High Line Canal Stormwater Conversion **December 1, 2022**

Design Report

Executive Summary

The City of Cherry Hills Village has commissioned a study of the impacts of repurposing the High Line Canal, an irrigation canal running approximately 4 miles through the Village, to convey stormwater. The 139-year-old canal was not intentionally designed for stormwater and there are several additional risks to conveyance and storage of stormwater. However, the Village's semi-rural character has preserved connections to the canal in a unique manner that mitigates many factors of the conversion from irrigation canal to stormwater feature.

The fundamental risk of converting the High Line Canal to convey stormwater is introduction of new inflows to the canal. A new inflow would be a storm sewer connection from upstream (east) of the canal that previously drained under the canal. As irrigation flows are reduced in the canal, there is more capacity for stormwater, but only to a certain point. Excess stormwater would overfill the canal and spill over the embankment into private, and less often public, property. This spill would cause new flooding and potential for embankment scour on the canal leading to catastrophic failure of the canal system.

In the Village, all upstream basins drain overland into the High Line Canal. There are no new inflows proposed by the City at this time. This gives the conversion of the canal a distinct advantage during implementation. The advantage is that the canal hydrology tomorrow is the same as yesterday – the conversion changes little in the effective hydrologic and hydraulic conditions of the canal within Cherry Hills Village. This also ensures that the canal will be able to maintain the existing vegetation community and may even offer opportunities for strategic enhancements of the plant community for the benefit of the Village and the public at large.

The most important change is in the operation, maintenance, and responsibility of the canal. The conversion will require the Village to acknowledge the risk of stormwater, mitigate for overflows, and design water quality features that function without adverse impact to the experience and nature of the corridor. The maintenance of vegetation and water quality features will require additional manpower to maintain water quality, safety of the recreation corridor, and protection of the ecology. Additional responsibilities related to the canal will extend from day-to-day operations immediately in and adjacent to the canal to local and regional cooperative emergency response on infrequent large storm events along the canal.

Implementation of the conversion has several phases – prerequisite phases outside of the Village's control and project phases within Village control. Among the prerequisites is determination of "jurisdictional waters of the US" by the US Army Corp of Engineers. Recent presentations on that determination indicate there is a low probability of jurisdictional waters within the Village based primarily on how disconnected the canal is from downstream waters. Another prerequisite, outside of the Village's control, is whether the State Historical Preservation Office elects to study the impacts to the canal embankment. Historical determination studies do not have final authority but do add time for study and a mitigation cost to memorialize the disturbed element. Finally, the Village will need a conversion agreement with Denver Water.

Following prerequisites, the project phases include: resources for a 33% increase in park land, ecological aspects of maintenance particularly related to trees, stormwater overflows, freeboard protection by raising the trail, outflow improvements, berms at key trail locations, and finally water quality improvements. The sequence is important to managing risk and making incremental improvements towards a full conversion over a period of years.

Denver Water will be transferring responsibility of the High Line Canal to local jurisdictions across the metro area in the next several years. So, although the inflows do not change, the responsibility for those inflows and their outflow from the canal will shift towards the City of Cherry Hills Village.

The conversion of the High Line Canal within Cherry Hills Village from irrigation to stormwater conveyance is technically feasible through advanced engineering design and expert infrastructure construction.

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Original presentation August 2022, report updated November 2022

I. Purpose

This report summarizes a year-long engineering study of the High Line Canal Stormwater Conversion. It is an analysis of the High Line Canal through Cherry Hills Village, specifying to the hydrologic and hydraulic conditions before and after installation of water quality features (water quality berms) and flood risk mitigation features (inlets, pipes, spillways). This analysis also includes how these features will affect the aesthetics, experience, and ecological function of the canal. One other purpose of this report is to assess the future additional costs to the City based on the proposed features. Additional information is provided on downstream flood risks, upstream redevelopment contributions to the canal, and engineering computations.

This report is intended to provide a conceptual perspective on stormwater conversion of the High Line Canal. Additional work is necessary to fully design proposed improvements. Following design, implementation of improvements will require significant coordination and approval from Denver Water Board and various agencies governing flood risk and environmental concerns. Finally, construction of proposed improvements would occur in a strategically phased approach to ensure maximum protection of downstream properties with optimum water quality treatment. This construction would allow for rapid revegetation to provide stabilization along the high- and low-banks of the canal.

II. Study Area

The study area is limited to the approximately 4 miles of the High Line Canal through the City of Cherry Hills Village. The study area includes the upstream drainage basins contributing developed and undeveloped flows to the High Line Canal. The study area includes downstream drainage channels conveying stormwater and floodwaters through the Village. See Figure 1.

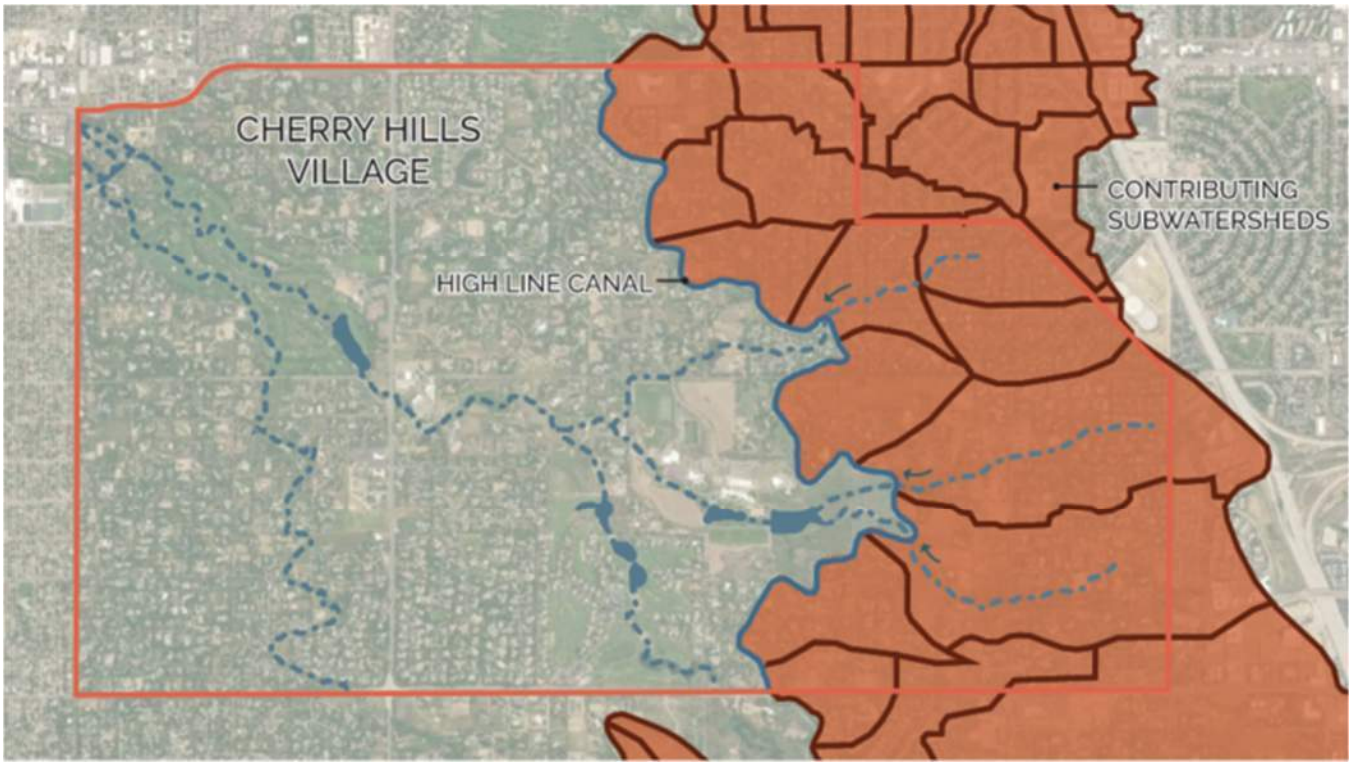


Figure 1 - Study Area. High Line Canal thru Cherry Hills Village. Upstream drainage basins in red. Downstream channel conveyances in blue. Map based on previous work by Mile High Flood District and Respec.

III. Hydrology

The hydrology for this report is unchanged from the analysis completed in the High Line Canal Masterplan by Mile High Flood District (MHFD) and Respec.

5.6 CHERRY HILLS VILLAGE
There are 9 spills in Cherry Hills Village, 5 of which are in the area bounded on the south by East Belleview Avenue, on the north by East Quincy Avenue, and on the east by South Holly Street, all near Blackmer Gulch. No structures appear to be potentially affected by these spills. These spills can all be eliminated by a 100-foot constructed overflow at Blackmer Gulch Tributary with a weir crest 4 feet above the canal bottom. No structures appear to be potentially affected by this alternative. This is included in the example solution.
The remaining 4 spills are located north of East Quincy Avenue and south of East Mansfield Avenue, near Quincy Gulch. Several structures appear to be potentially affected by these spills. Part of the example solution to eliminate these four spills is to create two constructed overflows. The first would be 210 feet long with a crest set 5.8 feet above the canal invert at the intersection of Quincy Gulch, located just downstream of where the footpath from South Dahlia Street connects with the High Line Canal trail. The second would be approximately 900 feet upstream of South Colorado Boulevard in Three Pond Park and would be 150 feet long with a crest set 5 feet above the canal invert. This overflow would also require a 1390-foot formalized channel down to the mainstem of Quincy Gulch. The final improvement included in the example solution is raising a low point in the canal embankment 800 feet downstream of South Colorado Boulevard by 1 foot for a length of 90 feet. This alternative would not increase the number of structures which are currently subject to 100-year flooding assuming the canal doesn't intercept Quincy Gulch flows. Master planned improvements would be necessary to avoid potential damage from increased flows if this alternative were implemented without such improvements. (High Line Canal Stormwater and Operations Master Plan – Final Report, Respec 2018)

Existing conditions hydrology estimates 2.2 square miles of tributary drainage area into the canal. This occurs through 12 distinct sub-watersheds with an average imperviousness of 23%. This is below the average imperviousness of 26% for the entire length of the High Line Canal. The Village portion of the canal represents 3.2% of the total tributary area to the High Line Canal.

The existing conditions hydrology accounts for several undeveloped parcels (as of October 2018) within the sub-watersheds upstream of the High Line Canal. Future development is regulated by Cherry Hills Village land use code and engineering criteria to detain developed flows and release at historic quantity, quality, and manner of flow.

Opportunities for upstream properties to develop or redevelop with use of the High Line Canal for water quality purposes will be feasible. The hydrologic and hydraulic impacts will be quantified in a drainage report for the applicant property and a license agreement for use of the public infrastructure is recommended. This concept is further described in subsequent sections of the report and appendices.

IV. Hydraulics

Background. The High Line Canal has operated as an irrigation canal since 1883. The hydraulics of an irrigation canal are controlled by several factors – primarily the nominal longitudinal slope of the canal. Irrigation canals were designed to convey water slowly with little scour potential to minimize maintenance and maximize delivery of water over a long period of time. The native soils along the canal also happen to have a high infiltration rate which is not highly desirable for efficient water delivery.

The hydraulics of a modern water quality feature share many of the same characteristics: shallow slopes, low velocity, minimal scour potential, and high infiltration.

Both features share the risk of water retained behind an earthen embankment. The earthen embankment is a gravity mass able to withstand the weight of the water and protect downstream properties from the canal water. When there is more water than the canal can convey, the embankment is overtopped. Water spills down the face of the embankment following natural watercourses. However, floodwater spills over the earthen embankment cause rilling and scour. This can lead to embankment instability, erosion, and ultimate breach of

the embankment spilling all tributary canal water at the breach. This is a significant risk to downstream people and property as a rapid 'flash flood' is unleashed on downstream areas. (Reference: Bureau of Reclamation, Canal Operation and Maintenance, Embankments; https://www.usbr.gov/assetmanagement/docs/Canal_Embankments.pdf)

Figure 2 - USBR, example ditch embankment failure

Floodplain. Another important aspect of the canal hydraulics is the interaction with the FEMA designated floodplains. There are two FEMA regulated flood sources that cross the High Line Canal: Quincy Gulch and Blackmer Gulch.

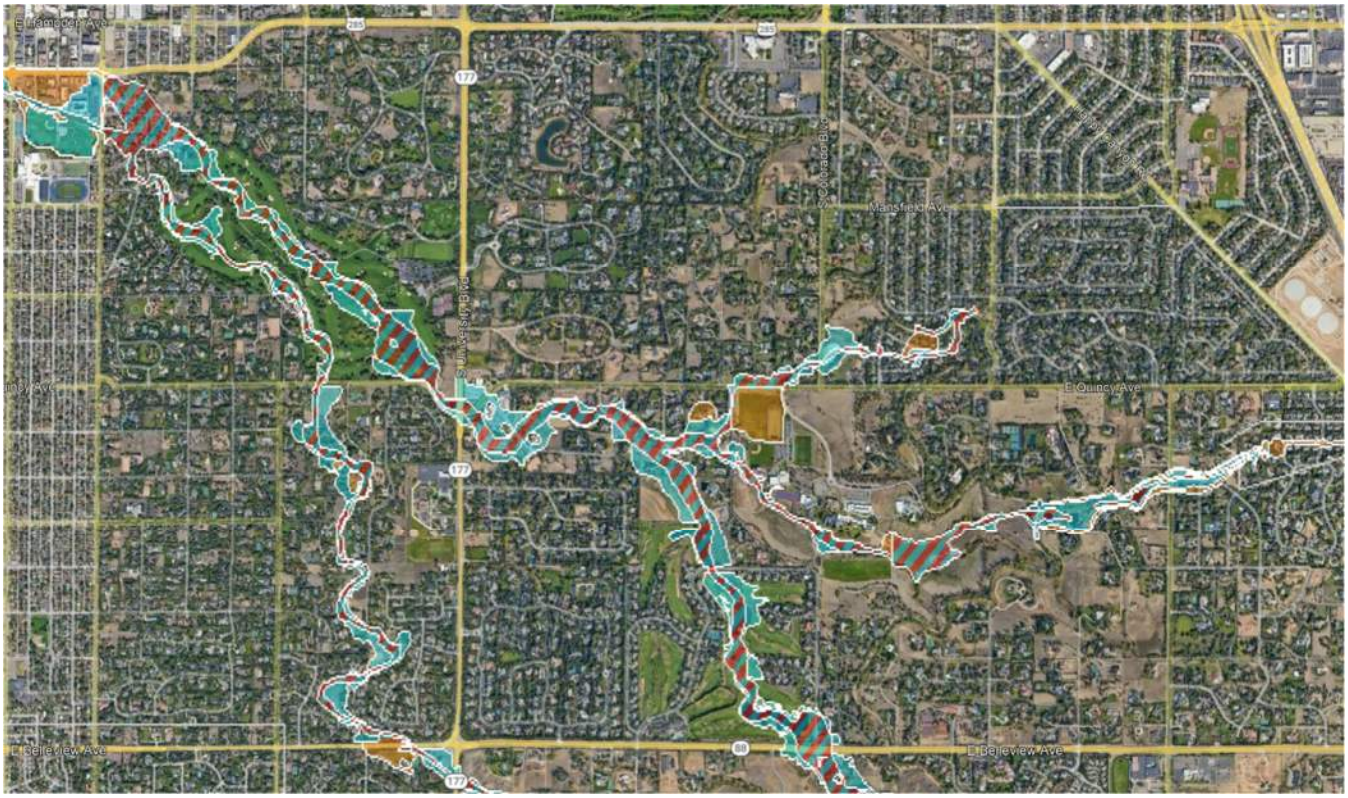


Figure 3 - Effective FEMA Special Flood Hazard Areas (floodplains)

It is important to recognize the conversion of the High Line Canal to convey stormwater includes additional mitigation measures that do not exist today: inlets, pipes, spillways. These additional 'perforations' of the canal are designed to mitigate against the canal failures that can lead to catastrophic flooding across a central portion of the City of Cherry Hills Village.

To be clear, these flood risks exist today.

And, given the conversion of more and more miles of the canal in communities where stormwater is not native to the canal system, the risks will increase.

Furthermore, specifically within the City of Cherry Hills Village the proposed inlets and pipes will result in more frequent, less intense stormwater discharges downstream of the canal. Controlled stormwater releases will happen more often than in past years, but with lower intensity. For example, in 2015 a significant thunderstorm led to flooding along the High Line Canal that led to overtopping of the canal embankment in Greenwood Village into Greenwood Gulch. The canal through Cherry Hills Village was at maximum capacity. The result of the canal overtopping led to street flooding near Random Road and temporary closures of Meade Lane in front of the former city offices. This was a significant rain event that led to a sudden discharge of stormwater from the canal.

In the proposed 'converted canal' condition, that storm event would likely have the same effect in Greenwood Village until they have the stormwater conversion and mitigation projects in place. (Several interim mitigation measures along Greenwood Gulch, coordinated through the MHFD, have been designed and installed since the 2015 event.) However, in Cherry Hills Village, the result would be excess stormwater that maxed out the canal in 2015 being distributed as controlled outflows from the inlets and pipes upstream of Colorado Boulevard, in Three Pond Park, at Dahlia Hollow and at the Blackmer Trib spillway.

The following pages provide more detailed description of the inflows and outflows from the proposed system.

Inflow and Outflows. Hydraulics of the canal can be explained in terms of flow into the canal from the eastern, upstream sub-watersheds and flows out of the canal both downstream in the canal itself and design outlets through inlets, pipes, and weirs.

Inflows. Inflows to the canal in the Village are generally overland flows into the eastern side of the canal. Each of these inflow locations can be seen in Figure 4. There are no known pipes conveying water under the canal in the study area.

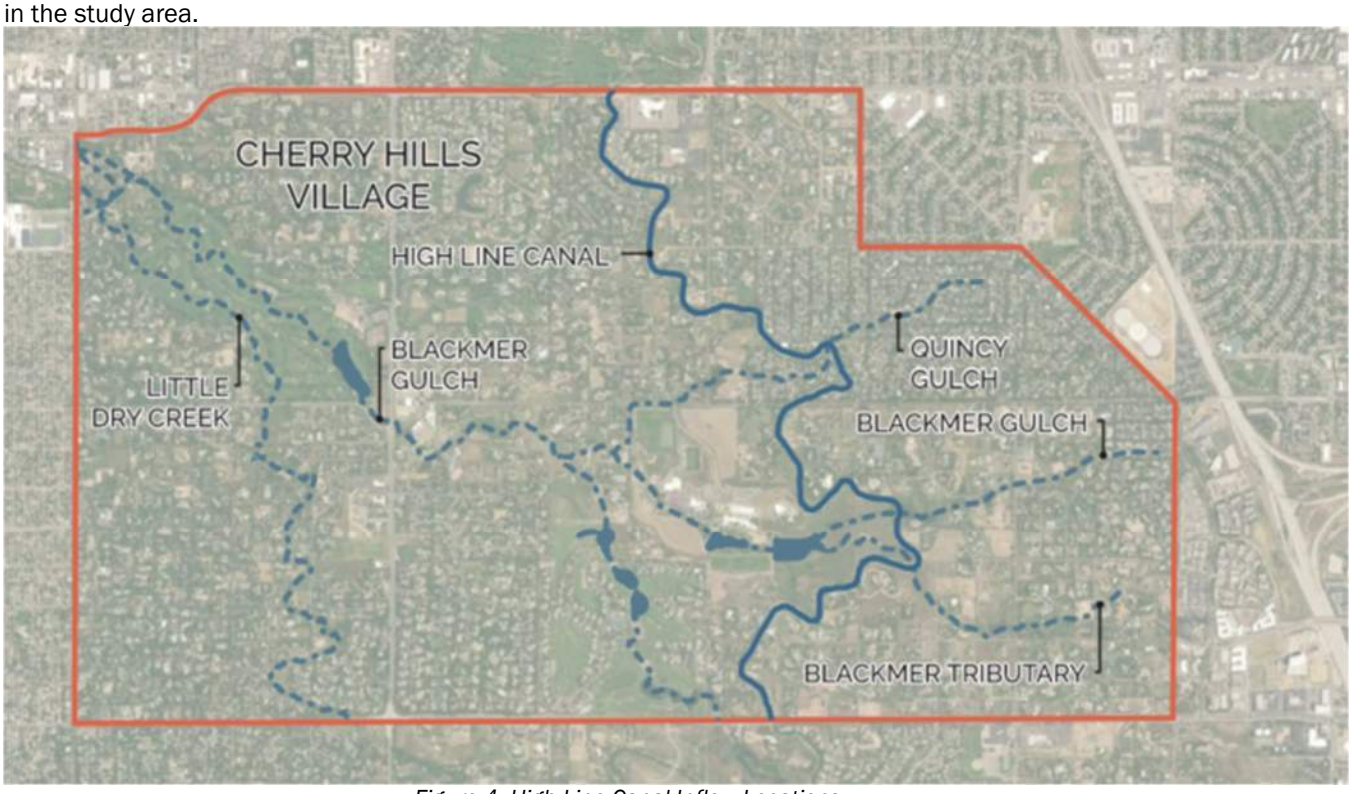


Figure 4: High Line Canal Inflow Locations

a. Blackmer Tributary. This is the southernmost defined drainage inflow to the High Line Canal in Cherry Hills Village. Site investigation and research with public works staff indicates there is no storm sewer conveyance (i.e., culvert) under the canal at this location. Flows in Blackmer Tributary drain overland into the High Line Canal. This is the largest single tributary subbasin at 299 acres.

b. Blackmer Gulch. This is the main stem of Blackmer Gulch located north of Blackmer Tributary. Like the tributary, there is no known conveyance under the canal. Flows in Blackmer Gulch drain overland into the High Line Canal. Blackmer Gulch is regulated by FEMA as a designated special flood hazard area (floodplain).

c. Quincy Gulch (260). This is a designated drainageway flowing through Dahlia Hollow Park as an open channel stream and into the High Line Canal. Upstream of the park, flows are urbanized in storm sewers fed by inlets, curb, and gutter. Quincy Gulch is also a FEMA designated special flood hazard area (floodplain). Quincy Gulch does have one corrugated metal pipe at the base of the embankment near the east end of Bellaire Circle. Investigation of this pipe shows no obvious upstream connection and no evidence of water flow and is assumed to be clogged or abandoned during upstream development sometime in the 1980s.

d. Informal Drainages
    i. Belleview Ave (westbound lanes, 257). The southernmost tributary basin to the High Line Canal starts along the westbound lanes of Belleview Avenue. Inflows are overland through primarily private property.

ii. Countryside Lane (258). This basin flows overland into a natural low point along the north property line of homes on Countryside Lane and into the High Line Canal. Interestingly, previous redevelopment in this area attempted to construct a storm sewer crossing under the canal. Permitting and license agreements were complicated by requiring city ownership and ultimately led to overland discharge from the detention and water quality pond.

iii. Dahlia Street (258). This is another natural low point in the eastern basins tributary to the High Line Canal, aligned with the north end of Dahlia Street. An informal trail crossing exists at this location connecting city trail to the High Line Canal trail.

iv. Tenaya Lane (259). Tenaya Lane dead ends at the canal and overland flows from the roadside ditches are tributary to the canal at this location. Similar to all informal drainages, several locations along the canal receive overland flows from private property landscape areas.

v. Quincy Avenue (259). Overland flows into the canal are most pronounced at Quincy Avenue, but overland flows drain into the canal along backyards and through Quincy Farm.

vi. Bellaire Street (Three Pond, 263) Located northwest of Dahlia Hollow Park; this informal drainage path drains developed suburban flows into the canal from a street side inlet. Additional water quality trash vaults and street side maintenance access is possible at this location.

vii. Colorado Blvd (263). Also, backyard overland flows into the canal in this sub-watershed but includes portions of the roadside drainage from Colorado Boulevard.

viii. Mansfield Ave (310). Primarily overland flows from landscape and pasture areas.

ix. Jefferson Ave/Covington Drive (312). Primarily overland flows from landscaped backyards and common areas. Interesting to note the church parking lot is a pervious water quality pavement with no direct stormwater connection to the canal.

Outflows. Outflows in the High Line Canal in the Village are proposed in several configurations to maximize the effectiveness of water quality treatment, minimize impact to the High Line Canal recreation amenities, and optimize efficiency of proposed improvements. Water quality berms are considered an 'outflow' for the purposes of conveying water downstream in the canal and ultimately downstream to Wellshire Golf Course. A map of each outflow can be found in Figure 5.

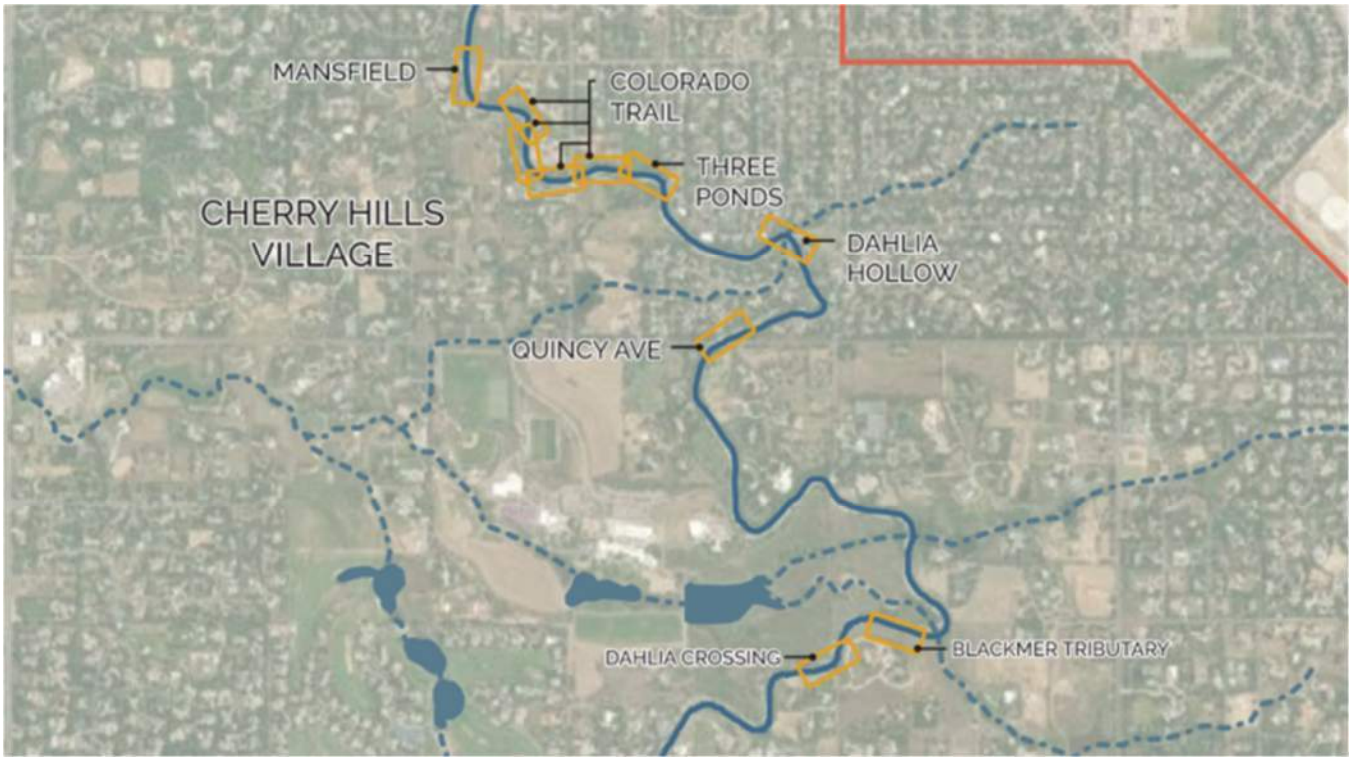


Figure 5: High Line Canal Outfall Locations

a. Inlets-Pipes. In several locations, inlets and pipes are proposed as outflow elements for stormwater flows exceeding water quality volumes in the canal.

   i. East of Colorado Boulevard. An inlet and pipe outflow are proposed for this section of the canal to take advantage of a low point and discharge path through Three Ponds Park. This pipe is part of the system of overflow pipes within the Three Ponds and Quincy Gulch drainage areas.
   ii. Three Pond. An inlet and pipe system at the natural swale in the northeast corner of Three Pond Park collects excess stormwater flows from the canal. A series of drop manholes safely dissipates hydraulic energy and releases flows past the base of the embankment and into the natural drainage of Three Ponds Park.
   iii. Quincy Gulch. A large inlet and pipe system provides relief of excess stormwater flows at the east end of Bellaire Circle. This is the largest pipe and inlet system owing to the significant inflows at Dahlia Hollow Park and risk to downstream properties.

b. Pipes
   i. Existing head gate. There is an existing head gate at Three Ponds Park, near the pedestrian bridge crossing the canal from East Oxford Place. This is an opportunity for minor relief flows through the existing irrigation head gate. Or a modification to upsize this release point and provide additional stormwater excess flow relief.
   ii. Quincy Avenue. An option to provide maintenance drainage relief at the Quincy Avenue water quality berm would discharge flows into the roadside swale during maintenance operations.

c. Spillways
    i. Blackmer Tributary. The release of excess stormwater flows at Blackmer Tributary is accomplished by a broad crested weir and armored spillway. The excess stormwater flows in the canal spill over the western or downstream side of the canal, crossing a concrete or sheet pile crest, and spiling down a slope armored with buried rock riprap 18 to 24-inch in diameter. This is a 200-foot-long broad crested weir structure built into the existing embankment.
    a. Other alternatives. There are other locations for weir-spillway outflows from the canal that can be optimized for minimizing disturbance or staging release of storm flows over a longer portion of the canal. These alternatives require significant consideration from stakeholders due to the impact on trees, vegetation, and user experience.

d. Water Quality Berms. Water quality berms are the primary feature for increasing residence time of stormwater in the canal for infiltration and collecting floatable and dispersed pollutants. These small dams in the canal hold back water, releasing it slowly through water quality outlet plates designed to drain a certain volume of water over a specific period of time. The water quality berms proposed in the Cherry Hills Village section of the canal are sited for multi-functional use and ease of maintenance.

    i. Mansfield Avenue. This is the northern most water quality berm proposed for the study area. This site was selected for its alignment with Mansfield Avenue which provides public right of way access to the berm site. This access route provides ease of access for maintenance vehicles and personnel. Additionally, this site aligns with the existing trail on the west side. The berm is configured to be compatible with a future trail crossing structure and is constructed of natural rock and soil materials. A buried wingwall structure is integrated into the pipe and inlet water quality structure.

    ii. Colorado Boulevard. This structure is also constructed of natural rock materials with a buried concrete cut-off wall and water quality inlet structure and pipe discharge. The alignment of this structure places the backwater of the water quality dam under the Colorado Boulevard bridge. As pollutants and debris accumulate behind the berm, the materials will be deposited out of sight under the bridge structure. Maintenance personnel will be able access the downstream end of the debris pile from the bridge deck using a vacuum truck. Or, by foot or with small track equipment on the downstream face of the bridge.

    iii. Quincy Avenue. As shown in Figure 6, this berm structure is similar to the Colorado Boulevard structure. The upstream debris pile will accumulate in the shadows of the Quincy Avenue bridge. This is a useful collection point because debris and sediment will not obstruct native vegetation present in other areas of the canal. There is no sunlight and no vegetation under the bridge today, this alignment takes advantage of the ‘dead zone’ under the bridge to collect stormwater trash and sediment.

    iv. Dahlia Street. This berm structure is similar to Mansfield in that the berm serves as an informal trail crossing between the trail at Dahlia Street and the High Line canal. This structure will be constructed with native rocks and boulders, with a water quality control plate integrated into an inlet and pipe structure.

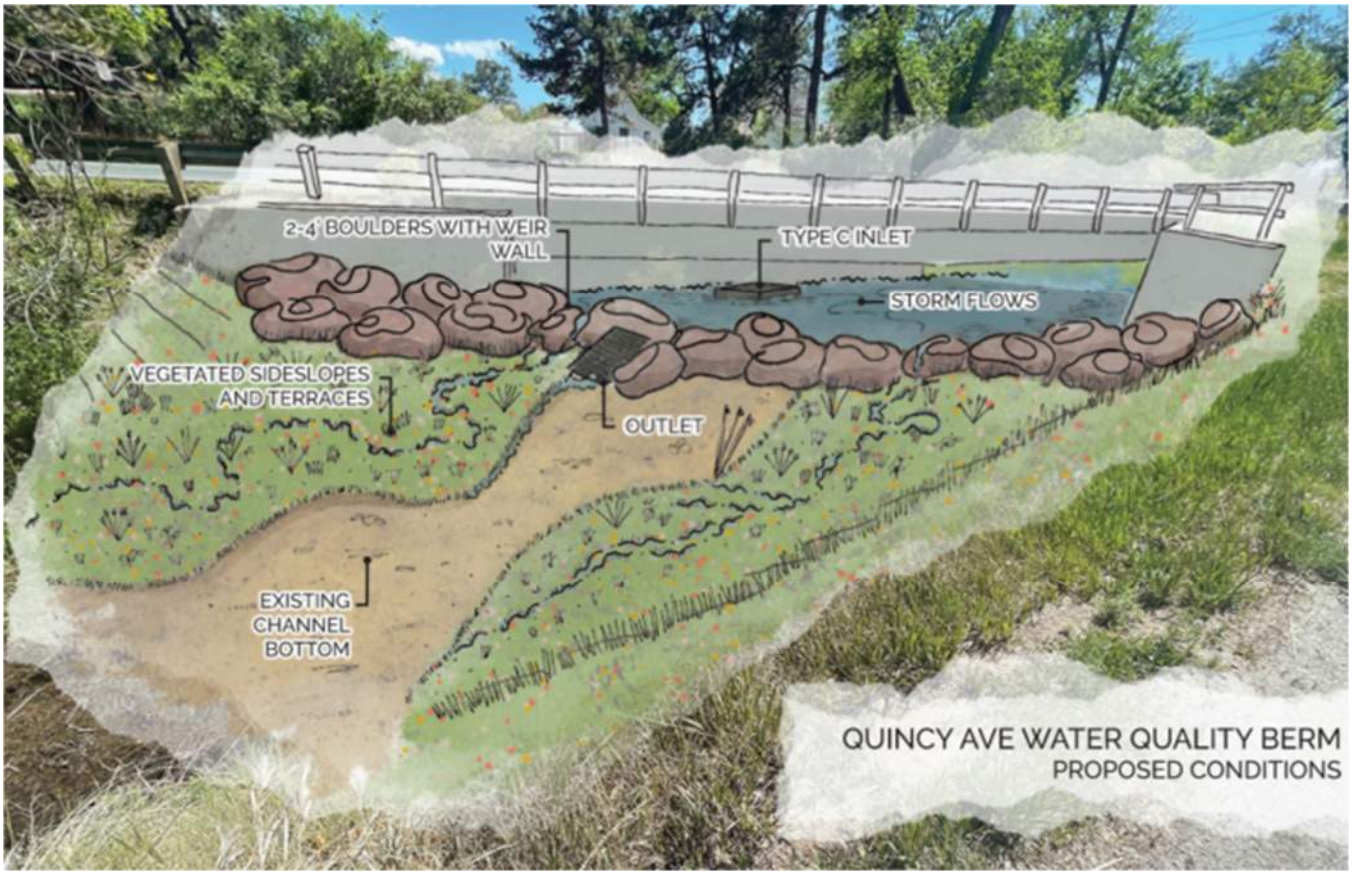


Figure 6 - Conceptual Rendering of Water Quality Berm at Quincy, looking south

V. Vegetation

Existing Conditions. The plant community found along the High Line Canal within the Village that exists today is comprised of a mostly native tree and shrub canopy or overstory with a non-native dominated herbaceous understory, thus leading to its description as the "Wooded Village" in the High Line Canal Conservancy's Canal Master Plan (2019). Within the proposed improvement areas, 39 total species were identified, comprised of seven grasses, 16 forbs or flowering plants, and 16 trees and shrubs. Twelve species were native, 23 were non-native, and four noxious species. The vegetation inventory was a rapid assessment of the dominant species and noxious or weedy species that may affect revegetation efforts as well as maintenance and management actions along the canal. For a complete list of documented species along the High Line Canal, please refer to the Denver Botanic Garden's *High Line Canal 2018 Botanical Survey* (2018).

The canal, by the very nature of its original purpose, has altered the plant community that originally occupied this area. By far the most common plant is smooth brome (*Bromus inermis*), a perennial, non-native grass. This species is very robust and well adapted to the dry climate of Colorado. It typically forms monocultures as it can outcompete most native species once established. Because of the robust nature of smooth brome, the canal corridor is very stable from an erosion potential perspective, but ecological function is limited due to the lack of native herbaceous diversity along the canal.

The forest canopy through Cherry Hills Village has become the iconic image of the High Line Canal. Mature cottonwoods (*Populous* sp.) and other native and non-native tree and shrub species provide shade and aesthetic value for trail users as well as habitat for wildlife. These systems have opportunistically developed over time and although the system contains an exceptional number of native trees, this is not necessarily a healthy or sustainable ecosystem. Figure 7 displays the typical tree canopy along the High Line Canal and trail, reflecting the number of trees and other vegetation. The density of shrub and tree stands limit line-of-sight which can cause hazardous trail conditions and limit wildlife movement through the forested areas pushing wildlife to use the trail and possibly introduce human-wildlife conflicts.

Figure 7 Typical Tree Canopy

a. *Revegetation Approach.*

There is an opportunity to modify existing grades in select areas that have the potential to create wetland plant communities to capitalize on the modified outflows proposed with this project. In these locations, existing low benches can be intentionally redesigned and or paired with existing mud flat areas to take advantage of anticipated flows with targeted weir design considerations and slight grading adjustments. An example of this can be seen in Figure 8, below, where a proposed wetland bench along the canal is shown. These minor adjustments to the proposed improvements can help promote revegetation opportunities and ecological function within the High Line Canal that could have long-term benefits for the Village.

Figure 9 Potential Wetland Bench Opportunity

Impacts to the existing vegetation from the proposed improvements offer an opportunity to increase native diversity along the canal. Revegetation efforts will focus on reintroducing appropriate native grasses and forbs into the canal ecosystem. Because the canal is considered a novel ecosystem, one that would not exist if not for human intervention, and not a native ecosystem, the plants selected will be chosen based on site soils and expected hydrologic and hydraulic conditions. The planting plans and revegetation approach will utilize the opportunity of site disturbance to promote native species establishment along the corridor that otherwise would not be introduced to this landscape because of the competitive advantage of smooth brome and the other dominant non-native species. The planting plan should utilize a variety of native wetland, riparian, and upland forb and grass species that add color, texture, and visual enhancements as well as opportunities for improving resilience through a mixture of warm and cool season species that are adapted to the specific soils found in the project areas. This strategy will also be applied to any tree species that will be planted as part of any project.

b. *Management.*

There are several management practices that can begin during the planning and design phases and continue past construction that will assist in successfully revegetating the areas around the proposed improvements.

- Pre-construction forestry operations
- Pre-construction weed control

These management actions, along with concurrent public education, will improve line-of-sight and, correspondingly, safety along the trail and the work site. Thinning the tree canopy will open the corridor for more effective weed control maintenance practices as well as provide for more effective wildlife movement to occur, potentially reducing human-wildlife conflicts. Additionally, pre-construction weed control will help limit the undesirable species seed bank and reduce competition for the desirable native species at the time of

revegetation. Weed control should occur on both the low-bank and high-bank of the canal using both mechanical and chemical treatments depending on the noxious and undesirable species present.

Post-construction weed control and watering will be needed over the first few years to help ensure establishment of the desired plant community. Proper timing of seeding and planting help improve the speed of establishment, but attention to maintenance needs can help overcome short comings during construction. To that end, the Village should budget to implement an adaptive management plan for vegetation establishment and maintenance over the first two to three years after construction has been completed. The proposed native plant palette does not require permanent irrigation; however, proposed container stock should anticipate the need for temporary watering for establishment. For planning purposes, temporary watering can be accomplished with an irrigation system, by hand, or watering truck and should anticipate occurring once a week during the growing season and as little as once a month during the dormant season, although a specific irrigation plan should be developed following the final design of the improvements.

These recommendations will help create a more diverse and resilient plant community along the canal and help ensure the Village can maintain the beauty and character of the beloved corridor.

c. *Irrigation*

In conjunction with all this work, the City of Cherry Hills Village is committed to supplying adequate water to all the new plantings recommended for the canal trail. A permanent irrigation system to supply water to trees and other vegetation is the best way to perform the watering which will be necessary for healthy plant establishment. Large numbers of new plantings can be watered by utilizing drip irrigation.

Irrigation should be added to the new trees to supply a consistent amount of water at regular intervals. Water is the most critical factor along the Front Range of Colorado and lack of water is a critical factor for this project. All costs, excluding the addition of irrigation are included in the costs quoted for planting. Trees and other vegetation should also be watered throughout the winter months to encourage root development. This should be done at least once per month but given how dry the winters in Colorado have been recently, twice per month may be necessary. Depending on the time of year that planting is being done and the species planted, it may be necessary to treat trees and other vegetation for certain insect species. This would be an additional charge that would need to be factored in and cannot currently be calculated. Overall, the most important factor for the reestablishment of trees and vegetation will be to have a frequent and adequate supply of water during the planting and early development of the trees and other vegetation.

VI. Other Improvements.

Additional improvements along the canal are related to the trail surface and increasing the height of the trail. There is approximately 1400 feet of trail west of Colorado Boulevard that will need to be raised up an average of 2.25 feet to provide additional freeboard for the canal embankment. This is an earthwork operation to remove the existing trail surface, scarify the existing canal embankment, add soil in compacted lifts, and replace the trail surface.

By raising the trail, the depth of the canal is increased, providing more capacity within the canal for conveying stormwater. In stormwater design, it is common to provide depth beyond what is expected to be wet during a design storm event. This additional depth is known as freeboard. Freeboard is intended to act as a 'safety factor' to contain flows that exceed the designed stormwater depth. An example of the benefit of freeboard is when leaf litter and small branches would dam up around a bend in the canal, raising the water upstream by several inches above what is expected. The additional depth from raising the trail then serves to contain the flows until the unintentional leaf-dam is broken by natural hydraulic forces or emergency maintenance operations.

VII. Operations and Maintenance.

Operations and maintenance of the converted canal will require additional manpower, equipment, and expertise to sustain the canal at the existing ecological and recreational experience. This occurs in several categories of work. Some have been identified by the High Line Canal Conservancy pilot studies. Some aspects are developed through MHFD maintenance operations tabulations for routine stormwater infrastructure maintenance. Budgeting and planning for these additional tasks will become the responsibility of the City of Cherry Hills Village. These maintenance categories include:

- Routine Maintenance. This includes trash and debris pick up, minor trail repairs, and minor vegetation clean-up or management. This is general contractor work with limited manpower and equipment requirements. If the City choses to participate in the maintenance contract currently being utilized by other partners, some of this work would be performed through this IGA.

- Noxious Weed Management. This is specific management of noxious weeds growing in and around the canal. This is specialized work with unique equipment, training and certifications.

- On-Call Tree Maintenance. This is specific management of the larger diameter or unique species trees. This work requires specialized experience, equipment, and safety requirements. This work also may require trail closures and specific safety measures. This work has been classified in two categories: “Immediate and High priority” to be completed within 3 years and “Medium and Low priority” to be completed within 10 years.

- Tree Inspection – Coordination. This is a higher-level management task requiring specialized training and education with lower requirements for equipment. This task is regularly scheduled and makes observations and recommendations to stakeholders to direct the labor for tree maintenance.

- Water Quality Maintenance. This is a stormwater specific task to clear debris and sediment accumulated upstream of the water quality berms. This is a common task for public works and stormwater management crews. This is basic labor but can require small construction equipment to collect and dispose of collected materials.

- Inlet-Pipe Maintenance. This is skilled infrastructure tasks that occur on a 25-to-50-year cycle. Concrete pipes, manholes, and inlets will require little to no work on an annual basis. Preventative maintenance occurs on 5- or 10-year cycles to extend the design life of the stormwater infrastructure.

- Spillway Maintenance. Similar to inlet-pipe maintenance, this is an infrequent, high-cost item. The spillways are expected to engage with stormwater on a 1% annual chance event. However, maintenance of the spillway armoring occurs on a preventative maintenance basis to limit weed and tree growth. Maintenance does require large construction equipment and significant labor.

- Safety and Outreach. This is a largely administrative task coordinated with contractors and stakeholders to identify risks and communicate the maintenance operations to the trail stakeholders. For example, this task would coordinate information from the tree inspection to communicate immediate needs for a trail closure to trail users and parks staff. This task has obvious crossover with existing roles associated with the High Line Canal but is included to reflect the additional efforts of the stormwater conversion.

- Irrigation. This includes both long- and short-term maintenance of the irrigation system in place. For trees and other new vegetation, drip irrigation is recommended. This task will require checks on the irrigation system in various reaches of the High Line Canal to ensure that an adequate and consistent supply of water is provided for the trees and vegetation.

- Staffing. There are no new skills or certifications required of the internal staff to complete operation and maintenance of a concerted canal system. However, there are additional man-hours required to complete the additional work on proposed improvements. This can be accomplished at a high level of service with a two-man crew of part time hires. But this could also be completed at a minimum level of service with existing manpower and advance scheduling of canal maintenance activities.

VIII. Permitting

There are several relevant local, state, and federal permits that are associated with implementation of the stormwater conversion of the canal. Given the unique nature of this conversion, there are many pilot studies and investigations currently underway to find the cleanest and most effective path to compliance.

a. USACE 404 Permit. The High Line Canal Conservancy and the High Line Canal Collaborative are working with ERO Resource Consultants and the U.S. Army Corps of Engineers to determine how the Clean Water Act Section 404 permits and "Waters of the US" determinations will work for the canal. Given the stormwater connections to the canal exist today in Cherry Hills Village, the permitting path may be streamlined compared to areas where new connections are being made to the canal. The jurisdictional determination of the canal has a significant effect on whether a wetland mitigation bank of any kind could be established along the canal. Having the canal be non-jurisdictional relieves the Village of USACE permitting requirements for any improvements to canal conditions but would not allow wetland mitigation credits to be generated within the canal.

b. Floodplain Permits. Earthwork, excavation and improvements to portions of the canal covered by FEMA regulated Special Flood Hazard Areas (floodplains) are required to have a City issued floodplain development permit. This permit authorizes the work once it has been proven to have no adverse impact on flooding. This permit will be required for work near Dahlia Hollow Park and anything within Blackmer Gulch. There is no current work proposed at Blackmer Gulch. And the work proposed at a Dahlia Hollow is intentionally below grade and intends to have a no-rise, no adverse impact on the Quincy Gulch floodplain.

c. Canal Water Quality Permit. Future homeowner discharge. Future drainage reports need analysis of no adverse impact, or mitigate impact, of the new homes and remodels discharge to the High Line. This can be documented as part of the Phase III drainage report required for all development and most redevelopment upstream of the High Line Canal. The City of Cherry Hills Village is not proposing any new stormwater flows and any news flows that are generated would need to be added into a stormwater management model. Furthermore, applicants that wish to utilize the High Line Canal to meet water quality requirements can be held responsible for the additional impact on operation and maintenance of the water quality facilities. The City would only manage the water once in the canal and private improvements would still be the individual homeowners responsibility. Since the water already drains to the canal, the correlated incentive to discharge towards the canal for the benefit of vegetation and trees does not exist. Regardless, stormwater facilities for detention will still be required for developments that increase impervious area such that stormwater is released at historic quantity, quality and manner of flow. The water quality treatment in the canal can be utilized to reduce the complexity of the outlet structure on the private pond, sending less water more often downstream and into the canal for beneficial use. This water quality benefit can include a license agreement similar to that of the stormwater blanket agreements that restricts changes to the detention outlet. This agreement can include a prorated cost share of the additional maintenance required. This would essentially be prorated based on drainage area and water quality volume for each specific sub-watershed. A one-acre parcel within a 200-acre sub-watershed draining to the canal could expect to pay an annual fee of 1/200, or 0.5% of the annual maintenance costs for the water quality in that section of the canal.

d. Other. There are possibly other permits required from Denver Water for use of the canal. These agreements are developing each year as more and more projects are implemented on the canal. These are usually in the form of Intergovernmental Agreements (IGAs).

IX. Sequence

The stormwater conversion of the High Line Canal is a multi-year, multi-agency, extended term endeavor. This study is one step in the City of Cherry Hills Village's investigation into feasibility of the conversion. The construction of the improvements has a similarly thoughtful process to ensure phases of the work are completed in an orderly manner. There are several steps worth noting to understand the sequence and timing of this work:

I. Prior Studies
   a. HLC Conservancy
   b. MHFD
   c. Private Partnerships in other jurisdictions

II. *Current Study* – CHV
   a. Planning
   b. 30% design
   c. Cost Analysis

III. Design Plans
   a. 60% design
   b. Permitting – USACE, SHPO, NFIP, etc.
   c. 90% design
   d. Implementation of agreements, IGAs
   e. 100% design
   f. Cost Estimating
   g. Construction Bidding (with attention per construction phase)
   h. Upstream Property Analysis

IV. Construction *(see additional phasing outline on following page)*
   a. Phased approach based on current conditions upstream and downstream
   b. Seasonal target for construction during low water and high revegetation potential
   c. Cycles into Operation and Maintenance for initial phase
   d. Next construction phase follows as seasons and budget allow

V. Operation and Maintenance
   a. Operation of converted canal system
   b. Maintenance of water quality features, vegetation, and recreation corridor
   c. 10-year cycle to review maintenance priorities

Phasing of construction is estimated as:

- Phase 1. Blackmer Trib overflow. Intercepting inflows to the canal as far upstream as possible is a first line of defense for mitigating canal flood risk in the Village. This overflow construction allows downstream canal improvements to proceed without additional risk of flows from upstream (south).

- Phase 2. Trail Improvements. Raising the trail west of Colorado Boulevard provides similar level of protection for canal flood events. This work should be done ahead of downstream improvements.

- Phase 3. Mansfield WQB. The water quality berm at Mansfield is the second phase of construction owing to its multi-functional purpose and isolated location. This installation allows the Village to learn and observe from the installation without the complexities of the parks, ponds, or other infrastructure.

- Phase 4. Irrigation. Extension and coordination of permanent irrigation systems.

- Phase 5. Three Pond Overflows. Installation of the overflow pipes at Three Pond Park is next. The overflows here provide a key relief for the stormwater inflows at Bellaire and the next WQB installation.

- Phase 6. Colorado WQB. With the upstream overflow pipes complete, the downstream water quality berm can be installed with confidence that any backwater surcharge is released safely.

- Phase 7. Dahlia overflow pipes. Given the complexity of the Dahlia overflow, this project can be moved to a point in the season when water control and trail traffic is a minimum.

- Phase 8. Quincy WQB.

- Phase 9. Dahlia WQB.

Phasing is influenced first by the risk mitigation of canal conversion – making sure we have the overflows and trail improvements done before water quality berms are placed in those reaches. Additional phasing discussion will be useful as budgets, priorities, and site-specific details are discovered in subsequent design phases. Partnerships can also adjust priorities to take advantage of funding or outreach advantages for specific reaches. Finally, in nearly all scenarios, the Dahlia water quality berm is one of the longest lead-time projects given the regulatory floodplain requirements and potential for lessons learned from other community projects.

X. References

a. Denver Water, High Line Canal Conservancy, general reference.
https://www.denverwater.org/tap/new-projects-take-shape-along-high-line-canal

b. Bureau of Reclamation, Vegetation.
https://www.usbr.gov/assetmanagement/docs/Canal_Vegetation.pdf

c. Bureau of Reclamation, Embankments.
https://www.usbr.gov/assetmanagement/docs/Canal_Embankments.pdf

d. High Line Canal Collaborative, Stormwater Technical Advisory Committee. Cost estimates. May 12, 2022.

e. High Line Canal Conservancy, Preliminary Tree Risk Assessment, SavATree, CHV TRA Data Analysis.xls, November 2022.

f. Mile High Flood District. Bid Tabulations for Stormwater Maintenance.
https://mhfd.org/resources/software/Bid Item Pricing.xls

Appendices

A. Property Owner Use of Canal
B. Cost Estimates – unit costs, 10 year, and capital
C. Conceptual Plans and Renderings
D. Hydraulic Calculations
E. June 2015 Flood Documentation Report
F. Irrigation and Tree Plans
    a. Short-Term Maintenance
    b. Long-Term Maintenance

A. Property Owner Use of Canal

HIGH LINE CANAL
CONSERVANCY

High Line Canal Use Agreement Background

Background

Denver Water along with leadership from local governments, agencies and the nonprofit High Line Canal Conservancy have achieved great successes for the people of the region and for future of the Canal as a recreational and environmental resource. We have not only deeply engaged all of the local agencies along the Canal, but also the people of the region and private philanthropy to invest in preserving and enhancing the High Line Canal for future generations - a task no one entity could have done alone. Together we conducted award-winning collaborative planning resulting in the foundational Community Vision Plan and The Plan for the High Line Canal, ultimately informed and endorsed by well over 5,000 residents and 11 governmental partners. While completing The Plan, together we also invested over $30M in public funding for the Canal. These successful collaborations culminated in agreements to create the Canal Collaborative: a formalized cooperative management structure for long term impact and sustainability.

Throughout this work, Denver Water has been a tremendous partner: supporting planning and the success of our nonprofit partner, the High Line Canal Conservancy. They have agreed to support the use of their 860 acre, 71 mile old Canal for the benefit of the public as a greenway and stormwater management resource. If we as a region were to work to purchase land and build such a tremendous resource, the expenditure would be in the $100s of millions.

Last year, in support of the transition of the Canal, Denver Water boldly reaffirmed their commitment to implementation of The Plan for the High Line Canal with a historic investment of $10M towards a *Forever Fund* that is being established to serve as a quasi-endowment for the Canal. Denver Water funds will be released into the *Forever Fund* over the next few years as a match to private donations raised by the Conservancy. Annual earnings from the Fund will be allocated through the newly formed Canal Collaborative to maintain the basic needs of the Canal and enhance the environmental health and stewardship of the corridor for future generations.

What's Next?

Today, the primary benefit of the Canal corridor has evolved from being a functional part of the Denver Water irrigation system with agricultural customers to serving as a recreational and ecological resource for hundreds of thousands of residents. With these changing uses, responsibility for the care of the Canal is shifting as well. While Denver Water will maintain ownership, share liability, and fulfill other ownership roles, maintenance of the corridor will shift over time to the entities with primary use of the Canal for both recreation and stormwater management.

Transition Timeline

Today, the Canal's on-the-ground maintenance is still managed by Denver Water and through a varied set of recreational leases and intergovernmental agreements (IGA)s with local jurisdictions and agencies. These historic leases, many dating back to the 1970s, divide the care for the Canal, with the local agencies managing the trail and a few feet on either side and Denver Water caring for the Canal channel and the remainder of the corridor. Over the next 3-4 years, as Denver Water completes their regular use of the Canal for irrigation delivery and remaining irrigation customers no longer rely on the Canal, it is time to again work together to set in place a transition timeline and for the agencies and governments using the Canal to set a maintenance transition timeline for the entire corridor. With the newly formed Canal Collaborative management structure in place, now is the time to ensure a new life for this regional legacy.

This O&M transition plan and timeline will be reflected in new use agreements that will consolidate the use of leases and IGAs to bring consistency and clarity to management of the Canal. As we collaborate to find agreement to the new use agreements and transition timelines, lets remember that there is great support from partners, as bulleted below.

- Funds will be allocated from the Forever Fund as leverage to increased local investment. Final estimation of the amount will be determined by the HLCC and Canal Collaborative.
- The HLCC is raising matching funds for all capital projects in the Capital Campaign including Canal-wide projects (tree planting and watering, signs, benches/furnishings).
- Denver Water will continue Canal sweeps in areas where irrigation water is still running.
- Denver Water will commit to additional maintenance (tree canopy care mostly) over the next four years.
- HLCC will work with Arapahoe County and other Counties to match Denver Water's maintenance commitment to complete needed maintenance on the Canal prior to the final transition timeline.
- HLCC will conduct a set number of jurisdictional clean ups of debris and trash through organized Youth Corp and Volunteer Stewardship Programs.
- Denver Water will provide local jurisdictions more flexibility and "authority" for use of the corridor within the Framework Plan guidelines and if project/need is accepted by the Canal Collaborative.
- Local jurisdictional partners will be given the opportunity to participate in combined service contracts for economies of scale/predictability and benefit from Conservancy support in managing these contracts.
- Jurisdictions will benefit from HLCC's communications, private funding, call center, programs, natural resources management planning, data management, coordination, and public relations.

HIGH LINE CANAL CONSERVANCY

High Line Canal Use Agreement Timeline

Background

As the partners work to develop and enter into new Use Agreements, this draft timeline has been created to spur discussion about the timeline for local partners to assume additional operational and maintenance responsibilities on the corridor. This draft timeline has been iterated by the Executive Committee of the Canal Collaborative Leadership Team.

Transition Planning: Spring 2022 – Spring 2023

- Complete existing condition assessments for the channel and trees
- Refine use agreement template and standards of care
- Develop transition plans indicating shared corridor responsibility between varied agencies and rough cost estimates (informed by condition assessments)
- Develop draft use agreements or modify existing lease or other agreement for each jurisdiction that includes a timeline for transition
- Agree to the baseline level of care and determine how liability can be mitigated

Sign Use Agreements or Modified Leases: Spring 2023 – Fall 2023

- Agreements include commitment to full corridor maintenance over a specified period of years
    - Typically, responsibilities for the corridor will be shared between multiple agencies
    - Agreements will specify a year when all maintenance is assumed by local agencies
    - Agreements may be contingent on the baseline level of care being achieved
    - By entering agreements, improvements on the corridor will be allowed to move forward
    - Additional benefits could include savings on land easement costs, streamlined approval processes and access to partner funds for maintenance

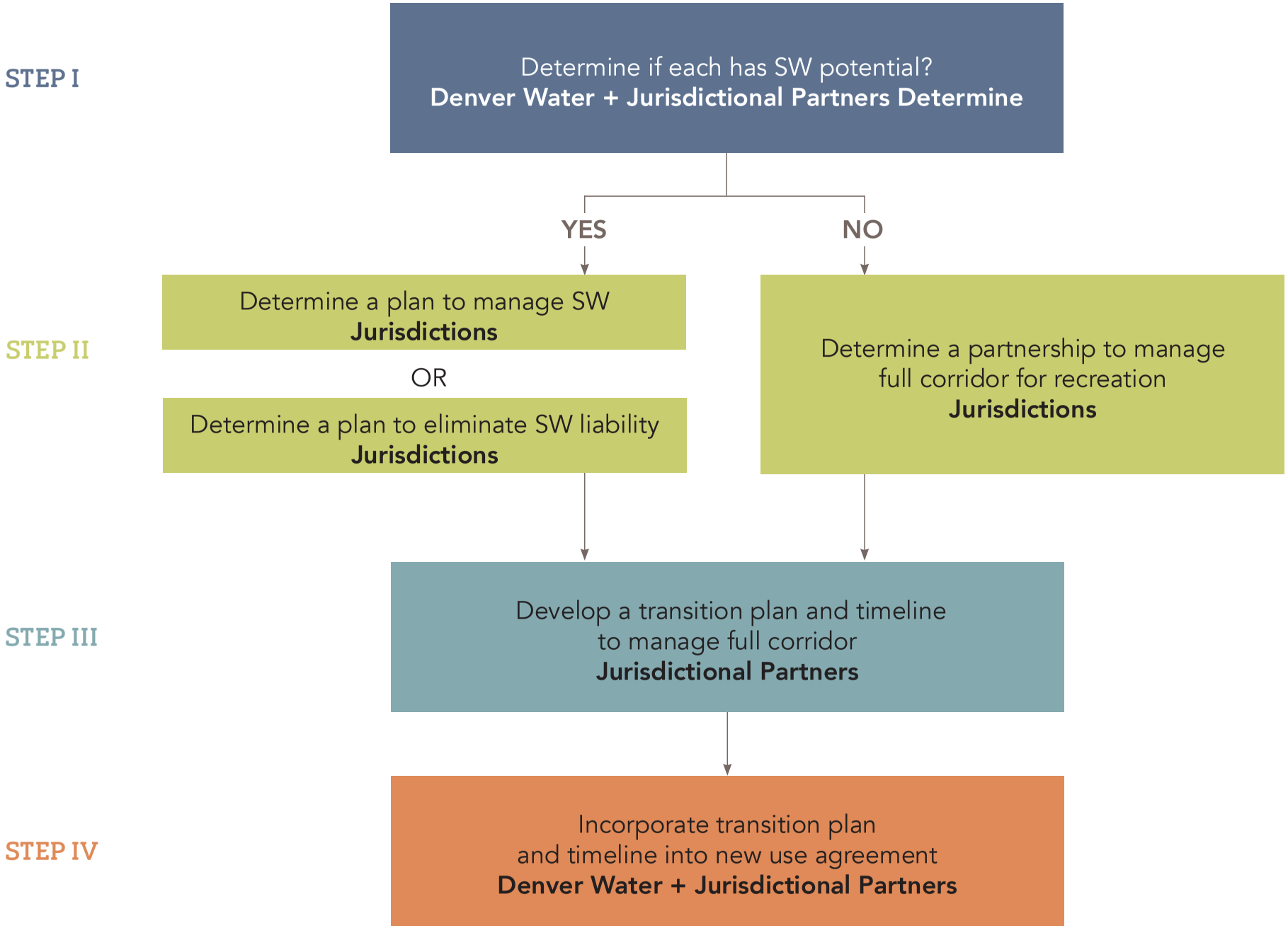
Transition Maintenance: 2023 – 2025

- Bring the Canal to the agreed upon baseline level of care (DW, Conservancy, partners)
- Jurisdictions that commit to the transition will have priority access to partnered funds for maintenance efforts
- Develop Canal-wide natural resources management plan

Use Agreements in Full Effect: 2026

- All use agreements will be in full effect and all maintenance responsibilities will have been assumed by the partners

FULL CORRIDOR CANAL MANAGEMENT DECISION TREE PROCESS



License Agreement

Date

<property owner> and City of Cherry Hills Village and Denver Water Board

Whereas, the High Line Canal has a 1999 policy that prohibits discharge of stormwater runoff entering the canal that is beyond the historic quantity, quality, and manner of flow;

And whereas, the use of High Line Canal right of way for conveying stormwater under or over the canal to follow gravity flow required a governmental or quasi-governmental agency to own the easement, operation and maintenance of such conveyance element;

And whereas, as of mm/dd/yyyy, the City of Cherry Hills assumed such easement over the High Line Canal within the City limits;

And whereas, <property owner> wishes to utilize the conversion of the High Line canal as water quality treatment for their proposed improvements;

Therefore, be it resolved, <property owner> shall provide the following to the City:

a. Phase III drainage report detailing existing and proposed drainage conditions on their property and all downstream, tributary, and off-site basins to the canal, with analysis, computations, and exhibits proving no adverse impacts to downstream properties from quantity, quality, or manner of flow,
b. Modifications to 'living' hydraulic model (SWMM) of High Line canal showing existing and proposed conditions do not adversely affect inflows and outflows from the canal
c. Operation and Maintenance agreement for length of canal affected by proposed inflows, generally understood to be length of the canal from inflow to the next downstream water quality berm, or,
d. Operation and Maintenance cost share agreement, paid as a lump sum fee to the license agreement for 100 years of operation and maintenance pro-rated to the subject property's land area within the basin tributary to the High Line Canal.

Upon review, and referral concurrence to the Mile High Flood District and Denver Water Board, the City shall provide approval of the High Line Canal addendum to the Phase III drainage report allowing off-site water quality treatment.

V-H-1
May 4, 1999

FOR THE CONSIDERATION OF THE BOARD:

POLICY REGARDING DRAINAGE
OF STORM WATER INTO
DENVER WATER'S DITCHES

Denver Water operates and maintains the High Line Canal and other ditch facilities within the Denver metro area and raw water collection areas. The introduction of storm water into these facilities, especially the High Line Canal, has caused problems in recent years and a formal Board policy on the issue would provide better guidance than the informal practice of the past. Following the adoption of a policy by the Board, staff will begin to deal with a number of nonconforming discharges from existing pipelines, sloping areas, and drainage ways.

The following policy is recommended:

> Denver Water's High Line Canal and other ditch facilities are not drainage ways. They are irrigation canals that, in some instances, bisect natural drainage ways or slopes that convey natural and modified surface drainage. Natural surface drainage is defined as runoff generated prior to any development in the area, unless that development predates the construction of the ditch or High Line Canal (1883).
>
> It is Denver Water's goal to exclude all surface drainage from the High Line Canal and other ditch facilities. Denver Water will not accept surface drainage that has been modified in quality, quantity (either peak flow rate or total volume) or manner of flow. To the extent that the existence of the High Line Canal or other ditch facility creates the potential for flooding beyond that caused by natural surface drainage, Denver Water will cooperate with local drainage authorities and other entities to design and construct culverts or other remedies to divert such drainage to acceptable storm water drainage ways. Under no circumstances will Denver Water direct surface runoff into the High Line Canal or other ditch facility.

It is recommended that the Board adopt the policy presented above regarding drainage of storm waters in its ditches.

Respectfully submitted,

H. J. Barry, Manager

Initiated by:

for Jon L. Diebel
Director of Engineering

Approved:

Stephen W. Work
Director of Operations
& Maintenance

Legal Approval:

for Patricia L. Wells
General Counsel

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Example of Phase III Drainage Report sections relevant to private property improvements discharging to the High Line Canal for water quality purposes:

VIII. WATER QUALITY ENHANCEMENT BEST MANAGEMENT PRACTICES

A. Non-structural BMPs
   1. Discussion of non-structural BMPs that will be part of the stormwater management plan

B. Structural BMPs
   1. Discuss the design of all structural water quality BMPs, including tributary areas, sizing, treatment volumes, design features, etc
   2. Discuss how runoff is conveyed from all pond outfalls to the nearest major drainageway, including a discussion of the flow path and capacity downstream of the outfall to the nearest major drainageway
   3. Discuss the operation and maintenance aspects of the design and easements and tracts that are required for stormwater quality enhancement purposes

C. Source Controls
   1. Discuss site activities or operations that have the potential to impact water quality
   2. Discuss the source controls that are necessary to prevent the potential for illicit discharge from site activities

IX. ADDITIONAL PERMITTING REQUIREMENTS

1. Compliance with Section 404 of the Clean Water Act
2. Compliance with the Endangered Species Act
3. Compliance with Other local, State, or Federal Permitting requirements

Figure 9 - Phase 3 Drainage Report Relevant Sections

1.0 Summary of Current General Principles of Drainage and Flood Control Law

1.1 Introduction

Photograph 2-1. Preserving a natural floodplain, including wetland areas, and using this area for flood control and conveyance, represents sound engineering in concert with established Colorado drainage law.

Drainage law not only has its basis in law made by the courts and the legislature but also relies to a large extent on the drainage facts that exist in each case. Therefore, a party with the most reliable facts and information will have a distinct advantage in court. Similarly, drainage engineering and design revolves around drainage law as well as the natural law of gravity.

This chapter deals with the general principles of drainage law along with local government drainage actions, financing, floodplain management, and special matters. This chapter is meant to provide an outline of the general principles of Colorado drainage law for the engineer and agency official. It is not meant to serve as a substitute for a lawyer's opinions, though this chapter may be of interest to practicing attorneys. Also, throughout this chapter cases from other jurisdictions are cited. Although they are from courts located in other states, they are cited since they provide the reasoning and law that most likely would be implemented by courts in the State of Colorado.

In using this chapter of the Urban Storm Drainage Criteria Manual (USDCM), the reader should be familiar with the entire USDCM and should pay particular attention to the *Policy* and *Planning* chapters. In the *Policy* chapter, 12 principles have been stated, with which the reader of this chapter should be familiar. Similarly, the following legal principles are summarized below for ready reference.

1.2 Legal Principles

1. The owner of upstream property possesses a natural easement on land downstream for drainage of surface water flowing in its natural course. The upstream property owner may alter drainage conditions so long as the water is not sent down in a manner or quantity to do more harm to the downstream land than formerly. Bittersweet Farms, Inc. v. Zimbelman, 976 P.2d 326 (Colo. App. 1998).

2. On July 1, 2003 the Colorado Legislature substantially changed the law in regard to the liability of governmental entities and the drainage, flood control, and stormwater facilities that they own or maintain. Governmental entities on and after July 1, 2003 have complete governmental immunity in regard to the drainage, flood control, and stormwater facilities that they own or maintain. The law in Colorado however did not change in regard to other facilities that a governmental entity owns and operates. In regard to those other facilities, a governmental entity's liability is determined as if it is a private party. However, the amount of its liability is limited by the Colorado Governmental Immunity Act.

3. A natural watercourse may be used as a conduit or outlet for the drainage of lands, at least where the augmented flow will not tax the stream beyond its capacity and cause flooding of adjacent lands. Ambrosio v. Pearl-Mack Construction Co., 351 P.2d 803 (Colo. 1960).

4. Ditch corporations that own ditches owe a duty to those property owners through which their ditches pass to maintain their ditches using ordinary care so as to prevent damage to adjoining real property. Oliver v. Amity Mut. Irrigation Co., 994 P.2d 495 (Colo. App. 1999). Further, ditch owners are not required under the law to accept stormwater runoff that is result of development that occurs after the ditch was constructed. The ditch owner would have a legal claim based upon trespass as well as a claim based upon the fact that the ditch is not a natural drainage and most likely the increased flows will be deposited into the ditch in a manner or quantity to do more harm than formerly. Hankins v. Borland, 431 P.2d 1007 (Colo. 1967).

5. Construction or enlargement of jurisdictional dams or reservoirs is subject to approval by the Colorado State Engineer's Office, which, depending on the size of the dam and the hazard classification, may include requirements for spillways to pass up to the Extreme Storm Precipitation (ESP) event[1]. A "jurisdictional dam" is defined as a dam that impounds water above the elevation of the natural surface of the ground creating a reservoir that meets one of the following conditions:

   i. Has a capacity of more than 100 acre-feet;

   ii. Has a surface area exceeding 20 acres at the high waterline; or

   iii. Exceeds 10 feet in height measured vertically from the elevation of the lowest point of the natural surface of the ground where that point occurs along the longitudinal centerline of the dam up to the flow line crest of the emergency spillway of the dam.

   Rules 4 & 5 of the Department of Natural Resources, Division of Water Resources, Office of the State Engineer, Rules and Regulations for Dam Safety and Dam Construction, 2-CCR 402-1, Effective Date: January 1, 2007.

6. The boundaries of the floodplain should be accurately determined and based on a reasonable standard. Mallett v. Mamarooneck, 125 N.E. 2d 875 (N.Y. 1955).

7. Adoption of a floodplain regulation to regulate flood-prone areas is a valid exercise of police power and is not a taking as long as the regulation does not go beyond protection of the public's health, safety, morals, and welfare. Hermanson v. Board of County Commissioners of Fremont, 595 P.2d 694 (Colo. App. 1979).

8. The adoption by a municipality of floodplain ordinances to regulate flood-prone areas is a valid exercise of police power and is not a taking. Morrison v. City of Aurora, 745 P.2d 1042 (Colo. App. 1987).

9. A zoning ordinance is not unconstitutional because it prohibits a landowner from using or developing his land in the most profitable manner. It is not required that a landowner be permitted to make the best, maximum or most profitable use of his property. Baum v. City and County of Denver, 363 P.2d 688 (Colo. 1961) and Sundheim v. Board of County Commissioners of Douglas County, 904 P.2d 1337 (Colo. App. 1995).

10. The Colorado Governmental Immunity Act (CGIA), in addition to providing complete immunity to

[1] The ESP event represents the greatest depth of precipitation for a given duration that is physically possible over a drainage basin through the application of modern meteorological techniques, based on Colorado extreme storm data approved by the State Engineer.

governmental entities for the drainage, flood control, and stormwater facilities that they own or maintain, also does not require a governmental entity to upgrade, modernize, modify, or improve the design or construction of a facility, including but not limited to the drainage, flood control and stormwater facilities that it owns or maintains. This same protection does not include private parties.

11. A "dangerous condition" constitutes an unreasonable risk to the health or safety of the public, which is known to exist or which in the exercise of reasonable care should have been known to exist and which condition is proximately caused by the negligent act or omission of the public entity in constructing or maintaining such facility. 24-10-103 (1.3) C.R.S. However, a dangerous condition shall not exist solely because the design of any facility is inadequate. Again, this protection does not extend to private parties.

12. Under the CGIA, a governmental entity is not protected by immunity in regard to the operation and maintenance of any "public water facility" or "sanitation facility." 24-10-106 (f) C.R.S.

13. However, under the CGIA, a "public water facility" does not include a "public sanitation facility;" a natural watercourse even if dammed, channelized, or used for transporting domestic water supplies; a drainage, borrow, or irrigation ditch even if dammed, channelized, or containing stormwater runoff or discharge; or a curb and gutter system. 24-10103 (5.7) C.R.S.

14. Also, under the CGIA, a "public sanitation facility" does not include a "public water facility;" a natural watercourse even if dammed, channelized, or containing stormwater runoff, discharge from a storm sewer; a drainage, borrow, or irrigation ditch even if the ditch contains stormwater runoff or discharge from storm sewers; a curb and gutter system or other drainage, flood control, and stormwater facilities. 24-10103 (5.5) C.R.S. Therefore, a public entity will be immune from liability in regard to all drainage and flood control facilities that it designs, constructs and maintains. Again, this protection does not extend to private parties.

15. Under the CGIA, a public entity will not be liable for its failure to upgrade, modernize, modify, or improve the design or construction of a drainage or flood control facility or any other facility that it owns or maintains whether it knows of a deficiency or not or whether it is a dangerous condition or not. 24-10-103 (2.5) C.R.S. The Colorado Legislature in enacting this law found that governmental entities ". . . provide essential public services and functions and the increased legal liability from not having this type of statutory protection poses the danger of disrupting or making prohibitively expensive the provision of such services and functions."

16. The CGIA has not been challenged in court since its adoption in 2003 although courts have considered whether its application was meant by the Colorado Legislature to be retroactive. Therefore, it is uncertain if the CGIA would withstand a legal challenge. Regardless, governmental entities should, to the best of their ability, attempt to construct, operate, and maintain the drainage, flood control, and stormwater facilities that they own to the same standard that private parties are required to meet.

17. CGIA does not protect a public entity from a claim based upon inverse condemnation. Inverse condemnation is defined as the taking of private property for a public or private use, without compensation, by a governmental or public entity which has refused to exercise its eminent domain power.

18. In imposing conditions upon the granting of land-use approvals, no local government shall require an owner of private property to dedicate real property to the public or pay money to a public entity in an amount that is determined on an individual and discretionary basis, unless there is an essential nexus between the dedication or payment and a legitimate local government interest and the dedication or

payment is roughly proportional both in nature and extent to the impact of the proposed use or development of such property. This law does not apply to any legislatively formulated assessment, fee, or charge that is imposed on a broad class of property owners by a local government. 29-20-203 C.R.S.

19. Public entities that own dams or reservoirs are not subject to strict liability for damages caused by water escaping from their dams or reservoirs. Further, those public entities have no duty to ensure that waters released from an upstream reservoir because of a dam failure would be contained by their facilities or would bypass those facilities without augmentation. Kane v. Town of Estes Park, 786 P.2d 412 (Colo. 1990).

20. A professional engineer is required not only to serve the interests of his or her employer/client but is also required, as his or her primary obligation, to protect the safety, health, property, and welfare of the public. Rule I 2. of The Colorado Rules of Professional Conduct of the State Board of Registration for Professional Engineers and Professional Land Surveyors.

21. Where a municipality imposes a special fee upon owners of property for purposes of providing a service and where the fee is reasonably designed to defray the cost of the service provided by the municipality, such a fee is a valid form of governmental charge within the legislative authority of the municipality. Bloom v. City of Fort Collins, 784 P.2d 304 (Colo. 1989).

2.0 General Principles of Drainage Law

> Very little is gained if the same act which dries up one tract of land renders the adjoining tract twice as difficult to redeem. Livingston v. McDonald, 21 Iowa 160, 170 (1866).

2.1 Private Liability

Traditionally, courts have analyzed the legal relations between parties in drainage matters in terms of such property concepts as natural easements, rights, privileges, and servitudes but have based liability for interfering with surface waters on tort principles. See Kenyon and McClure *Interferences With Surface Waters*, 24 Minn. L. Rev. 891 (1940). Drainage and flood control problems attendant with increased urbanization, the trend in tort law toward shifting the burden of a loss to the best risk-bearer, and complete or partial reinstitution of governmental immunity by the legislature will continue to change the traditional rules that have governed legal relations between parties in drainage matters. These changes are reflected in the three basic rules relating to drainage of surface waters that have been applied over a period of time in the United States: the common enemy rule, the civil law rule (later to be called a "modified civil law rule"), and the reasonable use rule.

2.1.1 Common Enemy Rule

Under the common enemy rule, which is also referred to as the common law rule, surface water is regarded as a common enemy, which each property owner may fight off or control as he or she will or is able, either by retention, diversion, repulsion, or altered transmission. Thus, there is no cause of action even if some injury occurs. All jurisdictions originally following this harsh rule have either modified the rule or adopted the civil law rule or reasonable use rule. 5 *Water and Water Rights*, §§450.6, 451.2 (R.E. Clark ed. 1972).

2.1.2 Civil Law Rule

The civil law rule, or natural flow rule, places a natural easement or servitude upon the lower land for the drainage of surface water in its natural course, and the natural flow of the water cannot be obstructed by the servient owner to the detriment of the dominant owner. 5 *Water and Water Rights*, §452.2A (R.E. Clark ed. 1972). Most states following this rule, including Colorado, have modified the rule. Under the modified rule, the owner of upper lands has an easement over lower lands for drainage of surface waters, and natural drainage conditions can be altered by an upper proprietor provided the water is not sent down in a manner or quantity to do more harm than formerly. Hankins v. Borland, 163 Colo. 575, 431 P.2d 1007 (1967); H. Gordon Howard v. Cactus Hill Ranch Company, 529 P.2d 660 (1974); Hoff v. Ehrlich, 511 P.2d 523 (1973); but see Ambrosio v. Perl-Mack Construction Company, 143 Colo. 49, 351 P.2d 803 (1960) and Bittersweet Farms, Inc. v. Zimbelman, 976 P.2d 326 (Colo. App. 1998).

2.1.3 Reasonable Use Rule

Under the reasonable use rule, each property owner can legally make reasonable use of his land, even though the flow of surface waters is altered thereby and causes some harm to others. However, liability attaches when the harmful interference with the flow of surface water is "unreasonable." Whether a landowner's use is unreasonable is determined by a nuisance-type balancing test. The analysis involves three inquiries:

1. Was there reasonable necessity for the actor to alter the drainage to make use of his or her land?

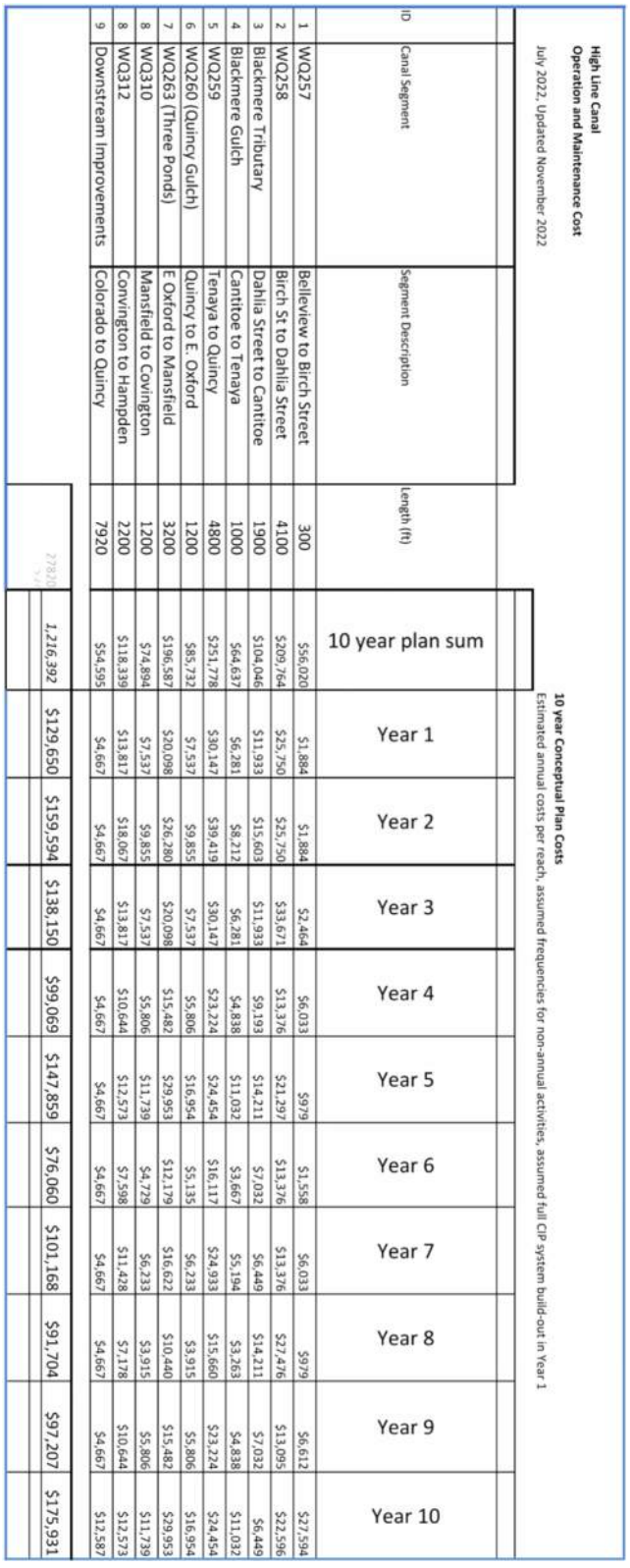
2. Was the alteration done in a reasonable manner?

3. Does the utility of the actor's conduct reasonably outweigh the gravity of harm to others?

Restatement Torts, §§822-831, 833 (1939); *Restatement (Second) Torts*, §158, Illustration 5. Alaska, Hawaii, Kentucky, Massachusetts, Minnesota, New Hampshire, New Jersey, North Carolina, North Dakota, Ohio and Utah have adopted this rule. Some states have restricted their application of the rule to urban areas (South Dakota and Texas). In Pendegast v. Aiken, 236 S.E. 2d 787 (1977), the North Carolina Supreme Court traces the common law rule to the civil law rule to adoption by that court of the reasonable use rule, starting at page 793:

> It is no longer simply a matter of balancing the interests of individual landowners; the interests of society must be considered. On the whole the rigid solutions offered by the common enemy and civil law rules no longer provide an adequate vehicle by which drainage problems may be properly resolved.

B. Operation and Maintenance and Capital Improvement Cost Estimates



High Line Canal
Operation and Maintenance Cost
July 2022, Updated November 2022

10 year Conceptual Plan Costs
Estimated annual costs per reach, assumed frequencies for non-annual activities, assumed full CIP system build-out in Year 1

ID	Canal Segment	Segment Description	Length (ft)	10 year plan sum	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
1	WQ257	Belleview to Birch Street	300	$56,020	$1,884	$1,884	$2,464	$6,033	$979	$1,558	$6,033	$979	$6,612	$27,594
2	WQ258	Birch St to Dahlia Street	4100	$209,764	$25,750	$25,750	$33,671	$13,376	$21,297	$13,376	$13,376	$27,476	$13,095	$22,596
3	Blackmere Tributary	Dahlia Street to Canttoe	1900	$104,046	$11,933	$15,603	$11,933	$9,193	$14,211	$7,032	$6,449	$14,211	$7,032	$6,449
4	Blackmere Gulch	Cantitoe to Tenaya	1000	$64,637	$6,281	$8,212	$6,281	$4,838	$11,032	$3,667	$5,194	$3,263	$4,838	$11,032
5	WQ259	Tenaya to Quincy	4800	$251,778	$30,147	$39,419	$30,147	$23,224	$24,454	$16,117	$24,933	$15,660	$23,224	$24,454
6	WQ260 (Quincy Gulch)	Quincy to E. Oxford	1200	$85,732	$7,537	$9,855	$7,537	$5,806	$16,954	$5,135	$6,233	$3,915	$5,806	$16,954
7	WQ263 (Three Ponds)	E Oxford to Mansfield	3200	$196,587	$20,098	$26,280	$20,098	$15,482	$29,953	$12,179	$16,622	$10,440	$15,482	$29,953
8	WQ310	Mansfield to Covington	1200	$74,894	$7,537	$9,855	$7,537	$5,806	$11,739	$4,729	$6,233	$3,915	$5,806	$11,739
8	WQ312	Convington to Hampden	2200	$118,339	$13,817	$18,067	$13,817	$10,644	$12,573	$7,598	$11,428	$7,178	$10,644	$12,573
9	Downstream Improvements	Colorado to Quincy	7920	$54,595	$4,667	$4,667	$4,667	$4,667	$4,667	$4,667	$4,667	$4,667	$4,667	$12,587
				1,216,392	$129,650	$159,594	$138,150	$99,069	$147,859	$76,060	$101,168	$91,704	$97,207	$175,931

Figure 10 - Estimated 10 year O&M Plan Costs

High Line Canal
Operation and Maintenance Cost

July 2022, Updated November 2022

Unit Cost per Design Reach

ID	Canal Segment	Segment Description	Length (ft)	Width (ft)	Segment %	Inflows	Outflows	ROW Area (SF)	Routine Maintenance	Noxious Weed Mitigation	On-Call Tree Care and Maintenance-Med-Low	On-Call Tree Care and Maintenance-Imm-High	Tree Inspection - Coordination	Water Quality Maintenance	Inlet-Pipe Maintenance	Spillway Maintenance	Safety and Outreach
									$/LF $2.08	$/LF $1.93	$/LF $1.11	$/LF $4.13	$/LF $1.58	$/EA $2,500	$/EA $390.00	$/EA $250	$/LF $0.07
1	WQ257	Belleview to Birch Street	300	100	1.1%	1	1	30000	$625	$580	$333	$1,239	$473	$5,054	$394	$0	$21
2	WQ258	Birch St to Dahlia Street	4100	100	14.7%	1	2	410000	$8,542	$7,920	$4,554	$16,928	$6,461	$8,605	$895	$0	$281
3	Blackmere Tributary	Dahlia Street to Cantitoe	1900	100	6.8%	1	2	190000	$3,958	$3,670	$2,110	$7,845	$2,994	$8,012	$833	$250	$130
4	Blackmere Gulch	Cantitoe to Tenaya	1000	100	3.6%	2	1	100000	$2,083	$1,932	$1,111	$4,129	$1,576	$7,770	$404	$0	$68
5	WQ259	Tenaya to Quincy	4800	100	17.3%	2	1	480000	$10,000	$9,273	$5,331	$19,818	$7,564	$8,794	$457	$0	$329
6	WQ260 (Quincy Gulch)	Quincy to E. Oxford	1200	100	4.3%	2	3	120000	$2,500	$2,318	$1,333	$4,954	$1,891	$13,039	$1,220	$0	$82
7	WQ263 (Three Ponds)	E Oxford to Mansfield	3200	100	11.5%	3	4	320000	$6,667	$6,182	$3,554	$13,212	$5,042	$19,513	$1,739	$0	$219
8	WQ310	Mansfield to Covington	1200	100	4.3%	1	2	120000	$2,500	$2,318	$1,333	$4,954	$1,891	$7,824	$814	$0	$82
8	WQ312	Convington to Hampden	2200	100	7.9%	1	1	220000	$4,583	$4,250	$2,443	$9,083	$3,467	$5,395	$421	$0	$151
9	Downstream Improvements	Colorado to Quincy	7920	65	28.5%	8	1	514800	$4,125						$7,920		$542
			27820 ft 5.27 miles														

Cost Estimates (HLC contract costs + MHFD bid tabulations)

Maintenance Item						Annual Unit Cost
Routine Maintenance - incl. irrigation	10000	2500		8600	11000	2.08
Noxious Weed Mitigation	10200	3025		9975	10200	1.93
On-Call Tree Care-Maintenance - Immd-High			81966			4.13
On-Call Tree Care-Med-Low				22050		1.11
Tree Inspection - Coordination	5640	0		8320	8320	1.58
WQ Maintenance					2500	2500.00
Inlet-Pipe Maintenance	4500	250		5000	9750	390.00
Spillway Maintenance	12500				12500	250.00
Safety and Outreach					25	0.07

Cost Estimat	Cost Estimate Notes	
Inflows	Inflows	2 for overland, +1 for pipes, swales, connections
Inflows	Inflows	2 for overland, +1 for pipes, swales, connections
Outflows:	Outflows:	2 for infiltration, +1 for other inlets, pipes, spillways, berms

Figure 11 - Estimated O&M Unit Costs

Stormwater Conversion Capital Improvement Project Cost Summary

Location	Subtotal	Contingency (25%)	Estimated Construction Cost
Mansfield	$132,840.42	$33,210.11	$166,050.53
Colorado	$326,499.42	$81,624.86	$408,124.28
Three Pond	$63,358.20	$15,839.55	$79,197.75
Dahlia Hollow	$64,449.00	$16,112.25	$80,561.25
Quincy Ave	$46,639.67	$11,659.92	$58,299.59
Blackmer Tributary	$515,573.42	$128,893.36	$644,466.78
Dahlia Crossing	$82,454.47	$20,613.62	$103,068.09
Permanent Irrigation	$360,000.00	$90,000.00	$450,000.00
		Total:	**$1,989,768.25**

Extra Costs:	
Permitting (8%)	$159,181.46
Design (10%)	$198,976.83
Administration (5%)	$99,488.41
Total Estimated Construction Cost:	**$2,447,414.95**

ICON ENGINEERING, INC.

High Line Canal Stormwater Conversion Cherry Hills Village

Blackmer Tributary Overflow Spillway

Engineer's Opinion of Probable Cost - 30% Design

September 2022

BID ITEM NO.	BID ITEM CODE	DESCRIPTION OF BID ITEM	PAY UNIT	QUANTITY	UNIT PRICE	TOTAL COST OF BID ITEM	CATEGORY TOTAL
Project Start-Up							**$14,015.58**
	GN-07-001	Project Sign	LS	1.00	$1,000.00	$1,000.00	
	GN-02-001	Mobilization	LS	1.00	$0.00	$0.00	
	GN-06-001	Water Control and Dewatering	LS	1.00	$0.00	$0.00	
	ESC-01-001	Erosion and Sediment Control	LS	1.00	$5,000.00	$5,000.00	
	GN-04-001	Construction Surveying	LS	1.00	$5,015.58	$5,015.58	
	GN-05-001	Traffic and Pedestrian Control	LS	1.00	$3,000.00	$3,000.00	
Removals							**$3,600.00**
	RR-06-018	Tree Removals (0-6")	EA	12.00	$300.00	$3,600.00	
	RR-06-018	Tree Removals (7-12")	EA		$500.00	$0.00	
	RR-06-018	Tree Removals (13-18")	EA		$750.00	$0.00	
	RR-06-018	Tree Removals (19-24")	EA		$1,000.00	$0.00	
	RR-06-018	Tree Removals (25-36")	EA		$1,500.00	$0.00	
	RR-06-018	Tree Removals (37-48")	EA		$2,500.00	$0.00	
	RR-06-018	Tree Removals (>49")	EA		$7,000.00	$0.00	
	GN-01-001	Clearing and Grubbing	AC		$5,000.00	$0.00	
Trail Improvements							**$490,557.84**
	ESP-07-001	Topsoil, Excavate, Stockpile, and Replace	CY	405	$17.00	$6,885.00	
	ESP-02-001	Excavation Cut and Fill Onsite	CY	6.32	$12.00	$75.84	
	ESP-02-002	Excavation, Cut and Fill Offsite	CY	859.00	$33.00	$28,347.00	
	RW-11-004	Soil Riprap, Type H	CY	1,187.00	$150.00	$178,050.00	
		Sheetpile	SF	3,960.00	$70.00	$277,200.00	
		Trail, Resin, 4-Inch Thick	SY	613.00	$106.25	$65,131.25	
Vegetation							**$7,400.00**
		Revegetation (30% of Total Cost)	AC	1.48	$5,000.00	$7,400.00	
	LS-06-001	Temporary Irrigation	EA		$1,500.00	$0.00	

Subtotal	$515,573.42
Contingency (25%)	$128,893.35
Estimated Construction Cost	**$644,466.77**

Notes:

1. Cost estimate doesn't include permits and engineering design

ICON ENGINEERING, INC.

High Line Canal Stormwater Conversion Cherry Hills Village

Colorado Water Quality Berm

Engineer's Opinion of Probable Cost - 30% Design

September 2022

BID ITEM NO.	BID ITEM CODE	DESCRIPTION OF BID ITEM	PAY UNIT	QUANTITY	UNIT PRICE	TOTAL COST OF BID ITEM	CATEGORY TOTAL
Project Start-Up							**$51,706.06**
	GN-07-001	Project Sign	LS	1.00	$1,000.00	$1,000.00	
	GN-02-001	Mobilization	LS	1.00	$17,794.19	$17,794.19	
	GN-06-001	Water Control and Dewatering	LS	1.00	$21,353.03	$21,353.03	
	ESC-01-001	Erosion and Sediment Control	LS	1.00	$5,000.00	$5,000.00	
	GN-04-001	Construction Surveying	LS	1.00	$3,558.84	$3,558.84	
	GN-05-001	Traffic and Pedestrian Control	LS	1.00	$3,000.00	$3,000.00	
Removals							**$10,800.00**
	RR-06-018	Tree Removals (0-6")	EA		$300.00	$0.00	
	RR-06-018	Tree Removals (7-12")	EA		$500.00	$0.00	
	RR-06-018	Tree Removals (13-18")	EA		$750.00	$0.00	
	RR-06-018	Tree Removals (19-24")	EA	2.00	$1,000.00	$2,000.00	
	RR-06-018	Tree Removals (25-36")	EA		$1,500.00	$0.00	
	RR-06-018	Tree Removals (37-48")	EA		$2,500.00	$0.00	
	RR-06-018	Tree Removals (>49")	EA		$7,000.00	$0.00	
	GN-01-001	Clearing and Grubbing	AC	1.76	$5,000.00	$8,800.00	
Trail Improvements							**$246,243.85**
	ESP-07-001	Topsoil, Excavate, Stockpile, and Replace	CY	1421.00	$17.00	$24,157.00	
	ESP-02-001	Excavation Cut and Fill Onsite	CY	71.10	$12.00	$853.20	
	ESP-03-001	Earthwork, Import Fill	CY	6,193.05	$33.00	$204,370.65	
	RT-02-001	Trail, Crusher Fines, 4-Inch Thick	SY	803.00	$21.00	$16,863.00	
Water Quality Berm							**$34,730.00**
	RW-12-003	Soil Riprap, Type M	CY	80.00	$130.00	$10,400.00	
	RW-07-002	Boulder, Ungrouted 24"	EA	16.00	$350.00	$5,600.00	
	RW-07-004	Boulder, Ungrouted 36"	EA	15.00	$400.00	$6,000.00	
	RW-07-006	Boulder, Ungrouted 48"	EA	3.00	$500.00	$1,500.00	
	SS-06-003	18" RCP	LF	40.00	$86.00	$3,440.00	
	SS-02-006	18" RCP FES	EA	1.00	$2,750.00	$2,750.00	
		Inlets	SF	9.00	$560.00	$5,040.00	
Spillway Overflow							**$46,360.00**
		Inlets	SF	36.00	$560.00	$20,160.00	
	SS-06-007	Reinforced Concrete Pipe (RCP), Class III, 42-Inch Diam	LF	61.00	$250.00	$15,250.00	
	RW-11-004	Soil Riprap, Type H	CY	73.00	$150.00	$10,950.00	
Vegetation							**$17,750.00**
		Revegetation (30% of Total Cost)	AC	3.25	$5,000.00	$16,250.00	
	LS-06-001	Temporary Irrigation	EA	1.00	$1,500.00	$1,500.00	

Subtotal	$326,499.91
Contingency (25%)	$81,624.98
Estimated Construction Cost	**$408,124.89**

Notes:

1. Cost estimate doesn't include permits and engineering design

ICON ENGINEERING, INC.

High Line Canal Stormwater Conversion Cherry Hills Village

Dahlia Water Quality Berm

Engineer's Opinion of Probable Cost - 30% Design

September 2022

BID ITEM NO.	BID ITEM CODE	DESCRIPTION OF BID ITEM	PAY UNIT	QUANTITY	UNIT PRICE	TOTAL COST OF BID ITEM	CATEGORY TOTAL
Project Start-Up							**$9,727.27**
	GN-07-001	Project Sign	LS	1.00	$1,000.00	$1,000.00	
	GN-02-001	Mobilization	LS	1.00	$0.00	$0.00	
	GN-06-001	Water Control and Dewatering	LS	1.00	$0.00	$0.00	
	ESC-01-001	Erosion and Sediment Control	LS	1.00	$5,000.00	$5,000.00	
	GN-04-001	Construction Surveying	LS	1.00	$727.27	$727.27	
	GN-05-001	Traffic and Pedestrian Control	LS	1.00	$3,000.00	$3,000.00	
Removals							**$0.00**
	RR-06-018	Tree Removals (0-6")	EA		$300.00	$0.00	
	RR-06-018	Tree Removals (7-12")	EA		$500.00	$0.00	
	RR-06-018	Tree Removals (13-18")	EA		$750.00	$0.00	
	RR-06-018	Tree Removals (19-24")	EA		$1,000.00	$0.00	
	RR-06-018	Tree Removals (25-36")	EA		$1,500.00	$0.00	
	RR-06-018	Tree Removals (37-48")	EA		$2,500.00	$0.00	
	RR-06-018	Tree Removals (>49")	EA		$7,000.00	$0.00	
	GN-01-001	Clearing and Grubbing	AC		$5,000.00	$0.00	
Water Quality Berm							**$69,927.20**
	ESP-07-001	Topsoil, Excavate, Stockpile, and Replace	CY	63.00	$17.00	$1,071.00	
	ESP-02-001	Excavation Cut and Fill Onsite	CY	9.35	$12.00	$112.20	
	ESP-03-001	Excavation, Import Fill	CY	128.00	$35.00	$4,480.00	
	RW-12-003	Soil Riprap, Type M	CY	312.00	$130.00	$40,560.00	
	RW-07-002	Boulder, Ungrouted 24"	EA	16.00	$350.00	$5,600.00	
	RW-07-004	Boulder, Ungrouted 36"	EA	9.00	$400.00	$3,600.00	
	RW-07-006	Boulder, Ungrouted 48"	EA	5.00	$500.00	$2,500.00	
		Inlet	SF	9.00	$560.00	$5,040.00	
	SS-06-003	18" RCP	LF	49.00	$86.00	$4,214.00	
	SS-02-006	18" RCP FES	EA	1.00	$2,750.00	$2,750.00	
Vegetation							**$2,800.00**
		Revegetation (30% of Total Cost)	AC	0.56	$5,000.00	$2,800.00	
	LS-06-001	Temporary Irrigation	EA		$1,500.00	$0.00	

Subtotal	$82,454.47
Contingency (25%)	$20,613.62
Estimated Construction Cost	**$103,068.09**

Notes:

1. Cost estimate doesn't include permits and engineering design

ICON ENGINEERING, INC.

High Line Canal Stormwater Conversion Cherry Hills Village

Dahlia Hollow Outfall

Engineer's Opinion of Probable Cost - 30% Design

September 2022

BID ITEM NO.	BID ITEM CODE	DESCRIPTION OF BID ITEM	PAY UNIT	QUANTITY	UNIT PRICE	TOTAL COST OF BID ITEM	CATEGORY TOTAL
Project Start-Up							**$9,564.00**
	GN-07-001	Project Sign	LS	1.00	$1,000.00	$1,000.00	
	GN-02-001	Mobilization	LS	1.00	$0.00	$0.00	
	GN-06-001	Water Control and Dewatering	LS	1.00	$0.00	$0.00	
	ESC-01-001	Erosion and Sediment Control	LS	1.00	$5,000.00	$5,000.00	
	GN-04-001	Construction Surveying	LS	1.00	$564.00	$564.00	
	GN-05-001	Traffic and Pedestrian Control	LS	1.00	$3,000.00	$3,000.00	
Removals							**$0.00**
	RR-06-018	Tree Removals (0-6")	EA		$300.00	$0.00	
	RR-06-018	Tree Removals (7-12")	EA		$500.00	$0.00	
	RR-06-018	Tree Removals (13-18")	EA		$750.00	$0.00	
	RR-06-018	Tree Removals (19-24")	EA		$1,000.00	$0.00	
	RR-06-018	Tree Removals (25-36")	EA		$1,500.00	$0.00	
	RR-06-018	Tree Removals (37-48")	EA		$2,500.00	$0.00	
	RR-06-018	Tree Removals (>49")	EA		$7,000.00	$0.00	
	GN-01-001	Clearing and Grubbing	AC		$5,000.00	$0.00	
Spillway Overflow							**$54,000.00**
	RW-11-004	Soil Riprap, Type H	CY	10.00	$150.00	$1,500.00	
		Inlet	SF	45.00	$560.00	$25,200.00	
	SS-06-003	Reinforced Concrete Pipe (RCP), Class III, 48-Inch Diam	LF	78.00	$350.00	$27,300.00	
Vegetation							**$2,400.00**
		Revegetation (30% of Total Cost)	AC	0.48	$5,000.00	$2,400.00	
	LS-06-001	Temporary Irrigation	EA		$1,500.00	$0.00	

Subtotal	$65,964.00
Contingency (25%)	$16,491.00
Estimated Construction Cost	**$82,455.00**

Notes:

1. Cost estimate doesn't include permits and engineering design

ICON ENGINEERING, INC.

High Line Canal Stormwater Conversion Cherry Hills Village

Mansfield Water Quality Berm

Engineer's Opinion of Probable Cost - 30% Design

September 2022

BID ITEM NO.	BID ITEM CODE	DESCRIPTION OF BID ITEM	PAY UNIT	QUANTITY	UNIT PRICE	TOTAL COST OF BID ITEM	CATEGORY TOTAL
Project Start-Up							**$21,472.54**
	GN-07-001	Project Sign	LS	1.00	$1,000.00	$1,000.00	
	GN-02-001	Mobilization	LS	1.00	$5,196.89	$5,196.89	
	GN-06-001	Water Control and Dewatering	LS	1.00	$6,236.27	$6,236.27	
	ESC-01-001	Erosion and Sediment Control	LS	1.00	$5,000.00	$5,000.00	
	GN-04-001	Construction Surveying	LS	1.00	$1,039.38	$1,039.38	
	GN-05-001	Traffic and Pedestrian Control	LS	1.00	$3,000.00	$3,000.00	
Removals							**$2,535.00**
	RR-06-018	Tree Removals (0-6")	EA		$300.00	$0.00	
	RR-06-018	Tree Removals (7-12")	EA		$500.00	$0.00	
	RR-06-018	Tree Removals (13-18")	EA		$750.00	$0.00	
	RR-06-018	Tree Removals (19-24")	EA	2.00	$1,000.00	$2,000.00	
	RR-06-018	Tree Removals (25-36")	EA		$1,500.00	$0.00	
	RR-06-018	Tree Removals (37-48")	EA		$2,500.00	$0.00	
	RR-06-018	Tree Removals (>49")	EA		$7,000.00	$0.00	
	GN-01-001	Clearing and Grubbing	AC	0.11	$5,000.00	$535.00	
Water Quality Berm							**$97,752.80**
	ESP-07-001	Topsoil, Excavate, Stockpile, and Replace	CY	86.4	$17.00	$1,468.80	
	ESP-03-001	Earthwork, Import Fill	CY	133.00	$35.00	$4,655.00	
	RW-12-003	Soil Riprap, Type M	CY	79.30	$130.00	$10,309.00	
	RW-07-002	Boulder, Ungrouted 24"	EA	29.00	$350.00	$10,150.00	
	RW-07-004	Boulder, Ungrouted 36"	EA	31.00	$400.00	$12,400.00	
	RW-07-006	Boulder, Ungrouted 48"	EA	4.00	$500.00	$2,000.00	
	SC-12-006	Concrete, Sturctural	CY	41.40	$1,100.00	$45,540.00	
		Inlet	SF	9.00	$560.00	$5,040.00	
	SS-06-003	18" RCP	LF	40.00	$86.00	$3,440.00	
	SS-02-006	18" RCP FES	EA	1.00	$2,750.00	$2,750.00	
Vegetation							**$3,650.00**
		Revegetation (30% of Total Cost)	AC	0.43	$5,000.00	$2,150.00	
	LS-06-001	Temporary Irrigation	EA	1.00	$1,500.00	$1,500.00	

Subtotal	$125,410.34
Contingency (25%)	$31,352.58
Estimated Construction Cost	**$156,762.92**

Notes:

1. Cost estimate doesn't include permits and engineering design

ICON ENGINEERING, INC.

High Line Canal Stormwater Conversion Cherry Hills Village

Quincy Avenue Water Quality Berm

Engineer's Opinion of Probable Cost - 30% Design

September 2022

BID ITEM NO.	BID ITEM CODE	DESCRIPTION OF BID ITEM	PAY UNIT	QUANTITY	UNIT PRICE	TOTAL COST OF BID ITEM	CATEGORY TOTAL
Project Start-Up							**$9,372.67**
	GN-07-001	Project Sign	LS	1.00	$1,000.00	$1,000.00	
	GN-02-001	Mobilization	LS	1.00	$0.00	$0.00	
	GN-06-001	Water Control and Dewatering	LS	1.00	$0.00	$0.00	
	ESC-01-001	Erosion and Sediment Control	LS	1.00	$5,000.00	$5,000.00	
	GN-04-001	Construction Surveying	LS	1.00	$372.67	$372.67	
	GN-05-001	Traffic and Pedestrian Control	LS	1.00	$3,000.00	$3,000.00	
Removals							**$0.00**
	RR-06-018	Tree Removals (0-6")	EA		$300.00	$0.00	
	RR-06-018	Tree Removals (7-12")	EA		$500.00	$0.00	
	RR-06-018	Tree Removals (13-18")	EA		$750.00	$0.00	
	RR-06-018	Tree Removals (19-24")	EA		$1,000.00	$0.00	
	RR-06-018	Tree Removals (25-36")	EA		$1,500.00	$0.00	
	RR-06-018	Tree Removals (37-48")	EA		$2,500.00	$0.00	
	RR-06-018	Tree Removals (>49")	EA		$7,000.00	$0.00	
	GN-01-001	Clearing and Grubbing	AC		$5,000.00	$0.00	
Water Quality Berm							**$36,167.00**
	RW-12-003	Soil Riprap, Type M	CY	17.10	$130.00	$2,223.00	
	RW-07-002	Boulder, Ungrouted 24"	EA	12.00	$350.00	$4,200.00	
	RW-07-004	Boulder, Ungrouted 36"	EA	55.00	$400.00	$22,000.00	
	RW-07-006	Boulder, Ungrouted 48"	EA	3.00	$500.00	$1,500.00	
	SS-06-003	18" RCP	LF	14.00	$86.00	$1,204.00	
		Inlet	SF	9.00	$560.00	$5,040.00	
	SS-02-006	18" RCP FES	EA	1.00	$2,750.00	$2,750.00	
Vegetation							**$1,100.00**
		Revegetation (30% of Total Cost)	AC	0.22	$5,000.00	$1,100.00	
	LS-06-001	Temporary Irrigation	EA		$1,500.00	$0.00	

Subtotal	$46,639.67
Contingency (25%)	$11,659.92
Estimated Construction Cost	**$58,299.59**

Notes:

1. Cost estimate doesn't include permits and engineering design

ICON ENGINEERING, INC.

High Line Canal Stormwater Conversion Cherry Hills Village

Three Pond Outfall

Engineer's Opinion of Probable Cost - 30% Design

September 2022

BID ITEM NO.	BID ITEM CODE	DESCRIPTION OF BID ITEM	PAY UNIT	QUANTITY	UNIT PRICE	TOTAL COST OF BID ITEM	CATEGORY TOTAL
Project Start-Up							**$9,538.20**
	GN-07-001	Project Sign	LS	1.00	$1,000.00	$1,000.00	
	GN-02-001	Mobilization	LS	1.00	$0.00	$0.00	
	GN-06-001	Water Control and Dewatering	LS	1.00	$0.00	$0.00	
	ESC-01-001	Erosion and Sediment Control	LS	1.00	$5,000.00	$5,000.00	
	GN-04-001	Construction Surveying	LS	1.00	$538.20	$538.20	
	GN-05-001	Traffic and Pedestrian Control	LS	1.00	$3,000.00	$3,000.00	
Removals							**$2,000.00**
	RR-06-018	Tree Removals (0-6")	EA		$300.00	$0.00	
	RR-06-018	Tree Removals (7-12")	EA		$500.00	$0.00	
	RR-06-018	Tree Removals (13-18")	EA		$750.00	$0.00	
	RR-06-018	Tree Removals (19-24")	EA	2.00	$1,000.00	$2,000.00	
	RR-06-018	Tree Removals (25-36")	EA		$1,500.00	$0.00	
	RR-06-018	Tree Removals (37-48")	EA		$2,500.00	$0.00	
	RR-06-018	Tree Removals (>49")	EA		$7,000.00	$0.00	
	GN-01-001	Clearing and Grubbing	AC		$5,000.00	$0.00	
Spillway Overflow							**$50,320.00**
	RW-11-004	Soil Riprap, Type H	CY	138.00	$150.00	$20,700.00	
		Inlet	SF	27.00	$560.00	$15,120.00	
	SS-06-007	Reinforced Concrete Pipe (RCP), Class III, 42-Inch Diam	LF	58.00	$250.00	$14,500.00	
Vegetation							**$1,500.00**
		Revegetation (30% of Total Cost)	AC	0.30	$5,000.00	$1,500.00	
	LS-06-001	Temporary Irrigation	EA		$1,500.00	$0.00	

Subtotal	$63,358.20
Contingency (25%)	$15,839.55
Estimated Construction Cost	**$79,197.75**

Notes:

1. Cost estimate doesn't include permits and engineering design

C. Conceptual Plans and Renderings

.

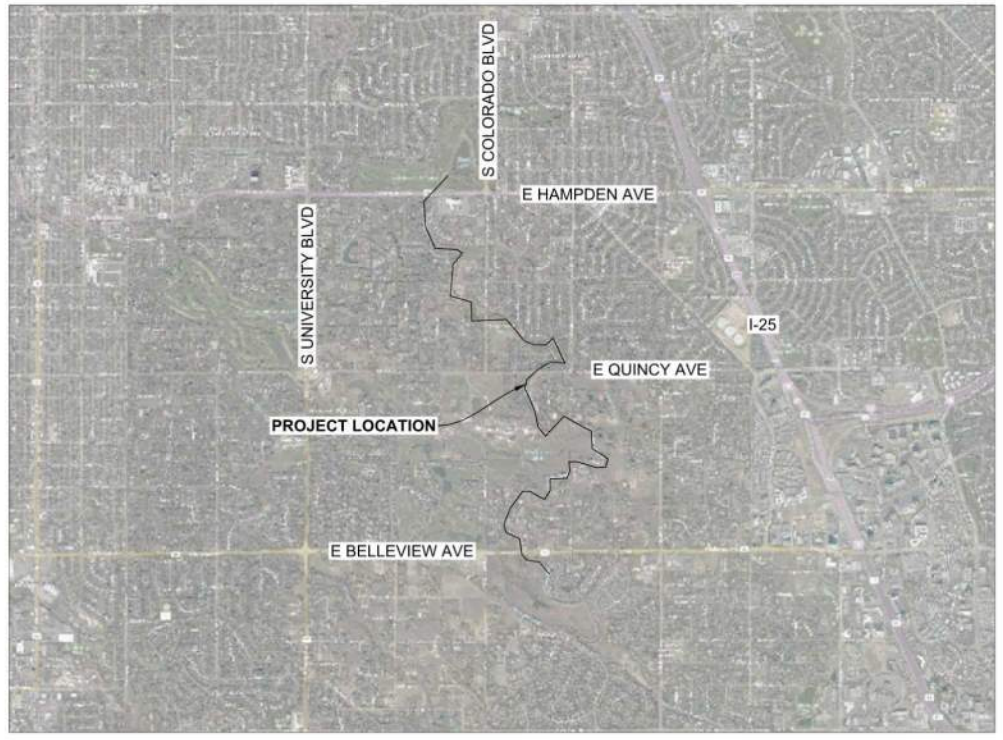
CITY OF CHERRY HILLS VILLAGE

HIGHLINE CANAL STORMWATER CAPITAL IMPROVEMENTS AND OPERATIONAL ANALYSIS

30% Design

AUGUST 2022

PROJECT NO.: 22-010



LOCATION MAP

NOT TO SCALE

INDEX OF SHEETS

- APPROVALS -

CITY OF CHERRY HILLS VILLAGE

JAY GOLDIE, CPM — DATE

EMILY BLACK — DATE

FOR AND ON BEHALF OF

ICON ENGINEERING, INC.

PROJECT MANAGER: TROY CARMANN, P.E., CFM — DATE

PROJECT ENGINEER: MADDIE LUDWIG, EI — DATE

City of Cherry Hills Village

ICON ENGINEERING

7000 S. YOSEMITE STREET SUITE 120
CENTENNIAL, CO 80112
PHONE (303) 221-0802

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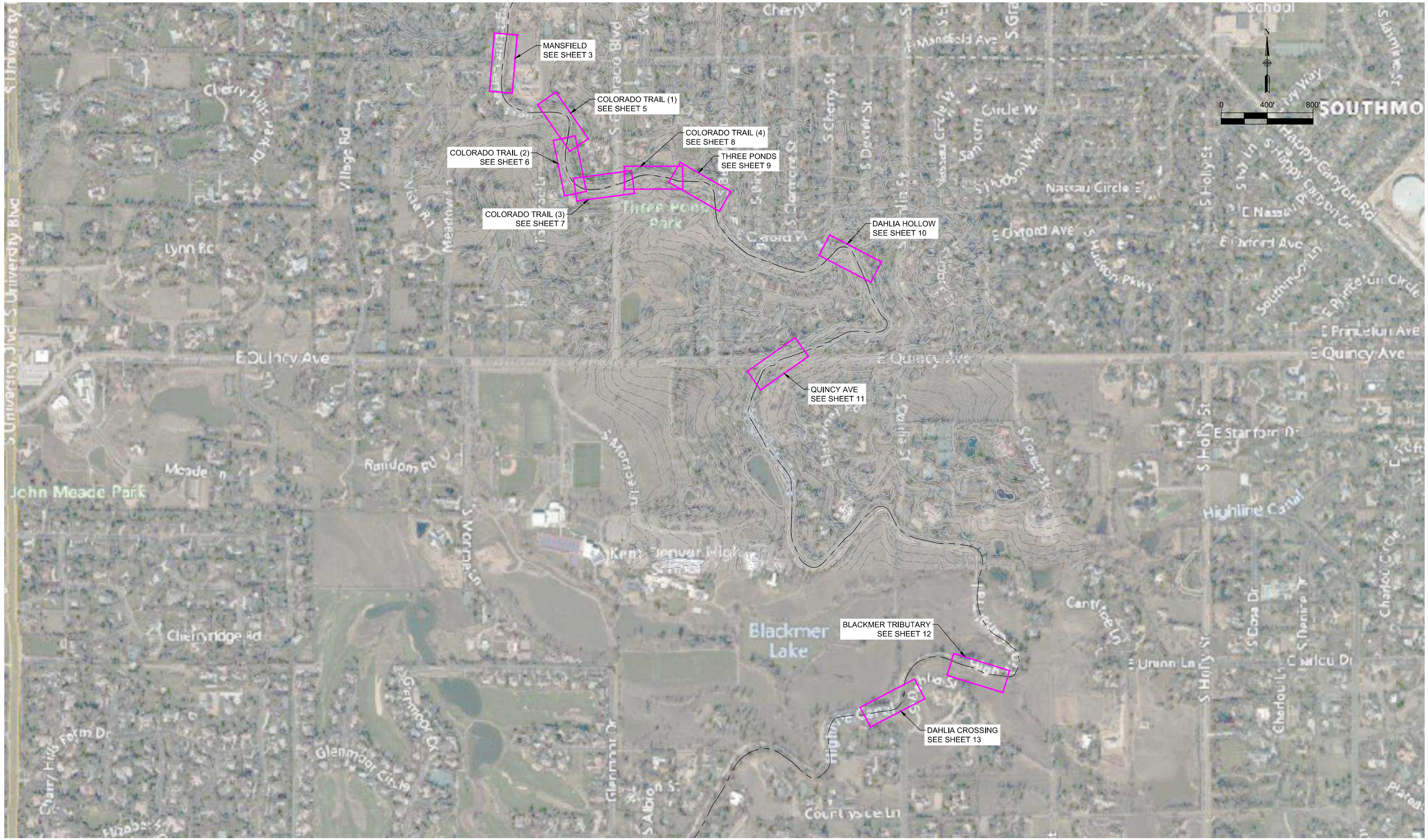

No.	DATE	REVISIONS	APPR.

DRAWN BY: BTB
DESIGNED BY:
APPROVED BY: TWC

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7000 S. Yosemite Street, Suite 120
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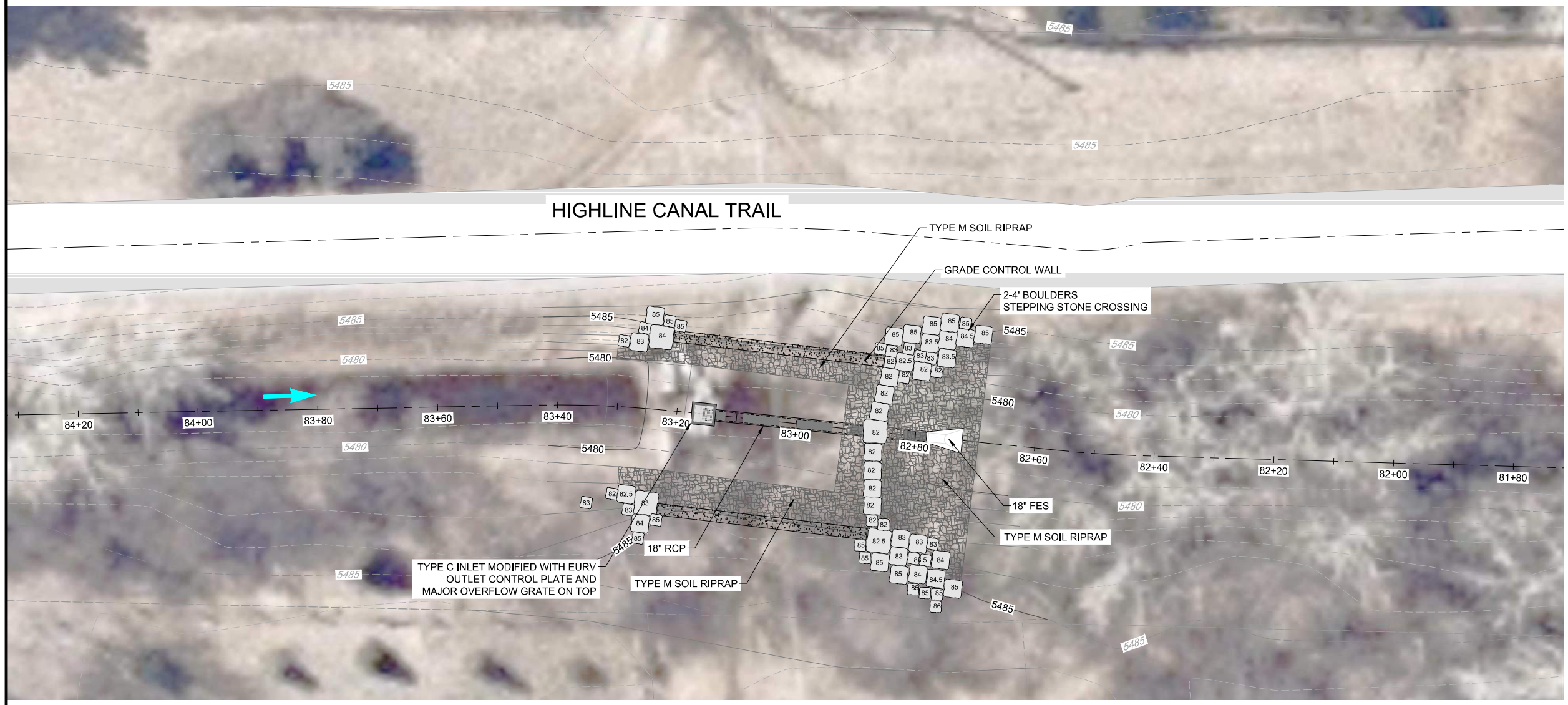
CHERRY HILLS VILLAGE HLC

30% Design

22-010 VICINITY MAP

DATE
AUG 2022

SHEET
2 OF 14



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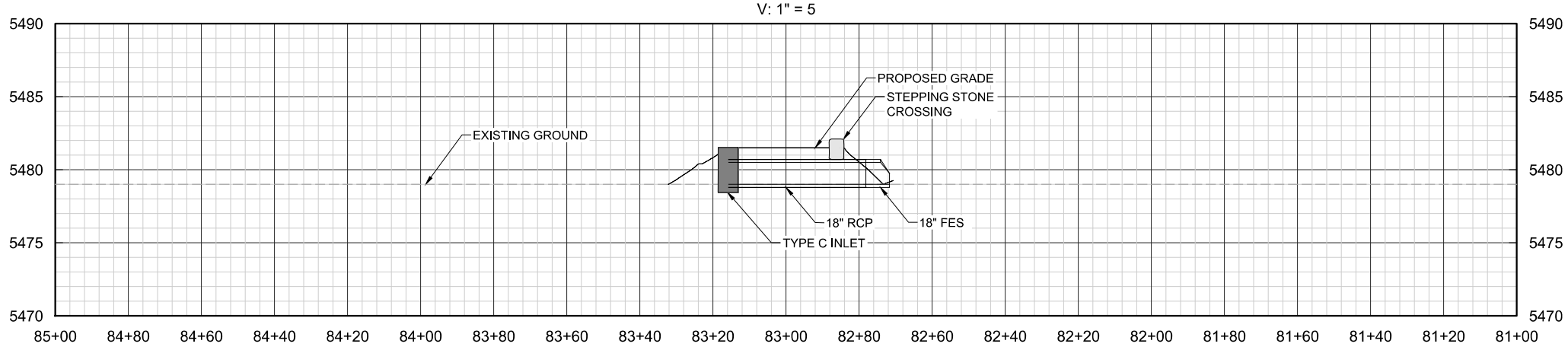
V: 1" = 5



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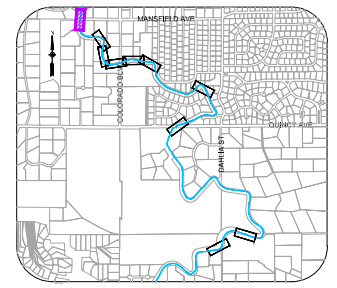

KEY MAP
N.T.S.

LEGEND

- Soil Riprap
- Concrete
- Proposed Trail

NOTES

1. NOTE

No.	DATE	REVISIONS	APPR.

DRAWN BY: BTB
DESIGNED BY: TJD
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CHERRY HILLS VILLAGE HLC

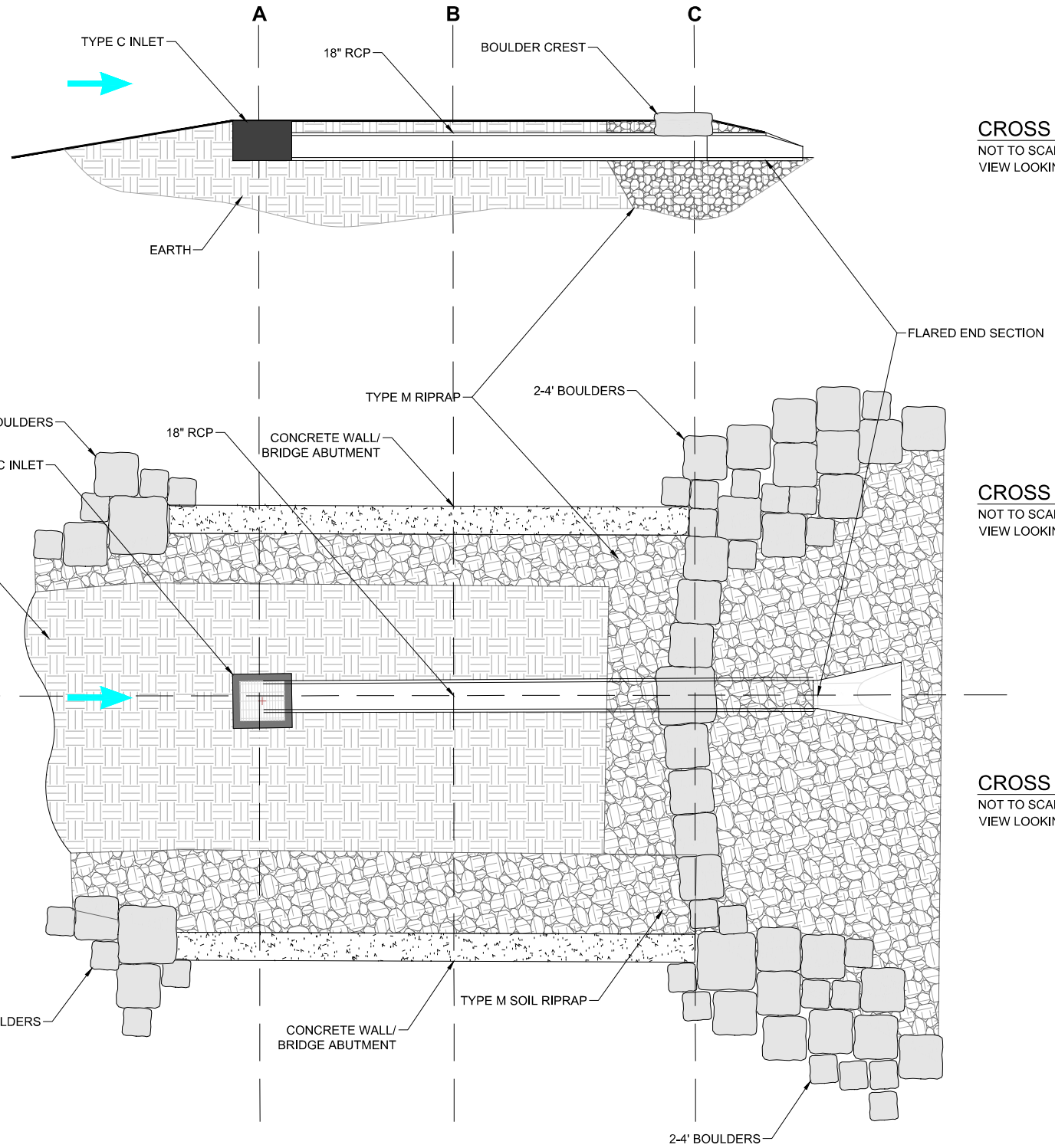
30% Design

22-010 MANSFIELD TRAIL WQ BERM - P&P

DATE
AUG 2022

SHEET
3 OF 17

PROFILE VIEW
NOT TO SCALE



MANSFIELD WATER QUALITY BERM DETAIL
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CROSS SECTION A
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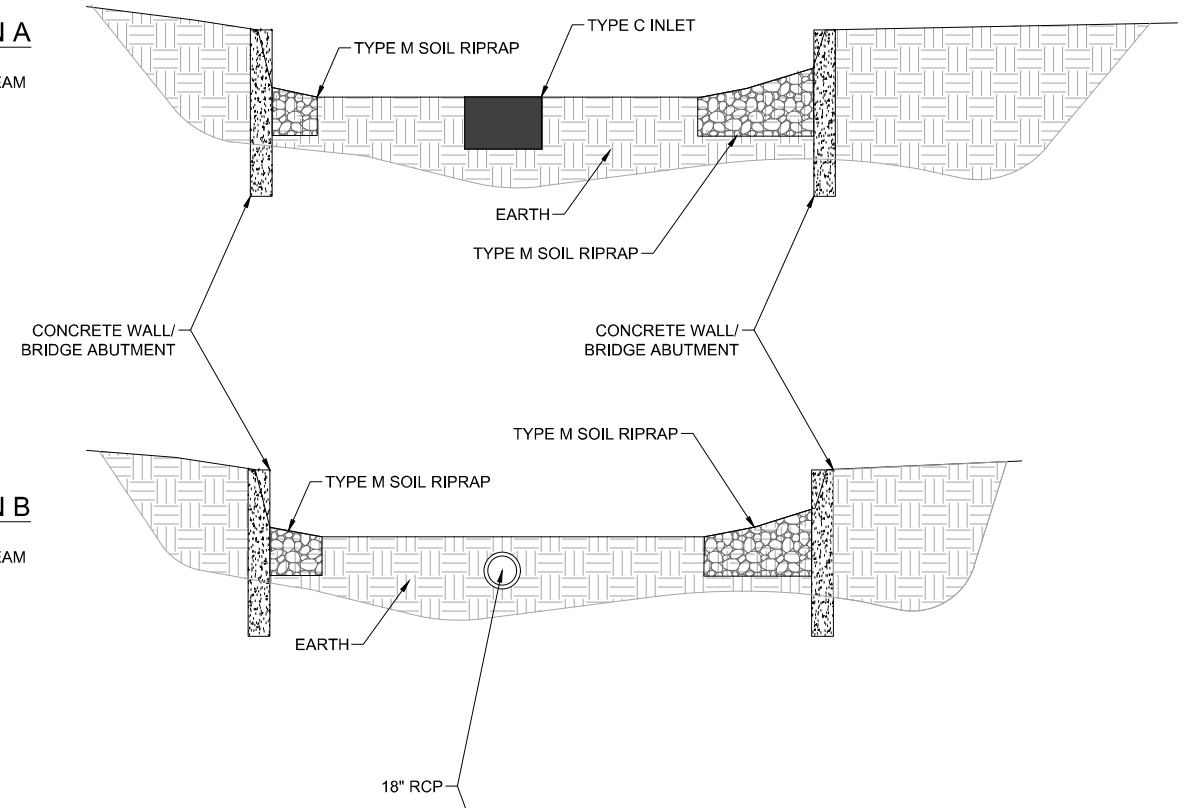
VIEW LOOKING DOWNSTREAM



CROSS SECTION B
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VIEW LOOKING DOWNSTREAM

CROSS SECTION C
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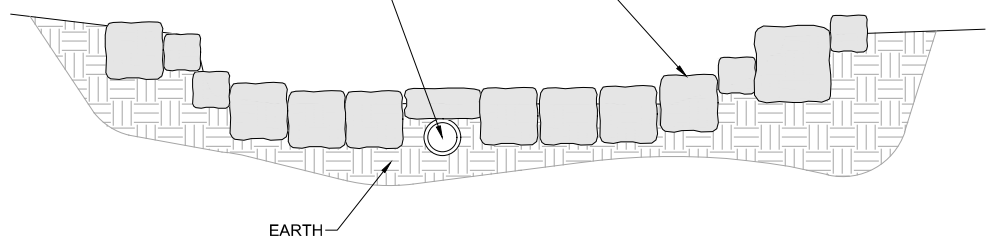
VIEW LOOKING DOWNSTREAM



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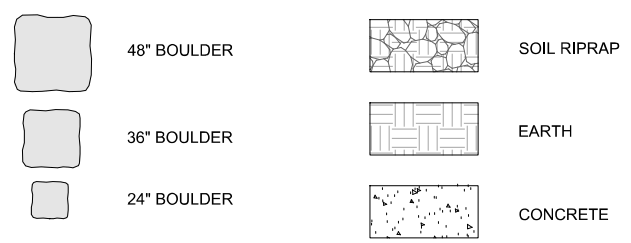

No.	DATE	REVISIONS	APPR.

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CHERRY HILLS VILLAGE HLC

30% Design

22-010 MANSFIELD WATER QUALITY BERM - DETAILS

DATE
AUG 2022

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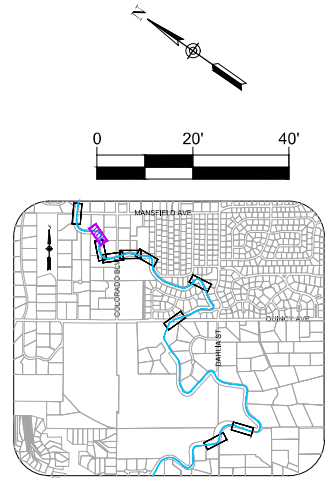


KEY MAP
N.T.S.

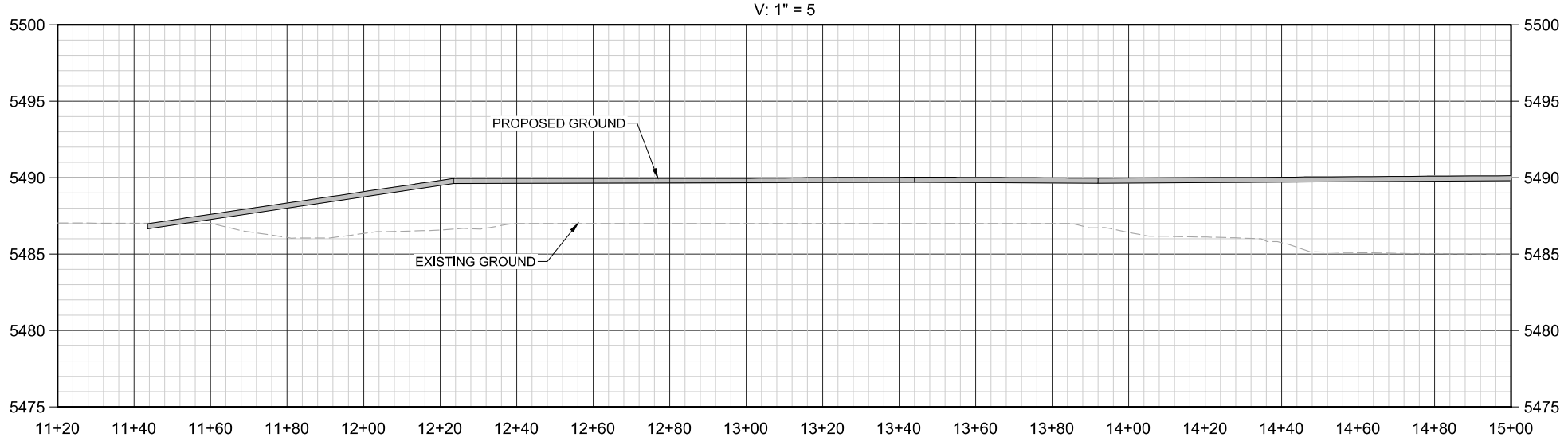
LEGEND

- Soil Riprap
- Concrete
- Proposed Trail

NOTES

1. NOTE

PROFILE OF CE-HLC TRAIL
H: 1" = 20
V: 1" = 5



No.	DATE	REVISIONS	APPR.

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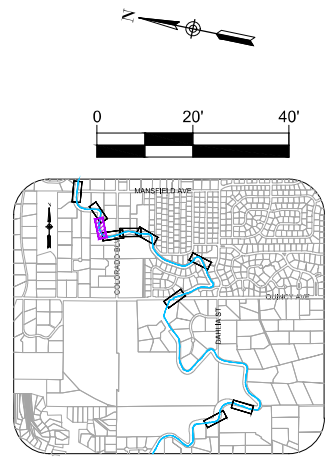
CHERRY HILLS VILLAGE HLC

30% Design

22-010 COLORADO TRAIL - P&P (1)

DATE
AUG 2022

SHEET
5 OF 17



LEGEND

- Soil Riprap
- Concrete
- Proposed Trail

NOTES

1. NOTE

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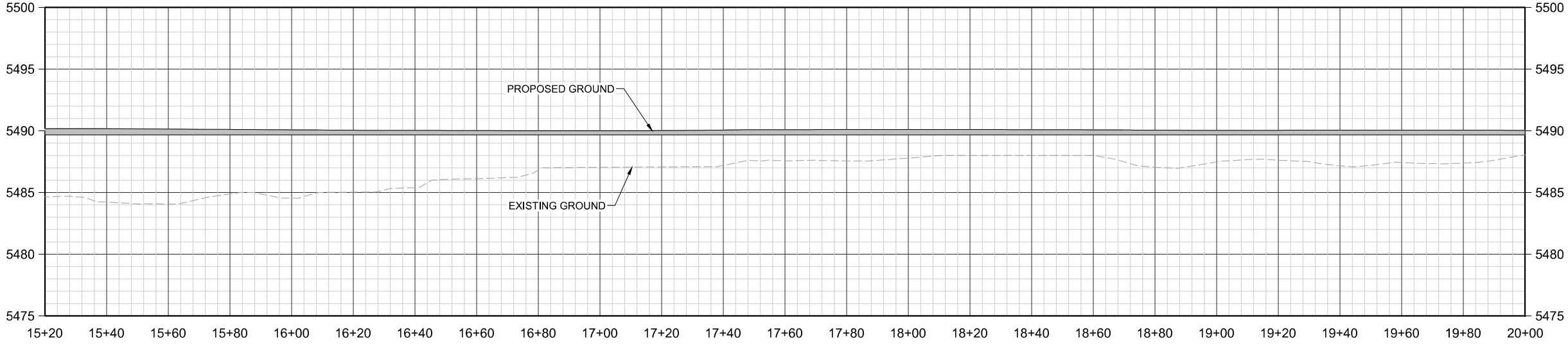

No.	DATE	REVISIONS	APPR.

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CHERRY HILLS VILLAGE HLC

30% Design

22-010 COLORADO TRAIL - P&P (2)

DATE
AUG 2022

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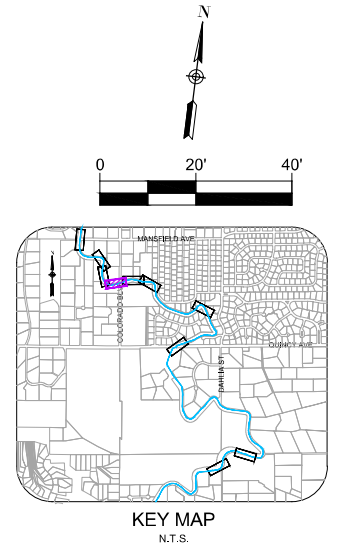


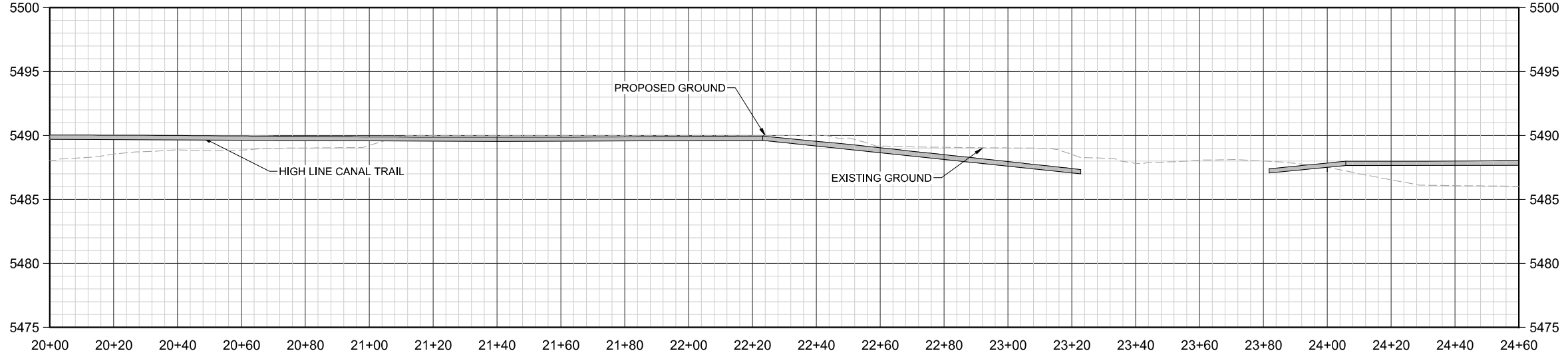
LEGEND

- Soil Riprap
- Concrete
- Proposed Trail

NOTES

1. NOTE

PROFILE OF CE-HLC TRAIL
H: 1" = 20
V: 1" = 5



No.	DATE	REVISIONS	APPR.

DRAWN BY: BTB
DESIGNED BY: TJD
APPROVED BY: TWC

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CHERRY HILLS VILLAGE HLC

30% Design

22-010 COLORADO TRAIL - P&P (3)

DATE
AUG 2022

SHEET
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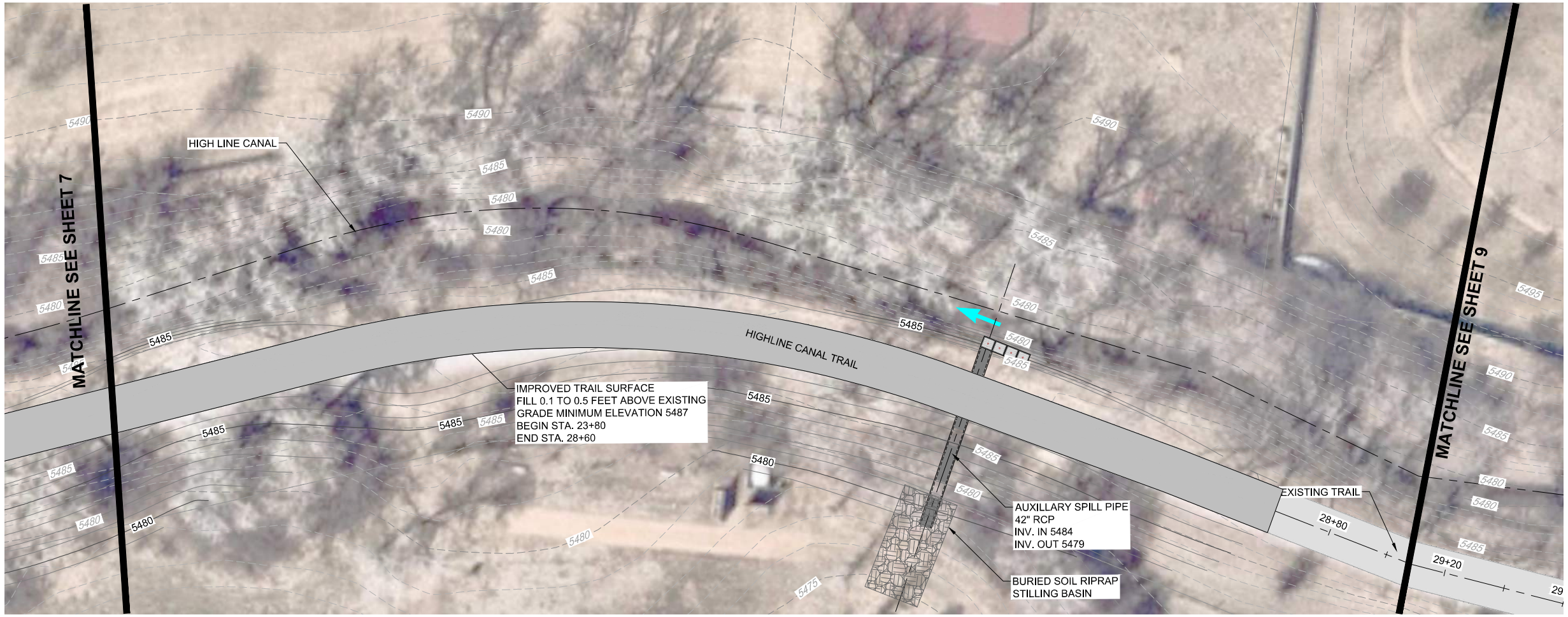

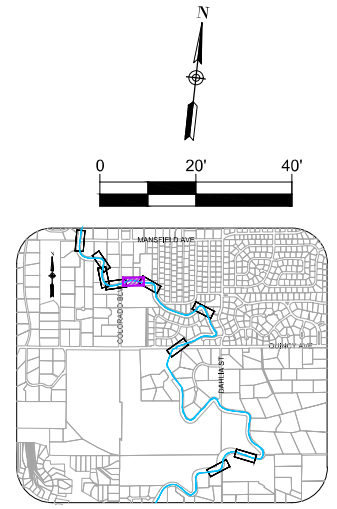

LEGEND

- Soil Riprap
- Concrete
- Proposed Trail

NOTES

1. NOTE

PROFILE OF CE-HLC TRAIL
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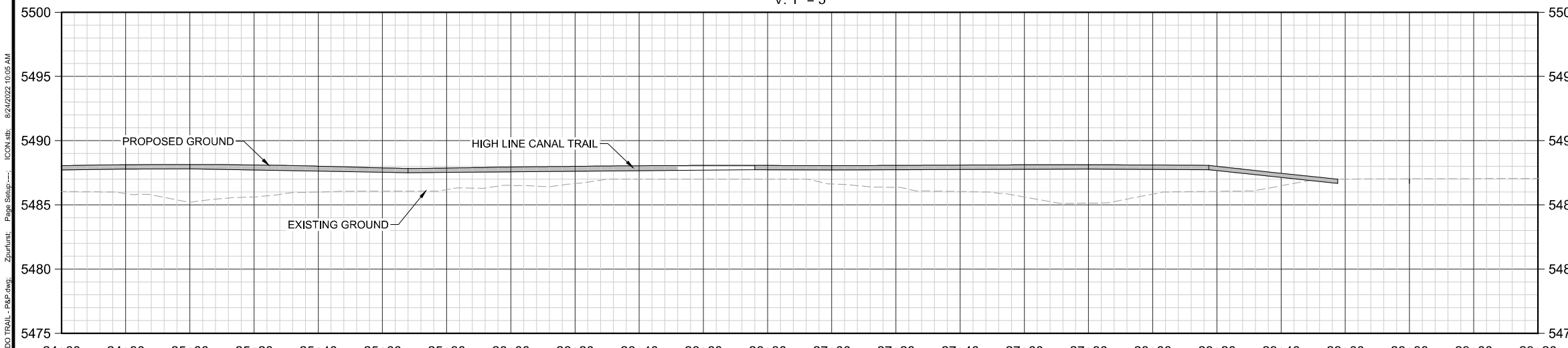
V: 1" = 5



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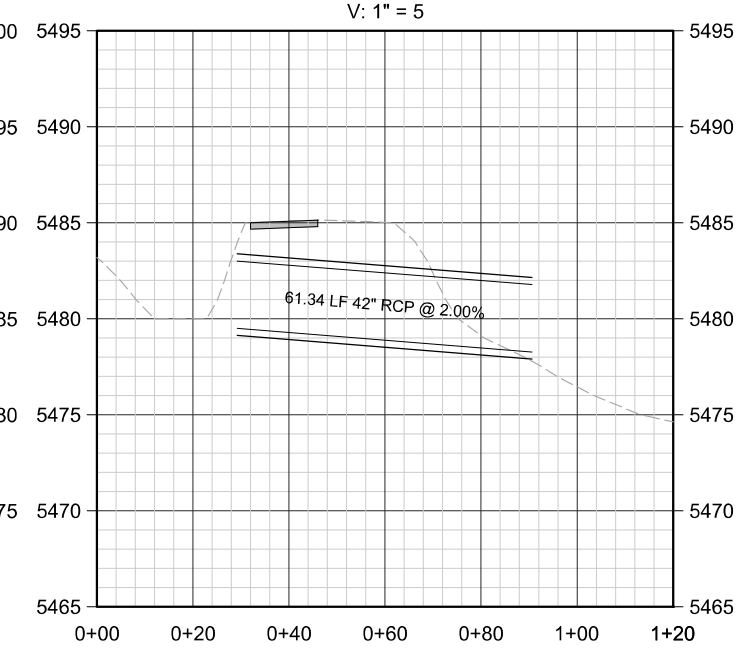

No.	DATE	REVISIONS	APPR.

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DESIGNED BY: TJD
APPROVED BY: TWC

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CHERRY HILLS VILLAGE HLC

30% Design

22-010 COLORADO TRAIL - P&P (4)

DATE
AUG 2022

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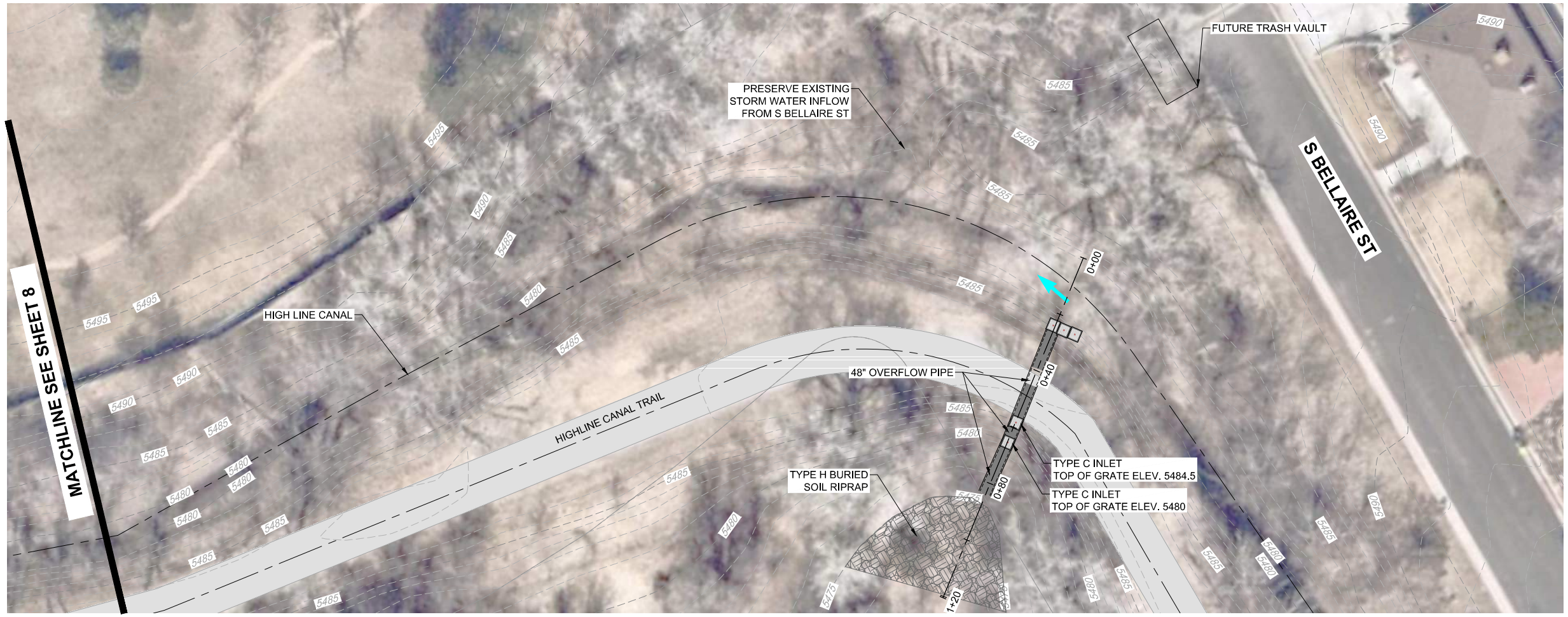

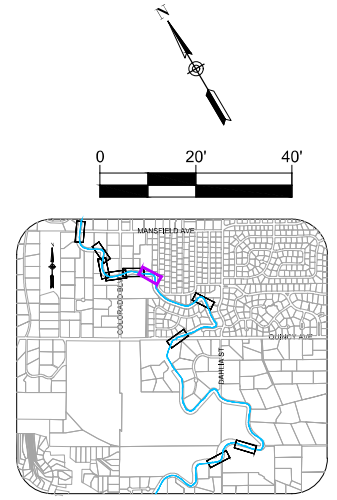

LEGEND

- Soil Riprap
- Concrete
- Proposed Trail

NOTES

1. NOTE

PROFILE OF ALIGNMENT - THREE PONDS OUTLET
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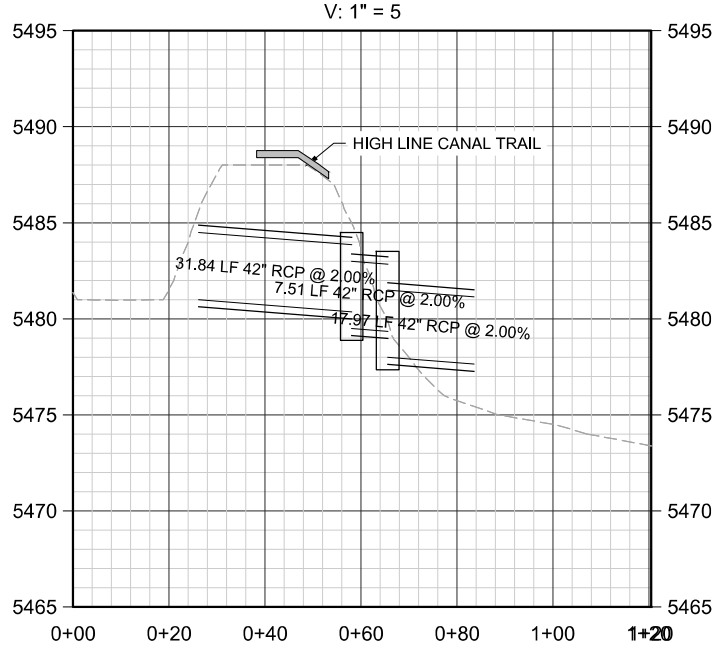
V: 1" = 5



No.	DATE	REVISIONS	APPR.

DRAWN BY: MJL
DESIGNED BY: MJL
APPROVED BY: TWC

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CHERRY HILLS VILLAGE HLC

30% Design

22-010 THREE PONDS - P&P

DATE
AUG 2022

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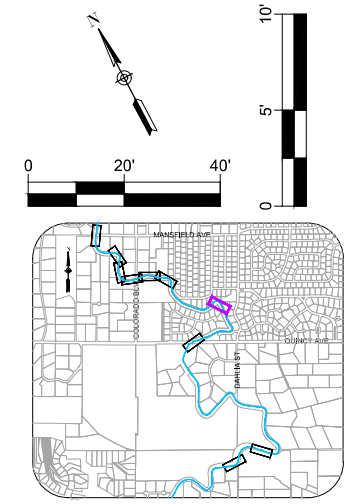

LEGEND

- Soil Riprap
- Concrete
- Proposed Trail

NOTES

1. NOTE

PROFILE OF ALIGNMENT - DAHLIA HOLLOW OURLET
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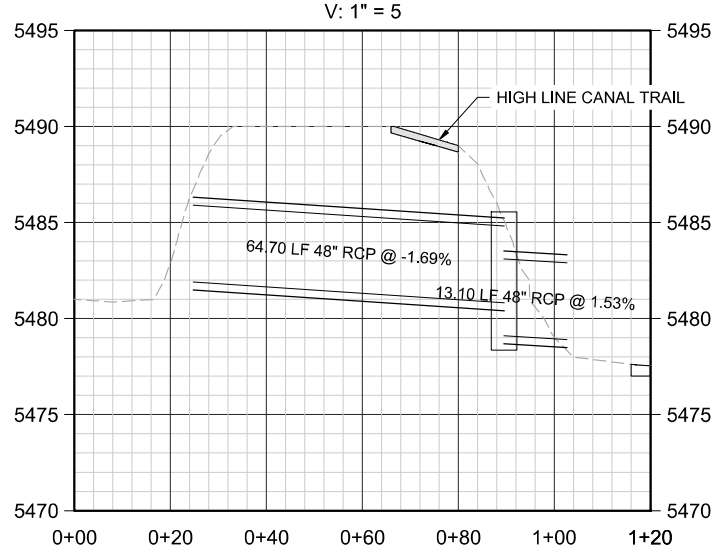

No.	DATE	REVISIONS	APPR.

DRAWN BY: BTB
DESIGNED BY: TJD
APPROVED BY: TWC

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CHERRY HILLS VILLAGE HLC

30% Design

22-010 DAHLIA HOLLOW - P&P

DATE
AUG 2022

SHEET
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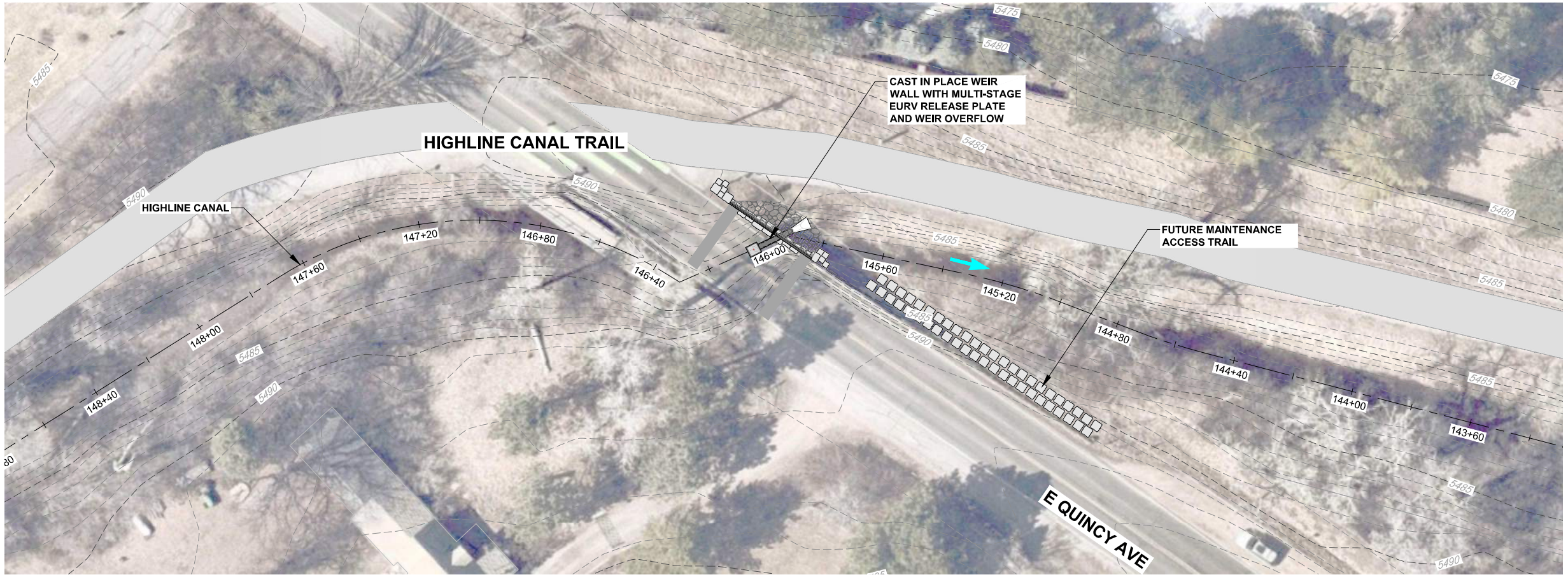

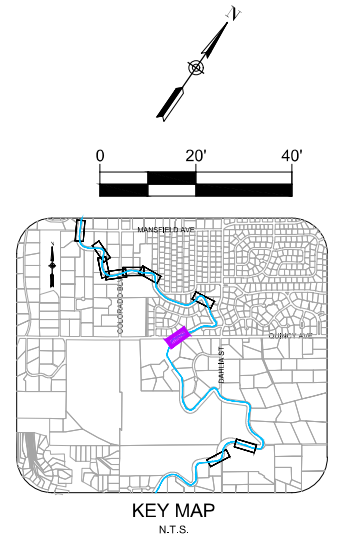

LEGEND

- Soil Riprap
- Concrete
- Proposed Trail

NOTES

1. NOTE

PROFILE OF CP-ALIGN-HLC
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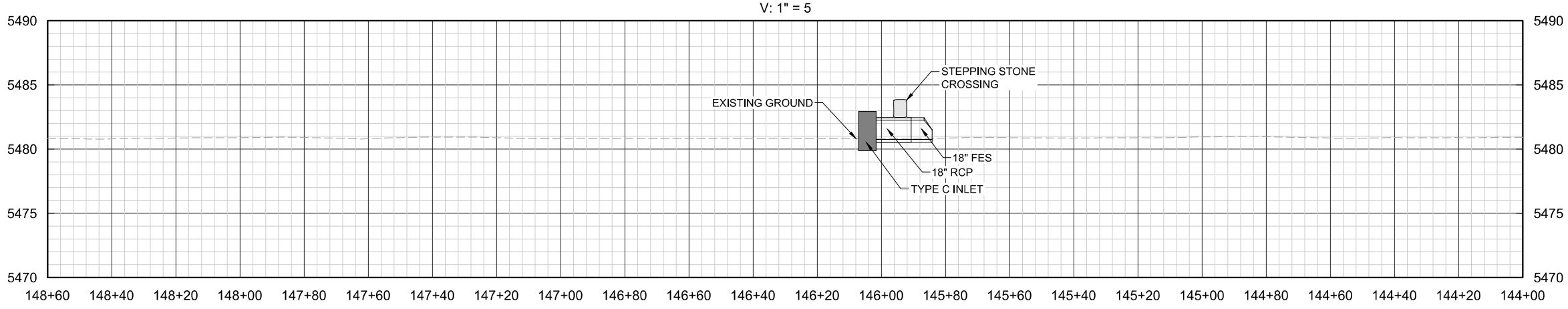
V: 1" = 5



No.	DATE	REVISIONS	APPR.

DRAWN BY: BTB
DESIGNED BY: TJD
APPROVED BY: TWC

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PREPARED BY:
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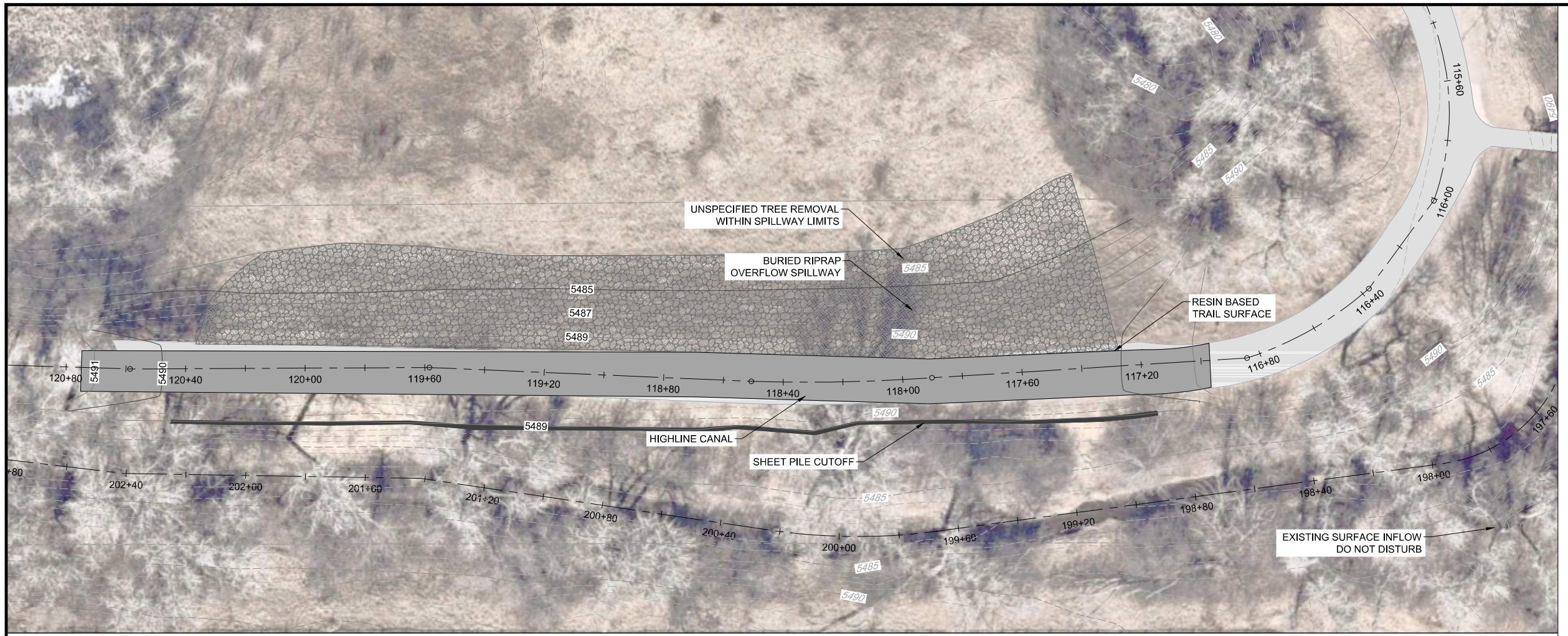
CHERRY HILLS VILLAGE HLC

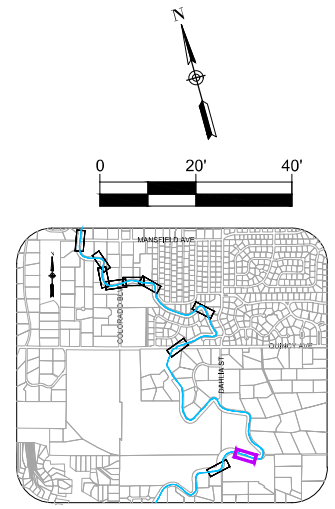
30% Design

22-010 QUINCY AVE - P&P

DATE
AUG 2022

SHEET
11 OF 17





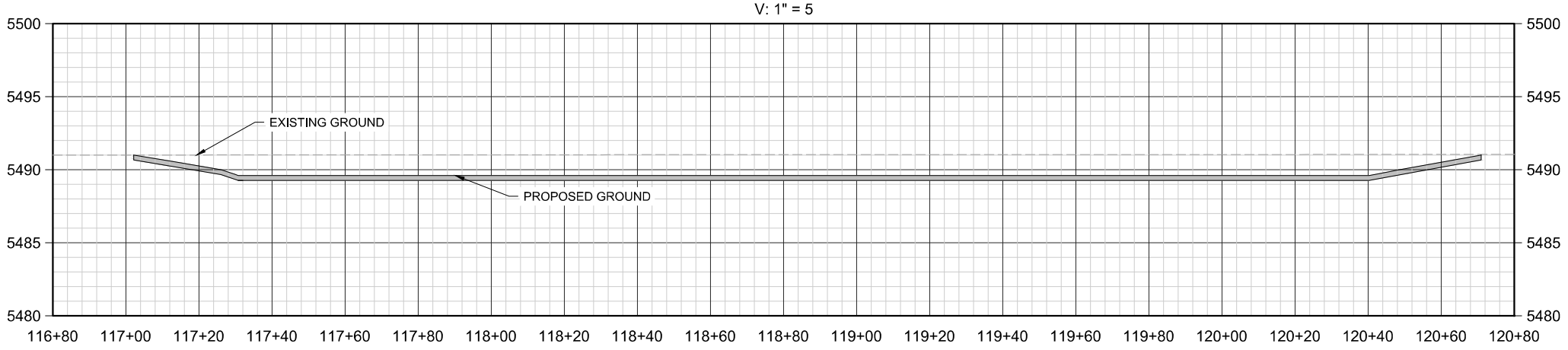
LEGEND

- Soil Riprap
- Concrete
- Proposed Trail

NOTES

1. NOTE

PROFILE OF CE-HLC TRAIL
H: 1" = 20
V: 1" = 5



No.	DATE	REVISIONS	APPR.

DRAWN BY: MJL
DESIGNED BY: MJL
APPROVED BY: TWC

Know what's below. Call before you dig.

PREPARED FOR: City of Cherry Hills Village

PREPARED BY:
ICON ENGINEERING
7000 S. Yosemite Street, Suite 120
Centennial, CO 80112
Phone (303) 221-0802

CHERRY HILLS VILLAGE HLC

30% Design

22-010

BLACKMER TRIBUTARY - P&P

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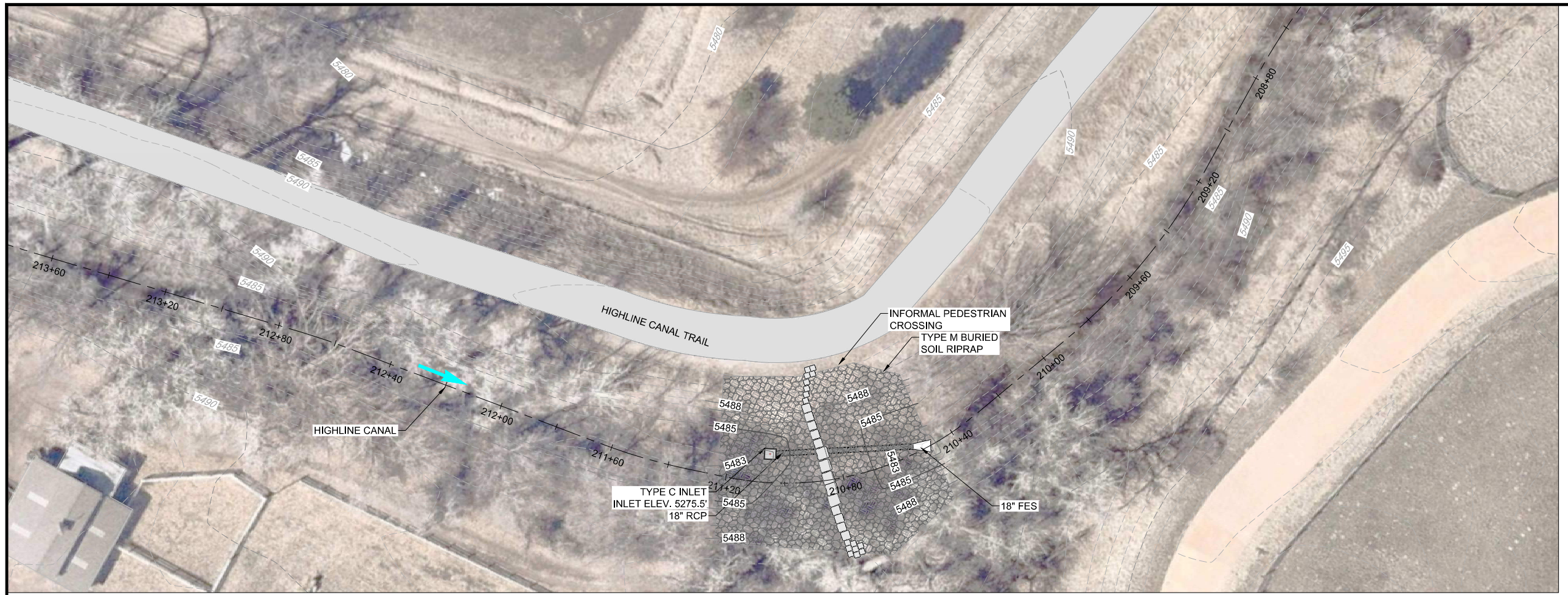
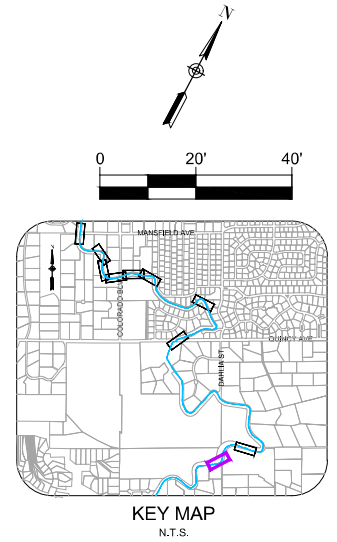
12 OF 17





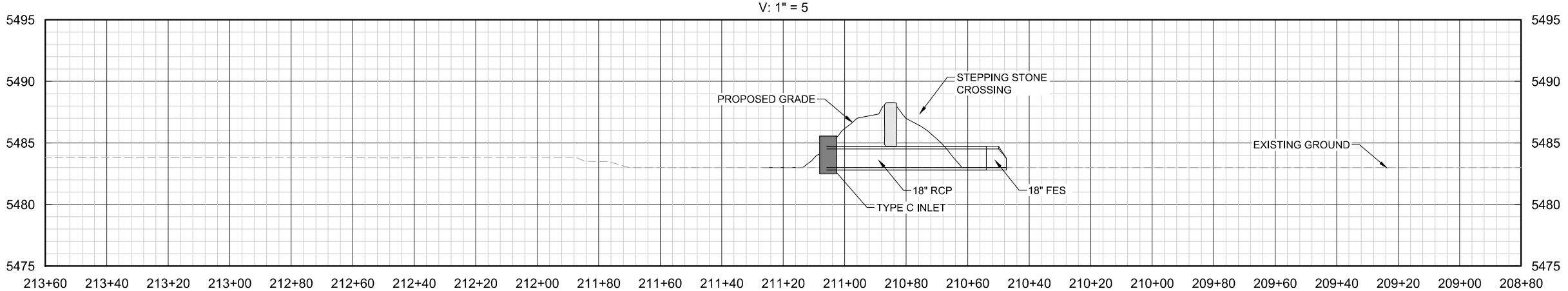
LEGEND

- Soil Riprap
- Concrete
- Proposed Trail

NOTES

1. NOTE

PROFILE OF CP-ALIGN-HLC
H: 1" = 20
V: 1" = 5



No.	DATE	REVISIONS	APPR.

DRAWN BY: BTB
DESIGNED BY: TJD
APPROVED BY: TWC

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PREPARED BY:
ICON ENGINEERING
7000 S. Yosemite Street, Suite 120
Centennial, CO 80112
Phone (303) 221-0802

CHERRY HILLS VILLAGE HLC

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22-010 DAHLIA CROSSING - P&P

DATE
JUN 2022

SHEET
13 OF 17

P:\P-22-010 CHV - HLC\06 DWG\04 CIVIL\04 PLAN SETS\DAHLIA CROSSING - P&P.dwg; Zpurfurst Page Setup:22X34 PDF - ICON.stb; 8/24/2022 10:14 AM

TABLE 1. MIX REQUIREMENTS FOR TYPE VL AND L VOID-FILLED RIPRAP (D_{50} = 6 TO 9 INCH)		
APPROPRIATE PROPORTIONS (BY VOLUME)	MATERIAL TYPE	MATERIAL DESCRIPTION
6 PARTS	RIPRAP	D_{50} = 6 INCH (TYPE VL) OR D_{50} = 9 INCH (TYPE L), SEE TABLE 3
1 PART	VOID-FILL MATERIAL	VTC (VEHICLE TRACKING CONTROL) ROCK (CRUSHED ROCK WITH 100% PASSING 4-INCH SIEVE, 50-70% PASSING 3-INCH SIEVE, 0-10% PASSING 2-INCH SIEVE)
1 PART	VOID-FILL MATERIAL	4-INCH MINUS PIT RUN SURGE (ROUND RIVER ROCK AND SAND, WELL GRADED, 90-100% PASSING 4-INCH SIEVE, 70-80% PASSING 1½-INCH SIEVE, 40-60% PASSING ⅜-INCH SIEVE, 10-30% PASSING #16 SIEVE)
1 PART	VOID-FILL MATERIAL	TYPE II BEDDING (CRUSHED ROCK WITH 100% PASSING 3-INCH SIEVE, 20-90% PASSING ¾-INCH SIEVE, 0-20% PASSING #4 SIEVE, 0-3% PASSING #200 SIEVE)
½ TO 1 PART	VOID-FILL MATERIAL	NATIVE TOPSOIL

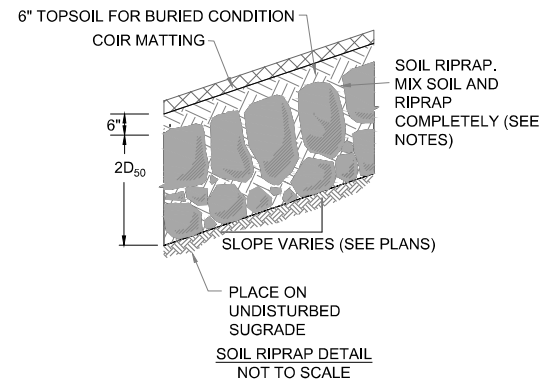
TABLE 2. MIX REQUIREMENTS FOR TYPE M AND H VOID-FILLED RIPRAP (D_{50} = 12 TO 18 INCH)		
APPROPRIATE PROPORTIONS (BY VOLUME)	MATERIAL TYPE	MATERIAL DESCRIPTION
6 PARTS	RIPRAP	D_{50} = 12-INCH (TYPE M) OR D_{50} = 18-INCH (TYPE H), SEE TABLE 3
2 PART	VOID-FILL MATERIAL	7-INCH MINUS CRUSHED ROCK SURGE (100% PASSING 7-INCH SIEVE, 80-100% PASSING 6-INCH SIEVE, 35-50% PASSING 3-INCH SIEVE, 10-20% PASSING 1½-INCH SIEVE)
1 PART	VOID-FILL MATERIAL	VTC (VEHICLE TRACKING CONTROL) ROCK (CRUSHED ROCK WITH 100% PASSING 4-INCH SIEVE, 50-70% PASSING 3-INCH SIEVE, 0-10% PASSING 2-INCH SIEVE)
1 PART	VOID-FILL MATERIAL	4-INCH MINUS PIT RUN SURGE (ROUND RIVER ROCK AND SAND, WELL GRADED, 90-100% PASSING 4-INCH SIEVE, 70-80% PASSING 1½-INCH SIEVE, 40-60% PASSING ⅜-INCH SIEVE, 10-30% PASSING #16 SIEVE)
1 PART	VOID-FILL MATERIAL	TYPE II BEDDING (CRUSHED ROCK WITH 100% PASSING 3-INCH SIEVE, 20-90% PASSING ¾-INCH SIEVE, 0-20% PASSING #4 SIEVE, 0-3% PASSING #200 SIEVE)
½ TO 1 PART	VOID-FILL MATERIAL	NATIVE TOPSOIL

TABLE 3. VOID-FILLED RIPRAP PLACEMENT AND GRADATION			
RIPRAP DESIGNATION	% SMALLER THAN GIVEN SIZE BY WEIGHT	INTERMEDIATE ROCK DIMENSION (INCHES)	D_{50}* (INCHES)
TYPE VL	70 - 100 50 - 70 35 - 50 2 - 10	12 9 6 2	6
TYPE L	70 - 100 50 - 70 35 - 50 2 - 10	15 12 9 3	9
TYPE M	70 - 100 50 - 70 35 - 50 2 - 10	21 18 12 4	12
TYPE H	70 - 100 50 - 70 35 - 50 2 - 10	30 24 18 6	18
*D_{50} = MEAN ROCK SIZE			

NOTE: MIX ON SITE AND PRIOR TO PLACEMENT

SOIL RIPRAP NOTES:

1. ELEVATION TOLERANCES FOR THE SOIL RIPRAP SHALL BE 0.10 FEET. THICKNESS OF SOIL RIPRAP SHALL BE NO LESS THAN THICKNESS SHOWN AND NO MORE THAN 2-INCHES GREATER THAN THE THICKNESS SHOWN.
2. WHERE "SOIL RIPRAP" IS DESIGNATED ON THE CONTRACT DRAWINGS, RIPRAP VOIDS ARE TO BE FILLED WITH NATIVE SOIL. THE RIPRAP SHALL BE PRE-MIXED WITH THE NATIVE SOIL AT THE FOLLOWING PROPORTIONS BY VOLUME: 65 PERCENT RIPRAP AND 35 PERCENT SOIL. THE SOIL USED FOR MIXING SHALL BE NATIVE TOPSOIL AND SHALL HAVE A MINIMUM FINES CONTENT OF 15 PERCENT. THE SOIL RIPRAP SHALL BE INSTALLED IN A MANNER THAT RESULTS IN A DENSE, INTERLOCKED LAYER OF RIPRAP WITH RIPRAP VOIDS FILLED COMPLETELY WITH SOIL. SEGREGATION OF MATERIALS SHALL BE AVOIDED AND IN NO CASE SHALL THE COMBINED MATERIAL CONSIST PRIMARILY OF SOIL; THE DENSITY AND INTERLOCKING NATURE OF RIPRAP IN THE MIXED MATERIAL SHALL ESSENTIALLY BE THE SAME AS IF THE RIPRAP WAS PLACED WITHOUT SOIL.
3. ALL SOIL RIPRAP THAT IS BURIED WITH TOPSOIL SHALL BE REVIEWED AND APPROVED BY THE ENGINEER PRIOR TO ANY TOPSOIL PLACEMENT.



SOIL RIPRAP DETAIL
NOT TO SCALE

RIPRAP DESIGNATION	% SMALLER THAN GIVEN SIZE BY WEIGHT	INTERMEDIATE ROCK DIMENSION (INCHES)	D_{50}* (INCHES)
TYPE VL	70 - 100 50 - 70 35 - 50 2 - 10	12 9 6 2	6
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TYPE M	70 - 100 50 - 70 35 - 50 2 - 10	21 18 12 4	12
TYPE H	70 - 100 50 - 70 35 - 50 2 - 10	30 24 18 6	18
*D_{50} = MEAN ROCK SIZE			

√OID-FILLED RIPRAP PLACEMENT AND GRADATION NOTES:

1. WHERE "VOID-FILLED RIPRAP" IS DESIGNATED ON THE CONTRACT DRAWINGS, RIPRAP SHALL BE MIXED WITH THE MATERIALS AND ASSOCIATED PROPORTIONS LISTED IN TABLE 1 OR TABLE 2 TO FILL THE VOIDS OF THE RIPRAP.
2. THE MIX PROPORTIONS PROVIDED IN TABLE 1 AND TABLE 2 ARE APPROXIMATE AND ARE SUBJECT TO ADJUSTMENT BY THE ENGINEER.
3. THE RIPRAP AND VOID-FILLED MATERIALS SHALL BE STOCKPILED SEPARATELY AND THOROUGHLY MIXED PRIOR TO PLACEMENT AND SHALL BE INSTALLED AND COMPACTED SO THAT A DENSE, INTERLOCKED LAYER OF RIPRAP AND VOID-FILL MATERIAL IS PROVIDED WITH RIPRAP VOIDS COMPLETELY FILLED. THE LOOSE MATERIAL SHALL BE PLACED IN A SINGLE LIFT OF SUFFICIENT HEIGHT SUCH THAT FINAL GRADE WILL BE ACHIEVED UPON COMPACTED. IF THE COMPACTED MATERIAL IS BELOW FINAL GRADE, PLACEMENT OF ONLY THE SMALLER VOID-FILL MATERIALS TO ACHIEVE FINAL GRADE IS NOT PERMITTED. IN SUCH CASES IT IS NECESSARY TO ADD MORE STANDARD SIZED VOID-FILLED RIPRAP AND REMIX THE ENTIRE THICKNESS OF ROCK TO ACHIEVE THE DESIGN SECTION. SEGREGATION OF MATERIALS SHALL BE AVOIDED AND IN NO CASE SHALL THE COMBINED MATERIAL CONSIST PRIMARILY OF THE VOID-FILL MATERIALS. THE DENSITY AND INTERLOCKING NATURE OF RIPRAP IN THE MIXED MATERIAL SHALL ESSENTIALLY BE THE SAME AS IF THE RIPRAP WAS PLACED WITHOUT FILLING THE VOIDS.
4. COMPACTION OF THE VOID-FILLED RIPRAP SHALL BE PERFORMED BY WHEEL ROLLING WITH HEAVY RUBBER-TIRED EQUIPMENT (E.G. FRONT END LOADER). THE MOISTURE CONTENT OF THE MIXTURE SHALL BE AT OPTIMUM CONDITIONS PRIOR TO COMPACTION AND WATER SHALL BE ADDED, AS NECESSARY, AT THE DIRECTION OF THE ENGINEER.
5. WHERE INDICATED ON THE DRAWINGS, A SURFACE LAYER OF MOIST TOPSOIL SHALL BE PLACED OVER THE VOID-FILLED RIPRAP. THE TOPSOIL SURFACE LAYER SHALL BE COMPACTED TO APPROXIMATELY 85% OF MAXIMUM DENSITY AND WITHIN TWO PERCENTAGE POINTS OF OPTIMUM MOISTURE IN ACCORDANCE WITH ASTM D698. TOPSOIL SHALL BE ADDED TO ANY AREAS THAT SETTLE.
6. ALL VOID-FILLED RIPRAP THAT IS BURIED WITH TOPSOIL SHALL BE REVIEWED AND APPROVED BY THE ENGINEER PRIOR TO ANY TOPSOIL PLACEMENT.

No.	DATE	REVISIONS	APPR.

DRAWN BY: MJL
DESIGNED BY: MJL
APPROVED BY: TWC

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PREPARED FOR: City of Cherry Hills Village

PREPARED BY:
ICON ENGINEERING
7000 S. Yosemite Street, Suite 120
Centennial, CO 80112
Phone (303) 221-0802

CHERRY HILLS VILLAGE HLC

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22-010

RIPRAP DETAILS

DATE
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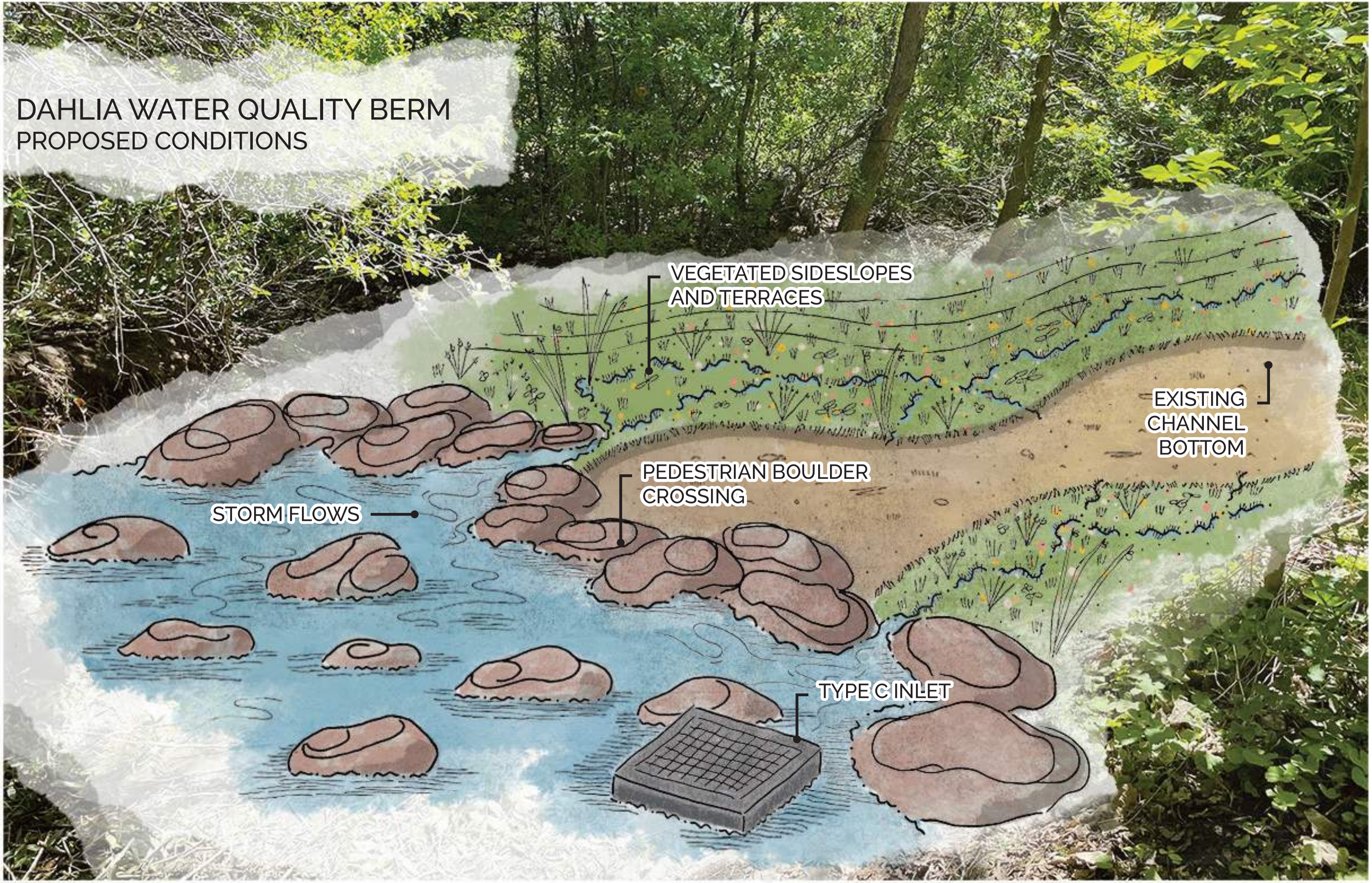
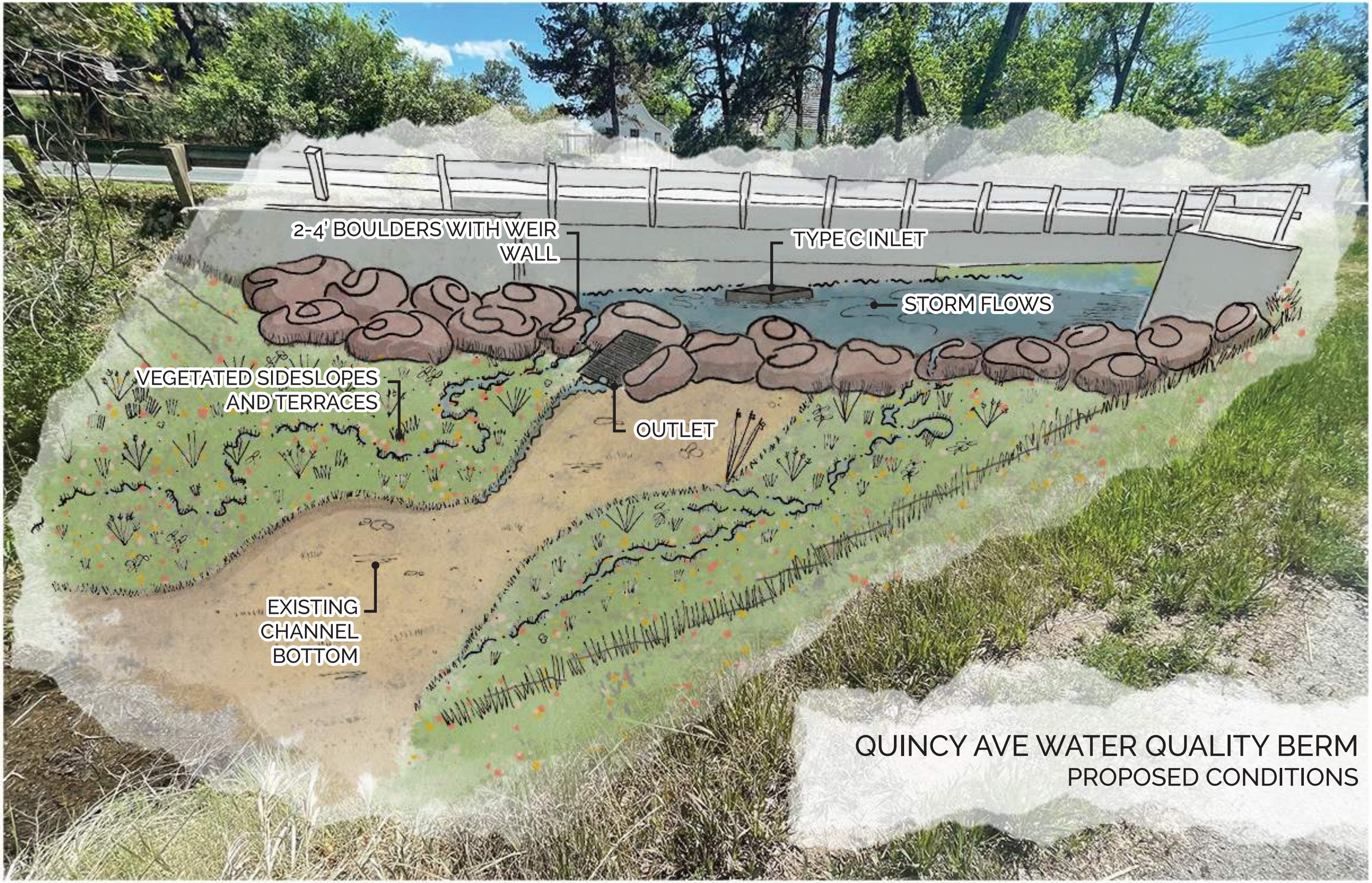
14 OF 17

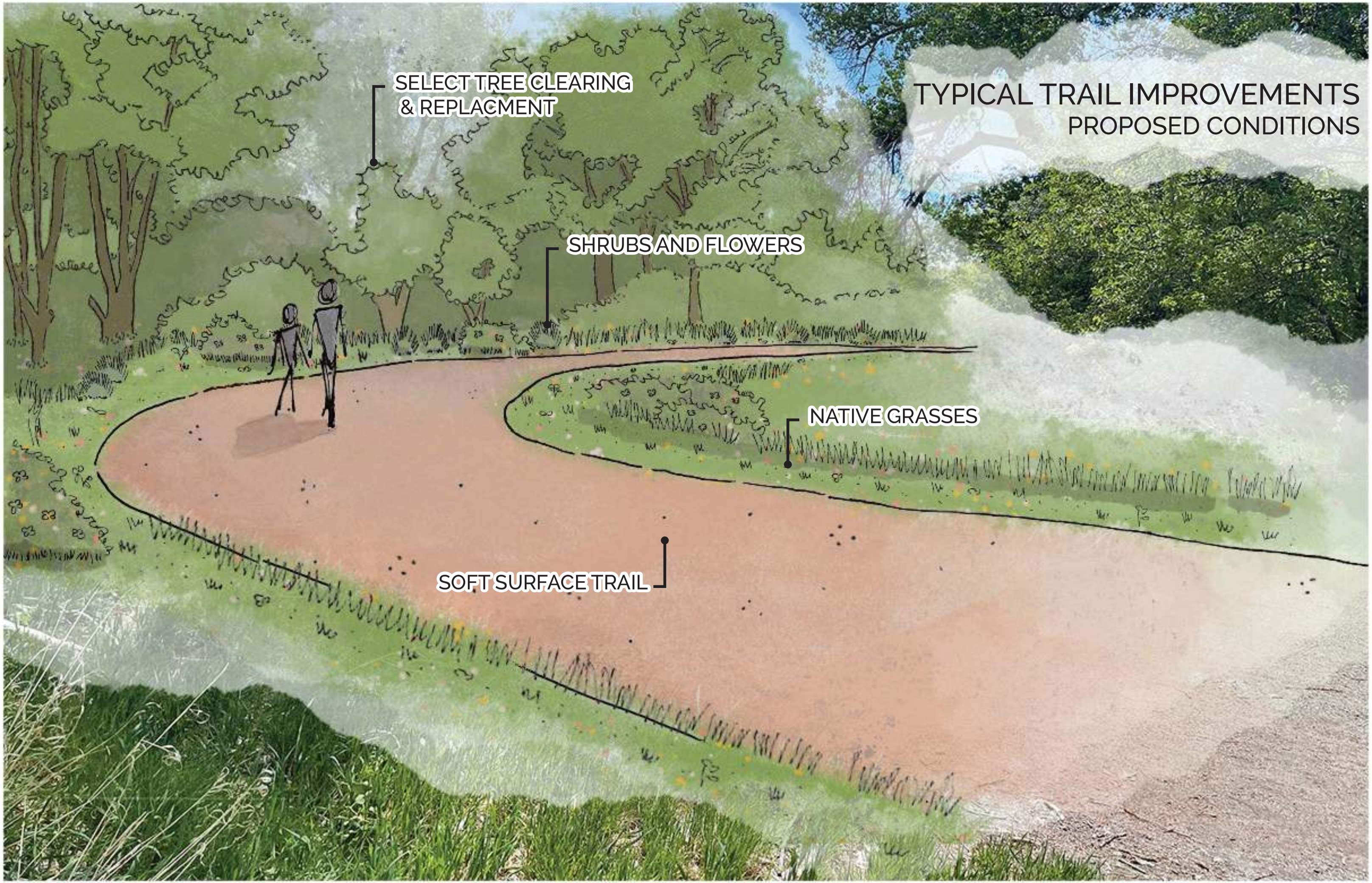
DAHLIA WATER QUALITY BERM
PROPOSED CONDITIONS





QUINCY AVE WATER QUALITY BERM
PROPOSED CONDITIONS

TYPICAL TRAIL IMPROVEMENTS
PROPOSED CONDITIONS



D. Hydraulic Calculations

.

	Estimated Volume (ac-ft)	Depth (ft)	Orifice Vertical Spacing (in)	Orifice area per row (in^2)	Stage of Orifice Centroid (ft)	Orifice Diameter (in)
Mansfield	0.394	2	8	1.45	0	1 and 3/8
					0.67	1 and 3/8
					1.33	1 and 3/8
Colorado	0.571	2	8	2.04	0	1 and 5/8
					0.67	1 and 5/8
					1.33	1 and 5/8
Quincy	0.876	2	8	2.99	0	1 and 15/16
					0.67	1 and 15/16
					1.33	1 and 15/16
Dahlia	0.702	2	8	2.45	0	1 and 3/4
					0.67	1 and 3/4
					1.33	1 and 3/4

E. June 2015 Flood Documentation Report

Flood Documentation Report

June 12, 2015 Flood Event
Cherry Hills Village, Colorado

This report summarizes the natural events leading up to, during, and following the heavy precipitation and resulting flooding of Cherry Hills Village on June 12, 2015.

Issued July 15, 2015; Finalized January 5, 2016

Flood Documentation Report

June 12, 2015 Flood Event
Cherry Hills Village, Colorado

Prepared by:

ICON Engineering, Inc.

Troy W. Carmann, PE CFM

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Summary

The flooding experienced in Cherry Hills Village on June 12, 2015 is a natural phenomenon for the downstream sub-basins of the overall Little Dry Creek watershed. Higher than normal precipitation in the days preceding the flood event saturated soils in the watershed, increased water levels in some ponds and reservoirs, and generally decreased the capacity of the watershed to slowly release rain water runoff. The impact was obvious to many residents, employees, visitors, and travellers in Cherry Hills Village on Friday morning. This report, more study and watershed coordination will decrease the future risk of flooding in Cherry Hills Village.

Table of Contents

Introduction

The June 12 flood event in Cherry Hills Village is a natural phenomenon in the downstream sub-basins of the larger Little Dry Creek watershed. The compounding effects of days of higher than normal precipitation preceding the event are evidenced in rainfall and runoff data and corroborated with witness accounts of the ponds within the watershed. The rainfall early in the morning of Friday June 12 exceeded the watershed's capacity to detain stormwater and the lower basins flooded as the flows exceeded the conveyance capacity at several road and irrigation ditch crossings.

There are many interesting and unique elements to the Little Dry Creek watershed, particularly as it relates to the June 12 flood event and the dynamics of the flooding in Cherry Hills Village (CHV). The entire contributing watershed to Cherry Hills Village is over 20 square miles. The headwaters at the natural bluffs south of Lone Tree all the way down through Centennial and Greenwood Village into Cherry Hills Village.

The natural stream channels are the obvious first element in the natural conveyance in the watershed. Little Dry Creek and Greenwood Gulch are the predominant natural channels along the downstream, west end, of CHV. Blackmer and Quincy Gulch take northern sub-basins and drain them west to a confluence with Greenwood Gulch. Little Dry Creek conveys flows through the remaining southwest quadrant of CHV.

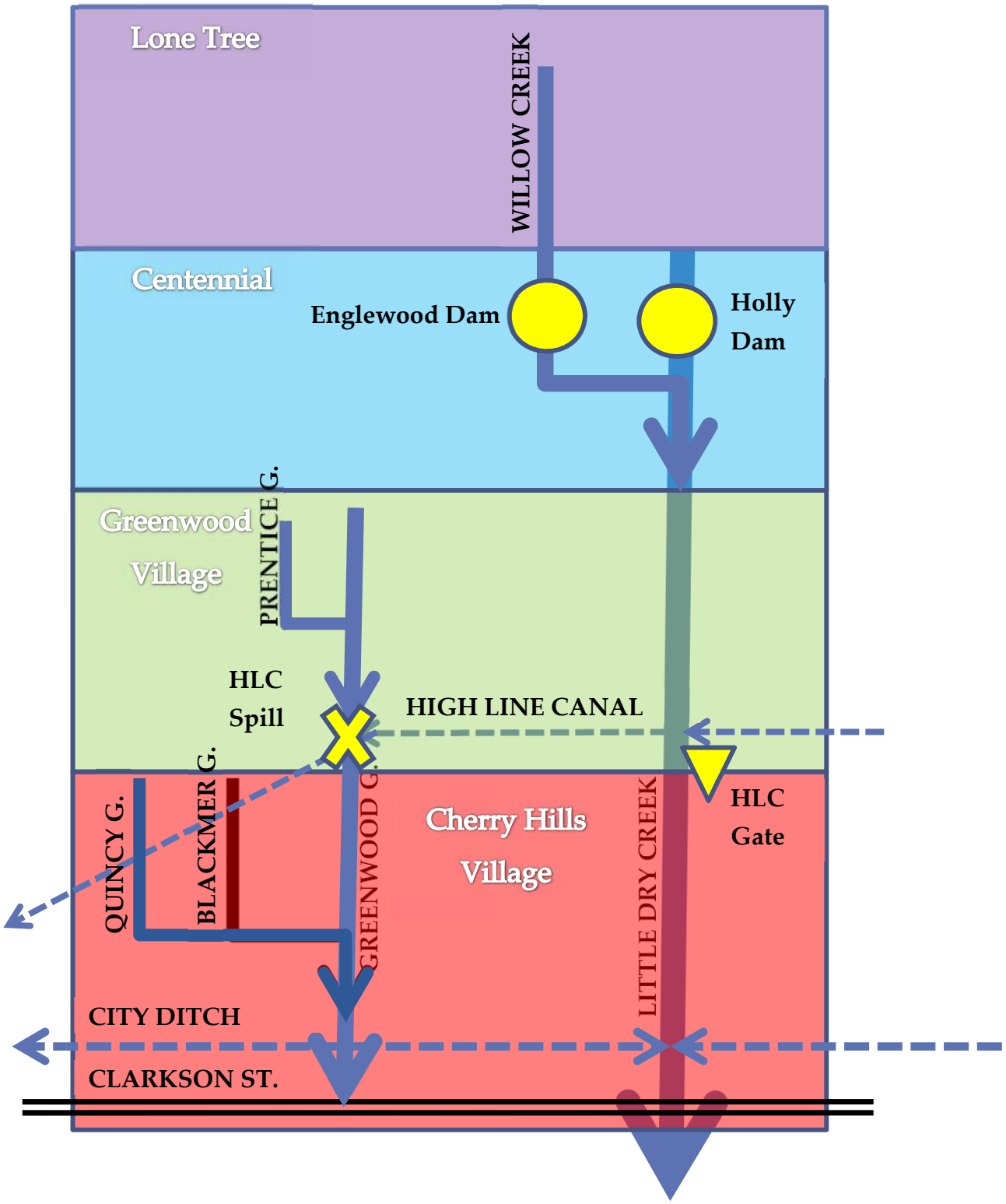
Irrigation ditches play a major role in the stormwater flows through CHV. The City Ditch intersects Little Dry Creek and Greenwood Gulch near Clarkson Street. The High Line Canal intersects Quincy and Blackmer Gulches within the City, but also intersects Greenwood Gulch and Little Dry Creek in Greenwood Village. The intersection of the ditches is a significant factor in the dynamics of major storm flows through the watershed.

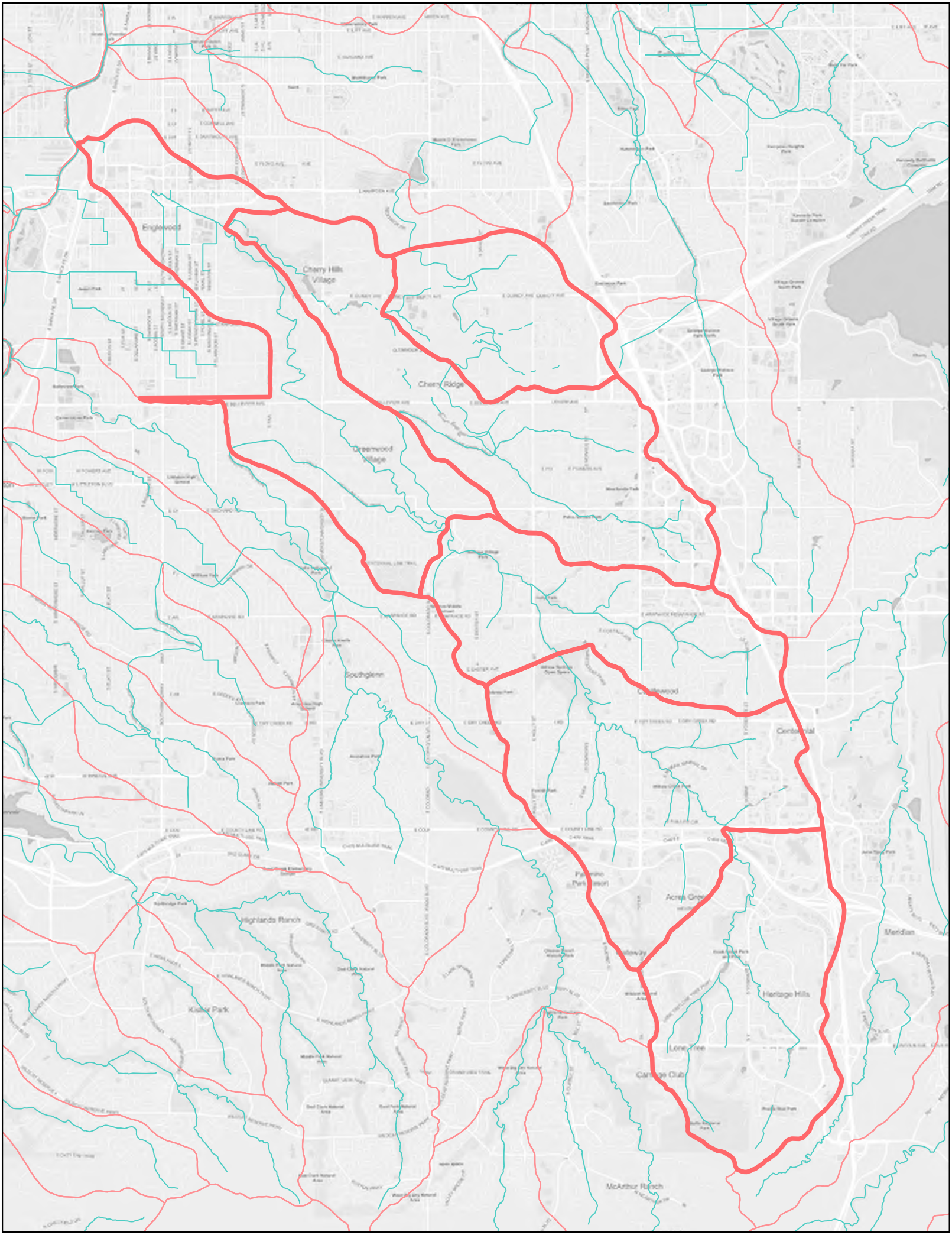
Reservoirs and regulatory dams are also significant in the Little Dry Creek watershed. The Blackmer Reservoir on the Kent Denver campus was built in the 1930s and still serves an important role in the control and release of minor and major storm flows. Further upstream in the City of Centennial, Holly Dam and Englewood Dam play a significant role as well. The controlled releases from each of these structures protected public and private property from further damages during this flood event. Without these reservoirs, there would have been more severe damage in a broader expanse of Cherry Hills Village and adjacent communities.

Additional elements such as the bridges, culverts, local drainage systems, private detention ponds, and roadways all played a part in conveying floodwaters through the basin on June 12th.

Elements

A graphic representation of the Little Dry Creek watershed as it relates to the key stormwater infrastructure elements that functioned during the June 12 flooding.




Englewood
Cherry Hills Village
Cherry Ridge
Greenwood Village
Southglenn
Centennial
Highlands Ranch
Meridian
Heritage Hills
Lone Tree
McArthur Ranch

Purpose of Report

This report is to gather information on a specific flood event in Cherry Hills Village on June 12, 2015 and present that information to interested parties in a manner that can be easily understood by non-technical audiences but easily scaled to support highly technical future analyses of various aspects of this storm. This report will inform citizens, government officials, and other interested parties on the effects and damage that floods can cause. Then this information can be used to leverage funding and priorities for structural (channel improvements, culvert upsizing, etc) and non-structural (procedures, policies, etc.) improvements identified by future detailed studies. Through the information in the report and future flood hazard mitigation activities, the ability of the community to withstand future flood events measured by reduced flood damages – the resiliency of the community should increase.

Authority and Acknowledgments

The report was authorized by the City of Cherry Hills Village with support from the Colorado Water Conservation Board.

There are a number of residents, staff, and community officials that contributed to the information contained in this report and associated technical appendices. In particular, the following agencies contributed to this report:

City of Englewood, City Ditch
Cherry Hills Country Club
Glenmoor Country Club
Denver Water Board, High Line Canal
Kent Denver School
City of Cherry Hills Village staff
Greenwood Village staff
City of Centennial, SEMSWA staff
City of Lone Tree staff
Urban Drainage and Flood Control District
Colorado State Engineer, Dam Safety Branch
FEMA Region VIII staff

Flooded Area Description

The flooded area can be generally described as the lower lands surrounding Little Dry Creek and Greenwood Gulch within the City of Cherry Hills Village from Clarkson upstream to approximately Colorado Boulevard. More specifically, there are distinct areas that experienced more severe flooding with higher depths or velocities and corresponding damages to public and private property.

The church located at 3600 S. Clarkson is one of the main areas where flood waters ponded for several days, impacting several private structures, roadways, and other basic utilities in the adjacent neighborhoods. Ponding reached depths of 9 feet deep according to contour mapping of the flooded area. The City Ditch was the discharge point for Greenwood Gulch flows and it could not handle the excessive volume of water coming down the morning of June 12th. Greenwood Gulch overtopped the City Ditch in the yard of 3701 S. Corona Street, flowed overland and down Kenyon Avenue, impacting several private homes, garages, and outbuildings, and ultimately ponding in the church lot, inundating the lower level of the church building. Ponding continued until floodwaters reached the elevation of the City Ditch culvert passing under Hampden Avenue. The gentle slope and size of the City Ditch culvert, as well as the perched elevation relative to the terrain on the church lot, limited the ability of the City Ditch to drain the floodwaters. Mechanical pumps were required to pump approximately 6 to 8 million gallons of water out of the church property.

The flooding also impacted travel on State Highway 177, South University Boulevard. Greenwood Gulch flows exceeded the capacity of the culverts under Quincy and University Blvd. The overtopping flows were approximately 2 feet deep in the travel lanes of University and closure was a prudent measure to ensure the safety of the travelling public. Flows on Quincy were less than 1 foot deep and spread in a broader weir flow condition. Meade Lane overtopped and flood flows were conveyed down the street from the Hutto Commons property much like was represented on the FEMA flood insurance rate map for the area.

Additional roadway flooding and private property damage occurred on the upper reaches of Greenwood, Blackmer and Quincy Gulches. A driveway was washed out at 8 Random Road. Channel erosion and scour was prevalent for nearly all properties along Random Road abutting Blackmer or Greenwood Gulch. Quincy Gulch overtopped the small channels along Quincy and Colorado, but was not adversely impacting roadways or travel lanes.

The High Line Canal was not running irrigation water at the time of the flood event according to reports by Denver Water Board personnel. However, the canal was observed by Village residents and public works staff to be within 6 to 9-inches of the top of the canal embankment in several locations. There are no reports of the canal overtopping within Cherry Hills Village. It is important to note the canal crosses both Little Dry Creek and Greenwood Gulch upstream in Greenwood Village.

Storm Characteristics and Rainfall Information

There are highly sophisticated hydrologic and hydraulic models that can be developed to recreate flood events. Highly detailed survey information, gage adjusted radar rainfall, and a broad range of assumptions on land cover, soil moisture, and other variables are input. The output can identify the routing of the storm over the watershed and resulting peaks in each modeled drainageway. These models are usually prioritized and funded for flood events affecting massive watersheds such as the Missouri River basin in the Dakotas or Mississippi River flooding in Louisiana. In most cases, such as the June 12 flood event, rainfall gages and stream gages are interpolated across a watershed and qualitative conclusions are drawn from the data based on known characteristics of the watershed during past flood events. In short, this storm, in this basin, with gage data and supported radar rainfall information can be reviewed and relied upon. But there is not enough time to develop a model and determine specific flow peaks at multiple specific locations in the watershed.

This flood event is directly linked to a storm cell that passed slowly through the lower reaches of the Little Dry Creek Basin in Cherry Hills Village between 5:00 and 10:00am on Friday June 12 (red arrows in figure below). However, the more intense rainfall in the basin late on the evening of June 11, from approximately 6:30 to 11:00pm (yellow arrows below) is just as important in understanding the hydraulic reaction of the watershed and sub-basins in Cherry Hills Village.

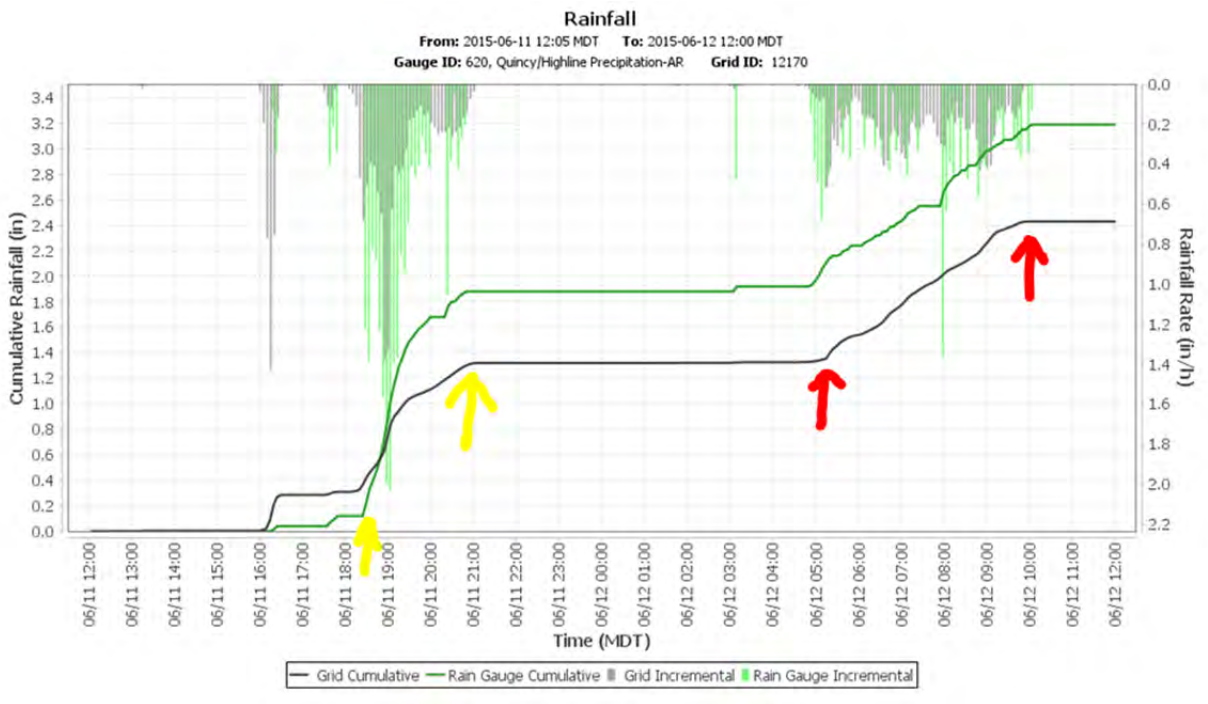


Figure: Rainfall accumulation at the gage at Quincy Avenue and the High Line Canal

Equally important is the storm cell that passed over the headwaters of Little Dry Creek in the same timeframe and contributed flows to Englewood Dam.

The National Weather Service radar covering the Denver Metro Area is a valuable dataset in the forensic analysis of a flood event. The Urban Drainage and Flood Control District (UDFCD) has funded and managed the Flash Flood Prediction Program (F2P2). This program combines the actual reports from automated gages through the UDFCD and compiles the corresponding radar data from that time period. The radar returns can estimate rainfall, scientists correlate the radar estimate with the point data from the gages, and create a Gage Adjusted Radar Rainfall (GARR) estimate. This is the information that provides another key point in the analysis of the storms on June 11 and 12th.

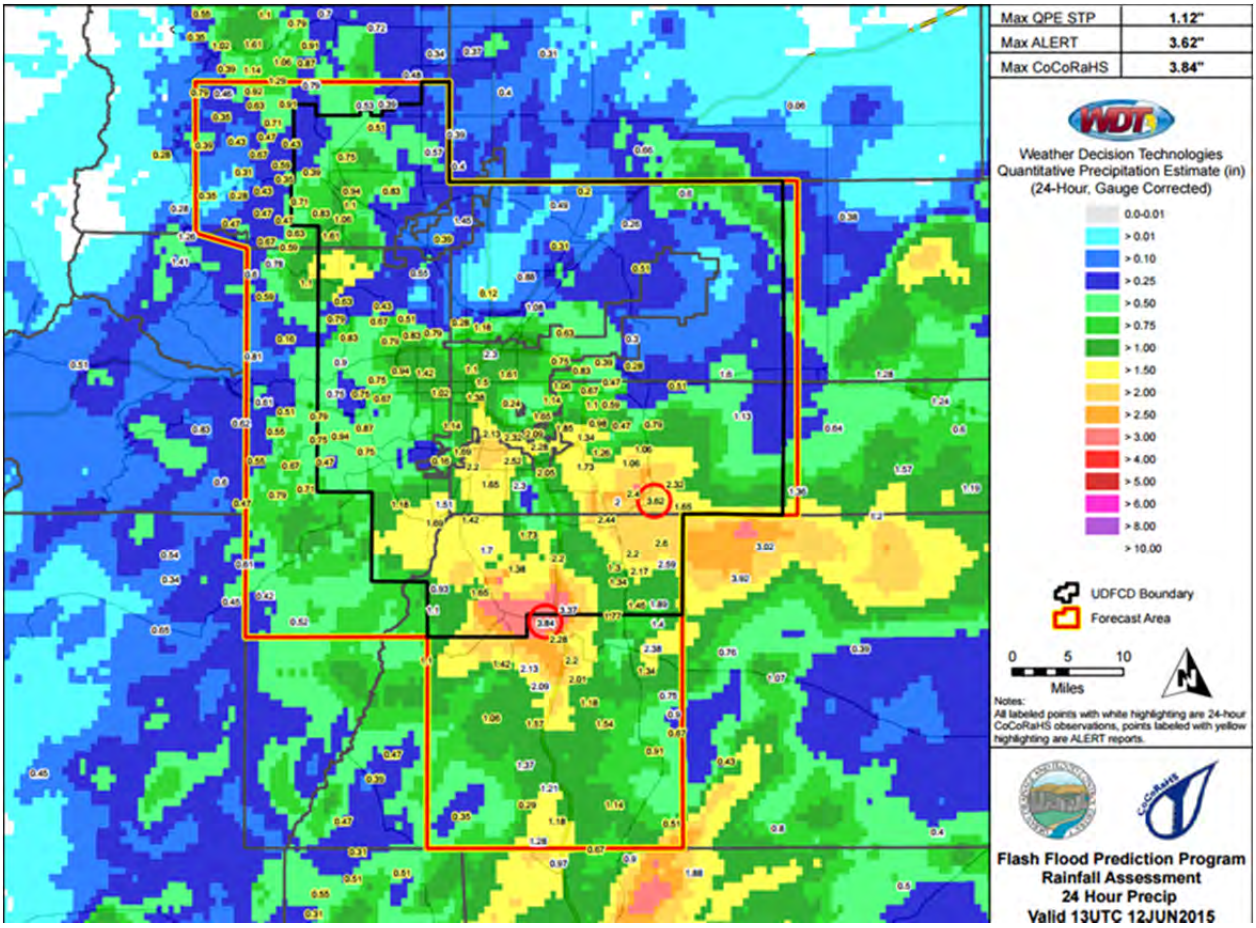


Figure: A 24-hour snapshot of rainfall accumulated through 1pm June 12th.

The rainfall totals exceeding 3-inches within Cherry Hills Village are important to note. However, just as important is the rainfall totals to the south, near the headwaters of Little Dry Creek in southern Lone Tree. These flows accumulated in the upper reaches of the basin late Thursday and early Friday morning. Englewood dam captured the peak from that southern cell. Reports and gage records show Englewood Dam filling 12 to 14-feet in the period from June 10 to June 12. Englewood Dam then

released approximately 200 cfs into Little Dry Creek for several hours. That flow ultimately combined with the rainfall in the lower basin and contributed to the longer duration of flows on Little Dry Creek.

Greenwood Gulch did not have the same level of reservoir attenuation; the resulting peak occurred faster and higher and receeded faster the as the volume of water moved through the Village.

There is another factor that develops as historic gage data is queried. As shown in the figures below, the 'wet spring' is recorded in the 2015 rainfall totals at Englewood Dam and Quincy at Highline for April and May. This correlates with anecdotal reports of saturated soil conditions throughout the Little Dry Creek basin in the weeks preceding the June 12th storm event.

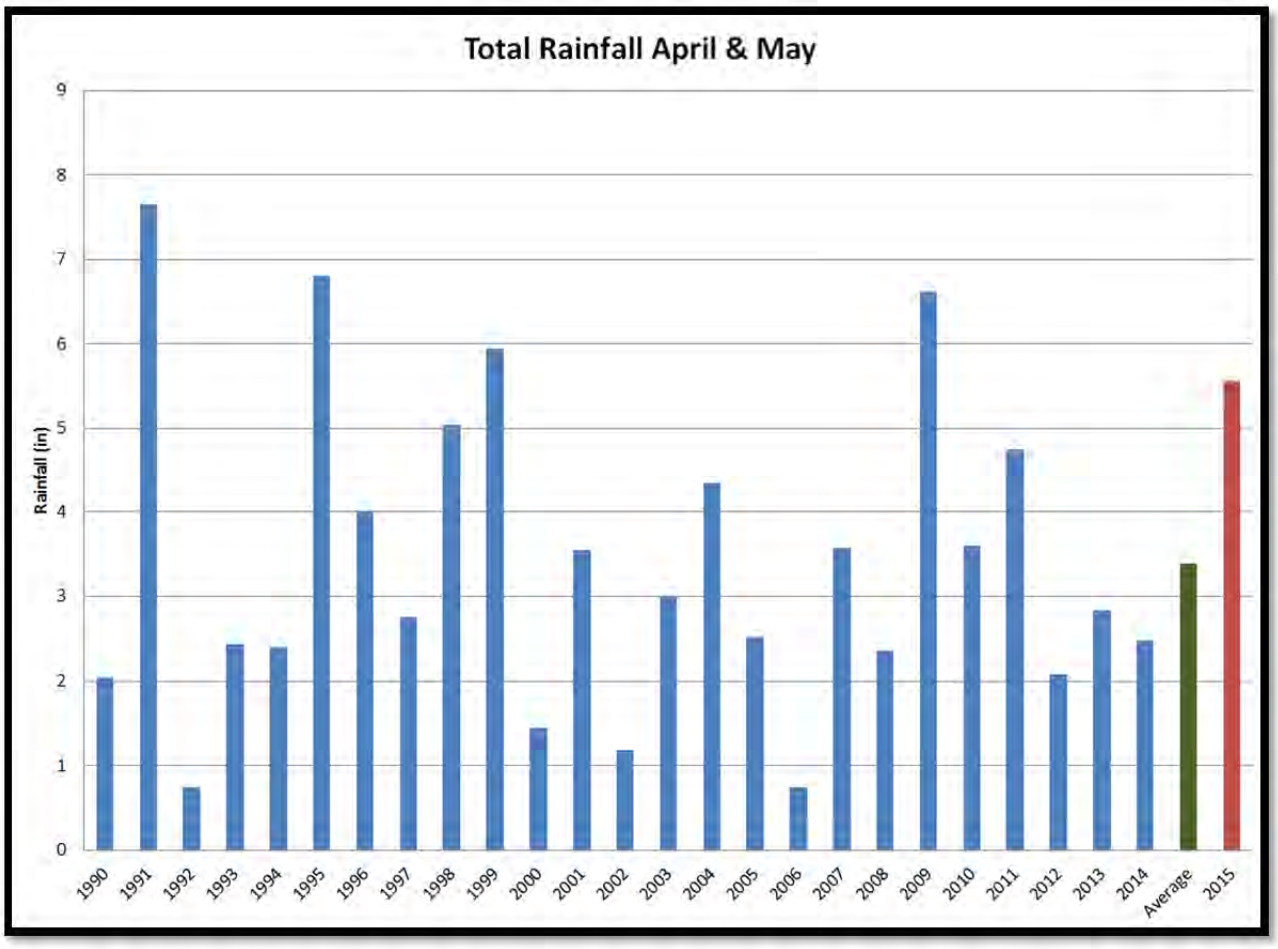


Figure: "Wet Spring" data from Englewood Dam

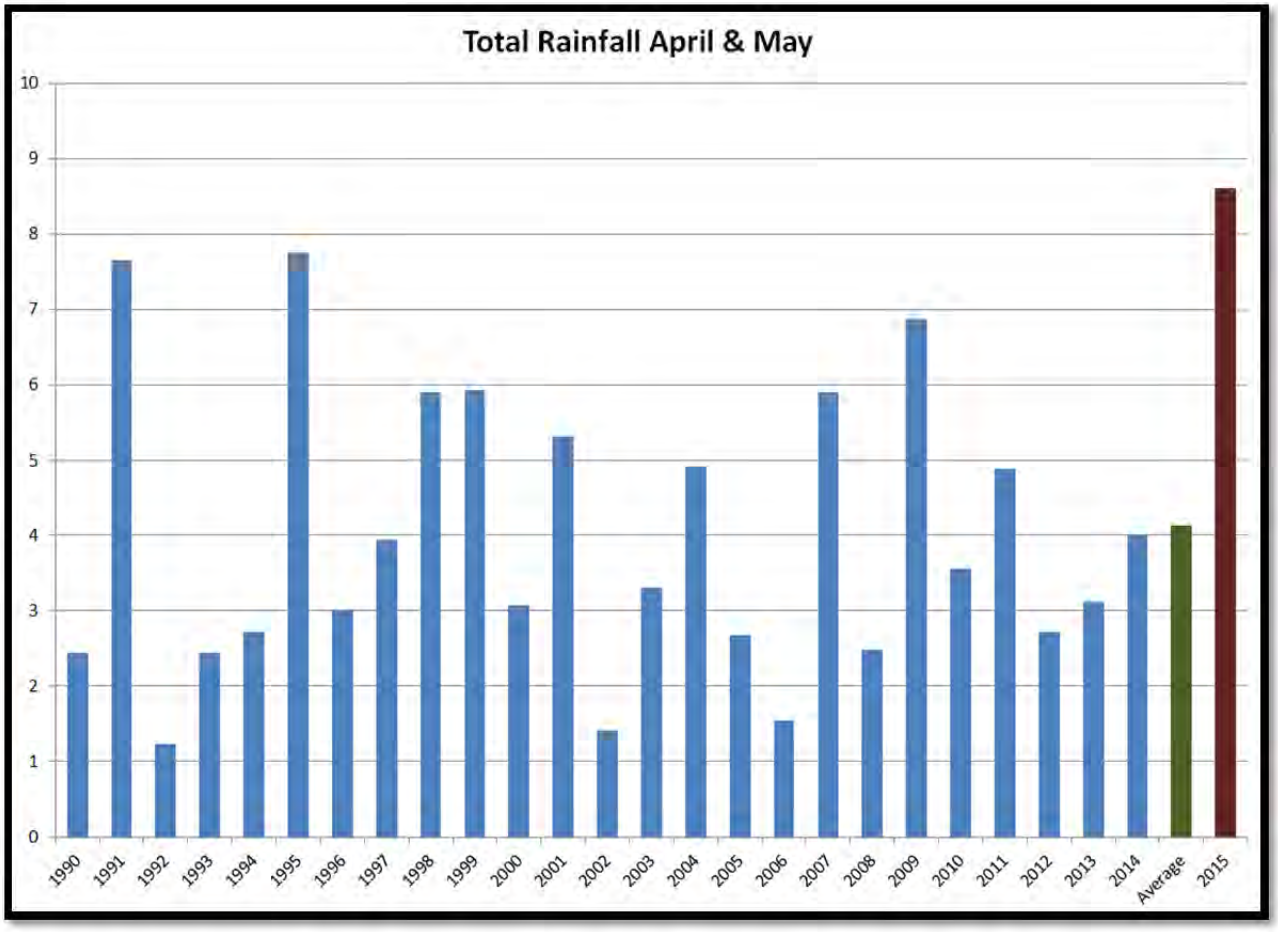


Figure: "Wet Spring" data from High Line Canal at Quincy Avenue

The gage data for Englewood Dam represents the moisture conditions in the upper Little Dry Creek basin. The gage data at Quincy High Line is representative of the soil conditions within the lower Little Dry Creek basin – within the jurisdiction of Cherry Hills Village. The above average 2015 moisture condition in both gage locations is suggestive of a basin-wide antecedent moisture condition that limits the infiltration capacity of the pervious soils across the watershed and within the ponds and impoundments. This leads to more runoff travelling through the watershed than in drier past years.

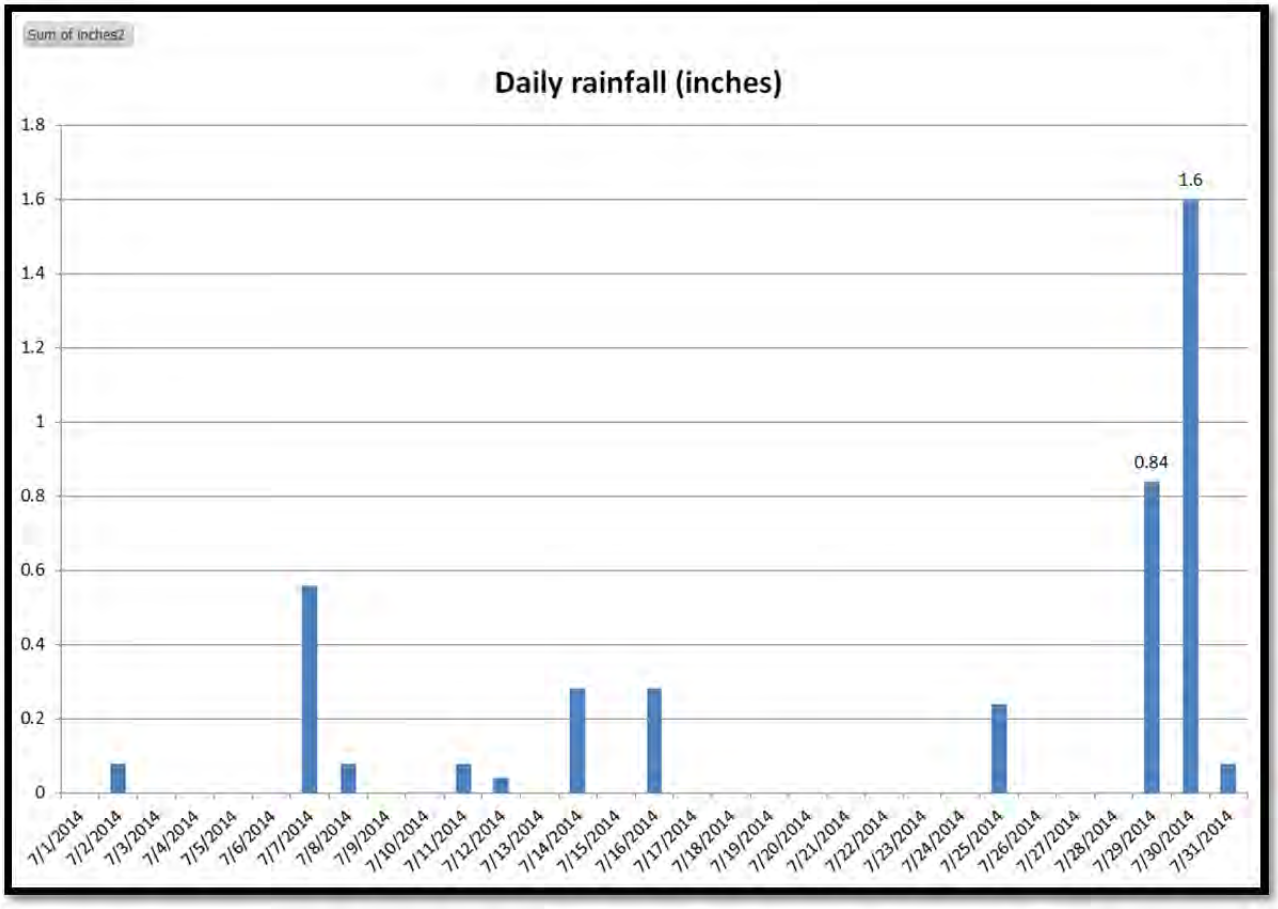


Figure: Quincy High Line daily rainfall data from July 2014

Further detailed analysis could confirm the specifics, but it appears from a cursory review that previous daily rainfall totals in July 2014 were similar to the June storm event. What are not immediately clear or confirmed are the other watershed conditions that existed at the time of the larger daily rainfalls. For example, the July 30, 2014 daily rainfall total of about 1.6 inches preceeded by approximately 0.8 inches of rain appears in both the Quincy and Englewood Dam gage data. See figure above. However, it is not matched with a 'wet spring' as documented in 2015 gage data.

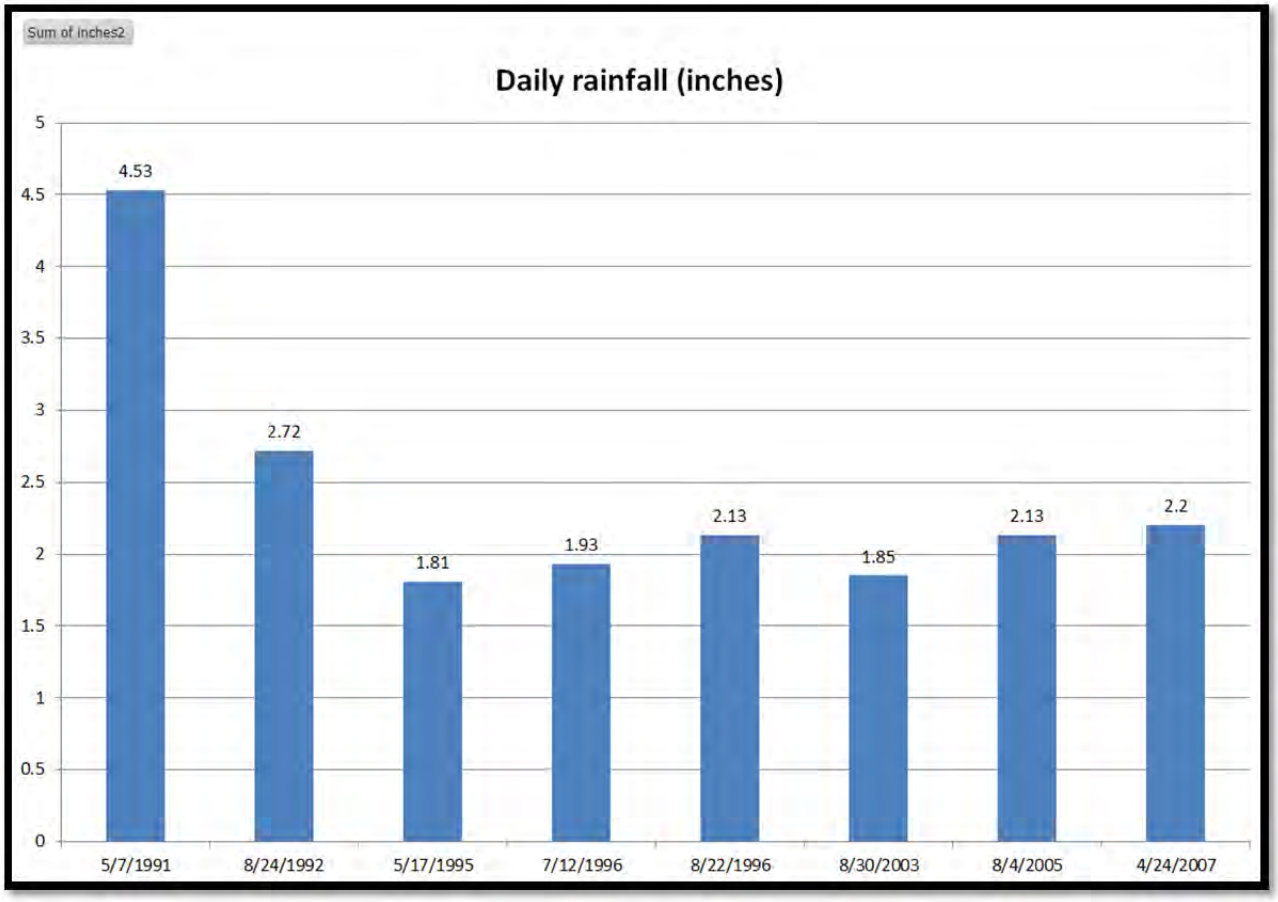
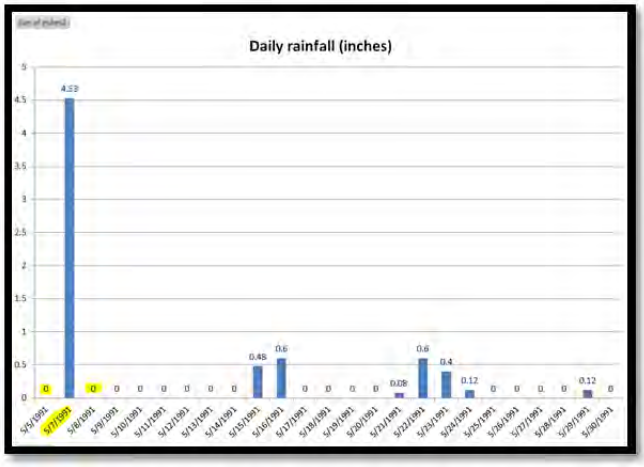
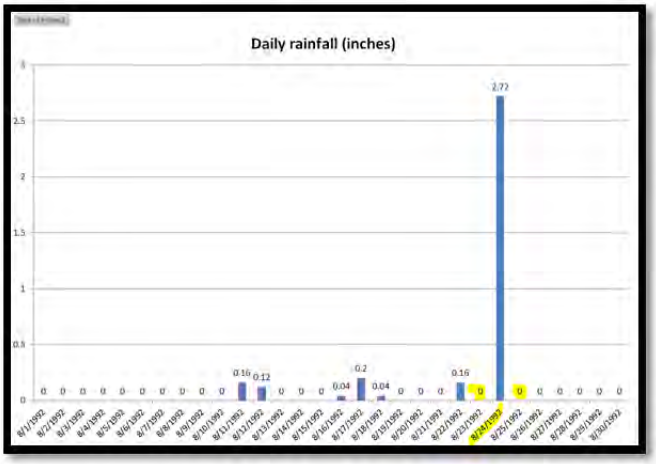


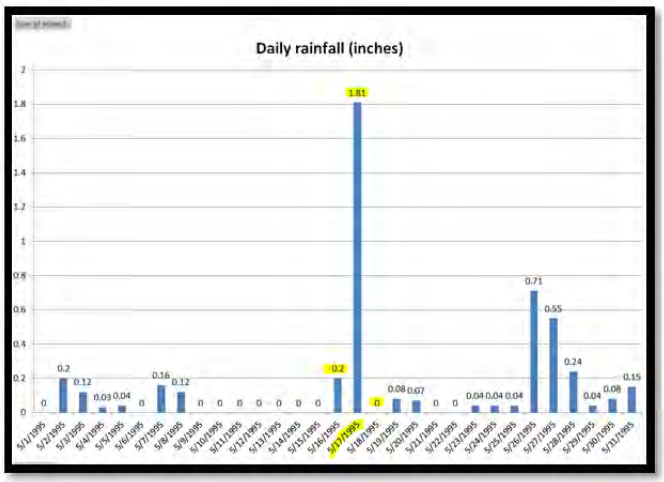
Figure: Quincy High Line daily rainfall over 1.75 inches

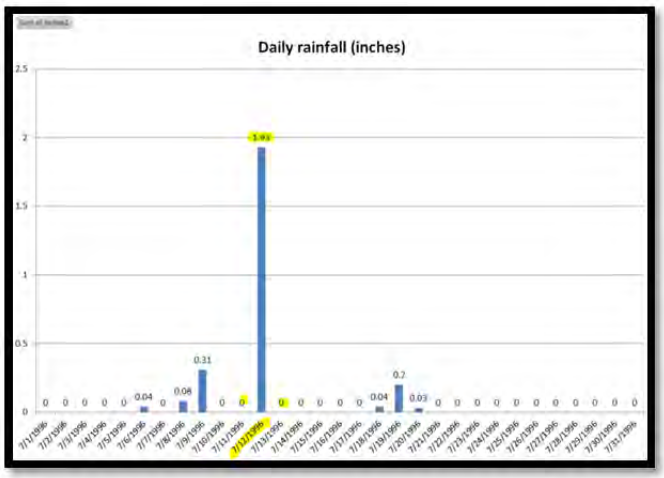
It has been noted that there are other rainfall events in the Village that have exceeded the rainfall totals experienced on June 12th, 2015. The maximum precipitation at the Quincy gage is approximately 1.75 inches on the evening of June 11th. There have been eight (8) storm events recorded by the Quincy gage since 1990 that exceeded 1.75 inches. Subsequent detailed analysis could investigate the rainfall events before and after each of these peak rainfall events. A snapshot of gage data before and after the peak events is shown in the figures below.



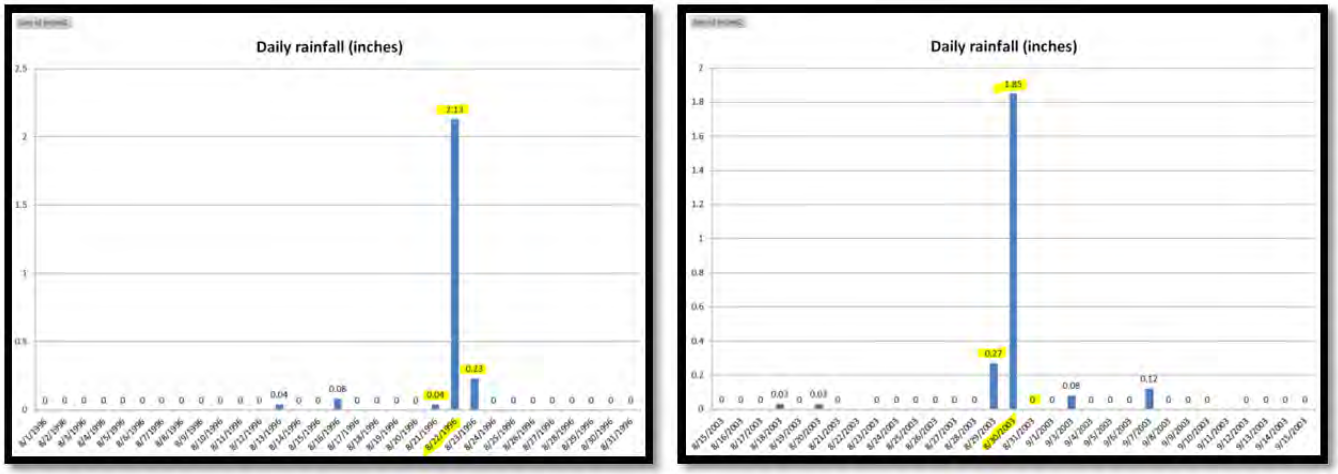


Figures: May 7, 1991 and August 24, 1992 storm event with zero precipitation days before and after

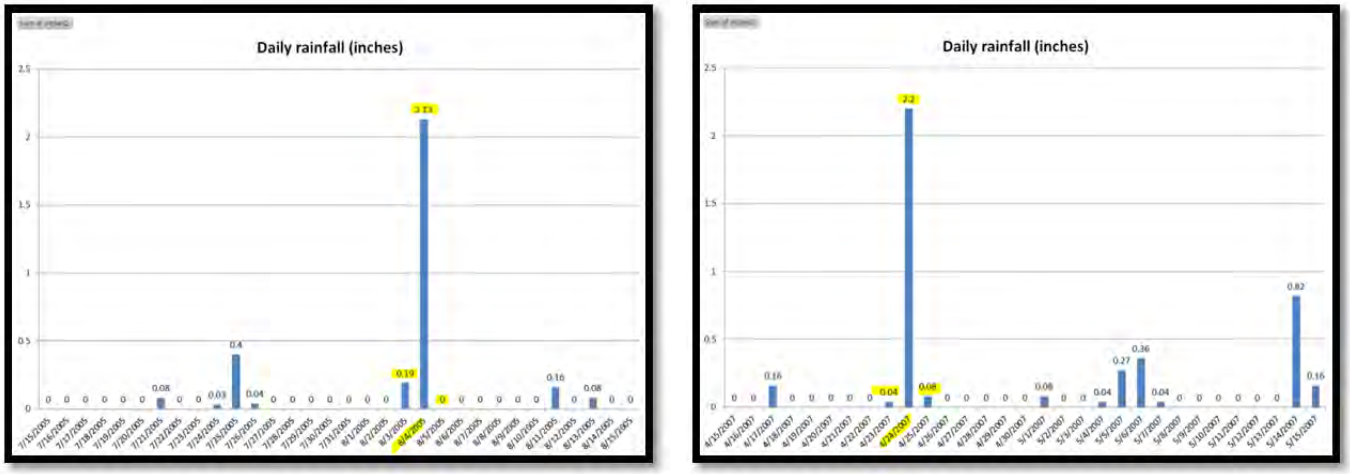




Figures: May 17, 1995 and July 12, 1996 storm event with 0 to 0.2" precipitation days before and after



Figures: August 22, 1996 and August 30, 2003 storm events with near zero precipitation days before and after



Figures: August 4, 2005 and April 24, 2007 storm events with zero and near zero precipitation days before and after

The June 12th storm characteristics are unique. This conclusion is supported by an initial investigation of the rainfall data for the Quincy High Line gage. Other storms have had higher peak rainfall. Other storms have had back to back rainfall. Other storms have followed wet spring conditions. However, it does not appear that there has been a storm since 1990 that has had as saturated of a watershed, with back to back rainfall events, with a total rainfall of approximately 3 inches within Cherry Hills Village. Additional investigation of the Englewood Dam gage data may support this same conclusion for the upper basin of the Little Dry Creek watershed.

Hydrologic and Hydraulic Investigations

No specific hydrologic or hydraulic investigations were completed for this report. However, hydrologic data is preserved through the UDFCD gage data. Previous Flood Hazard Area Delineation (FHAD) studies are also available for reference. Hydraulic information on flow rates in Little Dry Creek are available from the USGS.

Previous studies indicated the peak flows for each stream within the Little Dry Creek watershed. A snapshot of the UDFCD sponsored FHAD study is shown below.

Table III - 3
FHAD for Little Dry Creek (ARAPCO) and Tributaries
Peak Flow Comparison

Flooding Source and Location	Current FEMA Adopted Flow Rate* (cfs)				1986 McLaughlin Study	2002 WRC Engineering FHAD Study** (cfs)			
	10-Year	50-Year	100-Year	500-Year	100-Year	10-Year	50-Year	100-Year	500-Year
Blackmer Gulch									
At Confluence with Greenwood Gulch	1390	1850	1950	2330	1587	644	1307	1587	2442
At Confluence with Quincy Gulch	780	1040	1100	1330	985	389	794	985	1523
Little Dry Creek									
Clarkson Street	2275	3750	4580	5970	4581	1845	3633	4581	6855
Prentice Gulch									
At Mouth	640	870	920	1030	811	377	712	811	1163
Quincy Gulch									
At Confluence with Blackmer Gulch	610	810	850	1000	642	280	538	642	986
Greenwood Gulch									
At Bellview Road	1800	2550	2750	3200	2640	1156	2191	2640	3959
At Confluence with Prentice Creek	1700	2300	2450	2800	2112	1058	1842	2112	3225

* From the Arapahoe County FIS dated August 16, 1995
** Estimated Utilizing the 1986 McLaughlin hydrologic models.

Figure: UDFCD study flow rates for the Little Dry Creek Watershed

The USGS direct flow measurement at Little Dry Creek at Clarkson peaked at around 600 cfs, far less than the 4580 cfs, 100 year flow rate adopted by FEMA. This roughly correlates with the areal extent of the flooding on Little Dry Creek. The Little Dry Creek flows were largely contained within the channel and did not replicate the FEMA 100-year flood hazard area through Cherry Hills Village.

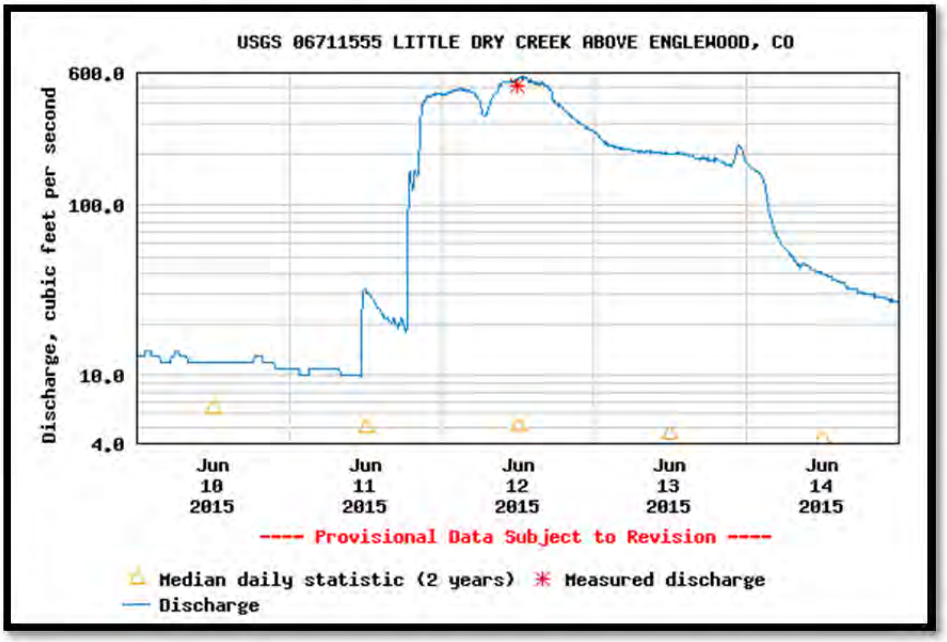


Figure: Little Dry Creek flow rates at Clarkson from June 10 to June 14th.

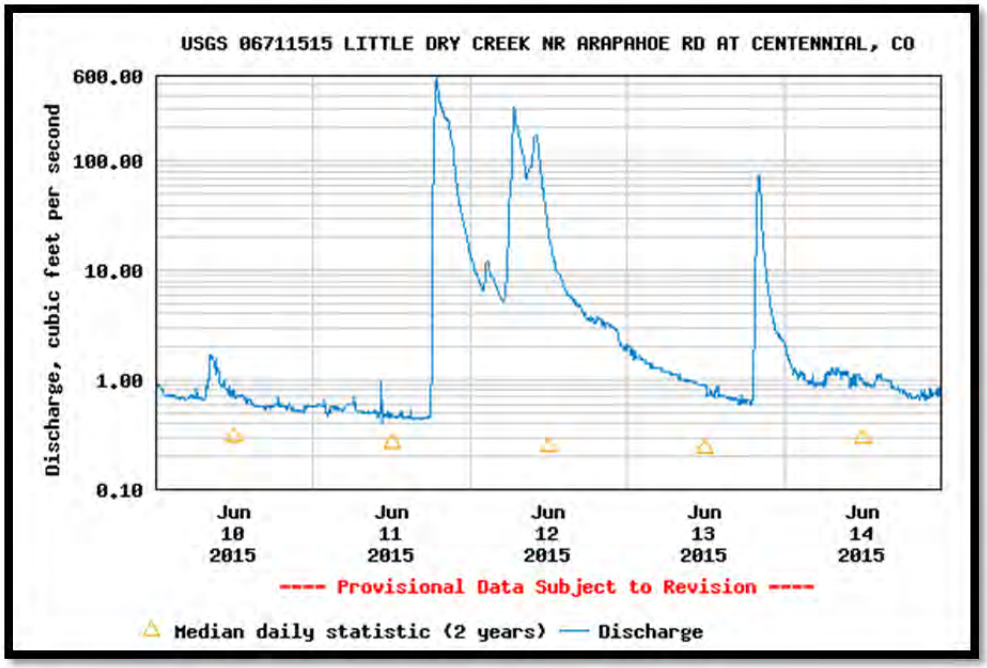


Figure: Little Dry Creek flow rates at Arapahoe Road from June 10 to June 14th.

The differences in gage data between Clarkson Street and Arapahoe Road on Little Dry Creek show the effects of other sub-basins in the watershed. The Clarkson gage stayed high for several days, while the gage further upstream was more variable.

Greenwood Gulch is a different story. Unfortunately, flow data is not available. But, the lateral extent of the flooding largely followed the delineation and depths shown on the FEMA Flood Insurance Rate Map (FIRM). There are differences, but those are attributable to the variables considered in the FEMA mapping. Free flow conditions are assumed in the FEMA floodplain analyses, debris accumulation on structures and other floatable debris impacts are not accounted in the modeling. However, every flood has some level of debris accumulated in the flood flows.

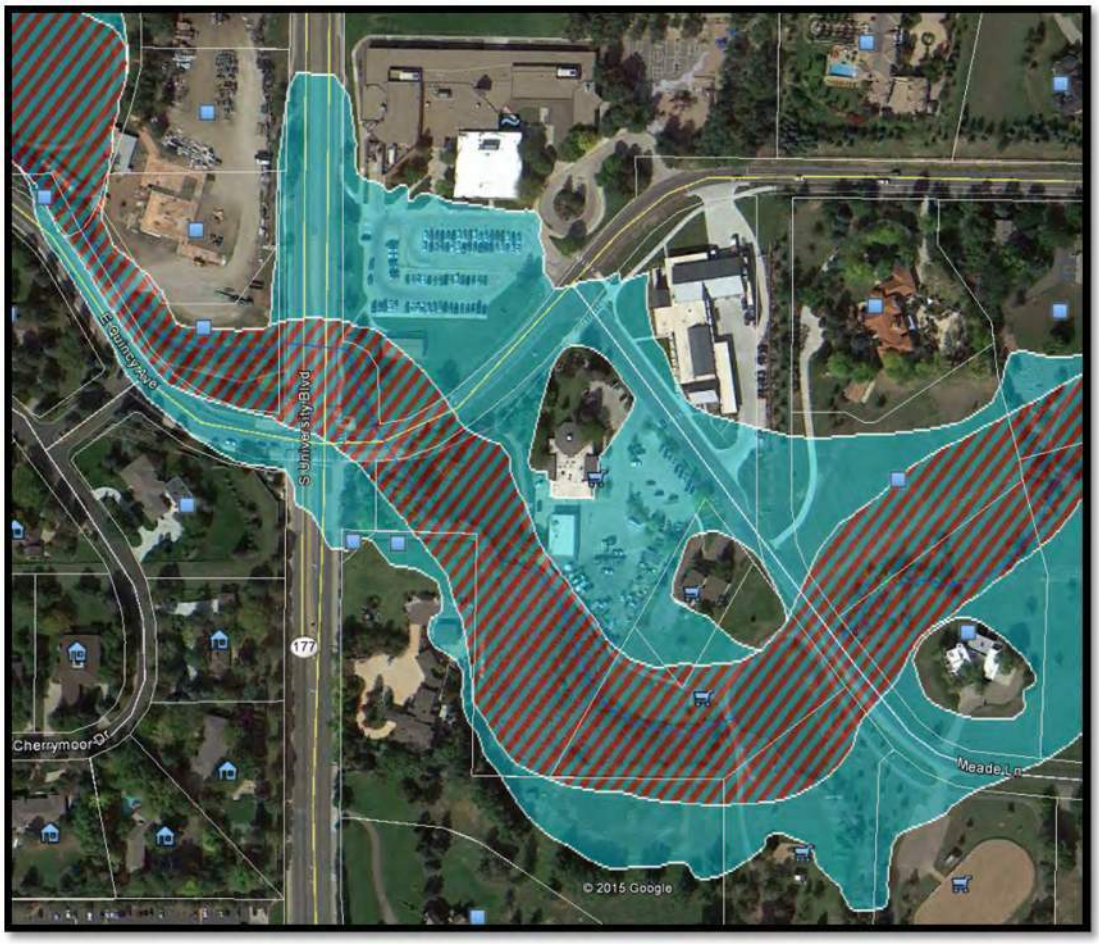


Figure: The Greenwood Gulch flood event was similar to the flood hazard area map

The flood flows during this storm event are similar to most other flood events along the Front Range of Colorado. There are variations from the 100-year flood flows published in the FEMA Flood Insurance Study. Little Dry Creek was much less than the 100 year flood flow based on actual USGS flow measurements and flood extents. Greenwood Gulch was likely much closer to the 100 year flow based on areal extent of the flooding. However, there is no correlating flow gage data to confirm the actual flow rates.

Estimated Flood Damages

There is no estimate on flood damages available at the time of this report. A summary of public and private property damages can be compiled with the assistance of affected residents and city staff. Damages may be compiled across the city, but detailed information on the source of the flooding, impacts to various levels of each structure (basement, first floor, etc) become valuable to the flood forensics. Strict dollar totals of damage are useful to the overall magnitude of the damages and can be used in future studies and grant applications for flood hazard mitigation.

Special Factors Affecting the Flood

There are several unique factors related to this flood event. The following key map roughly locates these areas by letter.

A. Greenwood Gulch at City Ditch. Greenwood Gulch is intercepted by City Ditch, the downstream capacity of City Ditch is not sufficient to safely convey major storm events north through City Ditch or south to Little Dry Creek. The City Ditch and its staff did everything possible with the limited gravity system in place at City Ditch. The upstream flows in City Ditch were released at the siphon under Little Dry Creek. This allowed the excess Greenwood Gulch flows to 'flow backward' or south into Little Dry Creek. The remainder of flow continued in City Ditch down to the culvert under Hampden. The excess overtopped the ditch and flowed down Kenyon Avenue to the church property.

B. Multiple day rainfall. Preceding rain fall in the basin, saturated soils and minimized available reservoir capacity. Previous rainfall events have contributed 2 inches of rain to the watershed, but there is no record of this many days of precipitation with accumulated totals over 3 inches in 24 hours.

C. High Line was dry. The High Line Canal was not flowing irrigation water at the time of the rainfall and subsequent flood event. This likely saved many structures from additional damage. If the canal had been running irrigation water, the excess flood waters would have had to continue downstream through Cherry Hills Village.

D. Greenwood Gulch intercepted by the High Line Canal in Greenwood Village. The Glenmoor Country Club receives surface water from Greenwood Gulch. However, Greenwood Gulch is intercepted by the High Line Canal in Greenwood Village, approximately ¾ mile upstream of Glenmoor (just northwest of "The Center" pool and tennis courts at the Preserve). This is likely what contributed most to the filling of the High Line Canal downstream through Cherry Hills Village.

E. Little Dry Creek at the High Line. Unlike Greenwood, Little Dry Creek passes over the High Line Canal. A siphon project was installed many years ago at the intersection of Little Dry Creek and the High Line Canal. The siphon conveys High Line flows under Little Dry Creek. The siphon structure also allows Denver Water to safely release excess stormwater captured in the upstream canal into

Little Dry Creek. This 'dump gate' function at Little Dry Creek is very valuable to protecting the canal from a breach condition south of that location. This dump gate does not provide any direct protection for Cherry Hills Village. In fact, the interception of Greenwood Gulch flows at the High Line supersede any backflow the Little Dry Creek dump gate may provide in that reach of the canal.

F. Blackmer Gulch at the High Line. Blackmer Gulch does not have a substantial conveyance under the High Line canal. The flows from upper Blackmer were at least ponded upstream of the canal. There are no reports or forensic data to determine if Blackmer flows overtopped the High Line canal and continued downstream to the reservoir. This is also true for the minor tributary to the south of Blackmer across the east of the property at 4750 S. Dahlia. Additional information from the homeowners along the High Line Canal near Blackmer would be useful in understanding how Blackmer drains at the High Line.

G. Blackmer Reservoir. The State Engineer had visited Blackmer Reservoir in May for a routine inspection of the structure that was originally constructed in the 1930s. The reservoir passed inspection with minor recommendations for maintenance of saturated soil conditions on the downstream end of the outlet structure. The dam was reclassified as a critical structure based on the downstream development and potential impact in the event of a full dam failure. After a site visit to the reservoir and review of the original construction drawings, the reservoir likely operated as designed. There is no manual operation of the dam outlet structure, no valve or other mechanism to release flows. Additional information on the outlet flume and hydraulics of the dam is available from the State Engineer.

H. Greenwood Gulch at Cherry Hills Country Club. The Cherry Hills Country Club (CHCC) has a long history with Greenwood Gulch and the grounds crew is very knowledgeable about the operation of the gulch in wet and dry conditions. Most notably, the CHCC has for many, many decades operated a piped diversion from Greenwood Gulch at the southeast corner of the club, along Quincy, and ultimately discharging into Little Dry Creek downstream of the Quincy bridge over Little Dry Creek. This approximately 18-inch diameter piped diversion structure relieved some of the flood flows on Greenwood Gulch, bypassing them directly to Little Dry Creek. Additional investigation of this diversion and potential to upsize this pipe could lead to reduced storm flows on Greenwood Gulch at City Ditch.

I. The UDFCD Flash Flood Prediction Program (F2P2) issued an alert for Arapahoe County the morning of Thursday June 11th calling for a high probability of heavy precipitation in the area for the next 24 hours.

J. City Ditch Breach. At some point during flood recovery operations, a hand dug trench was made in the south bank of City Ditch, approximately 100 feet upstream of the culvert under Hampden. The City Ditch staff identified this as a potential weak point in the city ditch embankment from this point forward and will require particular repairs to be done in that vicinity. The hand dug trench is relatively minor, but it exposes the fact that plans should be put in place to ensure emergency operations are planned in advance.

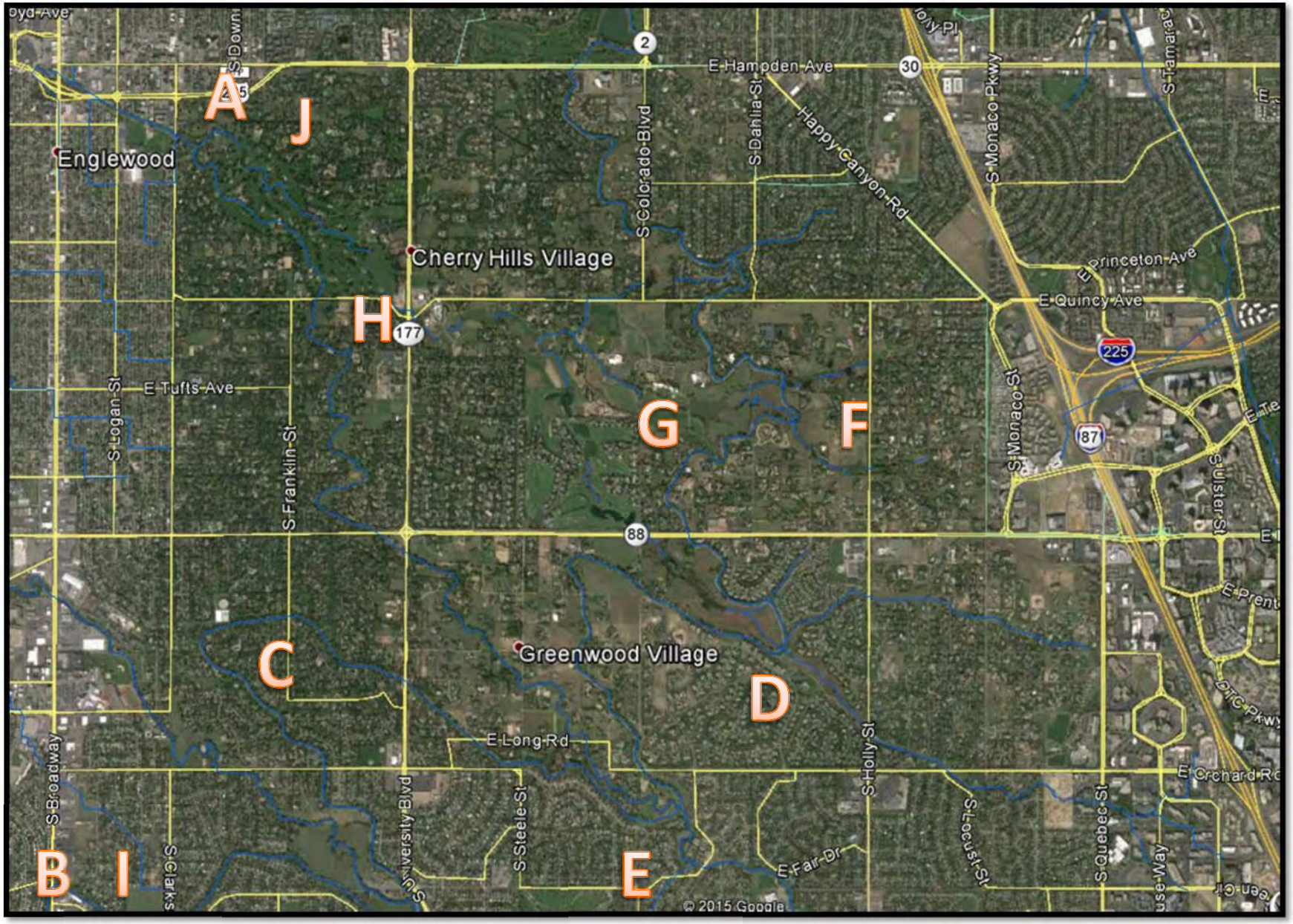


Figure: Key Issue general location map

Flood Hazard Mitigation

This report is not intended to provide a comprehensive look at projects or policies that can mitigate future flood damages resulting from floods as the June 12th flood event. However, a few notable projects have been previously identified by the Urban Drainage and Flood Control District (UDFCD) in the Little Dry Creek masterplan. And, another project has been identified in the course of flood recovery efforts at the church property.

Culverts at University.

The masterplan calls for additional culvert capacity under University Blvd and Quincy Ave. The proposed culverts are significantly larger than the multiple 30-inch diameter metal culverts that were superseded by the June 12th flood flows. The proposed mitigation work calls for triple 14-foot wide by 5 –foot tall concrete box culverts under University and the same under Quincy Avenue.

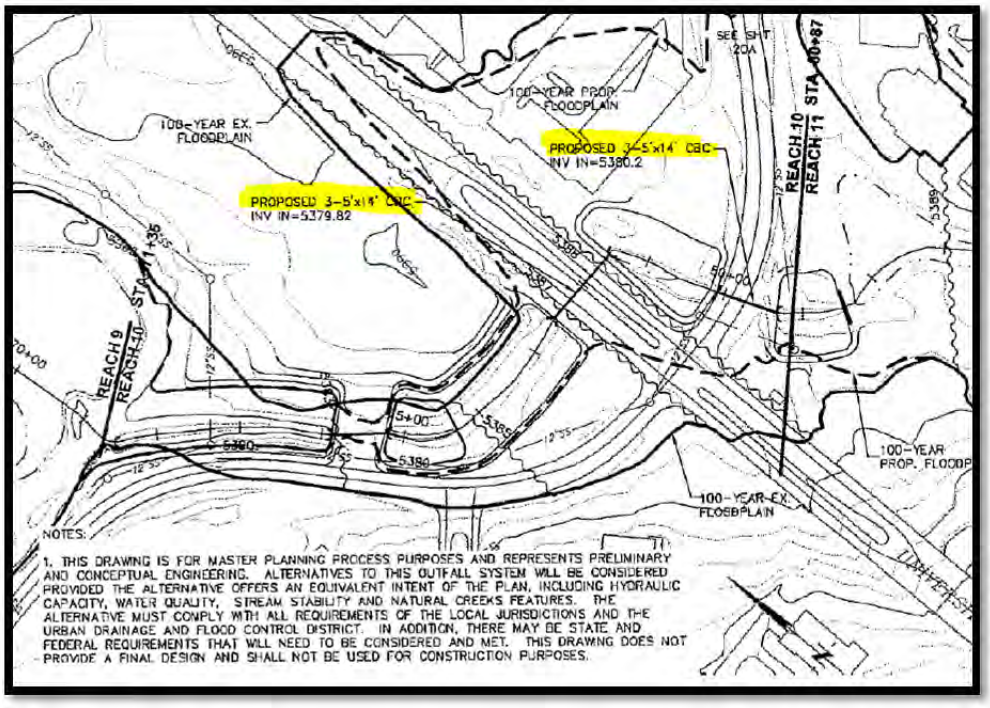


Figure: UDFCD Little Dry Creek Masterplan Improvements on Greenwood Gulch

Inlets at Clarkson

There are two existing storm sewer inlets in the east gutter of Clarkson Avenue. The storm inlets collect street runoff, convey stormwater through 18" +/- reinforced concrete pipes, and discharge into Little Dry Creek near the Clarkson Bridge. A 150-LF storm sewer extension into the church property could gravity drain the ponding to approximately the elevation of the church basement. Additional storm sewer capacity, decreased drain time during ponding, could be accomplished with replacement of the existing 350-LF of storm sewer from the Little Dry Creek outfall to the street inlet on the

northeast corner of Kenyon and Clarkson. Design and construction of this improvement would range from $90,000 to $300,000, or approximately $600/LF of storm sewer.

The drain would leave a residual ponding in the church property. To completely eliminate ponding during large storm events, the lowest grades of the property could be filled. A floodplain development permit would be required to prove the fill has no adverse impact on adjacent properties and insurable structures. Alternatively, a much deeper storm sewer could be connected through the lowest contours of the church property. To get this deep pipe to drain to Little Dry Creek, a tremendously deep excavation crossing dozens of existing utilities in and around Clarkson Street, would be required to drain into Little Dry Creek. A trenchless installation using underground boring and tunneling techniques would likely be more feasible, but just as expensive.

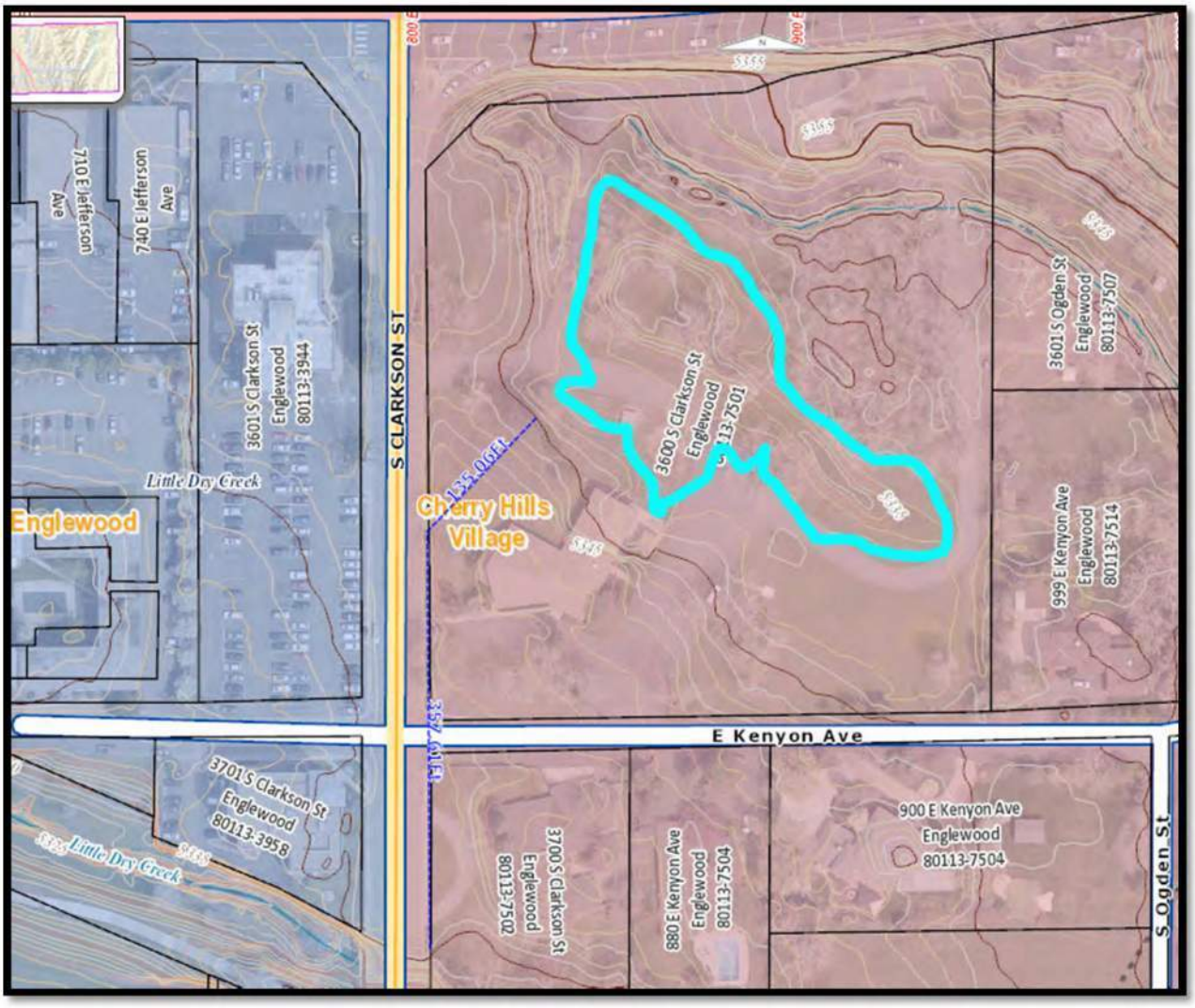


Figure: Potential 150 LF storm sewer extension and residual ponding at 3600 S. Clarkson

There are many factors that can affect the viability of this solution; existing dry utilities are the most notable obstacle to any retrofit gravity flow storm sewer installation. If existing utilities have already occupied the right-of-way or adjacent private property, the proposed storm sewer extension would have to avoid the conflicting utilities or pay for their relocation. However, if the proposed storm sewer can follow the existing storm sewer alignment with a slight upsizing of the pipe diameter, the solution may be reasonably straight forward storm sewer installation work.

Conceptual Storm Sewer Extension	
Clarkson Street Elevation	5342
Existing Storm Inlet depth	-5
Future Storm Drain elevation	5337
Approximate church basement elevation	*5337*
Existing City Ditch outlet elevation	*5338*

Figure: Approximate elevations at the church property tying into existing storm inlets

Conclusion

The June 12 flood event is a rare event, a fact supported by nearly every personal account of the storm: "I've never seen anything like this". The rainfall data supports that conclusion – there is no apparent record of a spring season of prolonged precipitation across the watershed, culminating in two storms dropping more than 1-inch of rainfall within a 12 hour period. The City of Cherry Hills Village and its residents experienced some horrible damages to personal property during this event. Extraordinary statistical markers are no consolation for the impacts of flood damages to personal keepsakes and irreplaceable heirlooms. Those distinct impacts from this flood event combined with the effects on regional travel, access to the Village Center, and other flood damage reports across the City lead to a need for additional study, prioritization of mitigation policies and procedures, and continued coordination with other agencies in the Little Dry Creek watershed.

Additional Information

Digital photos, videos, and other documentation is available in the City files.

F. Irrigation and Tree Plans

a. Short-Term Maintenance

The most critical element of tree planting success is the establishment of a healthy root system. There are several things that should be done to encourage vigorous root growth in the first few years. As well, during the first 5 years trees should be protected from insect pests that favor stressed, establishing trees. Finally, winter care for the trees is critical to allow for long and sustained healthy growth and establishment. The recommendations for care of the newly planted trees are outlined below.

At the time of planting, planting holes should be dug 2-3 times the width of the root ball and to a depth approximately 1" less than the depth of the root ball. Trees should have root stimulator added as well as a slow releasing nitrogen fertilizer which will not damage young fibrous roots or encourage rapid growth. The trees should be staked for support with 1-3 stakes per tree depending upon the size of the tree being planted. The area under the drip line of the tree should be mulched to a depth of 3" to help hold moisture in the soil and to reduce soil temperatures during the summer months. Depending on the time of year that planting is being done and the species being planted, it may be necessary to treat trees for prevention of certain insects. This would be an additional charge which cannot be calculated currently.

Irrigation should be added to the new trees to supply a consistent amount of water at regular intervals. Water is the most critical factor along the Front Range of Colorado and lack of water is a critical factor in the need for this project. All costs above, excluding the addition of irrigation are included in the costs quoted for planting. Trees should also be watered throughout the winter months to encourage root development. This should be done at least once per month but given how dry our winters have been recently, twice per month may be necessary. Depending on the time of year that planting is being done and the species being planted, it may be necessary to treat trees for prevention of certain insects. This would be an additional charge which cannot be calculated currently.

<u>Planting and Year 1:</u>
- Install trees
- Add root stimulator and Arbor Green Pro tree fertilizer
- Add irrigation
- Mulch root systems
- Stake trees for support
- Treat trees if necessary for insect prevention
- Winter water at least monthly

<u>Year 2:</u>
- Remove stakes from trees between 1 and 2 years in the ground
- Continue winter watering at least once per month
- Activate irrigation system and check for adequate moisture to trees (April)
- Treat trees if needed for insect prevention (Ash/Lilac Borer, Ips Beetle) ($8.00/tree)
- Fertilize trees with injection of Arbor Green Pro tree fertilizer ($6.00-$7.00/tree)
- Remove fine deadwood if needed
- Refresh mulch if needed
- Winterize sprinkler system
- Winter water at least once per month

<u>Years 3 - 5:</u>
- Continue winter watering at least once per month
- Activate irrigation system and check for adequate moisture to trees (April)
- Increase watering times slightly to compensate for growth of trees annually
- Treat trees if needed for insect prevention
- Fertilize trees with injection of Arbor Green Pro tree fertilizer
- Remove fine deadwood if needed
- Refresh mulch if needed
- Winterize sprinkler system

- Winter water at least once per month

b. Long-Term Maintenance

It is assumed at this point that tree establishment has occurred, but the trees will continue to require specific maintenance to keep them healthy and viable for generations to come. Long-term maintenance is difficult to predict with certainty but below is a list of potential maintenance needs after the trees have been in the ground for 5 years. Most of these services can be performed by the City of Cherry Hills Village.

- Assess the overall condition of all trees after new growth has occurred and quarterly after that each year (inspection fee will apply or can be completed by The City of Cherry Hills Village)
- Increase the amount of water being supplied to the trees by the irrigation system but reduce the frequency of that watering
- Broaden the mulch rings around the trees to the drip line of the trees
- Perform structural pruning as needed to develop a healthy crown formation for the future (will be quoted at the time or can be performed by The City of Cherry Hills Village)
- Continue annual deep root fertilization regiment with Arbor Green Pro tree fertilizer ($8.00/tree)
- Continue necessary insect prevention strategies and adjust as needed for new insect pests
- Inoculate the root systems of the trees with a starch-based polymer to increase the ability of the soil to hold moisture. (Every 3 years at $8.00/tree)
- Reduce winter watering to no more than once per month except in cases of trees that are known to be struggling.
- Begin complete crown cleaning pruning between years 8 and 10 and continue this program every 5 years or as needed.

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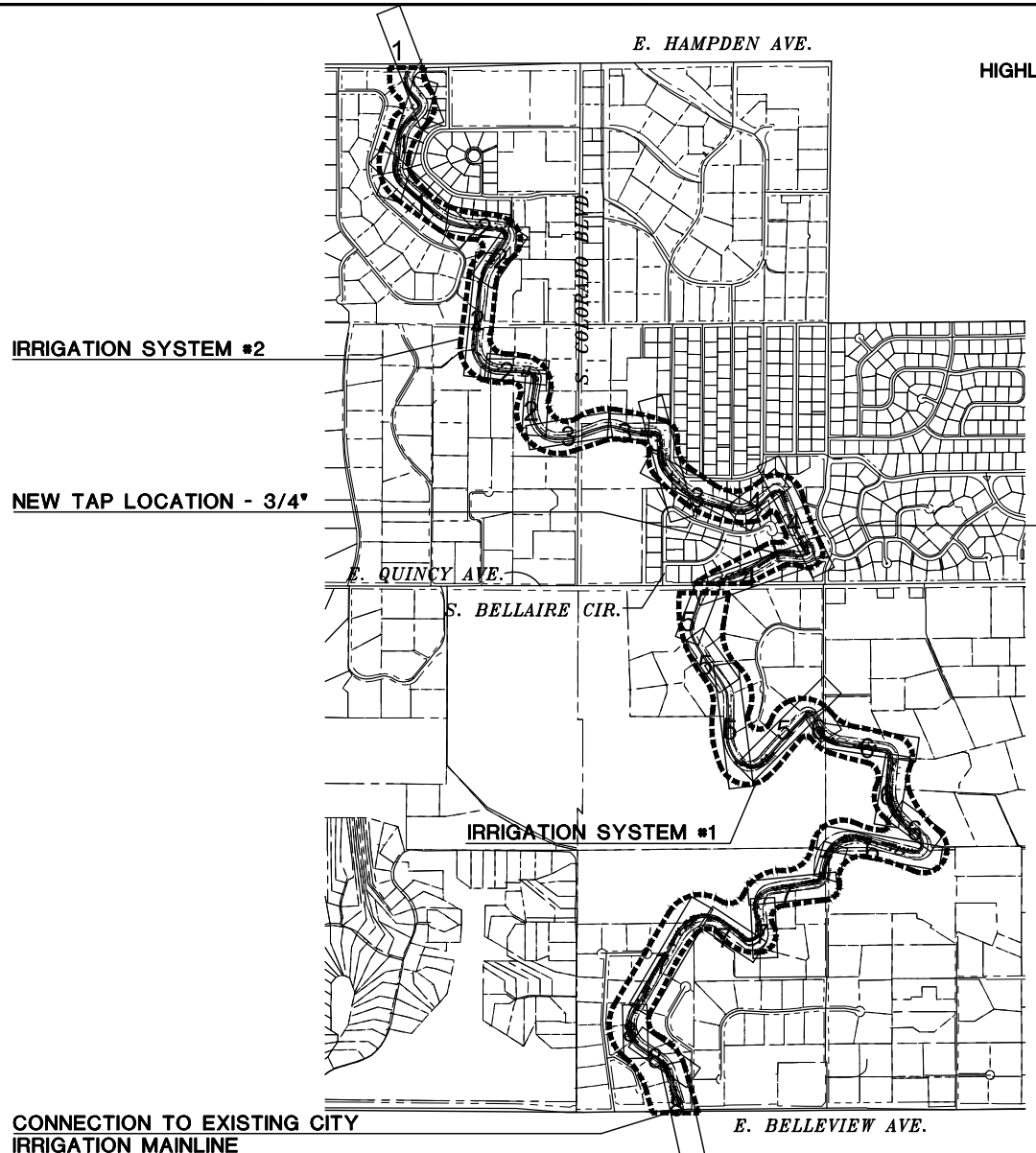
HIGHLINE CANAL TREE PLANTING PROJECT

City of Cherry Hills Village
2450 East Quincy Ave.
Cherry Hills Village, Colorado 80113
Contact: Ryan Berninzoni
Parks, Trails and Recreation Administration
Ph. 303-789-2541



Irrigation Construction Notes

1. ALL BASE INFORMATION HAS BEEN TAKEN FROM DRAWINGS PREPARED BY ICON ENGINEERING
2. REFER TO TECHNICAL SPECIFICATIONS AND CONSTRUCTION DETAILS FOR INSTALLATION PROCEDURES.
3. CONTRACTOR SHALL FIELD VERIFY PRESSURE AT BACKFLOW PREVENTER LOCATION FOR EACH TAP PRIOR TO ORDERING MATERIALS OR STARTING ANY IRRIGATION INSTALLATION AND NOTIFY CONSULTANT OF ANY DIFFERENCES FROM STATED PRESSURE. IF CONTRACTOR FAILS TO NOTIFY CONSULTANT HE ASSUMES FULL RESPONSIBILITY FOR ANY SYSTEM ALTERATIONS. EACH SYSTEM HAS BEEN DESIGNED FOR A STATIC PRESSURE OF 56-62 PSI.

TAP LOCATION/P.O.C. NUMBER	REQUIRED PRESSURE
TAP LOCATION #1	54 PSI
2	xx PSI

4. CONTRACTOR SHALL COORDINATE INSTALLATION OF SLEEVING WITH INSTALLATION OF CONCRETE FLATWORK AND PAVING. ALL SLEEVING IS BY CONTRACTOR UNLESS OTHERWISE NOTED; UNLESS NOTED OTHERWISE ON IRRIGATION PLANS INSTALL SLEEVING BASED ON SLEEVE SIZING GUIDE BELOW:

PIPE SIZE OR WIRE QUANTITY	REQUIRED SLEEVE
1" PIPING	1-2" PVC SLEEVE
1-1/2" - 2" PIPING	1-4" PVC SLEEVE
2-1/2" -PIPING	1-6" PVC SLEEVE

NOTE: EACH LENGTH OF SLEEVED PIPE SHOWN SHALL BE ROUTED THROUGH SEPARATE SLEEVE. IRRIGATION WIRE BUNDLE SHALL BE ROUTED IN SEPARATE SLEEVE/CONDUIT WITHOUT IRRIGATION PIPING

5. REFER TO PLANTING PLAN FOR EXACT TREE LOCATIONS AND QUANTITIES. TREES SHOWN ON IRRIGATION PLANS ARE APPROXIMATE.
6. VALVE BOXES SHALL BE LOCATED48" MINIMUM FROM CENTERLINE OF ALL SWALES, 48" MINIMUM FROM EDGES OF TRAIL.

NORTH

0 600' 1200'

No.	DATE	REVISIONS	RSA APPR.

PROJECT # 12-007-030-415

PLAN	
DRAWN	DCZ
DESIGNED	DCZ
CHECKED	DCZ

UTILITIES	
RESEARCHED	N/A
DRAWN	N/A
CHECKED	N/A

Avocet IRRIGATION DESIGN
7114 W. JEFFERSON AVENUE, SUITE 201
LAKEWOOD, COLORADO 80235
VOICE: 303.986.2175
FAX: 303.988.5814

ICON ENGINEERING, INC.
8100 South Akron Street, Suite 300, Centennial, CO 80112
Phone (303) 221-0802 / Fax (303) 221-4019
WWW.ICONENG.COM

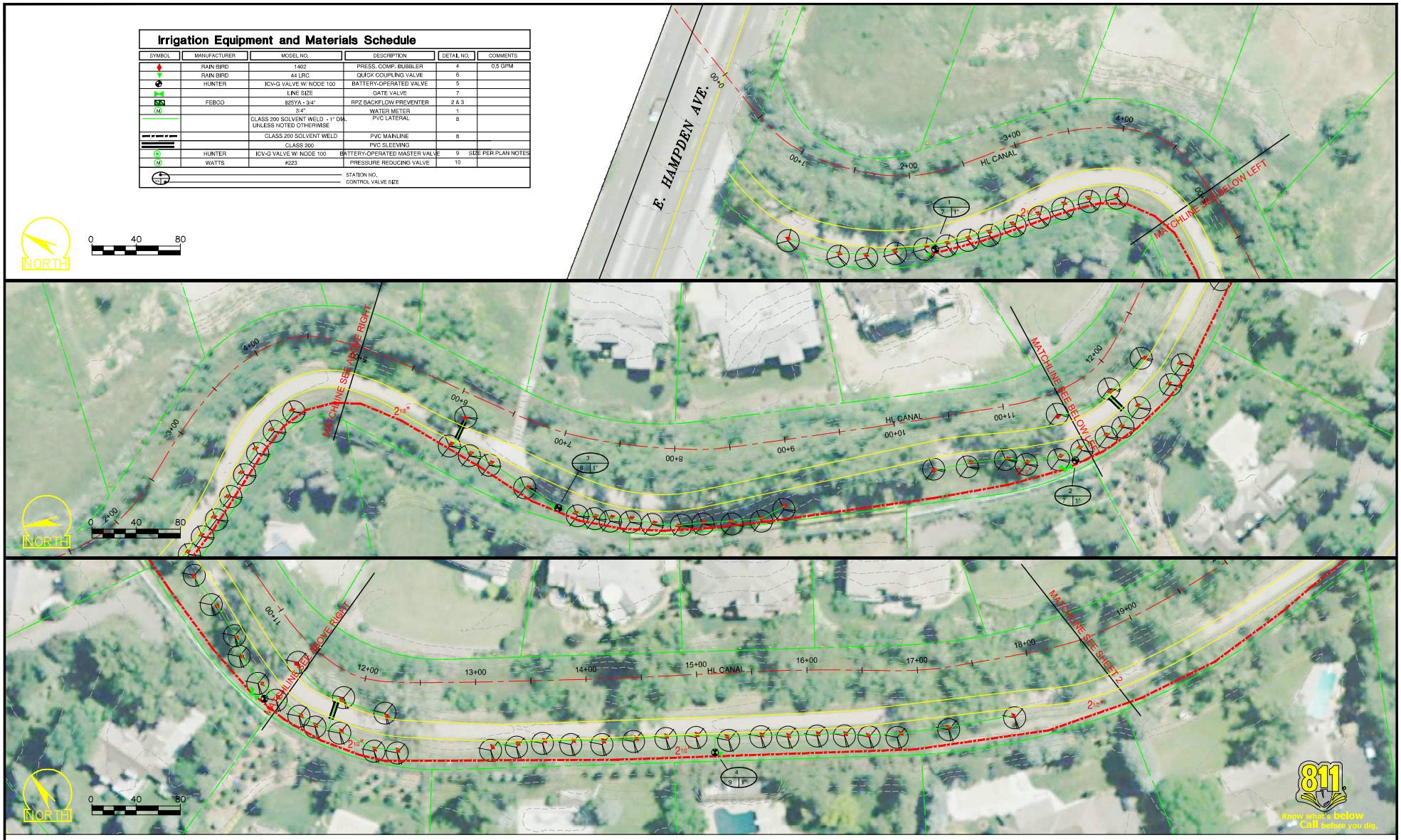
CITY OF CHERRY HILLS VILLAGE
HIGH LINE CANAL IRRIGATION
PLAN

DATE
DEC 2012

SHEET INDEX

Irrigation Equipment and Materials Schedule

SYMBOL	MANUFACTURER	MODEL NO.	DESCRIPTION	DETAIL NO.	COMMENTS
	RAIN BIRD	1402	PRESS. COMP. BUBBLER	4	0.5 GPM
	RAIN BIRD	44 LRC	QUICK COUPLING VALVE	6	
	HUNTER	ICV-G VALVE W/ NODE 100	BATTERY-OPERATED VALVE	5	
		LINE SIZE	GATE VALVE	7	
	FEBCO	825YA - 3/4"	RPZ BACKFLOW PREVENTER	2 & 3	
M		3/4"	WATER METER	1	
		CLASS 200 SOLVENT WELD - 1" DIA. UNLESS NOTED OTHERWISE	PVC LATERAL	8	
		CLASS 200 SOLVENT WELD	PVC MAINLINE	8	
		CLASS 200	PVC SLEEVING		
	HUNTER	ICV-G VALVE W/ NODE 100	BATTERY-OPERATED MASTER VALVE	9	SIZE PER PLAN NOTES
M	WATTS	#223	PRESSURE REDUCING VALVE	10	
			STATION NO. CONTROL VALVE SIZE		



No.	DATE	REVISIONS	R5A APPR.

PROJECT # 12-007-030-415

PLAN	
DRAWN	DCZ
DESIGNED	DCZ
CHECKED	DCZ

UTILITIES	
RESEARCHED	N/A
DRAWN	N/A
CHECKED	N/A

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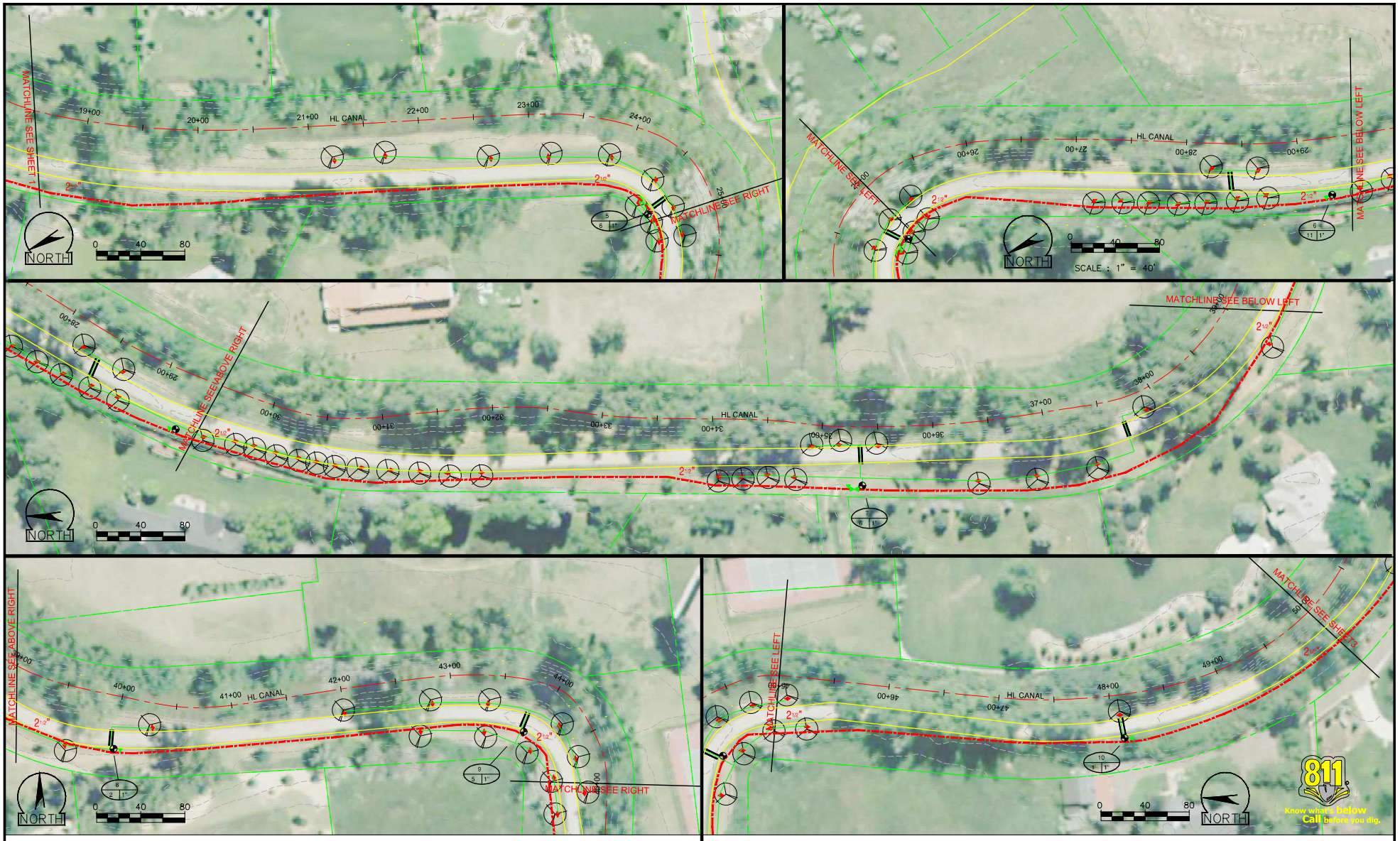
CITY OF CHERRY HILLS VILLAGE
HIGH LINE CANAL IRRIGATION
PLAN

DATE
DEC 2012

SHEET
1

811 Know what's below. Call before you dig.



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PLAN	
DRAWN	DCZ
DESIGNED	DCZ
CHECKED	DCZ

UTILITIES	
RESEARCHED	N/A
DRAWN	N/A
CHECKED	N/A

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IRRIGATION DESIGN
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LAKEWOOD, COLORADO 80235
VOICE: 303.986.2175
FAX: 303.989.5814

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PLAN

DATE
DEC 2012

SHEET
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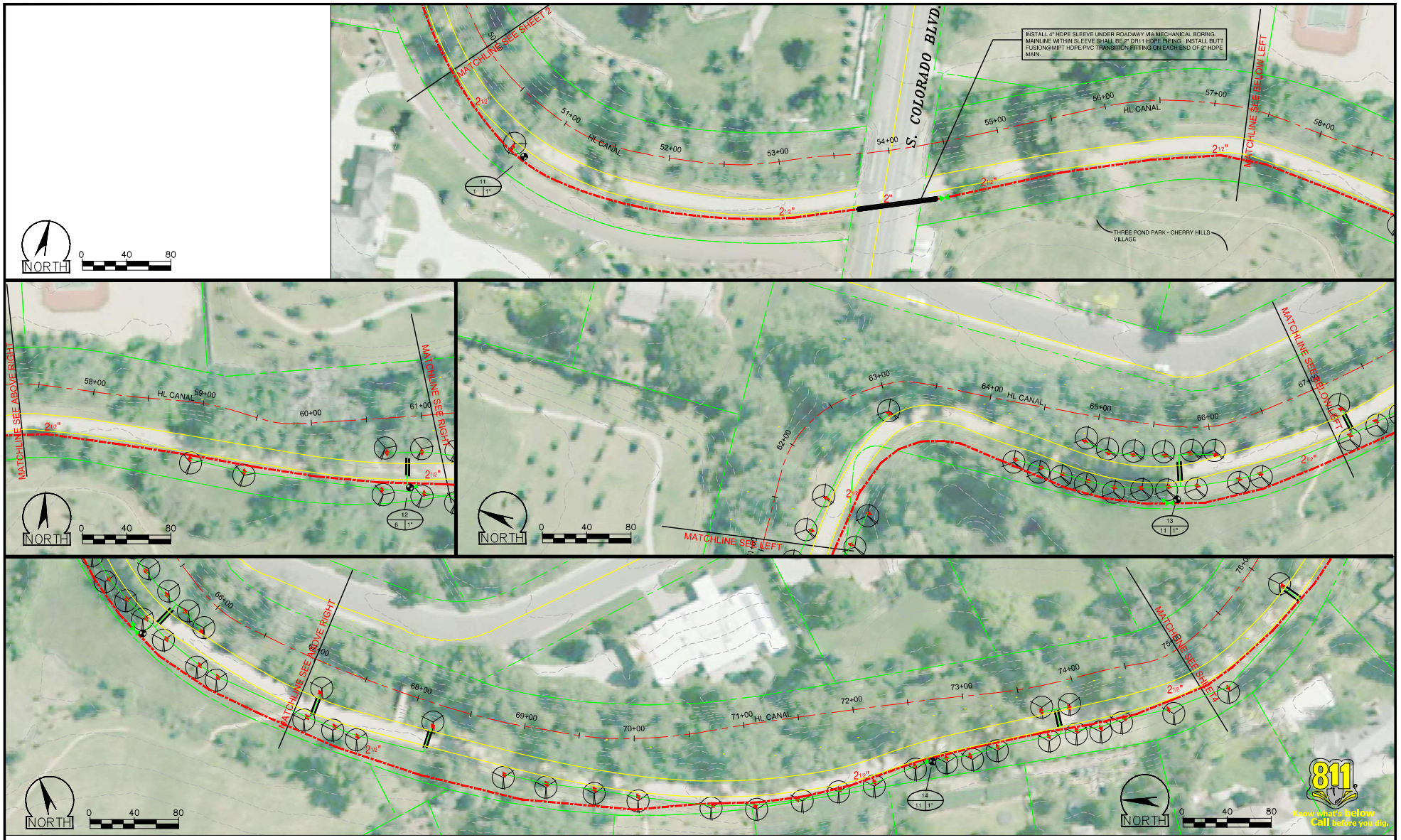

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PLAN	
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DESIGNED	DCZ
CHECKED	DCZ

UTILITIES	
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DRAWN	N/A
CHECKED	N/A

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4

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PLAN
DRAWN DCZ
DESIGNED DCZ
CHECKED DCZ

UTILITIES
RESEARCHED N/A
DRAWN N/A
CHECKED N/A

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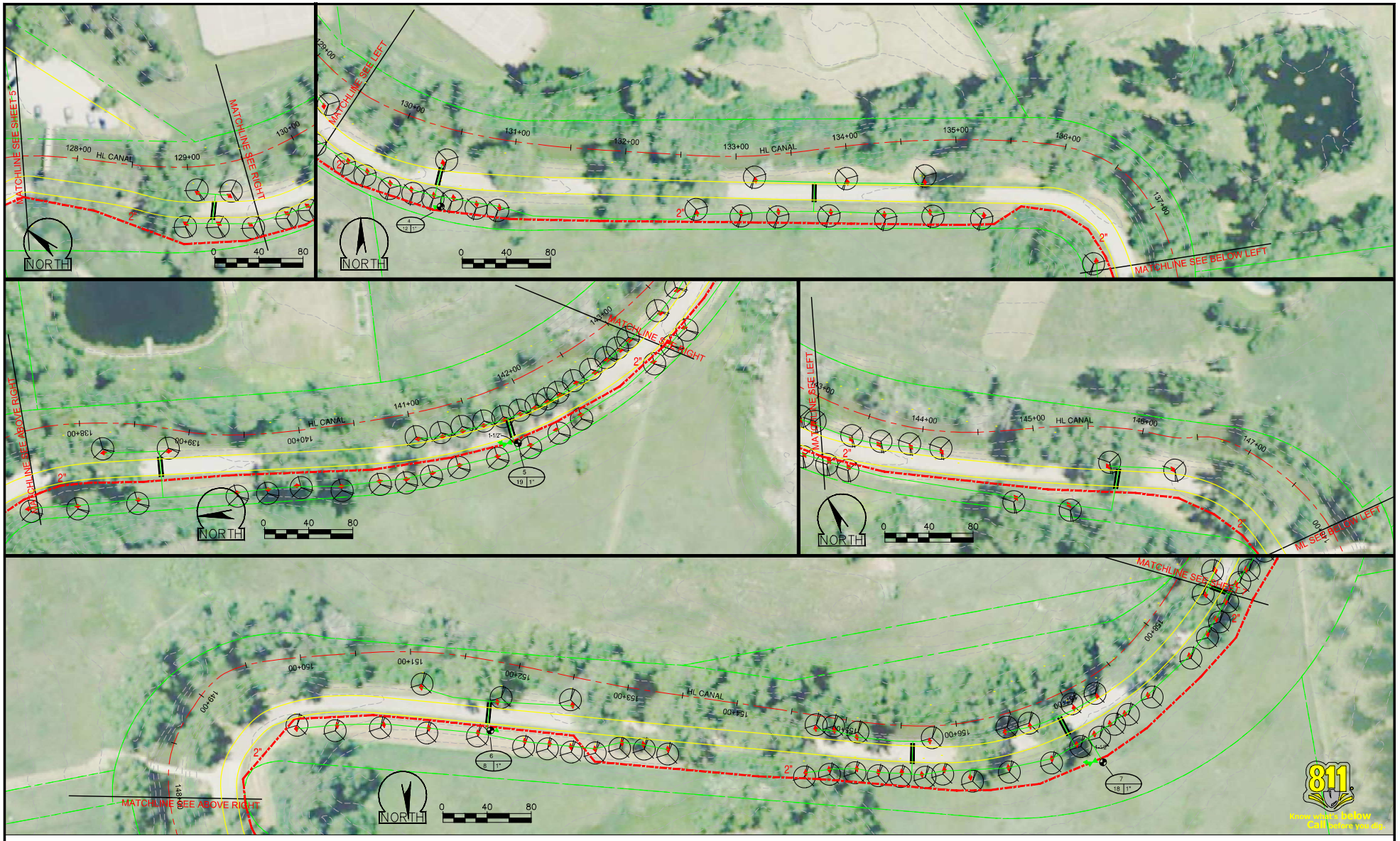
5



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CHECKED	DCZ

UTILITIES	
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CHECKED	N/A

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PLAN

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SHEET
6

No.	DATE	REVISIONS	RSA APPR.

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PLAN	
DRAWN	DCZ
DESIGNED	DCZ
CHECKED	DCZ

UTILITIES	
RESEARCHED	N/A
DRAWN	N/A
CHECKED	N/A

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DEC 2012

SHEET
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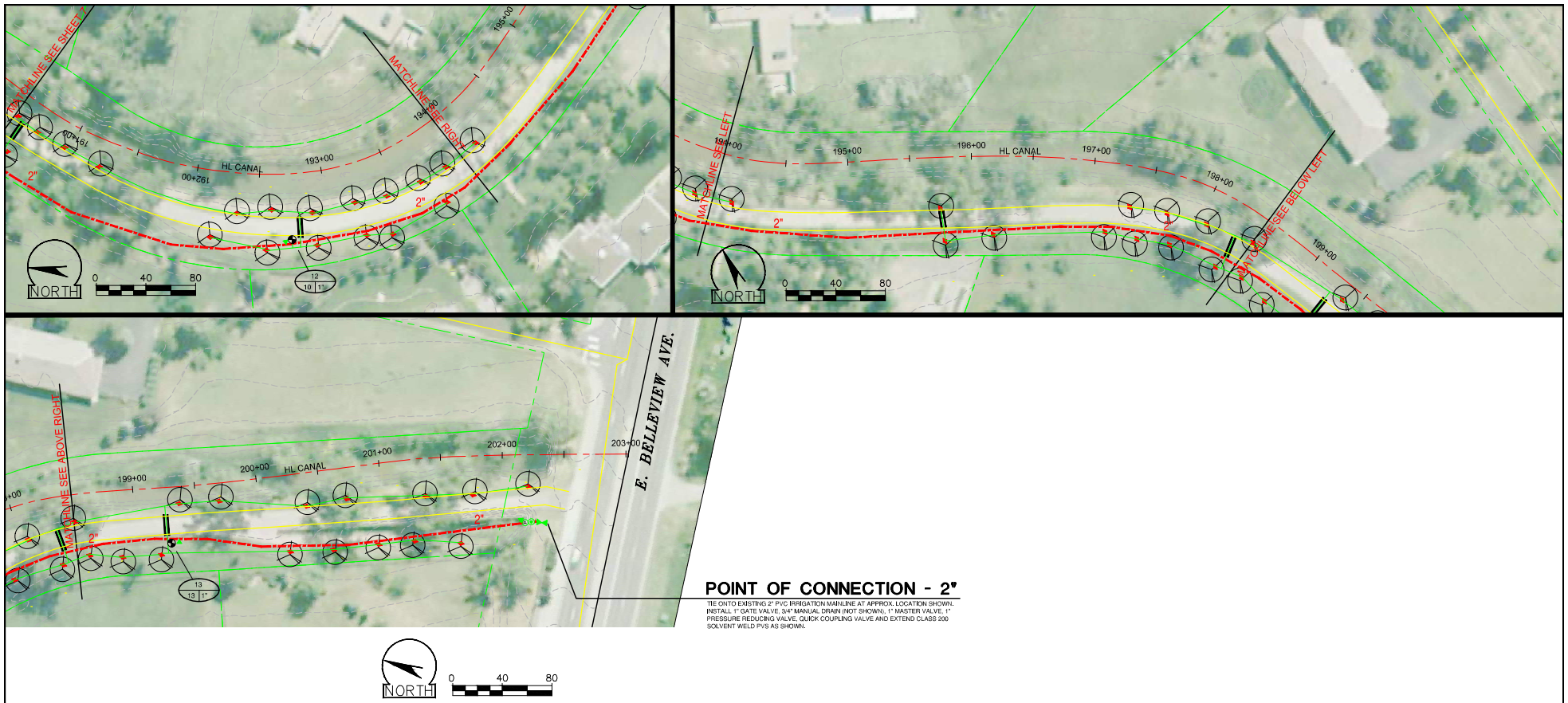

POINT OF CONNECTION - 2"

TIE ONTO EXISTING 2" PVC IRRIGATION MAINLINE AT APPROX. LOCATION SHOWN. INSTALL 1" GATE VALVE, 3/4" MANUAL DRAIN (NOT SHOWN), 1" MASTER VALVE, 1" PRESSURE REDUCING VALVE, QUICK COUPLING VALVE AND EXTEND CLASS 200 SOLVENT WELD PVS AS SHOWN.

Know what's **below** **Call** before you dig.

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CHECKED	DCZ

UTILITIES	
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DRAWN	N/A
CHECKED	N/A

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PLAN

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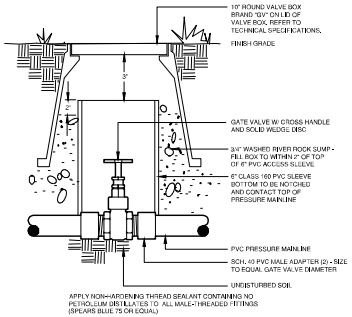
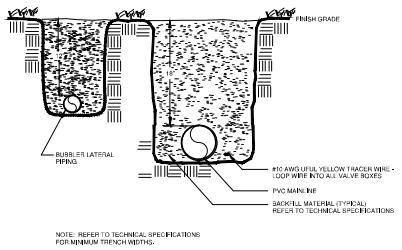
8

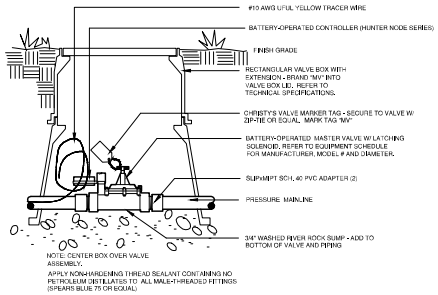


GATE VALVE 7



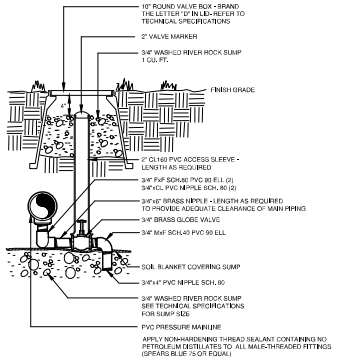
NOTE: REFER TO TECHNICAL SPECIFICATIONS
FOR MINIMUM TRENCH WIDTHS.

TRENCH 8

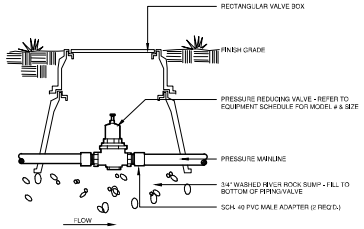


NOTE: CENTER BOX OVER VALVE
ASSEMBLY.
APPLY NON-HARDENING THREAD SEALANT CONTAINING NO
PETROLEUM DISTILLATES TO ALL MALE-THREADED FITTINGS
(SPEARS BLUE 75 OR EQUAL)

BATTERY-OPERATED MASTER VALVE 9



MANUAL DRAIN VALVE 10



NOTE: CENTER VALVE WITHIN VALVE BOX.
VALVE IS NOT TO BE EQUIPPED WITH INTEGRAL STRAINER
APPLY NON-HARDENING THREAD SEALANT CONTAINING NO
PETROLEUM DISTILLATES TO ALL MALE-THREADED FITTINGS
(SPEARS BLUE 75 OR EQUAL)

PRESSURE REDUCING VALVE 10

P.O.C. #2 LOCATION ONLY

No.	DATE	REVISIONS	RSA APPR.

PROJECT # 12-007-030-415

PLAN	
DRAWN	DCZ
DESIGNED	DCZ
CHECKED	DCZ

UTILITIES	
RESEARCHED	N/A
DRAWN	N/A
CHECKED	N/A

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CITY OF CHERRY HILLS VILLAGE
HIGH LINE CANAL IRRIGATION
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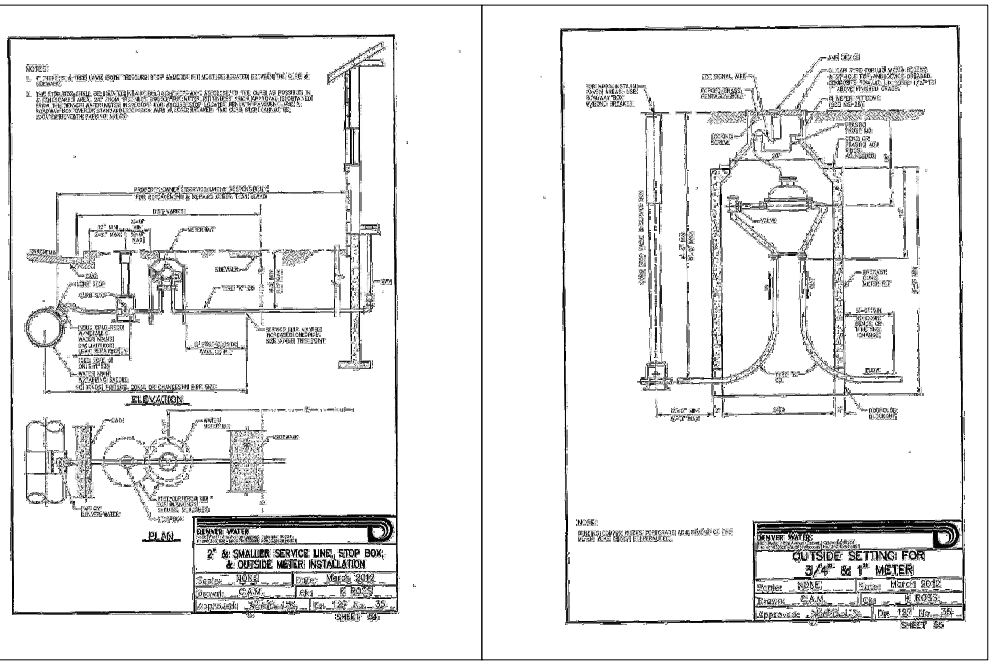

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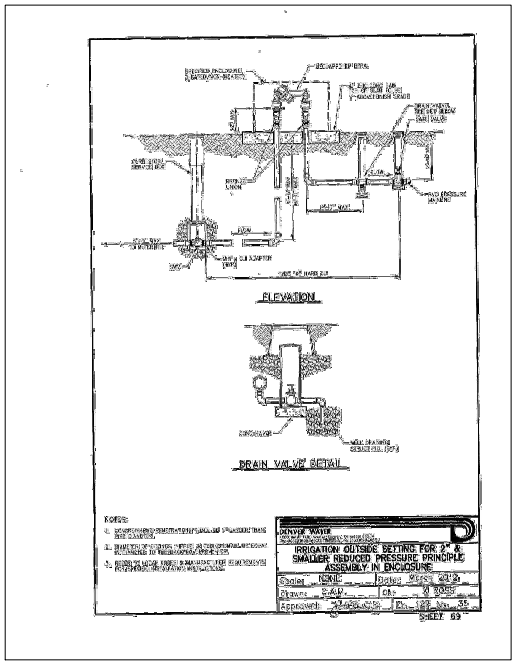
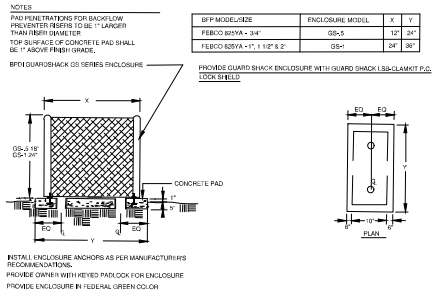
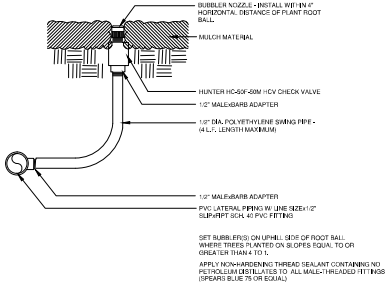


BACKFLOW PREVENTER 2

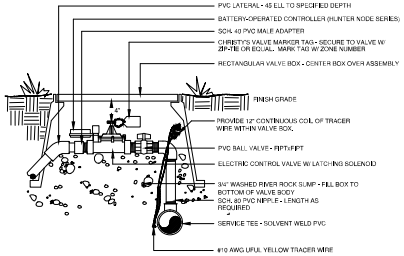


BFP MODEL/SIZE	ENCLOSURE MODEL	X	Y
FEBCO 825YA - 3/4"	GS-5	12"	24"
FEBCO 825YA - 1", 1 1/2" & 2"	GS-1	24"	36"

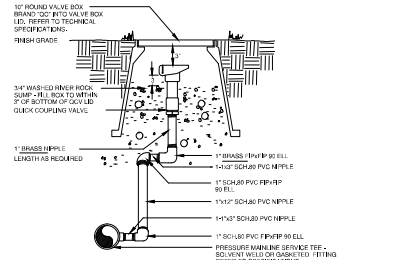
BACKFLOW ENCLOSURE 3



BUBBLER 4



BATTERY-OPERATED VALVE 5



QUICK COUPLING VALVE 6

No.	DATE	REVISIONS	RSA APPR.

PROJECT # 12-007-030-415

PLAN: DRAWN DCZ, DESIGNED DCZ, CHECKED DCZ

UTILITIES: RESEARCHED N/A, DRAWN N/A, CHECKED N/A

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LAKEWOOD, COLORADO 80235
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CITY OF CHERRY HILLS VILLAGE
HIGH LINE CANAL IRRIGATION
DETAILS

DATE DEC 2012

SHEET 9

DAVEY®
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High Line Tree Planting Plan

The City of Cherry Hills Village

Denver West
303-750-YARD (9273)
303-761-3052 • 303-761-3089 Fax
4450 S. Windermere St. • Englewood, CO 80110

Table of Contents

Denver West
303-750-YARD (9273)
303-761-3052 ● 303-761-3089 Fax
4450 S. Windermere St. ● Englewood, CO 80110

The High Line Canal is a critical part of the outdoor recreation opportunities within the city of Cherry Hills Village. The master plan for the City of Cherry Hills Village states that, "The goal is to increase and protect the amount of Village owned open space and identify and protect key scenic treasures." The High Line Canal is most definitely a scenic treasure which the city will continue investing in and improving.

Currently, the High Line Canal tree canopy is in a state of decline due in large part to two major factors. First and foremost, the tree canopy is made up predominantly of large Plains Cottonwood trees which are nearing the end of their useful life expectancy. Secondly, drought conditions over the past decade have caused significant decline in the overall health of these large and majestic trees. Many of these trees are currently viewed as hazardous to the health and safety of the general public who use the High Line Canal recreationally.

While there are many younger trees which have begun to grow underneath the existing larger tree canopy, many of these trees are also showing decline symptoms due to drought such as slow growth rates, smaller than expected leaves, leaf scorch and premature defoliation. The canal is well vegetated with shrubbery. This shrubbery is mainly along the canal itself rather than along both sides of the High Line Canal Trail.

The High Line Canal is included in the Colorado Historical Trail Registry. Due to this significant historical value, ensuring that the area continues to thrive is of the utmost importance to the city of Cherry Hills Village. The experience of walking or biking along the canal would be greatly enhanced by the introduction of new plant material along both sides of the trail. Additionally, the health and safety of the general public would be increased by the removal or pruning of currently hazardous trees.

It is the goal of the City of Cherry Hills Village to not only protect this scenic treasure, but also improve upon it into the future. With the current deteriorating tree canopy along the High Line Canal, planning for the future is a must to preserve the vegetation and wildlife. The plan provided analyzes the current tree canopy as well as provides recommendations for maintenance of the current canopy. Additionally, the plan provides recommendations for new tree plantings and their maintenance in the short and long term.

The High Line Canal corridor through Cherry Hills Village is a scenic and peaceful place that large numbers of the general public use for outdoor recreation such as walking, running and biking. The canal trail is lined heavily on the canal side with many different species of plants. The dominant plant lining the trail is the native Plains Cottonwood. This is followed by Willow. These two dominant species are generally in a state of rapid decline. The canal side of the trail does have large amounts of understory plants as well. These are comprised of several varieties of trees and shrubs which have volunteered from seed along the canal over many years.

The largest issue facing the future of the canal trail is the seriously declining over story tree canopy. These trees have reached their useful life span in most cases and are now not only becoming aesthetically displeasing but also hazardous. A critical component of outdoor recreation is the ability to maintain a high level of safety for the intended users. It is the view of the City of Cherry Hills Village that safety is and always should be of the utmost importance when it comes to providing outdoor recreation opportunities.

Step one in this process was to physically inventory and map the locations of existing plant material along the canal trail. This will act as the overall beginning point for the recommendations herein. By having a good understanding of current conditions, we can create a very accurate plan for creating the High Line Canal Trail of the future. Since we know that a large percentage of the aged and declining trees along the trail cannot be counted on in the future, we can plan for their eventual removal and replacement in a proactive way.

This approach has created four categories of recommendations to be made for the existing trees. First, there are many trees which should be removed. Second, there are trees which have declined but should have several years of useful life left. These trees were recommended for Safety Pruning. Third, are trees which are younger, more vigorous and capable of significant life expectancy. These trees were recommended for full pruning. Finally, the fourth category of trees are those that do not require any maintenance at this time or in the near future. These trees generally are young and in good condition.

In conjunction with the physical inventory and mapping of the canal trail, recommendations were also made for tree planting. This is an integral part of the process for two reasons. First, many trees have been recommended for removal. Replacement of these trees will help to re-create the scenic trail that is The High Line. Second, there are large areas especially along the western side of the trail which currently have no plants. These areas of the trail will be significantly enhanced by adding tree plantings for the future. The locations of plants draw the user's attention and can guide them along the trail. They can and do keep the user focused on the trail and will be a true enhancement for the trail users as they mature.

There are many areas along the canal where vegetation has been removed recently. Many of these areas will naturally return to vegetation either by seed or by regrowth from their stumps. In these situations, planting of new trees is not necessary. However, it should be understood that it could be several years before vegetation has completely rejuvenated.

The strategic goal of The City of Cherry Hills Village is to meet specific elements of the Arapahoe County Open Space Master Plan. The master plan talks about preservation of Riparian Corridors as well as regional trails. As well, the county residents strongly believe in preserving open space and protecting wildlife habitat and corridors. Finally, Denver Water believes that the High Line Canal tree canopy is an important recreational and aesthetic feature of the metro region deserving of preservation and enhancement.

The recommendations herein should be considered to be a road map with the end goal of significant enhancements to the safety, beauty and longevity of the High Line Canal Trail and tree canopy. There are many steps to be undertaken but the long-term goals are certainly attainable and sustainable. The steps in the process are outlined below.

It should be noted that planting of new trees can be started along the west side of the trail immediately. However, planting along the canal side of the trail should be done after tree removal and pruning work is completed so that new trees are not damaged in the process.

First and foremost, safety of the canal trail users is critical. To that end, it is deemed most important to remove trees which are hazardous due to general decline, lack of maintenance, structural defects or significant trunk lean. These trees have been inventoried, mapped and cost projected for immediate removal. The stumps of these trees have not been recommended for removal as many are inaccessible. In specific cases, stumps can be removed at the request of the City, the County or Denver Water and pricing can be provided at that time.

Second, trees that are recommended for safety pruning should be addressed. These again are trees that pose hazards to the public users of the trail. These trees have been inventoried, mapped and cost projected as well for immediate pruning.

Third, routine pruning of those trees which do not pose hazards should be performed. It is less likely that this work will damage the understory plants or new plantings. For that reason, new plantings can be placed along the canal side of the trail at the same time.

In conjunction with all of this work, the City of Cherry Hills Village is committed to supplying adequate water to all of the new plantings recommended for the canal trail. A permanent irrigation system to supply water to the trees is the best way to perform the watering which will be necessary for healthy plant establishment. Large numbers of new plantings can be watered by utilizing drip irrigation.

The High Line Canal is owned and operated by Denver Water. Therefore, obtaining input, direction and acceptance for this project is imperative for producing the results desired by the city of Cherry Hills Village. The tree planting plan herein utilizes the "High Line Canal Approved Tree and Shrub Species" list supplied by Denver Water, the Trees Across Colorado tree list which the City of Cherry Hills Village is currently utilizing for homeowners as well as a few additional species which can increase the beauty of the canal trail during spring and fall. These trees are very commonly planted along the Front Range of Colorado and should perform well along the canal trial while adding aesthetic value.

The tree planting recommendations take into account several factors. These factors include the size of the area to be planted in, the surrounding vegetation, the size of the mature plant and actual characteristics of the trees themselves. It should be noted that homeowner views were considered heavily as mountain views are important to the properties which line the High Line Canal and that view should not be impeded by tree plantings now or in the future.

There are twenty-three different species of trees recommended for planting as part of this plan. These trees all have unique characteristics of size, spring flowering, fall color and seed production for wildlife. The trees are a mixture of deciduous trees and evergreen trees. However, in an attempt to reduce maintenance overall, the recommendations heavily favor the deciduous trees to reduce watering needs, especially during the winter months. As well, overall maintenance needs were considered such as insect and disease issues and general pruning needs. Below is a list of the tree types recommended for planting as well as a brief explanation of their characteristics.

Autumn Blaze Maple- Fast growing cross between Silver Maple and Red Maple with orange-red fall color. Tree has a broad, oval head with a mature height of 50' and spread of 40'.

Northern Catalpa- Fast growing tree with large, heart-shaped leaves and white flowers in June. Produces seed pods for wildlife and is very low maintenance. Tree has a broad head with a mature height of 50' and spread of 30'.

Golden Rain Tree- Small to medium tree with interesting leaves, yellow flowers in early summer and yellowish brown seed pods which persist through winter. Tree has a round crown with a mature height of 30' and spread of 25'.

Swamp White Oak- Moderate growth rate but very hardy and performs well in clay soils. Dark green foliage with silvery undersides which turns reddish bronze in fall. Produces acorns for wildlife and matures at a height of 50' and spread of 40'.

Hackberry- Moderate growth rate with yellow-green foliage and interesting corky bark. Mature height of 50' and spread of 40'.

Red Oak- Moderate growth rate with spreading branches and round crown. Produces acorns for wildlife, leaves turn bright red in fall and has a mature height of 50' and spread of 30'.

Kentucky Coffee Tree- Moderate growth rate with an open spreading form and blue/green leaves which turn yellow in fall. Produces seed pods for wildlife and matures at a height of 50' and spread of 50'.

Glenleven Linden- Vigorous grower with a pyramidal crown formation. Matures to a height of 45' and spread of 30'.

Ohio Buckeye- Hardy tree with moderate growth rate. Glossy green leaves divided into 5 leaflets with white flowers in early spring and very interesting spiked green seeds in fall. Matures at a height of 35' and spread of 35'.

Bristlecone Pine: Hardy, slow grower that is very drought tolerant. White speckles on needles have interest and trees is insect and disease resistant. Matures at a height of 30' and spread of 15'.

Tatarian Maple- small tree with moderate growth rate. Yellow fall color and seeds produced for wildlife. Tree matures at a height of 25' and spread of 25'.

Radiant Crabapple- small tree with moderate growth rate. Reddish colored foliage, bright pink flowers and red apples through winter. Matures at a height of 15' and spread of 15'.

European Hornbeam- Narrow growth form and moderate growth rate and yellow fall color. Crown broadens to oval shape as it matures to height of 35' and a spread of 25'.

Canada Red Chokecherry- fast grower with green new growth which turns red as it matures. Produces dark fruits and is very hardy. Matures at a height of 25' and spread of 20'.

Coralburst Crabapple- small tree with moderate growth rate. Beautiful double pink flowers in spring on this dense, compact tree. Matures at a height of 12' and spread of 12'.

Autumn Purple Ash- fast grower with broad rounded crown. Fantastic fall color. Matures at a height of 50' and spread of 50'.

Shademaster locust- fast grower with a broad, rounded crown. This locust does not produce seed pods and matures at a height of 50' and spread of 35'.

Pinion Pine- Compact, slow growing native pine. Blue/green foliage with a nice scent and seeds are used by wildlife and humans. Very low maintenance and drought hardy maturing at a height of 25' and spread of 15'.

Redbud: Small, moderate growing tree with vibrant purplish pink blooms covering the tree in spring. Matures at a height of 10' and spread of 15'.

Newport Plum: Small tree with moderate growth rate and reddish foliage throughout the year and white blossoms in spring. Tree matures at a height of 15' and spread of 10'.

Aristocrat Pear: Vigorous grower with a strong central leader. Produces white flowers in spring and is disease resistant, turning reddish in fall. Matures at a height of 30' and spread of 15'.

Bur Oak: Large tree with moderate growth rate and interesting branching habit. Twigs are corky and tree turns yellow in fall. Matures at a height of 70' and spread of 50'.

Green Ash: (Marshall Seedless) Large tree with rounded symmetrical form with a moderate growth rate and yellow leaves in fall. Tree matures at a height of 50' and spread of 35'.

Short-Term Maintenance: (planting – 5 years) Page

The most critical element of tree planting success is the establishment of a healthy root system. There are several things that should be done to encourage vigorous root growth in the first few years. As well, during the first 5 years trees should be protected from insect pests that favor stressed, establishing trees. Finally, winter care for the trees is critical to allow for long and sustained healthy growth and establishment. The recommendations for care of the newly planted trees are outlined below.

At the time of planting, planting holes should be dug 2-3 times the width of the root ball and to a depth approximately 1" less than the depth of the root ball. Trees should have root stimulator added as well as a slow releasing nitrogen fertilizer which will not damage young fibrous roots or encourage rapid growth. The trees should be staked for support with 1-3 stakes per tree depending upon the size of the tree being planted. The area under the drip line of the tree should be mulched to a depth of 3" to help hold moisture in the soil and to reduce soil temperatures during the summer months. Depending on the time of year that planting is being done and the species being planted, it may be necessary to treat trees for prevention of certain insects. This would be an additional charge which cannot be calculated currently.

Irrigation should be added to the new trees to supply a consistent amount of water at regular intervals. Water is the most critical factor along the Front Range of Colorado and lack of water is a critical factor in the need for this project. All costs above, excluding the addition of irrigation are included in the costs quoted for planting. Trees should also be watered throughout the winter months to encourage root development. This should be done at least once per month but given how dry our winters have been recently, twice per month may be necessary. Depending on the time of year that planting is being done and the species being planted, it may be necessary to treat trees for prevention of certain insects. This would be an additional charge which cannot be calculated currently.

Planting and Year 1:

- Install trees
- Add root stimulator and Arbor Green Pro tree fertilizer
- Add irrigation
- Mulch root systems
- Stake trees for support
- Treat trees if necessary for insect prevention
- Winter water at least monthly

Year 2:

- Remove stakes from trees between 1 and 2 years in the ground
- Continue winter watering at least once per month
- Activate irrigation system and check for adequate moisture to trees (April)
- Treat trees if needed for insect prevention (Ash/Lilac Borer, Ips Beetle) ($8.00/tree)
- Fertilize trees with injection of Arbor Green Pro tree fertilizer ($6.00-$7.00/tree)
- Remove fine deadwood if needed
- Refresh mulch if needed
- Winterize sprinkler system
- Winter water at least once per month

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Years 3 - 5: Page

- Continue winter watering at least once per month
- Activate irrigation system and check for adequate moisture to trees (April)
- Increase watering times slightly to compensate for growth of trees annually
- Treat trees if needed for insect prevention
- Fertilize trees with injection of Arbor Green Pro tree fertilizer
- Remove fine deadwood if needed
- Refresh mulch if needed
- Winterize sprinkler system
- Winter water at least once per month

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Long-Term Maintenance: (5 years and beyond) Page

It is assumed at this point that tree establishment has occurred but the trees will continue to require specific maintenance to keep them healthy and viable for generations to come. Long-term maintenance is difficult to predict with certainty but below is a list of potential maintenance needs after the trees have been in the ground for 5 years. The majority of these services can be performed by the City of Cherry Hills Village.

- Assess the overall condition of all trees after new growth has occurred and quarterly after that each year (inspection fee will apply or can be completed by The City of Cherry Hills Village)
- Increase the amount of water being supplied to the trees by the irrigation system but reduce the frequency of that watering
- Broaden the mulch rings around the trees to the drip line of the trees
- Perform structural pruning as needed to develop a healthy crown formation for the future (will be quoted at the time or can be performed by The City of Cherry Hills Village)
- Continue annual deep root fertilization regiment with Arbor Green Pro tree fertilizer ($8.00/tree)
- Continue necessary insect prevention strategies and make adjustments as needed for new insect pests
- Inoculate the root systems of the trees with a starch based polymer to increase the ability of the soil to hold moisture. (every 3 years at $8.00/tree)
- Reduce winter watering to no more than once per month except in cases of trees that are known to be struggling.
- Begin complete crown cleaning pruning between years 8 and 10 and continue this program every 5 years or as needed.

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