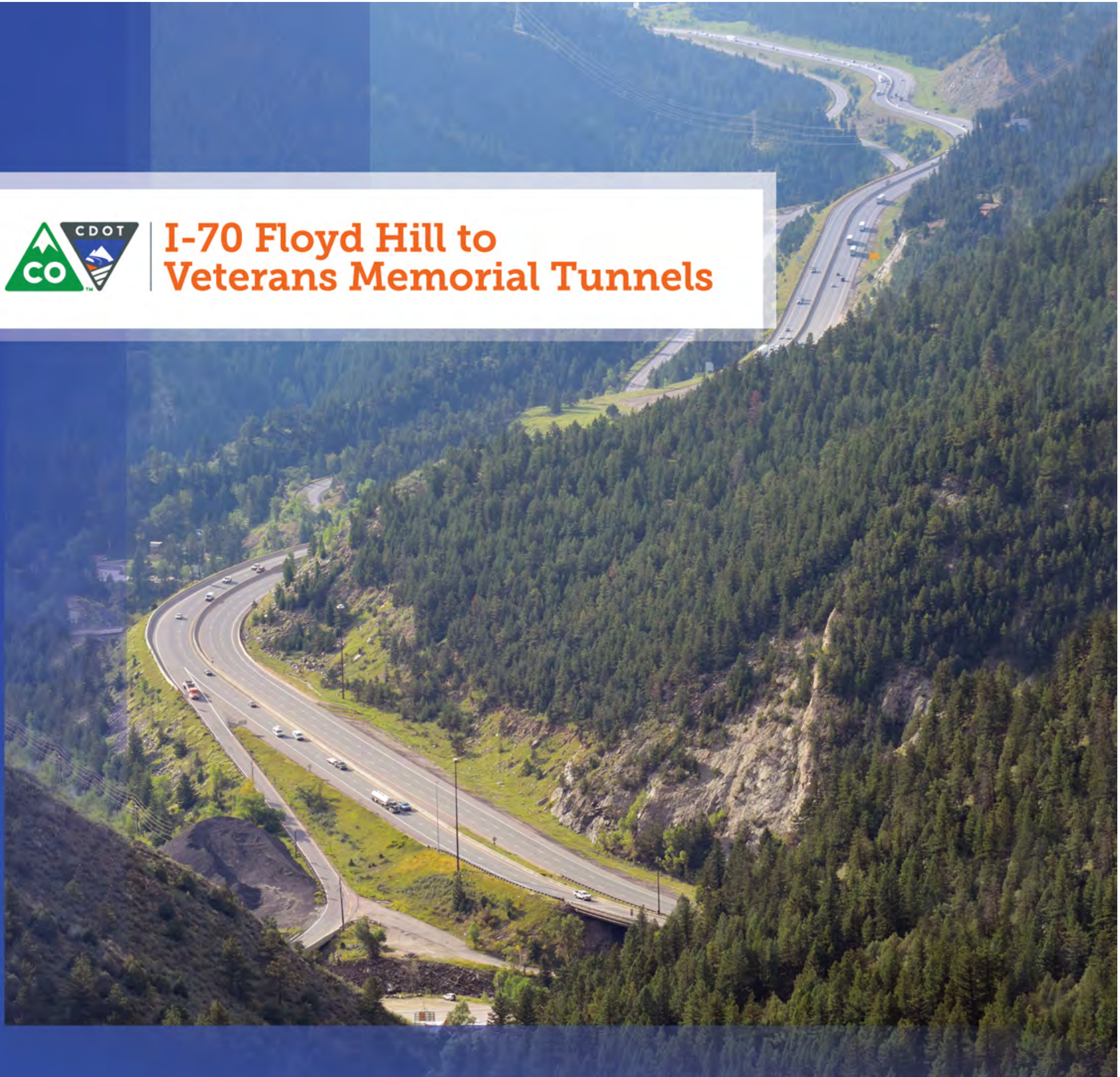
I-70 Floyd Hill to Veterans Memorial Tunnels



Draft Final

20% Drainage and Water Quality Technical Report

August 2020

Revised March 2021

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List of Exhibits

List of Acronyms

ac-ft	acre-feet
BMP	Best Management Practice
CBC	Concrete Box Culvert
CDOT	Colorado Department of Transportation
CDPS	Colorado Discharge Permit System
cfs	cubic feet per second
CMP	Corrugated Metal Pipe
CN	Curve Number
CR 65	County Road 65
CR 314	County Road 314
CUHP	Colorado Urban Hydrograph Program
DDM	Drainage Design Manual
D_{50}	Median Diameter
EA	Environmental Assessment
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
ft	feet
ft/sec	feet per second
HEC	Hydraulic Engineering Center
HEC-RAS	Hydraulic Engineering Center – River Analysis System
HEC-HMS	Hydraulic Engineering Center – Hydrologic Modeling System
HDPE	high-density polyethylene
HGL	Hydraulic Grade Line
HSG	Hydraulic Soil Group
HW/D	headwater to depth ratio
in	inches
in/hr	inches per hour
I-70	Interstate 70
MHFD	Mile High Flood District

min	minute
MP	Milepost
mph	miles per hour
MS4	Municipal Separate Storm Sewer System
NEPA	National Environmental Policy Act
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
ORD	OpenRoads Designer
PEIS	Programmatic Environmental Impact Statement
RCP	reinforced concrete pipe
ROD	Record of Decision
ROW	Right of way
SCAP	Sediment Control Action Plan
SQ	Square
SUDA	Subsurface Utility Design and Analysis
SWEEP	Stream and Wetland Ecological Enhancement Program
SWMM	Stormwater Management Model
US 6	U.S. Highway 6
US 40	U.S. Highway 40
USDCM	Urban Storm Drainage Design Criteria Manual
USGS	U.S. Geological Survey
WQCV	Water Quality Capture Volume

1. Introduction

The Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA), in cooperation with local communities and other agencies, are conducting the Interstate 70 (I-70) Floyd Hill to Veterans Memorial Tunnels Environmental Assessment (EA) Project to advance a portion of the program of improvements for the I-70 Mountain Corridor identified in the 2011 Tier 1 *Final I-70 Mountain Corridor Programmatic Environmental Impact Statement* (PEIS) and approved in the 2011 *I-70 Mountain Corridor Record of Decision* (ROD). The EA is a Tier 2 National Environmental Policy Act (NEPA) process and is supported by resource-specific technical reports.

1.1. Water Resources Scope of Work

The scope of the water resources portion of this Project is to evaluate and develop a 20% design for the two Action Alternatives to reconstruct a portion of I-70 between the Floyd Hill/Beaver Brook exit (Exit 248) and the Veterans Memorial Tunnels. This report is specific to the water resources portion of the Project, including:

- Water Quality
- Drainage analysis and design
- Impact analysis and mitigation measures for Clear Creek

The analysis and design have been broken into separate sections that will be discussed later in the report. These sections include:

- Project History
- Existing Drainage and Water Quality Condition
- Design Criteria
- Proposed Drainage Design
- Water Quality

1.2. Reference Documents

To prepare this report, the following documents were reviewed:

- Colorado Department of Transportation *Drainage Design Manual* (DDM)
- Mile High Flood District (MHFD) *Urban Storm Drainage Criteria Manual* (USDCM)
- Central City *Standards and Specification for Design and Construction*
- Clear Creek County *Roadway Design and Construction Manual*
- CDOT *I-70 Clear Creek Corridor Sediment Control Action Plan*

In addition, as-built drawings were reviewed and are listed in Section 4 Existing Conditions.

2. Proposed Action and Alternatives

2.1. Description of Proposed Action and Alternatives

CDOT and FHWA propose improvements along approximately 8 miles of the I-70 Mountain Corridor from the top of Floyd Hill through the Veterans Memorial Tunnels to the eastern edge of Idaho Springs. The purpose of the Project is to improve travel time reliability, safety, and mobility, and address the deficient infrastructure through this area.

NEPA documents report the major project elements to include:

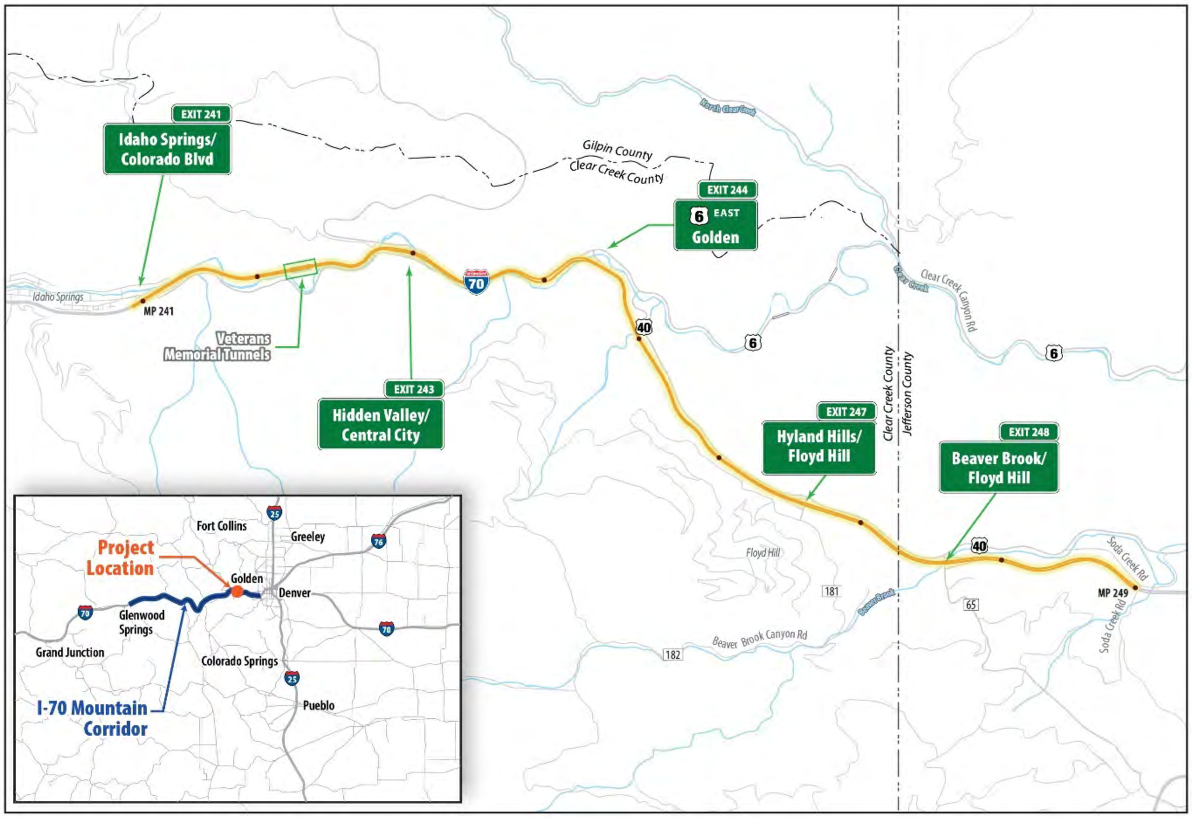
- Adding a third westbound travel lane to the two-lane section of I-70 from the current three-lane to two-lane drop (approximately milepost (MP) 246) through the Veterans Memorial Tunnels
- Constructing a new frontage road between the U.S. Highway 6 (US 6) interchange and the Hidden Valley/Central City interchange
- Improving interchanges and intersections throughout the Project area
- Improving design speeds and stopping sight distance on horizontal curves
- Adding an auxiliary lane to I-70 in the eastbound (uphill) direction of Floyd Hill between the US 6 interchange and the Hyland Hills/Floyd Hill interchange
- Improving the multimodal trail (Clear Creek Greenway) between US 6 and the Veterans Memorial Tunnels
- Reducing animal-vehicle conflicts and improving wildlife connectivity
- Providing two permanent air quality monitors at Floyd Hill and Idaho Springs to collect data on local air quality conditions and trends
- Coordinating rural broadband access with local communities, including providing access to existing/planned conduits and fiber in the interstate right-of-way

Additional major project elements related to hydraulics and water quality include:

- Stream modification to Clear Creek (not listed in major elements of Project)
- Bridge crossing of Sawmill Gulch

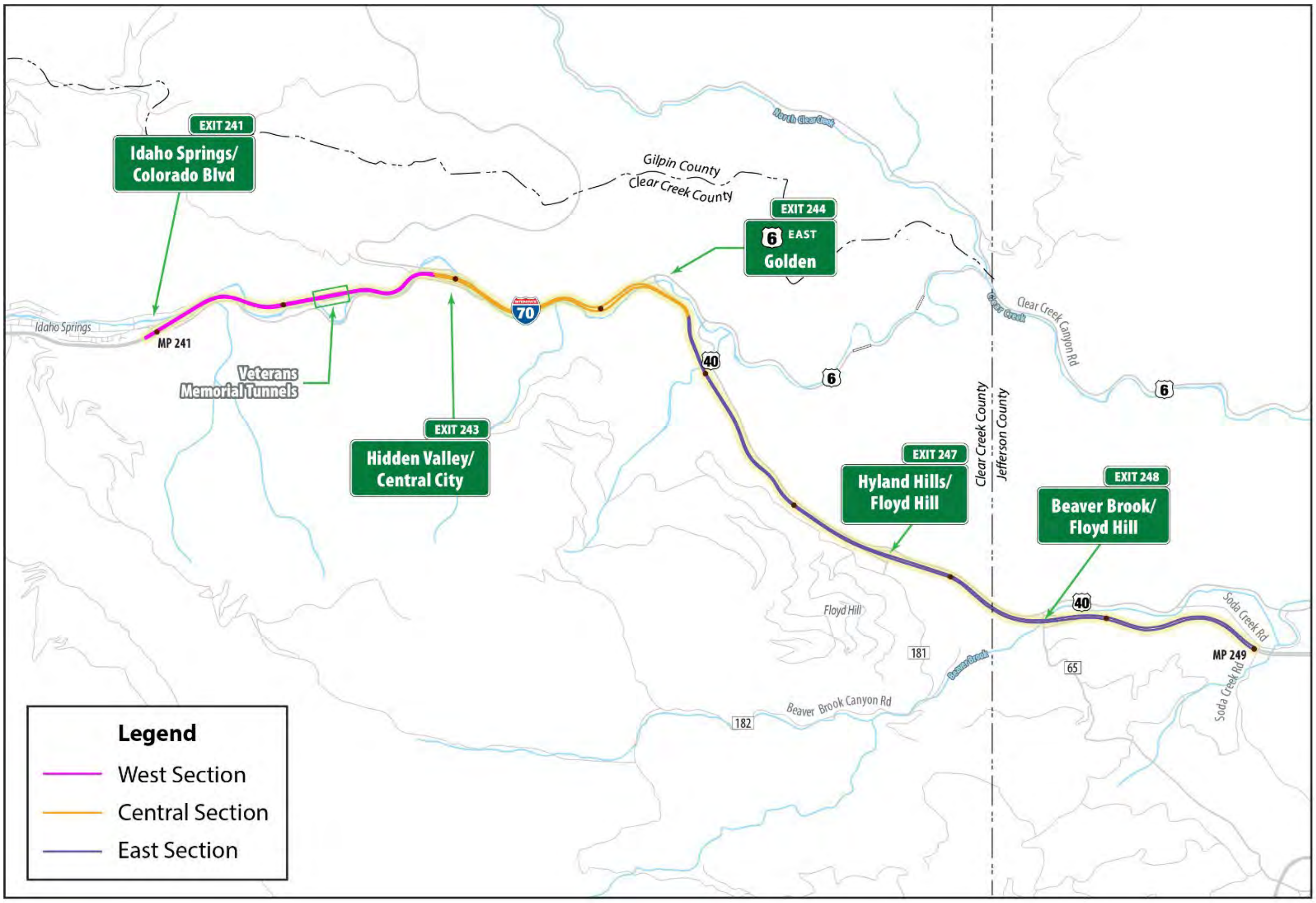
The Project is located on I-70 between MP 249 (east of the Beaver Brook/Floyd Hill interchange) and MP 241 (Idaho Springs/Colorado Boulevard), west of the Veterans Memorial Tunnels. It is located mostly in Clear Creek County, with the eastern end in Jefferson County (see Exhibit 1). The primary roadway construction activities would occur between County Road 65 (CR 65; the Beaver Brook/Floyd Hill interchange) and the western portals of the Veterans Memorial Tunnels (MP 247.6 and MP 242.3, respectively), with the Project area extended east and west to account for signing, striping, and fencing.

Exhibit 1 Project Location



Three alternatives are being evaluated in the EA: (1) No Action Alternative, (2) Tunnel Alternative, and (3) Canyon Viaduct Alternative. The Project improvements are grouped into three geographic sections: (1) East Section (top of Floyd Hill to US 6 interchange), (2) Central Section (US 6 interchange to Hidden Valley/Central City interchange), and (3) West Section (Hidden Valley/Central City interchange through Veterans Memorial Tunnels) (see Exhibit 2).

Exhibit 2 East, Central, and West Project Sections



The Action Alternatives—the Tunnel Alternative and Canyon Viaduct Alternative—include the same improvements in the East Section and West Section to flatten curves, add a third westbound travel lane (new lane would be an Express Lane), provide wildlife and water quality features, and improve interchange/intersection operations.

Through the Central Section between the US 6 interchange and the Hidden Valley/Central City interchange, the Action Alternatives vary in how they provide for the third westbound I-70 travel lane and frontage road connections as follows:

- The **Tunnel Alternative** would realign westbound I-70 to the north (along the curve between MP 244.3 and MP 243.7) through a new 2,200-foot-long tunnel west of US 6. Eastbound I-70 would be realigned within the existing I-70 roadway template to flatten curves to improve design speed and sight distance. The Tunnel Alternative contains two frontage road options as described below
  - o The Frontage Road North option repurposes much of the existing eastbound I-70 alignment for the US-6 frontage road along the north side of Clear Creek. This option is accounted for with the preliminary drainage and water quality design.
  - o The Frontage Road South option would create a US-6 frontage road along the south side of Clear Creek. The preliminary drainage and water quality design does not include the Frontage Road South option.

- The **Canyon Viaduct Alternative** would realign approximately one-half mile of both the westbound and eastbound I-70 lanes (along the curve between MP 244 and MP 243.5) on viaduct structures approximately 400 feet south of the existing I-70 alignment on the south side of Clear Creek Canyon. Through the realigned area, the frontage road would be constructed under the viaduct on the existing I-70 roadway footprint north of Clear Creek. The Clear Creek Greenway would be reconstructed along its current alignment on the south side of Clear Creek, north of the viaduct. The viaduct would cross above Clear Creek and the Clear Creek Greenway twice.

Additional information regarding the alternatives evaluated in the EA can be found in *the I-70 Floyd Hill to Veterans Memorial Tunnels Alternatives Analysis Technical Report* (CDOT, 2020).

3. Project History

The Project design approach was developed based on the CDOT *Drainage Design Manual*. Due to the location of the Project and prior commitments, water quality required specialize attention. The following sections highlight the initial design considerations as well as the relevant information and discussions that changed the design approach. Section 4, *Design Criteria*, documents what the final preliminary design approach is.

3.1. Water Quality and Environmental Considerations

CDOT has entered into a Memorandum of Understanding with various local and national agencies to:

> *"…work together toward the long-term protection of water quality and restoration of wetlands and aquatic resources within the I-70 Mountain Corridor."*

By entering this agreement, CDOT has committed to improve the water quality and stream health of Clear Creek along the I-70 Mountain Corridor.

3.1.1. Municipal Separate Storm Sewer System Discharge Permit

CDOT has been issued a permit to discharge runoff from its Municipal Separate Storm Sewer System (MS4) under the Colorado Discharge Permit System (CDPS). The Project is not within an urban or urbanizing area and, therefore, is not required to adhere to the requirements in the MS4 permit.

3.1.2. Section 303(d) Impaired Waters

The Project crosses or is adjacent to the following streams that are on Regulation 93 Colorado's Section 303(d) List of Impaired Waters and Monitoring and Evaluation List:

- Clear Creek
- Johnson Gulch
- Sawmill Gulch
- Beaver Brook
- Soda Creek

The pollutant of concern in Clear Creek is dissolved cadmium. For Johnson Gulch, Sawmill Gulch, Beaver Brook, and Soda Creek, the roadway pollutants of concern are dissolved cadmium, copper, and zinc.

3.1.3. I-70 Clear Creek Corridor Sediment Control Action Plan

CDOT has teamed up with the local mountain communities and regulatory agencies to develop the *I-70 Clear Creek Corridor Sediment Control Action Plan* (SCAP). The purpose of the SCAP is to document existing concerns with sediment loading derived from I-70 within the Clear Creek Watershed, quantify the sediment loading, and provide possible solutions that can be implemented with future projects along the I-70 Corridor. The SCAP identifies traction sand as the number one source of sediment.

While traction sand was the primary concern in the SCAP, CDOT no longer applies traction sand to the Project corridor during winter months. Instead of traction sand, deicing agents in the form of liquid magnesium chloride solution and solid sodium chloride salt deicers are used.

The SCAP is not a legally binding document. During the preliminary design phase, meetings with the Stream and Wetland Ecological Enhancement Program (SWEEP) committee concluded that the SCAP recommendations for water quality in the Project corridor were not applicable due to the change in winter maintenance activities.

3.1.4. Project Water Quality Approach

The Project Team has taken the recommendation from the SCAP and the SWEEP committee and developed a water quality approach to best satisfy the commitment to improve water quality and stream health of Clear Creek while also creating a solution that is viable for continual maintenance.

CDOT's *National Environmental Policy Act (NEPA) Manual*, provides a decision matrix tree to inform appropriate methods of water quality analysis. This Project results in the Stochastic Empirical Loading and Dilution Model (SELDM) to assess roadway water quality impacts to Clear Creek. The results of SELDM modeling informed the water quality approach, as this project is outside of an MS4 coverage area and has made commitments through the SCAP. The water quality approach, vetted through CDOT and SWEEP committee, for the Project is to design water quality Best Management Practices (BMP) to address the primary pollutant of concern for specific sections of the Project Area. Primary (1) and secondary (2) pollutants of concern for the Project Area are:

- West—(1) Sediment, (2) Metals
- Central—(1) Sediment, (2) Metals
- East—(1) Chloride, (2) Sediment

The West and Central Sections will, where feasible, route all roadway runoff to a water quality pond before discharging to Clear Creek. The Water Environmental & Reuse Foundation's *2016 Best Management Practice Performance Summary Report* indicates that extended detention basins have been shown to remove a moderate amount of sediments and dissolved metals in runoff; therefore, there should be a reduction in the roadway pollutants of concern.

The East Section will route roadway runoff over existing or proposed vegetation and allow for mixing with offsite runoff. Three primary reasons inform the treatment of chloride in the East section:

- Water quality ponds are not highly rated to treat dissolved pollutants such as deicing agents.
- Chloride concentrations can be reduced by diluting the pollutant with additional flow.
- Vegetation offers a limited amount of uptake to reduce chloride concentration.

See Section 6 of this report for design considerations for water quality BMPs. Further details of accepted formal and informal BMPs are documented in meeting notes that can be found in Appendix C. See the *I-70 Floyd Hill SELDM Memo* for more details on SELDM modeling and results.

3.2. Maintenance Consideration

The SCAP identified regular maintenance of the highway corridor as a major factor contributing to discharge of pollutants and sediment into Clear Creek. During the November 9, 2018, Maintenance Meeting with CDOT, the CDOT Maintenance team confirmed that only deicing agents are used along the Project corridor, that traction sand was no longer used.

3.2.1. Current Maintenance Operations

I-70 is a critical connection through the Rocky Mountains. According to the SCAP, a single CDOT Maintenance crew is responsible for the highway within the Project limits. In winter months, the highway must be kept free of snow and ice, leaving the summer months to perform scheduled maintenance and roadway repairs.

CDOT Maintenance personnel have indicated that the current highway design is difficult to maintain. Heavier-than-expected traffic loads have forced much of the maintenance effort to focus on maintaining the roadway surface and keeping the highway open and safe for the public.

The existing condition does not handle and convey stormwater and snow melt appropriately. In many locations, the curb has deteriorated and allows runoff to flow down fill embankments, eroding the fill slope. Sediment has built up along the shoulders and edges of the roadway, clogging and burying the existing drainage system.

3.2.2. Proposed Maintenance Criteria

Based on coordination with CDOT Maintenance crews, the following criteria have been developed to gauge maintainability of the proposed design.

- Sediment Removal
  - Ensure sediment be removed with a skid steer or front loader.
  - Provide well defined bottom of the facility so that Maintenance crews know when all the sediment has been removed
- Access
  - Ensure a vehicle with a trailer, a skid steer, and/or front loader to access the facility.
  - Provide access that is easy to enter and exit.
- Safety
  - Provide a safe area within the facility to perform maintenance activities.
  - Ensure maintenance does not require lane closures.
- Frequency
  - Provide a design that allows for the maintenance interval to be at least a year.
  - Provide guidance on duration of maintenance activity (based on an order of magnitude, hours, days, weeks, etc.).

3.3. Additional Considerations

During the preliminary design phase, the design team met with CDOT and the SWEEP Committee. Through these meetings, additional considerations were identified:

3.3.1. City of Blackhawk Water Intake

The City of Blackhawk recently completed upgrades to their water treatment plant at the Hidden Valley/Central City interchange, including a new intake along Clear Creek. Effects the Project will have on the ordinary high-water mark and flood water elevations at this intake should be considered. The intake cannot be negatively impacted by the Project. The existing and proposed water surface elevations based on the modeling performed for the preliminary design indicate minimal changes.

Impacts to the quality and quantity of water into the City of Blackhawk water treatment facility also will need to be considered during a future design phase. Major concerns identified by the City of Blackhawk include:

- Relocation of the intake
- Increased pollutants in the influent to the plant

3.3.2. Veterans Memorial Tunnels Fire Suppression System

There is an existing loading dock sediment trap located south of the east portals to the Veterans Memorial Tunnels. This loading dock trap is intended to capture sediment as well as to detain the runoff from the Fixed Fire Suppression System for the tunnels. This loading dock trap must be protected in place and not be negatively impacted by the Project.

4. Existing Conditions

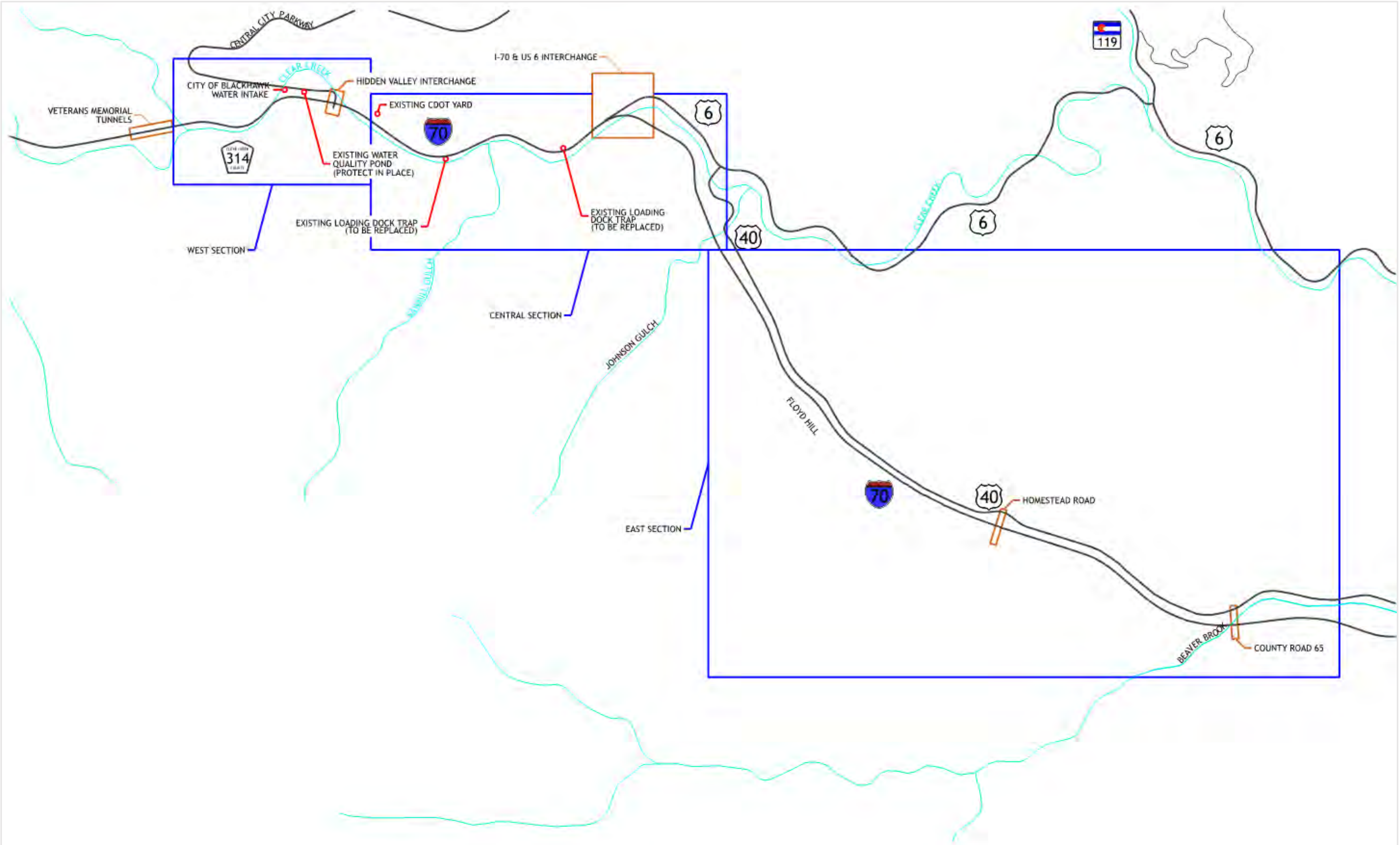
The Project corridor has a long history in Colorado, spanning back to the early 1930s. The first incarnation of I-70 was State Highway 2, which ran along Clear Creek. During the 1970s, SH 2 was replaced with I-70. The widening and realignment of SH 2 and US 40 into I-70 has resulted in a unique drainage pattern around the Project Area.

The following sections describe the existing drainage patterns, water quality features, and stream hydraulics. The existing conditions study for the 20% design focuses on the general drainage patterns and has not done an in-depth analysis of the existing systems, since much of it will be replaced with the proposed project improvements. The existing drainage and water quality systems were identified largely from as-built drawings and field visits. The as-built drawings used to identify the existing drainage systems include:

- Plan and Profile of Proposed A.W. Project No. 6007 State Highway No.2, June 1936
- Plan and Profile of Proposed Combined Federal Aid Project No. 181-E & 181-AR State Highway No.2, June 1936
- Plan and Profile of Final Federal Aid Project No. I70-3(73)253 State Highway No. 70, August 1973
- Plan and Profile of Proposed Federal Aid Project No. I70-3(1)250 State Highway No. 2, November 1959
- Plan and Profile of Federal Aid Project No. IR 070-3(154), November 1995.
- Plan and Profile Federal Aid Project No. IR 70-3(160) Interstate Highway No. 70, May 1998
- Highway Construction Bid Plans of As Constructed Federal Aid Project no. NHPP 0703-392 Twin Tunnels, August 2016

The Project has been divided into West, Central, and East Sections. Exhibit 3 illustrates these delineations and highlights key features discussed in the following section.

Exhibit 3 Project Segments—Existing Conditions



4.1. West Section: Veterans Memorial Tunnels to Hidden Valley/Central City Interchange

The Veterans Memorial Tunnels were reconstructed in 2014, rebuilding the interstate from MP 242.32 to MP 242.81. The project constructed and replaced numerous cross culverts along the project limits. These culverts allow offsite flow to cross under the interstate without overtopping. Both onsite and offsite runoff are routed to these crossings by shallow roadside ditches. Along eastbound I-70, roadway runoff is conveyed to inlets by existing concrete barrier and discharged directly into Clear Creek through numerous grate inlets.

Existing water quality features in this segment include a loading dock sediment trap near the east portal of the eastbound tunnel and several sediment trap inlets. The loading dock trap serves to intercept contaminants from the tunnel’s fire suppressions system and must be protected.

4.1.1. County Road 314

County Road 314 (CR 314) runs parallel to the south side of Clear Creek for approximately one mile from west of the Veterans Memorial Tunnels to Central City Parkway. Numerous culverts along this segment convey onsite and offsite flows to Clear Creek. The intersection of CR 314 and Central City Parkway is drained by a series of inlets that discharge to Clear Creek south of the eastern I-70 eastbound bridge.

4.1.2. Hidden Valley/Central City Interchange

The Hidden Valley/Central City interchange is the intersection of I-70, Central City Parkway, and US 6. The interchange was reconstructed in 1998. It is bounded by Clear Creek on three sides and a large rock face on the south side.

I-70 is drained by four existing storm drain systems. The western-most system is a single grate inlet that discharges directly into Clear Creek. There is a single inlet between this system and the Hidden Valley/Central City interchange, and then a series of inlets on either side of the bridge spanning Central City Parkway. All these systems convey flows directly to Clear Creek.

Central City Parkway is drained by two existing drainage systems. The western-most system consists of two Type R inlets just east of the bridge over Clear Creek. This system discharges into a water quality pond before being discharged into the second system. The second system consists of the remaining inlets along Central City Parkway north of I-70. This system is connected to a single outfall pipe north of the westbound I-70 off-ramp.

South of I-70, the Hidden Valley/Central City interchange area is drained by a system of inlets near the eastbound on- and off-ramps. These inlets are connected to the main I-70 drainage system that discharges to Clear Creek to the east. Offsite flows to the intersection are confined to the south side of CR 314 due to the roadway crown.

4.2. Central Section: I-70 from Hidden Valley/Central City Interchange to East of US 6 (Johnson Gulch)

Between the Hidden Valley/Central City interchange and the US 6 interchange, I-70 is drained by a combination of roadside swales and inlets. These systems are discharged directly into Clear Creek by culverts. The existing inlets and culverts adjacent to the rock wall appear to be buried or clogged with debris and sediment on a regular basis. Two existing loading dock traps exist in this section. The first is at MP 243.5, along the outside of eastbound I-70, while the second is situated between eastbound and westbound I-70 near MP 244. The second loading dock trap is perpetually full of water, indicating that is not functioning as intended. As I-70 crosses Clear Creek near the US 6 interchange, the existing structure has several deck drains that discharge directly below the structure to Clear Creek. Between the US 6 interchange and Johnson Gulch, eastbound I-70 sheet flows to a roadside ditch adjacent to the rock cut. Low flows are blocked by a recently constructed ditch check; however, large flows continue to flow down a steep embankment on either side of an abandoned abutment wall. See Exhibit 4 for a photo taken during a summer hailstorm event.

Exhibit 4 I-70 over Clear Creek at US 6 Interchange

Data Source: Google Maps Street view (Image capture: Sep 2019)

4.2.1. Sawmill Gulch/Greenway Trail

The Greenway Trail runs parallel to the south side of Clear Creek from the Hidden Valley/Central City interchange to the I-70 westbound US 6 off-ramp and generally sits at grade. The confluence of Sawmill Gulch and Clear Creek is on the south side of Clear Creek near I-70 MP 243.7. The watershed does not pass flows under CDOT facilities in the existing conditions; however, it does cross the Greenway Trail. Neither the Project survey nor field visits indicate that there are any culverts to convey flow under the Trail. It is assumed that runoff from Sawmill Gulch, as well as all adjacent hillside runoff in this section, sheet flows over the Trail.

4.2.2. US 6

The I-70 westbound on-ramp and the I-70 eastbound off-ramp connect to US 6 at the bottom of Floyd Hill. The I-70 westbound off-ramp and US 40 cross Clear Creek and connect to US 6 farther east. US 6 runs along Clear Creek and crosses it multiple times. Most of the runoff from US 6 is discharged directly into Clear Creek. Multiple culverts cross underneath US 6 to discharge the offsite areas into Clear Creek.

From I-70, US 6 is crowned normally. Runoff from the westbound side of the highway sheet flows into an adjacent swale, which conveys flow to a large 6-foot by 7-foot box culvert just east of I-70. Runoff from the eastbound side of the road sheet flows directly to Clear Creek. At the intersection of US 6 and the I-70 westbound off-ramp, runoff sheet flows to the west-southwest, into Clear Creek. Offsite flows at this location are conveyed to a 48-inch corrugated metal pipe (CMP) culvert that passes the flow under US 6 and into Clear Creek.

4.2.3. Johnson Gulch

There is a large existing culvert under I-70 to convey Johnson Gulch under both the interstate and US 40. The culvert entrance and exit are located within CDOT right of way (ROW). The culvert was located by drone, so the size of the culvert could not be confirmed, but it is assumed to be a 54-inch culvert. As a result, the culvert was not analyzed for capacity with the 20% design because it sits in a large depression, shown in Exhibit 5. The depression provides significant storage and provides approximately 40 feet of head on the culvert. Exhibit 5 is showing the upstream end of the culvert and looking northeast.

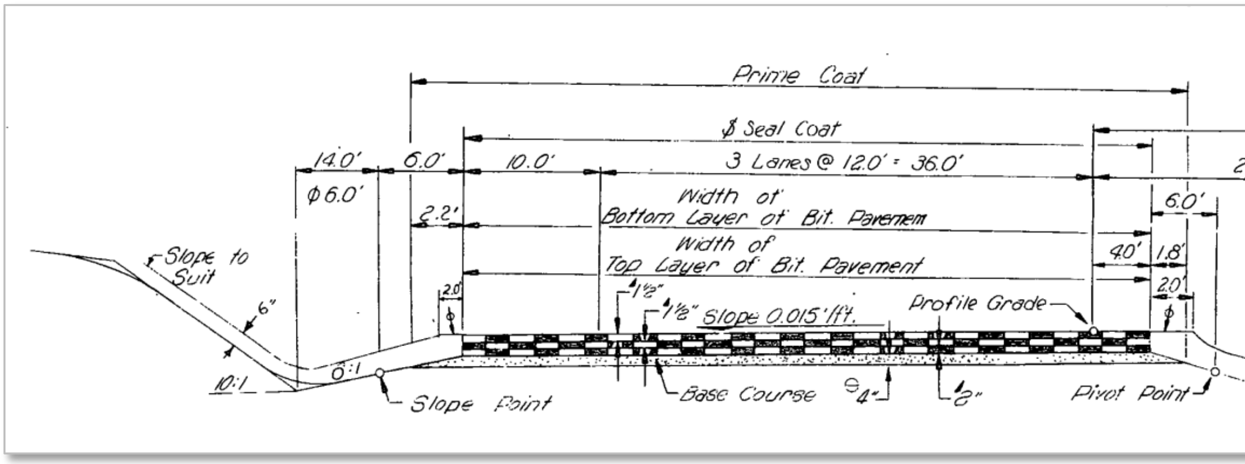
Exhibit 5 Johnson Gulch Culvert

4.3. East Section: I-70 from East of US 6 (Johnson Gulch) to CR 65

4.3.1. Eastbound I-70 to the top of Floyd Hill

From the interchange of I-70 and US 6, eastbound I-70 crosses Clear Creek and begins to ascend Floyd Hill. A small ditch runs along the side of the highway. As shown in Exhibit 6, the 1971 as-built drawings indicate that a small ditch with 6:1 side slopes and a flow line 20 feet from the edge of pavement was graded in. Over the decades, this ditch has been filled in with sediment and the original design has not been maintained.

Exhibit 6 1971 Original As-Built Drawing of Ditch Along I-70



While the original ditch depth is not present today, much of the flow from both the highway as well as the surrounding slopes flows down the old ditch alignment. When eastbound I-70 is sloped to the inside shoulder, concrete barrier intercepts the flows and conveys it to inlets. The inlets discharge to the outside shoulder ditch. In general, the existing surface drainage of eastbound I-70 ascending Floyd Hill matches the intended design; however, due to large amounts of sediment build up, primarily from traction sand, the ditch and existing facilities have become inundated. The ditch is also severely constricted in the areas where eastbound I-70 is adjacent to rock cuts.

4.3.1.1. Offsite Runoff

The large offsite area of Clear Creek County's Floyd Hill neighborhood drains down to the existing ditch along eastbound I-70. Since the eastbound I-70 drainage ditch is in poor condition, there is great concern with how the offsite flows are handled. As noted previously, the Project corridor has been in existence since the mid-1930s, with numerous projects widening and modifying the roadway. The record drawings were reviewed extensively to determine when and where culverts and other drainage systems were installed and what later projects did to accommodate them—be that by removing, abandoning, modifying, or using the systems.

The section of I-70 along Floyd Hill has stormwater runoff conveyance challenges. The record drawings indicate that several existing culverts from the 1930s and 1950s were removed in 1970 when I-70 was constructed. A revision to the record drawings proposed several culverts under I-70; however, these culverts were not constructed. A U.S. Geological Survey (USGS) Streamstats desktop review located significant flow conveyed to these culvert locations; however, a field visit, which was conducted in August 2018, did not find any culverts crossing under I-70. During preliminary design, CDOT Maintenance was queried; however, they could not find any records that explain why culverts were never installed.

The culverts that were shown on the 1970 I-70 record drawings are listed in Exhibit 7.

Exhibit 7 Floyd Hill Culverts

I-70 Milepost	Culvert Size	Drainage Area	Notes
245.85	30 inches	~ 100 acres	Outfall has potential to impact residential property
245.55	30 inches	~ 129 acres	Outfall has potential to impact residential property
245.30	24 inches	~ 9 acres	Outfall location has visible slope failure east of US 40

The lack of cross culverts impacts the proposed drainage system. If the culvert locations were used to convey offsite flows under the highway, the storm drain trunk line could be reduced in size. When presented with the above information, CDOT decided that using these culvert locations to restore historic drainage patterns most likely would cause damage to downstream properties.

4.3.2. I-70 Westbound to the Top of Floyd Hill

Typically, the highway is sloped to the outside shoulder. A small curb under the guardrail captures this flow and conveys it to inlets. Inlets are placed in the inside shoulder, typically under the center barrier, in a handful of places when the roadway slopes to the inside shoulder.

The 1971 as-built drawings do not show any edge treatment at the edge of the roadway. The guardrail and curb were later additions to protect the fill slope from erosion. The curb, which is composed of a piece of wood between the back of asphalt and guardrail post, has degraded significantly since its installation. In a few places, the curb has fallen away, allowing runoff to run down and erode the fill embankment. Maintenance activities have been performed to repair the fill embankment, but runoff must be prevented from sheet flowing down the embankment.

4.3.3. US 40

US 40 runs parallel with westbound I-70 going up the hill at a significantly lower elevation. At the bottom of Floyd Hill, US 40 crosses Clear Creek and connects with US 6. On the south side of US 40, a ditch collects the runoff from westbound I-70 and US 40. Three known culverts run underneath the road and discharge runoff down the bank to the north.

4.3.4. I-70 East of Floyd Hill to CR 65

From the high point, approximately 1,350 feet west of Homestead Road, both sides of I-70 drain to the east. The highway is crowned normally, with a small channel between the eastbound and westbound lanes. The existing roadway sheet flows into roadside ditches. Flows into the northern ditch or median ditch are collected and piped across the interstate to the south side of the highway. Here, runoff is conveyed to the east, ultimately joining Beaver Brook just south of the I-70 crossing.

4.3.4.1. Homestead Road Interchange

Homestead Road crosses over I-70, with the structure sloping from north to south. Minimal runoff crosses onto the structure from the north, as it can sheet flow down the embankments to I-70. The I-70 on- and off-ramps for Homestead Road are crowned to the east. Runoff from the embankments is intercepted by ditches at the toe of the slope and conveyed to existing culverts that pass the flow under Homestead Road to the east. From the east side of Homestead Road, the runoff is mixed with the I-70 runoff and conveyed to Beaver Brook.

4.3.4.2. CR 65 Interchange

CR 65 crosses over I-70 east of MP 247.5. The structure slopes south to north. Minimal runoff crosses onto the structure from the south, as the guardrail allows the runoff to sheet flow down the embankments to either I-70 or Beaver Brook. North of I-70, CR 65 continues to slope to the north, where it intersects with US 40.

Beaver Brook crosses diagonally under I-70 and through a 48-inch CMP. The downstream end of the culvert has a small grouted riprap pad, shown in Exhibit 8. It appears that the bottom of the pipe has been rehabilitated with a thin lining of concrete. Exhibit 8 is showing the downstream end of the culvert and looking southwest.

Exhibit 8 Beaver Brook Culvert

5. Design Criteria

The design criteria for the drainage and water quality portion of the Project were developed in November 2018 and presented in the *Drainage and Water Quality Baseline of Design Report*. Appendix A summarizes the criteria and discussions from the report and include any modifications since that report was written.

The hydrologic analysis of the Project used two methods for the development of peak flows. The Project's drainage design used the Rational Method; however, the Floyd Hill portion of the offsite drainage areas was analyzed using the Natural Resources Conservation Service (NRCS) Hydrograph Method. This was done because runoff from large offsite basins flow directly to the I-70 corridor. Conservatively, a minimum time of concentration of five minutes was used unless it was for a large offsite basin which drained to a proposed drainage system. Time of concentration calculations for these areas can be found in Appendix B.

Hydraulic criteria for storm drain, culverts, and ditches follow CDOT drainage criteria. Inlet and manhole structure account for depth of structure; however, structure bottoms were not sized for pipe connections. Cross culverts were not analyzed in the conceptual design and instead were proposed to be replaced using the minimum culvert diameters table from CDOT DDM. Due to expected changes in the proposed grading, ditches were conceptually design. Ditches were analyzed as either a v-shaped or trapezoidal ditch with standard shape to calculate the depth of flow in the section.

- V-shaped ditch—3:1 side slope
- Trapezoidal ditch—4-foot bottom width, 2:1 side slope

Energy dissipation and outfall paving were not designed. Outlet paving utilized CDOT's M&S Standard M-601-12, which bases riprap extents on pipe diameter. The conceptual design has located and quantified riprap and slope paving areas with the assumption that all riprap is uniform with the following dimensions:

- D_{50} = 12-Inch
- Riprap depth = twice the D_{50}

Deck drainage was coordinated with the Structures design team on the Project. The conceptual design uses single and double vane grate inlets to evaluate spread on the bridge sections. These grate sizes can be accommodated by the Structures group. The deck drainage flows are conveyed to drainage systems within the hydraulic design software, so these flows are conserved during the analysis of routing flows through the drainage systems.

6. Proposed Drainage Design

Two design alternatives have been considered at a conceptual level, Tunnel and Canyon Viaduct Alternatives. The Tunnel Alternative and the Canyon Viaduct Alternative have changes to the conceptual design that take place in the Central Section of the Project. The East Section and West Section of the project share the same conceptual designs.

Exhibit 9 highlights key elements of the conceptual drainage design. The conceptual drainage improvements for each Action Alternative include:

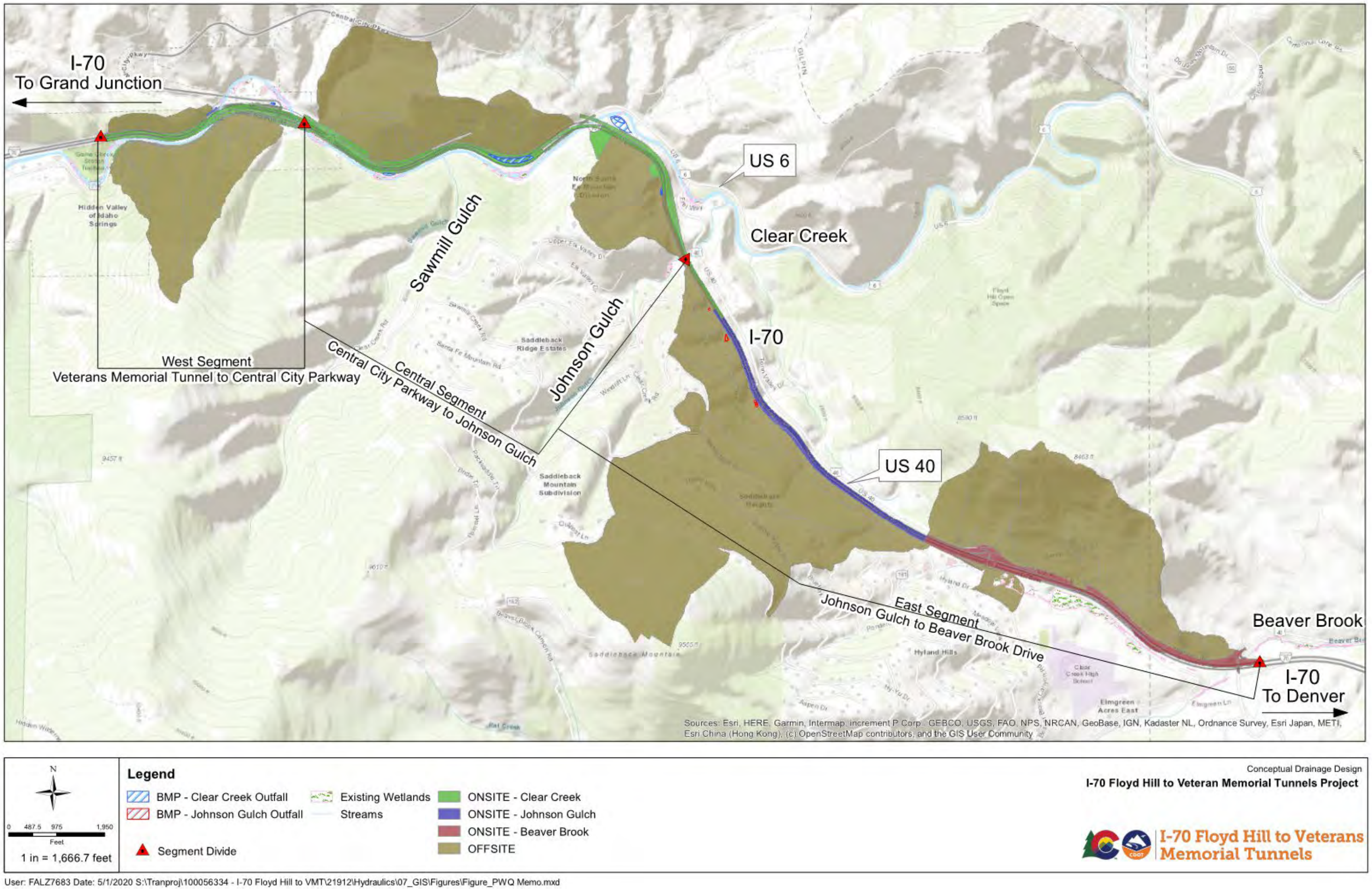
Tunnel Alternative

- Reconstruction of 8 bridges, 7 over Clear Creek
- Reuse of 4 existing bridges over Clear Creek
- Realignment of approximately 935 linear feet of Clear Creek
- 11 new storm drain outfalls into Clear Creek (+4 Deck Drains)
- Replacement of 1 culvert that outfall to Clear Creek
- Approximately 32,400 linear feet of Storm drains and 24,500 linear feet ditches

Canyon Viaduct Alternative

- Reconstruction of 12 bridges, 9 over Clear Creek
- Reuse of 4 existing bridges over Clear Creek
- Realignment of approximately 935 linear feet of Clear Creek
- 8 new storm drain outfalls into Clear Creek (+18 Deck Drains)
- Replacement of 9 culverts that outfall to Clear Creek
- Approximately 29,200 linear feet of Storm drains and 30,200 linear feet ditches

Exhibit 9 Elements of the Conceptual Drainage Design



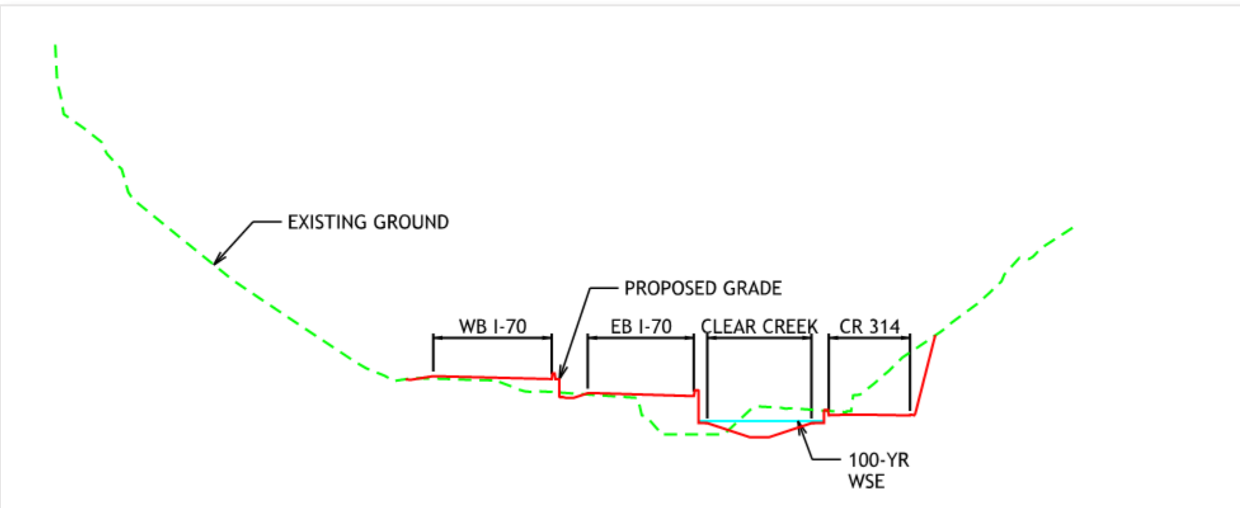
6.1. West Section: Veterans Memorial Tunnels to Hidden Valley/Central City Interchange

The Project will realign I-70 between the east portal of the Veterans Memorial Tunnels and the Hidden Valley/Central City interchange. The westbound lanes will be partially shifted onto the existing eastbound lanes, while the eastbound lanes will be pushed out into Clear Creek. Clear Creek will be realigned through this section.

6.1.1. Clear Creek Realignment

The conceptual design realigns approximately 935 feet of Clear Creek. The Creek will be shifted south from its current alignment, as shown in Exhibit 10.

Exhibit 10 Clear Creek Realignment



The conceptual design for the realignment attempted to keep the 10-year storm event from running along the face of the proposed roadway walls. The 100-year storm event is kept below the top of wall elevation to prevent the roadway from being inundated. Similar to the existing conditions, the banks qwfor the Creek will need to be armored in riprap to create a stable channel section. The conceptual design proposes riprap with a D_{50} of 12 inches; however, scour analysis and countermeasures will need to be developed a the design progresses.

A separate report, the *I-70 Floyd Hill to Veterans Memorial Tunnels Project Conceptual Clear Creek Baseline Hydraulics Report*, has been written to document the full modeling effort for the existing and proposed alignment of Clear Creek.

6.1.2. I-70 Veterans Memorial Tunnels to Clear Creek

Westbound I-70 will sheet flow into a roadside channel created from the proposed rock cut. This channel will convey runoff west. At the end of the ditch, a flared end section will collect the runoff into a new storm drain system that drains to the Clear Creek Pond. Where there is no ditch, westbound I-70 will be drained by a series of vane grate inlets.

Eastbound I-70 will be drained by a new storm drain system. Type 9 concrete barrier will separate the roadway from Clear Creek, preventing the runoff from sheet flowing directly into the Creek. Vane grates will intercept the flow and convey it to the Clear Creek Pond.

Offsite runoff along westbound I-70 will be mixed with the runoff generated by I-70 and conveyed to the Clear Creek Pond. Water quality will be provided by the Clear Creek Pond, which will be located northwest of I-70 crossing Clear Creek. The pond will occupy the footprint vacated by the realignment of westbound I-70.

6.1.3. CR 314

CR 314 will be realigned in two locations. The first realignment is directly west of the Hidden Valley/Central City interchange, while the second realignment is along the Clear Creek realignment. The proposed roadway will be crowned normally. The southside of CR 314 will sheet flow into the proposed curb and gutter, where it will be intercepted by inlets and conveyed to Clear Creek. Offsite flows from the south will be intercepted by the curb and gutter as well. The north side of CR 314, in general, will sheet flow into Clear Creek. In locations where a wall will be constructed, flows will be intercepted by the top of the wall and conveyed along the sidewalk to inlets.

Currently CR 314 runoff is not treated for water quality and proposed conditions will not provide water quality due to the lack of right of way. Underground facilities were not considered since they are difficult for CDOT to maintain.

6.1.4. Hidden Valley/Central City Interchange

The Hidden Valley/Central City interchange will only receive minor adjustments to the on- and off-ramps, expansion to accommodate extending US 6 to Central City Parkway, and the realignment of I-70 before the western Clear Creek crossing. Existing drainage networks which are being reused are identified as protect in place on the drainage exhibit sheets.

6.1.4.1. I-70

I-70 will be superelevated to the south. New inlets will be installed along the Type 9 barrier. These inlets will be connected to the existing storm drain system. The existing storm drain system directly adjacent to the bridges over Central City Parkway will be reused, as the roadway and bridges will not be modified.

6.1.4.2. Hidden Valley Ramps

The on- and off-ramps from I-70 will be sloped to drain toward Central City Parkway. Type 9 barrier will convey the flows to inlets. Between I-70 and the ramps, Type 9 barrier will prevent runoff from flowing across the pavement. Where Type 3 barrier is used, small v-ditches are proposed behind these barriers to convey flows to the intersection, where they are collected by inlets or flared end sections.

South of I-70, the existing inlet and storm drain system will be used to the greatest extent possible and identified as protect in place on the drainage exhibit sheets. The existing elliptical pipe will continue to convey runoff untreated to Clear Creek.

6.1.5. US 6

US 6 will be extended to the Hidden Valley/Central City interchange. The proposed alignment will run between eastbound I-70 and Clear Creek. The roadway will be crowned normally. A high point is located at the west end of the Clear Creek bridge. Flows west of this point will flow to the Hidden Valley/Central City interchange. East of the high point, flows are intercepted by the I-70 system.

6.1.6. Water Quality

The West Section adds two new ponds along the north side of I-70, Clear Creek pond (CC-PO-001) and Central City Parkway pond (CCP-PO-001).

Clear Creek pond drains I-70 between the Veterans Memorial Tunnels and the crossing of Clear Creek. The pond will take up the space of the existing I-70 footprint.

There is an existing water quality facility located between Central City Parkway and I-70. This facility treats runoff from Central City Parkway. The existing facility is impacted by tie down grading from the westbound on-ramp to I-70 and may be cost prohibitive to be protected in place. Central City pond replaces the existing facility and, in addition, drains the westbound on-ramp to I-70 and a small part of westbound I-70.

6.1.6.1. Untreated Areas

Untreated areas in conceptual design of the West Section include:

- CR314
- Portion of I-70 and Central City Parkway Interchange which reuses the existing drainage system.
- Deck drainage; however, riprap aprons will be provided at outlets to serve as sediment basins.

6.2. Central Section, Tunnel Alternative: I-70 from Hidden Valley/Central City Interchange to East of US 6 (Johnson Gulch)

Between the Hidden Valley/Central City interchange and the existing US 6 interchange, I-70 will be realigned to widen the curves. Eastbound I-70 will use the current I-70 footprint, while westbound I-70 will be pushed north, and elevated above eastbound I-70. US 6 will be extended along Clear Creek to the Hidden Valley/Central City interchange.

This segment of the Project is divided into three outfalls: West Bend, East Bend, and US 6. The systems are not separated by specific roadways, but rather by the overall Project Area that can be drained and treated in each water quality pond.

6.2.1. Westbound I-70

The vertical profile for westbound I-70 slopes east, away from the Hidden Valley/Central City interchange, to a low point just west of where the US 6 on-ramp crosses over I-70 (at approximate westbound I-70 Station 2057+00). The profile has a high point at approximately Station 2071+00. When the roadway is sloped to the outside shoulder, runoff will sheet flow into the adjacent rock fall ditch. When the roadway is sloped to the inside shoulder, inlets are placed against the Type 9 barrier to intercept the runoff. Westbound I-70 runoff west of Station 2060+00 is collected in the West Bend outfall system.

This ditch follows the roadway profile to the low point, were it is intercepted by a new culvert that conveys onsite and offsite flows in the rock fall ditch directly to Clear Creek. The rock fall ditch depth is required for rockfall mitigation, but, because of this depth, this low point cannot be taken to the West Bend Pond.

Prior to the proposed tunnel, all flows from westbound I-70 drain to the West Bend system or to the rock cut ditch. Runoff is expected to be captured prior to entering the tunnel. East of the tunnel, runoff is collected in vane grates and conveyed to one of two water quality BMPs, AFS pond and AFS engineered ditch. The portion of I-70 between Clear Creek and proposed Bridge A is routed to AFS (AFS-PO-001) pond. The portion east of Bridge A is routed to the AFS engineered ditch (AFS-BMP-001).

6.2.2. Eastbound I-70

The vertical profile for eastbound I-70 slopes east, away from the Hidden Valley/Central City interchange, to a low point at eastbound I-70 Station 1071+90. Runoff from the east of the Hidden Valley/Central City interchange to the end of the ditch at Station 1064+00 will drain to the West Bend outfall system. From Station 1064+00 to Station 1106+50, runoff will drain to the East Bend outfall system. The western-most section of this system includes the proposed deck drains for the new eastbound I-70 bridge over Clear Creek.

The profile has a high point at Station 1076+67, and another low point at Station 1091+89. The roadway is bounded by Type 9 concrete barrier or retaining walls for its entire length through this section, with the exception of left-hand curves, where sight distance allows for a small roadside ditch. Inlets will intercept the runoff whenever there is concrete barrier or walls. When the roadway is crowned to the inside shoulder and ditch, flared end sections or Type C inlets will collect the flow and convey it to the storm drain system.

For the portion of I-70 between Clear Creek and Johnson Gulch, runoff is collected in roadside ditches and conveyed to one of two water quality BMPs. The portion of I-70 between Clear Creek and proposed Bridge A is routed to AFS (AFS-PO-001) pond. The portion east of Bridge A will be routed to the AFS engineered ditch (AFS-BMP-001).

6.2.3. US 6

The vertical profile for US 6 has a high point just west of where it crosses Clear Creek (US 6 Station 703+14). US 6 is crowned normally in all tangent sections. Similar to eastbound I-70, US 6 is bounded by concrete barrier or retaining walls except when the left-hand curves allow for a small drainage ditch. Type R inlets will intercept runoff along the barriers and walls, while Type C inlets and flared end sections are proposed to collect the runoff in the ditches.

From the high point at Station 703+14 to Station 727+68, just west of where the US 6 westbound on-ramp begins, runoff is conveyed to the West Bend system. From the US 6 westbound on-ramp to just east of the East Bend pond (Station 759+23), runoff is conveyed to the East Bend system. East of this point, runoff is collected by the US 6 storm drain system.

The US 6 system is comprised of a small length of ditch and a handful of inlets which receive runoff from the eastbound I-70 deck drainage. These systems collect and convey the runoff from US 6 directly into Clear Creek. No treatment for this runoff is provided due to limited ROW.

6.2.4. Westbound I-70 On-Ramp from US 6

The westbound I-70 on-ramp from US 6 is sloped to the outside shoulder. A high point along the proposed bridge, right as the alignment crosses eastbound I-70, divides the runoff into two inlet catchment areas on the bridge deck, both of which drain to the West Bend system. Vane grates are proposed along the shoulder east of the bridge to intercept and convey the flows to the East Bend system. Deck drains proposed for this structure use downspouts—one at the west abutment and one at the easternmost bridge pier.

6.2.5. Westbound I-70 Off-Ramp to Hidden Valley/Central City Interchange

The westbound I-70 off-ramp to the Hidden Valley/Central City interchange peels off from westbound I-70 at Station 2060+00. The ramp is crowned to the outside shoulder. Runoff sheet flows into the adjacent rock fall ditch. This ditch will convey flows to the low point (westbound I-70 Station 2055+00). A proposed headwall will intercept flows at the low point and convey them to Clear Creek via a new culvert.

6.2.6. Offsite Runoff

An existing 6-foot by 4-foot box culvert at westbound I-70 Station 2045+00 will remain in place. This box conveys offsite flows under the existing CDOT yard and I-70 corridor. The box will need to be extended under the proposed US 6 alignment.

The rock fall ditch along the westbound I-70 off-ramp to the Hidden Valley/Central City interchange will intercept and convey offsite flows to the new culvert. The rock fall ditch continues to run along westbound I-70 from the ramp to the proposed tunnel. This portion of the rockfall ditch conveys flows to the East Bend system.

Hillside runoff between Clear Creek and Johnson Gulch is combined with onsite runoff in ditches along eastbound I-70. A concrete rectangular channel is designed to capture hillside runoff between the rock cut location (station 1121+00 to 1124+20).

6.2.7. Water Quality

Three ponds and one engineered ditch treat runoff from this section of I-70 and US 6; West Bend, East Bend, and AFS ponds and the AFS engineered ditch. All three pond outlet structures are influenced by the Clear Creek 10-year water surface elevation.

The West Bend pond is located between US 6 and Clear Creek, at westbound I-70 Station 2062+00. The pond drains eastbound I-70 and US 6 from Clear Creek to just west of the westbound I-70 on-ramp from US 6.

The East Bend pond is located between eastbound I-70 and US 6, at eastbound I-70 Station 1089+00. The pond drains eastbound I-70 and US 6 from the West Bend pond to west of I-70 crossing of Clear Creek.

The AFS pond is located east of the I-70 crossing of Clear Creek along the north side of the westbound I-70 off-ramp. The pond drains eastbound and westbound I-70 and westbound I-70 off-ramp from US 6.

The AFS engineered ditch is located approximately 1500 feet west of Johnson Gulch. Onsite from I-70 and hillside offsite runoff drains to this BMP. It is used to treat chlorides and deicing agents by slowing down velocities, diluting the concentration, and allowing for some infiltration.

6.2.7.1. Untreated Areas

Untreated areas in conceptual design of the Central Section (Tunnel Alternative) include:

- Westbound I-70 between US 6 westbound on-ramp and proposed tunnel exit.
- Westbound Hidden Valley/Central City off-ramp.
- Portions of US 6 near the US 6 and I-70 interchange.
- Eastbound I-70 on-ramp from US 6.

6.3. Central Section, Canyon Viaduct Alternative: I-70 from Hidden Valley/Central City Interchange to East of US 6 (Johnson Gulch)

Between the Hidden Valley/Central City interchange and the existing US 6 interchange, I-70 will be elevated onto bridges and realigned to widen the curves. Eastbound and westbound I-70 will follow the same alignment. The alignment crosses from the north side of Clear Creek to the south side, lands on an existing hill for approximately 1,000 feet, and then crosses back to the north side with bridge piers using the existing I-70 footprint. US 6 will be extended along Clear Creek to the Hidden Valley/Central City interchange and will use the I-70 footprint for its proposed alignment.

This segment of the Project is broken up into three outfalls: CA1, CA2, and CA3. The systems are not separated by specific roadways, but rather by the overall Project Area that can be drained and treated in each water quality pond.

6.3.1. I-70

The vertical profile for I-70 slopes east, away from the Hidden Valley/Central City interchange, to a low point at approximately Station 6051+00. On- and off-site runoff is collected in the CA1 system.

The bridge section begins at Station 5059+00 and Station 6061+10 for eastbound and westbound I-70, respectively. The bridge profile slopes from east to west and deck drainage is conveyed via downspouts at bridge pier locations to the CA2 system. A 1,000-foot section of the interstate lands on a raised hill and proposed ditches convey flows east to outfall down to Clear Creek. East of the hill, the bridge continues, and deck drainage is conveyed down to the CA2 system until Station 6089+00.

The bridge deck for westbound lanes continues until Station 6135+00. The bridge for eastbound ends at Station 5106+00 and then continues between Station 5126+50 and Station 5134+00. These bridge sections are drained with bridge deck inlets and outfall directly to Clear Creek. Runoff east of the bridges is collected using vane grate inlets and outfalls to an engineered ditch (CAFS-BMP-001). The engineered ditch outlets directly to Clear Creek under the I-70 bridges at Station 5126+50.

From the west abutment of eastbound I-70 (Station 5115+00), runoff is conveyed in ditches to the CAFS Pond. West of the CAFS (CAFS-PO-001) pond, ditches convey I-70 eastbound and US 6 eastbound on-ramp runoff west, down to Clear Creek. Westbound I-70 off-ramp to US 6 is mostly a bridge structure adjacent to I-70 westbound and deck drainage conveys runoff down to Clear Creek. The portion of I-70 between Johnson Gulch and proposed Bridge K and AB is combined with offsite runoff and routed to an engineered ditch (CAFS-BMP-001).

6.3.1.1. Sawmill Gulch

The I-70 alignment spans across Sawmill Gulch, prior to the confluence of Clear Creek. Preliminary design proposes two bridge crossings of the watercourse; Bridge R for I-70 Eastbound and Bridge Q for I-70 Westbound. At the preliminary design stage, hydraulic analysis and bridge hydraulics were not completed on Sawmill Gulch. Instead, the roadway profile and bridge design were set to provide a reasonable amount of height in anticipation of a future freeboard analysis which will need to be done as the design progresses. Field reviews noted a trail running parallel to Sawmill Gulch which requires further investigation regarding maintaining trail connectivity and usage to be considered as design advances.

6.3.2. US 6

The vertical profile for US 6 has a high point just west of where it crosses Clear Creek (Station 703+14). US 6 is crowned normally in all tangent sections. US 6 is bounded by concrete barrier or retaining walls until it passes under the I-70 bridges. US 6 then follows the existing I-70 footprint and leaves excess width for ditches on either side of the two-lane facility. Type R inlets will intercept runoff along the barriers and walls, while Type C inlets and flared end sections are proposed to collect the runoff in the ditches.

From the high point at Station 703+14 to Station 724+50, just east of were the I-70 westbound bridge begins, runoff is conveyed to the CA1 system. A trunk line is set within the north side of US 6 to allow for the existing concrete barrier adjacent to Clear Creek to be salvaged. East of the CA1 Pond, runoff is conveyed to the CA2 Pond primarily via ditches and some inlets.

East of this point, runoff is collected by the CA3 system, which uses a new culvert for one outfall and a separate system to the east as another outfall to Clear Creek. The US 6 system is comprised of a small length of ditch and a handful of inlets. These systems collect and convey the runoff from US 6 directly into the Clear Creek. No treatment for this runoff is provided due to the limited ROW.

6.3.3. Offsite Runoff

An existing 6-foot by 4-foot concrete box culvert at westbound I-70 Station 2045+00 will remain in place. This box conveys offsite flows under the existing CDOT yard and I-70 corridor. The box will need to be extended under the proposed US 6 alignment.

The rock fall ditch along the westbound I-70 off-ramp to the Hidden Valley/Central City interchange will intercept and convey offsite flows to the CA1 system. East of the CA1 Pond, six existing culverts are to be replaced under US 6. East of the CA2 Pond, a single new culvert is added for offsite flows.

Along the westbound I-70 on-ramp from US 6, offsite runoff will flow to a ditch that will be in the footprint of the existing I-70. This ditch becomes constrained between the rock wall and US 6 before it outfalls to the upstream end of the 6-foot by 7-foot concrete box culvert under US 6.

Hillside runoff between Clear Creek and Johnson Gulch is combined with onsite runoff in ditches along eastbound I-70.

6.3.4. Water Quality

Three ponds treat runoff from this segment of I-70 and US 6; CA1, CA2, and CAFS ponds. Both the CA1 and CA2 pond outlet structures are influenced by the Clear Creek 10-year water surface elevation. One engineered ditch, named CAFS, is used to treat chlorides and deicing agents on the east part of this section.

The CA1 Pond is located between US 6 and Clear Creek, at westbound I-70 Station 6062+00. The pond drains eastbound I-70 and US 6 from Clear Creek to the west abutments of I-70 structures Bridge M and N.

The CA2 Pond is located between Eastbound I-70 and US-6, at eastbound I-70 station 5089+00. The pond drains US 6 from the west abutments of I-70 structures Bridge M and N to west of the westbound I-70 on-ramp from US 6. Portions of deck drainage from I-70 are routed to the pond via downspout connections to the CA2 system.

The CAFS pond is located east of the I-70 crossing of Clear Creek along the south side I-70. The pond drains eastbound I-70 and captures offsite flows. This pond will prevent sediment loading to Clear Creek.

The CAFS engineered ditch is located approximately 1500 feet west of Johnson Gulch. Onsite from I-70 and hillside offsite runoff drains to this BMP. It is used to treat chlorides and deicing agents by slowing down velocities, diluting the concentration, and allowing for some infiltration.

6.3.4.1. Untreated Areas

Untreated areas in conceptual design of the Central Section (Canyon Alternative) include:

- Portion of I-70 between Bridge M and N and Bridge AB and C.
- Deck drainage for I-70 and on- and off-ramps to US 6 between Clear Creek and east abutments of Bridge AB and K. Riprap aprons will be provided at outlets to serve as sediment basins.
- CA3 drainage system draining I-70 via deck drains as it runs above US 6. Flows will be routed through ditch sections prior to discharge to Clear Creek.

6.4. East Section: I-70 from East of US 6 (Johnson Gulch) to CR 65

I-70 along Floyd Hill will be realigned to widen out curves and reduce the steep downgrades along westbound I-70. Eastbound I-70 will be widened and pushed into the hill side, requiring walls, barriers, and ditches to protect the highway from offsite flows. The existing outside edge of westbound I-70 will be maintained, to limit the amount of additional fill. A new viaduct structure for westbound I-70 is proposed from Station 2126+00 to Station 2134+00.

6.4.1. Johnson's Gulch

Johnson's Gulch is conveyed through I-70 by an existing pipe with an unknown diameter. During Over-The-Shoulder Review meeting with CDOT Hydraulics, CDOT requested full replacement of this culvert through jacking. Proposed improvements recommend an in-kind replacement at a minimum. Flows conveyed through this culvert are mostly offsite flows conveyed along Floyd Hill, local CDOT roadway runoff along Floyd Hill, and offsite Clear Creek County runoff.

6.4.2. Westbound I-70

The vertical profile of westbound I-70 slopes down toward Clear Creek at grades ranging from 6.0% to 6.8%. New Type 9 concrete barrier will be installed along the median as a barrier to oncoming traffic. The outside of westbound I-70 will have Type 3 guardrail.

As I-70 westbound slopes inside, inlets will be placed along the barrier to convey flow to the proposed BMPs. As I-70 westbound slopes outside, runoff will sheet flow through the guardrail and down the embankment. Turf reinforcement matting will be placed along the embankment to protect it from eroding.

6.4.3. Eastbound I-70 (Onsite)

The vertical profile for westbound I-70 slopes down toward Clear Creek at grades ranging from 4.2% to 7.5%. Runoff from the roadway will be kept separate from offsite flows so that it can be routed through the water quality ponds. This requires separate but parallel systems.

The main offsite storm drain trunk line will run down the inside edge of the shoulder. As such, the main trunk lines for the onsite systems are proposed in the inside shoulder. Inlets are directly connected to the trunk line when the roadway is sloped to the inside should. When the roadway is sloped to the outside shoulder, inlets are connected by a small trunk line, which crosses over to the main onsite trunk line when the roadway is sloped back to the inside shoulder.

6.4.4. Eastbound I-70 (Offsite)

Significant flow is expected to come toward eastbound I-70 from the southwest. In general, these flows will be intercepted by a ditch parallel to the roadway and conveyed west. Ditch flows are conveyed to a proposed storm drain line under the outside shoulder of eastbound I-70.

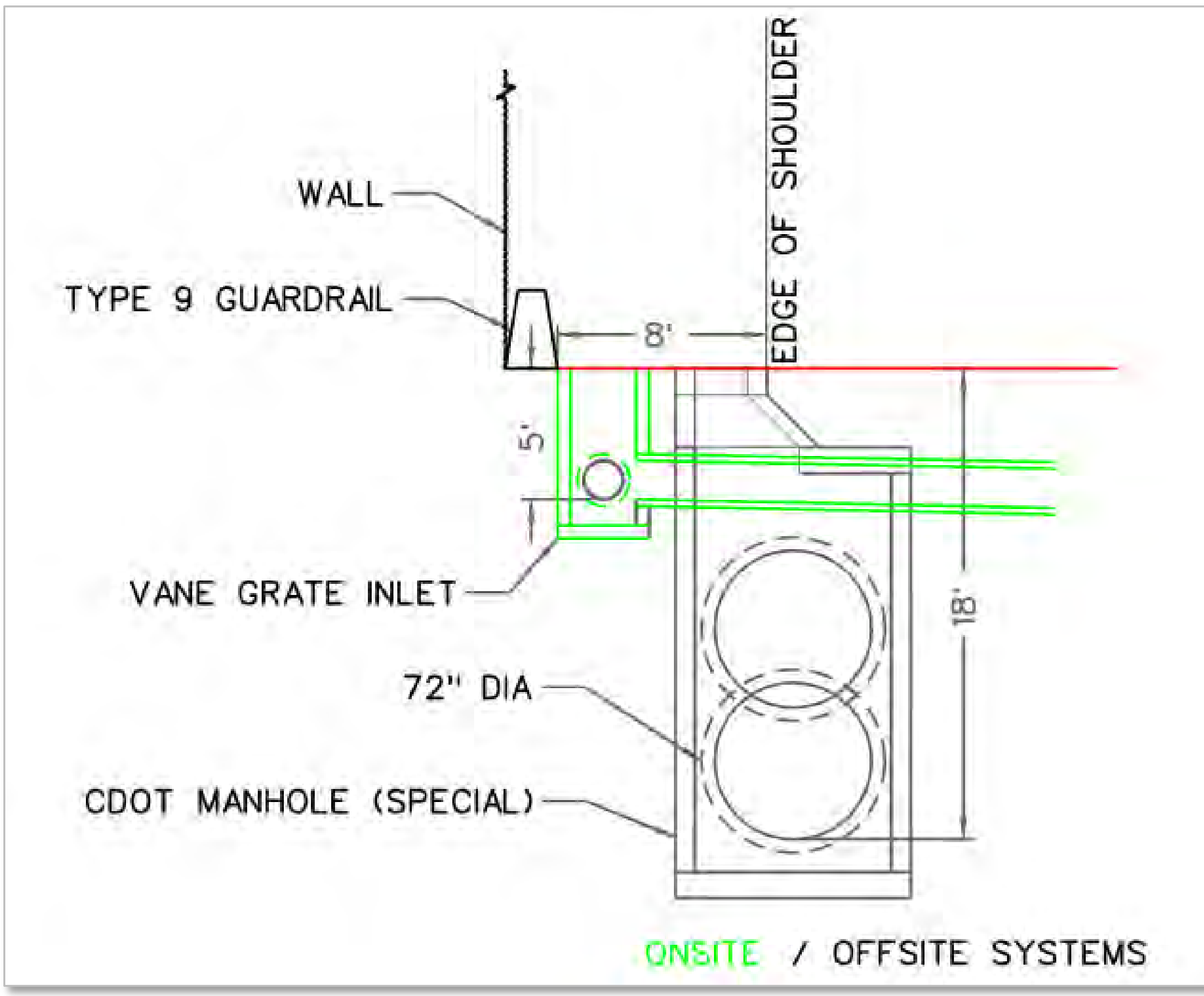
The offsite system has been laid out and analyzed at a conceptual level. The proposed roadside ditch will be a rectangular channel. The bottom width will be a minimum of 2 feet. The side wall adjacent to the roadway and the non-roadway side will be composed of concrete and have vertical walls 1 foot tall. From the top of the rectangular ditch, concrete paving will run up to existing grade with a side slope of 1.25:1. This ditch will need to be lined with concrete.

Ditches were designed to contain the 100-year storm event flows with no overtopping. These ditches require a variance from the CDOT drainage design criteria for the 10-year storm event requiring a one foot freeboard. The design of the ditch is constrained by the following:

- Inability to catch grade due to the existing rock slope adjacent to eastbound lanes of 1.25:1 or less
- Wall and/or barrier wall sections required by roadway for clear zone
- Large offsite areas and runoff potential

Eastbound I-70 has two systems in parallel; the offsite trunk line and the onsite collection system. The offsite trunk line is expected to be installed approximately 8-10 feet deep. The trunk line is proposed to have a slope of only 3%, compared to the roadway grades of 4.2% to 7.5%. This maximum slope is driven by the need to keep the velocities in the pipe below 22 feet per second (ft/sec). To achieve this grade, the main trunk line will need to be stepped at each manhole. Exhibit 11 shows a theoretical worst-case scenario, where an onsite inlet and offsite manhole must share the outside shoulder of eastbound I-70.

Exhibit 11 I-70 Eastbound—Onsite/Offsite Systems



A SUDA model was not constructed for the offsite system. Instead, a spreadsheet showing simplified routing of the Rational Method was used to determine the inlet spacing and trunk line size.

The offsite area draining toward eastbound I-70 was divided into 12 separate segments, based on where the proposed offsite ditch would change cross section conditions. The areas can be broken up into two categories: runoff from the adjacent hillside and larger offsite basins driven by the existing drainage features outside the Project limits.

The smaller adjacent hillside areas were assumed to have a time of concentration of 5 minutes, as the slopes vary from 3:1 to as steep as 1:1. Time of concentrations for the larger offsite areas were calculated and govern the peak flow rate calculations. The peak flow rate for each of the 12 areas was calculated using the NRCS Hydrograph Method.

The conceptual design used the offsite rectangular ditch sections to drain the small adjacent hillside areas down to an area that interacts with the larger offsite basins. These design points were drained into the offsite trunk line.

The design points for the offsite trunk line were based on the limits of each tributary area. To develop the design flows at each design point along the trunk line, the sum of the runoff generated by the tributary area for onsite and offsite was combined at specific point locations. These point locations are shown as headwalls or end sections that have a pipe connection to the trunk line. This means that routing through the proposed system is not accounted for; however, at such steep grades, the travel time through the proposed system is expected to be minimal.

When the design flow was known, the capacity of various size pipes was determined using Manning's equation, assuming the pipe was full, and had a design slope of 3%. An appropriate pipe size was selected for each segment of the offsite trunk line based on the 10-year design flow rate. After the size of pipe was selected, the required 100-year velocity was determined by taking the 100-year design flow rate and dividing it by the pipe's cross-sectional area. In cases where this resulted in a velocity greater than 22 ft/sec, the pipe was upsized until the velocity was brought down to less than 22 ft/sec.

6.4.5. US 40

Due to the addition of the barrier along I-70 westbound, no runoff from I-70 will be conveyed into the ditches along US 40. All the culverts under US 40 will stay in place, and the rest of the drainage patterns will remain the same.

6.4.6. Water Quality

The East Section adds two water quality ponds and one engineered ditch; Johnson Gulch 1 (JG-PO-001) and 2 (JG-PO-002) ponds, and East Floyd Hill BMP (EFH-BMP-001). All three features outlet to the offsite trunk line which outfalls to Johnson Gulch. Each water quality feature in the East Section is placed to allow for offsite flows to combine with onsite flows to dilute chloride and deicing agents on this section of the Project.

The Johnson Gulch 1 pond is located approximately 1000 feet east of Johnson Gulch. The pond is located on a small bench area alongside eastbound I-70 and is between two rock cut areas. The pond drains approximately 1000 feet of I-70. Offsite basin H drains down the hillside directly to the pond to combine with onsite runoff.

The Johnson Gulch 2 pond is located approximately 2000 feet east of Johnson Gulch. The pond is located on a small bench area alongside eastbound I-70 and is between two rock cut areas. The pond drains approximately 1000 feet of westbound I-70 and 2000 feet of eastbound I-70. Offsite basin G drains down the hillside directly to the pond to combine with onsite runoff. The pond also receives hillside runoff from offsite basin F which is conveyed through a concrete rectangular channel (OFF-CH-003) located between the top of the wall and the rock slope.

The EFH engineered ditch is located approximately 3500 feet east of Johnson Gulch. The BMP is located on a large bench area alongside eastbound I-70. Onsite (EFH system) and offsite trunk lines outfall to the engineered ditch. A large offsite basin E drains down the Floyd Hill neighborhood, at times crossing residential roads, directly to the pond to combine with onsite runoff. The pond also receives hillside runoff from offsite basin D which is conveyed through a concrete rectangular channel (OFF-CH-003) located between the top of the wall and the rock slope. The water quality BMP is used to treat chlorides and deicing agents by slowing down velocities, diluting the concentration, and allowing for some infiltration.

6.4.6.1. Untreated Areas

Untreated areas in conceptual design of the Central Section (Canyon Alternative) include:

- *Portions of westbound I-70 which sheet flow down embankment through openings in guardrail.
- All proposed work east of Floyd Hill which drain to Beaver Brook

*Note that this area is not captured and routed to a formal water quality BMP but it does allow for natural treatment over vegetated flow paths prior to reaching Clear Creek. This design reflects the Project's water quality approach.

7. Water Quality

As mentioned in Section 3.1.4, the Project is not required to comply with CDOT's MS4 Permit; however, CDOT has made a commitment to improve the stream health of Clear Creek. To achieve this, the Project is proposing to route a majority of the roadway runoff from the Project through water quality ponds, engineered ditches, roadside swales, and vegetated side slopes.

7.1.1. Existing Water Quality

There are a number of existing water quality features installed along the Project corridor, including:

- Sediment traps
- Loading dock traps
- Extended detention basins

In general, all existing water quality features will be removed and replaced with consolidated extended detention basins. The existing features that will remain in place are:

- Existing loading dock trap at the east portal of the Veterans Memorial Tunnels
- Existing extended detention basin at Central City Parkway

Reuse of the other existing facilities is not part of the conceptual design for several reasons. Based on discussion with CDOT Maintenance teams, the loading dock traps along the Project corridor have not intercepted much sediment historically. One of these traps is constantly full of water, indicating that the outfall is not functioning properly. Reconstruction and realignment of I-70 will place the existing sediment traps outside of the proposed highway shoulder, making these inlets ineffective.

7.1.2. Proposed Water Quality

Water quality was only analyzed for the Canyon Viaduct Alternative and the Frontage Road North option of the Tunnel Alternative. The Frontage Road South option of the Tunnel Alternative was not analyzed in preliminary design. The impervious areas along the Project corridor have not been recorded for specific basin areas and Project totals. This is because the MS4 Permit and similar water quality requirements are not applicable to this Project. In addition to small sections of roadway area that could not be routed to a water quality BMP, the following areas of the conceptual design do not have formal water quality treatment, which is similar to existing conditions:

- CR 314
- South portion of Hidden Valley/Central City interchange
- US 6 near I-70 and the US 6 interchange
- Outside sloping portions of I-70 westbound from east of US 6 to the top of Floyd Hill
- I-70 east of Floyd Hill to CR 65

As stated previously in Section 3.1.4, the water quality approach for the Project is to design water quality BMPs to address the primary pollutant of concern for each section.

For the West Section and Central Section, the treatment of sediments and metals in water quality ponds is designed by treating the water quality capture volume (WQCV). For the East Section, the treatment of chloride is handled by allowing roadway runoff to combine with offsite runoff and flow over existing or proposed vegetation as a means to filter.

CDOT and the SWEEP committee vetted and approved of the following water quality BMPs as best practices for treating sediment, metals, and solids for this Project.

7.1.2.1. Water Quality Ponds

Treatment of the WQCV is recommended to strive to improve stream health. The total treatment volume recommended is based on the total tributary area to the pond and the expected percent imperviousness of the contributing watershed. Offsite areas were assumed to be 45 percent impervious, per the recommendation from MHFD. These ponds have been graded to maximize the volume of the pond, while limiting the impact to the surrounding area. Exhibit 12 compares the WQCV to the volume provided in each pond.

Exhibit 12 Proposed Extended Detention Basins

Outfall	Pond ID	Total Area (ac)	Weighted Impervious (%)	WQCV (ac-ft)	WQ Volume Provided (ac-ft)
Clear Creek	CC-PO-001	22.66	58%	0.43	0.84
Central City	CCP-PO-001	6.75	100%	0.28	0.11
West Bend (Tunnel Alternative)	WB-PO-001	9.71	100%	0.40	0.67
East Bend (Tunnel Alternative)	EB-PO-001	54.43	59%	1.05	3.96
ASF Quarry (Tunnel Alternative)	ASF-PO-001	48.50	56%	0.91	1.98
Canyon_1 (Canyon Alternative)	CA1-PO-001	24.80	69%	0.53	0.68
Canyon_2 (Canyon Alternative)	CA2-PO-001	7.32	100%	0.31	0.28
ASF Quarry (Canyon Alternative)	CASF-PO-001	45.27	53%	0.81	0.22
Eastbound I-70 FH Offsite System (Johnson Gulch)	JG-PO-001	1.33	100%	0.06	0.76
	JG-PO-002	4.90	100%	0.20	0.71

Extended detention basins were designed to have enough volume for the WQCV and one foot of freeboard. The preliminary stage of design did not design extended detention features. Future design must consider the following:

- Forebay and appropriate energy dissipation
- Concrete trickle channel
- Micropool
- Water quality control structure
- Emergency overflow structure

7.1.2.2. Engineered Ditches

The water quality BMPs that are most applicable to the treatment of chloride in the Project's high altitude, cold climate are vegetated swales with check dams to improve performance. It is unlikely that vegetation will grow along eastbound I-70 where these proposed BMPs would be placed. In lieu of vegetated swales, the conceptual design proposed engineered ditches that contain:

- A wide ditch bottom (>10 feet)
- Soil riprap bottom and sides
- A series of permanent riprap check dams

The engineered ditches are placed to take advantage of two wide bench areas between the US 6 interchange and the top of Floyd Hill. The grading and check dam spacing have been completed for the conceptual design. For these engineered ditches, the future design must consider the following:

- Combined onsite and offsite flows using stormwater management model (SWMM) software
- Ditch lining requirements during minor and major storm events
- Maintenance access and requirements

7.1.2.3. Floyd Hill Westbound Side slopes

To slow down chloride conveyance, Floyd Hill westbound side slopes will allow for runoff to leave the pavement and flow down the vegetated side slopes to allow for update to reduce chloride concentration and to allow for dilution with offsite flows. This design promotes sheet flows and removes concentrated point discharges that causes erosions of side slopes.

7.1.2.4. Riprap Basins at Bridge Downspouts

Because of site constraints, there are some point discharges that will be routed close to Clear Creek. At all point discharges, a riprap stilling basin will be provided to slow down the release of roadway and bridge runoff into Clear Creek.

8. Next Steps

The goal of the conceptual design was to better determine the cost of the proposed alternatives. A drainage concept was put together and the level of detail of the analysis was largely consistent across the Project. Along the Project corridor, the drainage models were progressed to a point where spread and storm drain hydraulics could be determined. The exception is in the East Section of the Project, where drainage design east of Floyd Hill was shown but was not analyzed.

8.1. Design to be Evaluated—General

The following items need to be evaluated further:

- ROW Acquisition
    - No formal water quality BMPs are placed outside of CDOT ROW.
    - Potential water quality BMP in Johnson Gulch may require ROW agreements with Clear Creek County.
- Bridge Deck Drainage
    - Superelevation transition and low points on bridge decks should be eliminated as design advances past conceptual phase.
    - In the Tunnel Alternative, the I-70 westbound roadway profile should be revised to shift a low point east of the abutment of Bridge B. The conceptual design shows the low point on Bridge B.
    - Conceptual design shows deck drainage captured at abutment walls and pier locations. Downspouts that outlet to Clear Creek should be reviewed for water quality impacts. Recommend outlets be routed to riprap basin or vegetated ditch prior to Clear Creek.
- Tunnel Drainage and Discharge
    - Additional consideration is needed for the proposed tunnel, including drainage and treatment for any firefighting actions within the tunnel.
    - Determine the potential risk of violating a discharge permit due to discharging contaminated ground water that may present itself inside the tunnel.
    - This was not evaluated and the conceptual design for the Tunnel Alternative has a limited area on the east end of the tunnel entry portal to provide a treatment basin to manage contaminated discharges.
- Existing Bridge Abutment from before the 1970 I-70 Alignment
    - The former State Highway 2 roadway predates the I-70 highway. At the intersection of I-70 and US 6, there is an existing abutment from the State Highway 2 alignment which was not removed. The Project may impact this existing abutment and further geotechnical investigation needs to be done to ensure the hillside slope is stable. Additionally, hillside runoff flows drop vertically over this abutment in existing conditions. This condition is unmitigated in the conceptual design and will need to be considered as the Project progresses.
- Ditches
    - Due to expected changes in the proposed grading, ditches were conceptually design. Ditches were analyzed as either a v-shaped, trapezoidal with standard shape but will need to be designed as the Project progresses.
- Existing Culvert Analysis
    - Existing culvert data was not provided. Culvert replacements shown on the conceptual design were based on conditions found in desktop and field review, age, and potential for construction impacts.

- Large Existing Culverts, greater than 48-inches in diameter
  - Culverts were not analyzed. Conceptual design shows them to remain or to be replaced according to coordination during Over-The-Shoulder Review meeting with CDOT.

Culvert	Size	20% Design
CDOT Maintenance Facility	6-ft x 4-ft Box Culvert	To Remain
Two Bears & US 6	6-ft x 7-ft Box Culvert	To Remain
Johnson Gulch under I-70	54 inches (Assumed)	Replace using Jack and Bore

- Existing Culverts and Storm Drainage Systems to Remain/to be Removed
  - Existing infrastructure proposed to remain in place will need to be assessed for structural integrity prior to reuse.
  - Existing infrastructure not used for proposed drainage conveyance will be removed and not abandoned.

8.2. Design to be Evaluated—Sections

The following subsections provide details on each section's design as it relates to level of detail.

8.2.1. West Section: Veterans Memorial Tunnels to Hidden Valley/Central City Interchange

- Roundabouts at the Hidden Valley/Central City Interchange were added to the roadway geometry late in the design process. The drainage design at this interchange still reflect the roadway design tying into the existing Central City Parkway. Further design and analysis need to be done to evaluate the impact of the added roundabouts.
- Additional refinement to the design should be completed to maximize the reuse of the existing storm drain system.
- The large existing box culvert that conveys flows under the CDOT Yard and I-70 should be evaluated further for capacity, structural integrity, and practicality of reuse. At the time of the 20% design, the fate of the CDOT Yard is not known. There has been discussion that the Yard will be moved and replaced with tunnel operations; however, this is a major yard for the crew that maintains the Project corridor.

8.2.2. Central Section, Tunnel Alternative: I-70 from Hidden Valley/Central City Interchange to East of US 6 (Johnson Gulch)

- The drainage along US 6 could be optimized better if the roadway was sloped to a single side, instead of crowned normally.
- Additional analysis of the existing drainage systems east of the extension of US 6 should be evaluated for compliance with the current design criteria. It may be beneficial to update these facilities, as they are more than 50 years old.
- There is a low point in the westbound I-70 profile at Station 2108+00, which falls on the proposed structure across Clear Creek. Additional design revisions should be coordinated among the structure designers, roadway, and drainage team to attempt to remove or move the low point or the structure to avoid having this overlap.
- There is significant elevation drop along the westbound I-70 system as it outfalls to the pond AFS-PO-001. While velocity in the pipes will be controlled by stepping the storm drain profile, a

large energy dissipator is expected to be required to protect the pond at the downstream end of the system.

8.2.3. Central Section, Canyon Viaduct Alternative: I-70 from Hidden Valley/Central City Interchange to East of US 6 (Johnson Gulch)

- Pond grading for CA1-PO-001 should be evaluated to ensure sufficient volume is obtained while considering maintenance access and slope stability along Clear Creek.
- Culverts draining the offsite runoff will need to be analyzed. The conceptual design proposed 36-inch culverts as a placeholder until a design alternative is selected. The inlet and outlet protections and energy dissipation needed for the Sawmill Gulch culvert to operate effectively needs to be analyzed.
- Deck drainage downspouts may be routed via ditches against the proposed grade to treat bridge deck runoff in a water quality pond. These conveyance paths should be reviewed for feasibility with the proposed roadway design.
- Offsite flows along the I-70 westbound on-ramp from US 6 need to be evaluated further to ensure minor and major flows can be conveyed to the culvert under US 6 to the north. Grading is not fully developed, and the ditch may be too constrained between US 6 and the existing rock cut section.
- Additional analysis of the existing drainage systems east of the extension of US 6 should be evaluated for compliance with the current design criteria. It may be beneficial to update these facilities, as they are more than 50 years old.
- Bridge hydraulics and freeboard analysis should be done for the proposed Bridge R and G crossing Sawmill Gulch. Trail usage and connectivity require further investigation.

8.2.4. East Section: I-70 from East of US 6 (Johnson Gulch) to CR 65

- The area east of Johnson Gulch has been divided and analyzed in five different pieces. The four onsite systems have been evaluated for spread and capacity. The flows have been routed to the ponds and peak flows from these systems were used as the downstream connections to the offsite trunk line. A system to allow the ponds to receive offsite flows also should be considered. A more-detailed analysis of the hydrology and hydraulics between these five systems should occur using SWMM software.
- The offsite system of concrete ditches and storm drain trunk line has only been preliminarily sized, as noted in Section 6.3.3. Further design refinement to provide even a small ditch adjacent to the roadway barrier or back of wall should occur.
- An energy dissipator is needed at the base of the offsite trunk line, prior to discharging flows into Johnson Gulch.

9. Conclusion

The conceptual drainage design for the I-70 Floyd Hill to Veterans Memorial Tunnels Project provides a baseline drainage and water quality design and report. The design addresses concerns by the local community while still complying with CDOT design criteria. The proposed drainage design improvements that will accompany the roadway and structural infrastructure will ensure safety enhancements to the traveling public. The proposed improvements should reduce the pollutants within the runoff from I-70. Overall, the design provides a more stable, maintainable, and long-term design for drainage along the Project corridor.

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Appendices

Appendix A. Design Criteria

1. Design Criteria

The design criteria for the drainage and water quality portion of the project were developed in November 2018 and presented in the *Drainage and Water Quality Baseline of Design Report*. This appendix contains sections that summarize the criteria and discussions from the report and include any modifications since the report was written.

1.1 Governing Authorities

Table 1 summarizes the existing roadways that are expected to be impacted by the project, and the governing agency for the drainage design.

Table 1. Roadway Classifications

Roadway	Classification	Governing Agency
Interstate 70	Interstate	CDOT
CR 65	Minor Collector	CDOT
US 40	Major Collector	CDOT
Homestead Road	Minor Collector	Clear Creek County
US 6	Minor Arterial	CDOT
Central City Parkway	Major Collector	Central City
E. Idaho Springs Road (CR 314)	Minor Collector	Clear Creek County

1.2 Software

HEC-HMS is used for hydrologic analyses of select offsite ungaged watersheds. The software is on the approved software list found in Table 7.8 of CDOT's DDM.

All hydraulic analyses were completed using Bentley's OpenRoads Designer (ORD) Subsurface Utility Design and Analysis (SUDA) version 10.01.00.70. This single piece of software incorporates Bentley's Microstation, InRoads, StormCAD, and CivilStorm software into a single platform. CDOT is currently revising their CADD and drainage criteria to use ORD and SUDA as their standard platform for the design and analysis of their roadway projects.

Storm drain systems, including inlets, pipes, and ditches, were analyzed and sized using Bentley's StormCAD module within SUDA, a steady state hydrology and hydraulics engine.

Additional software, such as the Federal Highway Administration (FHWA) HY-8 and Hydraulic Toolbox were used to verify or supplement the main SUDA models. Spreadsheets were created to calculate Time of Concentrations and riprap sizing.

2. Hydrology

The Rational Method was used to determine peak flow rates for areas smaller than 90 acres. Areas larger than 90 acres were evaluated using the NRCS Hydrograph Method.

2.1 Elevation Data

Offsite elevation data is obtained from USGS Lidar point cloud data published July 2015. Onsite topography was provided by CDOT and surveyed by Woolpert in 2018.

2.2 Rainfall Data

Rainfall data were collected from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2. Rainfall Intensity-Duration-Frequency and Precipitation-Depth-Frequency Data are shown in **Table 2** and **Table 3**.

Table 2. Rainfall Intensity-Duration-Frequency

Duration (Min)	2-Yr (50% Annual) (in/hr)	5-Yr (20% Annual) (in/hr)	10-Yr (10% Annual) (in/hr)	25-Yr (4% Annual) (in/hr)	50-Yr (2% Annual) (in/hr)	100-Yr (1% Annual) (in/hr)
5	2.770	3.58	4.27	5.26	6.04	6.83
10	2.030	2.62	3.13	3.85	4.42	5.00
15	1.650	2.13	2.54	3.13	3.59	4.06
30	1.120	1.45	1.72	2.12	2.43	2.74
60	0.700	0.892	1.05	1.27	1.45	1.62
120	0.420	0.530	0.622	0.746	0.842	0.938
180	0.310	0.388	0.452	0.538	0.605	0.671
360	0.190	0.235	0.274	0.328	0.371	0.415
740	0.118	0.147	0.173	0.211	0.244	0.279
1440	0.073	0.092	0.109	0.137	0.160	0.186

Table 3. Rainfall Precipitation-Depth-Frequency

Duration (Min)	2-Yr (50% Annual) (in)	5-Yr (20% Annual) (in)	10-Yr (10% Annual) (in)	25-Yr (4% Annual) (in)	50-Yr (2% Annual) (in)	100-Yr (1% Annual) (in)
5	0.231	0.298	0.356	0.438	0.503	0.569
10	0.338	0.437	0.522	0.641	0.736	0.833
15	0.412	0.533	0.636	0.782	0.897	1.01
30	0.560	0.723	0.862	1.06	1.21	1.37
60	0.70	0.892	1.05	1.27	1.45	1.62
120	0.840	1.06	1.24	1.49	1.68	1.88
180	0.932	1.16	1.36	1.62	1.82	2.01
360	1.14	1.41	1.64	1.97	2.22	2.49
740	1.42	1.77	2.08	2.55	2.94	3.36
1440	1.75	2.20	2.62	3.28	3.84	4.45

2.3 Peak Flow Methodology

Hydrologic methods outlined in the Urban Drainage Flood Control District Urban Storm Drainage Criteria Manual (USDCM), Natural Resources Conservation Service (NRCS) Technical Release No. 55 (TR55), and the DOT DDM govern this project. The CDOT DDM defers to USDCM for the approach in Section 4.2.1.1 and defers to NRCS TR55 for the approach in Section 4.2.1.2; subsequently, the USDCM and NRCS TR55 are referenced directly in the sections below.

2.3.1 Rational Method

The Rational Method was used, generally, to determine peak flow rates for areas smaller than 90 acres. The governing equation is Equation 1:

$$Q = CIA \qquad \textit{Equation } 1$$

where,

Q = the peak rate of runoff (cfs)
C= Runoff coefficient per Table 4
I = intensity (inches/hour)
A = tributary area (acres).

The main assumptions of the Rational Method are: (1) storm duration equal to the time of concentration; (2) uniform rainfall distribution; and (3) homogeneous and uniform hydrologic losses.

2.3.1.1 Hydrologic Loss

Hydrologic losses in each watershed are modeled using a runoff coefficient. USDCM runoff coefficients vary based on percent impervious area and hydrologic soil group (USDCM Table 6-4). Based upon the USGS Soil Survey, the Project is primarily composed of Hydraulic Soil Group (HSG) Type D soils. For ease of calculations and conservativeness, the Project area is assumed to be all HSG Type D soils and either Streets or Undeveloped Area where Rational Method is used. Project-specific USDCM coefficients are summarized in **Table 4**.

Table 4. Runoff Coefficients

Land Use	% Impervious	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	500-Yr
Residential Lots (2.5 ac or larger)	12.0%	0.077	0.133	0.221	0.386	0.452	0.533	0.626
Parks, Cemeteries	10.0%	0.063	0.117	0.206	0.375	0.442	0.525	0.620
Undeveloped Area (Off-site flow analysis)	45.0%	0.339	0.404	0.465	0.571	0.614	0.669	0.732
Streets	100%	0.830	0.855	0.872	0.879	0.883	0.894	0.908

2.3.1.2 Time of Concentration

The time of concentration was determined by combining the overland and channelized flow for each watershed using USDCM Equation 6-2, noted below in Equation 2:

$$t_c = t_i + t_t \qquad \textit{Equation } 2$$

where:

t_c = Time of Concentration (min)
t_i = Initial Time for Overland Flow (min)
t_t = Travel Time for Channelized Flow (min)

The initial time for overland flow was determined using Equation 6-3 in the USDCM, noted below. The length of the overland flow must not exceed 300 feet.

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{{S_o}^{0.33}} \qquad \textit{Equation 3}$$

where:

t_i = Initial Time for Overland Flow (min)
C_5 = 5-Year Runoff Coefficient per USDCM Table 6-4
L_i = Length of Overland Flow (ft)
S_o = Slope of Overland Flow

The travel time for channelized flow was determined using Equation 6-4 in the USDCM, noted below.

$$t_t = \frac{L_t}{60K\sqrt{S_o}} \qquad \textit{Equation 4}$$

where:

t_t = Travel Time for Channelized Flow (min)
L_t = Length of Channelized Flow (ft)
K = Natural Resource Conservation Service (NRCS) Conveyance Factor, Table 6-2 in MHFD USDCM
S_o = Slope of Channelized Flow

Per USDCM, the minimum time of concentration is five (5) minutes for an urban watershed and 10 minutes for a non-urban watershed.

2.3.1.3 Peak Flows

When the time of concentration is calculated, this method assumes this value to be equal to the storm duration. The corresponding intensity for a 10-year frequency or 100-year frequency is interpolated from the Intensity-Duration-Frequency relationship in Table 2, and the peak flow is calculated from Equation 1. A summary of project peak flows using Rational Method is provided in the summary tables of the drainage area maps shown in Appendix C.

2.3.2 NRCS Type II Unit Hydrograph

The NRCS Type II Unit Hydrograph Method was used to determine peak flow rates for all subwatersheds in the Eastbound (EB) Floyd Hill Watershed. The EB Floyd Hill Watershed contains two subwatersheds in excess of 90 acres; however, the watershed drains towards proposed ponds along I-70. Hence, a hydrologic method that produces a reliable hydrograph was preferred for all subwatersheds. The NRCS unit hydrograph was selected in lieu of MHFD’s Colorado Urban Hydrograph Program (CUHP) since the Project is outside of an urban area and is situated in a different environment than metropolitan Denver.

2.3.2.1 HEC-HMS

Hydrographs are generated using HEC-HMS. Using the NRCS Curve Number Loss Model and the SCS Unit Hydrograph Transform Model, the software computer the hydrograph, described in full in TR55 Chapter 4. Inputs for these models include:

- Watershed Area (square miles)
- Curve Number
- Watershed Percentage Impervious
- Precipitation-Duration-Depth Table (see Table 3)
- Lag time (min)

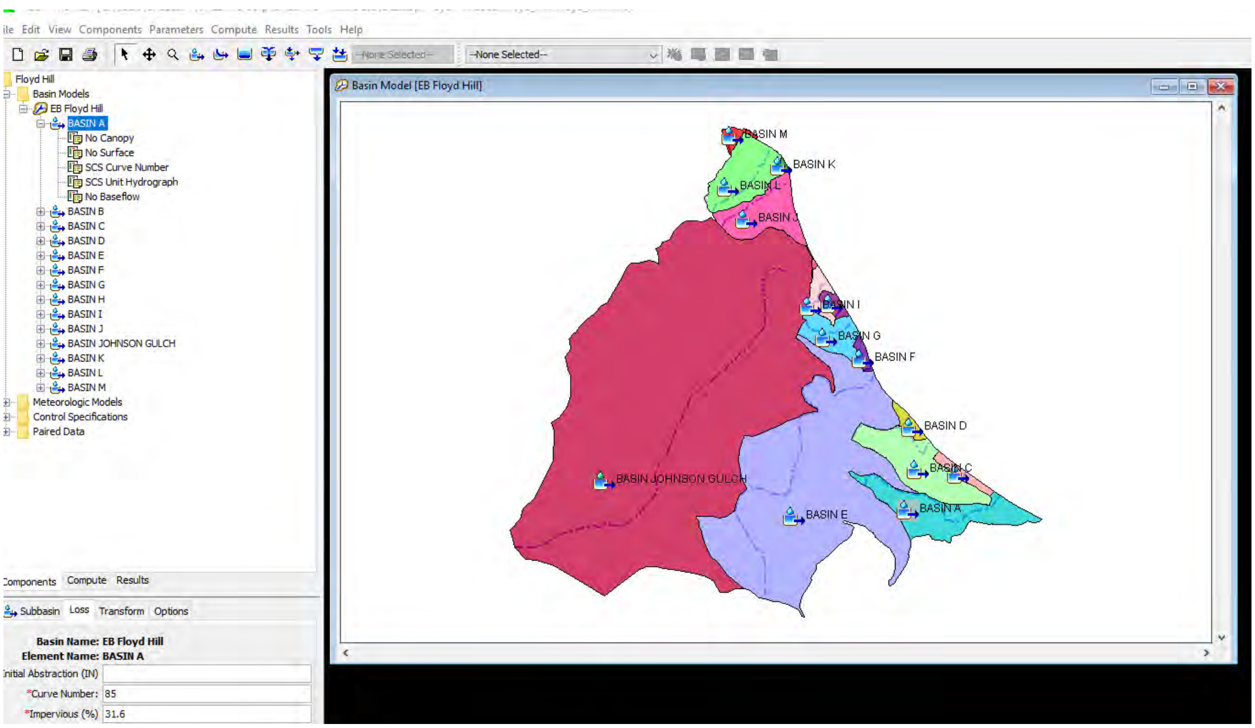


Figure 1. HEC-HMS Schematic

The following sections detail how the above listed inputs are obtained.

2.3.2.2 Hydrologic Loss

Hydrologic losses in each watershed are modeled using an NRCS Curve Number (CN). The CN of a watershed is area-weighted and is a function of the land uses and hydrologic soil groups (HSGs) within the watershed. Land use raster data is obtained from the 2016 National Land Cover Database (NLCD) that is publicly available from the Multi-Resolution Land Characteristics Consortium webpage. NLCD land cover categories are translated to TR55 land cover categories using the aerial and engineering judgement, see

Table 5. The 30-meter by 30-meter raster is converted to a polygon and projected to the project-specific coordinate system in GIS, see Figure 4.1.

Table 5. Land Cover Translation

NLCD Land Cover	TR55 Land Cover
Developed, Open Space	Pavement
Developed, Low Intensity	Pavement
Developed, Medium Intensity	Pavement
Developed, High Intensity	Pavement
Barren Land	Fallow
Deciduous Forest	Woods
Evergreen Forest	Woods
Shrub/Scrub	Brush
Herbaceous	Pasture, Grassland, or Range
Woody Wetlands	Woods

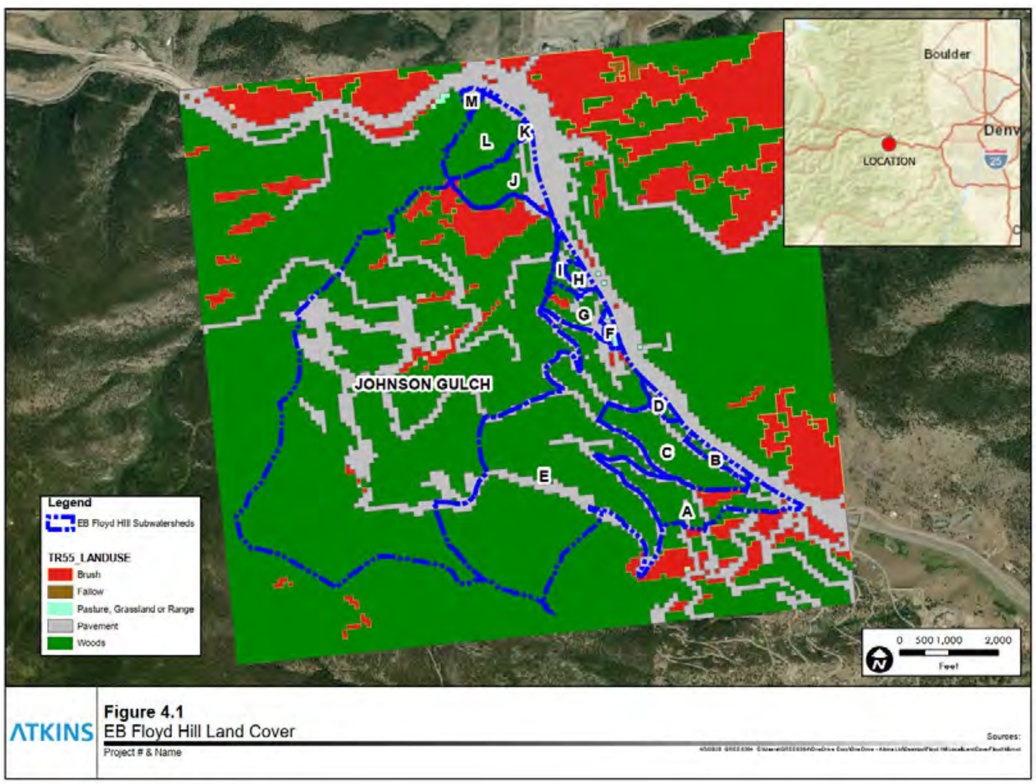
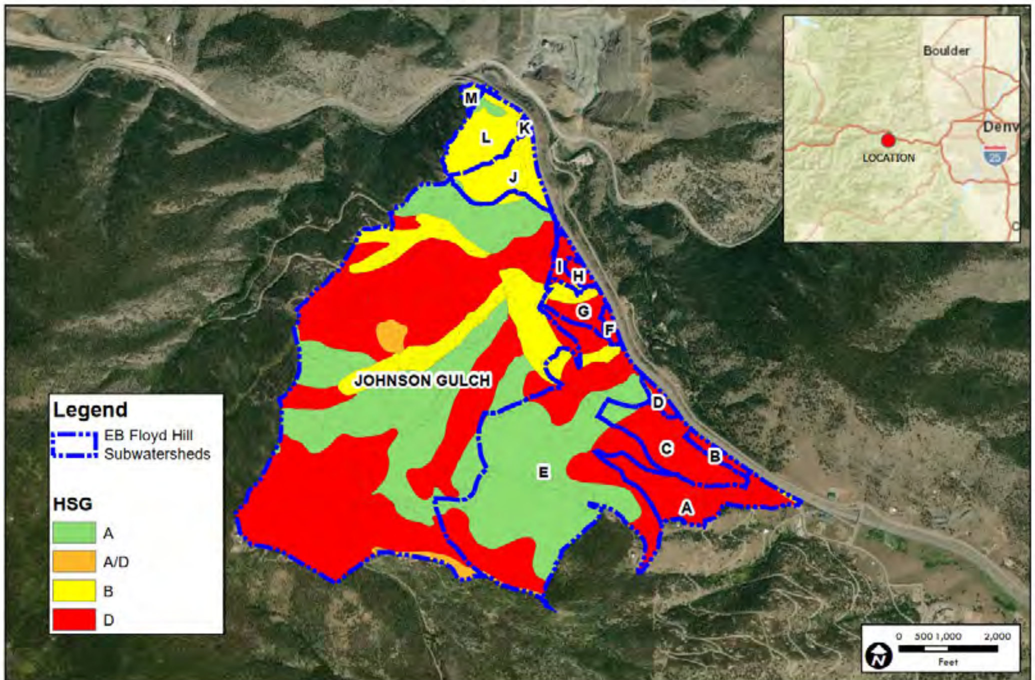


Figure 4.1
EB Floyd Hill Land Cover

Tabular and spatial 2019 Soil Survey Geographic Database (SSURGO) data is obtained from the NRCS Web Soil Survey website (Figure 4.2).



ATKINS Figure 4.2
EB Floyd Hill Hydrologic Soil Groups (HSGs)
Project # & Name

The HSG and Land Cover shapes are intersected and assigned a CN per **Table 8**; results shown in Figure 4.3. Woods are assumed to be in good condition, and brush is assumed to be in fair condition.

Table 6. NRCS Curve Numbers

Land Use	Hydraulic Condition	HGS Type A	HGS Type B	HGS Type C	HGS Type D
Pasture, grassland or range	Poor Fair Good	68 49 39	79 69 61	86 79 74	89 84 80
Fallow	--	77	86	91	94
Brush	Poor Fair Good	48 35 30	67 56 48	77 70 65	83 77 73
Woods	Poor Fair Good	57 43 32	73 65 58	82 76 72	86 82 79
Pavement	--	98	98	98	98

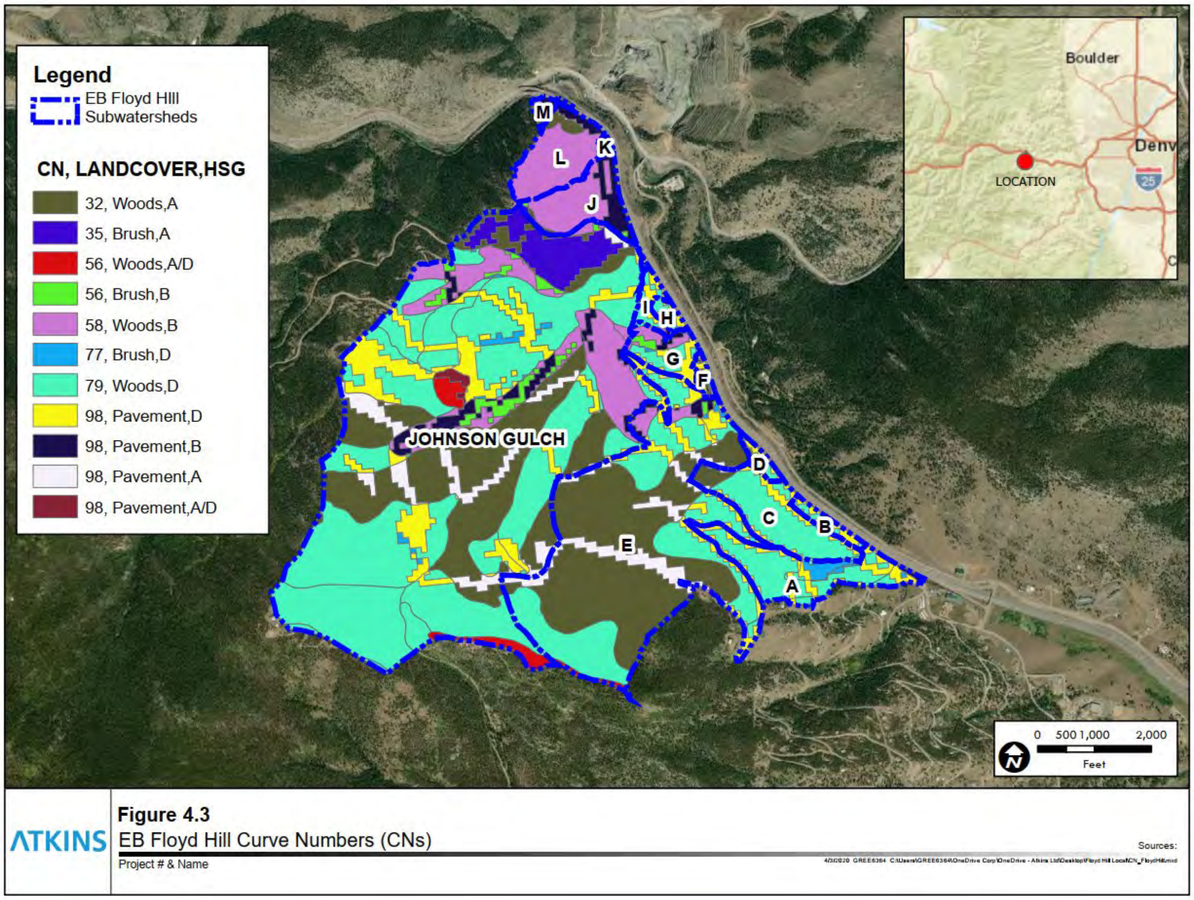


Figure 4.3
EB Floyd Hill Curve Numbers (CNs)

A weighted curve number for each subwatershed is found using Equation 5:

$$CN(weighted) = \frac{\sum CN_i \times A_i}{A_{TOTAL}} \qquad Equation\ 5$$

where i represents each CN shape within a subwatershed. Over 300 CN shapes were analyzed, and the calculations are provided in Appendix B. TR55 Land Cover type Pavement, shown in **Table 5**, is assumed to be impervious. Percentage impervious is found by the summation of Pavement Area within a subwatershed divided by the total subwatershed area. The weighted CN and percentage impervious for each subwatershed is summarized in **Table 9**.

Table 7. EB Floyd Hill Subwatershed Curve Numbers and Percentage Impervious

EB Floyd Hill Subwatershed ID	TR55 Land Cover	Percentage (%) Impervious
A	85	31.6
B	92	66.7
C	79	21.6
D	84	48.0
E	59	18.9

EB Floyd Hill Subwatershed ID	TR55 Land Cover	Percentage (%) Impervious
F	94	63.8
G	81	41.4
H	87	43.9
I	87	47.1
J	68	28.1
JOHNSON GULCH	68	17.4
K	95	92.8
L	59	9.7
M	62	44.6

2.3.2.3 Time of Concentration

TR55 time of concentration is calculated as the summation of sheet flow, shallow concentrated flows travel times, Equation 6.

$$t_c = t_{sheet} + t_{shallow-concentrated} + t_{channel} \qquad \text{Equation 6}$$

Sheet flow travel time is calculated per Equation 7:

$$t_{sheet}(minutes) = 60 \times \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{Equation 7}$$

where,

n = Manning's roughness coefficient (TR55 Table 3-1)
L = flow length (feet)
P_2 = 2-year, 24-hour rainfall (inches)
S = land slope (ft/ft).

After a maximum of 300 feet, sheet flow becomes shallow concentrated flow. Shallow concentrated flow travel time is calculated per Equation 8:

$$t_{shallow-concentrated}(minutes) = \frac{L}{60V} \qquad \text{Equation 8}$$

where,

L = flow length (ft)
V= velocity (feet/second).

The velocity is a function of slope and is obtained from Part 630 of the National Engineering Handbook, specific to flow in forest with heavy ground litter (Equation 9).

$$V = 2.516(s)^{0.5} \qquad \text{Equation 9}$$

Chanel flow time is calculated using Manning's Equation and assumes bank-full elevations. Bentley FlowMaster is used to calculate velocity, V, using fixed inputs of channel slope, bank-full depth, left- and right-side slope, and a roughness coefficient indicative of the bed material to solve for discharge and V. FlowMaster calculations are attached in Appendix B.

Channel flow travel time is calculated using Equation 10:

$$t_{channel}(minutes) = \frac{L}{60V} \qquad Equation\ 10$$

where,

L = flow length (feet)
V = velocity (feet/second).

2.3.2.4 Lag Time

The lag time in the time from the center of mass of excess rainfall to the hydrograph peak. Per Chapter 6 of the HEC-HMS Technical Reference Manual, the relationship between time on concentration and lag time in an ungaged watershed is suggested as:

$$t_{lag}(minutes) = 0.6t_c \qquad Equation\ 10$$

2.3.2.5 Peak Flows

EB Floyd Hill Basin	Drainage Area	10-Yr, 24-Hr Peak Discharge	100-Yr, 24-Hr Peak Discharge
	SQ MILES	CFS	CFS
BASIN A	0.0798	83.9	165.9
BASIN B	0.0102	17.9	31.1
BASIN C	0.0757	59.9	133.6
BASIN D	0.0079	12	22.6
BASIN E	0.4725	57.6	152.8
BASIN F	0.0059	10.9	18.7
BASIN G	0.0311	36.7	72.8
BASIN H	0.0073	9.1	16.9
BASIN I	0.0134	12.2	22.7
BASIN J	0.0557	33.5	80.5
BASIN JOHNSON GULCH	1.1862	339.2	941.7
BASIN K	0.0017	3.4	5.8
BASIN L	0.0585	7.4	28.2
BASIN M	0.0063	4.7	9.7

3. Hydraulics

The following sections outline the hydraulic criteria for the preliminary design.

3.1 Inlets

For Project uniformity and consistency with existing drainage structures, standard CDOT structures are proposed along all roads, regardless of the owner. **Table 8** outlines the spread requirements along each roadway for minor and major storms, as well as the limitation on the type of inlets.

A 50% clogging factor was applied to all grate inlets, while a 10% clogging factor was applied to all curb opening inlets. To be conservative with the preliminary design, no reduction factor will be applied for multiple inlets in a row. A manning's roughness coefficient of n=0.016 is used for the pavement roughness in calculating spread.

Table 8. Inlet Design Criteria

Owner	Classification	Inlet Type	Storm Return Period	Allowable Spread	Allowable Ponding Depth
CDOT	Interstate	Vane Grates	10-Year 50-Year 100-Year	Shoulder + 3 feet (min of 4 feet) Shoulder (Sags Only) 4 feet into travel lane	NA (minor & major)
	Minor Arterial	Type R Type C Type D	5-Year 50-Year	Shoulder + 4 feet (min of 4 feet) Shoulder + 3 feet	NA (minor) 6 inches at crown or 18 inches at gutter pan (major)
	Major Collector	Type R Type C Type D	5-Year 10-Year (Sags only)	Shoulder + 4 feet ½ of driving Lane	NA (minor) 6 inches at crown or 18 inches at gutter pan (major)
	Minor Collector	Type R Type C Type D	5-Year 10-Year (Sags only)	Shoulder + 4 feet ½ of driving lane	NA (minor) 6 inches at crown or 18 inches at gutter pan (major)
Central City	Major Collector	Type R Type 13 Type C	10-Year 100-Year	One 10-ft wide driving lane Confined to Right-of-way	No curb overtopping Confined to ROW or no more than 6-inches over crown, whichever is more restrictive (major)
Clear Creek County	Minor Collector	Type R (Preferred) Type C Type D	25-Year	No specific criteria Use: One 10-ft wide driving lane	No ponding on the roadway (25-Year)

Inlets were also be placed at certain locations regardless of spread and ponding depth requirements. Examples of such locations include:

- Upstream of expansion joints
- 10 feet upstream of super elevations transitions
- Median breaks
- Upstream of ramps and intersections

At super elevation transitions, an inlet was placed 10 feet upstream of the 0% cross slope. If the first inlet did not meet spread or ponding depth criteria, then a second inlet was placed 50 feet upstream of the first inlet. The second inlet was checked for compliance with depth and spread criteria. If the second inlet did not meet the requirements, a third inlet was placed 50 feet upstream of the second inlet. This process of adding inlets continued until all but the first inlet (the initial inlet 10 feet upstream of the 0% cross slope) met spread and depth criteria.

3.2 Storm Drains

Table 9 summarizes the requirement for the storm drain networks. In general, structures will be placed at all horizontal and vertical bends, pipe connections, and at the maximum spacing requirement noted below.

Table 9. Storm Drain Design Criteria

Owner	CDOT	Clear Creek County	City of Central
Minor Storm	Hydraulic Grade Line (HGL) contained within the pipe		Hydraulic Grade Line (HGL) contained within the pipe
Major Storm	HGL 1' below top of structure (Preferred)		HGL 1' below top of structure (Preferred)
Access Locations	≤ 48 inches 300 ft > 48 inches 600 ft	24 inches or less 200 ft > 24 inches 400 ft	48 inches or less 400 ft > 48 inches 500 ft
Minimum Pipe Size	18-in /15-in laterals to avoid utility conflict or meet cover requirements	18-in	12-in
Velocity	3 ft/sec min (minor) 22 ft/sec max (major)		2 ft/sec min (minor)
Minimum Slope	0.30% (0.50% Preferred)		
Allowable Pipe Material[1]	RCP, CMP, HDPE (Pipe Selection Manual)	CMP, RCP, HDPE	RCP, HDPE
Minimum Cover[2]	3 feet (preferred)		12 inches
Utility Clearances			18 inches to water and sewer lanes

[1]See the *List of Acronyms* at the start of this report
[2]Cover is measured from finished grade to top of storm drain

The Manning's roughness coefficients for pipes of the Project are presented in **Table 10**.

Table 10. Pipe—Manning's Roughness Coefficients

Material	Use	Roughness Coefficient
Concrete	Pipes	0.013
Corrugated Metal Pipe	Pipe	0.025
Polyvinyl Chloride	Pipe	0.013
Steel	Pipe	0.013

3.3 Ditches

Ditches are proposed along the roadway shoulder, behind walls, or adjacent to barriers. **Table 11** summarizes the requirements for all ditches. Open channels and streams that do not have a uniform cross section shall were evaluated using the Hydrologic Engineering Center's River Analysis System (HEC-RAS). See Section 5.2 for additional information.

Table 11. Ditch Design Criteria

Ditch Type	Criteria	Minor Storm	Major Storm
All	Return Period	10 Year	100 Year
Roadside	Freeboard	Most restrictive of: • 1 foot to bottom of proposed subgrade • 1 foot to existing edge of pavement • 1 foot from top of ditch	Edge of Pavement
	Lining	Utilize Guidance provided in the Hydraulic Engineering Center (HEC) 15 manual. Design with FHWA's Engineering Toolbox	NA
Top of Wall	Freeboard	NA	6 inches to top of wall
	Lining	Concrete	NA
Face of Barrier	Freeboard	NA	1 foot
	Lining	Concrete	NA

Ditches are expected to be lined in either concrete (n=0.013), grass with turf reinforcement matting (TRM) (N=0.030), or riprap (n=0.035).

3.4 Culverts

Culverts are defined as a continuous run of pipe that has no upstream or downstream pipe network. A culvert must convey flows from one end to the other without the addition of flow. Culverts must:

- Have a minimum velocity of 3 ft/sec in the 10-year event

Conform to the minimum diameter criteria in

- **Table 12**
- Conform to the headwater over depth (HW/D) criteria in **Table 13**
- All interstates will remain free of the 100-year water surface elevation

Table 12. Minimum Culvert Diameters

Application	Minimum Diameter (in)
Interstate	36
National Highway System—Non-Interstate	30
State and U.S. Highways and Approaches to Interstate	24
Irrigation Crossing and Side Drain	18
Storm Drain	18

Table 13. Culvert Allowable Headwater vs. Depth Criteria

Culvert Diameter	Allowable HW/D
Less than 36 inches	2.0
Larger than 36 inches but less than 60 inches	1.7
Larger than 60 inches but less than 84 inches	1.5
Larger than 84 inches but less than 120 inches	1.2
120 inches or larger	1.0

3.5 Extended Detention Basins

Extended detention basins were graded to maximize the volume of the pond. Large storm events will spill over the top of the water quality structure and flow to Clear Creek. One foot of freeboard will be provided for the 100-year storm to the top of pond. Extended detention basins should follow MHFD's recommendations.

The water quality volume should be maximized to the greatest extent practicable; ideally, treating water quality capture volume would be equal to or greater than MHFD's recommended value, calculated using:

$$WQCV = \left(\frac{a(0.91I^3 - 1.19I^2 + 0.78I}{12}\right)A$$

where:

WQCV = water quality capture volume (acre-feet)
A = drain time coefficient (1.0 for extended detention ponds)
I = imperviousness (%/100)
A = watershed area (acres)

3.6 Energy Dissipaters and Outfall Paving

Outfalls for pipes 36 inches and smaller have a flared end section. Outfalls for pipes 42 inches and greater use headwalls. Slope paving will be provided at all outfalls according to the CDOT standard plan M-601-12. The minimum thickness for the riprap outlet paving will be twice the D_{50} with a minimum thickness of an 18-inch thick layer. Geotextile will be placed underneath all riprap. For round pipes, the D_{50} will be determined using:

$$D_{50} = \frac{0.23Q}{Y_t^{1.2} D_c^{0.3}}$$

where:

D_{50}= median riprap particle size (inches)
Q= 10-year flow rate (cfs)
Y_t= Tailwater depth (ft)
D_c=depth of flow in the pipe

For rectangular boxes, the D_{50} will be determined using:

$$D_{50} = \frac{0.014H^{0.5}Q}{Y_t W}$$

where:

D_{50}= median riprap particle size (inches)
H= height of the box
Q= 10-year flow rate (cfs)
Y_t= Tailwater depth (ft)
W= Width of the box.

The D_{50} will be rounded up to 6, 9, 12, 18, or 24-inches to conform to standard CDOT specification for riprap sizes. When riprap is placed underwater, the required thickness of the riprap shall be doubled.

Any additional energy dissipaters should be designed according to MHFD USDCM and HEC-14.

4. Stream Hydrology and Hydraulics Analysis and Design Criteria

The following section documents the proposed design approach and criteria for designing non-uniform open channels, primarily for the realignment of Clear Creek.

4.1 Floodplain

The Project runs adjacent to Clear Creek between the Veterans Memorial Tunnels and US-6. A Zone A floodplain has been delineated by Federal Emergency Management Agency (FEMA) though this section of Clear Creek. The Project will document the design and impacts of all project related improvements and changes located in the 1% (100 year) and 0.2% (500 year) annual chance floodplain. The project will limit any changes to the 1% annual inundation area (floodplain limits) to CDOT ROW.

Proposed improvements will comply with all local, state, and federal regulations associated with the proposed modifications and will occur in coordination with CDOT and local agencies.

All proposed work in the regulated flood fridge or floodways will obtain a floodplain development permit. Proposed improvements shall either show a no rise, otherwise a conditional letter of map revision (CLOMR) will be prepared to document the proposed improvements, floodplain impacts and compliance with the applicable floodplain regulations.

4.1.1 Floodplain Modeling

Previously, HEC-RAS software version 5.0.5 was used to verify the current floodplain limits. Aqueveo's Surface-Water Modeling System (SMS) Version 13 will be used to design proposed improvements, compare and report the existing and proposed water surface elevations to determine low chord and freeboard requirement for various design elements. The model will use revised flow rates calculated based on guidance from FEMA Bulletin 17C.

The 2-dimensional analysis of Clear Creek considers channel, bridge scour, and scour countermeasures, as well as low chord and freeboard requirements. Additional discussion on the floodplains and floodplain modeling is provided in the *I-70 Floyd Hill to Veterans Memorial Tunnels Conceptual Clear Creek Baseline Hydraulics Report*.

4.2 Bridge Design

Table 14 summarizes the design requirement for bridge clearances, scour calculations, and scour countermeasure recommendations.

Table 14. Bridge Design Criteria

Criteria	CDOT Requirements
Minimum Freeboard to Structure Low Chord	4 feet (5 feet preferred for rafting)
Maximum Mean Velocity though the Bridge	16 feet-per-second
Scour Calculations	500-year return period HEC-18 and HEC-20 for calculations • General Scour (aggradation and degradation • Plan form change (lateral channel movement) • Contraction Scour • Local Scour (pier and abutment)
Scour Countermeasures	HEC-23

4.2.1 Deck Drainage

Deck drains will be added to structures whenever needed to ensure spread criteria is met. In addition, inlets will be provided upstream/downstream of the bridge expansion device to minimize flow across the expansion device. All deck drainage designs shall conform to the procedures in HEC-21.

4.3 Additional Considerations

In addition to the hydraulic criteria in this section, the realignment of Clear Creek also must consider the effects on recreational activities and wildlife habitat. There are no clear criteria for either of these considerations. As design progresses, coordination with interested parties must occur.

Appendix B. Calculations

1 Hydrology Calculations

HEC-HMS for NRCS Hydrograph Method

Time of Concentration for NRCS Hydrograph Method

I-70 Floyd Hill to Veterans Memorial Tunnels

BY: LG DATE: 03/15/20
CHECKED BY: SFM DATE: 04/06/20

PROPOSED OFFSITE DRAINAGE CONDITIONS

Drainage System	Subpath Path	TIME OF CONCENTRATION Tc																							Sub T_c
		SHEET FLOW[2]							SHALLOW CONCENTRATED FLOW[3]							CHANNEL FLOW[4]									
		L	n	$P_{2YR,24HR}$	Elev US	Elev DS	S	T_t	L	Cover	Elev US	Elev DS	S	V	T_t	L	W[5]	XS[5]	d[6]	Elev US	Elev DS	S	V	T_t	
		(ft)		(in)	(ft)	(ft)	(ft/ft)	(min)	(ft)	-	(ft)	(ft)	(ft/ft)	(ft/s)	(min)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(min)	(min)
EB FH-Basin E	1	300.0	0.400	1.75	9487	9418	0.230	26.33	1778.2	Forest	9418	8937	0.27	1.309	22.65	1451.6	22	0.020	0.440	8937	8817	0.08	11.76	2.06	51.0
EB FH-Basin E	2	300.0	0.400	1.75	8817	8708	0.363	21.93	1525.3	Forest	8708	8194	0.34	1.461	17.41	2061.8	22	0.020	0.440	8194	8028	0.08	11.76	2.92	42.3
EB FH-Basin E	3	146.3	0.206	1.75	8028	7965	0.431	6.77							0.00	920.2	-	-	1.000	7965	7656	0.34	9.15	1.68	8.4
EB FH-Basin C	1	300.0	0.400	1.75	8206	8023	0.610	17.82	113.0	Forest	8023	7971	0.46	1.707	1.10	1642.6	22	0.020	0.440	7971	7890	0.05	9.27	2.95	21.9
EB FH-Basin C	2							0.00							0.00	300.2	-	-	0.750	7890	7775	0.38	9.48	0.53	0.5
EB FH-Basin A	1	205.8	0.400	1.75	8520	8460	0.292	17.71						0.000	0.00	2176.9	22	0.020	0.440	8460	8307	0.07	10.98	3.30	21.0
EB FH-Basin A	2							0.00						0.000	0.00	1310.6	-	-	1.500	8307	7915	0.30	12.47	1.75	1.8
EB FH-Basin A	3							0.00						0.000	0.00	140.4	-	-	0.750	7915	7884	0.22	12.04	0.19	0.2
EB FH-Basin J	1	249.8	0.400	1.75	7956	7900	0.224	22.97						0.000	0.00	1543.2	-	-	1.500	7900	7375	0.34	13.61	1.89	24.9
JOHNSONS GULCH	1	279.6	0.400	1.75	9609	9529	0.286	22.80						0.000	0.00	9514.7	-	-	0.300	9529	7420	0.22	6.18	25.66	48.5
EB FH-Basin B	1	182.7	0.400	1.75	7934	7836	0.536	12.62						0.000	0.00									0.00	12.6
EB FH-Basin D	1	277.8	0.240	1.75	7926	7726	0.720	10.42						0.000	0.00									0.00	10.4
EB FH-Basin F	1	189.7	0.400	1.75	7790	7651	0.733	11.48						0.000	0.00									0.00	11.5
EB FH-Basin G	1	255.2	0.240	1.75	7882	7810	0.282	14.17						0.000	0.00	788.2	-	-	1.000	7810	7589	0.28	9.43	1.39	15.6
EB FH-Basin G	2							0.00						0.000	0.00	151.7	-	-	0.300	7589	7571	0.12	4.58	0.55	0.6
EB FH-Basin H	1	300.0	0.400	1.75	7698	7569	0.430	20.50	31.0	Forest	7569	7543	0.84	2.304	0.22									0.00	20.7
EB FH-Basin I	1	300.0	0.400	1.75	7864	7747	0.390	21.31	176.5	Forest	7747	7671	0.43	1.656	1.78	350.5	11.000	0.020	0.220	7671	7658	0.04	5.23	1.12	24
EB FH-Basin I	2	216.5	0.400	1.75	7658	7516	0.656	13.33						0.000	0.00									0.00	13
EB FH-Basin L	1	300.0	0.400	1.75	7995	7880	0.383	21.46	1643.6	Forest	7880	7308	0.35	1.484	18.46									0.00	40
EB FH-Basin M	1	300.0	0.400	1.75	7621	7467	0.513	19.09	209.3	Forest	7467	7258	1.00	2.514	1.39									0.00	20
EB FH-Basin K	1	151.7	0.400	1.75	7481	7360	0.798	9.28						0.000	0.00									0.00	9
								#DIV/0!						0.000	#DIV/0!									#DIV/0!	#DIV/0!
								#DIV/0!						0.000	#DIV/0!									#DIV/0!	#DIV/0!
								#DIV/0!						0.000	#DIV/0!									#DIV/0!	#DIV/0!
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								#DIV/0!						0.000	#DIV/0!									#DIV/0!	#DIV/0!

1. Time of concentration Tc= sheet flow + shallow concentrated flow + pipeline/channel flow per TR55 Chapter 3
2. Sheet Flow Travel Time in minutes $T_t=(0.007L^{4/5}n^{4/5})/(P_2^{1/2}S^{2/5})$ (L=length of flow path in feet, n=Manning's roughness coefficient - TR-55 Table 3-1, S=Slope of flow in ft/ft, P_2=2-year, 24-hour rainfall depth in inches)
   Lmax=300 ft
3. Shallow Concentrated Flow Travel Time in minutes T_t=L/60V
4. Pipeline Flow/ Channel Flow: Time estimated by dividing length of pipe or channel by the velocity, V, obtained using Manning's Equation. Calcs for V are in Bentley Flowmaster.
5. Roadway width, W, and cross-section slope, XS, are the controlling parameters for channel flow normal depth along offsite roads.

2 Hydraulics Calculations

Offsite Floyd Hill (OFF) - Ditch Calculations

Time of Concentration for Rational Method

Rectangular Channel (OFF-CH Ditch Calculations.fm8) Report

Label	Solve For	Discharge (cfs)	Normal Depth (ft)
OFF-CH-000a; Basin A - Subasin: 100YR Q = 18.3 cfs	Normal Depth	26.40	1.60
OFF-CH-000b; Basin A - Subasin: 100YR Q = 26.4 cfs	Normal Depth	18.30	0.92
OFF-CH-001; Basin B, 100YR Q = 31.2 cfs	Normal Depth	31.20	0.91
OFF-CH-002; Basin D, 100YR Q = 22.6 cfs	Normal Depth	22.60	0.71
OFF-CH-003; Basin F, 100YR Q = 18.7 cfs	Normal Depth	18.70	0.54
OFF-CH-004; Basin I, 100YR Q = 22.7 cfs	Normal Depth	22.70	0.63
OFF-CH-005; Basin K, 100YR Q = 5.7 cfs	Normal Depth	5.70	0.49

Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Bottom Width (ft)
Manning Formula	0.013	0.01000	2.00
Manning Formula	0.013	0.02000	2.00
Manning Formula	0.013	0.06000	2.00
Manning Formula	0.013	0.06320	2.00
Manning Formula	0.013	0.09320	2.00
Manning Formula	0.013	0.08810	2.00
Manning Formula	0.013	0.06690	1.00

Top Width (ft)	Critical Depth (ft)	Velocity (ft/s)	Flow Type
2.00	1.76	8.27	Supercritical
2.00	1.38	9.91	Supercritical
2.00	1.96	17.10	Supercritical
2.00	1.58	15.97	Supercritical
2.00	1.40	17.34	Supercritical
2.00	1.59	18.01	Supercritical
1.00	1.00	11.65	Supercritical

Bentley FlowMaster V8i (SELECTseries 1) [08.11.01.03]
Bentley Systems, Inc. Haestad Methods Solution Center

I-70 Floyd Hill to Veterans Memorial Tunnel
Drainage System: West Section - CC, CR314, CCP
Time of Concentration Calculations - Offsite Areas

I-70 Floyd Hill to Veterans Memorial Tunnels

Designer: SLC Checker: JLF

						Overland Flow					Channelized									
Area ID	Area (ac)	Area (sq mi)	Method	5-Yr Runoff Coef.	Land Use	Length (ft) (ft)	U/S Elev. (ft) (ft)	D/S Elev. (ft) (ft)	Slope (ft/ft)	Ti (min)	Length (ft)	U/S Elev. (ft)	D/S Elev. (ft)	Slope (ft/ft)	Conveyance Coef. (NRCS K)	Land Surface	Velocity (ft/sec)	Tt (min)	Tc (min)	**Tc Use (min)**
CC																				
A-CC-CH-016	1.79	0.0028	Rational Method	0.40	Undeveloped	80.26	7715	7650	0.810	2.6423	296.23	7650	7384.8	0.89525	10.00	Bare	9.4618	0.5218	3.164	**5.000**
A-CC-CH-015	2.34	0.0036	Rational Method	0.40	Undeveloped	78.7	7696	7620	0.966	2.4674	304.3	7620	7374	0.808413	10.00	Bare	8.9912	0.5641	3.032	**5.000**
A-CC-CH-014	1.91	0.0030	Rational Method	0.40	Undeveloped	102.9	7682.7	7655	0.269	4.3191	266.79	7655	7365	1.086997	10.00	Bare	10.4259	0.4265	4.746	**5.000**
A-CC-CH-006A	2.88	0.0045	Rational Method	0.40	Undeveloped	159.5	7677.8	7615	0.394	4.7372	236.5	7615	7360	1.078224	10.00	Bare	10.3838	0.3796	5.117	**5.117**
A-CC-CH-002A	4.82	0.0075	Rational Method	0.40	Undeveloped	199.58	7670	7600	0.351	5.5073	467.7	7600	7385	0.459696	10.00	Bare	6.7801	1.1497	6.657	**6.657**
A-CC-PO-001B	1.19	0.0019	Rational Method	0.40	Undeveloped	192.45	7560	7500	0.312	5.6245	288.5	7500	7350	0.519931	10.00	Bare	7.2106	0.6668	6.291	**6.291**
A-CC-PO-001A	0.88	0.0014	Rational Method	0.40	Undeveloped	56.2	7474.8	7450	0.441	2.7071	216.1	7450	7350	0.462749	10.00	Bare	6.8026	0.5295	3.237	**5.000**
CCP																				
A-CCP-IN-015	23.39	0.0365	Rational Method	0.40	Undeveloped	283.21	8225	8120	0.371	6.4402	1822.212	8120	7315	0.441771	10.00	Bare	6.6466	4.5693	11.010	**11.010**
CR314																				
A-CR-IN-019	9.85	0.0154	Rational Method	0.40	Undeveloped	283.9	8190	8090	0.352	6.5591	1403.4	8090	7340	0.534416	10.00	Bare	7.3104	3.1996	9.759	**9.759**
A-CR-CH-004	4.15	0.0065	Rational Method	0.40	Undeveloped	280.8	7940	7790	0.534	5.6777	579.9	7790	7340	0.775996	10.00	Bare	8.8091	1.0972	6.775	**6.775**
A-CR-IN-016B	3.82	0.0060	Rational Method	0.40	Undeveloped	174.15	7623	7550	0.419	4.8477	451	7550	7349	0.445676	10.00	Bare	6.6759	1.1259	5.974	**5.974**
A-CR-CH-002	1.98	0.0031	Rational Method	0.40	Undeveloped	229.1	7830	7690	0.611	4.9036	434	7690	7370	0.737327	10.00	Bare	8.5868	0.8424	5.746	**5.746**
A-CR-CH-003	1.55	0.0024	Rational Method	0.40	Undeveloped	279.8	7910	7740	0.608	5.4295	506.4	7740	7360	0.750395	10.00	Bare	8.6625	0.9743	6.404	**6.404**
A-EX-CR-CH-002	1.49	0.0023	Rational Method	0.40	Undeveloped	268.2	7770	7620	0.559	5.4646	314.4	7620	7370	0.795165	10.00	Bare	8.9172	0.5876	6.052	**6.052**
A-CR-CH-001	0.98	0.0015	Rational Method	0.40	Undeveloped	236.9	7780	7650	0.549	5.1685	302.8	7650	7370	0.924703	10.00	Bare	9.6161	0.5248	5.693	**5.693**
A-CR-IN-010B	0.67	0.0010	Rational Method	0.40	Undeveloped	135.8	7622	7550	0.530	3.9583	273.4	7550	7350	0.731529	10.00	Bare	8.5529	0.5328	4.491	**5.000**
A-CR-FES-006	0.61	0.0009	Rational Method	0.40	Undeveloped	88.6	7620	7570	0.564	3.1314	276.8	7570	7345	0.812861	10.00	Bare	9.0159	0.5117	3.643	**5.000**
A-CR-FES-001	0.40	0.0006	Rational Method	0.40	Undeveloped	91.37	7580	7500	0.876	2.7469	167.9	7500	7370	0.77427	10.00	Bare	8.7993	0.3180	3.065	**5.000**

I-70 Floyd Hill to Veterans Memorial Tunnel
Drainage System: Central Section (Tunnel) - West Bend, East Bend, AFS
Time of Concentration Calculations - Offsite Areas

I-70 Floyd Hill to Veterans Memorial Tunnels

Designer: EV Checker: JLF

						Overland Flow					Channelized									
Area ID	Area (ac)	Area (sq mi)	Method	5-Yr Runoff Coef.	Land Use	Length (ft) (ft)	U/S Elev. (ft) (ft)	D/S Elev. (ft) (ft)	Slope (ft/ft)	Ti (min)	Length (ft)	U/S Elev. (ft)	D/S Elev. (ft)	Slope (ft/ft)	Conveyance Coef. (NRCS K)	Land Surface	Velocity (ft/sec)	Tt (min)	Tc (min)	**Tc Use (min)**
West Bend																				
A-WB-TR-010	5.41	0.0085	Rational Method	0.40	Undeveloped	500	8070	7775	0.590	7.3295	516.399	7775	7278.297	0.961858	10.00	Bare	9.8074	0.8776	8.207	**8.207**
A-WB-TR-011A	4.29	0.0067	Rational Method	0.40	Undeveloped	500	8070	7785	0.570	7.4142	579.789	7785	7284.532	0.86319	10.00	Bare	9.2908	1.0401	8.454	**8.454**
A-WB-TR-012A	5.57	0.0087	Rational Method	0.40	Undeveloped	500	8070	7775	0.590	7.3295	790.673	7775	7295.622	0.606291	10.00	Bare	7.7865	1.6924	9.022	**9.022**
A-WB-TR-015A	2.86	0.0045	Rational Method	0.40	Undeveloped	500	8030	7645	0.770	6.7070	384.57	7645	7279.237	0.951096	10.00	Bare	9.7524	0.6572	7.364	**7.364**
A-WB-TR-016A	4.00	0.0063	Rational Method	0.40	Undeveloped	500	8075	7735	0.680	6.9907	490.335	7735	7291.145	0.905209	10.00	Bare	9.5142	0.8589	7.850	**7.850**
A-WB-TR-017A	3.94	0.0062	Rational Method	0.40	Undeveloped	500	8040	7610	0.860	6.4644	292.33	7610	7297.785	1.068021	10.00	Bare	10.3345	0.4714	6.936	**6.936**
A-WB-TR-018A	0.88	0.0014	Rational Method	0.40	Undeveloped	500	8040	7635	0.810	6.5947	227.508	7635	7315.753	1.403236	10.00	Bare	11.8458	0.3201	6.915	**6.915**
A-WB-TR-020	3.93	0.0061	Rational Method	0.40	Undeveloped	500	7950	7515	0.870	6.4395	157.312	7515	7321.317	1.231204	10.00	Bare	11.0960	0.2363	6.676	**6.676**
A-WB-TR-021	22.33	0.0349	Rational Method	0.40	Undeveloped	500	7885	7710	0.350	8.7231	781.78	7710	7324.77	0.49276	10.00	Bare	7.0197	1.8562	10.579	**10.579**
A-WB-TR-023	5.78	0.0090	Rational Method	0.40	Undeveloped	500	8000	7570	0.860	6.4644	260.185	7570	7326.74	0.934949	10.00	Bare	9.6693	0.4485	6.913	**6.913**
East Bend																				
A-EB-TR-004	8.98	0.0140	Rational Method	0.40	Undeveloped	500	7975	7565	0.820	6.5678	358.526	7565	7269.862	0.823199	10.00	Bare	9.0730	0.6586	7.226	**7.226**
A-EB-TR-005	6.00	0.0094	Rational Method	0.40	Undeveloped	500	7975	7680	0.590	7.3295	589.381	7680	7262.731	0.707978	10.00	Bare	8.4141	1.1674	8.497	**8.497**
A-EB-TR-006	2.92	0.0046	Rational Method	0.40	Undeveloped	500	7975	7770	0.410	8.2749	854.825	7770	7261.188	0.595223	10.00	Bare	7.7151	1.8467	10.122	**10.122**
A-EB-TR-007	2.96	0.0046	Rational Method	0.40	Undeveloped	500	7695	7510	0.370	8.5630	217.345	7510	7259.59	1.152134	10.00	Bare	10.7337	0.3375	8.900	**8.900**
A-EB-IN-031a	1.38	0.0022	Rational Method	0.40	Undeveloped	300	7560	7425	0.450	6.2139	48.151	7425	7257.534	3.477939	10.00	Bare	18.6492	0.0430	6.257	**6.257**
A-EB-TR-008	11.27	0.0176	Rational Method	0.40	Undeveloped	500	7975	7810	0.330	8.8958	1384.84	7810	7259.249	0.3977	10.00	Bare	6.3063	3.6599	12.556	**12.556**
A-EB-TR-009	7.21	0.0113	Rational Method	0.40	Undeveloped	500	7745	7545	0.400	8.3433	326.142	7545	7259.656	0.874907	10.00	Bare	9.3536	0.5811	8.924	**8.924**
AFS																				
EX-A-AFS-HW-002	35.75	0.0559	Rational Method	0.40	Undeveloped	500.00	7995	7961	0.068	15.0610	2301.35	7961	7359	0.261585	10.00	Bare	5.1145	7.4994	22.560	**22.560**
EX-A2-AFS-HW-004	37.31	0.0583	Rational Method	0.40	Undeveloped	500.00	7995	7815	0.360	8.6415	2083.11	7815	7278	0.257787	10.00	Bare	5.0773	6.8380	15.480	**15.480**
EX-A1-AFS-HW-004	1.14	0.0018	Rational Method	0.40	Undeveloped	180.44	7489	7350	0.770	4.0286	330.67	7350	7328	0.066531	10.00	Bare	2.5794	2.1367	6.165	**6.165**

						Overland Flow					Channelized									
Area ID	Area (ac)	Area (sq mi)	Method	5-Yr Runoff Coef.	Land Use	Length (ft) (ft)	U/S Elev. (ft) (ft)	D/S Elev. (ft) (ft)	Slope (ft/ft)	Ti (min)	Length (ft)	U/S Elev. (ft)	D/S Elev. (ft)	Slope (ft/ft)	Conveyance Coef. (NRCS K)	Land Surface	Velocity (ft/sec)	Tt (min)	Tc (min)	**Tc Use (min)**
Canyon 1																				
A-CA1-IN-012	6.08	0.0095	Rational Method	0.40	Undeveloped	276.396	8070	7910	0.579	5.4842	832.603	7910	7335	0.690605	10.00	Bare	8.3103	1.6698	7.154	**7.154**
A-CA1-CH-007B	3.88	0.0061	Rational Method	0.40	Undeveloped	256.478	8070	7945	0.487	5.5947	821.718	7945	7343	0.732611	10.00	Bare	8.5593	1.6001	7.195	**7.195**
A-CA1-CH-005B	3.89	0.0061	Rational Method	0.40	Undeveloped	263.016	8033	7860	0.658	5.1268	648.715	7860	7380	0.739924	10.00	Bare	8.6019	1.2569	6.384	**6.384**
Canyon 2																				
A-CA2-FES-007	27.15	0.0424	Rational Method	0.40	Undeveloped	173.819	7883	7855	0.161	6.6614	1184.428	7855	7275	0.489688	10.00	Bare	6.9978	2.8210	9.482	**9.5**
A-CA2-FES-003	9.97	0.0156	Rational Method	0.40	Undeveloped	298.773	8075	7950	0.418	6.3536	898.654	7950	7285	0.739996	10.00	Bare	8.6023	1.7411	8.095	**8.1**
A-CA2-FES-011	7.99	0.0125	Rational Method	0.40	Undeveloped	210.885	7990	7760	1.091	3.8785	706.557	7760	7280	0.679351	10.00	Bare	8.2423	1.4287	5.307	**5.3**
A-CA2-FES-009	6.85	0.0107	Rational Method	0.40	Undeveloped	250.319	7983	7875	0.431	5.7563	900.446	7875	7275	0.666336	10.00	Bare	8.1629	1.8385	7.595	**7.6**
A-CA2-FES-013	6.50	0.0102	Rational Method	0.40	Undeveloped	285.721	7975	7840	0.472	5.9664	967.262	7840	7265	0.594461	10.00	Bare	7.7101	2.0909	8.057	**8.1**
A-CA2-CH-013	3.68	0.0057	Rational Method	0.40	Undeveloped	239.518	7975	7870	0.438	5.6009	1191.539	7870	7265	0.507747	10.00	Bare	7.1256	2.7870	8.388	**8.4**
A-CA2-CH-014	3.55	0.0056	Rational Method	0.40	Undeveloped	253.586	7730	7630	0.394	5.9700	655.42	7630	7250	0.579781	10.00	Bare	7.6143	1.4346	7.405	**7.4**
A-CA2-FES-005	2.09	0.0033	Rational Method	0.40	Undeveloped	175.191	7753	7570	1.045	3.5863	290.796	7570	7275	1.014457	10.00	Bare	10.0720	0.4812	4.068	**5.0**
A-CA2-FES-015	1.83	0.0029	Rational Method	0.40	Undeveloped	98.036	7560	7535	0.255	4.2925	255.635	7535	7245	1.13443	10.00	Bare	10.6510	0.4000	4.693	**5.0**
Canyon 3																				
A-CA3-FES-004	11.19	0.0175	Rational Method	0.40	Undeveloped	274.719	7980	7865	0.419	6.0914	1631.523	7865	7260	0.370819	10.00	Bare	6.0895	4.4654	10.557	**10.6**
A-CA3-CH-010	3.92	0.0061	Rational Method	0.40	Undeveloped	188.512	7745	7690	0.292	5.6912	580.999	7690	7255	0.74871	10.00	Bare	8.6528	1.1191	6.810	**6.8**
A-CA3-CH-011	2.96	0.0046	Rational Method	0.40	Undeveloped	187.413	7690	7635	0.293	5.6635	320.54	7635	7270	1.138703	10.00	Bare	10.6710	0.5006	6.164	**6.2**
CAFS																				
EX-A-CAFS-CH-001	2.31	0.0036	Rational Method	0.40	Undeveloped	133.115	7471.917	7362.327	0.823	3.3843	733.122	7362.327	7316	0.063191	10.00	Bare	2.5138	4.8607	8.245	**8.245**
EX-A-CAFS-CH-004	37.40	0.0584	Rational Method	0.40	Undeveloped	500.00	7995	7815	0.360	8.6415	2083.11	7815	7278	0.257787	10.00	Bare	5.0773	6.8380	15.480	**15.480**
EX-A-CAFS-CH-006	3.15	0.0049	Rational Method	0.40	Undeveloped	500	7638	7317.19	0.642	7.1274	486.174	7317.19	7249.052	0.140151	10.00	Bare	3.7437	2.1644	9.292	**9.292**
EX-A-CAFS-FES-008	36.59	0.0572	Rational Method	0.40	Undeveloped	500.00	7995	7961	0.068	15.0610	2221.672	7961	7363.84	0.268789	10.00	Bare	5.1845	7.1421	22.203	**22.203**

Area ID	Area (ac)	Area (sq mi)	Method	5-Yr Runoff Coef.	Land Use	Overland Flow					Channelized									
						Length (ft) (ft)	U/S Elev. (ft) (ft)	D/S Elev. (ft) (ft)	Slope (ft/ft)	Ti (min)	Length (ft)	U/S Elev. (ft)	D/S Elev. (ft)	Slope (ft/ft)	Conveyance Coef. (NRCS K)	Land Surface	Velocity (ft/sec)	Tt (min)	Tc (min)	**Tc Use (min)**
Not Applicable																				

3 Water Quality Calculations

SUDA Model	Pond	Color	Proposed Roadway Area* (100% Impervious)	Offsite Tributary Area (45% Impervious)	Total Area	Weighted % Impervious	Required WQCV (ac-ft)**	Pond Bottom El	Pond Bottom Area (sqft)	Top of WQ Structure	Pond Area @ Top of WQ Structure (sqft)	Storage Volume per EDB (ac-ft)	WQCV Achieved?
West Section													
Clear Creek	**CC-PO-001**	Teal	5.31	17.36	22.66	58%	0.43	7336.00	5720.29	7339.50	16153.67	0.84	Y
CR-314		Green	2.03	25.43	27.45	49%	0.47						WQ Not Provided
Central City	**CCP-PO-001**	Red	6.75	0.00	6.75	100%	0.28	7310.00	1611.72	7312.00	3310.56	0.11	N
Central City		Red	6.48	13.45	19.94	63%	0.41						WQ Not Provided
Central Section (Tunnel)													
West Bend	**WB-PO-001**	Yellow	9.71	0.00	9.71	100%	0.40	7273.00	2727.15	7279.00	7323.57	0.67	Y
West Bend		Yellow	3.88	60.46	64.34	48%	1.08						WQ Not Provided
East Bend	**EB-PO-001**	Blue	13.68	40.75	54.43	59%	1.05	7254.00	34123.96	7258.00	52885.69	3.96	Y
US-6	**US6-PO-001**	Orange	4.00	4.37	8.36	71%	0.20						WQ Not Provided
ASF Quarry	**ASF-PO-001**	Pink	9.66	38.51	48.17	56%	0.90	7221.00	14722.45	7224.50	36280.23	1.98	Y
ASF Quarry	**AFS-BMP-001**	Pink	5.22	35.76	40.97	52%	0.72						WQ Not Provided
Central Section (Canyon)													
Canyon_1	**CA1-PO-001**	Yellow	10.97	13.83	24.80	69%	0.56	7273.00	5315.08	7276.50	12127.09	0.68	Y
Canyon_1	Deck Drainage	Yellow	4.18	0.00	4.18	100%	0.17						WQ Not Provided
Canyon_2	**CA2-PO-001**	Blue	6.19	0.00	6.19	100%	0.26	7256.00	2478.54	7259.00	5856.25	0.28	Y
Canyon_2	Culverts	Blue	0.00	66.82									
Canyon_3		Orange	5.95	18.07	24.01	59%	0.46						WQ Not Provided
Canyon ASF	**CASF-PO-001**	Pink	6.55	38.71	45.27	53%	0.81	7290.00	2801.35	7292.00	7118.22	0.22	N
Canyon ASF	**CASF-BMP-001**	Pink	2.23	36.56	38.79	48%	0.65						WQ Not Provided
Canyon ASF	Deck Drainage	Pink	9.60	3.15	12.75	86%	0.40						WQ Not Provided
East Section													
Not Captured	EB Embankment	Gray	7.75	0.00	7.75	100%	0.32						WQ Not Provided
Not Captured	Offsite Trunkline	Red	1.45	0.00	1.45	100%	0.06						WQ Not Provided
Johnson Gulch	**JG-PO-002**	Red	1.33	0.00	1.33	100%	0.06	7666.00	4759.37	7670.00	12468.99	0.76	Y
Johnson Gulch	**JG-PO-001**	Red	4.90	0.00	4.90	100%	0.20	7560.00	7736.00	7564.00	7736.00	0.71	Y
East Floyd Hill	**EFH-BMP-001**	Green	12.76	0.00	12.76	100%	0.53						WQ Not Provided
TOTAL	**Tunnel**		94.89	236.07	330.97		7.12					9.04	Y
TOTAL	**Canyon**		94.41	166.56	260.97		6.08					3.61	N
Floyd Hill Offsite		Teal	0.00	448.67	448.67	45%	7.21						WQ Not Provided
Beaver Brook		Purple	30.72	261.32	292.04	51%	5.07						WQ Not Provided

Note: Project is not within MS4 Permit Area. PWQ calculations are shown for information only. Water Quality Approach does not specify treatment area or WQCV requirements.

*Proposed roadway area includes roadside ditches

**WQCV equation from on MHFD USDCM

Equation 3-1 below is used to calculate WQCV as a function of imperviouisness and BMP drain time:

$$WQCV = a(0.91I^3 - 1.19I^2 + 0.78I)$$

Where: WQCV = Water Quality Capture Volume (watershed inches)

a = Coefficient corresponding to WQCV drain time; Drain time = 40 hours, a = 1.0

I = Imperviousness (%/100) = 1.0 (100% Impervious)

Therefore: $WQCV = 1.0(0.91*1^3-1.19*1^2+.78*1) = 0.5$ watershed inches

Equation 3-3 below will provide the watershed inches for various imperviousness and drain times.

$$V = \left(\frac{WQCV}{12}\right) A$$

Where:

V = required storage volume (acre-ft)

A = tributary catchment area upstream

WQCV = Water Quality Capture Volume (watershed inches)

Therefore: V (acre-ft) = 0.5/12 x A (acre) = 0.4167 x A acre-ft

Appendix C. Proposed Drainage Area Maps

Drainage System Legend

West Section
- Clear Creek
- CR314
- Central City Parkway

Tunnel Alternative Section
- West Bend
- East Bend
- US 6
- AFS Quarry

East Section
- Eastbound Floyd Hill
- Johnson Gulch
- Beaver Brook
- Offsite Floyd Hill

Canyon Viaduct Alternative Section
- Canyon Alternative 1
- Canyon Alternative 2
- Canyon Alternative 3
- Canyon AFS Quarry

Other Basin Areas
- Roadway Not Captured
- Large Culvert Cross-Drainage

I-70 Floyd Hill to Veterans Memorial Tunnels

DRAINAGE AREA MAP
COVER SHEET

Design by: E. Vega-Bazan Plot: 1 of 9
Drawn by: E. Vega-Bazan Date: August 17, 2020
Checked by: M. Tilko

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-CC-CH-001	0.618	0.872	0.894	N/A	5.00	2.32	3.80
A-CC-CH-002A	4.817	0.465	0.669	N/A	6.66	8.79	19.71
A-CC-CH-002B	0.417	0.465	0.669	N/A	5.00	0.84	1.92
A-CC-CH-003	0.529	0.872	0.894	N/A	5.00	1.99	3.26
A-CC-CH-006A	2.882	0.465	0.669	N/A	5.12	5.73	12.93
A-CC-CH-006B	0.306	0.872	0.894	N/A	5.00	1.15	1.89
A-CC-CH-008	0.219	0.465	0.669	N/A	5.00	0.44	1.01
A-CC-CH-011	0.198	0.465	0.669	N/A	5.00	0.40	0.91
A-CC-CH-012	0.041	0.465	0.669	N/A	5.00	0.08	0.19
A-CC-CH-013	0.246	0.465	0.669	N/A	5.00	0.49	1.13
A-CC-CH-014	1.905	0.465	0.669	N/A	5.00	3.81	8.74
A-CC-CH-015	2.336	0.465	0.669	N/A	5.00	4.67	10.76
A-CC-CH-016	1.785	0.465	0.669	N/A	5.00	3.57	8.22
A-CC-CH-017A	0.326	0.465	0.669	N/A	5.00	0.65	1.50
A-CC-CH-017B	0.247	0.872	0.894	N/A	5.00	0.93	1.52
A-CC-IN-001	0.177	0.872	0.669	N/A	5.00	0.67	0.82
A-CC-IN-002	0.371	0.872	0.894	N/A	5.00	1.39	2.28
A-CC-IN-003A	0.137	0.872	0.894	N/A	5.00	0.52	0.84
A-CC-IN-003B	0.350	0.872	0.894	N/A	5.00	1.31	2.15
A-CC-IN-004	0.185	0.872	0.894	N/A	5.00	0.69	1.14
A-CC-IN-005	0.342	0.872	0.894	N/A	5.00	1.28	2.10
A-CC-IN-006	0.421	0.872	0.894	N/A	5.00	1.58	2.59
A-CC-IN-007	0.416	0.872	0.894	N/A	5.00	1.56	2.56
A-CC-IN-008	0.395	0.872	0.894	N/A	5.00	1.48	2.43
A-CC-IN-009A	0.445	0.872	0.894	N/A	5.00	1.67	2.74
A-CC-IN-009B	0.106	0.465	0.894	N/A	5.00	0.21	0.65
A-CC-IN-010	0.422	0.872	0.894	N/A	5.00	1.58	2.60
A-CC-IN-011	0.124	0.872	0.894	N/A	5.00	0.46	0.76
A-CC-IN-014	0.013	0.465	0.669	N/A	5.00	0.03	0.06
A-CC-PO-001A	0.879	0.465	0.669	N/A	5.00	1.76	4.05
A-CC-PO-001B	1.186	0.465	0.669	N/A	6.29	2.21	4.96
A-CCP-CH-002	0.370	0.465	0.669	N/A	5.00	0.74	1.70
A-CCP-CH-003	0.164	0.465	0.669	N/A	5.00	0.33	0.76
A-CCP-IN-001	0.570	0.872	0.894	N/A	5.00	2.14	3.51
A-CCP-IN-002	0.313	0.872	0.894	N/A	5.00	1.18	1.93
A-CCP-IN-003	0.414	0.872	0.894	N/A	5.00	1.55	2.55
A-CCP-IN-004	0.267	0.872	0.894	N/A	5.00	1.00	1.64
A-CCP-IN-005	0.000	0.872	0.894	N/A	5.00	0.00	0.00
A-CCP-IN-006	0.170	0.872	0.894	N/A	5.00	0.64	1.05
A-CCP-IN-007	0.230	0.872	0.894	N/A	5.00	0.86	1.42
A-CCP-IN-008A	0.192	0.872	0.894	N/A	5.00	0.72	1.18
A-CCP-IN-008B	0.164	0.465	0.669	N/A	5.00	0.33	0.76
A-CCP-IN-009	0.196	0.872	0.894	N/A	5.00	0.74	1.21
A-CCP-IN-010	0.351	0.872	0.894	N/A	5.00	1.32	2.16
A-CCP-IN-011	0.109	0.872	0.894	N/A	5.00	0.41	0.67
A-CCP-IN-012	0.133	0.872	0.894	N/A	5.00	0.50	0.82
A-CCP-IN-013	0.244	0.465	0.669	N/A	5.00	0.49	1.13
A-CCP-IN-014	0.211	0.872	0.894	N/A	5.00	0.79	1.30
A-CCP-IN-015	0.402	0.465	0.669	N/A	5.00	0.80	1.85
A-CCP-IN-016	0.467	0.465	0.669	N/A	5.00	0.94	2.15
A-CCP-IN-017	0.126	0.872	0.894	N/A	5.00	0.47	0.78
A-CCP-IN-018	0.076	0.872	0.894	N/A	5.00	0.29	0.47
A-CCP-IN-019	0.304	0.872	0.894	N/A	5.00	1.14	1.87
A-CCP-IN-020	0.148	0.465	0.669	N/A	5.00	0.30	0.68
A-CCP-IN-021	0.683	0.872	0.894	N/A	5.00	2.56	4.20
A-CCP-IN-022	0.465	0.872	0.894	N/A	5.00	1.75	2.86
A-CCP-IN-023A	0.095	0.872	0.894	N/A	5.00	0.35	0.58
A-CCP-IN-023B	0.017	0.872	0.894	N/A	5.00	0.06	0.10
A-CCP-IN-024A	0.441	0.872	0.894	N/A	5.00	1.65	2.71
A-CCP-IN-024B	0.011	0.872	0.894	N/A	5.00	0.04	0.07
A-CCP-IN-025	0.345	0.872	0.894	N/A	5.00	1.30	2.13
A-CCP-IN-026	0.081	0.872	0.894	N/A	5.00	0.30	0.50
A-CCP-IN-027	0.237	0.465	0.669	N/A	5.00	0.47	1.09

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-CCP-IN-028	0.139	0.872	0.894	N/A	5.00	0.52	0.86
A-CCP-IN-029	0.189	0.872	0.894	N/A	5.00	0.71	1.16
A-CCP-IN-030	0.259	0.872	0.894	N/A	5.00	0.97	1.59
A-CCP-IN-031	0.064	0.872	0.894	N/A	5.00	0.24	0.39
A-CCP-IN-032	0.315	0.872	0.894	N/A	5.00	1.18	1.94
A-CCP-IN-033	0.369	0.465	0.669	N/A	5.00	0.74	1.70
A-CCP-IN-034	0.309	0.872	0.894	N/A	5.00	1.16	1.90
A-CCP-IN-035	0.134	0.872	0.894	N/A	5.00	0.50	0.83
A-CCP-PO-001	0.382	0.465	0.669	N/A	5.00	0.77	1.76
A-EX-CCP-IN-007	0.302	0.465	0.669	N/A	5.00	0.60	1.39
A-EX-CCP-IN-008	0.303	0.872	0.894	N/A	5.00	1.14	1.87
A-EX-CCP-IN-009	0.361	0.872	0.894	N/A	5.00	1.36	2.22
A-EX-CCP-IN-010	0.148	0.872	0.894	N/A	5.00	0.55	0.91
A-EX-CCP-IN-011	0.136	0.872	0.894	N/A	5.00	0.51	0.84
A-EX-CCP-IN-036	13.454	0.465	0.669	N/A	13.47	17.16	39.45
A-WB-CH-014	0.423	0.872	0.894	N/A	5.00	1.59	2.60
A-WB-CH-014A	0.350	0.465	0.669	N/A	5.00	0.70	1.61
A-WB-IN-020	0.506	0.872	0.894	N/A	5.00	1.90	3.11
A-WB-IN-023	0.116	0.872	0.894	N/A	5.00	0.44	0.72
A-WB-IN-024	0.261	0.872	0.894	N/A	5.00	0.98	1.61
A-WB-IN-025	0.367	0.872	0.894	N/A	5.00	1.38	2.26
A-WB-IN-026	0.587	0.872	0.894	N/A	5.00	2.20	3.61
A-WB-IN-027	0.583	0.872	0.894	N/A	5.00	2.19	3.59

ID	Area (ac)	C (25 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 25 (cfs)	Q 100 (cfs)
A-CR-CH-001	0.929	0.571	N/A	N/A	5.00	2.81	N/A
A-CR-CH-002	1.982	0.571	N/A	N/A	6.13	5.64	N/A
A-CR-CH-003	1.554	0.571	N/A	N/A	6.83	4.24	N/A
A-CR-CH-004	4.152	0.571	N/A	N/A	7.22	11.08	N/A
A-CR-FES-001	0.556	0.571	N/A	N/A	5.00	1.68	N/A
A-CR-FES-006	0.604	0.571	N/A	N/A	5.00	1.83	N/A
A-CR-FES-008	9.867	0.571	N/A	N/A	9.80	22.19	N/A
A-CR-IN-001	0.065	0.879	N/A	N/A	5.00	0.31	N/A
A-CR-IN-002A	0.041	0.879	N/A	N/A	5.00	0.19	N/A
A-CR-IN-002B	0.078	0.879	N/A	N/A	5.00	0.36	N/A
A-CR-IN-003	0.188	0.879	N/A	N/A	5.00	0.87	N/A
A-CR-IN-004A	0.052	0.879	N/A	N/A	5.00	0.24	N/A
A-CR-IN-004B	0.028	0.879	N/A	N/A	5.00	0.13	N/A
A-CR-IN-004C	0.047	0.879	N/A	N/A	5.00	0.22	N/A
A-CR-IN-005	0.082	0.879	N/A	N/A	5.00	0.38	N/A
A-CR-IN-006A	0.072	0.879	N/A	N/A	5.00	0.34	N/A
A-CR-IN-006B	0.040	0.879	N/A	N/A	5.00	0.18	N/A
A-CR-IN-006C	0.086	0.879	N/A	N/A	5.00	0.40	N/A
A-CR-IN-007	0.000	0.879	N/A	N/A	5.00	0.00	N/A
A-CR-IN-009A	0.081	0.879	N/A	N/A	5.00	0.38	N/A
A-CR-IN-009B	0.025	0.879	N/A	N/A	5.00	0.12	N/A
A-CR-IN-010A	0.130	0.879	N/A	N/A	5.00	0.60	N/A
A-CR-IN-010B	0.665	0.571	N/A	N/A	5.00	2.01	N/A
A-CR-IN-010C	0.053	0.879	N/A	N/A	5.00	0.25	N/A
A-CR-IN-011	0.047	0.879	N/A	N/A	5.00	0.22	N/A
A-CR-IN-012A	0.032	0.879	N/A	N/A	5.00	0.15	N/A
A-CR-IN-012B	0.169	0.879	N/A	N/A	5.00	0.79	N/A
A-CR-IN-012C	0.394	0.571	N/A	N/A	5.00	1.19	N/A
A-CR-IN-013	0.065	0.879	N/A	N/A	5.00	0.30	N/A
A-CR-IN-014	0.139	0.879	N/A	N/A	5.00	0.65	N/A
A-CR-IN-015	0.040	0.879	N/A	N/A	5.00	0.18	N/A
A-CR-IN-016A	0.082	0.879	N/A	N/A	5.00	0.38	N/A
A-CR-IN-016B	3.666	0.571	N/A	N/A	6.35	10.30	N/A
A-CR-IN-017	0.042	0.879	N/A	N/A	5.00	0.19	N/A
A-CR-IN-018	0.085	0.879	N/A	N/A	5.00	0.40	N/A
A-EX-CR-CH-002	0.976	0.571	N/A	N/A	6.09	2.78	N/A
A-EX-CR-CH-003	0.256	0.879	N/A	N/A	5.00	1.19	N/A
A-EX-CR-CH-004	0.080	0.571	N/A	N/A	5.00	0.24	N/A

Legend

	Existing	Proposed
Type R Inlet		
Single Vane Grate Inlet		
Double Vane Grate Inlet		
Type C Inlet		
Manhole		
Ditch		
Pipe		
Removal		
1' Contour		
Type 3 Barrier		
Type 7 Barrier		

Drainage System Legend

West Section
- Clear Creek
- CR314
- Central City Parkway

Tunnel Alternative Section
- West Bend
- East Bend
- US 6
- AFS Quarry

East Section
- Eastbound Floyd Hill
- Johnson Gulch
- Beaver Brook
- Offsite Floyd Hill

Canyon Viaduct Alternative Section
- Canyon Alternative 1
- Canyon Alternative 2
- Canyon Alternative 3
- Canyon AFS Quarry

Other Basin Areas
- Roadway Not Captured
- Large Culvert Cross-Drainage

0' 25' 100' 200'

I-70 Floyd Hill to Veterans Memorial Tunnels

DRAINAGE AREA MAP

Station 2000+00 to Station 2043+50

Design by: S. Criminski Plot: 2 of 9
Drawn by: S. Criminski Date: August 17, 2020
Checked by: M. Tilko

TUNNEL ALTERNATIVE - WEST SECTION

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-WB-IN-010	0.151	0.872	0.894	N/A	5.00	0.57	0.93
A-WB-IN-011	0.121	0.872	0.894	N/A	5.00	0.45	0.74
A-WB-IN-012	0.100	0.872	0.894	N/A	5.00	0.38	0.62
A-WB-IN-013	0.139	0.872	0.894	N/A	5.00	0.52	0.85
A-WB-IN-014	0.118	0.872	0.894	N/A	5.00	0.44	0.72
A-WB-IN-015	0.378	0.872	0.894	N/A	5.00	1.42	2.33
A-WB-IN-016	0.400	0.872	0.894	N/A	5.00	1.50	2.46
A-WB-IN-017	0.381	0.872	0.894	N/A	5.00	1.43	2.35
A-WB-IN-018	0.358	0.872	0.894	N/A	5.00	1.34	2.20
A-WB-IN-019	0.381	0.872	0.894	N/A	5.00	1.43	2.35
A-WB-IN-020	0.506	0.872	0.894	N/A	5.00	1.90	3.11
A-WB-IN-021	0.106	0.872	0.894	N/A	5.00	0.40	0.65
A-WB-IN-022	0.094	0.872	0.894	N/A	5.00	0.35	0.58
A-WB-IN-024	0.261	0.872	0.894	N/A	5.00	0.98	1.61
A-WB-IN-025	0.367	0.872	0.894	N/A	5.00	1.38	2.26
A-WB-IN-028	0.503	0.872	0.894	N/A	5.00	1.89	3.10
A-WB-IN-029	0.718	0.872	0.894	N/A	5.00	2.70	4.42
A-WB-IN-033	0.249	0.872	0.894	N/A	5.00	0.93	1.53
A-WB-IN-036	0.533	0.872	0.894	N/A	5.00	2.00	3.28
A-WB-IN-038	0.215	0.872	0.894	N/A	5.00	0.81	1.32
A-WB-IN-039	0.053	0.872	0.894	N/A	5.00	0.20	0.33
A-WB-IN-040	0.061	0.872	0.894	N/A	5.00	0.23	0.37
A-WB-IN-041	0.209	0.872	0.894	N/A	5.00	0.79	1.29
A-WB-IN-043	0.247	0.872	0.894	N/A	5.00	0.93	1.52
A-WB-IN-044	0.268	0.872	0.894	N/A	5.00	1.00	1.65
A-WB-IN-045	0.285	0.872	0.894	N/A	5.00	1.07	1.75
A-WB-IN-046	0.418	0.872	0.894	N/A	5.00	1.57	2.57
A-WB-IN-048	0.259	0.872	0.894	N/A	5.00	0.97	1.59
A-WB-CH-002	0.141	0.872	0.894	N/A	5.00	0.53	0.87
A-WB-CH-002A	0.166	0.465	0.669	N/A	5.00	0.33	0.76
A-WB-CH-003	0.137	0.872	0.894	N/A	5.00	0.51	0.84
A-WB-CH-003A	0.126	0.465	0.669	N/A	5.00	0.25	0.58
A-WB-CH-004	0.194	0.872	0.894	N/A	5.00	0.73	1.19
A-WB-CH-004A	0.106	0.465	0.669	N/A	5.00	0.21	0.49
A-WB-CH-005	0.082	0.872	0.894	N/A	5.00	0.31	0.50
A-WB-CH-005A	0.044	0.465	0.669	N/A	5.00	0.09	0.20
A-WB-CH-011	5.406	0.465	0.669	N/A	8.21	8.97	20.62
A-WB-CH-012	0.256	0.872	0.894	N/A	5.00	0.96	1.58
A-WB-CH-012A	4.294	0.465	0.669	N/A	8.45	7.01	16.12
A-WB-CH-013	0.222	0.872	0.894	N/A	5.00	0.83	1.37
A-WB-CH-013A	5.574	0.465	0.669	N/A	9.02	8.76	20.14
A-WB-CH-014	0.423	0.872	0.894	N/A	5.00	1.59	2.60
A-WB-CH-014A	0.350	0.465	0.669	N/A	5.00	0.70	1.61
A-WB-CH-016	0.213	0.872	0.894	N/A	5.00	0.80	1.31
A-WB-CH-016A	2.863	0.465	0.669	N/A	7.36	5.01	11.52
A-WB-CH-017	0.564	0.872	0.894	N/A	5.00	2.12	3.47
A-WB-CH-017A	4.002	0.465	0.669	N/A	7.85	6.79	15.62
A-WB-CH-018	0.632	0.872	0.894	N/A	5.00	2.37	3.89
A-WB-CH-018A	3.940	0.465	0.669	N/A	6.94	7.07	16.26
A-WB-CH-019	0.599	0.872	0.894	N/A	5.00	2.25	3.69
A-WB-CH-019A	0.882	0.465	0.669	N/A	6.92	1.59	3.65
A-WB-CH-020	1.105	0.465	0.669	N/A	5.00	2.21	5.09
A-WB-CH-021	3.931	0.465	0.669	N/A	6.68	7.16	16.48
A-WB-CH-022	22.334	0.465	0.669	N/A	10.58	32.05	73.66
A-WB-CH-023	5.777	0.465	0.669	N/A	6.91	10.38	23.88
A-WB-PO-001	0.107	0.872	0.894	N/A	5.00	0.40	0.66
A-WB-PO-001A	0.113	0.872	0.894	N/A	5.00	0.43	0.70
A-WB-PO-001B	0.105	0.465	0.669	N/A	5.00	0.21	0.48
A-WB-PO-001C	0.198	0.465	0.669	N/A	5.00	0.40	0.91

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-EB-IN-001A	0.159	0.872	0.894	N/A	5.00	0.60	0.98
A-EB-IN-002	0.130	0.872	0.894	N/A	5.00	0.49	0.80
A-EB-IN-004	0.181	0.465	0.669	N/A	5.00	0.36	0.83
A-EB-IN-004A	0.027	0.872	0.894	N/A	5.00	0.10	0.16
A-EB-IN-005	0.253	0.872	0.894	N/A	5.00	0.95	1.56
A-EB-IN-006	0.038	0.465	0.669	N/A	5.00	0.08	0.17
A-EB-IN-008	0.184	0.872	0.894	N/A	5.00	0.69	1.13
A-EB-IN-009	0.144	0.872	0.894	N/A	5.00	0.54	0.89
A-EB-IN-010	0.199	0.872	0.894	N/A	5.00	0.75	1.22
A-EB-IN-011	0.181	0.872	0.894	N/A	5.00	0.68	1.12
A-EB-IN-013	0.145	0.872	0.894	N/A	5.00	0.54	0.89
A-EB-IN-014	0.118	0.872	0.894	N/A	5.00	0.44	0.72
A-EB-IN-015	0.130	0.872	0.894	N/A	5.00	0.49	0.80
A-EB-IN-016	0.273	0.872	0.894	N/A	5.00	1.03	1.68
A-EB-IN-017	0.322	0.872	0.894	N/A	5.00	1.21	1.98
A-EB-IN-019	0.559	0.872	0.894	N/A	5.00	2.10	3.44
A-EB-IN-020	0.321	0.872	0.894	N/A	5.00	1.20	1.97
A-EB-IN-021	0.195	0.872	0.894	N/A	5.00	0.73	1.20
A-EB-IN-024	0.396	0.872	0.894	N/A	5.00	1.49	2.44
A-EB-IN-025	0.223	0.872	0.894	N/A	5.00	0.84	1.38
A-EB-IN-026	0.259	0.872	0.894	N/A	5.00	0.97	1.59
A-EB-IN-027	0.308	0.872	0.894	N/A	5.00	1.16	1.90
A-EB-IN-028	0.229	0.872	0.894	N/A	5.00	0.86	1.41
A-EB-IN-029	0.121	0.872	0.894	N/A	5.00	0.45	0.74
A-EB-IN-031	0.225	0.872	0.894	N/A	5.00	0.84	1.38
A-EB-IN-031A	1.383	0.465	0.669	N/A	6.26	2.58	5.94
A-EB-IN-031B	0.285	0.872	0.894	N/A	5.00	1.07	1.75
A-EB-IN-038	0.200	0.872	0.894	N/A	5.00	0.75	1.23
A-EB-PO-001	1.139	0.872	0.894	N/A	5.00	4.27	7.01
A-EB-PO-001A	3.735	0.465	0.669	N/A	5.00	7.47	17.20
A-EB-CH-001	0.424	0.465	0.669	N/A	5.00	0.85	1.95
A-EB-CH-002	0.182	0.465	0.669	N/A	5.00	0.36	0.84
A-EB-CH-003	9.006	0.465	0.669	N/A	7.23	15.88	36.53
A-EB-CH-004	5.997	0.465	0.669	N/A	8.50	9.76	22.44
A-EB-CH-004A	0.291	0.872	0.894	N/A	5.00	1.09	1.79
A-EB-CH-005	2.920	0.465	0.669	N/A	10.12	4.26	9.80
A-EB-CH-005A	0.269	0.872	0.894	N/A	5.00	1.01	1.65
A-EB-CH-006	2.964	0.465	0.669	N/A	8.90	4.70	10.80
A-EB-CH-006A	0.240	0.872	0.894	N/A	5.00	0.90	1.47
A-EB-CH-008	11.271	0.465	0.669	N/A	12.56	14.94	34.35
A-EB-CH-008A	0.358	0.872	0.894	N/A	5.00	1.34	2.20
A-EB-CH-039	0.291	0.872	0.894	N/A	5.00	1.09	1.79
A-EB-CH-040	0.312	0.872	0.894	N/A	5.00	1.17	1.92
A-EB-CH-041	0.373	0.872	0.894	N/A	5.00	1.40	2.30

Legend

	Existing	Proposed
Type R Inlet		
Single Vane Grate Inlet		
Double Vane Grate Inlet		
Type C Inlet		
Manhole		
Ditch		
Pipe		
Removal		
1' Contour		
Type 3 Barrier		
Type 7 Barrier		

Drainage System Legend

West Section
- Clear Creek
- CR314
- Central City Parkway

Tunnel Alternative Section
- West Bend
- East Bend
- US 6
- AFS Quarry

East Section
- Eastbound Floyd Hill
- Johnson Gulch
- Beaver Brook
- Offsite Floyd Hill

Canyon Viaduct Alternative Section
- Canyon Alternative 1
- Canyon Alternative 2
- Canyon Alternative 3
- Canyon AFS Quarry

Other Basin Areas
- Roadway Not Captured
- Large Culvert Cross-Drainage

0' 25' 100' 200'

N

I-70 Floyd Hill to Veterans Memorial Tunnels

DRAINAGE AREA MAP

Station 2043+50 to Station 2094+50

Design by: S. Criminski Plot: 3 of 9
Drawn by: S. Criminski Date: August 17, 2020
Checked by: M. Tilko

TUNNEL ALTERNATIVE - CENTRAL SECTION

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-EB-CH-008	11.271	0.465	0.669	N/A	12.56	14.94	34.35
A-EB-CH-008A	0.358	0.872	0.894	N/A	5.00	1.34	2.20
A-EB-CH-009	7.209	0.465	0.669	N/A	8.92	11.41	26.22
A-EB-IN-032	0.214	0.872	0.894	N/A	5.00	0.80	1.32
A-EB-IN-033	0.087	0.872	0.894	N/A	5.00	0.33	0.53
A-US6-IN-001a	0.186	0.872	0.894	N/A	5.00	0.70	1.15
A-US6-IN-001b	0.522	0.465	0.669	N/A	5.00	1.04	2.40
A-US6-IN-010	0.891	0.872	0.894	N/A	5.00	3.34	5.48
A-US6-IN-011	0.276	0.872	0.894	N/A	5.00	1.11	1.70
A-US6-CH-011b	0.149	0.465	0.669	N/A	5.00	0.30	0.68
A-US6-CH-011a	0.006	0.872	0.894	N/A	5.00	0.02	0.03
A-US6-CH-012b	1.239	0.465	0.669	N/A	5.00	2.48	5.71
A-US6-CH-012a	0.101	0.872	0.894	N/A	5.00	0.38	0.62
A-US6-CH-012c	0.091	0.872	0.894	N/A	5.00	0.34	0.56
BASIN M	3.127	--	--	62	20.48	4.70	9.70
A-AFS-HW-004A	1.509	0.872	0.894	N/A	5.00	6.51	11.52
A-AFS-HW-004B	0.753	0.872	0.894	N/A	5.00	3.25	5.75
A-AFS-IN-001	0.209	0.872	0.894	N/A	5.00	0.90	1.59
A-AFS-IN-002	0.137	0.872	0.894	N/A	5.00	0.59	1.04
A-AFS-IN-003	0.405	0.872	0.894	N/A	5.00	1.75	3.09
A-AFS-IN-004	0.290	0.872	0.894	N/A	5.00	1.25	2.21
A-AFS-IN-005	0.589	0.872	0.894	N/A	5.00	2.54	4.49
A-AFS-IN-006	0.390	0.872	0.894	N/A	5.00	1.68	2.98
A-AFS-IN-007	0.172	0.872	0.894	N/A	5.00	0.74	1.32
A-AFS-IN-008	0.495	0.872	0.894	N/A	5.00	2.14	3.78
A-AFS-IN-009	0.538	0.872	0.894	N/A	5.00	2.32	4.11
A-AFS-IN-010	0.528	0.872	0.894	N/A	5.00	2.28	4.03
A-AFS-IN-011	0.738	0.872	0.894	N/A	5.00	3.18	5.63
A-AFS-IN-012	0.437	0.872	0.894	N/A	5.00	1.89	3.34
A-AFS-IN-013	0.349	0.872	0.894	N/A	5.00	1.51	2.66
A-AFS-IN-014	0.362	0.872	0.894	N/A	5.00	1.56	2.76
A-AFS-IN-015	0.502	0.872	0.894	N/A	5.00	2.16	3.83
A-AFS-IN-016	0.225	0.872	0.894	N/A	5.00	0.97	1.72
A-AFS-IN-017	0.526	0.872	0.894	N/A	5.00	2.27	4.02
A-AFS-IN-018	0.641	0.872	0.894	N/A	5.00	2.77	4.89
A-AFS-IN-019	0.597	0.872	0.894	N/A	5.00	2.58	4.56
A-AFS-IN-021	0.023	0.872	0.894	N/A	5.00	0.10	0.18
A-AFS-IN-022	0.187	0.872	0.894	N/A	5.00	0.81	1.43
A-AFS-IN-023	0.159	0.872	0.894	N/A	5.00	0.69	1.22
A-AFS-PO-001	2.654	0.872	0.894	N/A	5.00	11.45	20.25
EX-A-AFS-HW-002	35.753	0.465	0.669	N/A	22.56	41.75	103.41
EX-A1-AFS-HW-004	1.143	0.465	0.669	N/A	6.17	2.47	6.12
EX-A2-AFS-HW-004	37.364	0.465	0.669	N/A	15.48	50.66	125.79

I-70 Floyd Hill to Veterans Memorial Tunnels

DRAINAGE AREA MAP

Station 2094+50 to Station 2144+00

Design by: S. Mehdi   Plot: 4 of 9
Drawn by: S. Mehdi   Date: August 17, 2020
Checked by: M. Tilko

TUNNEL ALTERNATIVE - CENTRAL SECTION

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-JG-IN-001	0.561	0.872	0.894	N/A	5.00	2.10	3.45
A-JG-IN-002	0.310	0.872	0.894	N/A	5.00	1.16	1.91
A-JG-IN-003	0.321	0.872	0.894	N/A	5.00	1.20	1.98
A-JG-IN-004	0.354	0.872	0.894	N/A	5.00	1.33	2.18
A-JG-IN-006	0.151	0.872	0.894	N/A	5.00	0.57	0.93
A-JG-IN-007	0.495	0.872	0.894	N/A	5.00	1.86	3.04
A-JG-IN-008	1.172	0.872	0.894	N/A	5.00	4.40	7.21
A-JG-IN-009	0.365	0.872	0.894	N/A	5.00	1.37	2.24
A-JG-IN-011	0.226	0.872	0.894	N/A	5.00	0.85	1.39
A-JG-IN-012	0.182	0.872	0.894	N/A	5.00	0.68	1.12
A-JG-IN-013	0.223	0.872	0.894	N/A	5.00	0.84	1.37
A-JG-IN-014	0.517	0.872	0.894	N/A	5.00	1.94	3.18
A-JG-IN-015	0.118	0.872	0.894	N/A	5.00	0.44	0.73
A-JG-IN-016	0.440	0.872	0.894	N/A	5.00	1.65	2.71
A-JG-IN-017	0.485	0.872	0.894	N/A	5.00	1.82	2.98
A-JG-IN-018	0.151	0.872	0.894	N/A	5.00	0.57	0.93
BASIN I	8.576	--	--	87	37.54	12.20	22.70
BASIN H	4.672	--	--	87	20.72	9.10	16.90
BASIN G	19.868	--	--	81	16.11	36.70	72.80
BASIN F	3.553	--	--	94	11.48	10.90	18.70
BASIN E	302.285	--	--	59	101.68	57.40	152.20
BASIN D	5.294	--	--	84	10.42	12.00	22.60
BASIN C	48.437	--	--	79	22.41	59.90	133.70
BASIN B	6.526	--	--	92	12.62	18.00	31.20
A-EFH-IN-008	0.622	0.872	0.894	N/A	5.00	2.33	3.83
A-EFH-IN-009	0.360	0.872	0.894	N/A	5.00	1.35	2.22
A-EFH-IN-010	0.459	0.872	0.894	N/A	5.00	1.72	2.83
A-EFH-IN-011	0.070	0.872	0.894	N/A	5.00	0.26	0.43
A-EFH-IN-012	0.120	0.872	0.894	N/A	5.00	0.45	0.74
A-EFH-IN-013	0.691	0.872	0.894	N/A	5.00	2.59	4.25
A-EFH-IN-014	0.825	0.872	0.894	N/A	5.00	3.10	5.08
A-EFH-IN-015	0.371	0.872	0.894	N/A	5.00	1.39	2.28
A-EFH-IN-016	0.456	0.872	0.894	N/A	5.00	1.71	2.81
A-EFH-IN-017	0.793	0.872	0.894	N/A	5.00	2.98	4.88

Legend

	Existing	Proposed
Type R Inlet		
Single Vane Grate Inlet		
Double Vane Grate Inlet		
Type C Inlet		
Manhole		
Ditch		
Pipe		
Removal		
1' Contour		
Type 3 Barrier		
Type 7 Barrier		

Drainage System Legend

West Section
Clear Creek
CR314
Central City Parkway
Tunnel Alternative Section
West Bend
East Bend
US 6
AFS Quarry
East Section
Eastbound Floyd Hill
Johnson Gulch
Beaver Brook
Offsite Floyd Hill
Canyon Viaduct Alternative Section
Canyon Alternative 1
Canyon Alternative 2
Canyon Alternative 3
Canyon AFS Quarry
Other Basin Areas
Roadway Not Captured
Large Culvert Cross-Drainage

0' 25' 100' 200'

N

I-70 Floyd Hill to
Veterans Memorial Tunnels

DRAINAGE AREA MAP

Station 2144+00 to Station 2197+00

Design by: S. Mehdi Plot: 5 of 9
Drawn by: S. Mehdi Date: August 17, 2020
Checked by: M. Tilko

TUNNEL ALTERNATIVE - EAST SECTION

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-EFH-IN-001	0.635	0.872	0.894	N/A	5.00	2.38	3.91
A-EFH-IN-002	0.415	0.872	0.894	N/A	5.00	1.56	2.55
A-EFH-IN-003	0.284	0.872	0.894	N/A	5.00	1.07	1.75
A-EFH-IN-004	0.618	0.872	0.894	N/A	5.00	2.32	3.80
A-EFH-IN-005	0.444	0.872	0.894	N/A	5.00	1.67	2.73
A-EFH-IN-006	0.451	0.872	0.894	N/A	5.00	1.69	2.77
A-EFH-IN-007	0.247	0.872	0.894	N/A	5.00	0.93	1.52
BASIN A	51.097	--	--	85	22.96	83.90	165.90
BASIN B	6.526	--	--	92	12.62	18.00	31.20
BASIN C	48.437	--	--	79	22.41	59.90	133.70
A-BB-A-001	19.410	--	--	--	--	--	--
A-BB-A-002	22.728	--	--	--	--	--	--
A-BB-A-003	0.093	--	--	--	--	--	--
A-BB-A-004	19.780	--	--	--	--	--	--
A-BB-A-005	1.246	--	--	--	--	--	--
A-BB-A-006	2.157	--	--	--	--	--	--
A-BB-A-007	1.551	--	--	--	--	--	--
A-BB-A-008	0.271	--	--	--	--	--	--
A-BB-A-009	0.505	--	--	--	--	--	--
A-BB-A-010	0.874	--	--	--	--	--	--
A-BB-A-011	0.239	--	--	--	--	--	--
A-BB-A-012	2.243	--	--	--	--	--	--
A-BB-A-013	9.628	--	--	--	--	--	--
A-BB-A-014	0.490	--	--	--	--	--	--
A-BB-A-015	2.009	--	--	--	--	--	--
A-BB-A-016	2.165	--	--	--	--	--	--
A-BB-A-017	0.385	--	--	--	--	--	--
A-BB-A-018	1.282	--	--	--	--	--	--
A-BB-A-019	0.156	--	--	--	--	--	--
A-BB-A-020	4.338	--	--	--	--	--	--
A-BB-A-021	1.222	--	--	--	--	--	--
A-BB-A-022	0.951	--	--	--	--	--	--
A-BB-A-023	1.262	--	--	--	--	--	--
A-BB-A-024	0.341	--	--	--	--	--	--

Legend

	Existing	Proposed
Type R Inlet		
Single Vane Grate Inlet		
Double Vane Grate Inlet		
Type C Inlet		
Manhole		
Ditch		
Pipe		
Removal		
1' Contour		
Type 3 Barrier		
Type 7 Barrier		

Drainage System Legend

West Section
- Clear Creek
- CR314
- Central City Parkway

Tunnel Alternative Section
- West Bend
- East Bend
- US 6
- AFS Quarry

East Section
- Eastbound Floyd Hill
- Johnson Gulch
- Beaver Brook
- Offsite Floyd Hill

Canyon Viaduct Alternative Section
- Canyon Alternative 1
- Canyon Alternative 2
- Canyon Alternative 3
- Canyon AFS Quarry

Other Basin Areas
- Roadway Not Captured
- Large Culvert Cross-Drainage

N

0' 25' 100' 200'

I-70 Floyd Hill to Veterans Memorial Tunnels

DRAINAGE AREA MAP

Station 2197+00 to Station 2300+00

Design by: J. Falzetti Plot: 6 of 9
Drawn by: J. Falzetti Date: August 17, 2020
Checked by: M. Tilko

TUNNEL ALTERNATIVE - EAST SECTION

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-BB-A-025	6.476	--	--	--	--	--	--
A-BB-A-026	143.210	--	--	--	--	--	--
A-BB-A-027	1.620	--	--	--	--	--	--
A-BB-A-028	1.657	--	--	--	--	--	--
A-BB-A-029	0.694	--	--	--	--	--	--
A-BB-A-030	3.080	--	--	--	--	--	--
A-BB-A-031	14.768	--	--	--	--	--	--
A-BB-A-032	0.770	--	--	--	--	--	--
A-BB-A-033	1.963	--	--	--	--	--	--
A-BB-A-034	0.182	--	--	--	--	--	--
A-BB-A-035	1.745	--	--	--	--	--	--
A-BB-A-036	2.034	--	--	--	--	--	--
A-BB-A-037	2.986	--	--	--	--	--	--
A-BB-A-038	4.986	--	--	--	--	--	--
A-BB-A-039	2.379	--	--	--	--	--	--
A-BB-A-040	0.116	--	--	--	--	--	--
A-BB-A-041	0.103	--	--	--	--	--	--
A-BB-A-042	5.087	--	--	--	--	--	--
A-BB-A-043	0.179	--	--	--	--	--	--
A-BB-A-044	1.017	--	--	--	--	--	--
A-BB-A-045	1.395	--	--	--	--	--	--

I-70 Floyd Hill to Veterans Memorial Tunnels

DRAINAGE AREA MAP

Station 2197+00 to Station 2382+50

Design by: J. Falzetti Plot: 7 of 9
Drawn by: J. Falzetti Date: August 17, 2020
Checked by: M. Tilko

TUNNEL ALTERNATIVE - EAST SECTION

Legend

	Existing	Proposed
Type R Inlet		
Single Vane Grate Inlet		
Double Vane Grate Inlet		
Type C Inlet		
Manhole		
Ditch		
Pipe		
Removal		
1' Contour		
Type 3 Barrier		
Type 7 Barrier		

Drainage System Legend

West Section
- Clear Creek
- CR314
- Central City Parkway

Tunnel Alternative Section
- West Bend
- East Bend
- US 6
- AFS Quarry

East Section
- Eastbound Floyd Hill
- Johnson Gulch
- Beaver Brook
- Offsite Floyd Hill

Canyon Viaduct Alternative Section
- Canyon Alternative 1
- Canyon Alternative 2
- Canyon Alternative 3
- Canyon AFS Quarry

Other Basin Areas
- Roadway Not Captured
- Large Culvert Cross-Drainage

N

0' 25' 100' 200'

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-CA1-CH-001A	0.125	0.872	0.894	N/A	5.00	0.47	0.77
A-CA1-CH-001B	0.244	0.465	0.669	N/A	5.00	0.49	1.12
A-CA1-CH-002	0.191	0.465	0.669	N/A	5.00	0.38	0.88
A-CA1-CH-003A	0.266	0.872	0.894	N/A	5.00	1.00	1.64
A-CA1-CH-003B	0.237	0.872	0.894	N/A	5.00	0.89	1.46
A-CA1-CH-003C	0.152	0.465	0.669	N/A	5.00	0.31	0.70
A-CA1-CH-004A	0.229	0.872	0.894	N/A	5.00	0.86	1.41
A-CA1-CH-004B	0.189	0.465	0.669	N/A	5.00	0.38	0.87
A-CA1-CH-005A	0.315	0.872	0.894	N/A	5.00	1.18	1.94
A-CA1-CH-005B	3.885	0.465	0.669	N/A	6.40	7.20	16.57
A-CA1-CH-005C	0.212	0.465	0.669	N/A	5.00	0.42	0.98
A-CA1-CH-006A	0.317	0.872	0.894	N/A	5.00	1.19	1.95
A-CA1-CH-006B	0.207	0.465	0.669	N/A	5.00	0.41	0.95
A-CA1-CH-007A	0.271	0.872	0.894	N/A	5.00	1.02	1.67
A-CA1-CH-007B	3.875	0.465	0.669	N/A	7.20	6.85	15.75
A-CA1-CH-007C	0.157	0.465	0.669	N/A	5.00	0.31	0.72
A-CA1-CH-008A	0.211	0.872	0.894	N/A	5.00	0.79	1.30
A-CA1-CH-008B	0.117	0.465	0.669	N/A	5.00	0.23	0.54
A-CA1-CH-017	0.385	0.872	0.894	N/A	5.00	1.45	2.37
A-CA1-CH-018	0.724	0.872	0.894	N/A	5.00	2.72	4.45
A-CA1-CH-019	0.163	0.872	0.894	N/A	5.00	0.61	1.00
A-CA1-CH-021	0.622	0.872	0.894	N/A	5.00	2.33	3.83
A-CA1-CH-023	0.253	0.872	0.894	N/A	5.00	0.95	1.56
A-CA1-IN-001	0.433	0.872	0.894	N/A	5.00	1.63	2.67
A-CA1-IN-003	0.097	0.872	0.894	N/A	5.00	0.36	0.60
A-CA1-IN-003A	0.381	0.872	0.894	N/A	5.00	1.43	2.35
A-CA1-IN-004	0.173	0.872	0.894	N/A	5.00	0.65	1.06
A-CA1-IN-005A	0.199	0.872	0.894	N/A	5.00	0.75	1.23
A-CA1-IN-005B	0.213	0.872	0.894	N/A	5.00	0.80	1.31
A-CA1-IN-007	0.376	0.872	0.894	N/A	5.00	1.41	2.31
A-CA1-IN-007A	0.329	0.872	0.894	N/A	5.00	1.24	2.03
A-CA1-IN-008	0.296	0.872	0.894	N/A	5.00	1.11	1.82
A-CA1-IN-009	0.175	0.872	0.894	N/A	5.00	0.66	1.08
A-CA1-IN-010	0.167	0.872	0.894	N/A	5.00	0.63	1.03
A-CA1-IN-011	0.041	0.465	0.669	N/A	5.00	0.08	0.19
A-CA1-IN-011A	0.071	0.872	0.894	N/A	5.00	0.27	0.44
A-CA1-IN-011B	6.079	0.465	0.669	N/A	7.20	10.77	24.77
A-CA1-IN-012	0.388	0.872	0.894	N/A	5.00	1.46	2.39
A-CA1-IN-013	0.489	0.872	0.894	N/A	5.00	1.84	3.01
A-CA1-IN-014	0.596	0.872	0.894	N/A	5.00	2.24	3.67
A-CA1-IN-015	0.063	0.872	0.894	N/A	5.00	0.24	0.39
A-CA1-IN-016	0.076	0.872	0.894	N/A	5.00	0.29	0.47
A-CA1-IN-017	0.322	0.872	0.894	N/A	5.00	1.21	1.98
A-CA1-IN-018	0.332	0.872	0.894	N/A	5.00	1.24	2.04
A-CA1-IN-019	0.220	0.872	0.894	N/A	5.00	0.83	1.36
A-CA1-IN-020	0.128	0.872	0.894	N/A	5.00	0.48	0.79
A-CA1-IN-021	0.129	0.872	0.894	N/A	5.00	0.48	0.79
A-CA1-IN-022	0.048	0.872	0.894	N/A	5.00	0.18	0.30
A-CA1-IN-023	0.115	0.872	0.894	N/A	5.00	0.43	0.71
A-CA1-IN-024	0.189	0.872	0.894	N/A	5.00	0.71	1.16
A-CA1-IN-025	0.128	0.872	0.894	N/A	5.00	0.48	0.79
A-CA1-IN-026	0.196	0.872	0.894	N/A	5.00	0.73	1.21
A-CA1-IN-027	0.329	0.872	0.894	N/A	5.00	1.23	2.02
A-CA1-IN-028	0.562	0.872	0.894	N/A	5.00	2.11	3.46
A-CA1-IN-029	0.521	0.872	0.894	N/A	5.00	1.95	3.20
A-CA1-IN-030	0.227	0.872	0.894	N/A	5.00	0.85	1.40
A-CA1-IN-032	0.180	0.872	0.894	N/A	5.00	0.68	1.11
A-CA2-CH-001	0.140	0.872	0.894	N/A	5.00	0.51	0.84
A-CA2-CH-002	0.020	0.872	0.894	N/A	5.00	0.09	0.15
A-CA2-CH-003A	0.240	0.465	0.669	N/A	5.00	0.48	1.11
A-CA2-CH-003B	0.340	0.872	0.894	N/A	5.00	1.28	2.10
A-CA2-CH-004A	0.460	0.872	0.894	N/A	5.00	1.73	2.83
A-CA2-CH-004B	0.260	0.465	0.669	N/A	5.00	0.52	1.19

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-CA2-CH-005A	0.180	0.872	0.894	N/A	5.00	0.68	1.11
A-CA2-CH-005B	0.110	0.465	0.669	N/A	5.00	0.23	0.52
A-CA2-CH-006	0.170	0.465	0.669	N/A	5.00	0.34	0.78
A-CA2-CH-007A	0.080	0.872	0.894	N/A	5.00	0.31	0.51
A-CA2-CH-007B	0.110	0.465	0.669	N/A	5.00	0.22	0.50
A-CA2-CH-008	0.180	0.465	0.669	N/A	5.00	0.36	0.82
A-CA2-CH-009A	0.200	0.872	0.894	N/A	5.00	0.75	1.23
A-CA2-CH-009B	0.170	0.872	0.894	N/A	5.00	0.65	1.07
A-CA2-CH-009C	0.030	0.872	0.894	N/A	5.00	0.12	0.20
A-CA2-CH-013	3.670	0.465	0.669	N/A	8.40	6.02	13.84
A-CA2-CH-014	3.550	0.465	0.669	N/A	7.40	6.20	14.26
A-CA2-CH-016	0.020	0.465	0.669	N/A	5.00	0.05	0.11
A-CA2-FES-003	9.970	0.465	0.669	N/A	8.10	16.65	38.30
A-CA2-FES-005	2.090	0.465	0.669	N/A	5.00	4.19	9.64
A-CA2-FES-007	27.150	0.465	0.669	N/A	9.50	41.29	94.90
A-CA2-FES-009	6.850	0.465	0.669	N/A	7.60	11.81	27.17
A-CA2-FES-011	7.990	0.465	0.669	N/A	5.30	15.74	36.22
A-CA2-FES-013	6.500	0.465	0.669	N/A	8.10	10.86	24.96
A-CA2-FES-015	1.830	0.465	0.669	N/A	5.00	3.66	8.43
A-CA2-IN-001	0.627	0.872	0.894	N/A	5.00	2.33	3.83
A-CA2-IN-002	0.572	0.872	0.894	N/A	5.00	2.13	3.49
A-CA2-IN-003	0.708	0.872	0.894	N/A	5.00	2.64	4.32
A-CA2-IN-004	0.731	0.872	0.894	N/A	5.00	2.72	4.46
A-CA2-IN-005	0.810	0.872	0.894	N/A	5.00	3.05	5.01
A-CA2-IN-006	0.600	0.872	0.894	N/A	5.00	2.24	3.67
A-CA2-IN-007	0.050	0.872	0.894	N/A	5.00	0.18	0.30
A-CA2-IN-008	0.100	0.872	0.894	N/A	5.00	0.39	0.64
A-CA2-IN-009	0.100	0.872	0.894	N/A	5.00	0.38	0.63
A-CA2-IN-010	0.080	0.872	0.894	N/A	5.00	0.29	0.47
A-CA2-IN-011	0.080	0.872	0.894	N/A	5.00	0.29	0.48
A-CA2-IN-012	0.110	0.872	0.894	N/A	5.00	0.42	0.69
A-CA2-IN-013	0.070	0.872	0.894	N/A	5.00	0.28	0.46
A-CA2-IN-015	0.060	0.872	0.894	N/A	5.00	0.22	0.36
A-CA3-CH-001	0.116	0.872	0.894	N/A	5.00	0.43	0.71
A-CA3-FES-004	11.184	0.465	0.669	N/A	10.60	16.04	36.86
A-CA3-IN-001	0.692	0.872	0.894	N/A	5.00	2.60	4.26
A-CA3-IN-002	0.154	0.872	0.894	N/A	5.00	0.58	0.95
A-CA3-IN-004	0.033	0.872	0.894	N/A	5.00	0.12	0.20
A-CA3-IN-014	0.909	0.872	0.894	N/A	5.00	3.41	5.59
A-CA3-IN-017	0.717	0.872	0.894	N/A	5.00	2.69	4.41

Legend

	Existing	Proposed
Type R Inlet		
Single Vane Grate Inlet		
Double Vane Grate Inlet		
Type C Inlet		
Manhole		
Ditch		
Pipe		
Removal		
1' Contour		
Type 3 Barrier		
Type 7 Barrier		

Drainage System Legend

West Section
- Clear Creek
- CR314
- Central City Parkway

Tunnel Alternative Section
- West Bend
- East Bend
- US 6
- AFS Quarry

East Section
- Eastbound Floyd Hill
- Johnson Gulch
- Beaver Brook
- Offsite Floyd Hill

Canyon Viaduct Alternative Section
- Canyon Alternative 1
- Canyon Alternative 2
- Canyon Alternative 3
- Canyon AFS Quarry

Other Basin Areas
- Roadway Not Captured
- Large Culvert Cross-Drainage

0' 25' 100' 200'

N

I-70 Floyd Hill to Veterans Memorial Tunnels

DRAINAGE AREA MAP

Station 2043+50 to Station 2094+50

Design by: S. Criminski Plot: 8 of 9
Drawn by: S. Criminski Date: August 17, 2020
Checked by: M. Tilko

CANYON VIADUCT ALTERNATIVE - CENTRAL SECTION

ID	Area (ac)	C (10 Year)	C (100 Year)	CN	Time of Concentration (min)	Q 10 (cfs)	Q 100 (cfs)
A-CA3-CH-005	0.140	0.465	0.669	N/A	5.00	0.28	0.65
A-CA3-CH-010	3.919	0.465	0.669	N/A	6.80	7.09	16.31
A-CA3-CH-011	2.963	0.465	0.669	N/A	6.20	5.55	12.77
A-CA3-IN-003	0.113	0.872	0.894	N/A	5.00	0.42	0.70
A-CA3-IN-006	0.136	0.872	0.894	N/A	5.00	0.51	0.84
A-CA3-IN-007	0.036	0.872	0.894	N/A	5.00	0.14	0.22
A-CA3-IN-008	0.029	0.872	0.894	N/A	5.00	0.11	0.18
A-CA3-IN-010	0.024	0.872	0.894	N/A	5.00	0.09	0.15
A-CA3-IN-011	0.105	0.872	0.894	N/A	5.00	0.39	0.64
A-CA3-IN-015	0.448	0.872	0.894	N/A	5.00	1.68	2.76
A-CA3-IN-016	0.679	0.872	0.894	N/A	5.00	2.55	4.18
A-CA3-IN-018	0.526	0.872	0.894	N/A	5.00	1.97	3.23
A-CA3-IN-019	1.010	0.872	0.894	N/A	5.00	3.79	6.22
A-CAFS-CH-001	1.319	0.872	0.892	N/A	5.00	5.69	10.04
A-CAFS-CH-002	0.698	0.872	0.892	N/A	5.00	3.01	5.32
A-CAFS-CH-002A	0.591	0.465	0.669	N/A	5.00	1.36	3.37
A-CAFS-CH-003	0.161	0.872	0.892	N/A	5.00	0.69	1.23
A-CAFS-CH-003A	0.124	0.465	0.669	N/A	5.00	0.28	0.71
A-CAFS-CH-005	0.907	0.872	0.892	N/A	5.00	3.91	6.91
A-CAFS-CH-005A	0.593	0.465	0.669	N/A	5.00	1.36	3.39
A-CAFS-CH-006	0.573	0.872	0.892	N/A	5.00	2.47	4.36
A-CAFS-CH-010	0.104	0.872	0.892	N/A	5.00	0.45	0.79
A-CAFS-IN-003	0.154	0.872	0.892	N/A	5.00	0.66	1.17
A-CAFS-IN-004	0.145	0.872	0.892	N/A	5.00	0.63	1.11
A-CAFS-IN-005	0.327	0.872	0.892	N/A	5.00	1.41	2.49
A-CAFS-IN-006	0.336	0.872	0.892	N/A	5.00	1.45	2.56
A-CAFS-IN-007	0.456	0.872	0.892	N/A	5.00	1.97	3.48
A-CAFS-IN-008	0.186	0.872	0.892	N/A	5.00	0.80	1.42
A-CAFS-IN-009	0.196	0.872	0.892	N/A	5.00	0.85	1.49
A-CAFS-IN-010	0.262	0.872	0.892	N/A	5.00	1.13	2.00
A-CAFS-IN-011	0.714	0.872	0.892	N/A	5.00	3.08	5.44
A-CAFS-IN-012	0.361	0.872	0.892	N/A	5.00	1.56	2.75
A-CAFS-IN-013	0.645	0.872	0.892	N/A	5.00	2.78	4.91
A-CAFS-IN-014	0.069	0.872	0.892	N/A	5.00	0.30	0.53
A-CAFS-IN-015	0.814	0.872	0.892	N/A	5.00	3.51	6.20
A-CAFS-IN-016	0.550	0.872	0.892	N/A	5.00	2.37	4.19
A-CAFS-IN-017	0.697	0.872	0.892	N/A	5.00	3.01	5.31
A-CAFS-IN-018	0.565	0.872	0.892	N/A	5.00	2.44	4.30
A-CAFS-IN-019	0.733	0.872	0.892	N/A	5.00	3.16	5.58
A-CAFS-IN-020	0.287	0.872	0.892	N/A	5.00	1.24	2.19
A-CAFS-IN-021	0.292	0.872	0.892	N/A	5.00	1.26	2.22
A-CAFS-IN-022	0.326	0.872	0.892	N/A	5.00	1.41	2.48
A-CAFS-IN-023	0.243	0.872	0.892	N/A	5.00	1.05	1.85
A-CAFS-IN-024	0.272	0.872	0.892	N/A	5.00	1.18	2.07
A-CAFS-IN-025	0.284	0.872	0.892	N/A	5.00	1.22	2.16
EX-A-CAFS-CH-001	2.312	0.465	0.669	N/A	8.25	4.39	10.91
EX-A-CAFS-CH-004	37.404	0.465	0.669	N/A	15.48	50.72	125.92
EX-A-CAFS-CH-006	3.152	0.465	0.669	N/A	9.29	5.58	13.86
EX-A-CAFS-FES-008	36.594	0.465	0.669	N/A	22.20	43.08	106.72

I-70 Floyd Hill to Veterans Memorial Tunnels

DRAINAGE AREA MAP

Station 2094+50 to Station 2144+00

Design by: S. Mehdi Plot: 9 of 9
Drawn by: S. Mehdi Date: August 17, 2020
Checked by: M. Tilko

CANYON VIADUCT ALTERNATIVE - CENTRAL SECTION

Legend

	Existing	Proposed
Type R Inlet		
Single Vane Grate Inlet		
Double Vane Grate Inlet		
Type C Inlet		
Manhole		
Ditch		
Pipe		
Removal		
1' Contour		
Type 3 Barrier		
Type 7 Barrier		

Drainage System Legend

West Section
- Clear Creek
- CR314
- Central City Parkway

Tunnel Alternative Section
- West Bend
- East Bend
- US 6
- AFS Quarry

East Section
- Eastbound Floyd Hill
- Johnson Gulch
- Beaver Brook
- Offsite Floyd Hill

Canyon Viaduct Alternative Section
- Canyon Alternative 1
- Canyon Alternative 2
- Canyon Alternative 3
- Canyon AFS Quarry

Other Basin Areas
- Roadway Not Captured
- Large Culvert Cross-Drainage

0' 25' 100' 200'
N