Phase 1: Flood Mitigation Master Plan for Bear Canyon Creek
Conceptual Alternative Development

Background

The current conditions along Bear Canyon Creek do not represent a natural ecosystem. Currently, many non-native species are present that negatively contribute to the functioning of the system. Species diversity is low, consisting of primarily non-native crack willow (Salix fragilis), Russian olive (Elaeagnus angustifolia), and Siberian elm (Ulmus pumila). Crack willow specifically is highly susceptible to breaking branches during extreme weather events, and likely contributed to the clogging of culverts and subsequent overland flooding. In urbanized neighborhoods, constrained channels undermine the root systems of species such as Siberian Elm, resulting in large woody debris transported downstream during an extreme event.

In addition, unstable channel conditions contribute to the generation and transport of sediment. In the upper reaches of Bear Canyon Creek, channel slope in excess of 5 to 7 percent create excessive potential energy which results in high velocities and channel shear stress. The stream transitions from its headwaters as a cascading gully in the sandstone of the Fountain Formation which make up the Flatirons to an alluvial floodplain across the Pierre shale to the east, passing through the uplifted sandstone layers of the Dakota sandstone making up the first hogback west of boulder. The changes in gradient result in an imbalance of energy which seeks equilibrium through picking up and transporting sediment. This high energy gradient passes through the softer alluvium formed by natural erosive forces forming meanders until the stream meets a constriction, either from the hard underlying sandstone or by an anthropomorphic feature such as a bridge or culvert. As flows pass through a constriction, the head loss is translated upstream as a slowing in velocity and the sediment load is deposited, while the cleaner water then accelerates through the constriction.

In an extreme event, such as the 2013 flood, deposition at these constrictions actually block the channel and flows overtop whatever feature has formed the constraint. In the case of a culvert or bridge, these overtopping flows then find their way back to the natural stream valley via roadways and neighborhoods, picking up more debris from damaged structures and creating more deposition zones where smaller constrictions develop. Typically, the culverts and bridges are designed for a 10-25 year event considering debris blockage. In the 2013 event, characterized as a 25-50 year peak flow over the Bear Canyon Creek watershed, the actual precipitation distribution was on the order of a *one thousand year event*. This resulted in saturated soils and friable (easily transported) debris in the floodplain which created a slurry flow as the peak runoff occurred. Culverts and bridges were completely blocked by debris, and the resultant overtopping condition resembled a 100 year flooding event. This resemblance however, is only in the pathways seen by the floodwaters. An actual 100 year event would produce greater depth along these pathways, creating far more damage to structures and utilities.

The purpose of this study is to explore mitigation strategies aimed at reducing damage from flood events. The creek in general has been described as being relatively stable during baseflow conditions and smaller events, requiring only routine maintenance. Conceptual level alternatives have been developed here which address the problems associated with larger events, but must also take into account the underlying morphology and ecology of the stream. These alternatives fall into three categories: non-structural measures, structural improvements, and debris management. Non-structural alternatives will target vegetation management and maintenance. The riparian zone will be evaluated for vegetative debris production, transport and control, while the maintenance program will be assessed and suggestions made for improvements. Structural alternatives consist of stream restoration, floodplain connection and capacity improvements to stream crossings. The feasibility of debris control structure solutions will be evaluated as well as improvements to pedestrian crossings. Finally, debris catchment areas will be evaluated for storage potential, location relative to downstream crossings and maintenance access. They will also be evaluated as either public or ecosystem amenities depending on ownership and designated use.

Reach 1

Reach 1 extends from the upstream limit of the study area at the corporate limits to just upstream of Lehigh Street. The reach consists of City open space, medium density suburban, and high density townhome use. Major constrictions occur at Wildwood Road, a pedestrian bridge connecting Bear Creek Elementary school to Bear Mountain Drive, and an old boiler tank crossing the stream at Wildwood and Ithaca. The stream itself transitions from a high gradient,cascading gully section upstream of Wildwood to a V-shape section below Wildwood which becomes deeply incised downstream of Ithaca.

Vegetation management and debris control are crucial to improving the capacity of the channel. Invasive species should be controlled and the channel stabilized to reduce channel degradation. Several opportunities exist for debris mitigation, including areas immediately upstream of Wildwood and Lehigh. Another opportunity exists for a larger area immediately adjacent to the Bear Creek Elementary school within the Bear Creek park. These areas could be graded to receive debris deflected into them with strategically placed rock structures in the stream, and maintenance access provided to remove the accumulated debris periodically.

The area immediately adjacent to Wildwood above Ithaca is currently degraded and full of invasive species, both willow and elm trees. This area could be regraded to connect the floodplain and stabilized with non-structural treatments such as root wads and faschines (bundles of straw staked with native willow and seeded with a riparian see mix). The area could then be replanted and managed as a riparian corridor per the greenways master plan.

The Wildwood culvert should be assessed for improvements to hydraulics and debris control. These improvements may consist of maintenance near the up and downstream face of the structure for sediment and vegetation, modifications to the structure including beveling of the top section, placing fins or a debris deflector in front of the entrance or increasing the cell size or number. The pedestrian bridge (CR-R1-2) was replaced after the 2013 flood, however the channel approaches up and downstream are severely incised and should be stabilized. The old boiler section will probably need to be removed, and the sharp bend below assessed for stability.

Reach 2

Reach 2 is divided into two sections. Reach 2A extends from the crossing at Lehigh to Broadway, while reach 2B extends from Broadway to Moorhead. The upstream limits of these reaches are technically at the upstream face of these crossings so that the downstream mitigation impacts can be assessed.

Reach 2A is an urban transportation zone, with the floodplain mainly confined to Table Mesa Drive and the creek situated within the parkway. The stream channel is designed to contain the 25 year event with drop structures and crossings sized for stability and conveyance, while the Parkway itself forms the floodplain. Residential structures are minimally impacted by the flooding source, however commercial properties at the downstream limits of the reach are susceptible to damage in larger events. The Harvard lane culvert in particular has insufficient capacity to pass flood flows, especially with debris blockage, and overland flows are translated to Reach 2B, where substantial damage results.

Debris management is limited in this area to the catchment immediately upstream of Lehigh described earlier, and a small catchment upstream of Yale Road. The catchment at Yale receives flows from a significant tributary area, and could be important in mitigating debris downstream.

A great opportunity exists to combine an enlarged channel through this reach capable of conveying up to the 100 year event with a pedestrian path system. Culverts downstream of this area have already been improved to this degree, and the crossing at Lehigh would benefit greatly from enlarging the structure to accommodate both foot traffic and flood flows. This could be combined with a structural channel section downstream to Harvard with at grade crossings in between to minimize cost. The crossing at Harvard Lane and Broadway has already undergone a preliminary feasibility analysis and conceptual level design, but must include a more comprehensive consideration of the hydraulics involved.

Reach 2B extends from Broadway to Moorhead Street. This reach performed well during the 2013 flood, with the exception of damage caused by spill flows from upstream. The area immediately downstream of Moorhead is inundated by flows contributed by Skunk Creek from the north upstream of US Highway 36, as well as the culvert from the highway itself. For this reason, the areas of flooding immediately upstream and extending downstream are included in Reach 3. No opportunities for flood mitigation as part of this plan are identified in Reach 3B.

Reach 3

Reach 3 is also divided into two sections for the same reasons identified in Reach 2. Reach 3A begins at US Highway 36 and extends through the University of Colorado South Campus to Baseline Road. This reach is currently undeveloped except for the lower limits, and consists of disturbed land and low flow crossings. The channel has insufficient capacity for any flows above the 2 year event, and is overgrown with invasive species. Poor outlet conditions at the US Highway 36 culvert exacerbate flooding upstream and create a spill situation across highway 36 in extreme events. A private drive at the downstream limits of the reach just upstream of Baseline contribute to spills across Baseline, severely limiting the effectiveness of the Bear Canyon Creek culvert under Baseline Road.

The outlet conditions for the Highway 36 culvert could be greatly enhanced by regarding the area immediately downstream and reworking the pedestrian path. Currently, the separation wall for the path effectively limits flows in the culvert to only one of the two cells. By extending the path approach farther to the east, perhaps incorporating this into improvements with the

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pedestrian bridge immediately downstream, the hydraulic efficiency of the Highway 36 crossing may be enough to pass extreme events. It may also be necessary to install a third cell at this crossing to insure passage of higher flows given debris blockage and pedestrian path considerations.

Downstream of the pedestrian bridge, the floodplain opens up to the South Boulder Campus of the University of Colorado. A master plan has been developed for this area that includes residential/institutional use (student housing) and incorporates a stream crossing for access. Vegetation management could enhance the conveyance capabilities in this area and reduce floodplain width. It is anticipated however, that this measure will not provide sufficient gains to eliminate flooding which impacts downstream areas adjacent to Baseline Road. A strategy which incorporates a complete restructuring of the riparian corridor through this reach including grading to reconnect the floodplain (FC-R3-1), stabilization of the stream, and a careful design of any crossings could provide benefits to both the property owner (CU) and residential and commercial interests downstream.

Finally, the private drive located immediately upstream of Baseline Road severely limits the capacity of the Baseline culvert. This drive consists of two 36” squashed culverts which barely have sufficient capacity to convey the channel discharges during spring runoff events. This drive may benefit from a much larger culvert, a combination culvert low water crossing, or by abandoning the crossing altogether. This crossing would require investigation in conjunction with both improvements upstream aimed at confining the floodplain, and consideration of containing resultant flows to downstream reaches.

Reach 3B begins at Baseline and extends downstream to Mohawk Drive. This area is greatly influenced by the dynamics of flooding upstream. Spills which occur above baseline are transmitted overland through residential neighborhoods to the confluence area immediately upstream of Foothills Highway. This is a complicated confluence zone influenced by both South Boulder Creek to the south and east, and Skunk Creek to the west. The channel itself in Reach 3B functions relatively well except for a sharp bend to the right immediately upstream of Mohawk. Damages in this area are mainly influenced by spills upstream of the reach, and thus no mitigation measures are planned for this reach as a part of this study. The capacity and stability of the channel will, however be assessed as part of containing flows from upstream.