## Upper Arkansas Watershed Partnership:

### Stream Corridor Hazard and Floodplain Connectivity Assessment

# Opportunities for Fluvial Hazard Mitigation and Improved Stream Corridor Function

**December, 2022**

## Limitations and Disclaimer

The Fluvial Hazard Zone boundary attempts to delineate the extent of the area likely to be influenced by fluvial processes. While fluvial processes are unlikely to occur outside of the Fluvial Hazard Zone boundary, events such as debris flows, debris jams, landslides, earthquakes, dam failures, and diversion channel captures may trigger geomorphic responses not mapped within the Fluvial Hazard Zone. Furthermore the Fluvial Hazard Zone does not capture all flood hazards such as water inundation, that may occur. In addition to the aforementioned, the following is a list of acknowledged limitations of the Fluvial Hazard Zone maps:

Fluvial Hazard Zone mapping may not capture geomorphic hazards resulting from catastrophic events such as a dam failure.

Fluvial Hazard Zone mapping may not account for all bedrock that may be controlling vertical or lateral channel movements, especially if this bedrock is covered by alluvial or aeolian deposits.

The Fluvial Hazard Zone map identifies fluvial geomorphic hazards within and adjacent to the stream corridor that has been mapped (i.e., the study reaches). Adjacent hazards related to tributary streams, gullies, and fans may not be mapped or identified unless explicitly stated.

The DRAFT Fluvial Hazard Zone (FHZ) summary for the Chaffee FHZ Study and DRAFT FHZ mapping products were developed using remotely-sensed data products, statistical analysis, and expert judgment. FHZ maps are intended to delineate the area a stream has occupied in recent history, may occupy, or may physically influence as the stream stores and transports water, sediment, and debris. They do not predict the magnitude, frequency, or rate of fluvial geomorphic hazards. The intended use of DRAFT FHZ maps is to inform land-use planning, emergency planning, floodplain management, and stream corridor conservation efforts. Further investigation may be necessary to inform site-scale development.

The FHZ map authors make no representations or warranties, expressed or implied, as to the accuracy, completeness, timeliness, or rights to the use of FHZ maps. The authors shall not be liable for any errors, omissions, or inaccuracies in such information regardless of their cause, and shall not be liable for any decision made, action taken, or action not taken by the user in reliance upon such information. The authors shall not be liable for any general, special, indirect, incidental, or consequential damages including, but not limited to, lost revenues or lost profits resulting from the use or misuse of the information contained on FHZ maps.

It is the responsibility of the FHZ map sponsor agency to evaluate the FHZ and revise the FHZ maps as conditions in the watershed change over time based on the best data and technical guidance available.

## Introduction

This memo identifies potential opportunities for mitigating fluvial hazards and improving stream corridor function in the stream corridors studied as part of the Upper Arkansas Watershed Partnership's DRAFT FHZ mapping assessment. The opportunities were identified during the fluvial hazard zone mapping process and are by no means intended to be a comprehensive analysis. While ecological uplift (i.e., improved stream corridor health) may be part of a multi-benefit of many of these opportunities, the primary focus was on mitigation of existing fluvial hazards.

**The following County-wide actions are recommended to improve information and communication related to fluvial hazards:**

- Debris flow hazard mapping is available for the county through the Colorado Geological Survey which has funding to complete these studies on a first-come first-serve basis. Chaffee County does not have any comprehensive mapping or information about debris flow locations, susceptibility, or likelihood despite many private residences living in these high-hazard areas.
- Establish a stream corridor overlay.
- Incorporate a fluvial geomorphic hazard review where development is proposed within or adjacent to Active Stream Corridors and ephemeral drainages.
- Begin a stream corridor crossing upgrade process - prioritize and fund crossing retrofits and/or replacements along with improvements to roadways to make them more resilient to fluvial processes. These investments are often multi-benefit opportunities (see structures GIS file and photos developed for this study for additional information).
- Evaluate opportunities for flood warning systems for our most high-hazard drainages (Cottonwood, Chalk, North Fork, South Ark (Maysville area particularly), Poncha Creek (for Poncha Springs), Ute Creek, and Little Cochetopa.
- Incorporate fluvial hazard planning into county planning (see https://www.coloradofhz.com/s/CWCB-FHZ-Quick-Start-v12.pdf for starting point ideas).
    - Local hazard mitigation plans are used to identify, assess, and reduce the impact of disasters. A local hazard mitigation plan should incorporate an assessment of a community's susceptibility to fluvial hazards via FHZ mapping. Local hazard mitigation plans should also seek to identify mitigation opportunities (such as asset relocation), or social measures (such as education or insurance), in order to help safeguard life, property, and the economic vitality of communities.
    - Pre-disaster recovery plans identify specific actions aimed at minimizing the impact and cost of recovery. Pre-disaster recovery planning should incorporate the areas of known susceptibility to fluvial hazards (i.e., FHZ maps) and promote recovery actions that are commensurate with long-term risk reduction (e.g., asset relocation, property buyouts, floodplain reconnections, etc.)
    - Emergency response planning should utilize FHZ maps when planning for evacuation routes and evacuation centers, as well as to assess the viability of proposed emergency response facilities (e.g., fire and police stations, medical facilities, critical transportation infrastructure, etc.) should a flood event occur.
    - Comprehensive recovery ordinances typically establish the framework for a variety of post-disaster tasks such as: stream channel and debris management; stabilization of damaged buildings; identification of

other life/safety risks; repair of damaged infrastructure; and mitigation options and funding to rebuild to different standards or to potentially relocate certain uses. The FHZ may be used to help identify a boundary within which these activities are regulated.

**At the reach level, opportunities are divided into four overarching strategies and broadly summarized below:**

- **Strategy 1: Land and Water Protection**
- **Strategy 2: Corridor Rehabilitation, Reconnection, and/or Restoration**
- **Strategy 3: Infrastructure Considerations and Retrofits**
- **Strategy 4: Mitigate Existing Hazards**

***Note: Identified opportunities did not attempt to identify land ownership, the willingness of landowners to participate, or other aspects related to cost or feasibility.***

### Strategy 1: Land and Water Protection

Ultimately the most cost-effective and resilient option to minimize damage from future flood events is to avoid investments in infrastructure that is not compatible or adaptable to fluvial processes (erosion and deposition) through forward-looking land-use planning that directs land development and infrastructure away from areas subject to fluvial hazards. Limiting development within the FHZ may also:

- Provide for temporary flood water storage and allow for a reduction of peak flood flows in adjacent and downstream communities (Habersack et al., 2015; Sholtes and Doyle, 2010).
- Reduce reliance on channelization, levees, and bank armoring, which are often detrimental to stream health, are expensive to maintain, and often increase erosion and deposition processes in adjacent and downstream communities (Brierley and Fryirs, 2005; Brookes, 1988; Huggett, 2003; Nagle, 2007).
- Increase channel stability by improving floodplain connection and sediment transport.
- Reduce costs of future flood recovery efforts.
- Reduce public expenditures for disaster response and recovery.

#### Stream Corridor Easements and/or Fee Simple Purchases

Strategies for preserving land within the fluvial hazard zone may include conservation or stream corridor easements for parcels (whole or in part) identified in the mapping. The implementation of a stream corridor easement program may be a means to balance the human use of the corridor with a dynamic stream channel. A stream corridor easement allows landowners to divest from areas where repetitive losses are experienced or anticipated, while the easement purchaser makes a long-term investment in the soils, property, infrastructure, and ecosystem in the watershed. The resulting protected corridor provides relief to landowners and taxpayers as the need for channel controlling interventions and maintenance goes away.

Through a Stream Corridor Easement, the landowner sells or donates their right to modify a stream's channel thereby allowing the natural processes of erosion and deposition to continue in perpetuity within the protected easement corridor. The Stream Corridor Easement has no effect on land use or activities outside of the contractual boundary and the landowner may be able to use the land within the easement for agricultural, forestry, and

recreational purposes in a manner that does not interfere with the basic intent to allow the stream channel to move and access its floodplain. In general, Stream Corridor Easements are prioritized for areas in stream corridors with existing or easily rehabilitated floodplains in areas where human actions have not already limited natural movement.

#### Conservation of Agricultural Land and Practices

Many lands adjacent to streams are currently being used for agriculture and/or grazing. Generally speaking, these land uses are considered compatible with areas within a Fluvial Hazard Zone. This mapping could be used as a basis for incorporating and prioritizing agricultural land uses in stream corridors.

#### Land Management

There are many ways for local governments to incorporate Fluvial Hazard Zone mapping into their long-term and land-use planning. The CWCB has produced a Planning for Fluvial Hazards QuickStart Guide outlining the many different ways that FHZ mapping can be incorporated into local planning and administration. Some of these include integration with comprehensive plans and parks and open space plans. Among many strategies, it may be possible to adopt the Fluvial Hazard Zone mapping as the county's Best Available Floodplain within the existing county floodplain regulations. Currently, there is not a comprehensively mapped and adopted FEMA floodplain through these river corridors and this mapping may be able to be used in its place until such products become available.

### Strategy 2: Corridor Rehabilitation, Reconnection, and Restoration

Fluvial Hazard Zone maps can be used to identify and prioritize the restoration and rehabilitation of natural depositional areas which can trap debris and sediment that erodes from upstream reaches in locations where the consequence of aggradation is low. These areas can act as a sediment sink and energy sponge, absorbing material and energy from debris flows and mitigating impacts to downstream residents and communities. This strategy seeks to recommend measures that can be taken in storage reaches to dissipate energy and store sediment upstream of developed areas in order to reduce fluvial geomorphic hazards in populated areas.

### Strategy 3: Infrastructure Retrofits and Upgrades

Infrastructure may create circumstances that increase the sensitivity of the creek or the type and magnitude of a geomorphic response during a flood. The two consistent culprits in the Chaffee County study streams are road crossings and road and railway embankments.

#### Road Crossings

Bridges and culverts are important infrastructure assets that too frequently disrupt the natural movement of water and sediment. Commonly this disruption results in aggradation (build-up) of sediment above them (which can cause a channel to shift in search of a new path), degradation (erosion of sediment below them), and even avulsion (a process where a stream creates a new channel in a different location). The resulting instability caused by poorly designed bridges and culverts often leads to damage to streambanks, damage to roadways and road embankments, and other nearby infrastructure, and can even threaten life and property well outside of mapped

floodplains. Geomorphic-compatible design of bridges and crossing structures is an emerging topic as there is great interest to have resilient infrastructure that is also sensitive to aquatic and terrestrial organism passage.

#### Roads and Railway Bed Improvement

Roads and railway beds impact the stream corridors in two ways. When built parallel to the river valley river meanders are often straightened out by means of fill and armoring resulting in the truncation of former river meanders. The shortened meanders force the river into bends that are too tight, increase the slope and energy of the river, and reduce floodplain services as well as habitat. Over time a river will attempt to adjust to this imposition transferring energy downstream and often causing ongoing problems with the protection and maintenance of highway or railway embankments. Second, when built perpendicular to a river valley Active Stream Corridor processes and functions are impeded. Like de facto dams made of earthen and stone fill, these structures impact flow depths, shear stresses, and sediment transport capacities of channels. These constrictions can affect both upstream and downstream areas.

Because both of these impacts often legacy issues, immediate change may be impractical, however, discussion and documentation are important for several reasons. First, it is possible to quickly retrofit crossings and road/rail beds with a series of culverts (or even additional pre-fabricated bridges) that will provide more opportunity for water moving across a floodplain to pass through road embankments. Second, crossings are consistently being redesigned and rebuilt, especially at the county level, and flagging specific structures and lengths of the roadway for re-assessment by and including geomorphic and stream process experts will add resiliency to the transportation network. Such assessment and planning may also illuminate opportunities to redesign or relocate roadways and crossings for better safety and may present an opportunity for consolidation of infrastructure. Lastly, in the event of a major flood disaster where the road and crossing systems will need to be completely rebuilt, concepts for doing so in a more resilient manner will already be developed and available so that any future tax-supported infrastructure investments are made with the goal of long term river and infrastructure resilience.

### Strategy 4: Mitigate Existing Hazards

In contrast to the strategies outlined in Strategy 2, Fluvial Hazard Zone maps can also be used to identify reaches where the transfer of sediment and debris to natural or restored depositional areas should be prioritized. These areas are generally reaches that are highly altered, developed, inhabited, and have little to no floodplain connection. This section describes measures that can be taken in the transfer reaches to facilitate energy and sediment movement through the reach and into the planned storage reaches described above.

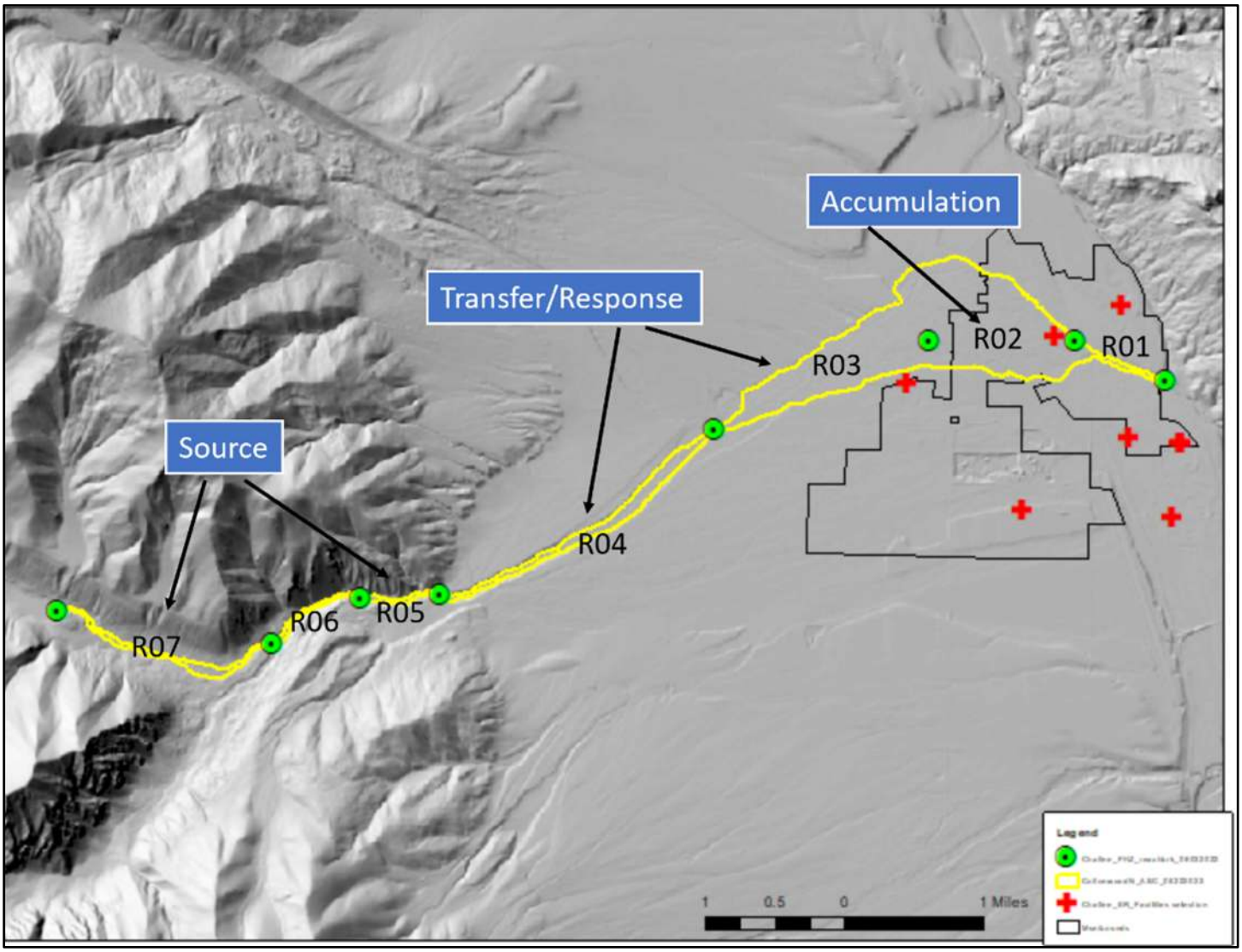
#### Plan for a Disaster

Ensure that loss of function is recognized in local hazard mitigation and emergency response plans. Consider secondary/alternative options.

**For each opportunity the following information is provided:**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">A unique number that is linked to an online webmap for reference.</td><td colspan="3">Brief description of opportunity location (see accompanying polygon file for additional general area).</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Brief description of the existing hazard/opportunity.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">One of the four strategies listed above.</td><td>Brief description of the strategy to mitigate hazard(s).</td><td>$ = <$100k<br>$$ = <$500k<br>$$$ = <$1m<br>$$$$ = >$1m</td><td>Possible local, state, federal, and/or NGOs that may be willing to assist.</td></tr>
<tr><td colspan="3">Photo or aerial of the opportunity (generalized and when available).</td></tr>
</table>

## Cottonwood Creek



**Cottonwood R07**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CW7</td><td colspan="3">Vicinity of CR 344 crossing over Cottonwood Creek.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Crossing is undersized relative to the potential sediment and debris coming from the watershed (further exacerbated by the dam-effect of the roadway as it bisects the Active Stream Corridor). Development on d/s side of CR 344 bridge vulnerable if bridge plugs and flanks (large wood loading upstream of structure is excellent habitat, however mobility of this material through the culvert is not guaranteed even though the culvert is better-sized than most found in the County.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Mitigate Existing Hazards</td><td>Further engineering, sediment, and debris analysis/study to consider existing structure limitations, risks, and consequences as well as whether options for improvement exist.</td><td>$</td><td>County, Private landowner(s)</td></tr>
<tr><td colspan="3"> 
</td></tr>
</table>

**Cottonwood R06**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CW6</td><td colspan="3">Where CR 306 contacts that channel and or is placed on fill in the Active Stream Corridor.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Highway washout is all but assured in a significant flow event due to the confined corridor, high shear stresses and stream power, and debris loads both from upstream and adjacent hillslopes. There are also at least three drainages, and several possible debris flow paths, from the north that could block the highway and creek.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Mitigate Existing Hazards</td><td>County should be prepared for having this roadway become impassable following a flood event. Ensure this topic is discussed in local hazard and emergency planning.</td><td>$</td><td>County</td></tr>
<tr><td colspan="3"> 
</td></tr>
</table>

**Cottonwood R05**

| ID | Location | | |
|---|---|---|---|
| CW5a | CR306 crossing u/s of Cottonwood Hot Springs | | |
| | Justification | | |
| | Bridge washout/flanking and roadway damage of CR306 and crossing likely during flood event. County crossing forces the channel into a sharp bend. Plugging of the bridge may cause the channel to avulse as it flows down valley eroding a new channel out of the roadway before re-entering the existing channel further downstream toward the hot springs. | | |
| Type | Description | Cost | Partners |
| Infrastructure Retrofits and Upgrades | Further engineering, sediment, and debris analysis/study to consider existing structure limitations, risks, and consequences as well as whether options for improvement exist. | $$ | County |
| |  | | |

**Cottonwood R05 (cont.)**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CW5b</td><td colspan="3">Vicinity of Cottonwood Hot Springs - commercial and residential development.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Commercial business and private property damage possible.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Mitigate Existing Hazards</td><td>Evacuation plans for moving staff, customers, and residents out of the valley bottom during a flood may be the only way to prepare for the existing hazard.</td><td>$</td><td>Private</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

**Cottonwood R04**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CW4a</td><td colspan="3">Vicinity of Michigan Ditch diversion to CR 340 crossing.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Reach appears to have good riparian health and large wood accumulation. It has, thus far, been spared from development. This is an important corridor to protect as it has the potential to capture and accumulate large amounts of sediment and debris; doing so may provide protection to downstream residents and infrastructure.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Corridor Rehabilitation, Reconnection, and/or Restoration<br><br>Land and Water Protection</td><td>Work with landowners to assess stream corridor connectivity and riparian function. Specific management recommendations beyond these are limited due to access which prevented our ability to evaluate the current condition of the reach beyond what was visible from public roads.</td><td>$</td><td>NGO, Private</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

**Cottonwood R04 (cont.)**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CW4b</td><td colspan="3">Vicinity of CR 340 and CR 338 crossings</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Development in ASC in the vicinity of both these county road crossings seems particularly vulnerable to flooding due to undersized road crossings and water backing up behind the road prisms.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Mitigate Existing Hazards</td><td>A conceptual design is needed to evaluate the avulsion pathway to the north, enhanced crossings, and debris passages concerns specific to this area.</td><td>$$$</td><td>Private</td></tr>
<tr><td colspan="3">  <br>  </td></tr>
</table>

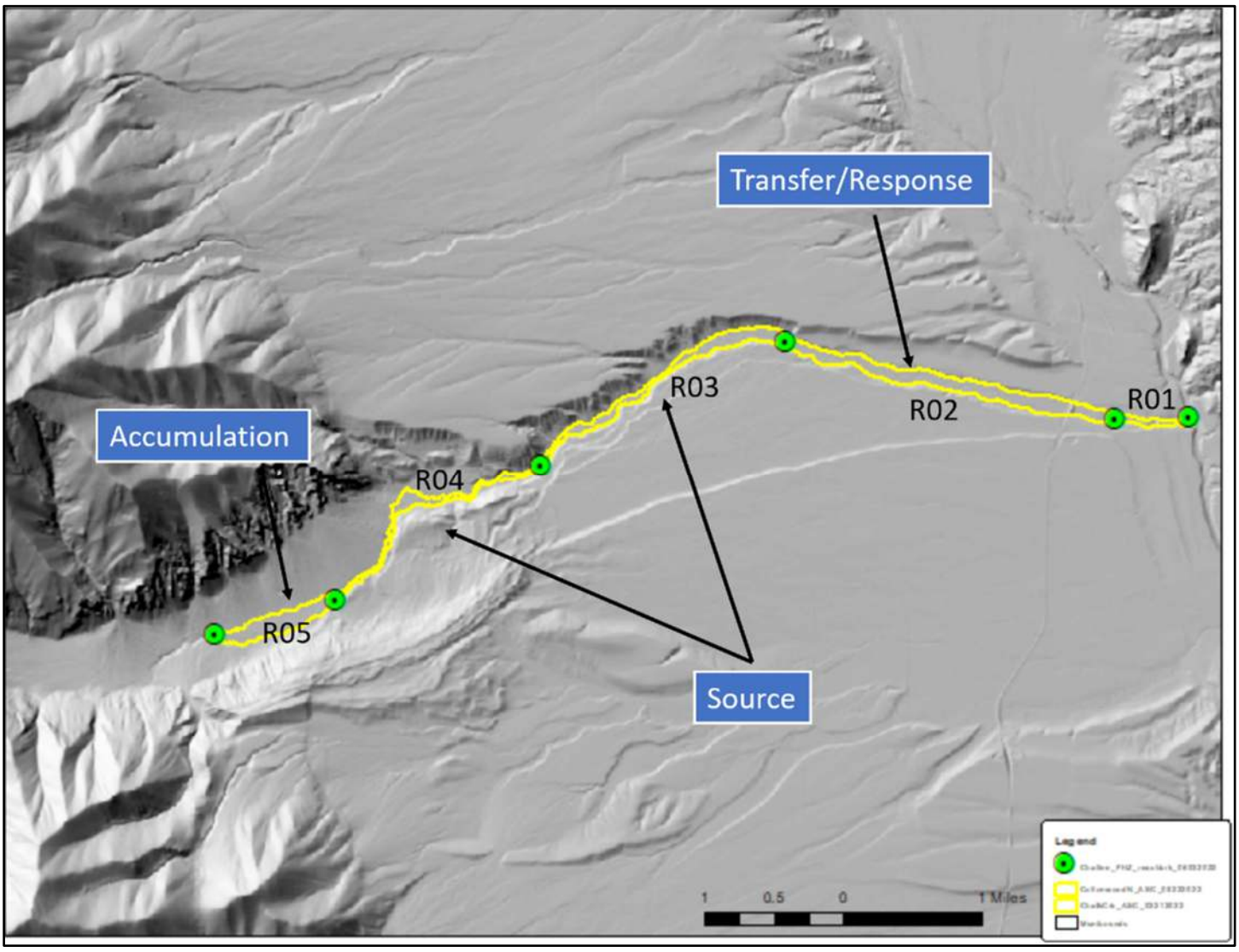
**Cottonwood R03**

| ID | Location | | |
|---|---|---|---|
| CW3a | Downstream from CR 361 crossing (generally) | | |
| | Justification | | |
| | The area where geomorphic floodplain width expands dramatically could become a natural deposition area for sediment and debris. | | |
| Type | Description | Cost | Partners |
| Corridor Rehabilitation, Reconnection, and/or Restoration<br><br>Land and Water Protection | Maintain field in agricultural use. Investigate opportunities for stream corridor restoration. | $-$$ | Private, NGO |
| |  | | |

**Cottonwood R03 (cont.)**

| ID | Location | | |
|---|---|---|---|
| CW3b | CR 350 crossings | | |
| | Justification | | |
| | Undersized road crossings at sharp angles combined with the historic lengthening of stream channel (reducing the slope) make an avulsion likely here. | | |
| Type | Description | Cost | Partners |
| Land and Water Protection | Maintain field in agricultural use. | $-$$ | Private, NGO |

## Chalk Creek


Transfer/Response
Accumulation
Source
R01
R02
R03
R04
R05
1
0.5
0
1 Miles

**Chalk R05**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CK5</td><td colspan="3">Upstream of CR 290 crossing of Chalk Creek. Vicinity of Bunny Lane.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">A unique natural depositional pockets that exists on Chalk Creek downstream of Alpine Lake. This is an expansive floodplain with good energy dissipation potential coming from the ponds and vegetation. Most of the land is in public trust with Colorado Parks and Wildlife.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Corridor Rehabilitation, Reconnection, and/or Restoration</td><td>Meet with CPW to discuss challenges and opportunities of stream corridor health (there is private landowner development and clearing of vegetation in the vicinity of the stream corridor) and ensure long-term protection for this reach. Maybe an opportunity to enhance this site further with a low-tech restoration project.</td><td>$-$$</td><td>NGO, Private</td></tr>
<tr><td>Land and Water Protection</td><td colspan="3">  </td></tr>
</table>

**Chalk R04**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CK4a</td><td colspan="3">TreeHouse Hot Springs vicinity - unnamed County Road.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Low clearance bridge has the potential to be blocked given the sediment and debris supply upstream from the Chalk Cliffs. Existing infrastructure located within the Active Stream Corridor is vulnerable to fluvial hazards.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Mitigate Existing Hazards</td><td>Concept designs that address hazards, bank erosion, and whether debris accumulation issues can be mitigated. Evacuation planning and awareness is highly recommended.</td><td>$-$$$$</td><td>Private, County</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

**Chalk R04 (cont.)**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CK4b</td><td colspan="3">Vicinity of Mount Princeton Hot Springs.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">New development at Mt Princeton Hot Springs in the 1) Active Stream Corridor and 2) below erodible hillslopes, and 3) adjacent to small bridges is at risk from compounding and complex natural processes.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Mitigate Existing Hazards</td><td>Concept designs that address depositional hazards, bank erosion, and debris accumulation issues. Evacuation planning and awareness, including staff training, is highly recommended.</td><td>$$</td><td>Private, County</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

**Chalk R03**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CK3</td><td colspan="3">From Princeton Parkway (approximately) to downstream of the fish hatchery.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Further study to understand the condition of this reach is needed. Reach may be an area where ecological uplift and stream corridor function can be enhanced for the benefit of watershed health without significant intervention.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Corridor Rehabilitation, Reconnection, and/or Restoration<br><br>Land and Water Protection</td><td>Meet with landowners to discuss challenges and opportunities of stream corridor health and protection in this reach. Could be a candidate for PALS and other low-tech improvements.</td><td>$-$$$</td><td>NGO, Private</td></tr>
<tr><td colspan="3"> 
</td></tr>
</table>

**Chalk R02**

| ID | Location | | |
|---|---|---|---|
| CK2a | CR 286 and US 285 crossing vicinity. | | |
| | Justification | | |
| | US 285 bridge has significant impacts on the lower end of the reach. It also appears that there may be a fish passage blockage created by the roadway crossings here. | | |
| Type | Description | Cost | Partners |
| Infrastructure Retrofits and Upgrades | Conceptual design to address crossing impacts on stream corridor health and hazards. Evacuation planning and awareness consideration for upstream property. | $-$$$$ | County, CDOT, Private |
| |  | | |

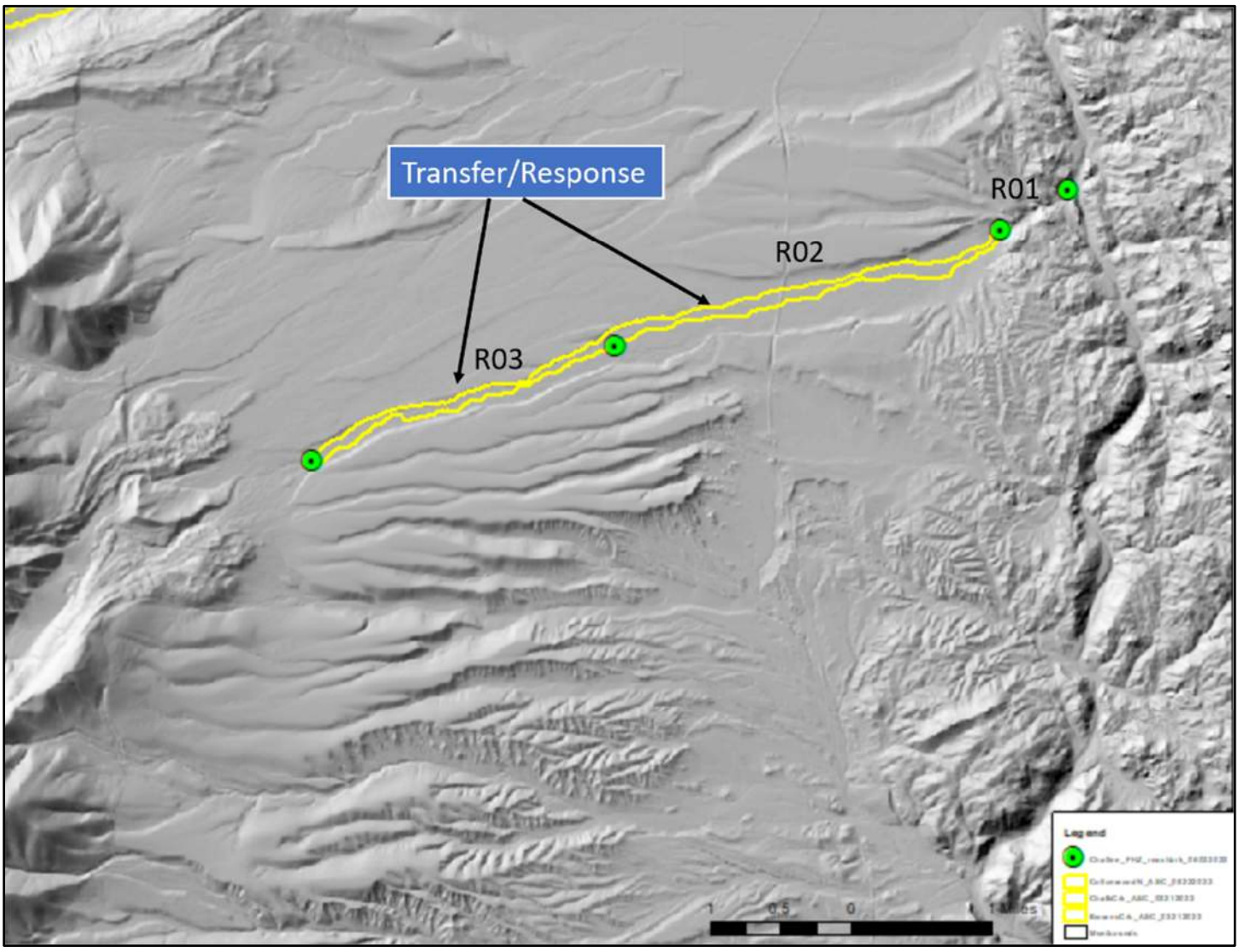
**Chalk R02 (cont.)**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CK2b</td><td colspan="3">Upstream and downstream of Highway 285 crossing</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Undeveloped stream corridors – there appears to be evidence of past beaver ponds downstream of the highway. Upstream, the channel has been straightened for agriculture.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Corridor Rehabilitation, Reconnection, and/or Restoration<br><br>Land and Water Protection</td><td>Investigate landownership and conservation/restoration potential.</td><td>$</td><td>NGO, Private</td></tr>
</table>


**Chalk R01**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">CK1</td><td colspan="3">CR197A and Railroad crossing vicinity.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">The road to the trailer park causes a localized constriction (under the railroad bridge). Increased shear stress and stream power are likely to result in erosion in this reach during a flood as a result of sediment supply disruption from CO 285 crossing upstream.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Infrastructure Retrofits and Upgrades</td><td>Relocate roadbed fill to reestablish channel floodplain. Ensure railroad bridge modifications/improvements reduce constrictions of the stream corridor.</td><td>$</td><td>County, State, Feds, Union Pacific</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

## Browns Creek



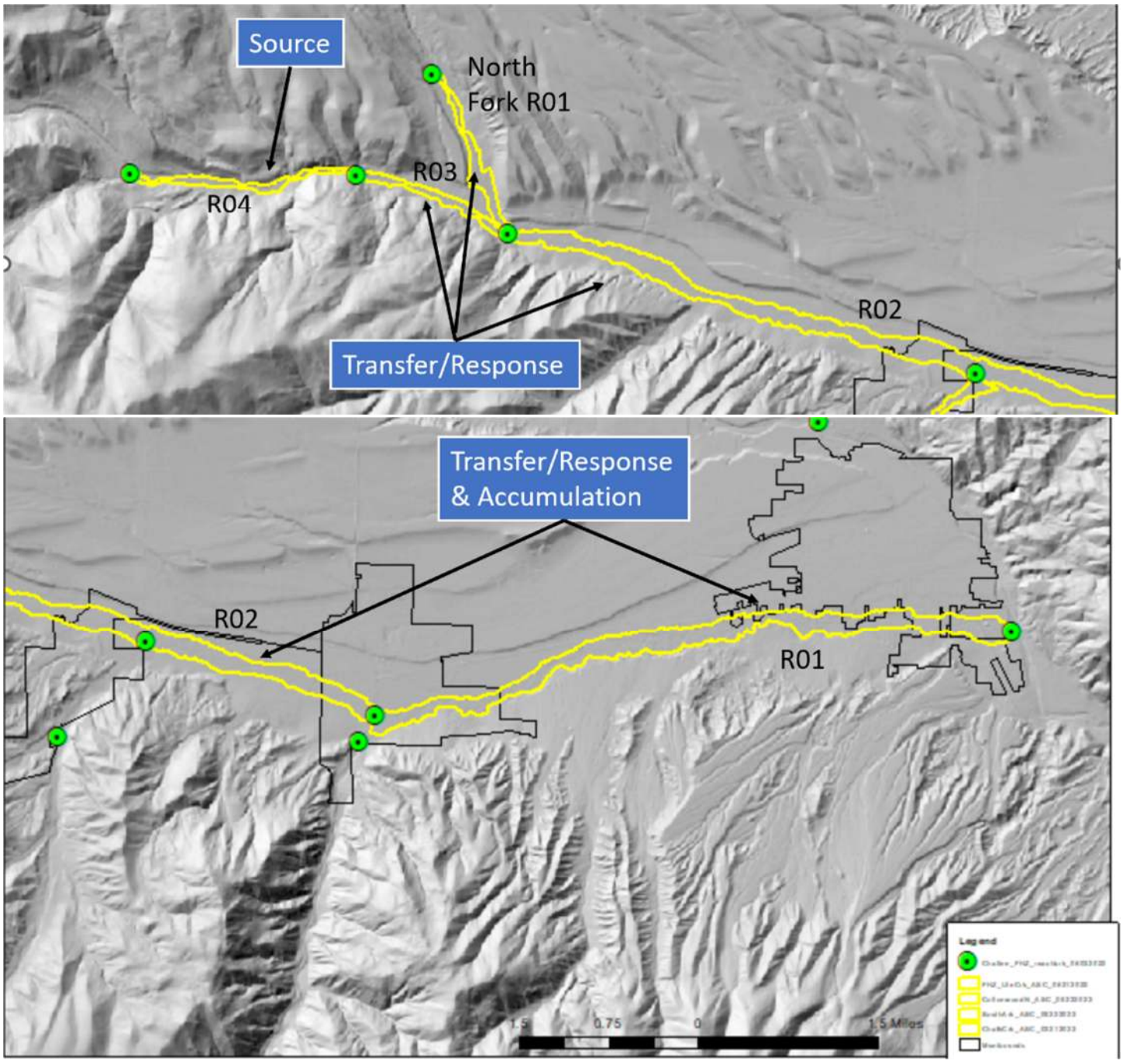
**Browns R03**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">BC3</td><td colspan="3">Entire reach.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Roadways perpendicular to valley are likely to act as dams during a flood when numerous undersized culvert crossings plug. CR 261C (river right (south) side) seems to follow a secondary drainage and may be at times lower than existing Creek bed creating a potential avulsion pathway. Floodfactor modeling has nearly whole valley bottom as wet/vulnerable to flooding.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Infrastructure Retrofits and Upgrades<br><br>Mitigate Existing Hazards</td><td>Conceptual design to address numerous undersized crossings. Evacuation planning and awareness consideration for landowners.</td><td>$$</td><td>Private, County</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

**Browns R02**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">BC2</td><td colspan="3">Entire reach.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Existing open space with compatible land use (ranching). The stream corridor is degraded.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Corridor Rehabilitation, Reconnection, and/or Restoration</td><td>Meet with landowners to discuss challenges and opportunities of stream corridor health and protection in this reach. Could be a candidate for PALS and other low-tech improvements (e.g., restore floodplain connectivity and riparian vegetation). Riparian corridor pasture management practices and possible conservation easement(s) could also be discussed.</td><td>$-$$$</td><td>Private, NGO</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

## South Arkansas River



**South Ark R04**

| ID | Location | | |
|---|---|---|---|
| SA4 | Vicinity of Monarch River Estates | | |
| | Justification | | |
| | Development in Monarch River Estates appears to be vulnerable to future flooding and/or fluvial hazards - especially if watershed conditions change due to a wildfire or in the case of a large flood event. | | |
| Type | Description | Cost | Partners |
| Mitigate Existing Hazards | Use FloodFactor model and updated CWCB floodplain model to provide guidance to landowners about flood inundation risk. | $ | Private |
| |  | | |

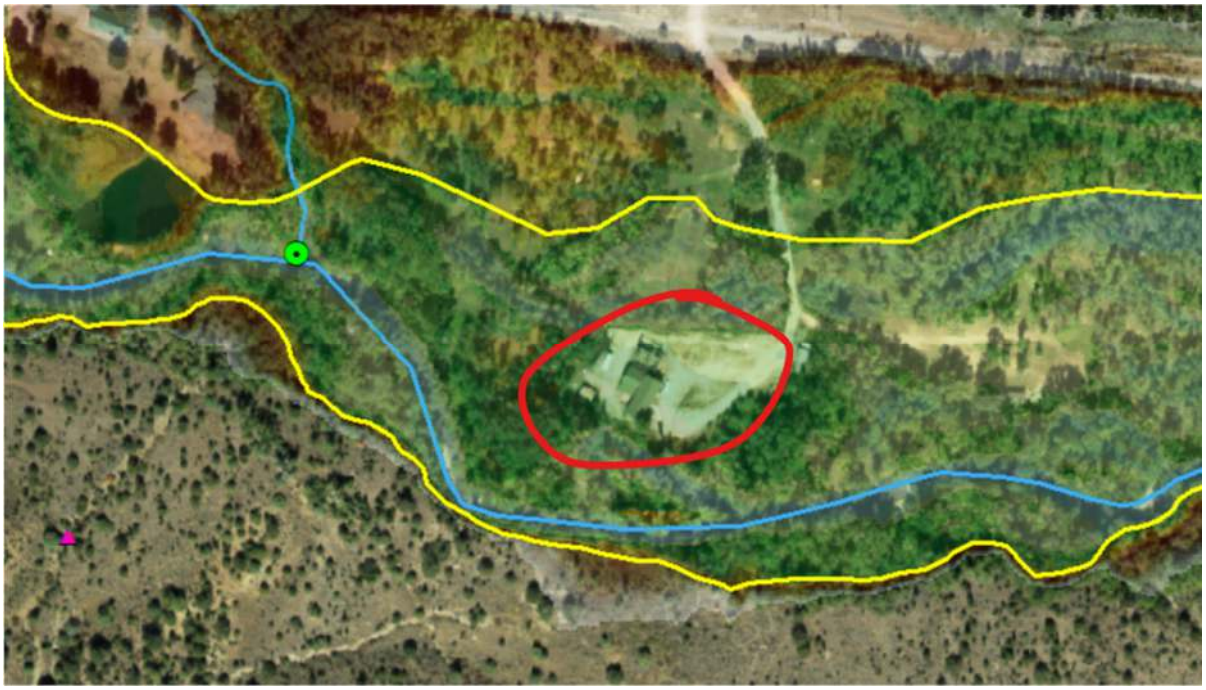
**South Ark R03**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">SA3a</td><td colspan="3">Maysville</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Roadways and undersized crossings are preventing the proper transport of sediment and debris. A known issue in Maysville based on observance of excavated channel materials up and downstream of the bridge(s). These structures are likely to cause the channel to avulse during a flood thus threatening nearby existing infrastructure (lives/property).</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Infrastructure Retrofits and Upgrades<br><br>Mitigate Existing Hazards</td><td>Flood hazard mitigation study and infrastructure upgrade study. Consider sediment supply from upstream and whether opportunities exist to trap more of it upstream, most likely channel is naturally aggradational here and deposition opportunities should be maintained within reach.</td><td>$$$</td><td>County, Private</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

**South Ark R03 (cont.)**

| ID | Location | | |
|---|---|---|---|
| SA3b | Maysville | | |
| | Justification | | |
| | Several houses in Maysville are built on debris fans. | | |
| Type | Description | Cost | Partners |
| Mitigate Existing Hazards | Debris fan mapping and mitigation study for Maysville. Near-term and immediate hazard communication with residents. | $-$$$$ | Private, County |
| |  | | |

**South Ark R02**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">SA2a</td><td colspan="3">Vicinity of the confluence of North Fork with the South Arkansas River off CR 220 d/s of Maysville.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Electric substation is located in the Active Stream Corridor just downstream of the confluence of the North Fork. May be vulnerable to floods.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Mitigate Existing Hazards</td><td>Further investigate the vulnerability of substation and whether mitigation measures can be made. Consider the ramifications of the substation going offline.</td><td>$</td><td>State, Feds, County, Private Corp</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

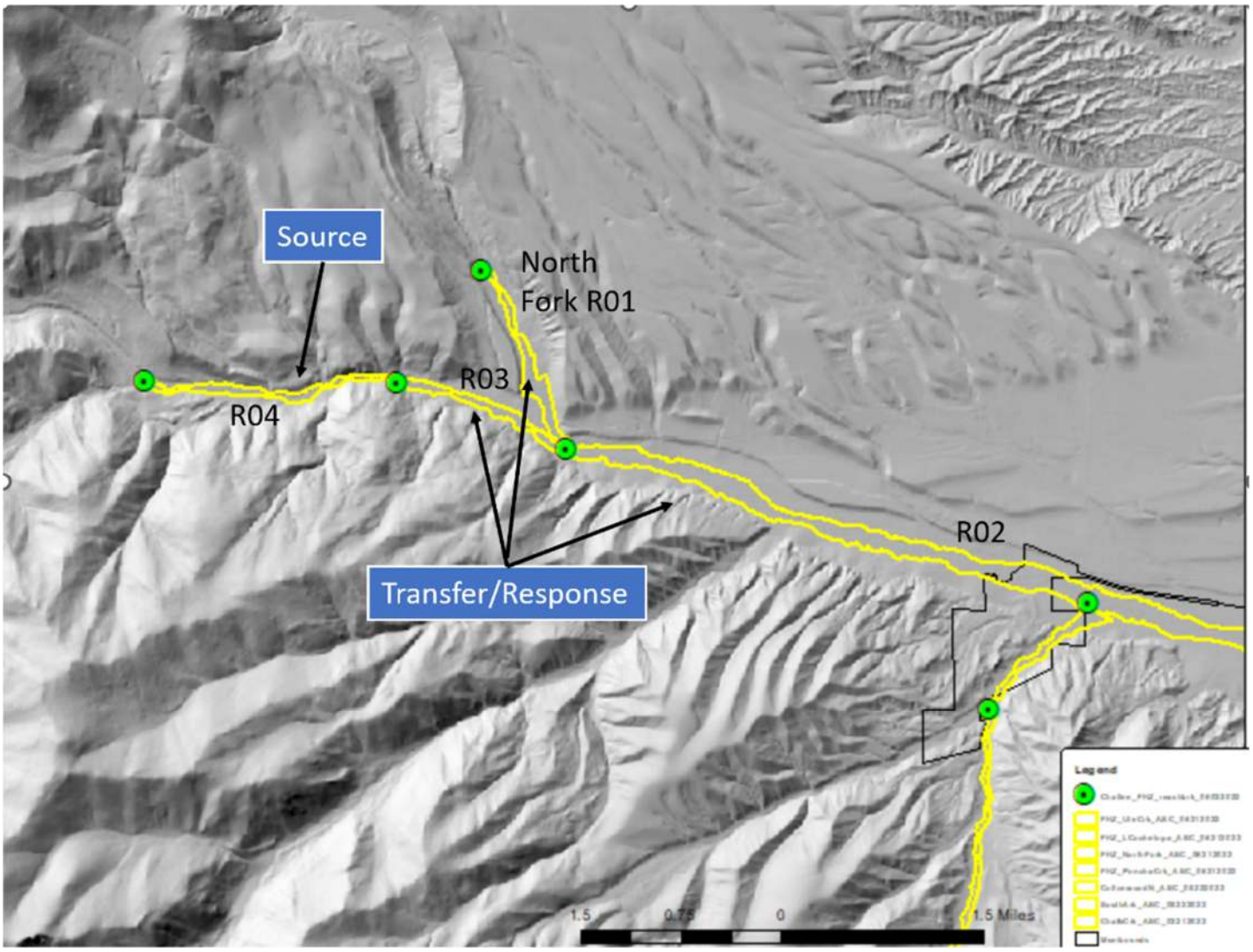
**South Ark R02 (cont.)**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">SA2b</td><td colspan="3">Entire reach</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Maintain current open space land use; Restore floodplain connectivity and riparian vegetation (beavers).</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Corridor Rehabilitation, Reconnection, and/or Restoration</td><td>Meet with landowners to discuss challenges and opportunities of stream corridor health and protection in this reach. Could be a candidate for PALS and other low-tech improvements.</td><td>$-$$$</td><td>Private, NGO</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

**South Ark R01**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">SA1</td><td colspan="3">Numerous sites in South Ark 01.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Existing development in Active Stream Corridor combined with undersized crossing and elevated road decks threaten life and property.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Mitigate Existing Hazards</td><td>Numerous hazards exist here. Simple actions include lowering the road deck at Little River Lane to protect existing houses (provide preferentially flow paths for flood waters). More complex actions include infrastructure retrofits, buyouts of non-compatible land use, and infrastructure retrofits. Also, include hazard communication with landowners.</td><td>$-$$$$</td><td>Private, County</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

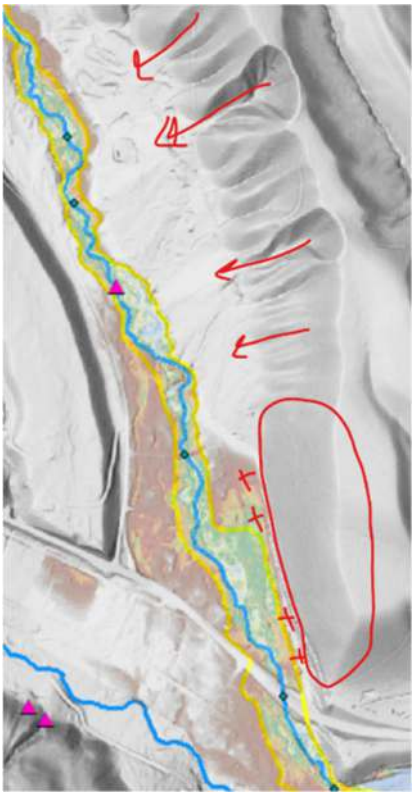
## North Fork of the South Arkansas River



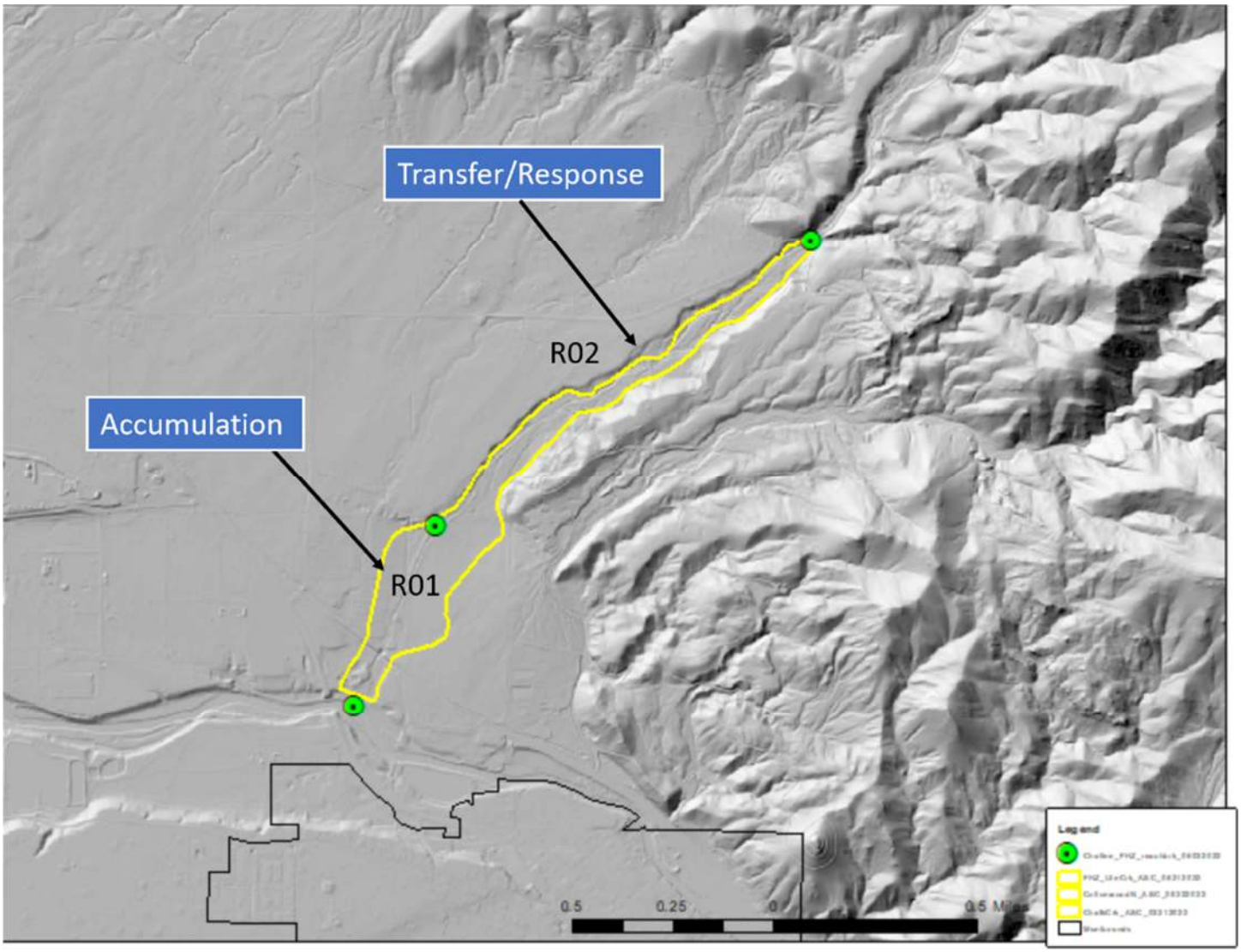
**North Fork R01**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">NF1a</td><td colspan="3">Entire reach.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Development on both sides of the channel in a response reach. The watershed above is mostly forested and vulnerable to wildfire. Not much corridor exists upstream to attenuate sediment and debris.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Mitigate Existing Hazards<br><br>Infrastructure Retrofits and Upgrades</td><td>Conduct a study to further define the flood, debris flow, and avulsion hazard potential of this area and to identify specific mitigation strategies for these homeowners.</td><td>$$</td><td>County, Private landowner(s)</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

**North Fork R01**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">NF1b</td><td colspan="3">Lower end of reach, east side of valley above CO 50 crossing.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">LiDAR indicates hillslope failure potential as does surficial geology map. Houses are constructed in an area that may be susceptible to landslide.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Mitigate Existing Hazards</td><td>Contact the Colorado Geologic Survey to determined landslide hazard potential of this area and to identify specific mitigation strategies for these homeowners.</td><td>$</td><td>County, Private landowner(s)</td></tr>
<tr><td colspan="3">  <br>Red arrows indicate area upvalley where landsliding has occurred. The southern end of this geologic formation (red circle) has not had these type of failures. Houses exist at the toe of this slope (approximated by red “x”).</td></tr>
</table>

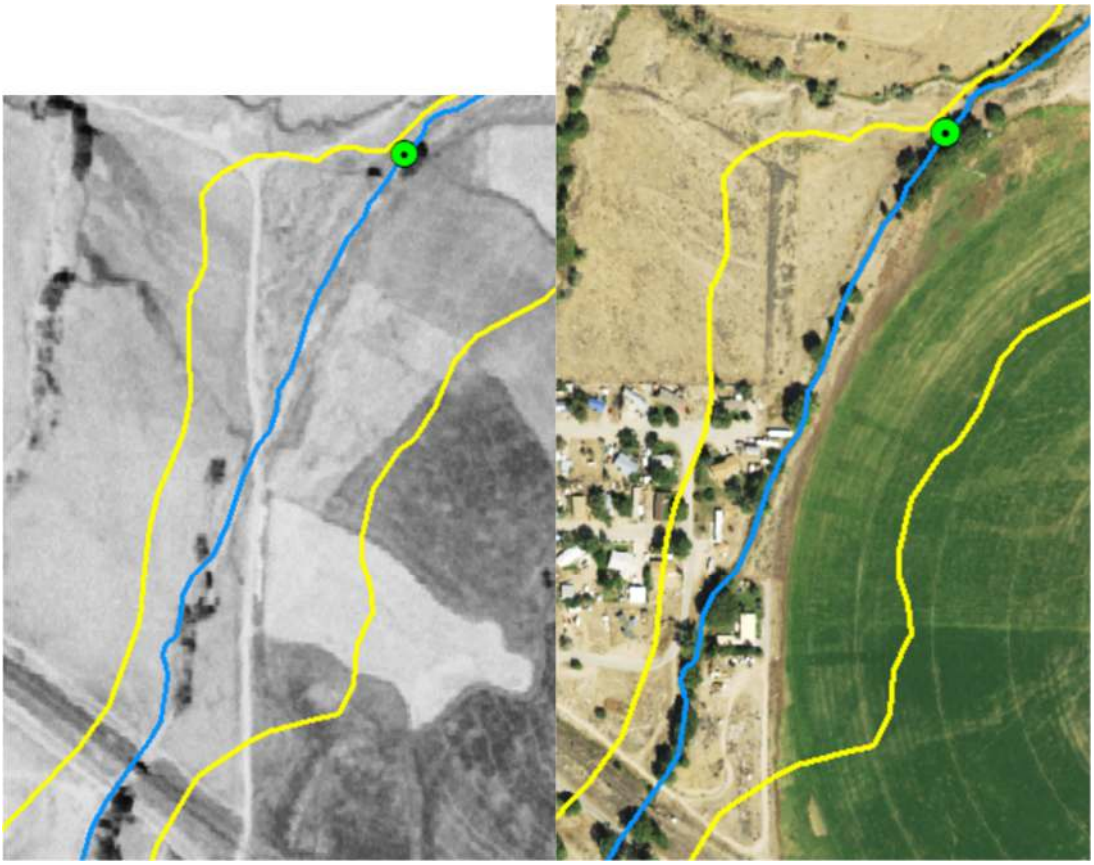
## Ute Creek


Transfer/Response
RO2
Accumulation
RO1
0.5
0.25
0
0.5 Miles
Legend

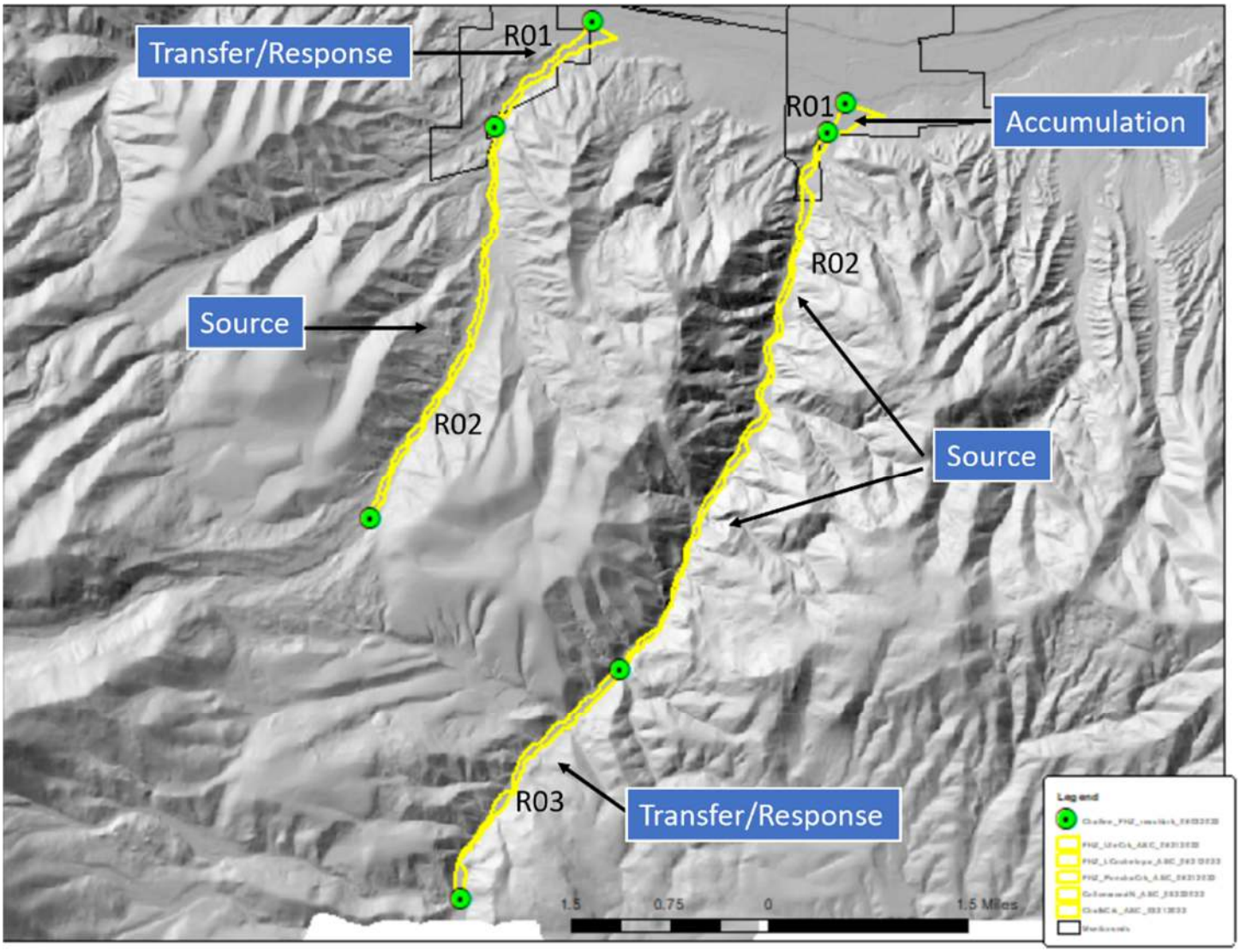
**Ute Creek R02**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">UC2</td><td colspan="3">CR 156 crossing (top of reach)</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Significantly undersized crossing along with unpermitted dams and sediment basins create significant avulsion hazard potential as well as increasing threat to development in the Active Stream Corridor downstream of the crossing.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Infrastructure Retrofits and Upgrades</td><td>Replace existing “dam” with an appropriately sized bridge (see the photo below of bridge that exists further up the Ute Creek corridor). Restore corridor. Relocate sediments downstream to reconnect the incised channel.</td><td>$$$</td><td>County</td></tr>
<tr><td colspan="4">  </td></tr>
</table>

**Ute Creek R01**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">UC1</td><td colspan="3">CR 156a and 156c vicinity</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Homes lie in Active Stream Corridor.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Mitigate Existing Hazards</td><td>Educational campaign to raise awareness of flood potential in this area and work on evacuation planning. Possible land trade opportunity to relocate some of these structures. At least campaign to get flood insurance for these structures. Consult updated FEMA regulatory maps when they become available in 2023.</td><td>$-$$$$</td><td>County</td></tr>
<tr><td colspan="4">  <br>1953 2019</td></tr>
</table>

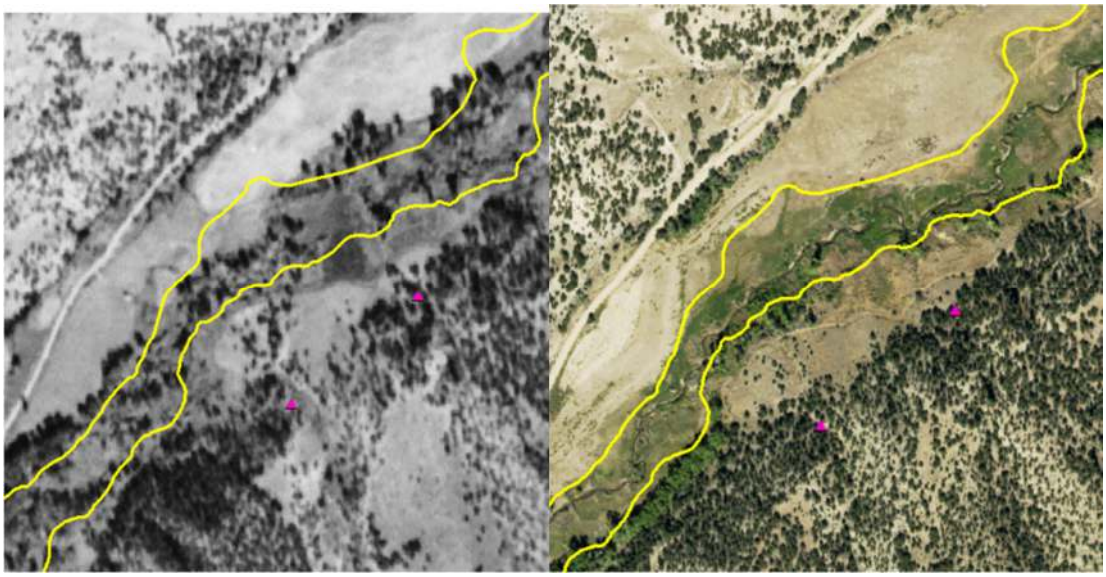
## Little Cochetopa Creek



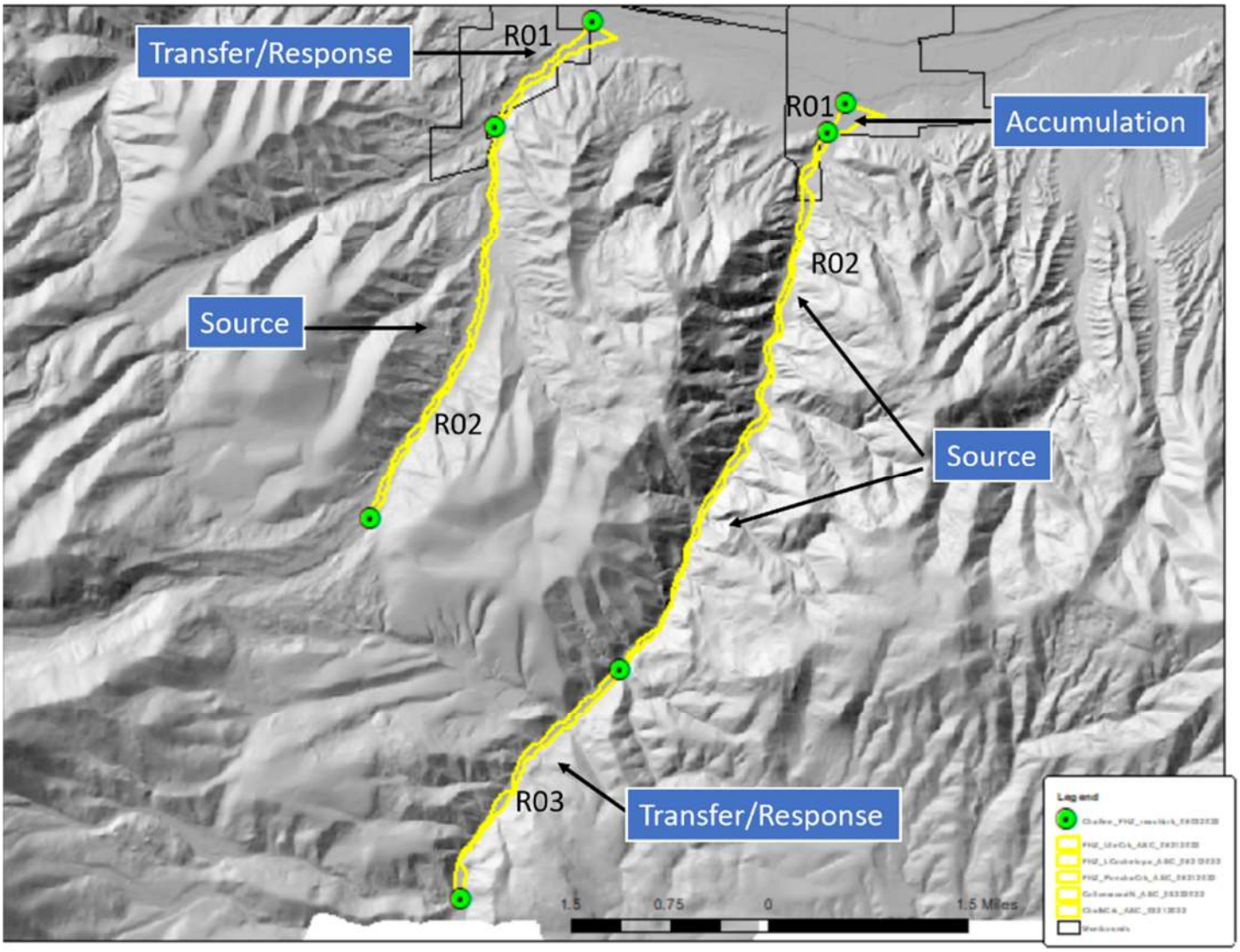
**Little Cochetopa R02**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">LC2</td><td colspan="3">Entire reach where crossings/development intersect the fluvial hazard zone.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Development on both sides of the channel in source reach. Watershed above is mostly forested and vulnerable to wildfire. Not much corridor exists upstream to attenuate sediment and debris. Recent flooding damaged many crossings.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Infrastructure Retrofits and Upgrades</td><td>Provide guidance and assistance to landowners for crossing upgrades.</td><td>$$</td><td>County, Private landowner(s)</td></tr>
<tr><td colspan="4">  undersized crossing and road dam spring ‘22<br>  replacing washed out culvert summer ‘22.</td></tr>
</table>

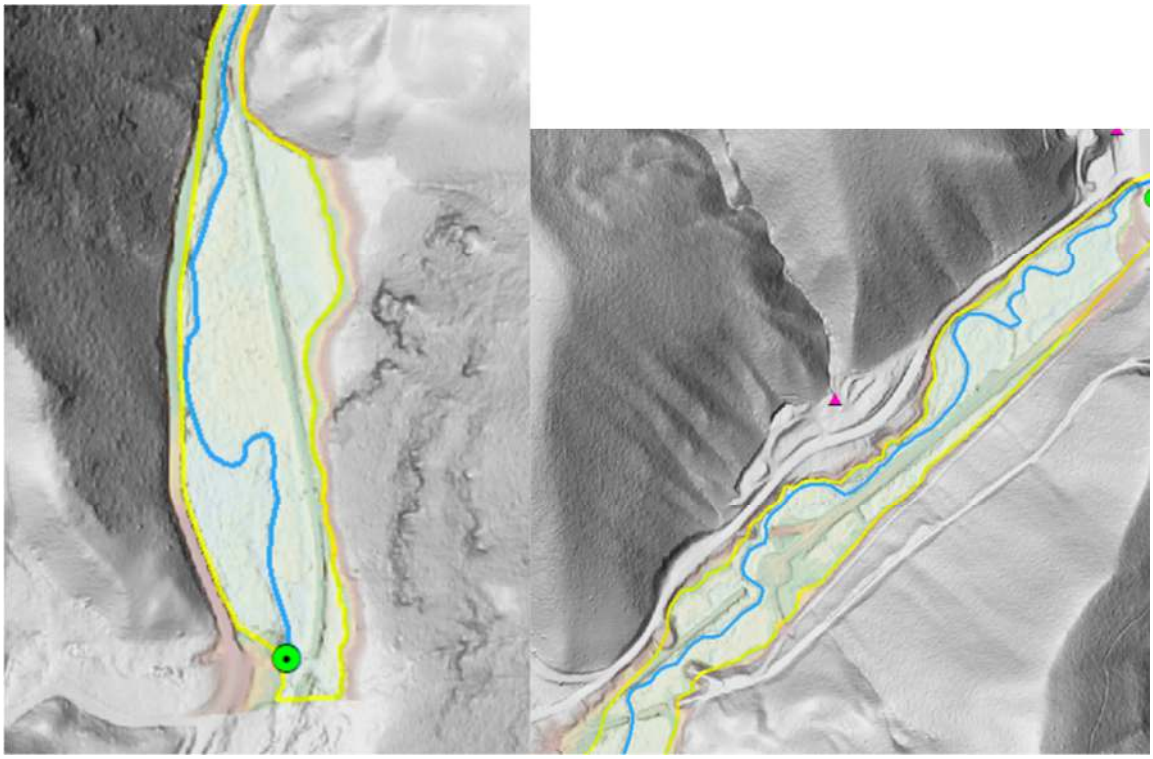
**Little Cochetopa R01**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">LC1</td><td colspan="3">Near the confluence of L.Cochetopa and S. Arkansas River</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Steep fire and flood-prone watershed upstream. This is a response reach with an accumulation zone near the confluence with the South Ark (alluvial fan). Floodplain alterations have degraded stream health. Riparian vegetation and beaver dam removal has contributed to channel incision and floodplain disconnection.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Corridor Rehabilitation, Reconnection, and/or Restoration<br><br>Land and Water Protection</td><td>Meet with landowners to discuss challenges and opportunities of stream corridor health and protection in this reach. (Note: It is our understanding that this property was notified of a violation from the ACOE and is currently working with a consultant on a restoration project).</td><td>$-$$$</td><td>NGO, Private</td></tr>
<tr><td colspan="4">  <br>Cottonwood trees visible along the creek in 1953 (left) are all but absent in 2019 (right).</td></tr>
</table>

## Poncha Creek



**Poncha Creek R03**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">PC3a</td><td colspan="3">Entire reach.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Unused railbed bifurcates floodplain. Sediment and water storage functions have been reduced and riparian and aquatic habitats are disconnected.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Corridor Rehabilitation, Reconnection, and/or Restoration<br><br>Land and Water Protection</td><td>Reach-scale concept design to identify areas where railbed can be removed and floodplain reconnected.</td><td>$-$$$</td><td>Federal, private</td></tr>
<tr><td colspan="3">  </td></tr>
</table>

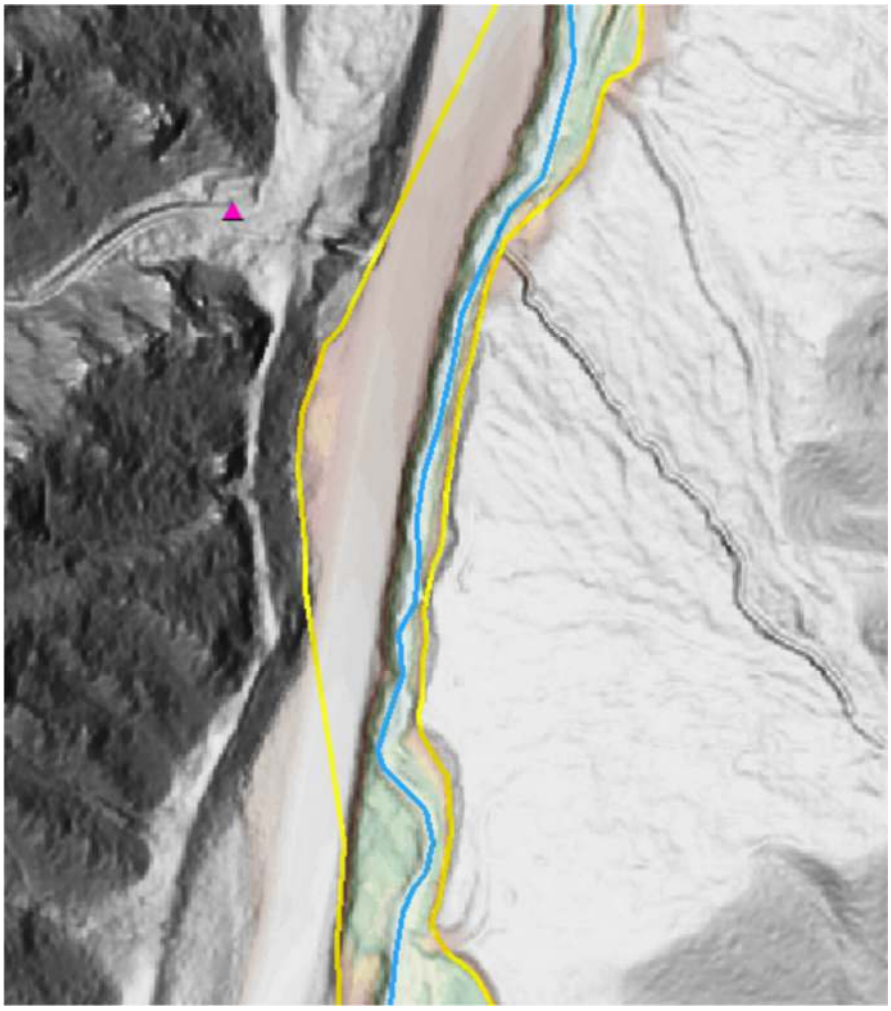
**Poncha Creek R03 (cont.)**

| ID | Location | | |
|---|---|---|---|
| PC3b | SH 285 crossing over Poncha Creek near Marshall Pass Road. | | |
| | Justification | | |
| | The culvert under the highway is grossly undersized. Roadway creates a dam that will pond water affecting upstream property owners but more importantly, if it overtops could run down the highway causing much damage. | | |
| Type | Description | Cost | Partners |
| Infrastructure Retrofits and Upgrades | Design plan for crossing improvement(s). | $$$ | CDOT, County |
| |  | | |

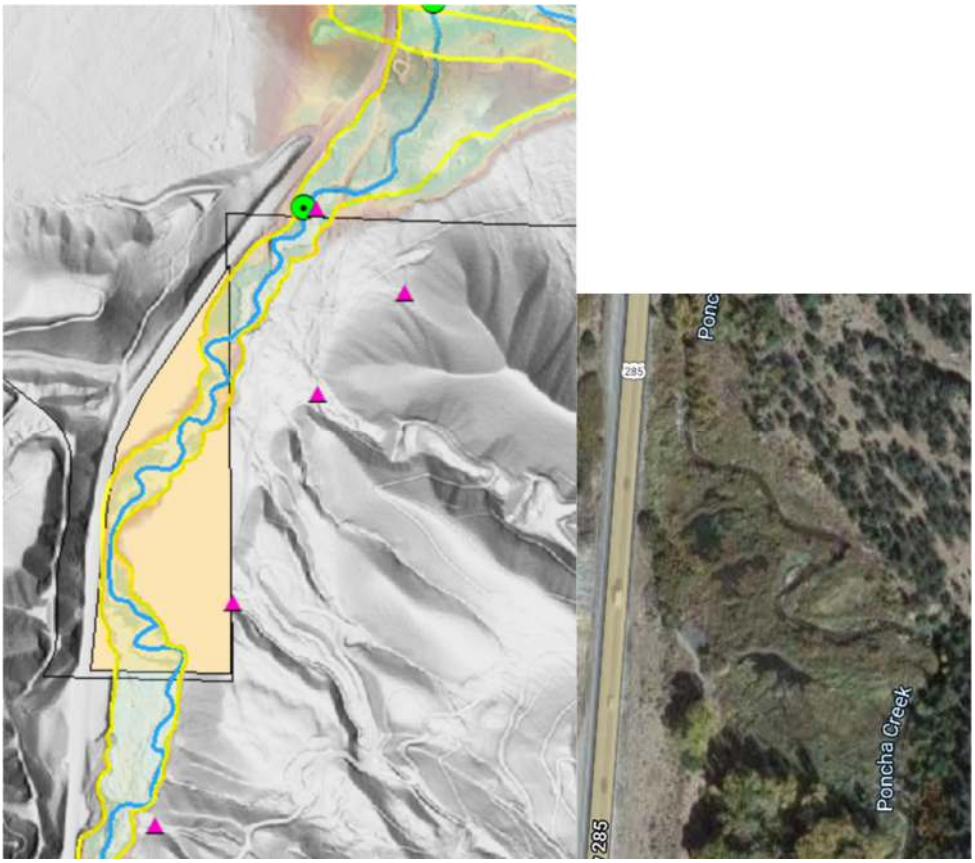
**Poncha Creek R02**

| ID | Location | | |
|---|---|---|---|
| PC2a | Near upper end of reach in the vicinity of Willow Lane | | |
| | Justification | | |
| | Significant channel and floodplain alteration. Conversion of response reach to transport reach. | | |
| Type | Description | Cost | Partners |
| Corridor Rehabilitation, Reconnection, and/or Restoration | Evaluate landowner concerns in this reach and investigate whether opportunities to restore floodplain connection. | $-$$$ | Private, NGO |

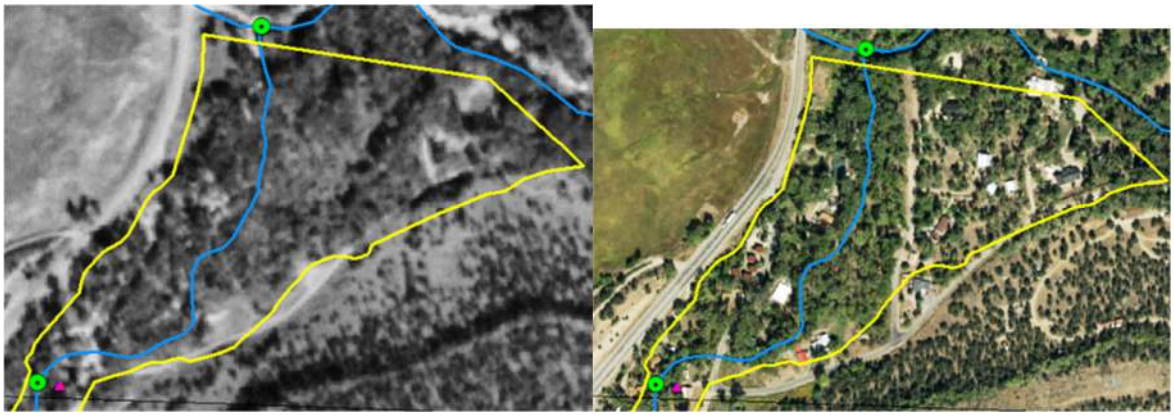
**Poncha Creek R02 (cont.)**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">PC2b</td><td colspan="3">Entire reach but most specifically where CO 285 contacts that channel and or is placed on fill in the Active Stream Corridor.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Highway washout is all but assured in a significant flow event. State/County should be prepared for having this roadway become impassable following a flood event.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Mitigate Existing Hazards</td><td>Ensure this topic is discussed in local hazard and emergency planning.</td><td>$</td><td>CDOT/County</td></tr>
<tr><td></td><td colspan="3">  </td></tr>
</table>

**Poncha Creek R02 (cont.)**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">PC2c</td><td colspan="3">The lower end of reach in vicinity of Town of Poncha Springs Park</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Poncha Creek R02 is a steep confined transport reach with numerous debris fans. A large flood will deliver this material directly into the development located at the mouth of the canyon. Small floodplain pockets do exist upstream of this development and may help buffer flood impacts.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td rowspan="2">Corridor Rehabilitation, Reconnection, and/or Restoration<br><br>Land and Water Protection</td><td>Field investigation to evaluate opportunities to maximize floodplain connection and storage potential to buffer downstream development from flood and debris impacts.</td><td>$</td><td>Town of Poncha Springs, Private</td></tr>
<tr><td colspan="3"> 
</td></tr>
</table>

**Poncha Creek R01**

<table>
<tr><td>ID</td><td colspan="3">Location</td></tr>
<tr><td rowspan="3">PC1</td><td colspan="3">Entire reach.</td></tr>
<tr><td colspan="3">Justification</td></tr>
<tr><td colspan="3">Numerous homes lie in Active Stream Corridor at the mouth of a steep canyon with significant flood and debris loading potential.</td></tr>
<tr><td>Type</td><td>Description</td><td>Cost</td><td>Partners</td></tr>
<tr><td>Mitigate Existing Hazards</td><td>Educational campaign to raise awareness of flood and avulsion potential in this area and develop actionable evacuation plans. Consult updated FEMA regulatory maps but also discuss the likelihood of sediment and debris filling channel(s) and causing water to seek new routes.</td><td>$-$$$$</td><td>County</td></tr>
<tr><td colspan="4">  <br>1953 2019</td></tr>
</table>