexity and capacity, improved riparian vegetation, lowered the flood flow water surface elevations and velocities relative to existing conditions, and re-established access infrastructure. Therefore, flood risk was reduced, creek function was improved, and landowner access has an added level of resiliency.

The MCDA analysis during the 60% design process identified Alternative #4 (Priority II Geomorphic Restoration and Re-alignment for 400 cfs and sediment transport) as the alternative for construction. The goals within this alternative included Roadway Improvements, Ecosystem Enhancements, Channel Flow Capacity, Sediment Reduction and Stabilization and Risk Reduction. These goals were achieved by excavating a new floodplain and stream channel at the elevation of the existing incised stream. The channel was design and constructed with the appropriate dimension, pattern and profile to fit the floodplain.

The completed project provides the following:

- Increased channel capacity throughout the project reach, including the upsized culverts, increasing floodplain attenuation by re-grading the channel banks, as well as Jack hammering bedrock outcrops (Photos 4-6)
- Road and driveway safety; (Photos 4-8)
- Total shear stress for the 25-year flow was reduced, reducing potential erosion;
- Six rock cross-vane structures, ten log drop structures, four rock steps, and two rock ramps were installed to stabilize the channel from an active head cut, increase stream channel complexity, and decrease flow velocities (Photos 6, 7)
- Streambanks were reinforced to resist excessive shear stresses; (Photo 4-8)
- Floodplain was reconnected to the stream and revegetated to begin the reestablishment of riparian vegetation; (Photos 4, 6, 7)

Photo 4. Two 72” culverts installed (replaced two 36” culverts) Stone toe was placed on both banks for approximately 30’, along with coir matting, seed, container plantings, and willow stakes

Photo 5. 60” bottom culvert installed (replaced 18” culvert)

Photo 6. rock crossvane was installed to reduce the risk of head cutting upstream, and to stabilize the stream bankfull channel, floodplain re connected to stream.

Photo 7. Rock cross vanes and a rock sill were installed to complete the grade drop to the elevation of the downstream culverts

Photo 8. Vegetated Soil lifts installed to address bank hazard in two areas along the road embankment, where sparse vegetation, steep slopes, and poor soil dominated

Conclusions and Discussion

All project goals and objectives for the CWCB Watershed Restoration funding were met. The objective for the chosen alternative for construction was to create a new, stable stream and floodplain at the existing channel-bed elevation. This was accomplished by excavating a new floodplain and stream channel at the elevation of the existing incised stream. The new channel was designed and constructed with the appropriate dimension, pattern, and profile (based on reference reach data) to fit the floodplain. CPRW will continue to monitor the project yearly for up to 5 years until the vegetation has established using the Bank Stability Assessment protocol that was developed in 2015 for post-fire restoration projects. Based upon the results of monitoring and site visits, we will address any issues that may arise accordingly. The in-stream structures may require maintenance over time. Timing of maintenance will depend on frequency of significant run-off events (>Q25). AloTerra has recommended that the landowners or CPRW staff investigate the in-stream structures after storm events greater than Q10.

The project construction was a challenge given the site constraints including the private road, steep terrain, and timeline conflicts with one of the landowners who was building a new home at the same time as the project. The home construction was supposed to be completed by June 2018, however the construction was still ongoing in September. This resulted in a few access issues on the steep, narrow road and impacted the start date. These issues were not something we planned for since the home was supposed to be completed well before we started. Another challenge that arose were delays in the construction start date. The construction was supposed to begin on 9/1/18, but it was delayed by a

month because AloTerra decided to use a larger piece of equipment at the last minute which meant a CDOT permit needed to be secured, and also because of the road access issues from the landowner's home construction. Construction did finally begin the first week of October. Most of the construction went smoothly, however, it was delayed when AloTerra was working on breaking up the bedrock to replace the bottom culvert. The hammer they rented broke several times delaying construction for a week at the beginning of November. Because of this, we did lose the opportunity to complete the installation of the remaining erosion matting, seed and native plantings at the bottom 200 feet of stream channel. There were several snow storms at the site in November, and there is still snow in the stream channel which is not conducive to laying erosion matting and planting. AloTerra will provide us with a list of the remaining tasks and we will be organizing a final 1-day volunteer project in March or April 2019 to complete the planting and erosion control on the bottom 200 ft of the project.

Our key lesson learned from this project is the importance of coordination and communication between all parties for restoration projects on private land. For over three years we worked closely with the landowners, AloTerra, and stakeholders to ensure the process went smoothly and that the needs and concerns were addressed. Because of the working relationship we built with the landowners, we were able to successfully work through construction delays, timing issues & the private home construction. In the future, we will continually check in with the contractor regarding important project details like permits to prevent similar project delays.

The completion of this project is a huge milestone because it wrapped up the last CPRW post-fire restoration project from the 2012 High Park Fire. The project will benefit all stakeholders involved including the private landowners, North Poudre Irrigation, Northern Water, CDOT, and the City of Fort Collins. The project also increases the resiliency of the upper watershed and has made the stream channel more resilient to future storm events. The UT3 channel now has increased channel capacity including upsized culverts, a stabilized channel, increased stream channel complexity, the stream channel has been reconnected to the floodplain, native vegetation & erosion control has been added, and the private roadway safety has been improved.

Actual Expense Budget

Task	Description	Total Budget/Grant Funds	Previously Invoiced	Current Invoice	Remaining Total	Percent Complete
1	project coordination & reporting	$5,399	$0	$3,861	$1,538.39	71.5%
2	final design & planning	$131	$0	$0	$131.00	100.0%
3	mob & grading	$15,000	$0	$12,075	$2,925.00	80.5%
4	installing structures	$54,470	$0	$41,212	$13,257.60	75.7%
	TOTALS	75,000.30	0.00	57,148.31	17,851.99	2.28%

Match Reported		***Total Match Required***	**Previously Invoiced**	***Current Match Reporting***	***Remaining Match Needed***	
		$75,000.00	***$0.00***	**$31,142.59**	***$43,857.41***	

References

BAER. 2012. High Park Fire Burned Area Emergency Response (BAER) Report. July 17, 2012

Schumm, S. A., M.D. Harvey, and C.C. Watson. 1984. *Incised channels: Morphology dynamics and control*. Littleton, Colorado, Water Resources Publications, 200 p.

Simon, A., A. Curini, S. Darby, and E. Langendoen. 1999. *Stream-bank mechanics and the role of bank and near-bank processes in incised channels*. In Incised River Channels, Darby S. and Simon A, (eds). Wiley: New York; 123–152.

Rosgen, D.L. 1997. *A Geomorphological Approach to Restoration of Incised Rivers.* Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision, 1997. S.S.Y. Wang, E.J. Langendoen and F.D. Shields, Jr. (eds.) ISBN 0-937099-05-8.

Appendix A

Final UT3 Project Report, As-built Plan Set, and Weekly Construction Reports

Unnamed Tributary 3

As-built Report for Stream Resiliency and Restoration

COALITION FOR THE POUDRE RIVER WATERSHED

AloTerra Restoration Services

5 | SMOOTH STONES RESTORATION PLLC

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BACKGROUND

The project described herein as the UT3 Post-fire Restoration Project ("the Project") builds on the 30% and 60% designs submitted, providing field fitting design work, construction work, bioengineering, and revegetation work. The primary deliverables for the Project is to develop 60% design plans, construction cost estimates, complete cultural review, 404 pre-construction notification and permitting, and construction/revegetation.

Watershed History

The Unnamed 3 tributary (BAER HUC Unnamed 3, henceforth referred to as "UT3"), an approximately 210 acre sub-watershed located in the Cache la Poudre River Watershed of Larimer County, was burned at a high severity in the High Park Fire of 2012, resulting in substantial debris flows and sedimentation of important infrastructure. Immediately downstream of UT3 is CO HWY 14 and the Munroe Tunnel, an integral drinking and irrigation water supply tunnel for downstream municipalities. Fort Collins is the nearest large city (140,000 residents), with the smaller town of Poudre Park being located approximately three miles upstream. UT3 is located at Latitude 40°41'29.37"N and Longitude 105°15'22.43"W.

The UT3 watershed is characterized by steep, forested, lower montane drainages, composed of a variety of decomposed granite to clay-silt loams in watershed number 10190007141014 (BAER Report, July 17, 2012). A closed coniferous overstory was present before the High Park Fire of 2012. The majority of the canopy remained in place near the base of ephemeral drainages on the site's lower elevations. The 2012 High Park Fire burned over 50% of the site at a high soil and canopy severity, resulting in an estimated 531% increase in expected post-fire peak flows (BAER Report, July 17, 2012). Since the fire, and during the 2013 flood and subsequent high flow events, debris flows from this watershed caused the blockage of Munroe Tunnel, a primary drinking water supply conveyance for the City of Fort Collins. Additionally, debris flow risks from this tributary continue to threaten the primary access road for residents and CO HWY 14. Natural and active revegetation has occurred in the contributing watershed, and gulches have been treated with directional felling of trees. Despite these changes, signs of substantial erosion (in contributing gullies) and bankfull flow indicators in the main channel indicate that soil surface and shallow subsurface soil properties remain in a highly-altered state in the contributing watershed.

DESIGN HISTORY

Over the winter of 2015/2016, a reach of UT3 was surveyed and assessed by the design team as part of a separate 30% design project. This reach, which is also the design (i.e., study) reach for this 60% design report, is 966 ft. in length, with the downstream end forming a confluence with the main stem of the Cache la Poudre River (**Figure 1**).

In January 2016, AloTerra submitted a 30% design report to the Coalition for the Poudre River Watershed (CPRW) for resiliency improvements at UT3. Analyses in this report included initial geomorphic surveys, ecological assessments, hydrologic and hydraulic modeling, and stakeholder engagement. Site surveys, field inventories (including photographic inventories), a basic hydraulic model, and desktop analyses were used to develop a summary of existing conditions. In June 2016, AloTerra was contracted by CPRW to advance design to a 60% level of completion. As part of this 60% design effort, the description of existing conditions was further refined, goals were re-evaluated, the support for alternative 4 was confirmed, the design flow was refined, and additional surveying and analysis of site conditions were conducted. That work is summarized below.

PROJECT GOALS

As part of this design project, the following goals were developed collaboratively among staff and stakeholders of the Coalition for the Poudre River Watershed, and staff of AloTerra and Five Smooth Stones River Restoration (5SSR).

Roadway Improvements and Stabilization Goal

Improved Sustainability and Robustness: The design should be sustainable with the current and expected future flow regimes as well as feasible with respect to implementation.

- Improved Accessibility and Vertical Grades: The existing roadway has a steep grade and problems with access. This project should decrease the vertical grades in turns and improve access.
- Roadway Width and Turnouts: The roadway should provide areas for turnouts to assist with vehicle passing and emergency access.

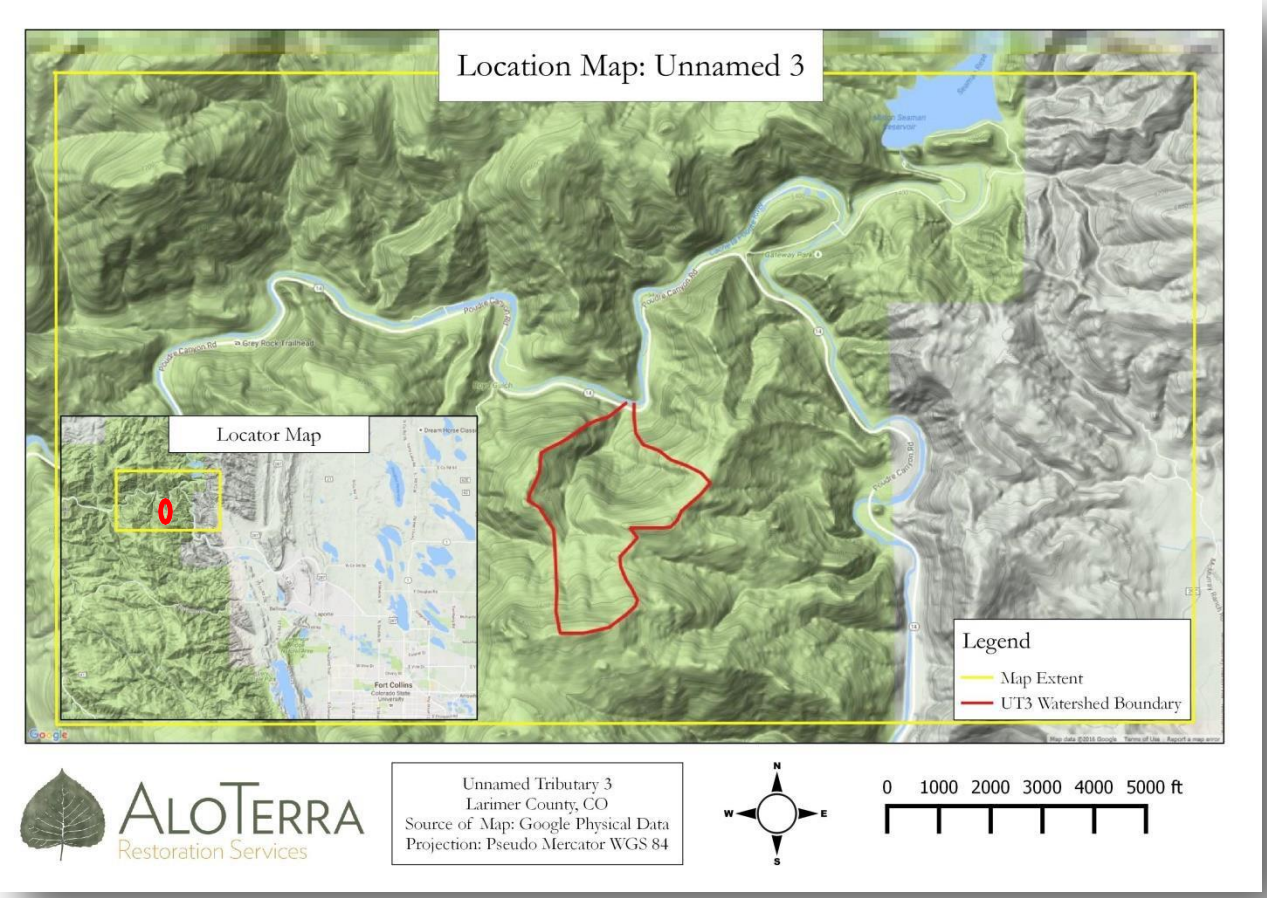


Figure 1. Location Map

Ecosystem Enhancements Goal

Short Term Revegetation: Native herbaceous revegetation that will be noticed in years 1-5 after treatment, providing approximately 30% vegetation cover and 70% total ground cover (vegetation and litter).

- Long Term Vegetation Enhancements: Successful native shrub and tree establishment will be most noticeable five years after treatment, providing increased woody root biomass on treated slopes.
- Ecological Sustainability: The restored vegetation community should not require significant maintenance given the existing and expected future hydrology.
- Ecological Resiliency: The project should be resilient enough to recover from design flows (25-year flood).
- Restoration and Connectivity: Restoration and connectivity of the channel and riparian zone with the surrounding plant communities and geomorphic conditions.

Sediment Reduction, Stabilization, and Channel Enhancement Goal

- Reduction of Bank Erosion and Lateral Bank Migration: Reduce bank erosion and lateral bank migration to pre-fire levels, within the limitations of the current roadway conditions.
- Sediment Trapping Efficiency: The potential for additional sediment trapping should be increased in the main channel and in contributing gullies.
- Sustainable Sediment Transport Balance: Promote sustainable sediment transport balance without aggrading or degrading the channel.
- Multi-stage Channel: Promote channel and bed diversity through a multi-stage design approach.
- Large Flood Sediment Pulses from Dam, Embankment and Fill Slope Failure: The risk of entrained sediment sources from structural failures should be reduced.

Risk Reduction Goal

- No Increase in Liability to Funders: The funders of this project should not pay for a design that increases or transfers liability.
- Flood Reduction Risk to Roadway: Currently the roadway experiences overtopping/flooding at 200 cfs due to poor structural design and undersized culverts.
- Reduced risk to Power Poles: The power pole on the left bank at Lat 40°41'23.04"N Long 105°15'27.25"W should not be negatively impacted by the final design.
- Ease of Permitting and Approval: There is a scheduling risk related to permitting and the approval process.

IMPLEMENTATION AND BENEFITS

The UT3 Project increased the floodplain capacity, reduced potential bank erosion and channel incision, increased channel complexity and capacity, improved riparian vegetation, lowered the flood flow water surface elevations and velocities relative to existing conditions, and re-established access infrastructure. Therefore, flood risk was reduced, creek function was improved, and landowner access has an added level of resiliency.

Work items that were completed to meet project objectives included:

- Three culvert crossings were added, four 72” pipes replaced four 32” pipes, and a 60” pipe replaced an 18” pipe;
- 100 feet of vegetated soil lifts were constructed to improve steep slopes adjacent to the driveway to reduce risk of bank sloughing;
- 440 feet of bank grading and stabilization;
- 400 feet of channel realignment;

- Six rock cross-vanes installed;
- 200 tons of toe rock installed;
- 10 Log drop structures installed;
- Four rock steps installed;
- Two constructed rock ramps installed;
- 36 feet of stacked boulder walls installed to fortify road and culverts;
- 1400 square yards of erosion control fabric installed;
- 0.8 acres seeded and mulched; (1lb wetland, 7.8 lbs of riparian, and 55 lbs of erosion control)
- 385 riparian and upland plants installed;
- 1000 wetland plants installed;
- 800 live willow stakes installed; and
- 45 tons of road base installed to repair damaged roads from construction activity.

The Primary Benefits of the UT3 Project Included:

- Increased channel capacity throughout the project reach, including the upsized culverts, increasing floodplain attenuation by re-grading the channel banks, as well as Jack hammering bedrock outcrops.
- Road and driveway safety;
- Total shear stress for the 25-year flow was reduced, reducing potential erosion;
- Six rock cross-vane structures, ten log drop structures, four rock steps, and two rock ramps were installed to stabilize the channel from an active head cut, increase stream channel complexity, and decrease flow velocities.;
- Streambanks were reinforced to resist excessive shear stresses; and
- Floodplain was reconnected to the stream and revegetated to begin the reestablishment of riparian vegetation;

PRE-EXISTING CONDITIONS AND PROBLEM AREAS

Since the 2012 fire, road grading and realignments, culvert replacement, and other repair work has been performed by local residents. Additionally, recent property acquisitions and residential development has led to the construction of additional roads and road improvements necessary to maintain adequate access to properties in UT3. While current road conditions are an improvement over the immediate post-fire condition, results of a geomorphic assessment and hydraulic analysis indicate significant risk remains to the road, channel, and water quality during a 25-year flood event.

Pre-existing stream crossings are poorly designed and undersized, posing a threat to channel stability as well as sediment loading downstream during high flow events. Some alterations and fill that have occurred within the channel pose a threat to channel stability as well as sediment loading downstream. This includes multiple, small, in-channel grade control structures (cobble, small boulder material) constructed immediately upstream of the most downstream road crossing and above the river bed. There is also a small pond/settling basin upstream of the second existing road crossing with a small dam constructed of cobble and small boulder-sized material. All of these structures have been constructed by the property owners.

It is expected that with discharges of 200-300 cfs, there could be major damage to the culverts, roadway, sediment traps and grade control structures (e.g., check dams) that could result in 300-350 TNs of sediment transported downstream, and ultimately to the Poudre River.
Drainage along the east side of the road is rudimentary, and likely a source of fine sediment to the UT3 channel as well as to the drainage ditch on the south side of HWY 14.

DESIGN CHANGES AND FIELD ADJUSTMENTS

As shown on the as-built drawings (Appendix A), significant design changes were made during construction. The designed creek channel profile was modified due to the presence of bedrock throughout. The presence of bedrock throughout most of the project site limited excavation depths in some areas, limited the ability to adequately anchor proposed log structures, and forced field fitting to other areas to adequately reduce downstream velocities and grade drop. Therefore, the positioning of rock cross-vanes and log steps were installed to maintain the channel slope and mitigate potential head cutting.

All rocks and logs used for the project were found on site. The cost of hauling building materials was a major limiting factor for this project. Strategic use of existing on-site material was imperative to the success of the project.

As part of the 30% design process, and addressed by the 60% design process, these challenges were organized into seven problem areas (**Figure 2**):

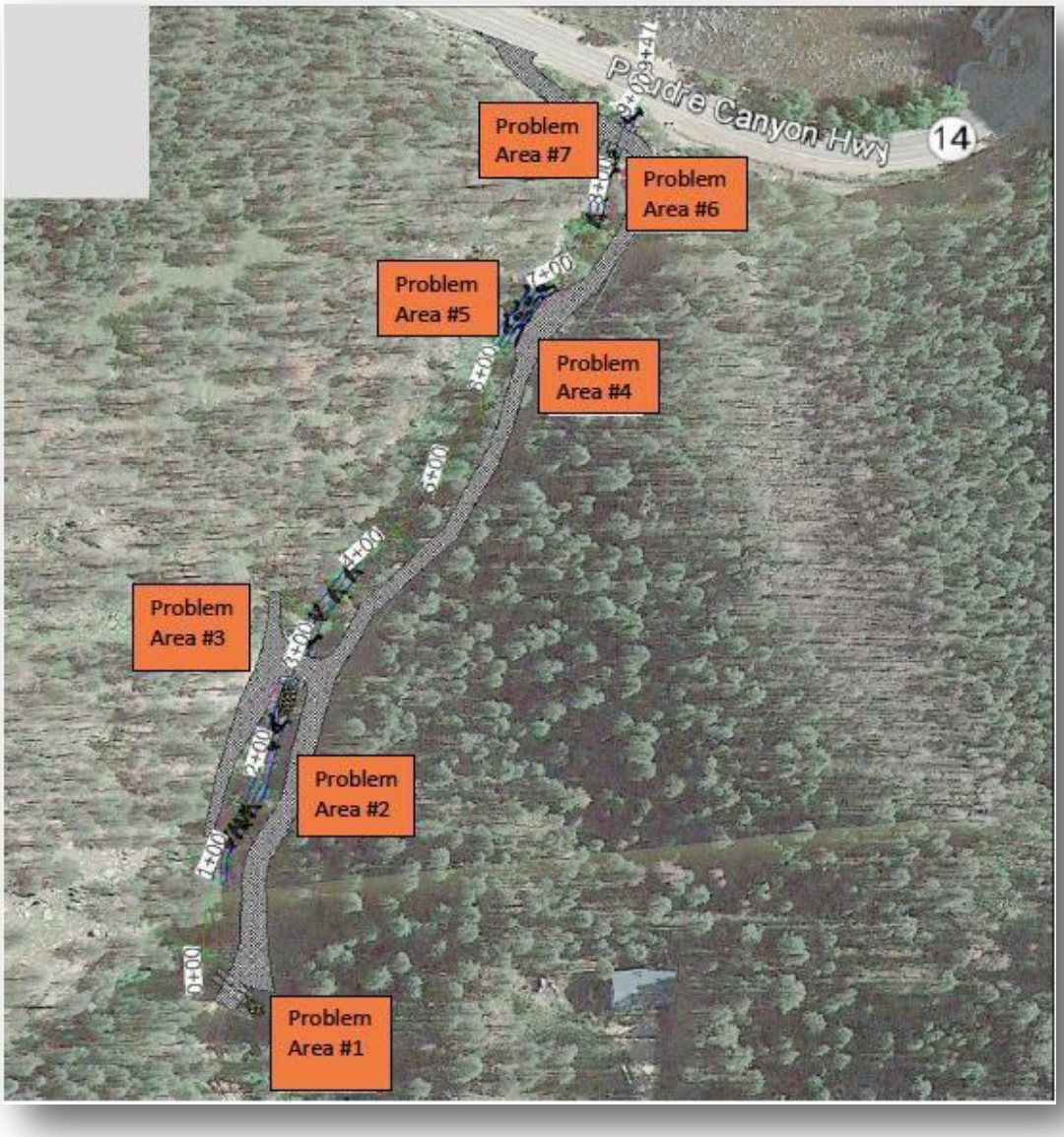


Figure 2. General location of problem areas #1-7

Problem Area #1: This stream crossing is on the way to Gene's property located on a tributary to UT3. The drainage area of the stream on this tributary is 0.1 square miles. The culvert invert elevation is well above base flow. Base flow through fill material and the embankment is lower than the culvert invert. An old roadway cut on the right side of the channel looking downstream has left un-vegetated fill material along this side of the channel. The main concern at this location is the lack of design for overflow under high flow conditions. This reach could be at risk of channel evolution and significant channel change that would result in an increased sediment supply rate.

Work Completed to Address Problem Area #1: The existing two 32” culverts were replaced with two 72” culverts, as well as recreating the scour pool above the culverts. The fine sediment that was removed was used as fill on the adjacent floodplain in an area that was previously used by the landowners as a borrow pit to create a smooth surface reducing the risk of a hydraulic jump. The area was stabilized with seed, wood straw, willow cuttings, as well as shrub containers.

Problem Area #2: An approximately 35-foot long detention pond has been constructed by a property owner upstream of this crossing. The berm and check dam of this pond would likely fail under high flows of 200 cfs or greater. It has captured multiple cubic yards of fine sediment over the year or so since it was constructed. The undersized sediment basin is constructed with a check dam above the profile of the existing reach slope. This configuration could result in up to 20 TNs of sediment being transports downstream with a failure of the check dam. It is likely that the check dam will see partial failure with a discharge of greater than 200 cfs. This problem area is located at Station 0+00 to 1+90 on the existing Longitudinal Profile.

Photo 1. View Downstream Station 0+00

Work Completed to Address Problem Area #2: The effort to restore this area required complete channel and bank grading from 0+00 through +- 1+00. Starting at Station 0+00 a rock crossvane was installed to reduce the risk of head cutting upstream, and to stabilize the stream bankfull channel (**Photo 1**). Moving downstream through station 0+90 bedrock was encountered in the stream channel bottom as well as multiple areas on the left bank. Excavation of this area was sufficient to increase the bankfull width increasing the capacity of the channel. The left bank was stabilized with seed and wood straw, as well as tree and shrub containers, and willow cuttings were installed where bedrock was not encountered. In this reach the right stream bank was stabilized with coir matting 700, as well as seed, willow cuttings, tree and shrub containers, as well as wetland plugs. Earlier design iterations had included using log drop structures in this reach. However, due to the presence of bed rock, it was determined that installing the log drop structures at an appropriate depth would require excavation through bedrock which was not possible. Furthermore, the bedrock would not allow for adequate securing of the logs.

Station 1+00 - +- Station 1+90 was characterized by the previously constructed in stream pond. Starting at station 1+00 a bedrock outcrop was jack hammered to increase channel capacity and reduce lateral scour on the opposite bank. After this nick point was removed the bedrock shelf ended. It was at this point the channel was able to begin dropping in elevation to start resembling the designed profile slope. Seven log drop structures were installed to minimize the risk of head cutting in this area and allow for a stable drop in grade. Additionally, at station 1+30 through station 1+60, two rock cross vanes and a rock sill were installed to complete the grade drop to the elevation of the downstream culverts (**Photo 2**). In this area, the floodplain area was constricted because of the valley wall bedrock and the road, therefore the rock structures also served the purpose of additional bank stabilization. Stabilization of both left and right banks in this reach was accomplished through seeding, coir matting, tree and shrub containers, willow cuttings, and wetland plugs.

Photo 2. View Upstream Station 1+60

Problem Area #3: This second road crossing involves a large amount of fill. There are two culverts, 36" and 30", that could potentially convey 90 cfs before the roadway is overtopped. The 30" CMP is buried somewhere within the crossing, whose outlet is still visible on the downstream side of this crossing. At flows above 90 cfs, these culverts and the roadway would be overtopped with water flooding over the road. These culverts are not sufficient, undersized, and also partially clogged. The existing culverts currently convey less than the calculated 90 cfs combined before the roadway will be overtopped. This configuration could result in up to 150 TNs of sediment being transported downstream with a failure of these culverts. It is likely that the existing culverts and roadway fill will experience partial failure with a discharge of greater than 150 cfs. This problem area is located at Station 1+90 to 2+50 on the existing Longitudinal Profile.

Work Completed to Address Problem Area #3: All existing culverts were removed and replaced with two 72" culverts (**Photo 3**). Hand stacked rock protection was installed on both the upstream and downstream faces of the embankment around the culverts. Additionally, on the upstream streambank walls, stacked boulder walls were installed to protect the inlet to the culvert pipes and driveway width. Bedrock was encountered during the excavation of the existing culverts resulting in an inability to install the new culvert pipes to the designed depth. In an effort to stabilize this downstream section,

the following prescription was adapted. Immediately downstream of the culverts, a fifteen-foot constructed reinforced rock ramp was installed to the width of the culvert egress. Willow cuttings as well as wetland plugs were placed within the rock ramp. Right and left banks were stabilized with stacked rock walls immediately adjacent to the egress. Stone toe was placed on both banks for approximately 30', along with coir matting, seed, container plantings, and willow stakes (**Photo 4**). Downstream of the rock ramp, a rock vane was installed. The throat width of the vane was set to match the width of both culverts combined. The arms of the vane also were installed from valley wall to valley wall. The resulting structure will serve to greatly reduce head cutting in the stream channel, provide a preferred drop in elevation, as well as serve to protect both the constructed streambanks and upstream valley walls. At station 2+40 and 2+50, two rock sills were installed to prevent head cutting upstream to the crossvane, as well as to provide an opportunity for aggradation within the stream channel, reducing the immediate chance of silt moving downstream during the first runoff flows post construction.

Photo 3. View Downstream Middle Culverts and Rock walls

Photo 4. View Upstream Station 2+25

Problem Area #4: Area #4 is defined along the channel profile stations 4+00 through 5+00. The existing driveway access runs parallel to the stream channel through this reach. The channel shows signs that it has recovered and revegetated since flooding, however the road embankment shows evidence of high erodibility potential.

Work Completed to Address Problem Area #4: Vegetated soil lifts were installed to address the bank hazard in two areas along the road embankment, where sparse vegetation, steep slopes, and poor soil dominated (**Photos 5 & 6**). Tree enhancement was performed throughout the reach as well to help vegetative reestablishment.

Photo 5. View Upstream Station 4+00 Vegetated Soil lifts

Photo 6. View Upstream Station 4+50 Vegetated Soil Lifts

Problem Area #5: The landowner has discussed plans to widen the road and install an additional stream crossing. This problem area is located at Station 5+00 to 6+00 on the existing Longitudinal Profile. The design team has considered the concerns of a future crossing with landowner Patrick Tovaas. No work was done in this area.

Problem Area #6: Three check dams and small undersized sediment basins are constructed with check dams above the profile of the existing reach slope. This configuration could result in up to 45 TNs of sediment being transports downstream with a failure of the check dams. It is likely that the check dams will see partial failure with a discharge of greater than 200 cfs. This problem area is located at Station 6+00 to 7+25 on the existing Longitudinal Profile.

Work Completed to Address Problem Area #6: At station 6+00 a bedrock outcrop was jack hammered and removed to reduce horizontal scour on the right bank as well as providing additional channel capacity. The excavated rock was used to build a constructed rock ramp. The rock ramp served as a steep vertical drop stabilization measure that was then supported by a constructed rock cross vane. Additional grade control structures were added moving further downstream to reduce headcutting potential. Three log drops, a crossvane, and a step pool sequence completed the reach providing proper grade drop to the downstream culvert, as well as reinforcing the newly constructed stream bed (**Photos 7 & 8**).

Photo 7. View Upstream Station 7+00

Photo 8. View Upstream Station 7+30

Problem Area #7: The undersized and partially clogged culverts currently convey less than 18 cfs before the roadway will be overtopped. This configuration could result in up to 20 TNs of sediment being transported downstream with a failure of these culverts. It is likely that the existing culverts and roadway fill will see partial failure with a discharge of greater than 100 cfs. This problem area is located at Station 8+40 to 8+65 on the existing Longitudinal Profile. Currently, low flow from the main channel is shunted at an angle into a 30" corrugated metal pipe culvert under the roadway.

Work Completed to Address Problem Area #7: Jack hammering was required to excavate bed rock throughout this reach to install a 60" culvert (**Photos 9 & 10**). The rock that was excavated in this area was used throughout problem area 4. The upstream side of the culvert was protected with hand stacked boulder walls. The downstream side of the culvert was stabilized with rock that was excavated during the cutting process.

Photo 9. View Upstream Station 8+00 Jack hammering

Photo 10. View Upstream Station 8+00 Culvert install

PROJECT CLOSEOUT

Weekly construction project reports with photos have been submitted electronically to CPRW. A General Stormwater permit was obtained for this project and will be closed out when an appropriate vegetative cover has been established.

CONCLUSION

Based on site characterization and identification of the seven problem areas, five (5) conceptual alternatives for watershed resiliency were developed. These alternatives were ranked using a Multi-Criteria Decision Analysis (MCDA) tool. The MCDA compared multiple design alternatives and ranked how each scheme was anticipated to meet project criteria (e.g., criteria were developed from the goals). The criteria defined for this project fell into the five categories of goals:

- Roadway Improvements;
- Ecosystem Enhancements;
- Channel Flow Capacity;
- Sediment Reduction and stabilization; and
- Risk Reduction.

MCDA analysis, as evaluated by CPRW staff and stakeholders during the 60% design process, made clear that Alternative #4 (Priority II Geomorphic Restoration and Re-alignment for 400 cfs and sediment transport) was the preferred alternative.

The objective for the preferred alternative was to create a new, stable stream and floodplain at the existing channel- bed elevation. We accomplished this by excavating a new floodplain and stream channel at the elevation of the existing incised stream. The new channel was designed and constructed with the appropriate dimension, pattern, and profile (based on reference reach data) to fit the floodplain.

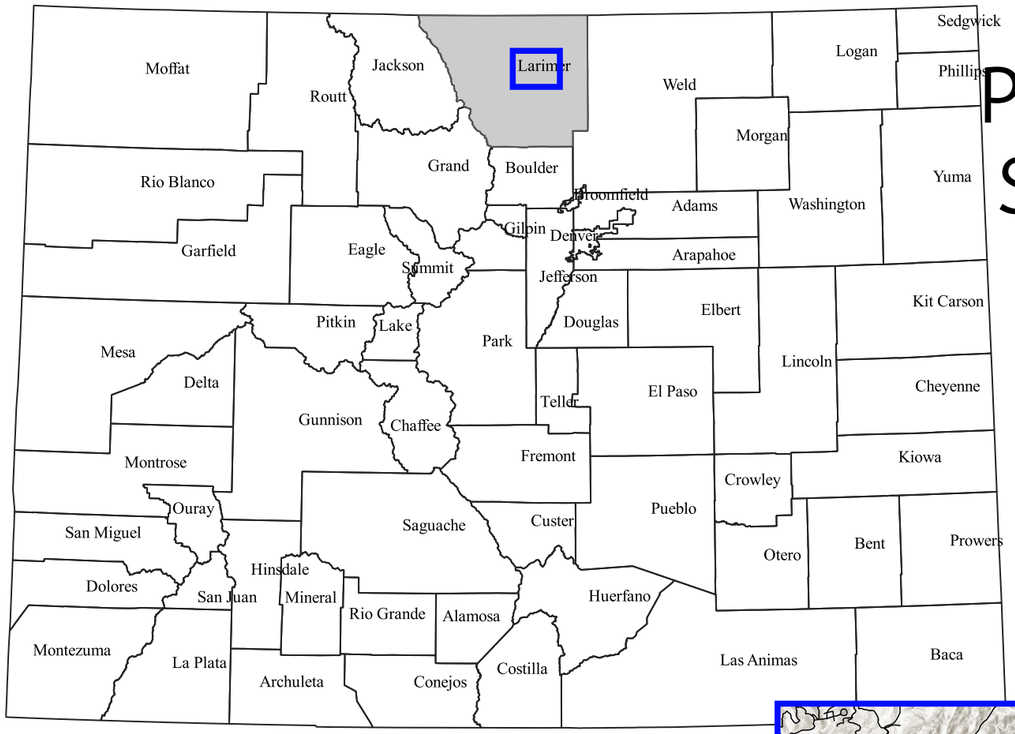
Appendix A

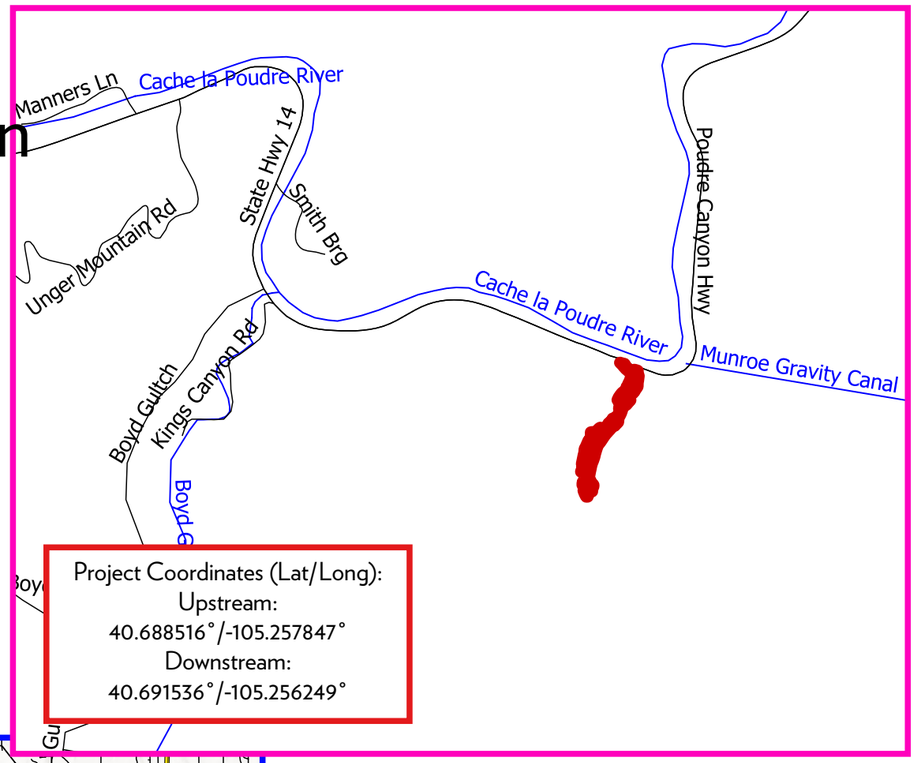
As-Built Plan Set

Unnamed 3
Post-Fire Restoration Stream Restoration and Resiliency

12/18/2018

Near Bellvue
Larimer County, CO





Project Coordinates (Lat/Long):
Upstream:
40.688516°/-105.257847°
Downstream:
40.691536°/-105.256249°

PREPARED FOR:

Coalition for the Poudre River Watershed

PREPARED BY:

AloTerra Restoration Services

5 Smooth Stones Restoration PLLC

Tailwater Limited

PLAN LEGEND

- DESIGN CENTERLINE DESIGN
- BANKFULL CHANNEL LIMITS
- OF GRADING
- LIMITS OF DISTURBANCE
- CULVERT
- SCOUR POOL
- LOG DROP
- CROSS-VANE
- CULVERT
- BOULDER TOE
- ROCK VANE
- SOIL LIFT
- BEDROCK
- STEP POOL
- ROCK RAMP

Sheet List Table	
Sheet Number	**Sheet Title**
-	COVER
2	TABLE OF CONTENTS & LEGEND
3	REDLINES - OVERVIEW
4	CONSTRUCTED WORK - UPSTREAM
5	CONSTRUCTED WORK - DOWNSTREAM
6	REVEGETATION - OVERVIEW

As - Built

DATE ISSUED:
12/18/2018

Table of Contents

Unnamed Tributary 3

PREPARED FOR:
Coalition for the Poudre River Watershed

PREPARED BY:
AloTerra Restoration Services
5 | Smooth Stones Restoration PLLC
Tailwater

PROJECTION: ESPG: 102653
NAD 83 / State Plane Colorado North

SOURCE OF MAP: Google Satellite Imagery

0+90
0+00
0+00
1+00
2+00
3+00
4+00
4+50
5+00
6+00
6+72
7+00
7+88

0 50 100 150 200 250 ft

N

As - Built

DATE ISSUED:
12/18/2018

Geomorphic RedLines

Project Overview

Unnamed Tributary 3

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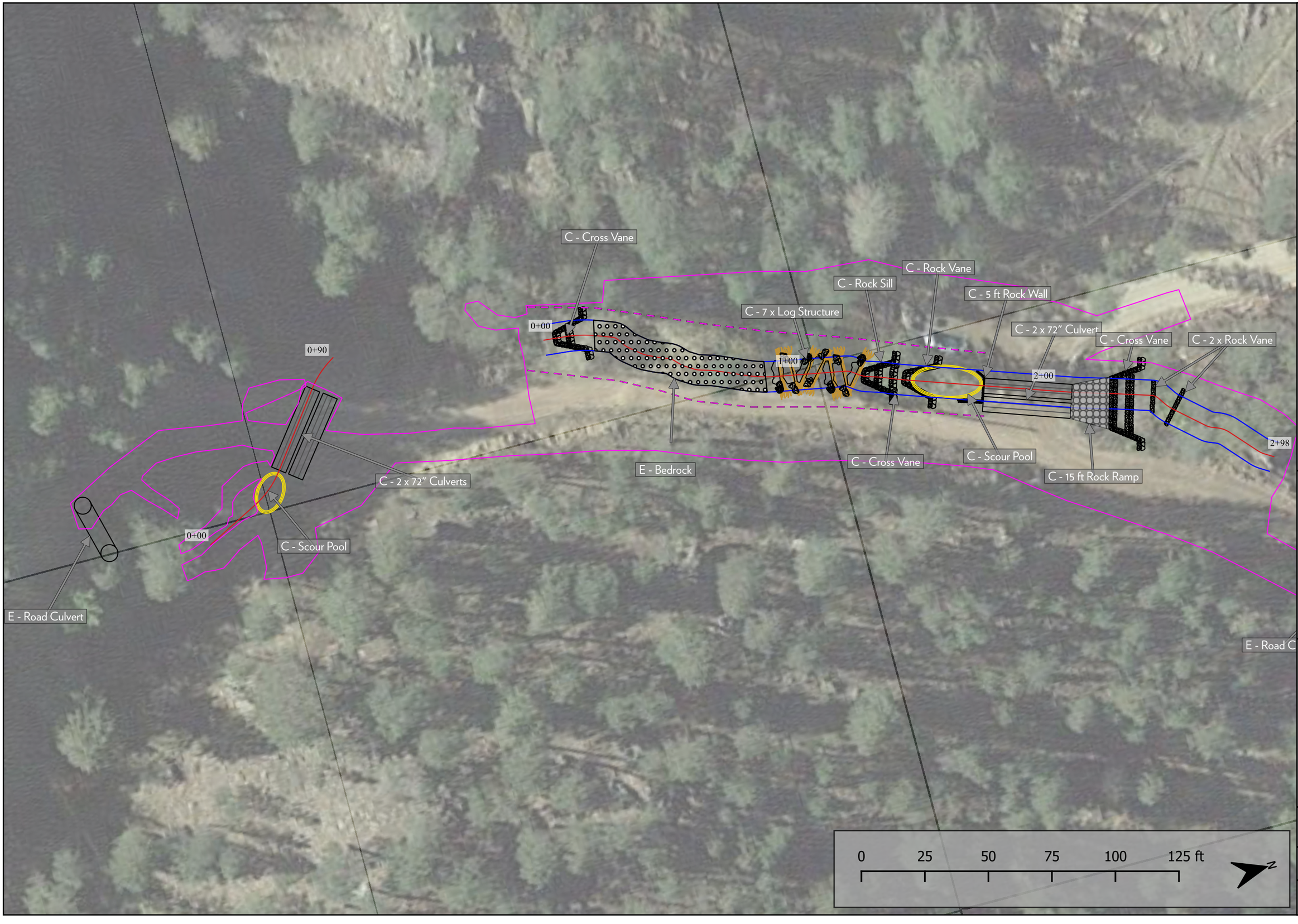
PROJECTION: ESPG: 102653
NAD 83 / State Plane Colorado North

SOURCE OF MAP: Google Satellite Imagery

SHEET NO:
3 of 6



As - Built

DATE ISSUED:
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Geomorphic Construction

Upstream Reach

Unnamed Tributary 3

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PROJECTION
ESPG: 102653
NAD 83 / State Plane Colorado North

SOURCE OF MAP:
Google Satellite Imagery

SHEET NO:
4 of 6

Rock Vane

2+98

4+00

4+50

5+00

6+00

6+72

7+00

7+88

E - Road Culvert

C - Soil Lift

E - Boulder Toe

C - 15 ft Rock Ramp

C - Cross Vane

C - 3 x Log Drop

C - 3 x Step Pool

C - 1 x 60" Culvert

C - Boulder Toe

C - Cross Vane

0 25 50 75 100 125 ft

N

As - Built

DATE ISSUED:
12/18/2018

Geomorphic Construction

Downstream Reach

Unnamed Tributary 3

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Tailwater

PROJECTION: ESPG: 102653
NAD 83 / State Plane Colorado North

SOURCE OF MAP: Google Satellite Imagery

SHEET NO:
5 of 6

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DATE ISSUED:
12/18/2018

Revegetation Implementation

Project Overview

Unnamed Tributary 3

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PREPARED BY:
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5 | Smooth Stones Restoration PLLC
Tailwater

PROJECTION: ESPG: 102653 NAD 83 / State Plane CO North

SOURCE OF MAP: Google Satellite Imagery

SHEET NO: 6 of 6

Appendix B

Weekly Construction Reports

10/8/18- 10/12/18 Weekly report

10/8 skid loader delivered to site. Rich and David B. met onsite to discuss construction design implementation.

10/9 Excavator delivered to site

Started excavating 0+00- 1+80

Encountered bedrock throughout on bottom of channel and river left. Was able to install two rock vanes in section +- 0+20 and 0+ 50 as a replacement for log drops. Will have to adjust planting in this area.

Started building retaining walls around culverts at Station 1+80. Vertical stone walls were used to reinforce road, and allow as much room for the road as possible.

10/10 Continued retaining wall construction around culverts.

Added log steps around station 1+00 to drop stream elevation below bed rock sections to drop stream elevation to reach downstream designed elevations.

Salvaged rock from all upstream areas for log drops and cross vane construction.

10/11 Rain and snow Finalized retaining walls, rough graded stream channel from 1+00-1+50. Added two more log drops around 1+30.


KOMATSU

10/12 Constructed cross vane at station 2+20 below culverts. Completed retaining walls on downstream side of culvert at 2+00

Progress report 10/15-10/19

10/15/18 – snow, no work

10/16/18 – Began dry stack retaining wall on top culvert.

Installed coir matting along slope Right bank 0+00 – 1+50

Installed coir matting Right and left bank below second culvert crossing.

Started soil lifts Right bank +- Station 4+00

10/17/18 – Completed soil lifts a at station 4+00

Installed cross vane to complete elevation transition above second culvert.

Installed two additional log drops +- 2+00.

Completed retaining wall at top culvert

10/18/18

Installed sill below crosssvane 2+80

Added stone protection at outlet of second culvert

Continued adding coir matting throughout

10/19/18

Completed soil lifts Right bank 4+50

UT3 Progress Report 10/22-10/26

10/22 Final graded above upper culvert, continued retaining wall at upper culvert. Graded upper portion of driveway to reduce chamber, continued stabilization in areas between middle and upper culverts.

10/23: Plant pick up for volunteer event, Added two additional rock sills below middle culvert to aid in elevation drop and replace log drops that could not be place due to bedrock.

10/24: Pick up for volunteer event, Excavated and rough graded 5+00-6+40

10/25: Hammer Delivered, started excavation and hammering bed rock at bottom culvert, Volunteer event. 

10/26: Continued bottom culvert excavation


DEERE

UT3 Progress Report week of 11/5-11/9/18

11/5 No work.. Excavator hammer broken down

11/6 Hammer fixed, hammered on bedrock from 10:00-1:00, broken down again.

Continued stabilizing disturbed areas.

11/7 Continued hammering on bottom Culvert

Seeded and stabilized area upstream of top culvert next to driveway.

11/8 Completed bed rock removal, and installed bottom Culvert

Continued willow installation from middle culvert to bottom section.

11/9 Completed bottom section including: Rip rap around bottom culvert, step pool sequence leading into bottom culvert, final graded slopes, cleaned up graded around the whole bottom area.