# CO 119 BIKEWAY

## PRELIMINARY DRAINAGE REPORT

July 2022

**Prepared for:**

**Boulder County Community Planning & Permitting**

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MULLER ENGINEERING COMPANY

This report has been prepared based on certain key assumptions made by Muller Engineering Company (Muller) which substantially affect the conclusions and recommendations. These assumptions, although thought to be reasonable and appropriate, may not prove to be true in the future. The conclusions and recommendations of Muller are conditioned upon these assumptions.

This report for the CO 119 Bikeway Project was prepared by me or under my direct supervision in accordance with the provisions of the *Boulder County Storm Drainage Criteria Manual, Boulder County Multimodal Transportation Standards, and Colorado Department of Transportation Drainage Design Manual* and was designed to comply with the provisions thereof.

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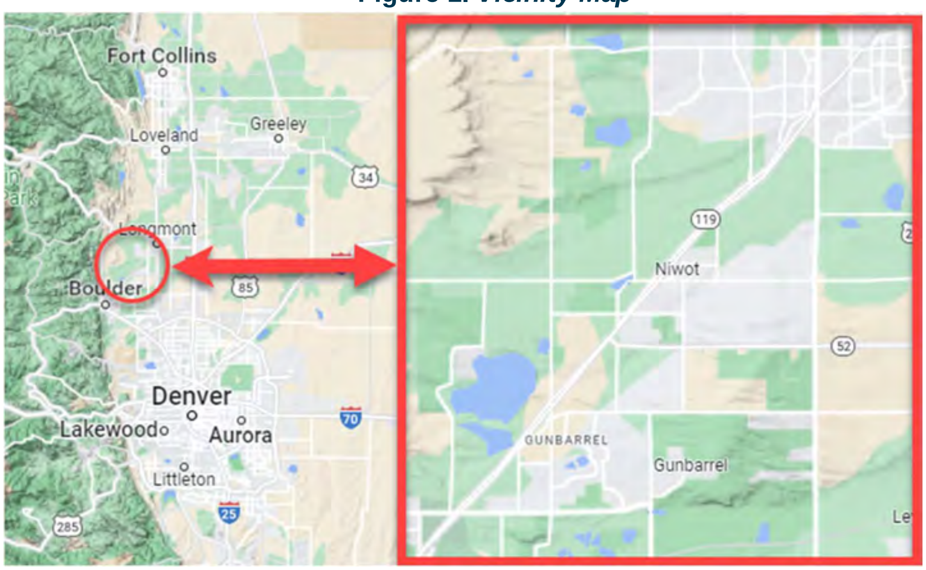
# 1 INTRODUCTION

Muller Engineering Company, Inc. (Muller), on behalf of Boulder County, has prepared the following drainage report for the CO 119 Bikeway project. This report describes the project, the existing site conditions, the drainage design criteria, the hydrologic and hydraulic analyses, and the proposed drainage design improvements recommended for the project.

## 1.1 Location and Project Area Description

The CO 119 Bikeway project is located along Colorado State Highway 119 (CO 119) in Boulder County, Colorado. The proposed bikeway is located primarily in the median of CO 119 with some sections slightly outside of the highway. The project traverses unincorporated Boulder County, the City of Boulder, and the City of Longmont. The south end of the project starts just south of $47^{th}$ Street in the City of Boulder and the north end of the project is at Hover Street in the City of Longmont. Please refer to **Figure 1**.

**Figure 1.** ***Vicinity Map***




The project is specifically located in Sections 2, 3, 10, 15, 16, 20, and 21 of Township 1 North, Range 70 West of the Sixth Meridian, Sections 25, 35, and 36 of Township 2 North, Range 70 West of the Sixth Meridian, and Sections 17, 19, 20, 30 of Township 2 North, Range 69 West of the Sixth Meridian in Boulder County, Colorado.

CO 119 is functionally classified as a Principal Arterial/Freeway Expressway. Generally, the project area is bound by undeveloped, farmland with some areas of suburban development. Suburban development, industrial development, and commercial development occurs beyond the immediate undeveloped land in all directions.

The project area is primarily located in Colorado Department of Transportation (CDOT) right-of-way. Adjacent parcels of land are owned by other government agencies, businesses, and individual property owners. The Burlington Northern and Santa Fe (BNSF) Railroad Company owns property adjacent to the northbound CO 119 lanes through the majority of the project area.

There are approximately 41 irrigation crossings through the project area. Irrigation ditch companies include Boulder and Whiterock, Boulder Creek Supply Canal, Star Ditch, Williamson Ditch, and Holland Ditch.

**Table 1.** *Existing Site Information*

| | |
|---|---|
| **Legal Description** | Townships 1 and 2 North, Range 69 and 70 West of the Sixth Colorado Meridian |
| **City and County** | Unincorporated Boulder County, City of Boulder, and City of Longmont |
| **Adjacent Land Use** | Undeveloped, residential development, commercial development |
| **Major Drainageways** | Fourmile Canyon Creek, Boulder Creek, Dry Creek, and Lefthand Creek |
| **Irrigation Facilities** | Several including Boulder and Whiterock, Boulder Creek Supply Canal, Star Ditch, Williamson Ditch, and Holland Ditch |
| **Hydrologic Soil Group** | A, B, C, and D – Mostly C and D |
| **Topography** | Gently sloping terrain with slopes ranging from 0-25% (typically 1-3%). Considerable wetlands and high groundwater. |

## 1.2 Project Description and Intent

The purpose of the CO 119 Bikeway project is constructing a concrete, high-speed bikeway along CO 119 to improve safety and accessibility for bicycles and similar modes of transportation.

In addition to carrying considerable vehicle traffic between Boulder and Longmont, CO 119 and nearby pathways are popular for commuting cyclists and recreational cyclists. Boulder County is proposing the CO 119 Bikeway project to provide an improved alternative for cyclists using the CO 119 corridor. The project will also feature spurs off the main bikeway to connect to existing trails in the area. Specific project improvements include:

- Grading and constructing a bike path along CO 119 from 47th Street in Boulder to Hover Street in Longmont. At-grade crossings, underpasses, and bridges will be designed for the bike path

- Supplementary improvements include:
  - Traffic support for intersections along CO 119 impacted by bike path
  - Structural design of underpasses and bridges
  - Landscaping improvements
  - Lighting for underpasses and other locations
  - Floodplain analysis
  - Irrigation coordination

## 1.3 Previous Drainage Studies

Muller has received several drainage reports from Boulder County, the City of Longmont, the City of Boulder, and CDOT. The following information summarizes the relevant reports and their impacts on the CO 119 Bikeway project.

The *Hydrology and Hydraulics Report for the Intersections of SH 119 at Jay Road and SH 119 at Niwot Road* report published by Fellsburg, Holt, and Ullevig describes improvements to the intersections of CO 119 at Jay Road and CO 119 at Niwot Road. The report focuses on water quality requirements associated with these two projects. The report states that the majority of drainage facilities were designed for the 2-year event for water quality treatment. The report also describes the Boulder and Whiterock irrigation channel through the intersection at Jay Road which will be impacted by the CO 119 Bikeway project.

The *SH 119 at SH 52 (Mineral Road) Final Drainage Report* published by Muller Engineering Company was intended for an improved intersection of CO 52 with CO 119 which was not constructed. Information regarding how runoff from the IBM Campus and offsite areas is managed and impacts CO 119 was applied to the drainage design for the CO 119 Bikeway project.

The *Final Drainage Report – Front Range Health and Wellness Center* published by Park Engineering Consultants describes a development on the north end of the project area. The report states that no runoff from this development reaches a receiving culvert which will be impacted by the CO 119 Bikeway project.

The *Vojta Farm Final Stormwater Report* published by Drexel, Barrell, and Company describes a residential development at the intersection of 47$^{th}$ Street and Jay Road in the City of Boulder. The development is within an offsite basin which drains to the project area. The report states two detention ponds were constructed to capture and release flow at historic flowrates. The report states that the 10-year event is conveyed to a storm sewer network along 47$^{th}$ Street and the 100-year event overflows into undeveloped land east of 47$^{th}$ Street.

## 1.4 Floodplain

The CO 119 Bikeway project improvements will cross three Federal Emergency Management Administration (FEMA) regulated floodplains. The three floodplains are Fourmile Canyon Creek, Dry Creek, and Lefthand Creek. Please refer to the FEMA Flood Insurance Rate Maps (FIRM ette) included in Appendix A. The flood map numbers for Fourmile Canyon Creek and Dry Creek are 08013C0411K and 08013C0404J respectively. The flood map numbers for Lefthand Creek are 08013C04010J, 08013C0407J, and 08013C0269J.

The local regulatory agencies are Mile High Flood District (MHFD) for Fourmile Canyon Creek and Dry Creek and Colorado Water Conservation Board (CWCB) for Lefthand Creek. The floodplain administrators are Boulder County for all three floodplains and Boulder County and the City of Boulder for Fourmile Canyon Creek.

### 1.4.1 Fourmile Canyon Creek

Fourmile Canyon Creek is in a FEMA designated special flood hazard area Zone AE which is defined as an area that presents a 1% annual chance of flooding and has base elevations provided per hydraulic modeling performed. Muller has received the HEC-RAS model for the “Fourmile Canyon Creek Bikeway – Railroad Underpass Project” which was submitted as a no-rise condition in October 2019.

The railroad underpass project has not been built. Therefore, Boulder County directed Muller to use the effective conditions model completed for the Railroad Underpass project as the existing conditions model for the CO 119 Bikeway project. Boulder County also directed Muller to turn off lateral weir optimization in the HEC-RAS model. Muller will use the hydrology data included in the railroad underpass project HEC-RAS model which is from a FEMA Flood Insurance Study which last revised in August 2019.

### 1.4.2 Dry Creek

Dry Creek is in a FEMA designated special flood hazard area Zone A which is defined as an area that presents a 1% annual chance of flooding and without base elevations. Muller received a HEC-RAS model from Boulder County that was completed in 2012 by Belt Collins West Ltd. for the purpose of modeling the LOBO Trail: IBM Connection project. Per the “LOBO Trail: IBM Connection Final Hydraulic Design Report”, the trail project caused a water surface elevation drop of more than 0.3 feet. Therefore, a LOMR should have been completed for trail project, but according to Boulder County, it was not completed. The project appears to have been constructed around 2017 but no as-built geometry data is available. For purposes of this project, Boulder County has directed Muller to use the 2012 proposed conditions model as the effective model and incorporate survey data to develop an existing conditions model for the proposed bikeway. Muller will use the hydrology data associated with the proposed conditions model.

### 1.4.3 Lefthand Creek

Lefthand Creek is in a FEMA designated special flood hazard area Zone AE which is defined as an area that presents a 1% annual chance of flooding and has base elevations provided per hydraulic modeling performed. The basis of the floodplain model for Lefthand Creek is the

Colorado Hazard Mapping Program (CHAMP). The primary purpose of CHAMP was to identify flood risks in northeast Colorado following the 2013 flood event.

AECOM, the contractor for CWCB, completed a floodplain model of Lefthand Creek for CHAMP. The model was then used as the existing conditions model for a separate project, the “1901 South Hover Street Development Project”. The developer for the project contracted AECOM to prepare a CLOMR for this project. A 2D model was used for the CLOMR application.

Muller has been directed to use the geometry associated with the corrected effective model (versus the proposed conditions geometry) which AECOM developed for the CLOMR. Muller is proceeding with the geometry associated with the corrected effective model. HEC-RAS version 5.0.7 will use 1D capabilities to model the floodplain. Muller will use the hydrology data included in the CLOMR model which is based on the CHAMP study.

Additional cross sections will likely need to be developed by Muller and inserted into the HEC-RAS model to cover Lefthand Creek further upstream beyond the model limits.

## 1.5 Relationship to CO119 Mobility Improvements Project

The CO 119 Bikeway project is currently on roughly the same design schedule as the CO 119 Safety and Mobility Improvements project. The CO 119 Safety and Mobility Improvements project is a CDOT project being designed in coordination with the Regional Transportation District (RTD). The project improvements include the following:

- Bus Rapid Transit (BRT)/queue jump modifications at five intersections on CO 119
    - Jay Road, 63rd Street, State Highway 52, Niwot Road, and Airport Road
- Major realignment of the CO 119/ CO 52 intersection
- New Regional Transportation District (RTD) Park-and-Ride facilities at two intersections
    - 63rd Street and Niwot Road

The CO 119 Bikeway and CO 119 Safety and Mobility Improvements projects, to date, have been designed and coordinated congruently. The drainage design and analysis of the CO 119 Bikeway project has considered the drainage design and overall design of the CO 119 Safety and Mobility Improvements project and vice-versa.

The drainage design and analysis described in this drainage report is based on the assumption that the CO 119 Mobility Improvements project will be constructed in a similar timeframe as the CO 119 Bikeway project.

# 2 DRAINAGE BASINS AND SUB BASINS

## 2.1 Major Basin Description

### 2.1.1 Project Area

The project area is located within four principal watersheds. The watersheds are Fourmile Canyon Creek, Boulder Creek, Dry Creek, and Lefthand Creek.

At the south end of the project, runoff near and south of 47th Street reaches a relatively small drainageway which then reaches Boulder Creek. From 47th Street to a point south of Jay Road, runoff drains to Fourmile Canyon Creek which is a tributary to Boulder Creek. Runoff from the Jay Road intersection and a small amount of land to the north and south of the intersection drains to an unnamed tributary to Boulder Creek. Runoff north of the Jay Road intersection to Monarch Road drains to Dry Creek. Runoff from Monarch Road to the north limits of the project area drains to Lefthand Creek.

Boulder Creek, Dry Creek, and Lefthand Creek are tributaries to the St. Vrain River.

### 2.1.2 Offsite Area

Offsite area within the Boulder Creek and Dry Creek watersheds generally flows southeast toward the project area. Offsite area within the Lefthand Creek watershed generally flows north toward to project area.

The proposed bikeway is primarily located within the median of CO 119. The northbound and southbound lanes of CO 119 are typically elevated upon embankments above the surrounding topography such that offsite flow is prevented from reaching the proposed bikeway. Exceptions are at the southern end of the project, near the IBM Campus at the CO 119/ CO 52 intersection, and at the northern end of project.

At the southern end of the project, the proposed bikeway is outside of the median from roughly 47th St to Jay Road. A relatively small (1.9 acre) offsite basin and larger (102 acre) offsite basin reach the proposed bikeway. The larger basin consists of mostly undeveloped land with a portion of residential development. The drainage patterns of the residential development area were briefly described in the *Vojta Farm Final Stormwater Report.*

Near the IBM Campus, the CO 119 Mobility Improvements project would realign the CO 119/ CO 52 intersection such that the proposed bikeway would be within the CO 119 median. If the CO 119 Safety and Mobility Improvements project is not constructed, the proposed bikeway would be outside of the median and subject to offsite flow. The *SH 119 at SH 52 (Mineral Road) Final Drainage Report* describes offsite flow patterns in this area. The report states that runoff from the majority of the IBM Campus is captured by a separate storm drain system and conveyed south. However, runoff from the parking lots on the east side of the IBM Campus and adjacent land (solar panel fields) drains toward CO 119 and therefore is relevant to the project. The drainage report states specific 5-year and 100-year flowrates from the IBM Campus reaching a ditch parallel to the existing SB CO 119 lanes and a 24" cross culvert under SB CO 119 and NB CO 119. Runoff from the solar panel fields was determined using the typical basin delineation process outlined below. Runoff from the solar panel fields typically reaches irrigation and/or drainage facilities which cross CO 119.

At the northern end of the project, the proposed bikeway is between SB CO 119 and Dry Creek Drive in Longmont. The proposed bikeway is subject to offsite flow from Dry Creek Drive and the undeveloped infield between Dry Creek Drive and SB CO 119. The contributing basin consists of mostly undeveloped land, its area is approximately 5.2 acres.

## 2.2 Sub Basin Description

Smaller areas draining to the four major creeks were broken down into sub basins (hereinafter referred to simply as "basins"). The design point (or outlet) of basins is a hydraulic facility such as a roadside ditch, culvert, inlet, water quality pond, or major creek.

Basins were delineated using existing survey contours and topography of existing features provided by CDOT and LiDAR contours referenced from Boulder County. Proposed basins were also delineated using proposed contours and proposed infrastructure.

## 2.3 Historic Drainage Patterns

The northbound and southbound lanes of CO 119 generally sends roadway runoff flows to the outside of the highway. However, throughout the project length, there are multiple sections where roadway runoff from SB and/or NB CO 119 flows toward the median. In addition, considerable roadway runoff from major intersecting streets (63rd Street, Jay Road, Niwot Road) and minor intersecting streets (such as 55th Street, 83rd Street, etc.) reaches the median.

Runoff within the CO 119 median generally follows a flat (~1.0%) and poorly defined swale. Runoff then typically reaches an open ditch or channel traversing the median. The ditch or channel directs flow to a culvert crossing under either NB CO 119 or SB CO 119. The ditch and culvert systems intended use are for stormwater conveyance, irrigation conveyance, irrigation return flow conveyance, or a combination of these.

Muller has received a record of irrigation facilities from Boulder County and other resources. Muller is working on and will continue to work on coordinating with the irrigation owners to better understand irrigation flow distribution and intended use of existing facilities.

# 3 DRAINAGE DESIGN CRITERIA

Drainage design for the bikeway is based on historic drainage patterns, the CO 119 Safety and Mobility Improvements project, and the following technical criteria documents:

- Boulder County Storm Drainage Criteria Manual (SDCM), 2016
- Boulder County Multimodal Transportation Standards (MTS), 2012
- CDOT Drainage Design Manual, 2019

## 3.1 Hydrologic Criteria

The Hydrologic Criteria Table in **Appendix A** provides a full summary and comparison of the hydrologic criteria identified in the technical criteria documents listed above. **Table 2** shows the applied hydrologic criteria for the CO 119 Bikeway project.

**Table 2.** *Applied Hydrologic Criteria*

| Hydrologic Criteria | Applied Criteria |
|---|---|
| Design Frequency | |
| Cross Drainage | |
| Multi-lane Road (Urban) | 100-year |
| Multi-lane Road (Rural) | 50-year |
| Two Lane Road (Urban) | 100-year |
| Two Lane Road (Rural) | 25-year |
| Culvert Outlet Scour Protection | 10-year |
| Pedestrian Walkways and Bikeways | 5-year |
| Parallel Drainage | |
| Roadway Overtopping & Revetment | *Same as for cross drainage* |
| Side Drains | 10-year |
| Storm Drains | |
| Major Storm | 100-year |
| Minor Storm | 5-year |
| Channels | |
| Capacity | *Depends on roadway classification* |
| Lining | 10-year |
| Hydrologic Procedure Selection | |
| Hydrologic Peak Prediction Procedure | |
| Drainage Area | Rational Method (<200 ac)<br>CUHP and EPA-SWMM (>200 ac) |
| Time of Concentration (Tc) for Rational Method | |
| Min. Tc for urban areas | 5 min. |
| Min. Tc for non-urban areas | 10 min. |
| Max. Overland Flow Path Length (urban, rural) | 300 ft, 500 ft |

### 3.1.1 Hydrologic Methodology

All basins are less than 200 acres; therefore, the Rational Method was used to calculate peak flowrates. See the Existing and Proposed Hydrology Calculation Packets included in **Appendix B** for full procedures and calculations.

Proposed basin delineations considered grading and new impervious areas from the CO 119 Safety and Mobility project. Due to this methodology, the result is that many proposed basins contain new impervious areas (bus lanes, widened portions of CO 119, etc.) associated with the CO 119 Safety and Mobility project.

Rainfall data was taken from NOAA Atlas 2. Per Section 500 of the *Boulder County Storm Drainage Criteria Manual*, Boulder County refers to the rainfall data source selected by Mile High Flood Control District. Per Chapter 5 of the Mile High Flood District *USDCM Volume 1* (2017), Mile High Flood District has adopted NOAA Atlas 14 as its rainfall data source. Therefore, final design hydrology calculations will use rainfall data from NOAA Atlas 14.

## 3.2 Hydraulic Criteria

The Hydraulic Criteria Table in **Appendix A** provides a full summary and comparison of hydraulic criteria identified in the technical criteria documents listed above. **Table 3** shows the applied criteria for the CO 119 Bikeway project.

### 3.2.1 Hydraulic Methodology

The proposed drainage improvements include inlets, storm drain, manholes, culverts, and roadside ditches to meet the criteria identified in **Table 3**. Preliminary hydraulic calculations used Bentley FlowMaster, Bentley OpenRoads Designer, and MHFD-Inlet to analyze proposed ditches, inlets, cross culverts, and storm drain systems. See the Proposed Hydraulic Calculation Packet included in **Appendix C** for full procedures and calculations.

**Table 3.** *Applied Hydraulic Criteria*

| Hydraulic Criteria | Applied Criteria |
|---|---|
| Storm Drain and Culverts | |
| Min. Pipe Diameter | |
| Storm Drain Trunk, Median Drain, Side Drain, Irrigation | 18 in. |
| Lateral (Median drain to cross culvert; Curb inlet to trunk line) | 15 in. |
| Cross Culvert (for State Highways) | 24 in. |
| Pipe Velocity | |
| Minimum | 3 ft/s |
| Maximum | 15 ft/s |
| Manhole Spacing (Max) | |
| 15 in. - 48 in. pipe | 300 ft |
| >48 in. pipe | 600 ft |
| Maximum Allowable Culvert Headwater to Depth Ratio | |
| D (dia. or ht. or rise) < 36 in. | 2.0 |
| 36 in. ≤ D ≤ 60 in. | 1.7 |
| 60 in. < D < 84 in. | 1.5 |
| 84 in. ≤ D < 120 in. | 1.2 |
| 120 in. ≤ D | 1.0 |
| Channels and Roadside Ditches | |
| Ditch Linings | |
| Riprap Sizing | Use HY-8 or FHWA software |
| Channel/Ditch Design | |
| Side Slope (H:V, max) | 3:1 |
| Froude Number (max.) | 0.6 (grass), 0.8 (riprap) |
| Minimum Freeboard | 1-foot |
| Max. Longitudinal Slope | 0.6% (grass-lined)<br>1.0% (riprap-lined)<br>0.5% (natural)<br>while V>7 fps and Froude # < 0.8 if flow depth exceeds 1 ft |
| Min. Longitudinal Slope | 0.2% (grass-lined and riprap-lined)<br>Match adjacent for natural |

# 4 DRAINAGE DESIGN AND ANALYSIS

## 4.1 Proposed Drainage Design

The proposed drainage design consists of the following elements:

- Proposed 18” RCP to convey flows under the bikeway at low-points.
- At locations where the bikeway crosses existing ditches, a proposed culvert under the bikeway will be placed to allow flow within ditches to cross bikeway. The proposed culvert sizes will match the existing culvert sizes crossing either NB or SB CO 119.
  - At locations where proposed bikeway grading covers the inlet or outlet end of an existing culvert crossing NB or SB CO 119, the existing culvert will be extended with the same size and material as the existing pipe.
- Type 13 inlets will be located on both sides of underpasses to collect flow. A network of 15” PVC pipes will convey flow to a pump station where flow will be discharged to the ground surface. Further details of pump stations will be completed with final design.
- The only modification to an existing cross culvert or other drainage facility for the CO 119 roadway is approximately 0.25 miles southwest of the CO 119/ Jay Road intersection. At this location, an existing 36” RCP crossing SB CO 119 will need to be replaced along with a Type D inlet in the highway median.
- Ditch grading ditches as needed to convey stormwater to specific locations.

## 4.2 Hydrologic Analysis

Overall, there are no changes to historic flow patterns. The proposed bikeway does not interfere with existing drainage patterns throughout the CO 119 corridor.

Peak flowrates were calculated at key design points where runoff leaves the project area and other facilities of interest such as existing culvert, inlets and water quality ponds. **Table 4** provides a comparison of the existing and proposed 5-year and 100-year flowrates at these key design points. There are repeated locations in **Table 4** such as the Boulder and Whiterock Irrigation Ditch and the ditch between northbound CO 119 and the BNSF railroad. **Table 4** refers to specific points along the project corridor, therefore runoff to the Boulder and Whiterock Irrigation ditch could decrease in one location and increase in another location. Please refer to the existing basin maps, proposed basin maps, and irrigation crossing inventory map in **Appendix A** for illustration on specific points which Table 4 refers to. Irrigation systems are denoted in the “ID” column in **Table 4**, the ID corresponds with the irrigation crossing inventory map in **Appendix A**. Please note, **Table 4** is not filled out for the CO 119/ CO 52 intersection and areas north and south of this intersection. Ongoing and future coordination with CO 119 Safety and Mobility Improvements project will dictate proposed drainage patterns in these areas.

**Table 4.** *Existing and Proposed Flowrate Comparison*

| Design Point | Description | Contributing Basins | | Design Storm $Q_5$ (cfs) | | | Major Storm $Q_{100}$ (cfs) | | | Irrigation ID |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Existing | Proposed | Existing | Proposed | Δ Flow | Existing | Proposed | Δ Flow | |
| DP1018L | Fourmile Creek | X1016L, X1017L, X1018L, X1021R | P1013R, P1016L, P1017L, P1018L, P1021R, P1021RA | 5.3 | 30.7 | 25.4 | 35.4 | 152.5 | 117.1 | |
| DP1030R | Ditch between NB SH 119 and BNSF Railroad | X1029R, X1030R, X1032R | P1034R | 28.6 | 0.2 | -28.4 | 144.0 | 143.9 | -0.1 | |
| DP1034R | Boulder and Whiterock Irrigation Ditch | X1034R | P1034R | 0.2 | 0.2 | 0.1 | 3.1 | 1.9 | -1.2 | |
| DP1044L | Water Quality Extended Detention Basin North of Jay Road | X1047L | P1043R, P1044L | 1.1 | 0.9 | -0.1 | 12.3 | 9.4 | -2.9 | ID-5 |
| DP1056L | Boulder and Whiterock Irrigation Ditch | X1054R, X1056L | Mobility Hub Jay Rd Inlet, P1048L, P1053L, P1054R, P1056L, P1057L, P1067L, P1063R, P1069R | 4.0 | 7.7 | 3.7 | 16.5 | 24.6 | 8.2 | |
| DP1069R | Boulder and Whiterock Irrigation Ditch | X1069R | Mobility Hub Jay Rd Inlet, P1048L, P1053L, P1054R, P1056L, P1057L, P1067L, P1063R, P1069R | 0.7 | 8.5 | 7.8 | 11.4 | 35.3 | 23.9 | ID-9 |
| DP1082L | Boulder and Whiterock Irrigation Ditch | X1077R, X1080R, X1083R | P1076L, P1077R, P1080R, P1082L | 2.2 | 2.7 | 0.5 | 14.6 | 7.5 | -7.1 | ID-13 |
| DP1082R | Ditch between NB SH 119 and BNSF Railroad | X1082R | P1082R | 0.0 | 0.1 | 0.0 | 0.7 | 0.7 | 0.0 | |
| DP1088R | City of Boulder and Others Irrigation Line | X1088R | P1088R | 1.2 | 1.9 | 0.7 | 8.1 | 9.4 | 1.3 | ID-14 |
| DP2010R | Ditch between NB SH 119 and BNSF Railroad | X2010R | P2010R | 1.0 | 0.7 | -0.3 | 10.0 | 5.1 | -4.8 | |
| DP2022R | Ditch between NB SH 119 and BNSF Railroad | X2022R, X2022RA | P2021L, P2022L, P2022R | 0.3 | 1.3 | 1.0 | 3.2 | 10.8 | 7.6 | |
| DP2031R | Ditch between NB SH 119 and BNSF Railroad | X2031R | P2030L, P2031R, P2032L | 0.6 | 1.1 | 0.6 | 8.0 | 8.7 | 0.7 | ID-16 |

**Table 4 (continued).** *Existing and Proposed Flowrate Comparison*

| Design Point | Description | Contributing Basins | | Design Storm $Q_5$ (cfs) | | | Major Storm $Q_{100}$ (cfs) | | | Irrigation ID |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Existing | Proposed | Existing | Proposed | Δ Flow | Existing | Proposed | Δ Flow | |
| DP2059R | Boulder Reservoir Spillway/ Boulder County Irrigation Ditch | X2056R, X2060R | P2049L, P2058L, P2059R, P2062L | 3.5 | 5.0 | 1.5 | 19.3 | 24.4 | 5.1 | ID-17 |
| DP2064R | Ditch between NB SH 119 and BNSF Railroad | X2064R | P2063R, P2064R, P2066R | 2.6 | 4.1 | 1.5 | 13.5 | 17.3 | 3.8 | |
| DP2079L | City of Boulder and Northern Colorado Water Conservancy District Irrigation Line | X2079R | P2075L, P2077L, P2079L | 1.2 | 1.4 | 0.2 | 7.5 | 7.2 | -0.2 | ID-19 |
| DP2085R | Ditch between NB SH 119 and BNSF Railroad | X2085R | P2084L, P2085R | 1.3 | 1.8 | 0.5 | 8.9 | 9.7 | 0.8 | |
| DP2085L | Dry Creek | X2090R, X2099R, X2100R | P2085L, P2092R, P2093R, P2098R, P2100R, P2100L | 2.3 | 3.0 | 0.8 | 18.5 | 19.2 | 0.7 | |
| DP3049R | Star Irrigation Ditch | X3049R | P3049L, P3049R | 2.4 | 3.4 | 1.0 | 10.3 | 11.9 | 1.7 | ID-30 |
| DP3052R | Ditch between NB SH 119 and BNSF Railroad | X3052L | P3052R | 0.7 | 0.9 | 0.2 | 2.8 | 3.2 | 0.4 | |
| DP4028R | Water Quality Extended Detention Basin North of Niwot Road | X4019RA, X4021R, X4023R, X4028R | P4021R, P4023R, P4028L, P4028R | 4.1 | 8.7 | 4.6 | 21.9 | 23.2 | 1.3 | |
| DP4044R | Williamson Irrigation Ditch | X4019RA, X4021R, X4023R, X4028R, X4044R | P4021R, P4023R, P4028L, P4028R, P4040L, P4044R | 4.1 | 7.0 | 2.9 | 21.9 | 26.4 | 4.5 | ID-31 |
| DP4054R | Ditch between NB SH 119 and BNSF Railroad | X4054R | P4053L, P4054R | 1.0 | 1.7 | 0.7 | 8.5 | 10.2 | 1.7 | |
| DP4065R | Williamson Irrigation Ditch | X4065R | P4060L, P4065R | 1.4 | 1.5 | 0.2 | 9.6 | 8.2 | -1.5 | ID-32 |
| DP4075L | Ditch outside and adjacent to SB SH 119 | X4076LA | P4075L | 0.7 | 0.2 | -0.5 | 8.0 | 4.2 | -3.8 | |
| DP4076L | Ditch outside and adjacent to SB SH 119 | X4076L | P4074R, P4076L | 0.4 | 1.7 | 1.2 | 1.8 | 7.0 | 5.2 | ID-37 |
| DP4081L | Ditch outside and adjacent to SB SH 119 | X4082L | P4081R, P4081L | 0.8 | 1.6 | 0.8 | 6.9 | 7.7 | 0.7 | |
| DP4087L | Point outside of SB SH 119, potentially a secondary line of Williamson Irrigation Ditch | X4087L | P4086R, P4087L | 1.7 | 1.8 | 0.1 | 9.1 | 8.7 | -0.4 | |
| DP4091L | Point outside of SB SH 119 | X4091L | P4091R, P4091L | 2.5 | 2.7 | 0.2 | 9.3 | 9.2 | -0.1 | |

**Table 4 (continued).** *Existing and Proposed Flowrate Comparison*

| Design Point | Description | Contributing Basins | | Design Storm $Q_5$ (cfs) | | | Major Storm $Q_{100}$ (cfs) | | | Irrigation ID |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Existing | Proposed | Existing | Proposed | Δ Flow | Existing | Proposed | Δ Flow | |
| DP4095R | Point outside of SB SH 119 | X4096L | P4093L, P4095R | 1.2 | 1.3 | 0.1 | 3.8 | 3.8 | 0.0 | |
| DP4114L | Point outside of SB SH 119 | X4114L | P4108R, P4114L | 1.8 | 2.4 | 0.6 | 12.2 | 13.8 | 1.6 | |
| DP5001L | Point outside of SB SH 119 | None | P4117R, P5001L | 0.0 | 2.2 | 2.2 | 0.0 | 10.6 | 10.6 | |
| DP5006R | Storm system at existing underpass near Airport Road | X5006R, X5007R | P5006R, P5007R | 1.3 | 1.4 | 0.2 | 5.5 | 5.7 | 0.2 | |
| DP5011L | Lefthand Creek | X5011L, X5011R | P5011R, P5011L | 2.5 | 2.7 | 0.2 | 15.8 | 15.0 | -0.9 | |
| DP5013L | Lefthand Creek | X5013L | P5013L | 1.6 | 1.7 | 0.2 | 8.0 | 8.4 | 0.5 | |
| DP5023R | Ditch between NB SH 119 and BNSF Railroad | X5023R | P5023L, P5023R | 1.3 | 1.4 | 0.1 | 7.4 | 7.8 | 0.4 | |
| DP5033R | Lefthand Creek | X5033R | P5030L, P5033R | 1.2 | 1.2 | 0.0 | 8.9 | 6.5 | -2.4 | |
| DP5041R | Ditch between NB SH 119 and BNSF Railroad | X5041R | P5040L, P5041R | 0.5 | 0.6 | 0.1 | 4.8 | 2.4 | -2.4 | |
| DP5048R | Ditch between NB SH 119 and BNSF Railroad | X5048R | P5048L, P5048R | 0.5 | 1.4 | 1.0 | 5.0 | 4.7 | -0.3 | |
| DP5064R | Ditch between NB SH 119 and BNSF Railroad | X5052L, X5064R | P5064R | 1.9 | 2.1 | 0.2 | 16.5 | 12.5 | -3.9 | |
| DP5066R | Ditch between NB SH 119 and BNSF Railroad | X5066R | P5066R | 0.3 | 0.5 | 0.1 | 6.2 | 5.0 | -1.3 | |
| DP5068R | Holland Ditch | X5068R, X5075R | P5052L, P5066L, P5076R, P5068R, P5084L, P5084R | 5.3 | 9.2 | 3.9 | 46.0 | 56.6 | 10.6 | ID-34 |

## 4.3 Hydraulic Analysis

Proposed ditches, inlets, and pipes were analyzed for capacity and meeting criteria. An analysis for every ditch, inlet, and pipe was not performed at the preliminary level. Rather, a typical ditch, inlet, and pipe was compared to peak flowrates to understand the performance of proposed hydraulic facilities at a broad level.

### 4.3.1 Ditches

Proposed ditches adjacent to the bikeway were evaluated based on the capacity of a 6”, 12”, or 18” triangular ditch. Bentley FlowMaster results show a 6” or 12” triangular ditch typically has sufficient capacity to convey the 5-year and 100-year peak flowrates. Please refer to hydraulic calculations in **Appendix C** for more information.

Maximum and minimum longitudinal slope criteria will be subject to proposed grading for the bikeway and existing terrain. A 3:1 (H:V) side slope is anticipated to be feasible in most locations for proposed ditches. A minimum freeboard of 1-ft will not be feasible if a 6” or 12” ditch is selected. Preliminary calculations show a maximum Froude number of 0.6 is feasible for the 5-yr design storm for proposed ditches.

### 4.3.2 Inlets

CDOT Type C and D area inlets are proposed at roughly five-to-ten locations. Nomograph data from the CDOT *Drainage Design Manual* (2019) was used to evaluate the capacity of Type C inlets. Results show a Type C inlet will have sufficient capacity for the 5-yr design storm. Please refer to hydraulic calculations in **Appendix C** for more information.

CDOT Type 13 grate inlets are proposed at the bikeway underpasses. Mile High Flood District MHFD-Inlet results show a single Type 13 inlet has insufficient capacity in the 5-yr design storm. Management of runoff around and to the proposed underpasses will need to be analyzed more closely in the next phase of design to reduce runoff to the underpasses and/or upsized the proposed facilities. Please refer to hydraulic calculations in **Appendix C** for more information.

### 4.3.3 Pipes

There are two primary applications for proposed drainage pipes, pipe networks for the pump systems at the underpasses and cross-culverts at the bikeway low points.

Results indicate 15” plastic pipes used for the pipe networks at underpasses have sufficient capacity for the 5-year design storm. The hydraulic grade line elevation exceeds the top of pipe elevation in the 100-year event. The analysis was limited to pipes draining by gravity. Potential pump stations and associated discharge pipes were not evaluated during preliminary design.

Results indicate that an 18” culvert crossing the bikeway typically has sufficient capacity to convey flow under the bikeway. An 18” RCP has been selected as the standard size/material for this application.

### 4.3.4 Pump Stations

Pump station design was not completed with preliminary design and will be completed in the next phase of design.

### 4.3.5 Riprap

Riprap is placed at the outfall of proposed pipes which are intended for stormwater. The selected dimensions and size of riprap is based on CDOT M-Standard M-601-12.

## 4.4 Floodplain Impacts

### 4.4.1 Fourmile Canyon Creek

A proposed bridge for the bikeway spans Fourmile Canyon Creek adjacent to SB (southbound) CO 119. The proposed bikeway will generally be located above the FEMA Zone AE floodplain. As of the preliminary design stage, the abutments of the proposed bridge have been placed to coincide with the CO 119 SB bridge over the creek to avoid eliciting a rise in water surface elevation. The deck of the proposed bridge does not encroach into the Zone AE floodplain.

### 4.4.2 Dry Creek

The proposed bikeway will traverse the median of CO 119 and cross Dry Creek. An 12'x8' box culvert crossing under SB CO 119 is used to carry bicyclists, pedestrians, etc. along the "LOBO Reservoir Trail" which is adjacent to Dry Creek. A levee wall separates the LOBO Reservoir Trail from Dry Creek. The proposed bikeway has been designed to traverse up and over the eastern end of an existing box culvert.

A spur connection is proposed from the proposed bikeway to the LOBO trail in the highway median. The spur connection will create an opening in a retaining wall along the existing trail to allow bicyclists and pedestrians to transfer between paths.

Impacts of these improvements to the floodplain are anticipated to be minimal. Ongoing modeling is being performed to confirm the impacts and to determine the need for a no rise certification or Certified Letter of Map Revision (CLOMR).

### 4.4.3 Lefthand Creek

The floodway and floodplain are very expansive around the Lefthand Creek crossing. The proposed bikeway will be located within the Regulatory Floodway and the Zone AE Floodplain from north of Airport Road to the northern limits of the project per the CHAMP floodplain model .

Two structures are being evaluated to determine if they encroach into the Regulatory Floodway and Zone AE Floodplain. The two structures are a proposed underpass for the bikeway under southbound CO 119 south of Airport Road and a proposed bridge spanning Lefthand Creek north of Airport Road.

The water surface elevation of the Zone AE Floodplain is anticipated to rise more than 0.01 feet due to the bikeway improvements. Therefore, a CLOMR and Letter of Map Revision (LOMR) are anticipated for the improvements.

# 5 WATER QUALITY

Polluted stormwater runoff is commonly transported via municipal separate storm sewer systems (MS4s) into nearby rivers and streams. Under the 1987 Clean Water Act (CWA) Amendments, the Environmental Protection Agency (EPA) developed Stormwater Phase I and Phase II Regulations which established a MS4 program that manages and regulates stormwater impacts on water quality. The MS4 stormwater management program is intended to improve the Nation's waterways by reducing the quantity of pollutants that stormwater picks up and carries into the storm sewer systems. Among other requirements, the regulations require regulated entities to acquire a National Pollutant Discharge Elimination System (NPDES) Permit for their stormwater discharges.

In Colorado, these regulations are administered by the Colorado Department of Public Health and Environment's (CDPHE) Water Quality Control Commission (WQCC). The Colorado stormwater NPDES permit program is referred to as the Colorado Discharge Permit System (CDPS). The WQCC division regulates sources of pollution from pipes and drains (that do not include runoff from agricultural fields) that flow directly from qualifying municipalities to state waters via two types of permits: individual permits (large entities that need their own permit to cover the work they do) and General Phase II permits.

This project has overlapping MS4 permits, CDOT's individual permit and Boulder County's Statewide General Permit. CDOT is regulated by a Phase I MS4 permit (COS-000005) that covers state and interstate highways and their rights-of-way within urbanized boundaries, as defined by CDPHE. Boulder County is regulated by Statewide standard MS4 General Permit (COR090000). As part of these permits, there are several different programs in place to reduce the amount of pollutants entering Colorado's waterways. Two of the programs that are examined herein are the Permanent Water Quality (PWQ) Program and the Construction Sites Program. Below is a discussion of the project's permanent water quality and construction stormwater management needs as they pertain to these programs.

## 5.1 Permanent Water Quality

Muller has evaluated the project permanent water quality needs for both CDOT's and Boulder County's MS4 permit. Both permits have a PWQ control measure exemption for trail projects. Therefore, PWQ control measures are not required for the project.

## 5.2 Construction Stormwater Management

A Stormwater Management Plan (SWMP) and SWMP Site Maps are required as part of the permits for Stormwater Discharges Associated with Construction Activity. The plans need to identify BMP/Control Measures, non-structural (i.e., administrative measures, phasing, signs) and structural, which will be used throughout each phase of the construction project to minimize erosion and protect water quality. The Stormwater Management Plan (SWMP) and the SWMP Site Maps will be included with the project Final Construction documents.

# 6 CONCLUSIONS

## 6.1 Compliance with Standards

The drainage design for CO 119 Bikeway Project is in accordance with the CDOT Drainage Design Criteria Manual, the Boulder County Storm Drainage Criteria Manual, and the Boulder County Multimodal Transportation Standards.

## 6.2 Drainage Concept

This report presents the drainage analyses and design for the CO 119 Bikeway Project. The overall drainage concept is outlined below:

1. Historic drainage patterns will be maintained.
2. Culverts, inlets, and ditches have been designed to manage runoff.
3. Drainage design assumes the CO 119 Safety and Mobility project is constructed concurrently.
4. Trail projects are exempt from post-construction stormwater quality management per CDOT's and Boulder County's MS4 permits. Therefore, permanent water quality control measures are not required.

# 7 REFERENCES

AECOM, *Conditional Letter of Map Revision Lefthand Creek 1901 South Hover Street Development Project, Longmont, Boulder County*, 2020

Belt Collins West LTD., *LOBO Trail: IBM Connection Final Hydraulic Design Report*, 2012

Boulder County *Multimodal Transportation Standards (MTS)*, 2012

Boulder County *Storm Drainage Criteria Manual (SDCM)*, 2016

Colorado Department of Transportation (CDOT) *Drainage Design Manual,* 2019

Felsburg, Holt & Ullevig, *Hydrology and Hydraulics Report for the Intersections SH 119 at Jay Rd and SH 119 at Niwot Rd,* May 2012

Muller Engineering Company, *SH 119 at SH 52 (Mineral Road) Final Drainage Report*, November 2005

Drexel , Barrell, and Co., *Vojta Farm Final Stormwater Report*, July 9, 2008

USGS StreamStats, *United States Department of the Interior*, Accessed June 24, 2022

# APPENDIX A

## Maps and References

Hydrologic Criteria Table

Hydraulic Criteria Table

Existing Basin Map

Proposed Basin Map

Irrigation Crossing Inventory Map

Hydrologic Soils Report (NRCS)

Point Precipitation Data (NOAA Atlas 2)

FEMA Flood Zone Maps

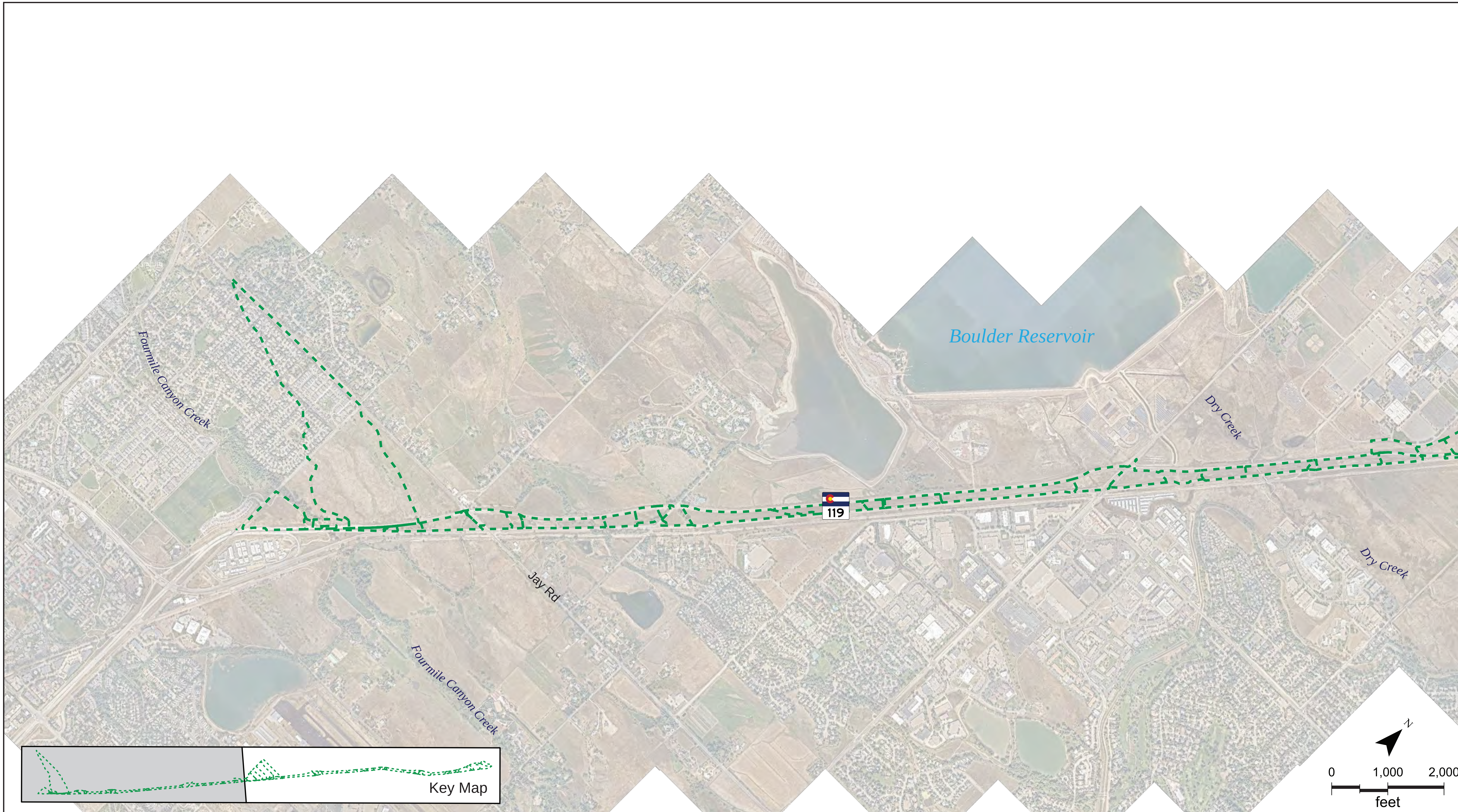
# Hydrologic Criteria Table

| SH 119 Bikeway Hydrologic Design Criteria | | | | | |
|---|---|---|---|---|---|
| | CDOT | | Boulder County | | |
| Hydrologic Criteria | CDOT Drainage Design Manual (2019) | | Multimodal Transportation Standards (MTS) [2012] or Storm Drainage Criteria Manual (SDCM) [2016] | | Applied Criteria |
| **Design Frequency** | | | | | |
| Cross Drainage | | | | | |
| Multi-lane Road (Urban) | 100-year | Table 7.2 | Minor: 5-year<br>Major: 100-year | Section 3, 304 (SDCM) | 100-year |
| Multi-lane Road (Rural) | 50-year | | | | 50-year |
| Two Lane Road (Urban) | 100-year | | | | 100-year |
| Two Lane Road (Rural) | 25-year (assuming Q<4000 cfs) | | | | 25-year |
| Culvert Outlet Scour Protection | 10-year | | - | | 10-year |
| Pedestrian Walkways and Bikeways | 2-year to 5-year | | 5-year | 5.7.4 (MTS) | 5-year |
| Parallel Drainage | | | | | |
| Roadway Overtopping & Revetment | *Same as for cross drainage* | Table 7.2 | Minor: 5-year<br>Major: 100-year | Section 3, 304 (SDCM) | *Same as for cross drainage* |
| Side Drains | 2 to 5-year | | | | 10-year |
| Storm Drains | | | | | |
| Major Storm | 100-year | Table 7.2 | 100-year | Section 3, 304 and Section 9 (SDCM) | 100-year |
| Minor Storm | 2 to 5-year | | 5-year | | 5-year |
| Channels | | | | | |
| Capacity | *Refer to Parallel or Cross Drainage* | Ch. 8.4 | Minor: 5-year<br>Major: 100-year | Section 3, 304 and Section 7 (SDCM) | *Depends on roadway classification* |
| Lining | | | | | 10-year |
| **Hydrologic Procedure Selection** | | | | | |
| Hydrologic Peak Prediction Procedure | | | | | |
| Drainage Area | Rational Method (<200 ac)<br><br>CUHP (most desireable), NRCS TR55, Snyder's Unit Hydrograph, SCS Synthetic Unit Hydrograph, others (>200 ac) | Ch. 7.4.1 | Rational Method<br>(not to exceed 90 ac ) | Section 6, 602 (SDCM) | Rational Method (<200 ac)<br><br>CUHP and EPA-SWMM (>200 ac) |
| Time of Concentration (Tc) for Rational Method | | | | | |
| Min. Tc for urban areas | 5 min. | Ch. 7.4.5 | 5 min. | Section 6, 602.2 | 5 min. |
| Min. Tc for non-urban areas | 10 min. | | 10 min. | | 10 min. |
| Max. Overland Flow Path Length (urban) | 300 ft | | 300 ft | Section 6, Table 600-1 | 300 ft |
| Max. Overland Flow Path Length (rural) | 500 ft | | 500 ft | | 500 ft |

# Hydraulic Criteria Table

| SH 119 Bikeway Hydraulic Design Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|
| Hydraulic Criteria | CDOT | | Boulder County | | MHFD | | Applied Criteria |
| | CDOT Drainage Design Manual (2019) | | Multimodal Transportation Standards (MTS) [2012] or Storm Drainage Criteria Manual (SDCM) [2016] | | Urban Storm Drainage Criteria Manual (USDCM) | | |
| Bike Trails | | | | | | | |
| Minimum Transverse Slope | - | - | 2.0% | 5.7.3.2 (MTS) | - | - | 2.0% |
| Storm Drain and Culverts | | | | | | | |
| Min.Pipe Diameter | | | | | | | |
| Storm Drain Trunk, Median Drain, Side Drain, Irrigation | 18 in. | Ch. 13.3.6 | 18 in. | Section 802.4 (SDCM) | - | - | 18 in. |
| Lateral (Median drain to cross culvert; Curb inlet to trunk line) | 15 in. | | 15 in. | | | | 15 in. |
| Cross Culvert (for State Highways) | 24 in. | Table 9.4 | 18 in. (for any culvert) | Section 1002.2 (SDCM) | | | 24 in. |
| Pipe Velocity | | | | | | | |
| Minimum | 3 ft/s | Ch. 13.3.6 | Not Stated - Refer to MHFD | - | 3 ft/s | Ch. 11.4.4.6 | 3 ft/s |
| Maximum | Consistent with velocity in downstream channel, energy dissipators required for V>16 fps in channels | Ch. 9.2.2 | 15 fps | Section 802.6 (SDCM) | - | - | 15 ft/s |
| Manhole Spacing (Max) | | | | | | | |
| 15 in. - 48 in. pipe | 300 ft | Table 13.3 | Not Stated - Refer to MHFD | - | <400 ft | Ch. 7.4.2 | 300 ft |
| >48 in. pipe | 600 ft | | | | | | 600 ft |
| Maximum Allowable Culvert Headwater to Depth Ratio | | | | | | | |
| D (dia. or ht. or rise) < 36 in. | 2.0 | Table 9.3 | 2.0 (100-yr) | Section 1002.4 (SDCM) | - | - | 2.0 |
| 36 in. ≤ D ≤ 60 in. | 1.7 | | 1.5 (100-yr) | | | | 1.7 |
| 60 in. < D < 84 in. | 1.5 | | | | | | 1.5 |
| 84 in. ≤ D < 120 in. | 1.2 | | | | | | 1.2 |
| 120 in. ≤ D | 1.0 | | | | | | 1.0 |
| Channels and Roadside Ditches | | | | | | | |
| Ditch Linings | | | | | | | |
| Riprap Sizing | Use HY-8 or FHWA software | Ch. 11.5 | Not Stated - Refer to MHFD | - | Unit discharge/slope equations by CSU, USDA, or USACE | Ch. 8.1.2 | Use HY-8 or FHWA software |
| Channel/Ditch Design | | | | | | | |
| Side Slope (H:V, max) | 3.0:1 (grass), 2.5:1 (riprap) | Table 8.2 | Not Stated - Refer to MHFD | - | Non-cohesive Soils/Poor vegetation: 7 ft/s Cohesive Soils and Vegetation: 5ft/s | Table 8-3 | 3:1 |
| Froude Number (max.) | 0.6 (grass), 0.8 (riprap) | | No max if flow depth is less than 1 foot. 0.8 if flow depth > 1 ft. | Table 700-3 | - | - | 0.6 (grass), 0.8 (riprap) |
| Minimum Freeboard | 1-foot | | Not Stated - Refer to MHFD | - | 1.5 feet (recommended - not required) | Table 8-2 | 1-foot |
| Max. Longitudinal Slope | 0.6% (grass-lined)<br>1.0% (riprap-lined)<br>0.5% (natural) | | Designed such that V> 7 fps and Froude # is less than 0.8 (only if flow depth > 1.0 ft) | Table 700-3 | - | - | 0.6% (grass-lined)<br>1.0% (riprap-lined)<br>0.5% (natural)<br>while V>7 fps and Froude # < 0.8 if flow depth exceeds 1 ft |
| Min. Longitudinal Slope | 0.2% (grass-lined and riprap-lined)<br>Match adjacent for natural | | - | - | - | - | 0.2% (grass-lined and riprap-lined)<br>Match adjacent for natural |
| Bridges | | | | | | | |
| Freeboard | | | | | | | |
| Low to Moderate Debris Stream | 2 ft | Ch. 10.2.2 | 1 ft above EGL | 1004.1 | - | - | 2 ft |
| High Debris Stream | 4 ft | | | | | | 4 ft |

# Existing Basin Map




Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| | | | |
|---|---|---|---|
| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
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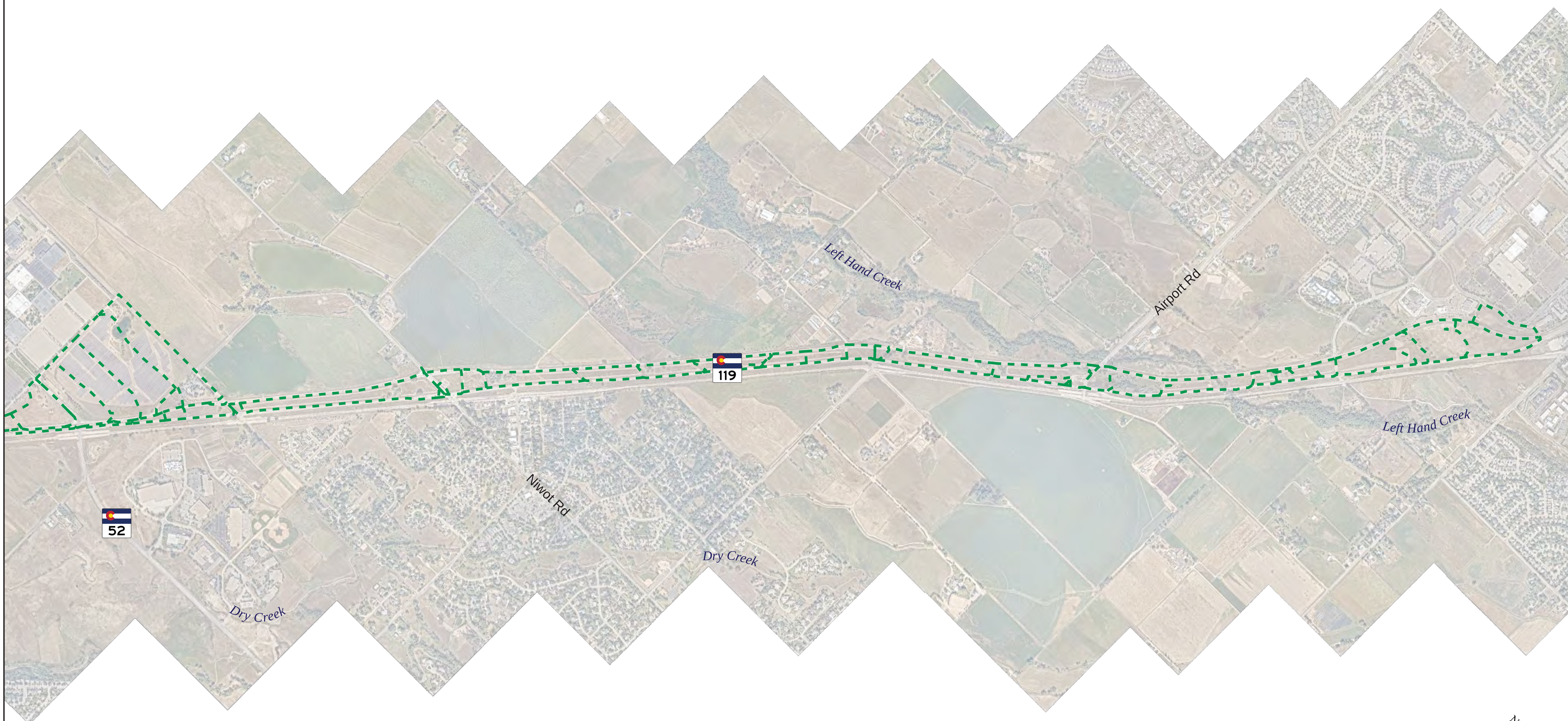


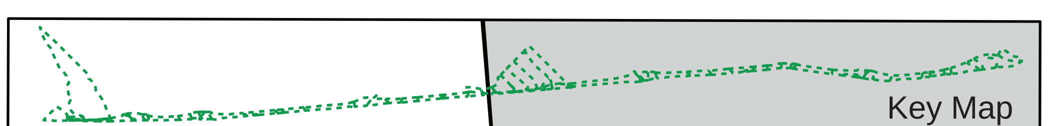


MULLER

Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC)
C5
C100

DP
123R
Design Point

| | | | | | |
|---|---|---|---|---|---|
| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | | | Project No. / Code |
| No Revisions: | | | | | |
| Revised: | Designer: ACF | Structure Numbers | | | |
| | Detailer: SR2 | | | | |
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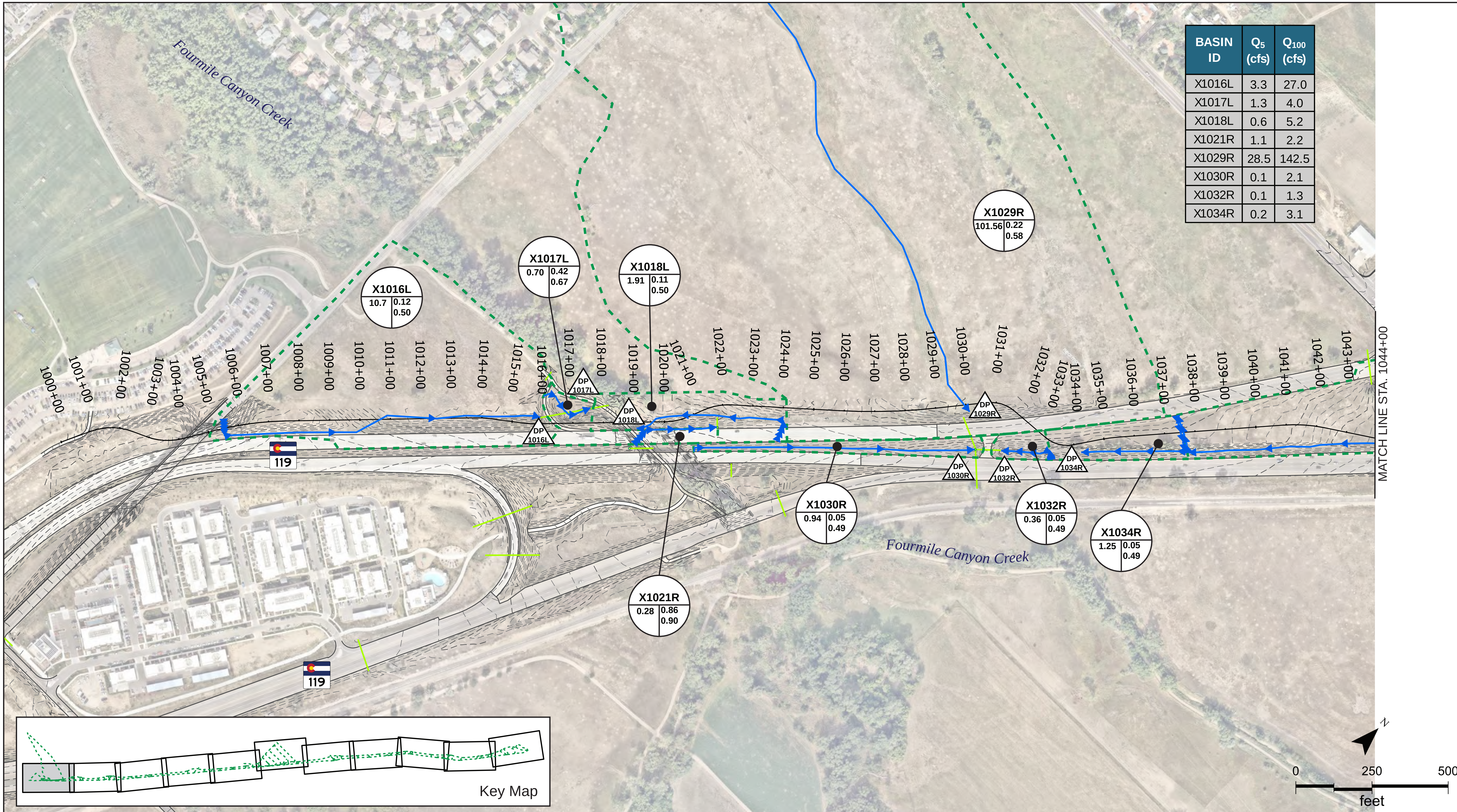


| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X1016L | 3.3 | 27.0 |
| X1017L | 1.3 | 4.0 |
| X1018L | 0.6 | 5.2 |
| X1021R | 1.1 | 2.2 |
| X1029R | 28.5 | 142.5 |
| X1030R | 0.1 | 2.1 |
| X1032R | 0.1 | 1.3 |
| X1034R | 0.2 | 3.1 |

MULLER

CDOT

Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| | | | |
|---|---|---|---|
| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
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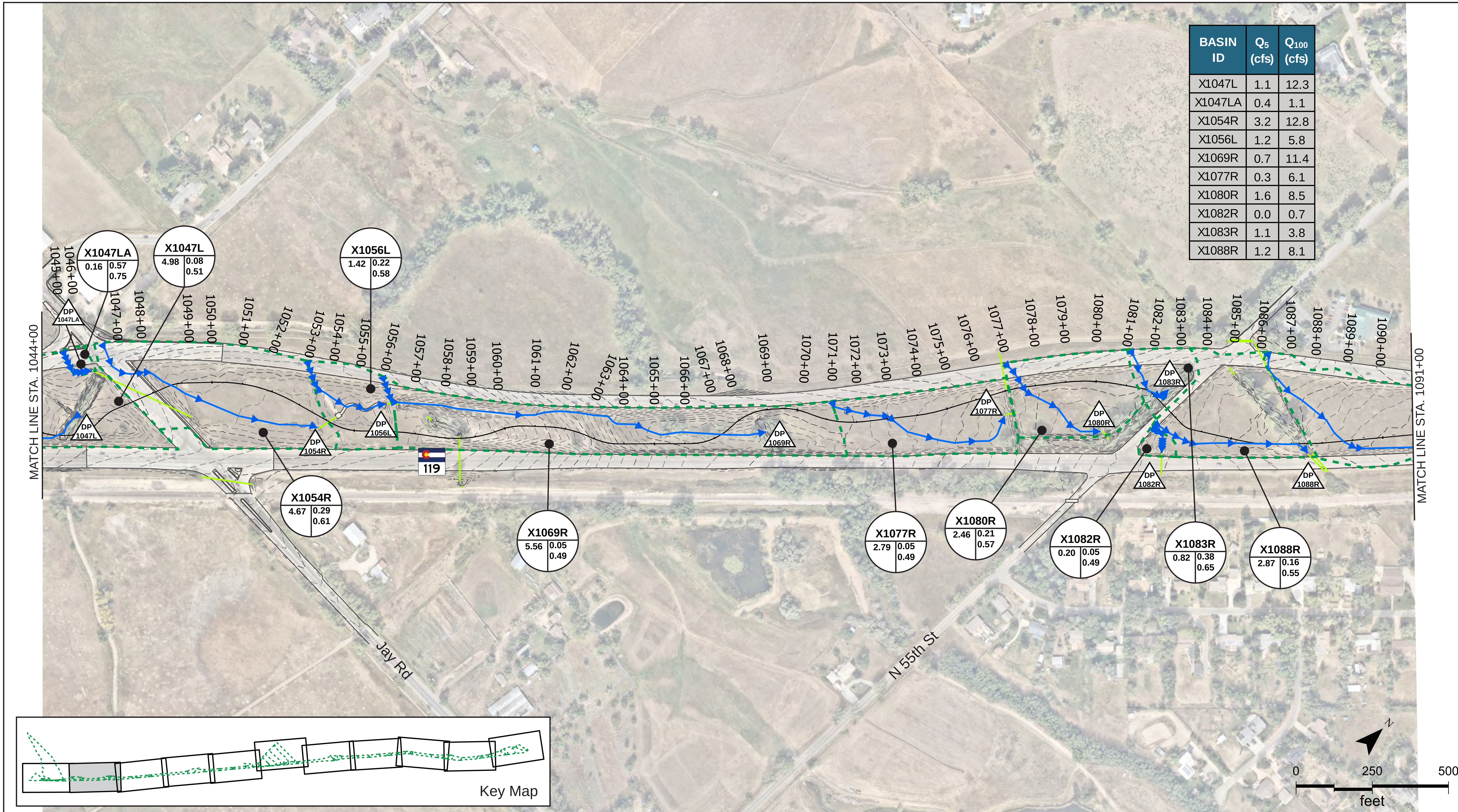


| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X1047L | 1.1 | 12.3 |
| X1047LA | 0.4 | 1.1 |
| X1054R | 3.2 | 12.8 |
| X1056L | 1.2 | 5.8 |
| X1069R | 0.7 | 11.4 |
| X1077R | 0.3 | 6.1 |
| X1080R | 1.6 | 8.5 |
| X1082R | 0.0 | 0.7 |
| X1083R | 1.1 | 3.8 |
| X1088R | 1.2 | 8.1 |

MULLER

Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
|---|---|---|---|
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
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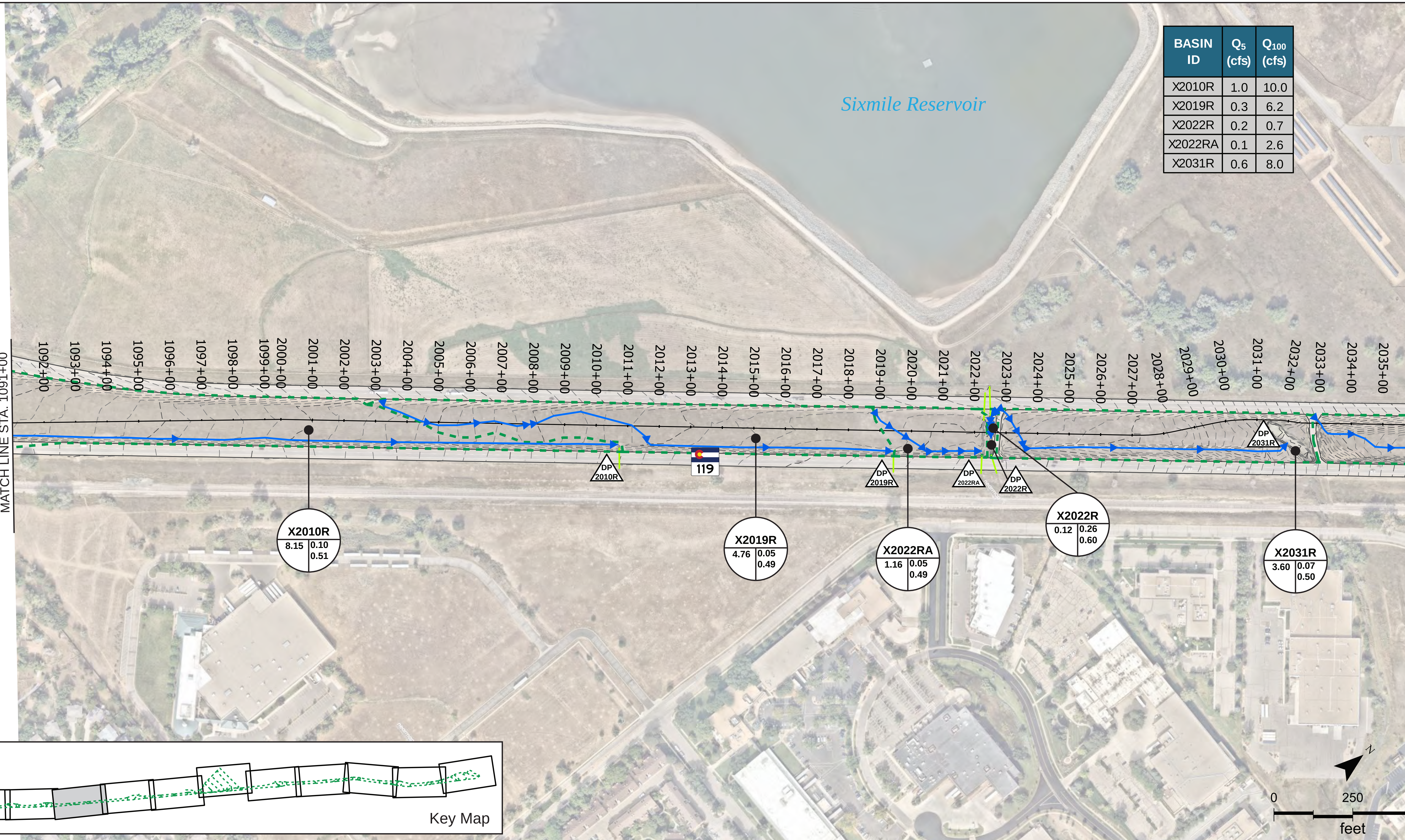



| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X2010R | 1.0 | 10.0 |
| X2019R | 0.3 | 6.2 |
| X2022R | 0.2 | 0.7 |
| X2022RA | 0.1 | 2.6 |
| X2031R | 0.6 | 8.0 |

MULLER

CDOT

Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

As Constructed

No Revisions:

Revised:

Void:

EXISTING DRAINAGE BASIN MAPS
CO 119 BIKEWAY

| | |
|---|---|
| Designer: | ACF |
| Detailer: | SR2 |
| Sheet Subset: | DRAINAGE |

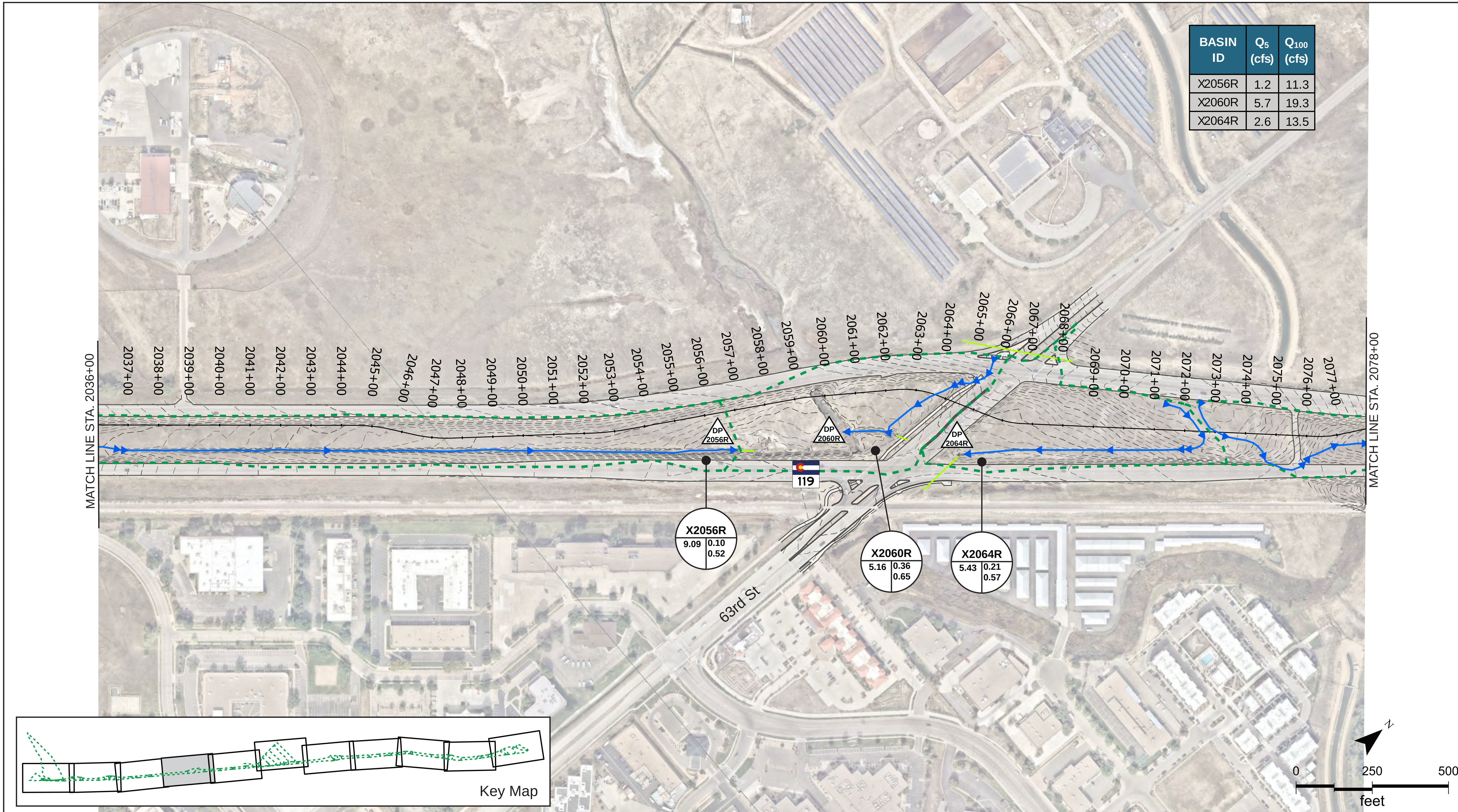
Structure Numbers

Sheet Subset: 5 of 13

Project No. / Code

Sheet Subset:

| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X2056R | 1.2 | 11.3 |
| X2060R | 5.7 | 19.3 |
| X2064R | 2.6 | 13.5 |



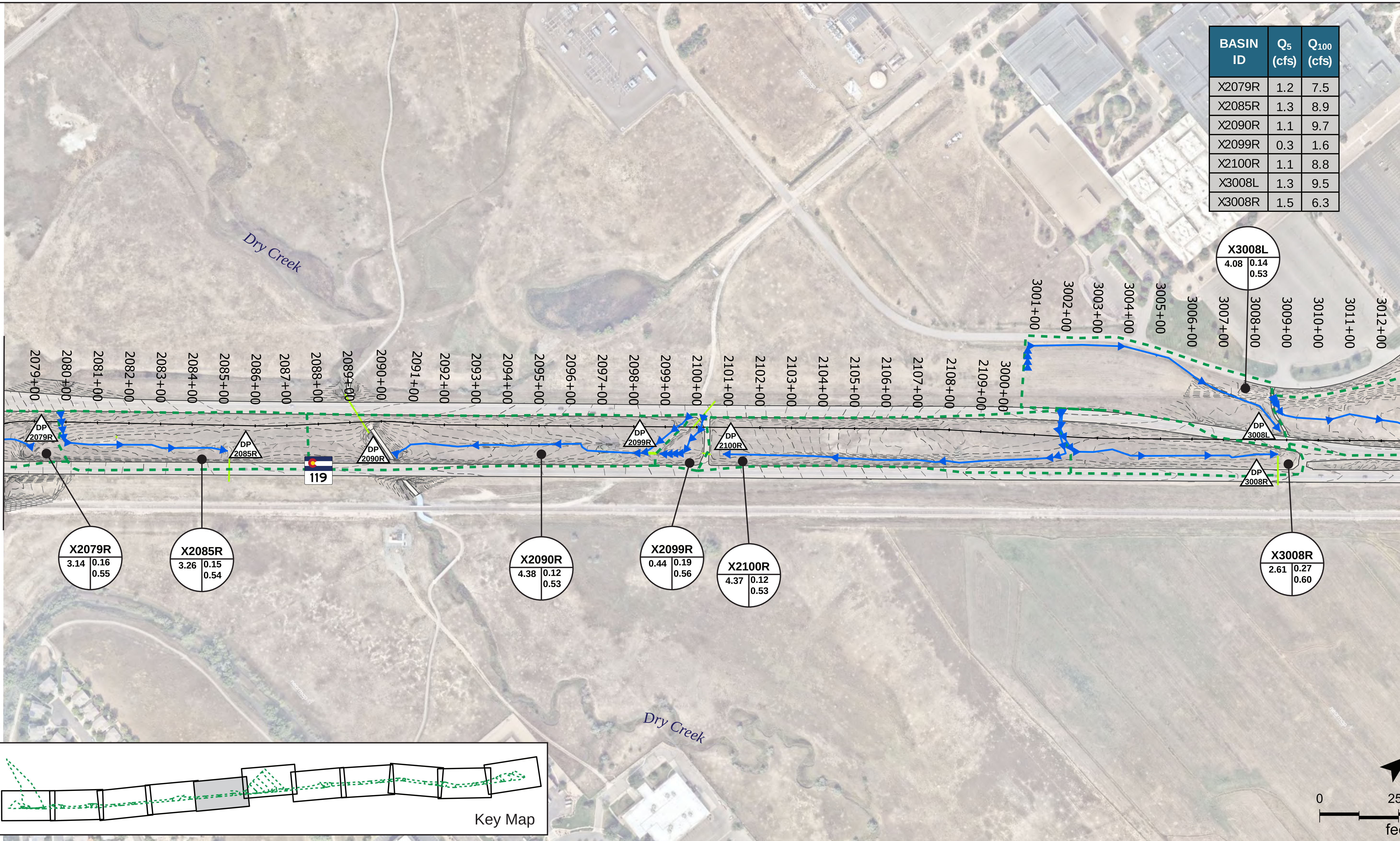

Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
|---|---|---|---|
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: 6 of 13 | Sheet Subset: |

MULLER
CDOT




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X2079R | 1.2 | 7.5 |
| X2085R | 1.3 | 8.9 |
| X2090R | 1.1 | 9.7 |
| X2099R | 0.3 | 1.6 |
| X2100R | 1.1 | 8.8 |
| X3008L | 1.3 | 9.5 |
| X3008R | 1.5 | 6.3 |

MULLER

CDOT

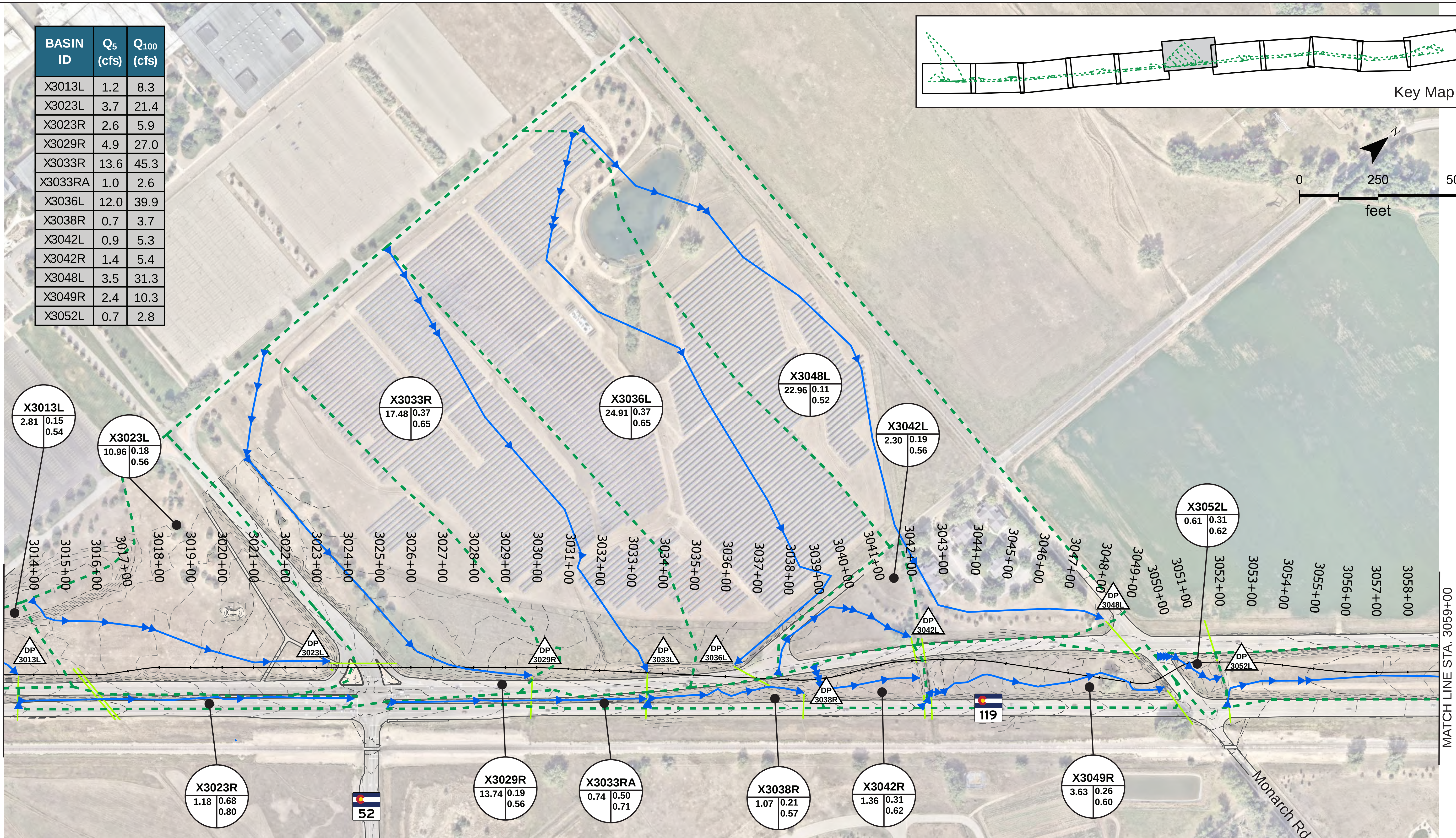
Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | | Project No. / Code |
|---|---|---|---|---|
| No Revisions: | | | | |
| Revised: | Designer: ACF | Structure Numbers | | |
| | Detailer: SR2 | | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: | 7 of 13 | Sheet Subset: |

| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X3013L | 1.2 | 8.3 |
| X3023L | 3.7 | 21.4 |
| X3023R | 2.6 | 5.9 |
| X3029R | 4.9 | 27.0 |
| X3033R | 13.6 | 45.3 |
| X3033RA | 1.0 | 2.6 |
| X3036L | 12.0 | 39.9 |
| X3038R | 0.7 | 3.7 |
| X3042L | 0.9 | 5.3 |
| X3042R | 1.4 | 5.4 |
| X3048L | 3.5 | 31.3 |
| X3049R | 2.4 | 10.3 |
| X3052L | 0.7 | 2.8 |

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CDOT

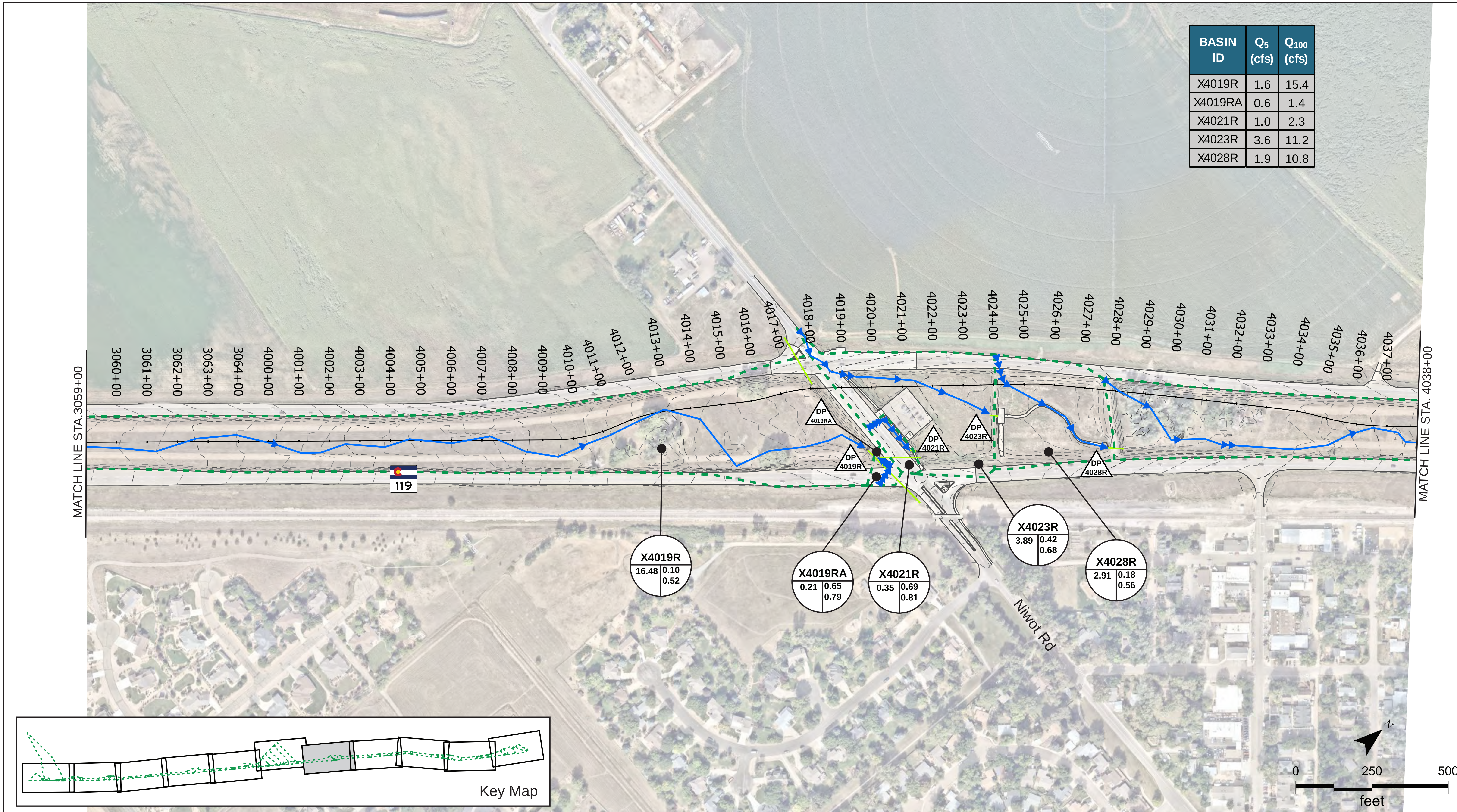
Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | | Project No. / Code |
|---|---|---|---|---|
| No Revisions: | | | | |
| Revised: | Designer: ACF | Structure Numbers | | |
| | Detailer: SR2 | | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: | 8 of 13 | Sheet Subset: |

| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X4019R | 1.6 | 15.4 |
| X4019RA | 0.6 | 1.4 |
| X4021R | 1.0 | 2.3 |
| X4023R | 3.6 | 11.2 |
| X4028R | 1.9 | 10.8 |




Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

MULLER

| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
|---|---|---|---|
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: 9 of 13 | Sheet Subset: |

| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X4044R | 0.7 | 9.8 |
| X4054R | 1.0 | 8.5 |
| X4065R | 1.4 | 9.6 |
| X4076LA | 0.7 | 8.0 |
| X4076L | 0.4 | 1.8 |
| X4082L | 0.8 | 6.9 |


Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

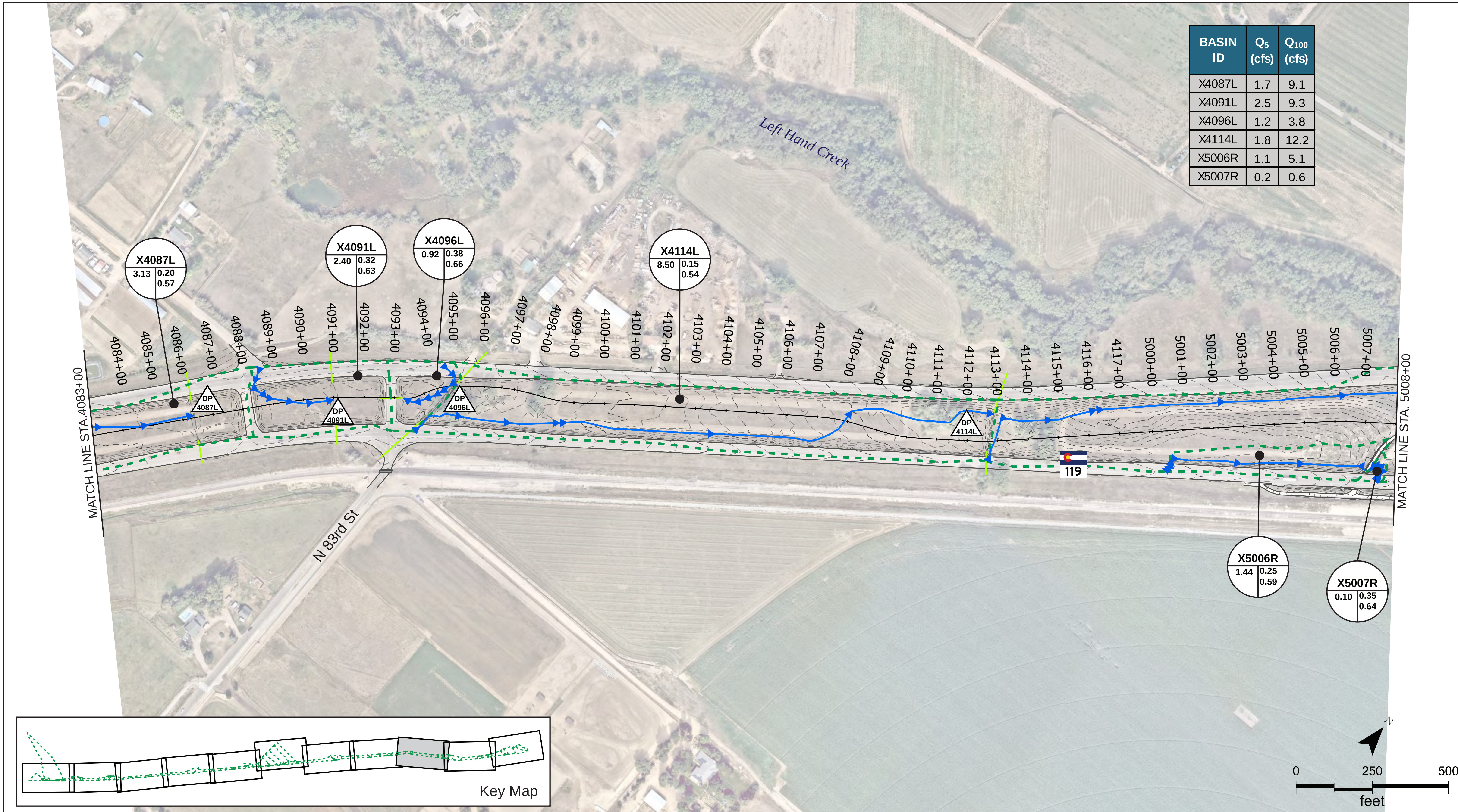
BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

MULLER

CDOT

| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
|---|---|---|---|
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: 10 of 13 | Sheet Subset: |




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X4087L | 1.7 | 9.1 |
| X4091L | 2.5 | 9.3 |
| X4096L | 1.2 | 3.8 |
| X4114L | 1.8 | 12.2 |
| X5006R | 1.1 | 5.1 |
| X5007R | 0.2 | 0.6 |

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CDOT

Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

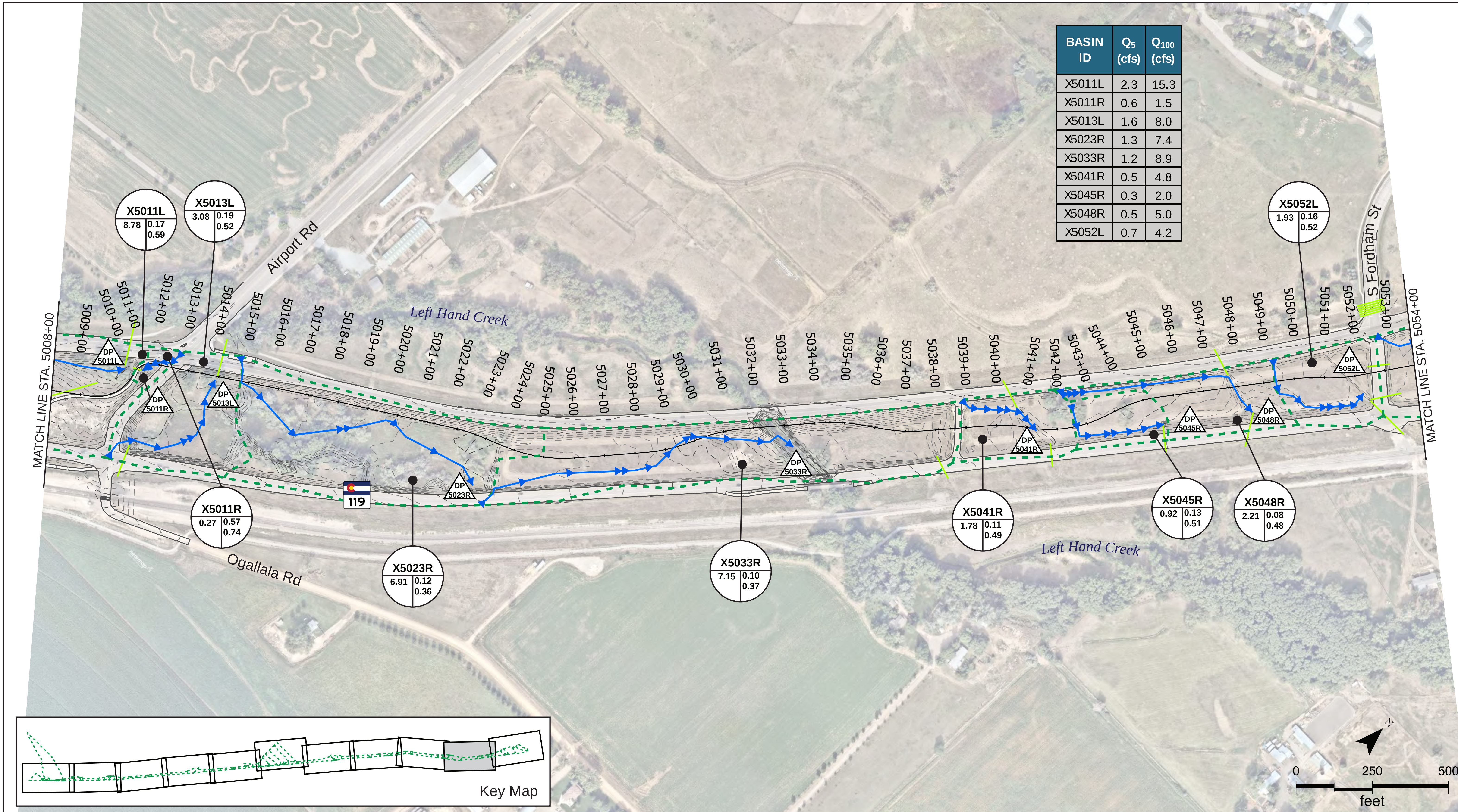
DP 123R
Design Point

As Constructed
No Revisions:
Revised:
Void:

EXISTING DRAINAGE BASIN MAPS
CO 119 BIKEWAY

Designer: ACF
Detailer: SR2
Sheet Subset: DRAINAGE
Structure Numbers
Sheet Subset: 11 of 13

Project No. / Code
Sheet Subset:




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X5011L | 2.3 | 15.3 |
| X5011R | 0.6 | 1.5 |
| X5013L | 1.6 | 8.0 |
| X5023R | 1.3 | 7.4 |
| X5033R | 1.2 | 8.9 |
| X5041R | 0.5 | 4.8 |
| X5045R | 0.3 | 2.0 |
| X5048R | 0.5 | 5.0 |
| X5052L | 0.7 | 4.2 |

MULLER

CDOT

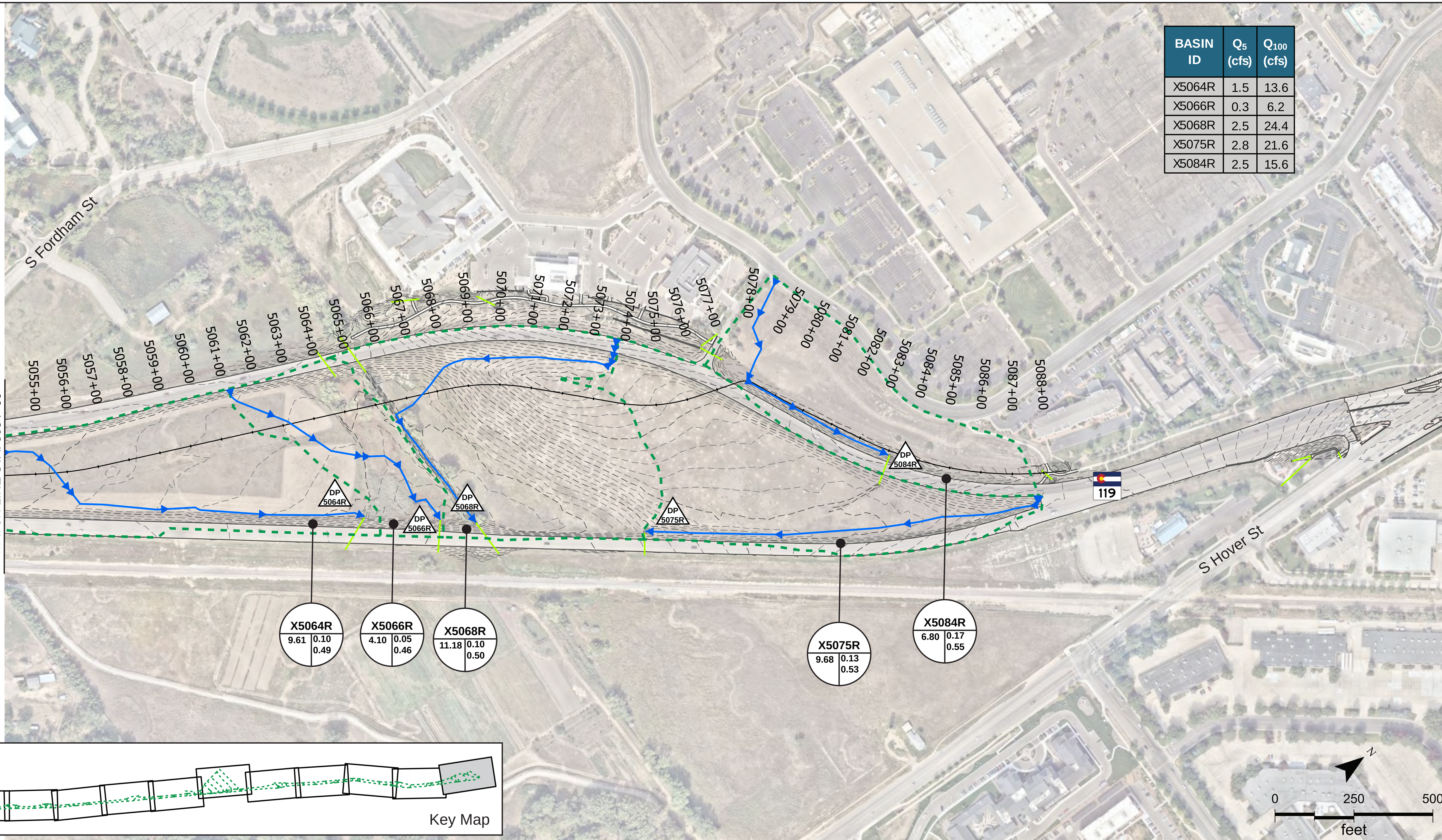
Existing Basin
Basin Flowpath
Proposed Bikeway ALG
Existing Pipe
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
|---|---|---|---|
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: 12 of 13 | Sheet Subset: |

| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| X5064R | 1.5 | 13.6 |
| X5066R | 0.3 | 6.2 |
| X5068R | 2.5 | 24.4 |
| X5075R | 2.8 | 21.6 |
| X5084R | 2.5 | 15.6 |

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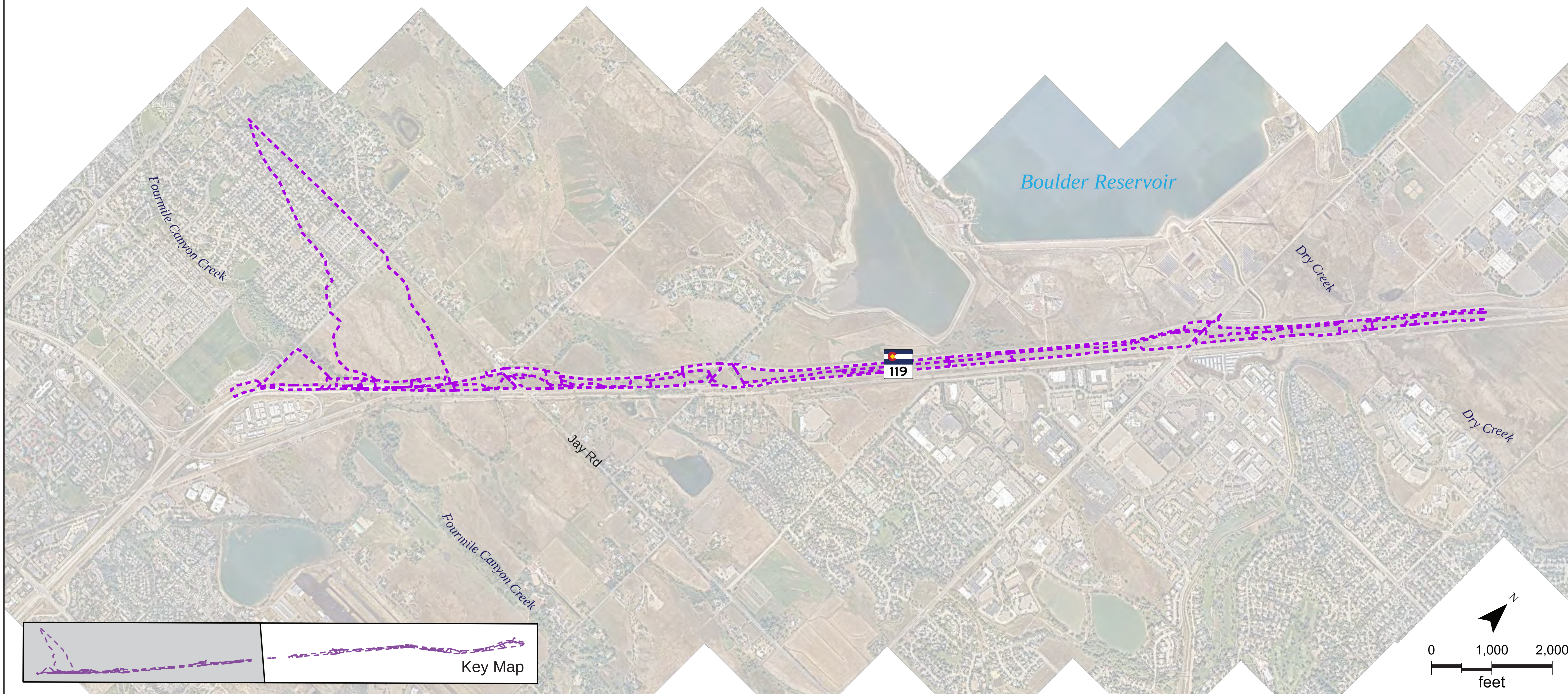
CDOT

| | | | |
|---|---|---|---|
| Existing Basin | Existing Pipe | BASIN ID / AREA (AC) / C5 / C100 | |
| Basin Flowpath | Survey Major Contour | DP 123R | |
| Proposed Bikeway ALG | Survey Minor Contour | Design Point | |

| As Constructed | EXISTING DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
|---|---|---|---|
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: 13 of 13 | Sheet Subset: |

# Proposed Basin Map




Proposed Basin
Basin Flowpath
Proposed Bikeway Layout
Future Bikeway
Bikeway Underpass
Proposed Mobility Layout
Proposed Bikeway ALG
Existing Pipe
Proposed Major Contour
Proposed Minor Contour
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

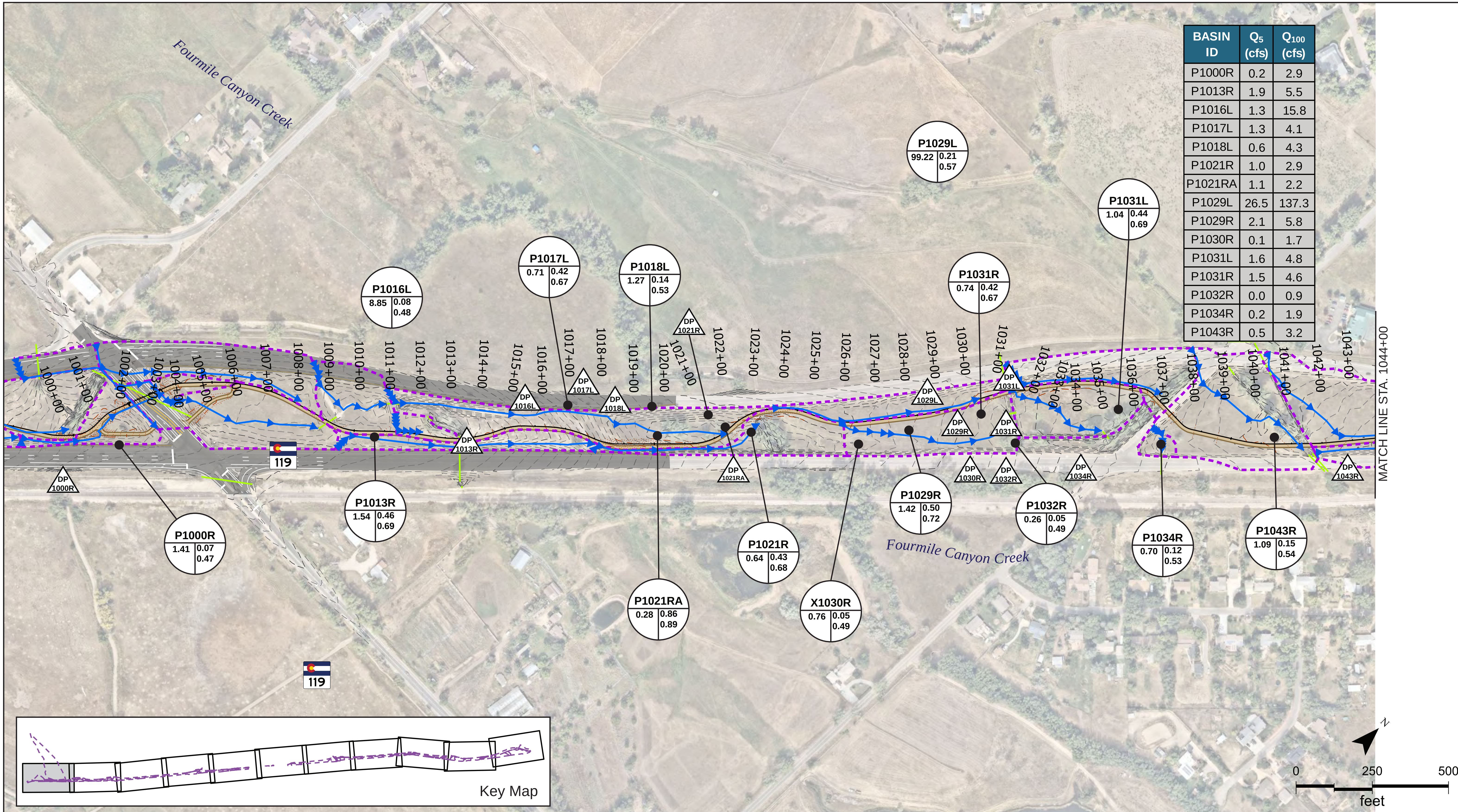
| As Constructed | PROPOSED DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | | Project No. / Code |
|---|---|---|---|---|
| No Revisions: | | | | |
| Revised: | Designer: ACF | Structure Numbers | | |
| | Detailer: SR2 | | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: | 1 of 13 | Sheet Subset: |

MULLER
CDOT


Proposed Basin
Basin Flowpath
Proposed Bikeway Layout
Future Bikeway
Bikeway Underpass
Proposed Mobility Layout
Proposed Bikeway ALG
Existing Pipe
Proposed Major Contour
Proposed Minor Contour
Survey Major Contour
Survey Minor Contour
BASIN ID
AREA (AC) | C5 | C100
DP 123R
Design Point

MULLER
CDOT

| As Constructed | PROPOSED DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | | Project No. / Code |
|---|---|---|---|---|
| No Revisions: | | | | |
| Revised: | Designer: ACF | Structure Numbers | | |
| | Detailer: SR2 | | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: | 2 of 13 | Sheet Subset: |




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| P1000R | 0.2 | 2.9 |
| P1013R | 1.9 | 5.5 |
| P1016L | 1.3 | 15.8 |
| P1017L | 1.3 | 4.1 |
| P1018L | 0.6 | 4.3 |
| P1021R | 1.0 | 2.9 |
| P1021RA | 1.1 | 2.2 |
| P1029L | 26.5 | 137.3 |
| P1029R | 2.1 | 5.8 |
| P1030R | 0.1 | 1.7 |
| P1031L | 1.6 | 4.8 |
| P1031R | 1.5 | 4.6 |
| P1032R | 0.0 | 0.9 |
| P1034R | 0.2 | 1.9 |
| P1043R | 0.5 | 3.2 |

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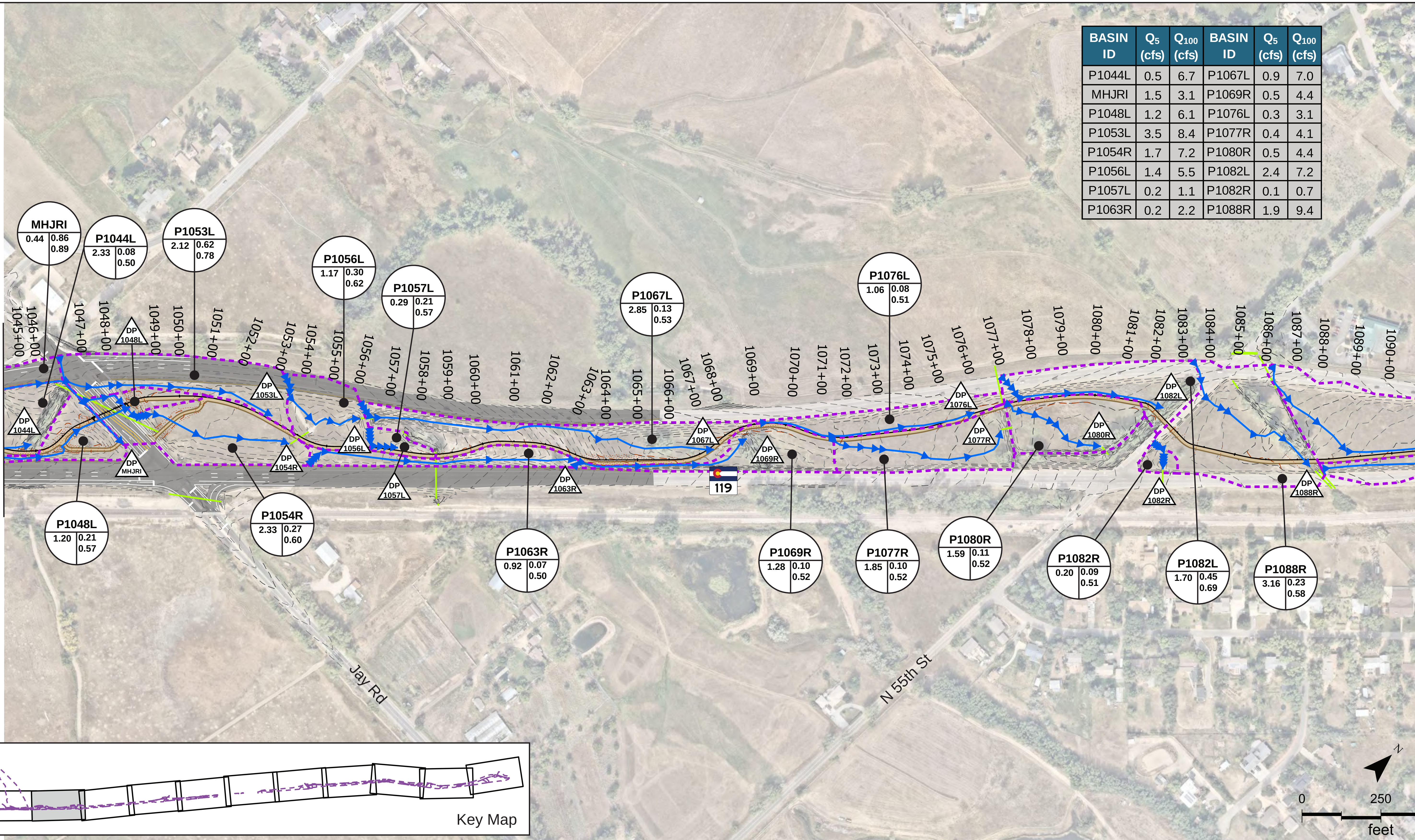
CDOT

- Proposed Basin
- Basin Flowpath
- Proposed Bikeway Layout
- Future Bikeway
- Bikeway Underpass
- Proposed Mobility Layout
- Proposed Bikeway ALG
- Existing Pipe
- Proposed Major Contour
- Proposed Minor Contour
- Survey Major Contour
- Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| As Constructed | PROPOSED DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
|---|---|---|---|
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: 3 of 13 | Sheet Subset: |




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) | BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|---|---|
| P1044L | 0.5 | 6.7 | P1067L | 0.9 | 7.0 |
| MHJRI | 1.5 | 3.1 | P1069R | 0.5 | 4.4 |
| P1048L | 1.2 | 6.1 | P1076L | 0.3 | 3.1 |
| P1053L | 3.5 | 8.4 | P1077R | 0.4 | 4.1 |
| P1054R | 1.7 | 7.2 | P1080R | 0.5 | 4.4 |
| P1056L | 1.4 | 5.5 | P1082L | 2.4 | 7.2 |
| P1057L | 0.2 | 1.1 | P1082R | 0.1 | 0.7 |
| P1063R | 0.2 | 2.2 | P1088R | 1.9 | 9.4 |

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CDOT

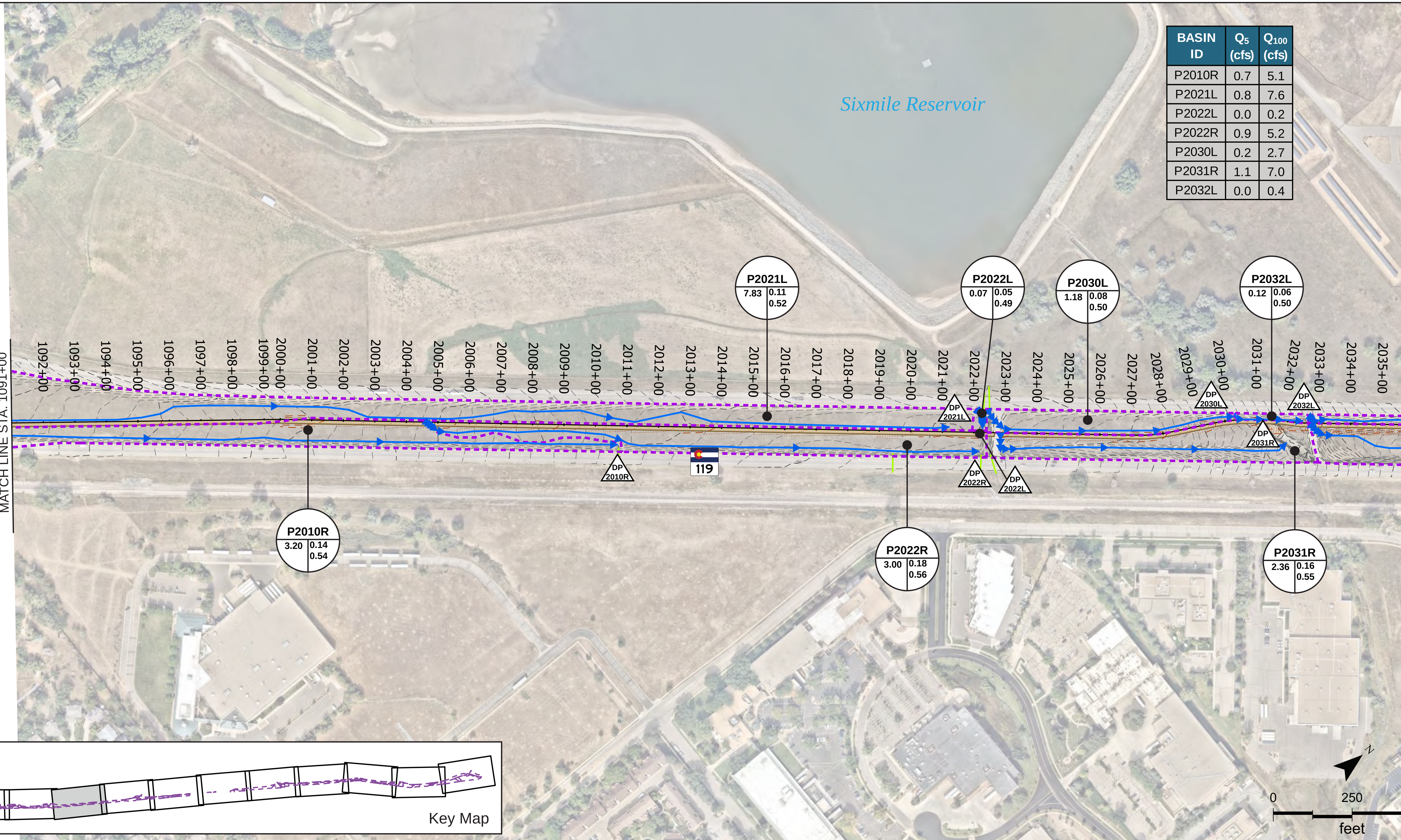
Proposed Basin
Basin Flowpath
Proposed Bikeway Layout
Future Bikeway
Bikeway Underpass
Proposed Mobility Layout
Proposed Bikeway ALG
Existing Pipe
Proposed Major Contour
Proposed Minor Contour
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| As Constructed | PROPOSED DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
|---|---|---|---|
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: 4 of 13 | Sheet Subset: |

| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| P2010R | 0.7 | 5.1 |
| P2021L | 0.8 | 7.6 |
| P2022L | 0.0 | 0.2 |
| P2022R | 0.9 | 5.2 |
| P2030L | 0.2 | 2.7 |
| P2031R | 1.1 | 7.0 |
| P2032L | 0.0 | 0.4 |

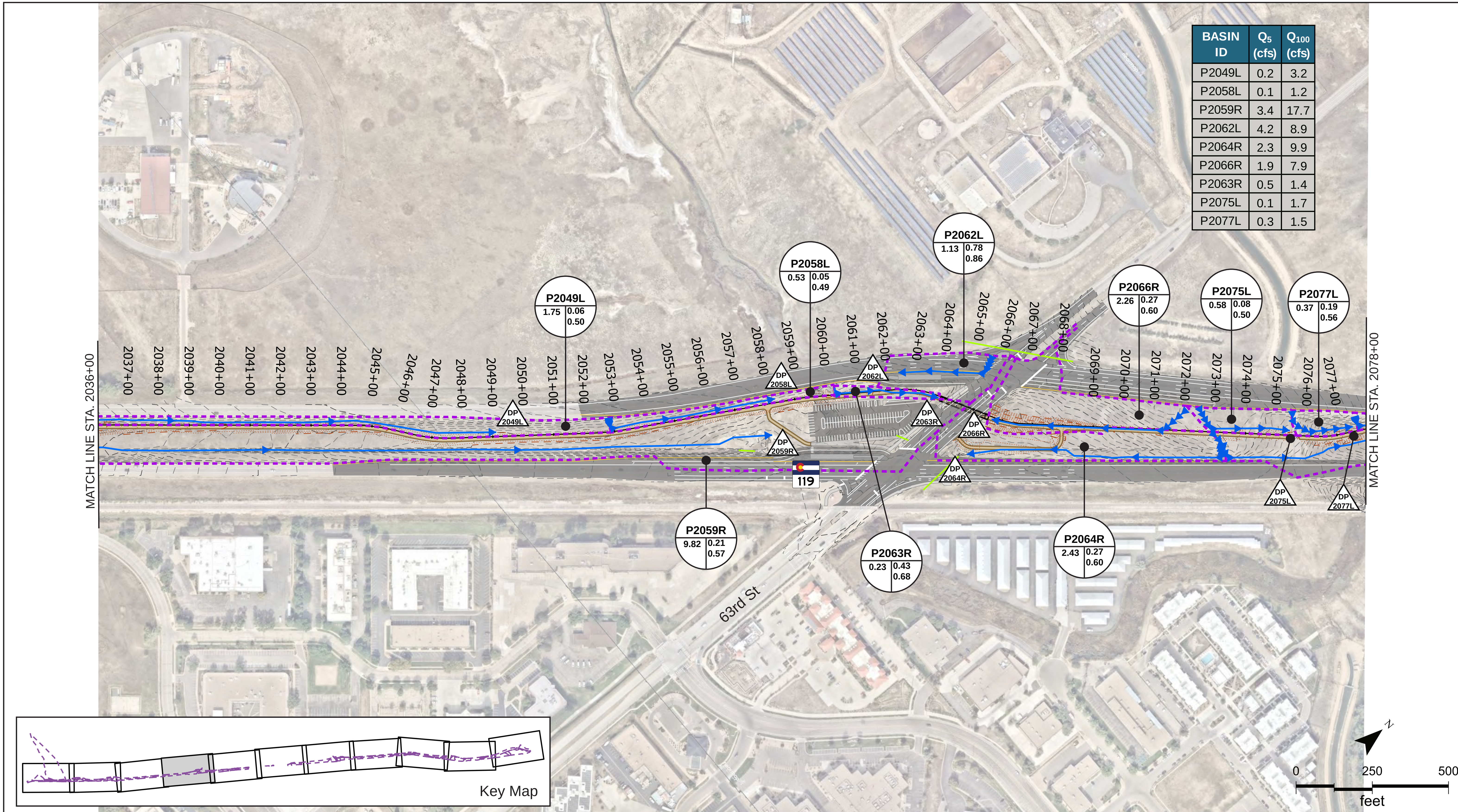



Proposed Basin
Basin Flowpath
Proposed Bikeway Layout
Future Bikeway
Bikeway Underpass
Proposed Mobility Layout
Proposed Bikeway ALG
Existing Pipe
Proposed Major Contour
Proposed Minor Contour
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100
DP 123R
Design Point

MULLER
CDOT

| | | | |
|---|---|---|---|
| As Constructed | PROPOSED DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: 5 of 13 | Sheet Subset: |




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| P2049L | 0.2 | 3.2 |
| P2058L | 0.1 | 1.2 |
| P2059R | 3.4 | 17.7 |
| P2062L | 4.2 | 8.9 |
| P2064R | 2.3 | 9.9 |
| P2066R | 1.9 | 7.9 |
| P2063R | 0.5 | 1.4 |
| P2075L | 0.1 | 1.7 |
| P2077L | 0.3 | 1.5 |

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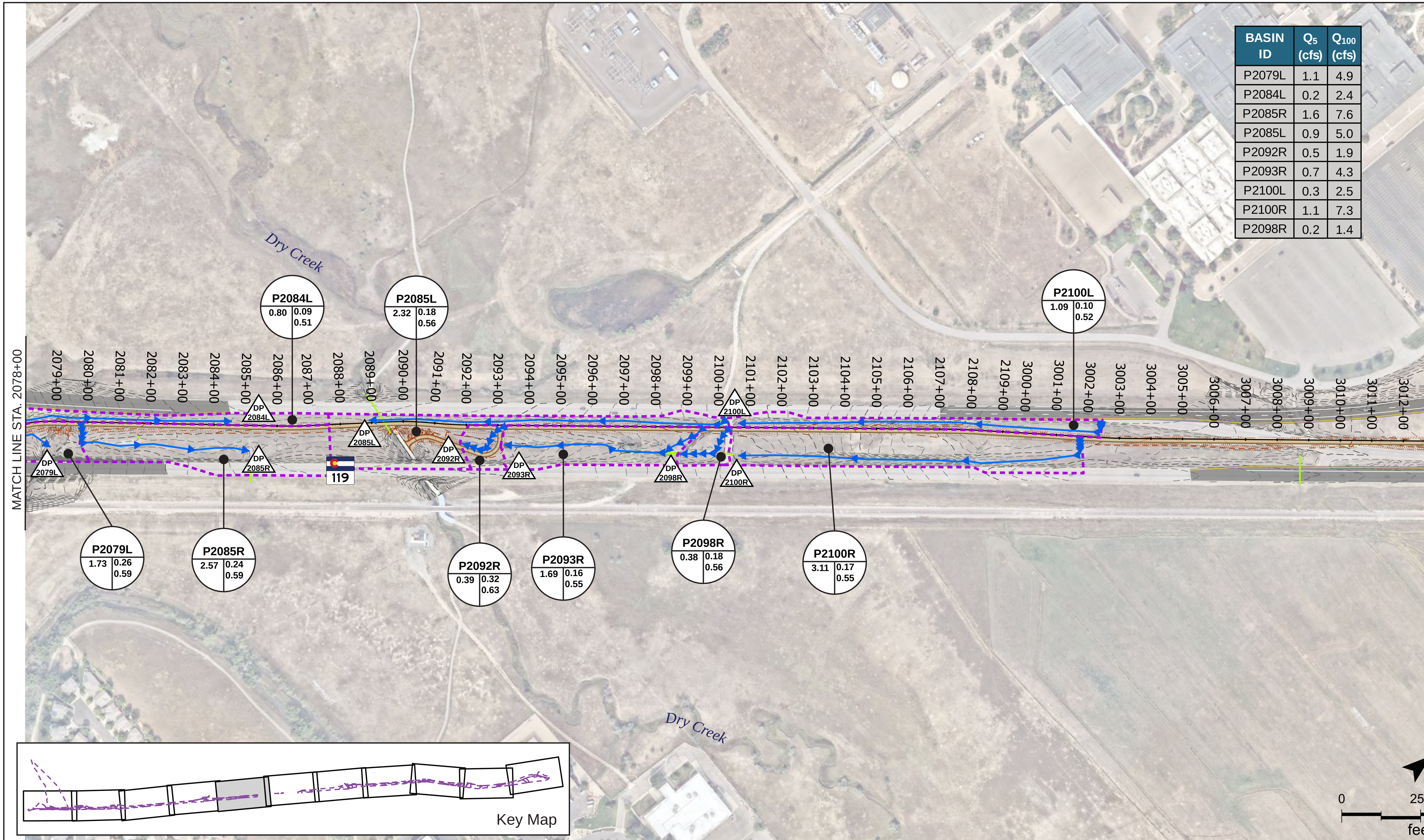
CDOT

Proposed Basin
Basin Flowpath
Proposed Bikeway Layout
Future Bikeway
Bikeway Underpass
Proposed Mobility Layout
Proposed Bikeway ALG
Existing Pipe
Proposed Major Contour
Proposed Minor Contour
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| As Constructed | PROPOSED DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | Project No. / Code |
|---|---|---|---|
| No Revisions: | | | |
| Revised: | Designer: ACF | Structure Numbers | |
| | Detailer: SR2 | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: 6 of 13 | Sheet Subset: |




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| P2079L | 1.1 | 4.9 |
| P2084L | 0.2 | 2.4 |
| P2085R | 1.6 | 7.6 |
| P2085L | 0.9 | 5.0 |
| P2092R | 0.5 | 1.9 |
| P2093R | 0.7 | 4.3 |
| P2100L | 0.3 | 2.5 |
| P2100R | 1.1 | 7.3 |
| P2098R | 0.2 | 1.4 |

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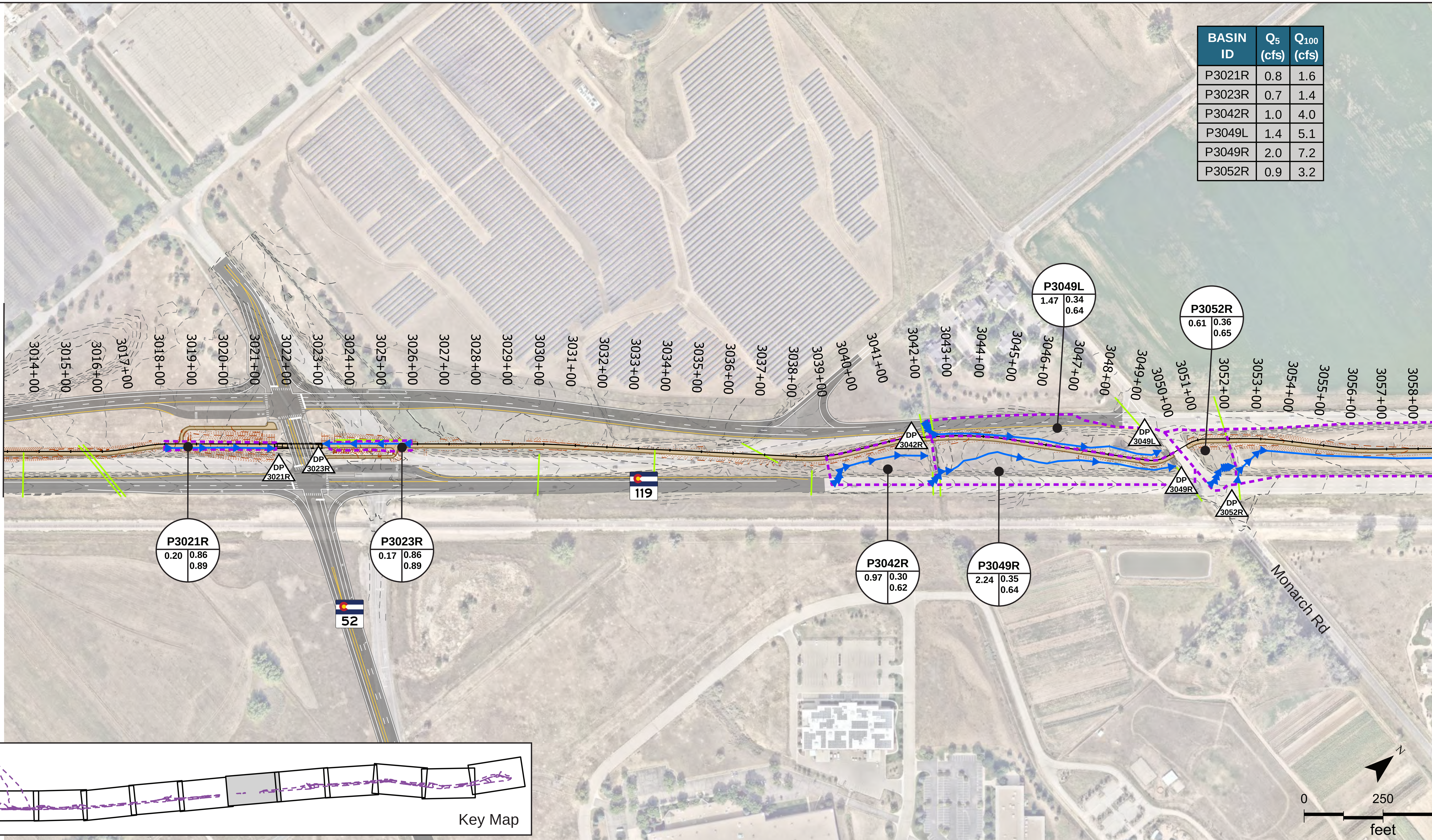
CDOT

Proposed Basin
Basin Flowpath
Proposed Bikeway Layout
Future Bikeway
Bikeway Underpass
Proposed Mobility Layout
Proposed Bikeway ALG
Existing Pipe
Proposed Major Contour
Proposed Minor Contour
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| As Constructed | PROPOSED DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | | Project No. / Code |
|---|---|---|---|---|
| No Revisions: | | | | |
| Revised: | Designer: ACF | Structure Numbers | | |
| | Detailer: SR2 | | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: | 7 of 13 | Sheet Subset: |




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| P3021R | 0.8 | 1.6 |
| P3023R | 0.7 | 1.4 |
| P3042R | 1.0 | 4.0 |
| P3049L | 1.4 | 5.1 |
| P3049R | 2.0 | 7.2 |
| P3052R | 0.9 | 3.2 |

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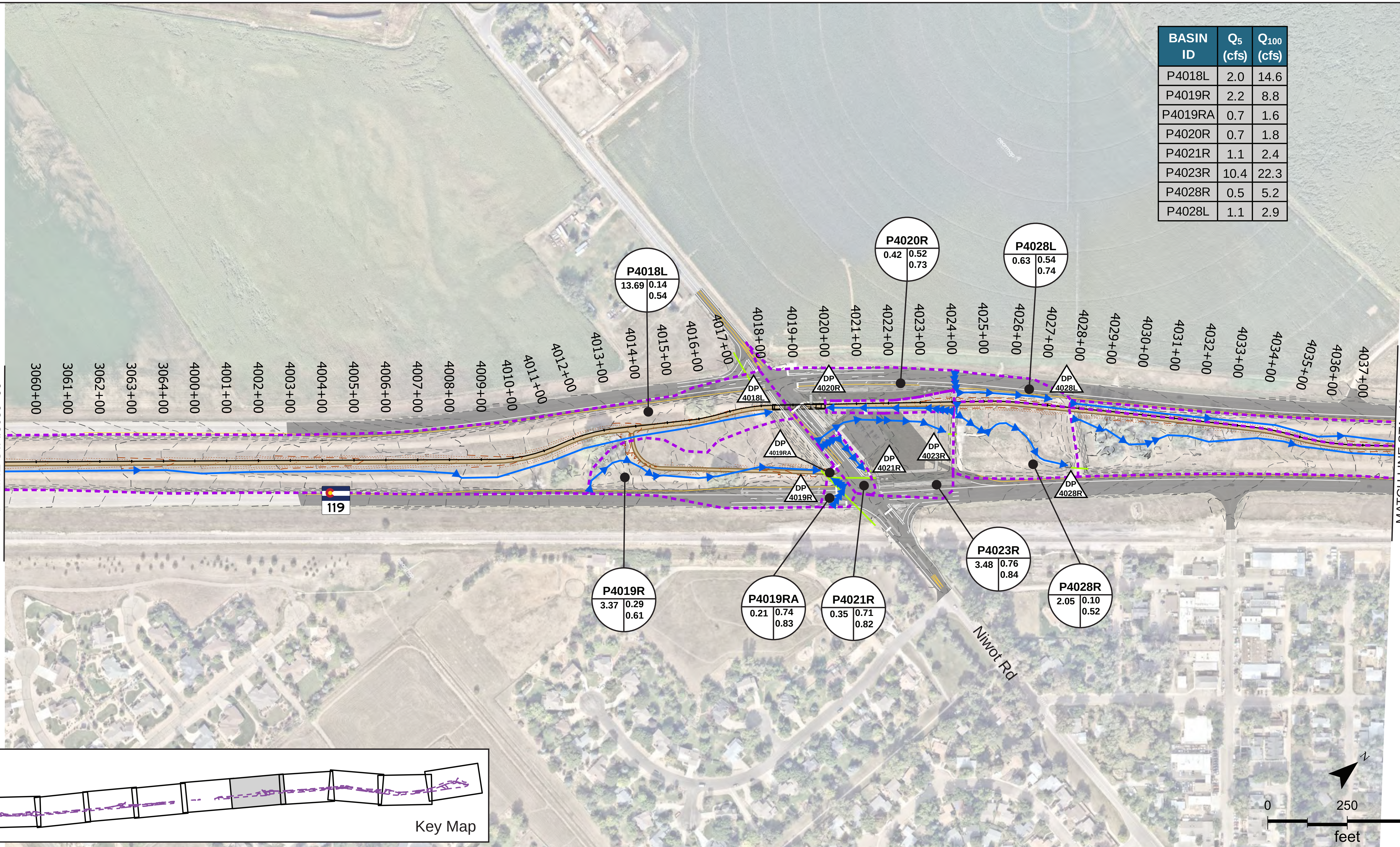
CDOT

- Proposed Basin
- Basin Flowpath
- Proposed Bikeway Layout
- Future Bikeway
- Bikeway Underpass
- Proposed Mobility Layout
- Proposed Bikeway ALG
- Existing Pipe
- Proposed Major Contour
- Proposed Minor Contour
- Survey Major Contour
- Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| As Constructed | PROPOSED DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | | Project No. / Code |
|---|---|---|---|---|
| No Revisions: | | | | |
| Revised: | Designer: ACF | Structure Numbers | | |
| | Detailer: SR2 | | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: | 8 of 13 | Sheet Subset: |




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| P4018L | 2.0 | 14.6 |
| P4019R | 2.2 | 8.8 |
| P4019RA | 0.7 | 1.6 |
| P4020R | 0.7 | 1.8 |
| P4021R | 1.1 | 2.4 |
| P4023R | 10.4 | 22.3 |
| P4028R | 0.5 | 5.2 |
| P4028L | 1.1 | 2.9 |

MULLER

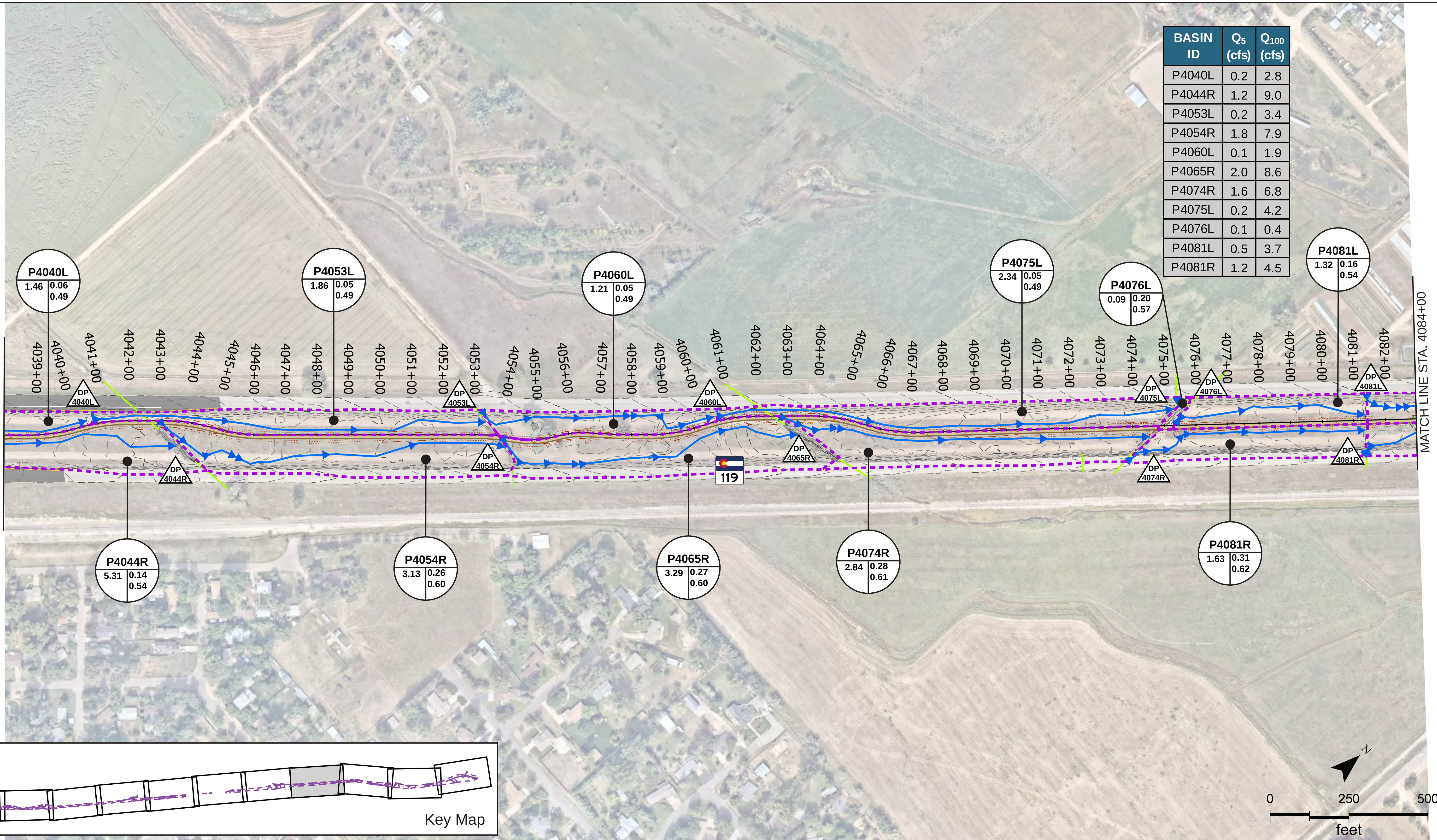
CDOT

Proposed Basin
Basin Flowpath
Proposed Bikeway Layout
Future Bikeway
Bikeway Underpass
Proposed Mobility Layout
Proposed Bikeway ALG
Existing Pipe
Proposed Major Contour
Proposed Minor Contour
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| | | | | |
|---|---|---|---|---|
| As Constructed | PROPOSED DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | | Project No. / Code |
| No Revisions: | | | | |
| Revised: | Designer: ACF | Structure Numbers | | |
| | Detailer: SR2 | | | |
| Void: | Sheet Subset: DRAINAGE | Sheet Subset: | 9 of 13 | Sheet Subset: |




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| P4040L | 0.2 | 2.8 |
| P4044R | 1.2 | 9.0 |
| P4053L | 0.2 | 3.4 |
| P4054R | 1.8 | 7.9 |
| P4060L | 0.1 | 1.9 |
| P4065R | 2.0 | 8.6 |
| P4074R | 1.6 | 6.8 |
| P4075L | 0.2 | 4.2 |
| P4076L | 0.1 | 0.4 |
| P4081L | 0.5 | 3.7 |
| P4081R | 1.2 | 4.5 |

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CDOT

- Proposed Basin
- Basin Flowpath
- Proposed Bikeway Layout
- Future Bikeway
- Bikeway Underpass
- Proposed Mobility Layout
- Proposed Bikeway ALG
- Existing Pipe
- Proposed Major Contour
- Proposed Minor Contour
- Survey Major Contour
- Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

As Constructed

No Revisions:

Revised:

Void:

PROPOSED DRAINAGE BASIN MAPS
CO 119 BIKEWAY

Designer: ACF

Detailer: SR2

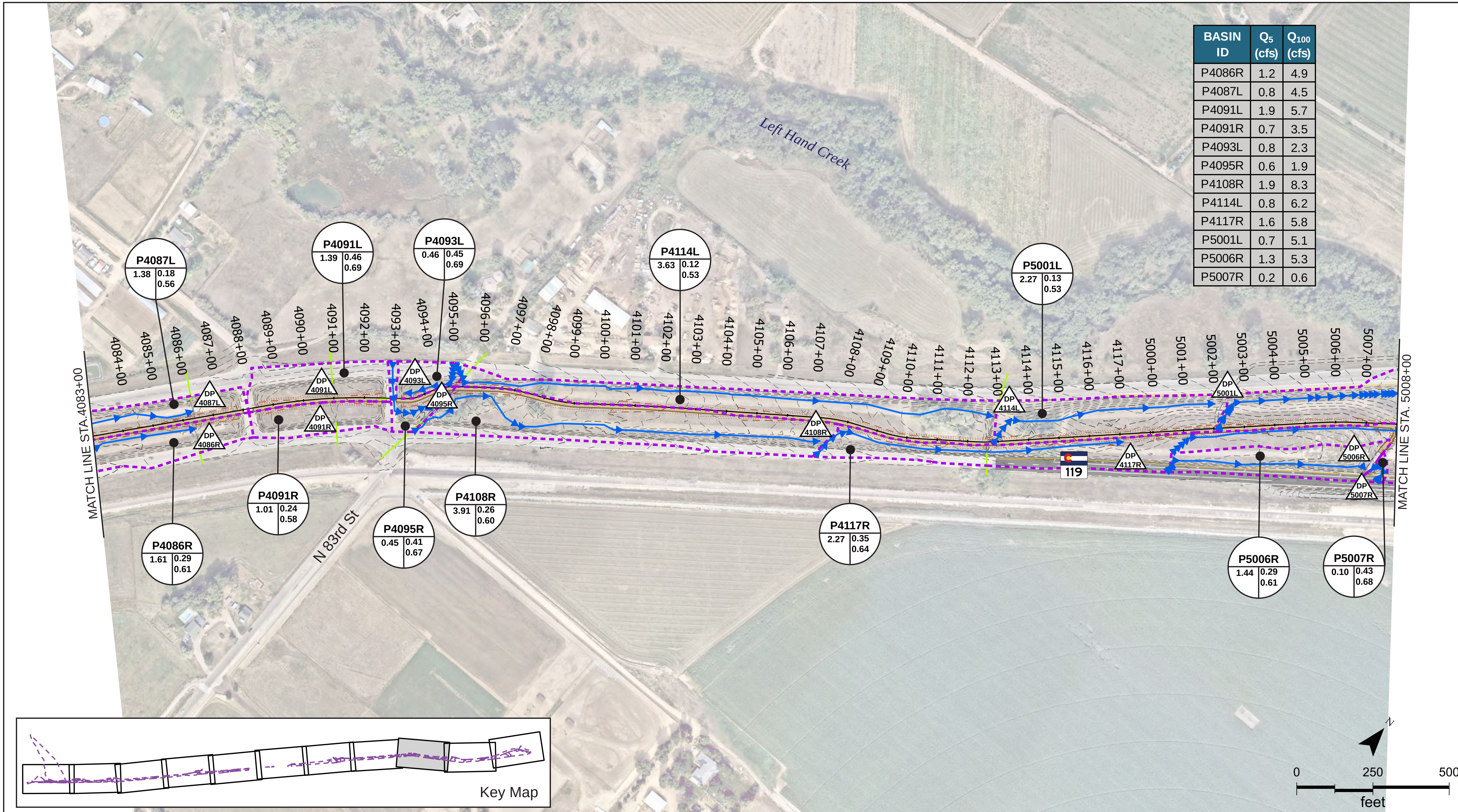
Sheet Subset: DRAINAGE

Structure Numbers

Sheet Subset: 10 of 13

Project No. / Code

Sheet Subset:




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| P4086R | 1.2 | 4.9 |
| P4087L | 0.8 | 4.5 |
| P4091L | 1.9 | 5.7 |
| P4091R | 0.7 | 3.5 |
| P4093L | 0.8 | 2.3 |
| P4095R | 0.6 | 1.9 |
| P4108R | 1.9 | 8.3 |
| P4114L | 0.8 | 6.2 |
| P4117R | 1.6 | 5.8 |
| P5001L | 0.7 | 5.1 |
| P5006R | 1.3 | 5.3 |
| P5007R | 0.2 | 0.6 |

MULLER

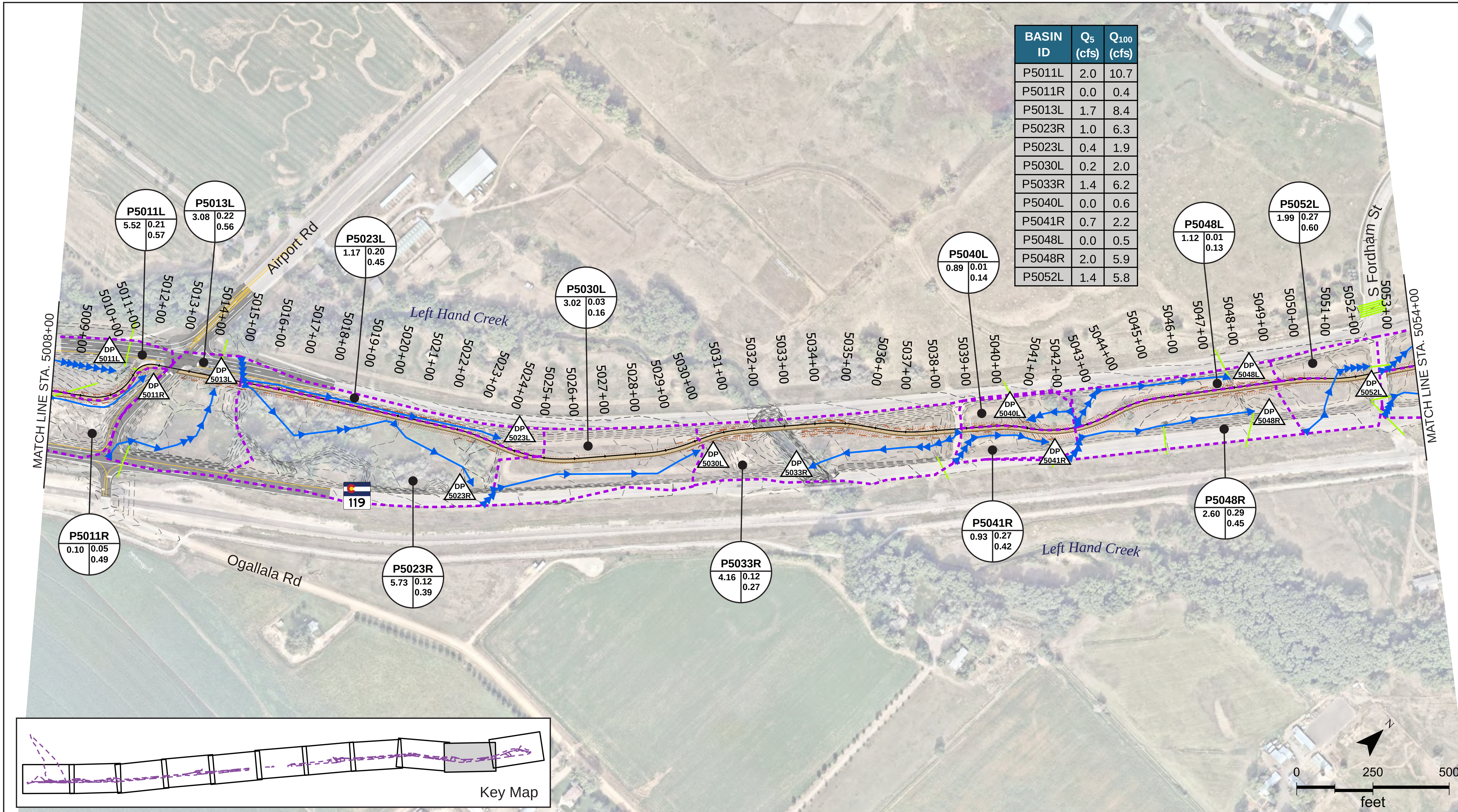
CDOT

- Proposed Basin
- Basin Flowpath
- Proposed Bikeway Layout
- Future Bikeway
- Bikeway Underpass
- Proposed Mobility Layout
- Proposed Bikeway ALG
- Existing Pipe
- Proposed Major Contour
- Proposed Minor Contour
- Survey Major Contour
- Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| | | | | |
|---|---|---|---|---|
| As Constructed | PROPOSED DRAINAGE BASIN MAPS<br>CO 119 BIKEWAY | | | Project No. / Code |
| No Revisions: | | | | |
| Revised: | Designer: ACF | Structure Numbers | | |
| Void: | Detailer: SR2 | | | |
| | Sheet Subset: DRAINAGE | Sheet Subset: | 11 of 13 | Sheet Subset: |




| BASIN ID | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|
| P5011L | 2.0 | 10.7 |
| P5011R | 0.0 | 0.4 |
| P5013L | 1.7 | 8.4 |
| P5023R | 1.0 | 6.3 |
| P5023L | 0.4 | 1.9 |
| P5030L | 0.2 | 2.0 |
| P5033R | 1.4 | 6.2 |
| P5040L | 0.0 | 0.6 |
| P5041R | 0.7 | 2.2 |
| P5048L | 0.0 | 0.5 |
| P5048R | 2.0 | 5.9 |
| P5052L | 1.4 | 5.8 |

MULLER

CDOT

Proposed Basin
Basin Flowpath
Proposed Bikeway Layout
Future Bikeway
Bikeway Underpass
Proposed Mobility Layout
Proposed Bikeway ALG
Existing Pipe
Proposed Major Contour
Proposed Minor Contour
Survey Major Contour
Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

As Constructed
No Revisions:
Revised:
Void:

PROPOSED DRAINAGE BASIN MAPS
CO 119 BIKEWAY

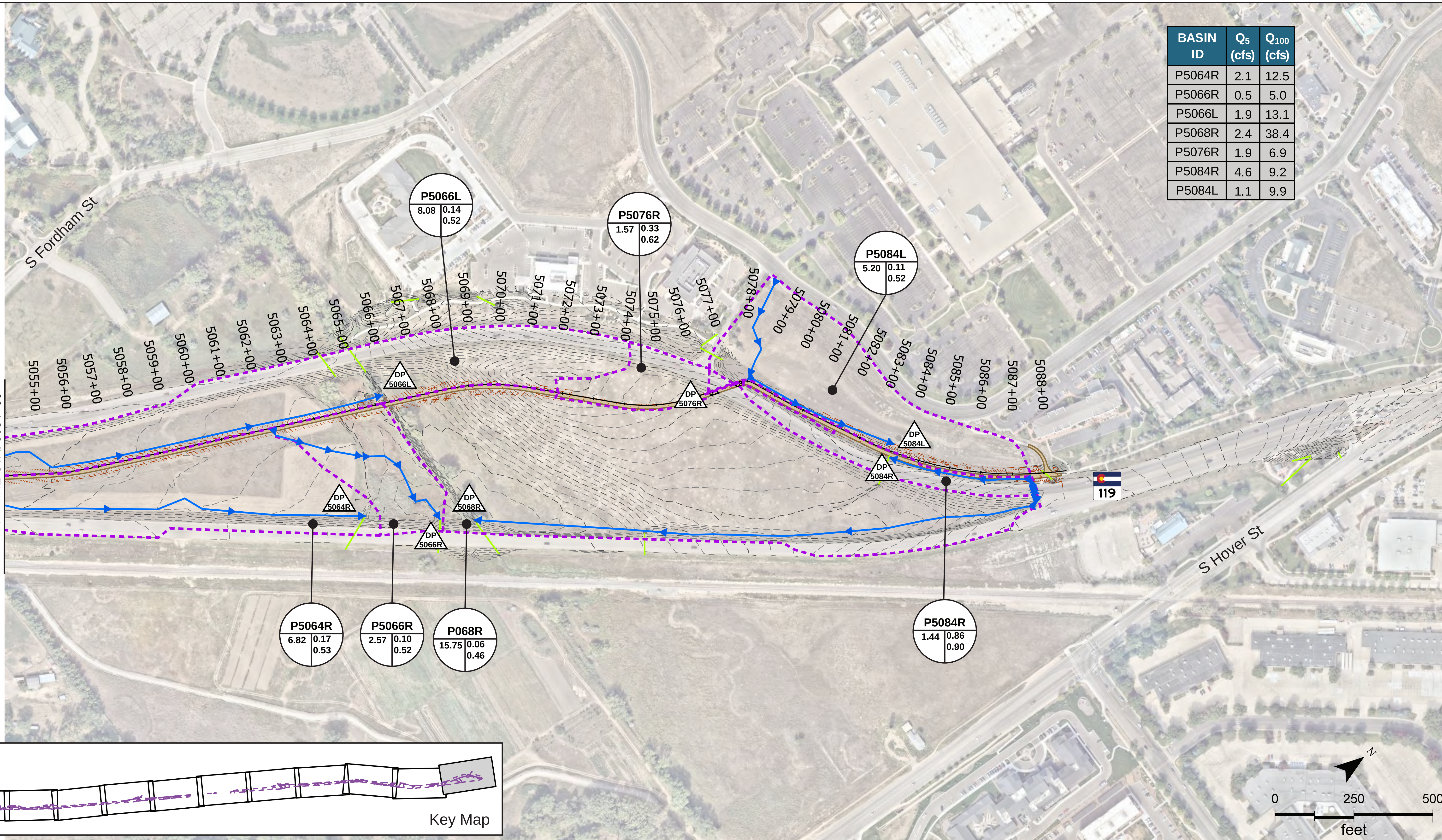
Designer: ACF
Detailer: SR2
Sheet Subset: DRAINAGE

Structure Numbers

Sheet Subset: 12 of 13

Project No. / Code

Sheet Subset:

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| P5066R | 0.5 | 5.0 |
| P5066L | 1.9 | 13.1 |
| P5068R | 2.4 | 38.4 |
| P5076R | 1.9 | 6.9 |
| P5084R | 4.6 | 9.2 |
| P5084L | 1.1 | 9.9 |

MULLER

CDOT

- Proposed Basin
- Basin Flowpath
- Proposed Bikeway Layout
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- Bikeway Underpass
- Proposed Mobility Layout
- Proposed Bikeway ALG
- Existing Pipe
- Proposed Major Contour
- Proposed Minor Contour
- Survey Major Contour
- Survey Minor Contour

BASIN ID
AREA (AC) | C5 | C100

DP 123R
Design Point

| | |
|---|---|
| As Constructed | |
| No Revisions: | |
| Revised: | |
| Void: | |

PROPOSED DRAINAGE BASIN MAPS
CO 119 BIKEWAY

| | | | |
|---|---|---|---|
| Designer: | ACF | Structure Numbers | |
| Detailer: | SR2 | | |
| Sheet Subset: | DRAINAGE | Sheet Subset: | 13 of 13 |

Project No. / Code

Sheet Subset:

# Irrigation Crossing Inventory Map


## SH 119 MOBILITY IMPROVEMENTS

*Irrigation Crossing Inventory*

COLORADO Department of Transportation

Page 1

0 500 1000
FEET
scale 1:6,000
1" = 500'

- Parcel Boundary
- SH 119 Right-of-Way (approx.)
- Proposed SH 119 Bikeway
- Proposed SH 119 Design Layout
- Main Ditch
- Lateral Ditch
- Field Lateral
- Tailwater Ditch
- Perennial Stream
- Intermittent Stream

*Stream and Ditch data provided by County of Boulder Open Data Catalog*


# SH 119 MOBILITY IMPROVEMENTS

*Irrigation Crossing Inventory*

COLORADO Department of Transportation

Page 2

0 500 1000
FEET
scale 1:6,000
1" = 500'

Parcel Boundary
SH 119 Right-of-Way (approx.)
Proposed SH 119 Bikeway
Proposed SH 119 Design Layout
Main Ditch
Lateral Ditch
Field Lateral
Tailwater Ditch
Perennial Stream
Intermittent Stream

*Stream and Ditch data provided by County of Boulder Open Data Catalog*


## SH 119 MOBILITY IMPROVEMENTS

*Irrigation Crossing Inventory*

COLORADO
Department of Transportation

0 500 1000
FEET
scale 1:6,000
1" = 500'

Parcel Boundary
SH 119 Right-of-Way (approx.)
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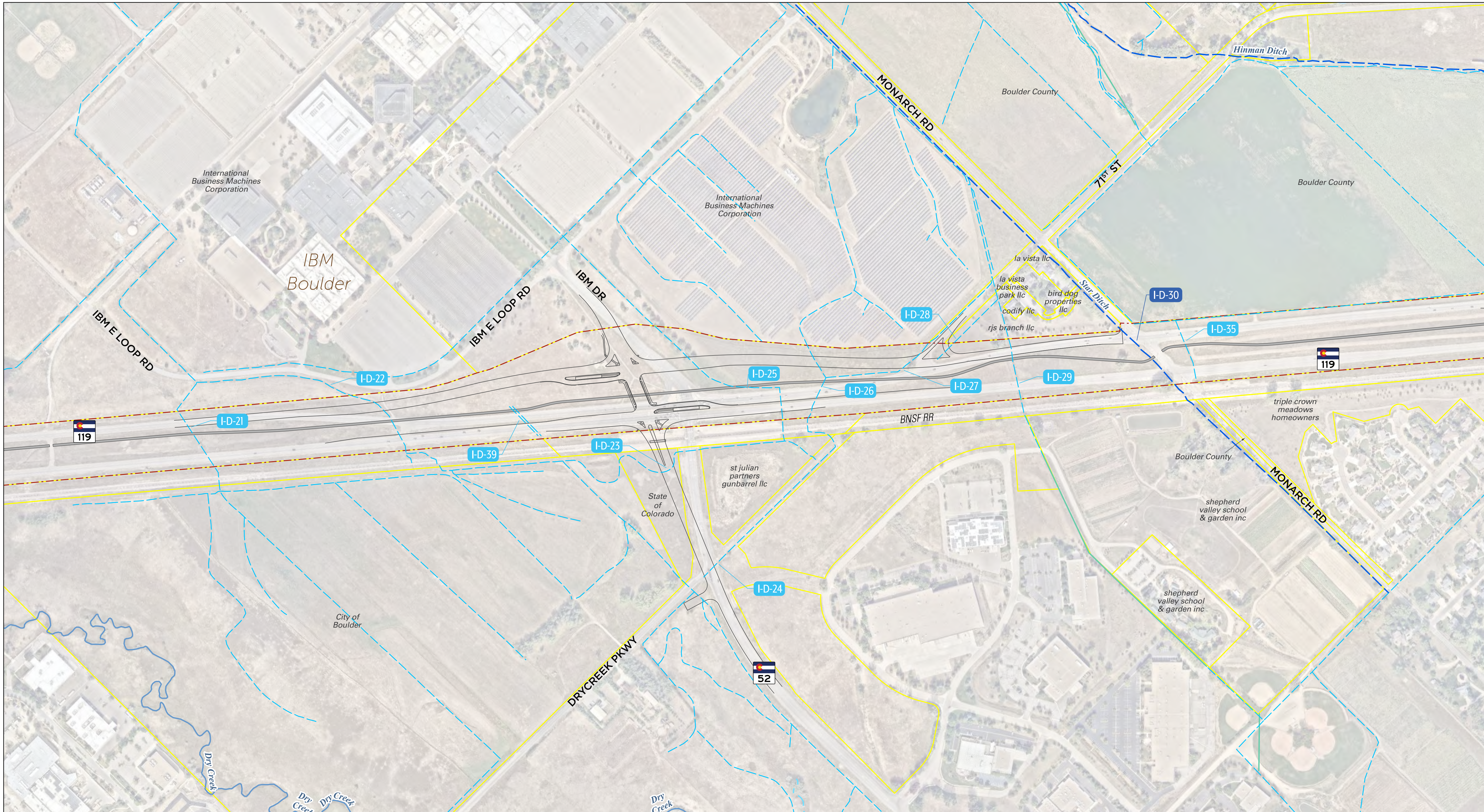
Proposed SH 119 Design Layout
Main Ditch
Lateral Ditch
Field Lateral
Tailwater Ditch
Perennial Stream
Intermittent Stream

*Stream and Ditch data provided by County of Boulder Open Data Catalog*




## SH 119 MOBILITY IMPROVEMENTS

*Irrigation Crossing Inventory*

COLORADO Department of Transportation

0 500 1000 FEET scale 1:6,000 1" = 500'

Parcel Boundary
SH 119 Right-of-Way (approx.)
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# SH 119 MOBILITY IMPROVEMENTS

*Irrigation Crossing Inventory*

COLORADO
Department of Transportation

0 500 1000
FEET
scale 1:6,000
1" = 500'

Parcel Boundary
SH 119 Right-of-Way (approx.)
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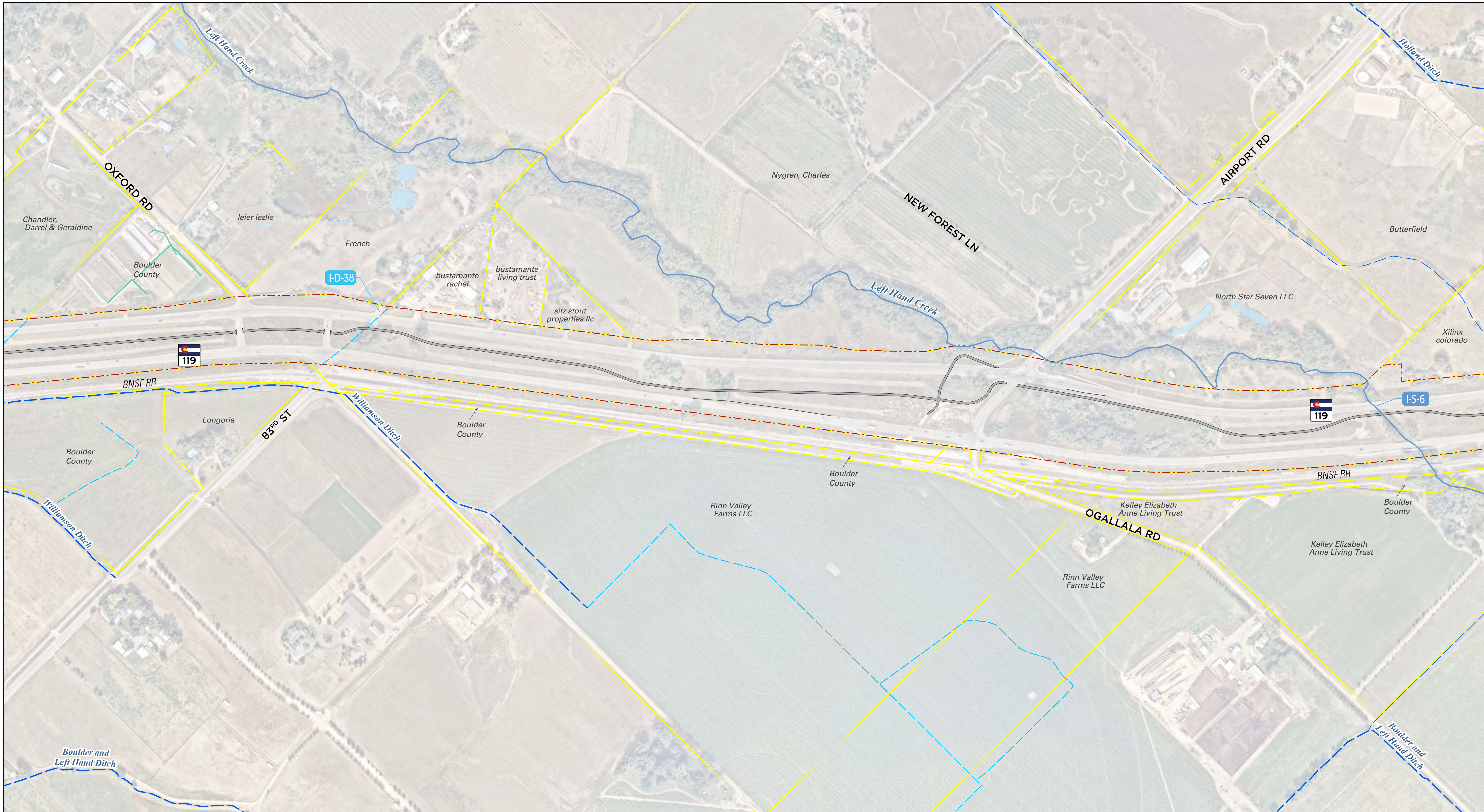
Proposed SH 119 Design Layout
Main Ditch
Lateral Ditch
Field Lateral
Tailwater Ditch
Perennial Stream
Intermittent Stream

*Stream and Ditch data provided by County of Boulder Open Data Catalog*




# SH 119 MOBILITY IMPROVEMENTS

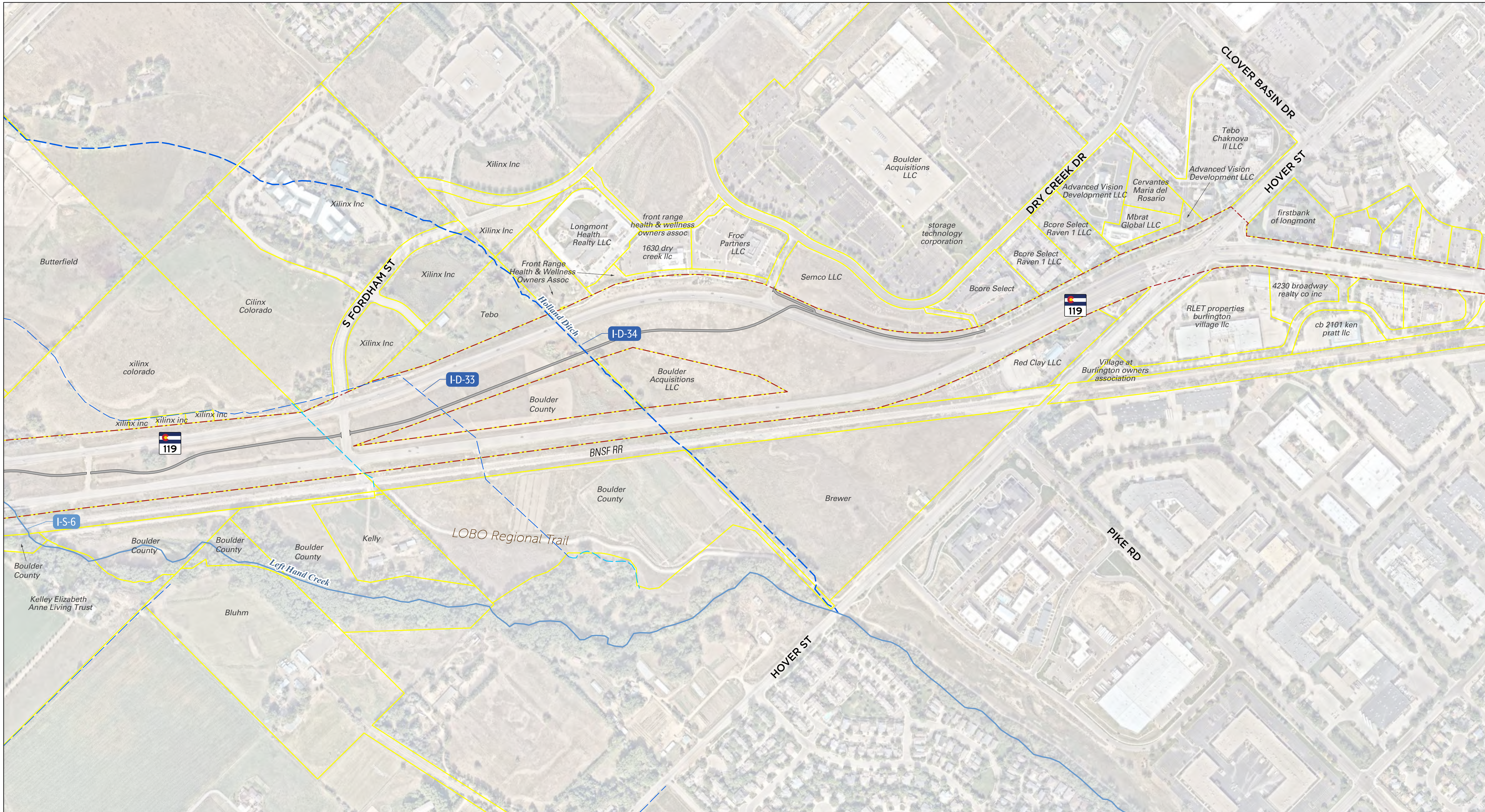
*Irrigation Crossing Inventory*

COLORADO
Department of Transportation

0 500 1000
FEET
scale 1:6,000
1" = 500'

Parcel Boundary
SH 119 Right-of-Way (approx.)
Proposed SH 119 Bikeway
Proposed SH 119 Design Layout
Main Ditch
Lateral Ditch
Field Lateral
Tailwater Ditch
Perennial Stream
Intermittent Stream

*Stream and Ditch data provided by County of Boulder Open Data Catalog*




# SH 119 MOBILITY IMPROVEMENTS

*Irrigation Crossing Inventory*

COLORADO
Department of Transportation

0 500 1000
FEET
scale 1:6,000
1" = 500'

- Parcel Boundary
- SH 119 Right-of-Way (approx.)
- Proposed SH 119 Bikeway
- Proposed SH 119 Design Layout
- Main Ditch
- Lateral Ditch
- Field Lateral
- Tailwater Ditch
- Perennial Stream
- Intermittent Stream

*Stream and Ditch data provided by County of Boulder Open Data Catalog*

Page 7

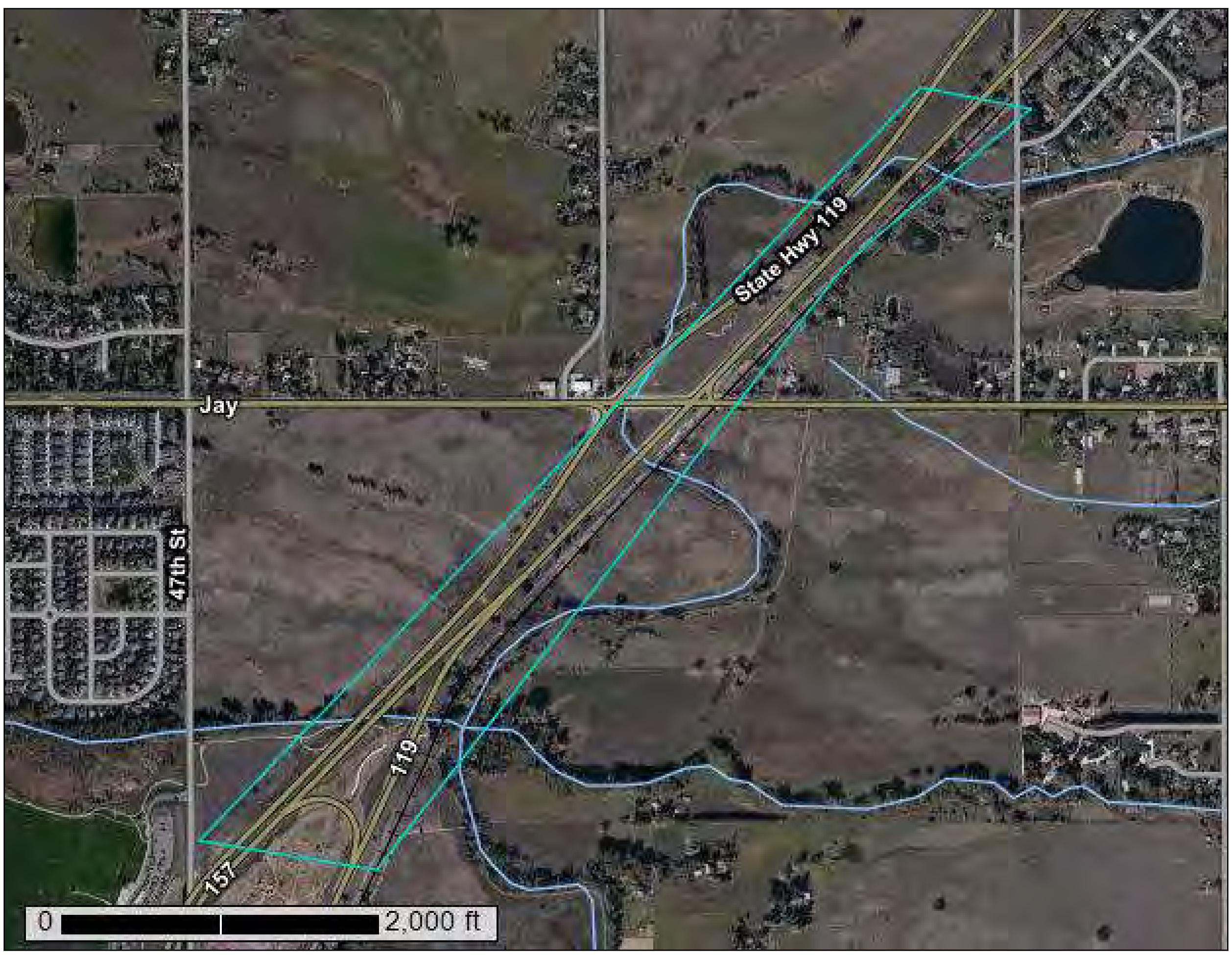
# Hydrologic Soils Report (NRCS)

United States Department of Agriculture
NRCS
Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

# Custom Soil Resource Report for

# Boulder County Area, Colorado



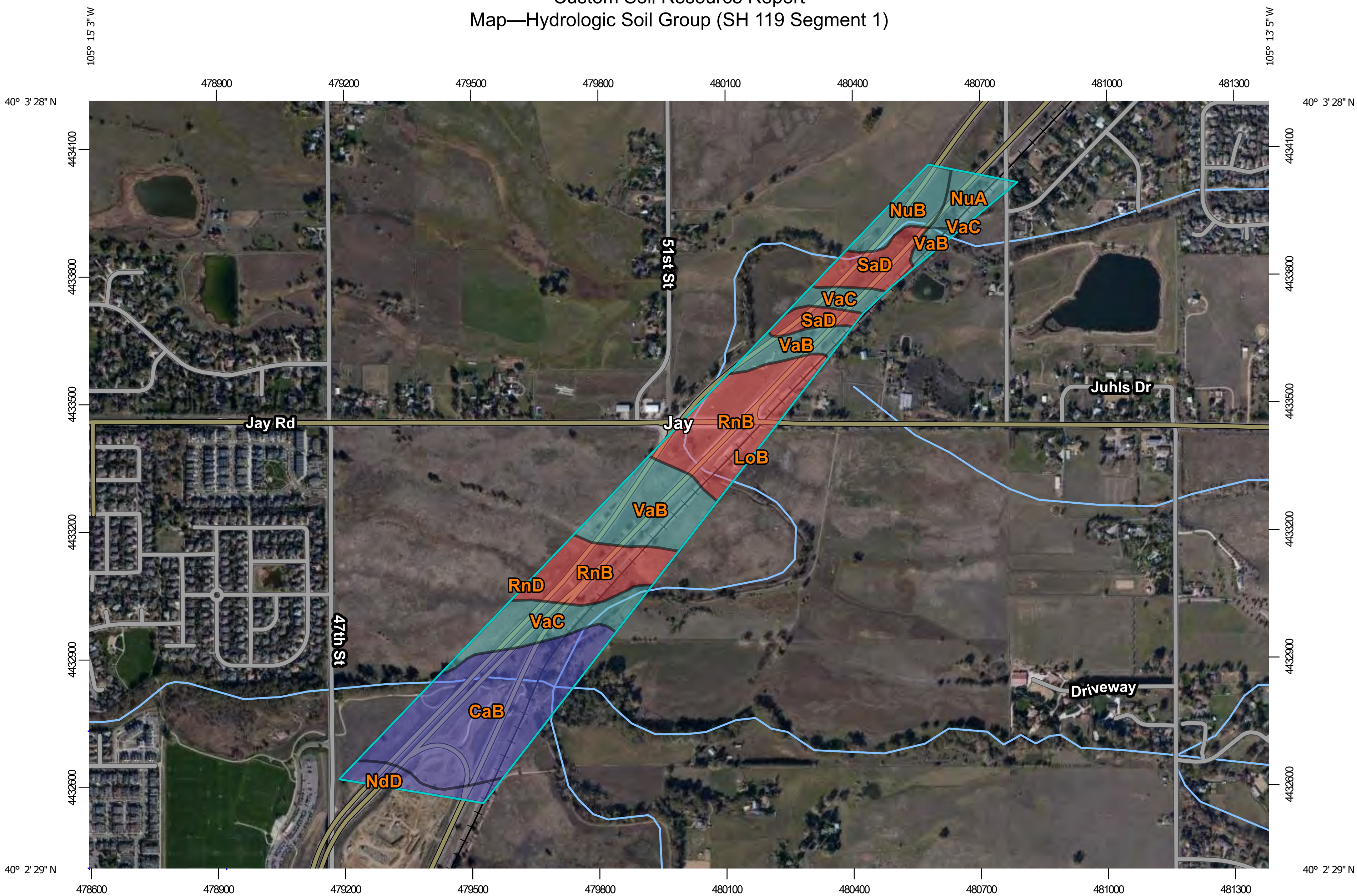

January 27, 2022

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Custom Soil Resource Report
Map—Hydrologic Soil Group (SH 119 Segment 1)




Map Scale: 1:12,700 if printed on A landscape (11" x 8.5") sheet.

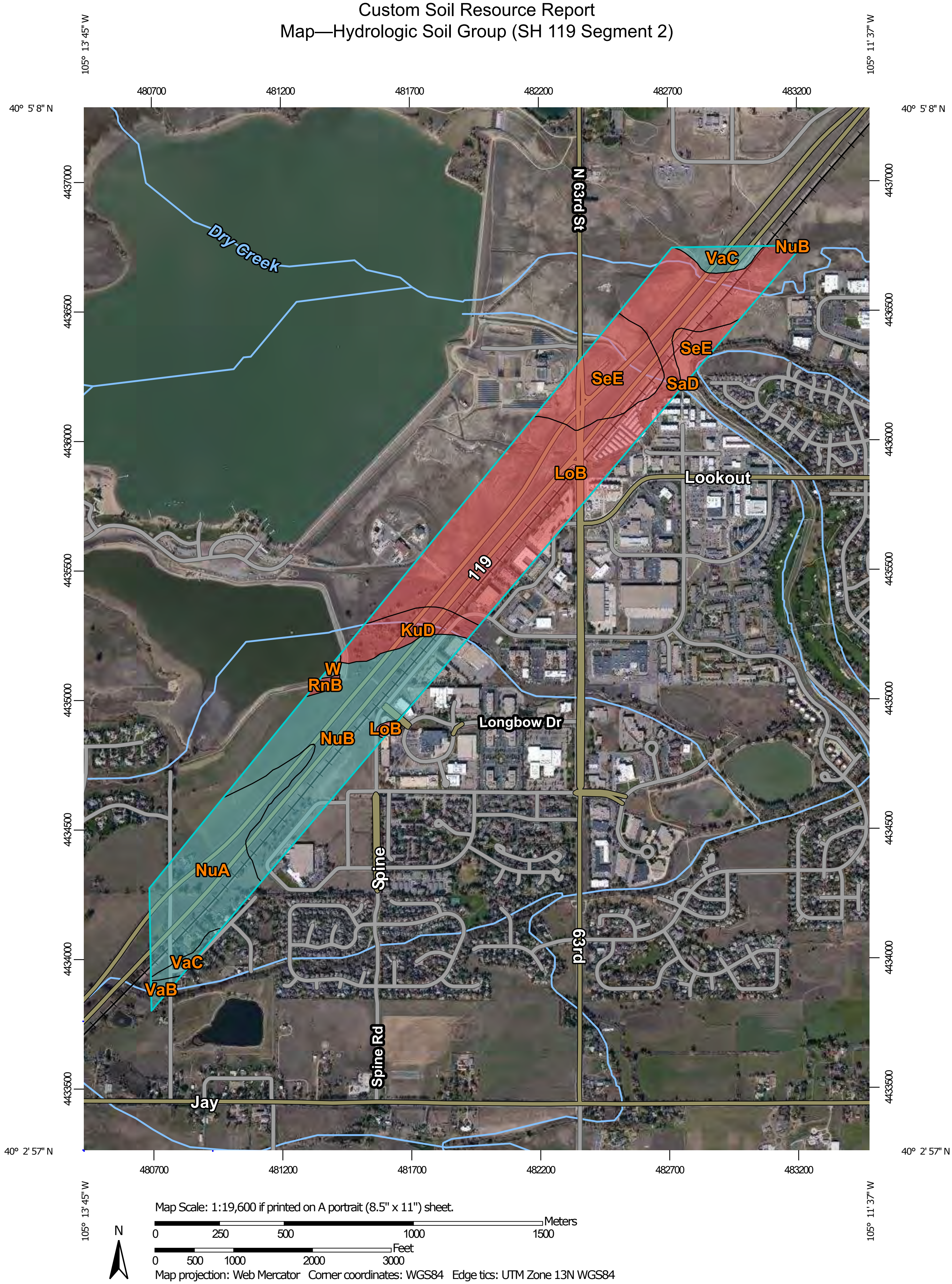
N

Meters: 0 150 300 600 900

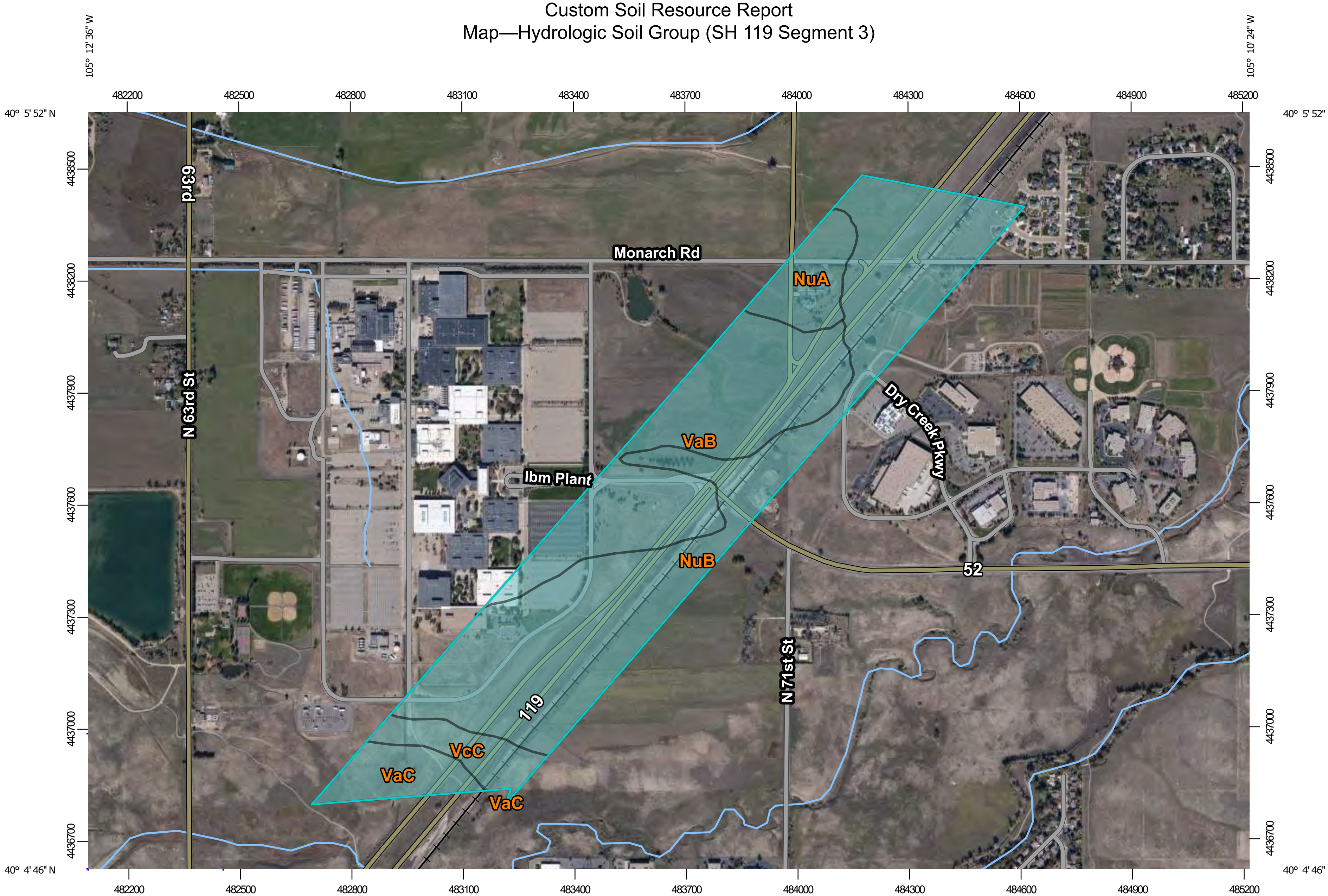
Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

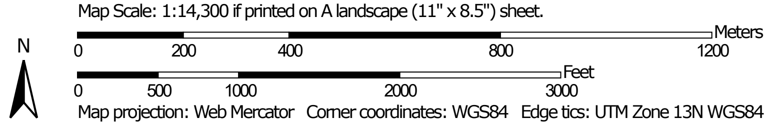
Custom Soil Resource Report
Map—Hydrologic Soil Group (SH 119 Segment 2)



Custom Soil Resource Report
Map—Hydrologic Soil Group (SH 119 Segment 3)

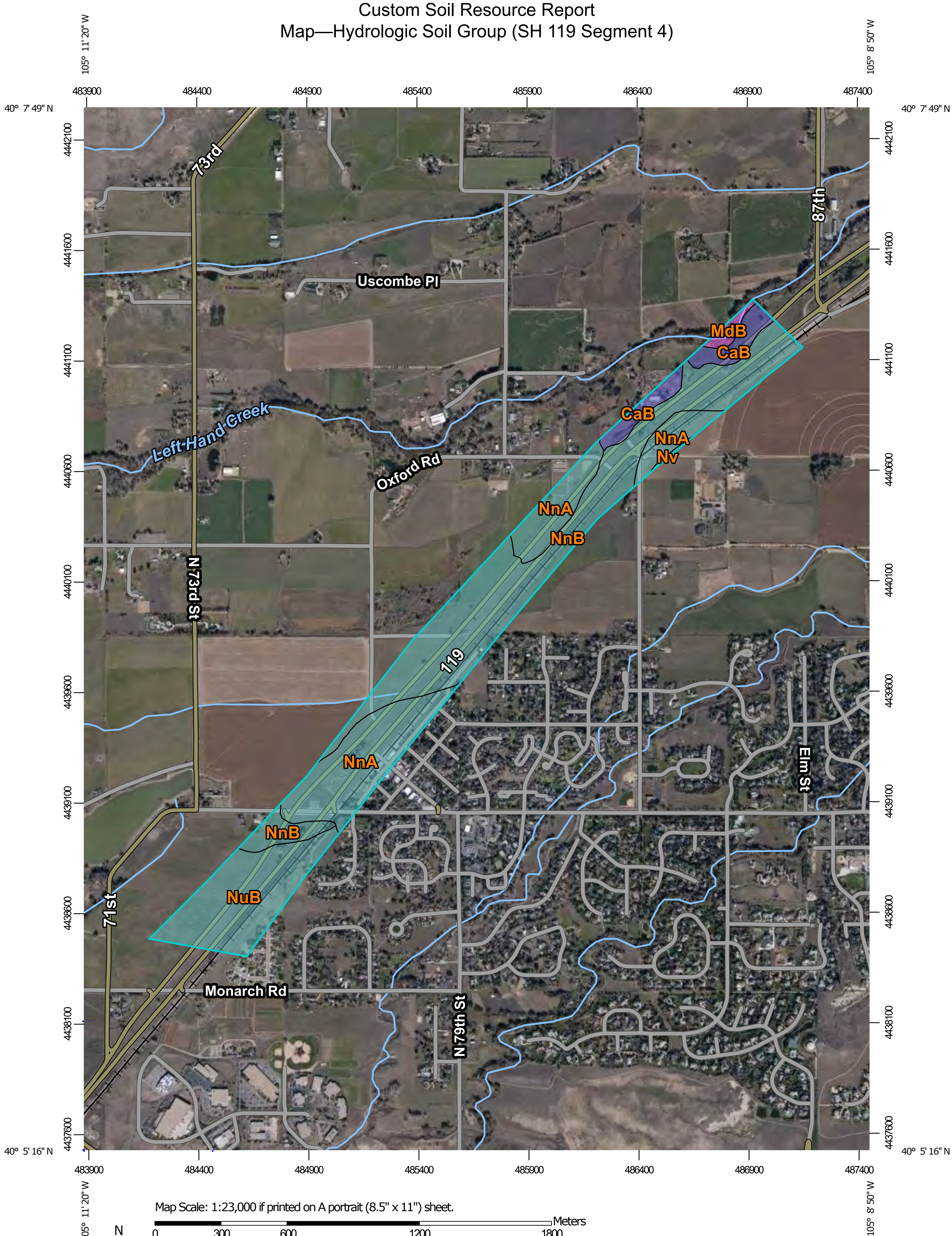



Map Scale: 1:14,300 if printed on A landscape (11" x 8.5") sheet.




Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

Custom Soil Resource Report
Map—Hydrologic Soil Group (SH 119 Segment 4)




Map Scale: 1:23,000 if printed on A portrait (8.5" x 11") sheet.

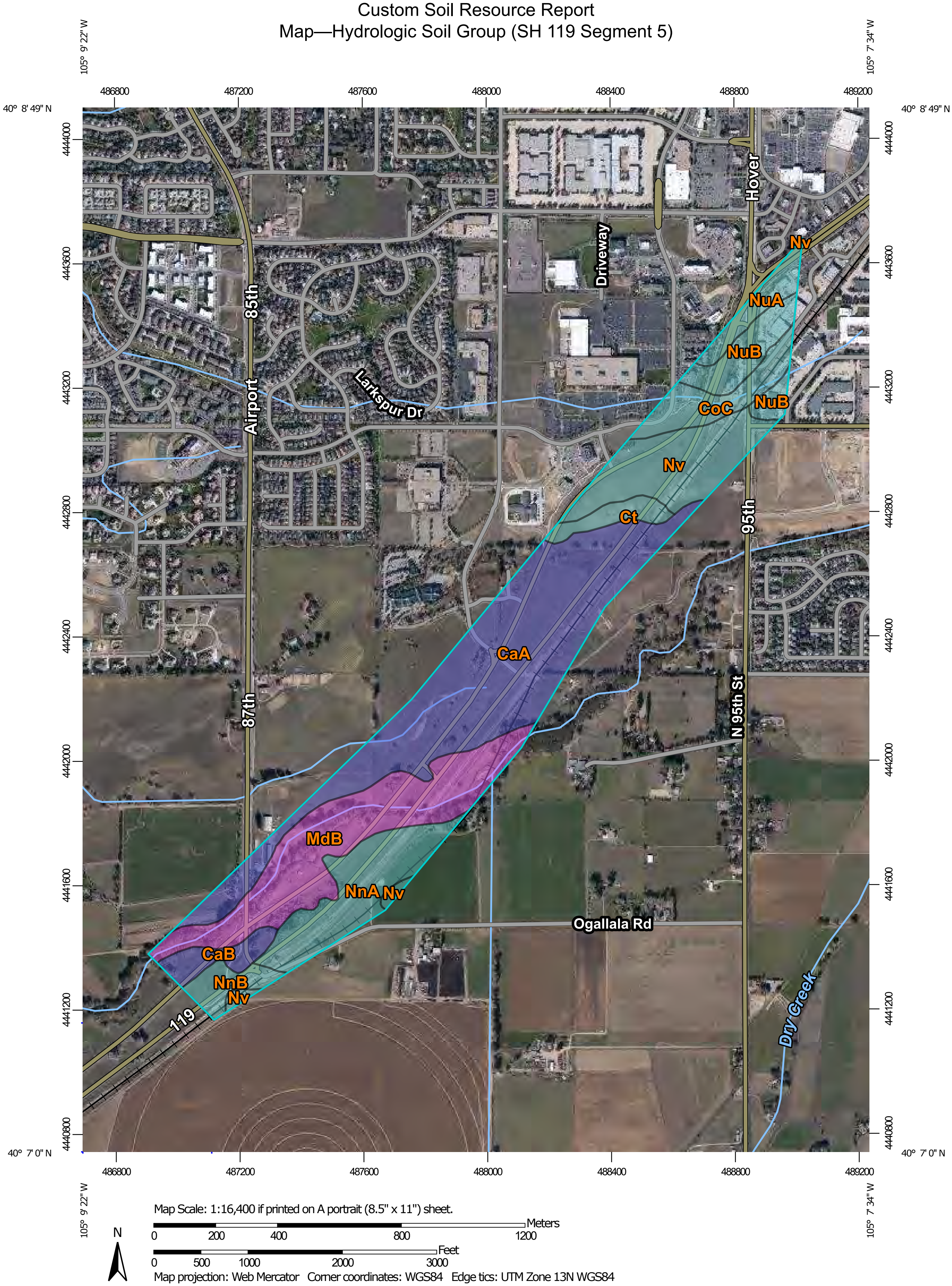
Meters: 0, 300, 600, 1200, 1800

Feet: 0, 1000, 2000, 4000, 6000

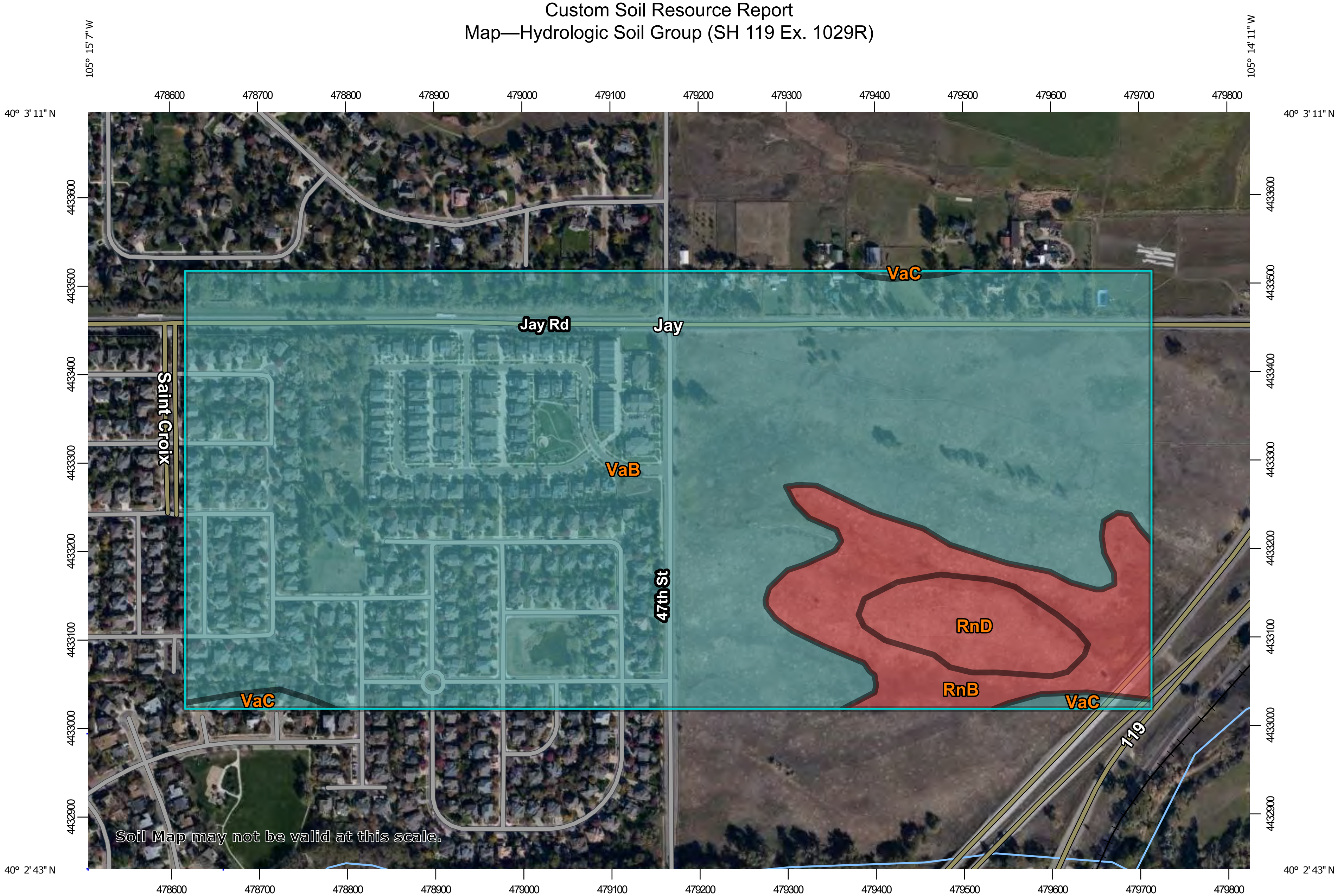
N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

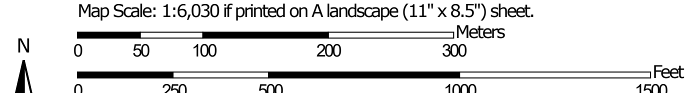
Custom Soil Resource Report
Map—Hydrologic Soil Group (SH 119 Segment 5)



Custom Soil Resource Report
Map—Hydrologic Soil Group (SH 119 Ex. 1029R)

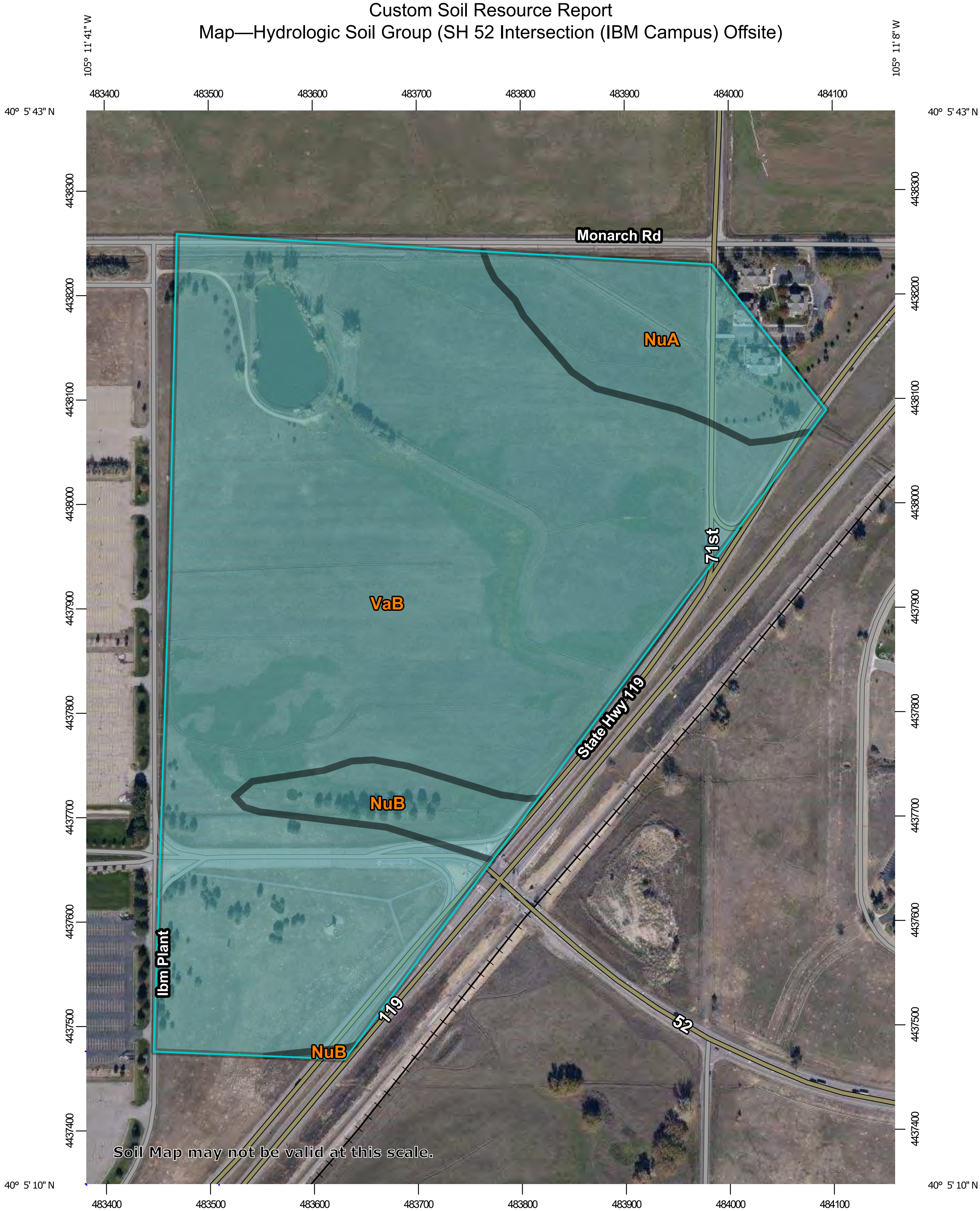



Map Scale: 1:6,030 if printed on A landscape (11" x 8.5") sheet.




Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

Custom Soil Resource Report
Map—Hydrologic Soil Group (SH 52 Intersection (IBM Campus) Offsite)

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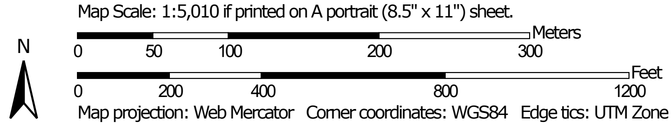



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

## MAP LEGEND

**Area of Interest (AOI)**
- Area of Interest (AOI)

**Soils**

**Soil Rating Polygons**
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

**Soil Rating Lines**
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

**Soil Rating Points**
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

**Water Features**
- Streams and Canals

**Transportation**
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

**Background**
- Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Boulder County Area, Colorado
Survey Area Data: Version 18, Sep 2, 2021

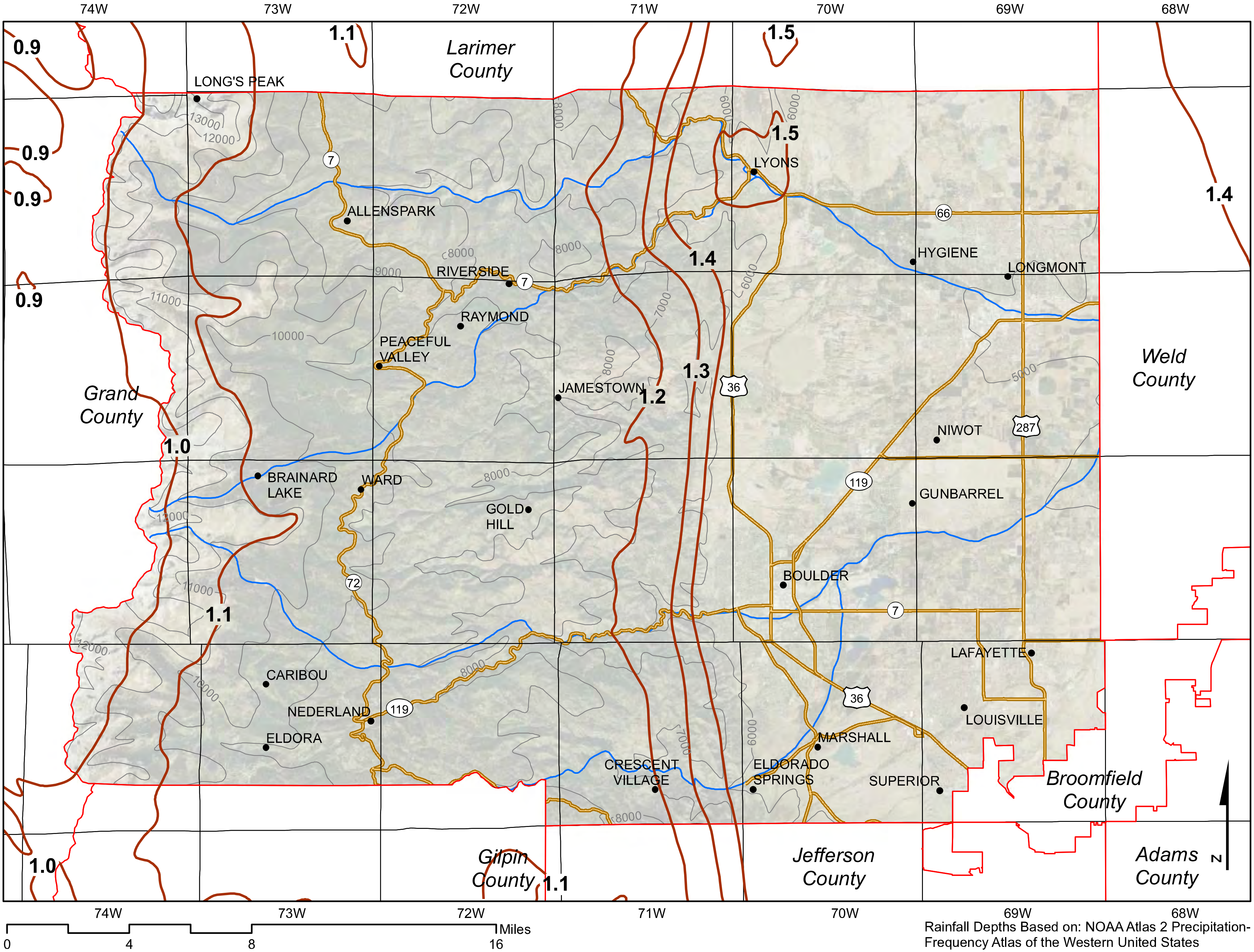
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 1, 2018—Oct 31, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

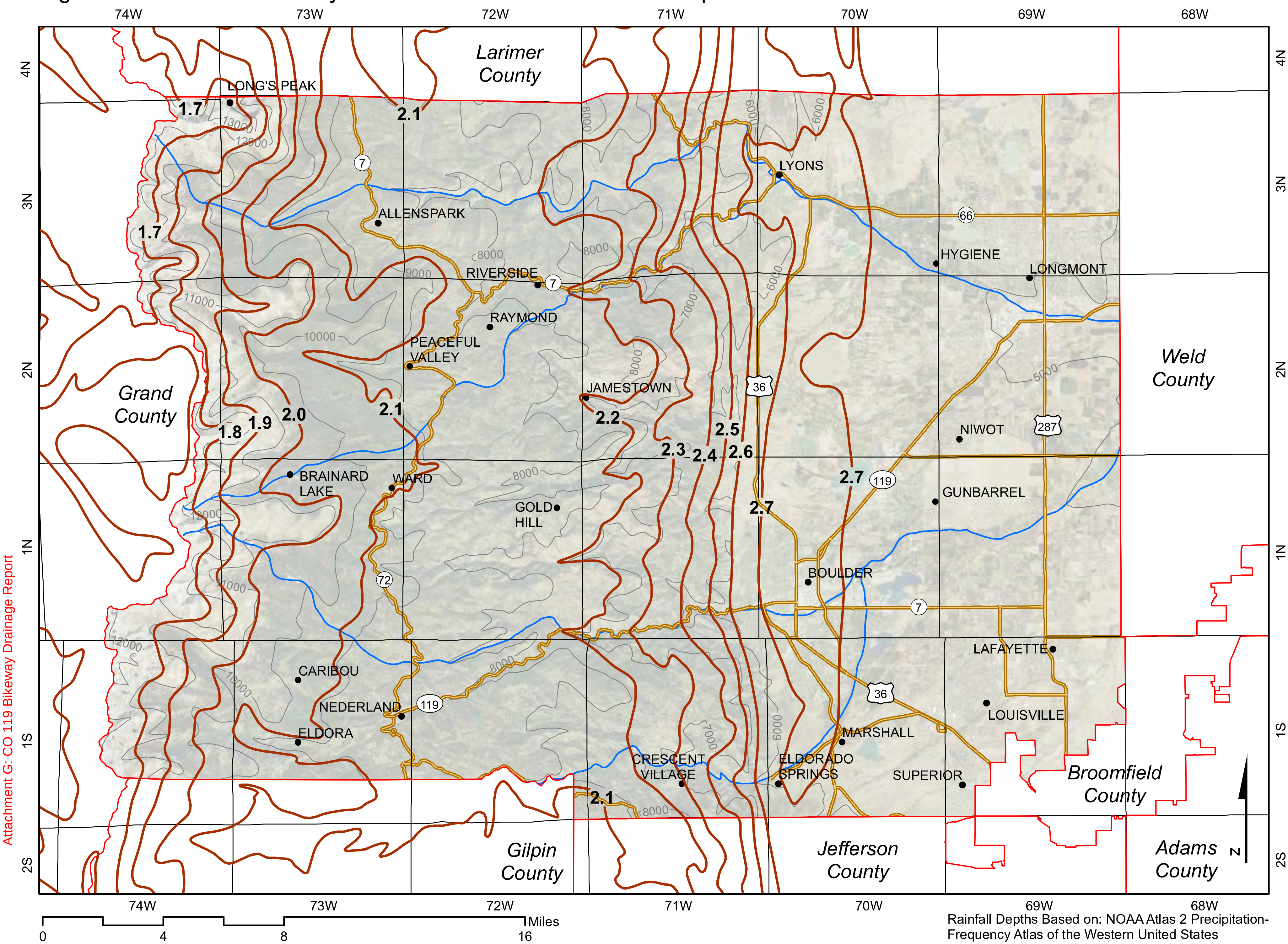
# NOAA Atlas 2 Rainfall Data (from Boulder County Storm Drainage Criteria Manual)

# Figure 500-1 Boulder County 5-Year 1-Hour Point Rainfall Depths




Rainfall Depths Based on: NOAA Atlas 2 Precipitation-Frequency Atlas of the Western United States

# Figure 500-3 Boulder County 100-Year 1-Hour Point Rainfall Depths




Rainfall Depths Based on: NOAA Atlas 2 Precipitation-Frequency Atlas of the Western United States

Figure 5. *Relation between annual and partial-duration series.*

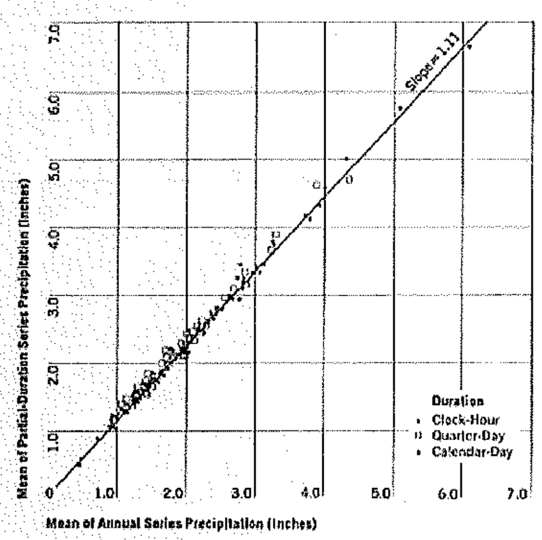
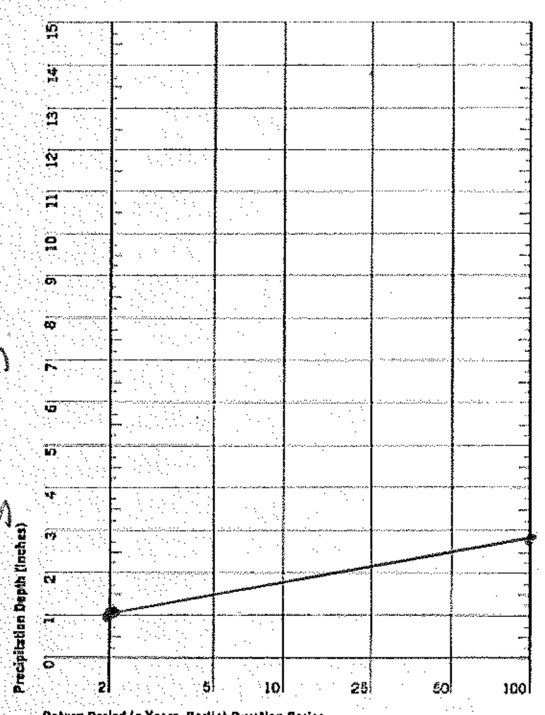



Figure 7. *Principal paths of moisture inflow in the western United States for storms producing large precipitation amounts. Toned areas are major orographic barriers.*




2-yr
=1.01 in

100-yr
=2.74 in

Figure 6. *Precipitation depth versus return period for partial-duration series.*

portant. Next, an examination was made of factors that combined topographic and meteorologic considerations, such as distance and direction to moisture sources. Each factor considered was a measure of some physical reality, and each was understandably related to variation in the precipitation-frequency regime.

Finally, various climatological and meteorological factors that could be indexes of variation of the precipitation-frequency values were considered. The procedure used for developing interpolating equations was a multiple-regression screening technique. This process was done by computer using a least-squares technique. The computer program was capable of accepting a total of 174 independent variables for as many locations as data were available. The number of variables screened for the various relations ranged between 60 and 100. This does not mean that 60 or more completely different factors could be identified. For example, several factors might involve different measures of slope. Moreover, these measures of slope might be over different distances or have different orientations. In each instance, the practice was to permit the computer to select the most critical of the various measures of each factor.

Although the computer program treated each variable as linear during the regression analysis, it was possible through internal computations to use logarithms, powers, roots, reciprocals, or combinations of any or all of the factors. The computer program selected the single variable most highly correlated with the precipitation-frequency value under investigation. The next step was to select the variable that, combined with the variable already selected, would explain the greatest variation in the precipitation-frequency values. The third, fourth, fifth, and further variables were selected in a similar manner. The program continued to select

| Region of applicability[1] | Corr. coeff. | No. of stations | Mean of computed stn. values (inches) | Standard error of estimate (inches) |
|---|---|---|---|---|
| Gila, Williams, and lower Colorado River Basins (1) | 0.84 | 86 | 1.86 | 0.21 |
| Little Colorado, San Juan, and Virgin River Basins, except higher elevations of south-facing slopes (2)[2] | 0.81 | 105 | 1.36 | 0.20 |
| Higher elevations of south-facing slopes of Little Colorado, San Juan, and Virgin River Basins (2)[2] | 0.93 | 41 | 1.31 | 0.13 |
| Rio Grande Basin north of El Paso, Tex. (3) | 0.77 | 110 | 1.35 | 0.18 |
| Crest of Continental Divide and Sangre de Cristo Mountains to generalized 7,000-ft contour from southern Wyoming to southern tip of Sangre de Cristo Mountains (4) | 0.83 | 122 | 1.43 | 0.22 |
| Upper Colorado and Gunnison River Basins and Green River Basin below confluence of Green and Yampa Rivers (5) | 0.79 | 69 | 1.12 | 0.13 |
| Yampa River Basin, Green River Basin above confluence of Green and Yampa Rivers, and Bear River Basin east of Wasatch Mountains (6) | 0.83 | 29 | 1.03 | 0.08 |
| Mountains of central Utah (7) | 0.85 | 86 | 1.35 | 0.18 |
| Western Utah and Nevada, except Snake and Virgin River Basins and spillover zone east of Sierra Nevada Crest (8)[3] | 0.71 | 79 | 1.03 | 0.13 |
| Western Utah and Nevada, except Snake and Virgin River Basins and spillover zone east of Sierra Nevada crest (8)[3] | 0.71 | 55 | 1.04 | 0.15 |
| Big Horn River Basin above Saint Xavier and minor portions of North Platte, Powder, Tongue, and Yellowstone River Basins (9) | 0.78 | 55 | 1.25 | 0.21 |
| Upper Missouri River Basin above Holter Dam, Mont.; Snake River Basin above Alpine, Wyo.; and upper Yellowstone River Basin above Springdale, Mont. (10) | 0.76 | 57 | 1.19 | 0.16 |
| From generalized 4,000-ft contour on east to crests of Crazy and Little Belt Mountains and Lewis Range on west (11) | 0.80 | 52 | 1.67 | 0.26 |
| West of Continental Divide, but east of Bitterroot Range and Cabinet and Selkirk Mountains (12) | 0.85 | 44 | 1.36 | 0.12 |
| Mountainous region of eastern Washington and Oregon and of Idaho west of Bitterroot Range crest and Continental Divide, and north of southern boundary of Snake River Basin—excluding Snake River Valley below a generalized 5,000-ft contour (13) | 0.78 | 147 | 1.44 | 0.24 |
| Orographic region east of crest of Cascade Range and west of Snake River Basin (14) | 0.90 | 115 | 1.75 | 0.35 |
| Western slopes of Coast Ranges, Olympic Mountains, and Cascade Range (15) | 0.87 | 125 | 3.69 | 0.48 |
| Eel River Basin; southern portion of Klamath River Basin; and Cottonwood, Elder, Thomas, and Gladstone Creeks (16) | 0.91 | 39 | 4.19 | 0.50 |
| Russian River, Cache and Putah Creeks, and coastal drainages west of Russian River (17) | 0.84 | 63 | 5.31 | 0.78 |
| Santa Cruz Mountains and La Panza, Santa Lucia, and Coast Ranges (18) | 0.95 | 55 | 4.32 | 0.45 |
| Diablo, Gabilan, and Temblor Ranges (19) | 0.82 | 58 | 2.21 | 0.35 |
| San Rafael, San Bernardino, Santa Monica, and San Gabriel Mountains (20) | 0.88 | 149 | 3.98 | 0.59 |
| Santa Ana, Santa Rosa, Coyote, and other extreme southern coastal mountains (21) | 0.88 | 34 | 2.44 | 0.33 |
| Northern Sierra Nevada north of Mokolumne River Basin (22) | 0.92 | 84 | 4.56 | 0.53 |
| Southern Sierra Nevada south of Consumnes River Basin (23) | 0.88 | 61 | 3.43 | 0.53 |
| Southeastern desert region of California (24) | 0.89 | 41 | 1.07 | 0.16 |
| Spillover zone east of Sierra Nevada crest (25) | 0.94 | 41 | 2.05 | 0.27 |
| Spillover zone east of crest of coastal mountains of southern California (26) | 0.97 | 10 | 2.08 | 0.15 |

[1] Numbers in parentheses refer to geographic regions shown in figure 8.
[2] Two different equations were used in region 2. See text for explanation.
[3] Two different equations were used in region 8. See text for explanation.

Table 3. *Statistical parameters for relations used for interstation interpolation of 2-yr 24-hr precipitation values*

# FEMA Flood Zone Maps

# (Order: Fourmile Canyon Creek, Dry Creek, Lefthand Canyon Creek [3])

# National Flood Hazard Layer FIRMette

FEMA

105°14'51"W 40°2'47"N


105°14'13"W 40°2'20"N

Feet

0 250 500 1,000 1,500 2,000

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

**SPECIAL FLOOD HAZARD AREAS**
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

**OTHER AREAS OF FLOOD HAZARD**
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

**OTHER AREAS**
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

**GENERAL STRUCTURES**
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

**OTHER FEATURES**
- B 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

**MAP PANELS**
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 7/7/2022 at 12:23 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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# National Flood Hazard Layer FIRMette

FEMA

105°12'24"W 40°5'1"N


105°11'46"W 40°4'33"N

Feet 1:6,000

0 250 500 1,000 1,500 2,000

*Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020*



## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

**SPECIAL FLOOD HAZARD AREAS**
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

**OTHER AREAS OF FLOOD HAZARD**
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

**OTHER AREAS**
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

**GENERAL STRUCTURES**
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

**OTHER FEATURES**
- 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

**MAP PANELS**
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

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# National Flood Hazard Layer FIRMette

FEMA

105°9'11"W 40°7'49"N


105°8'33"W 40°7'21"N

Feet 1:6,000

0 250 500 1,000 1,500 2,000

*Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020*

## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

**SPECIAL FLOOD HAZARD AREAS**
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

**OTHER AREAS OF FLOOD HAZARD**
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

**OTHER AREAS**
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

**GENERAL STRUCTURES**
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

**OTHER FEATURES**
- B 20.2 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

**MAP PANELS**
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

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# National Flood Hazard Layer FIRMette

FEMA

105°8'34"W 40°8'16"N


0 250 500 1,000 1,500 2,000 Feet

1:6,000

105°7'56"W 40°7'48"N

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020



## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

**SPECIAL FLOOD HAZARD AREAS**
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

**OTHER AREAS OF FLOOD HAZARD**
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

**OTHER AREAS**
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

**GENERAL STRUCTURES**
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

**OTHER FEATURES**
- B 20.2 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

**MAP PANELS**
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

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# APPENDIX B

## Hydrology

Existing Hydrology Calculations

Proposed Hydrology Calculations

# Existing Hydrology Calculations

# CALCULATION COVER SHEET

| | | | |
|---|---|---|---|
| **Project Name:** | SH 119 Bikeway | **Project No.** | 21015 (Muller) |
| **Design Calculation:** | Existing Hydrology | **Version:** | 1 |
| **Originator** | ZDS | **Date:** | February 3, 2022 |
| **Checker** | ACF | **Date:** | February 17, 2022 |

**Purpose:**
Analyze the existing hydrologic conditions and determine peak flowrates for the SH 119 Bikeway project.

**References:**

**Criteria Manuals Used:**

Colorado Department of Transportation (CDOT) *Drainage Design Manual,* 2019
Boulder County *Multimodal Transportation Standards (MTS)*, 2012
Boulder County *Storm Drainage Criteria Manual (SDCM)*, 2016

**Referenced Data Sources:**
CDOT, *Topographic Survey,* Received July 2021
CDOT, *SUE (QL C&D)*, Received December 2021
Boulder County, *LiDAR*, Accessed January 2022
United States Department of Agriculture Natural Resources Conservation Service (NRCS), *Web Soil Service for Hydrologic Soil Group*, Accessed January 2022
National Oceanic and Atmospheric Administration, *Point Frequency Data Server*, Accessed January 2022
Microsoft Corp., *Bing Maps Aerial*, Accessed January 2022
Alphabet Inc., *Google Earth Aerial*, June 2021 Imagery

**Previous Reports:**

Felsburg, Holt & Ullevig, *Hydrology and Hydraulics Report for the Intersections SH 119 at Jay Rd and SH 119 at Niwot Rd,* May 2012
Muller Engineering Company, *SH 119 at SH 52 (Mineral Road) Final Drainage Report*, November 2005

Refer to the drainage report for the appendices referenced below:

**Appendix A**
Hydrologic and Hydraulic Criteria Table
Existing Basin Maps

**Appendix B**
Proposed Hydrology Calculation Packet

Refer to the Drainage Report for full citations of references.

## Criteria:

Runoff from existing basins for the proposed project was determined using CDOT and Boulder County drainage manuals. Refer to the Hydrologic Criteria Table in **Appendix A** of the Drainage Report for the complete comparison of analyzed criteria. **Table 1** shows the applied criteria for this calculation packet.

***Table 1.*** *Applied Hydrologic Criteria Table*

| Hydrologic Criteria | Applied Criteria |
|---|---|
| **Design Frequency** | |
| Cross Drainage | |
| Multi-lane Road (Urban) | 100-year |
| Multi-lane Road (Rural) | 50-year |
| Two Lane Road (Urban) | 100-year |
| Two Lane Road (Rural) | 25-year |
| Culvert Outlet Scour Protection | 10-year |
| Pedestrian Walkways and Bikeways | 5-year |
| Parallel Drainage | |
| Roadway Overtopping & Revetment | *Same as for cross drainage* |
| Side Drains | 10-year |
| Storm Drains | |
| Major Storm | 100-year |
| Minor Storm | 5-year |
| Channels | |
| Capacity | *Depends on roadway classification* |
| Lining | 10-year |
| **Hydrologic Procedure Selection** | |
| Hydrologic Peak Prediction Procedure | |
| Drainage Area | Rational Method (<200 ac)<br>CUHP and EPA-SWMM (>200 ac) |
| Time of Concentration (Tc) for Rational Method | |
| Min. Tc for urban areas | 5 min. |
| Min. Tc for non-urban areas | 10 min. |
| Max. Overland Flow Path Length (urban) | 300 ft |
| Max. Overland Flow Path Length (rural) | 500 ft |

## Background and Rationale:

- The project is located along SH 119 from Boulder, Colorado to Longmont, Colorado.
- Project improvements include:
    - Grading and constructing a bike path along SH 119 from Foothills Parkway in Boulder to Hover Street in Longmont. At-grade crossings, underpasses, and bridges will be designed for the bike path.

    - Supplementary improvements include:
        - Traffic support for intersections along SH 119 impacted by bike path.
        - Structural design of underpasses and bridges.
        - Landscaping improvements.
        - Lighting for underpasses and other locations.
        - Floodplain analysis.
        - Irrigation coordination.
- Drainage generally flows east through the project area, flow directions are not uniform throughout the project length however.
- Design points (DP) for basins are located at the receiving point (stormwater ditches, stormwater pipes and culverts, stormwater area inlets, irrigation ditches, irrigation pipes and culverts, and streams and rivers) and where runoff leaves the project area.
- Basins were delineated using survey contours and topography provided by CDOT and LiDAR contours referenced from Boulder County.
- Basin ID's correspond with centerline stationing for the proposed alignments for the bike path using L and R for left and right designation. Basins with the same station and a greater offset were labeled with increasing alphabetical letters (i.e., the design point for X4019RA has a greater offset distance than X4019R).
- Topographic survey indicates an underground storm drain system at the west side of the SH 119/Airport Road intersection. A drainage report request was submitted on January 27, 2022 to better understand this system.
- Basins were analyzed for peak discharge using rational method, then DPs with multiple contributing areas were routed to determine overall peak discharge leaving the project area.
    - An exception is for Basin X3029R, contributing offsite flow to this basin was taken from the *SH 119 at SH 52 (Mineral Road) Final Drainage Report* and added to the routed flow from X3023L and X3029R.

## Assumptions/Givens:

### Rational Method Givens

- Hydrologic Soil Group HSG A, B, C, and D
- Rainfall data for 1-hour precipitation values were taken from NOAA Atlas 2 and compared to data published in the Boulder County Storm Drainage Criteria Manual
    - NOAA Atlas 2
        - Isopluvial maps were used to interpolate rainfall depths for the 2-yr and 100-yr events with storm durations of 6 hours and 24 hours
        - These rainfall depths were used in the appropriate equations in Table 11 to determine the rainfall depths for the 2-yr and 100-yr events with a 1-hour storm duration.
            - Equations for Region 1 (South Platte watershed) were selected
        - The results for the 2-yr and 100-yr events with a 1 hour storm duration were plotted on Figure 6 to obtain rainfall depths for the 5-yr, 10-yr, 25-yr, and 50-yr events with a 1-hour storm duration

        - The results were consistent with the UD-Rain spreadsheet, indicating the regression was correct
    - Boulder County Storm Drainage Criteria Manual
        - Isopluvial maps specific to Boulder County provide the rainfall depth for 5-yr and 100-yr return events with a 1-hour storm duration.
        - These rainfall depths for a 1-hour storm duration match the results taken from NOAA Atlas
        - The equation for rainfall intensity (500.1) matches the equation used for the calculations presented in this calculation packet (please refer to attachments).
- Land use types and percent imperviousness provided in (Table 6-3 of USDCM) used for this project are:
    - Streets: Paved, 100% imperviousness
    - Streets: Gravel (Packed), 40% imperviousness
    - Undeveloped Areas: Greenbelts, Agricultural, 2% imperviousness
    - Business: Suburban Areas, 75% imperviousness
    - Residential: 0.25 Acres or Less, 45% imperviousness
- USDCM Equations 6-3, 6-4, and 6-5 were used to calculate the time of concentration required to calculate intensity.

**Rational Method Assumptions**

- The following land use types and percent imperviousness values were not taken from USDCM but were assumed:
    - Google Earth imagery indicates that solar panels are currently placed on the IBM property between the main IBM campus and SH 119. A 50% imperviousness was assumed for fields with solar panels.
    - Irrigation ponds were assumed to be 98% impervious.

**General Assumptions**

- Roadside ditches parallel to SH 119 coupled with the embankment of SH 119 prevent offsite flow from reaching the median of SH 119. Therefore, off-site basins were not analyzed with the exception of areas where the proposed bike path is outside of the SH 119 median.
    1. Three large watersheds (Fourmile Creek, Dry Creek, and Lefthand Creek) cross the proposed bike path design. Total flowrate values for these watersheds were provided via floodplain models from Boulder County. Local areas within the project site contributing to each of these watersheds were evaluated.
- Irrigation ownership data from Boulder County was used to aid basin delineations. Irrigation ownership data indicates roughly 35 irrigation systems crossing SH 119 (and subsequently the proposed bike path) within the project area. Irrigation ditches traversing SH 119 have not been assumed to flow full, and thus have capacity to intercept stormwater based on topography.
- There are two culverts as possible design points for Basin X4096L, an 18” CSP crossing SB SH 119 to the north and an 18” CSP crossing N 83rd St to the southwest. The 18” CSP crossing SH 119 to the north was assigned as the design point for Basin X4096L because topographic survey indicates the invert of this pipe is lower. No flow has been assumed to reach the 18” CSP crossing N 83rd Street.

- An irrigation ditch traverses Basin X5052L. This is the only irrigation ditch that has been assumed to flow full and not intercept stormwater runoff due to the shallow depth of the irrigation ditch. The design point for Basin X5052L is an 18” CSP which conveys flow northeast across S Fordham St.

**SH 119 and SH 52 Intersection / IBM Campus Offsite Flow Assumptions and Analysis**

- Basins X3029R, X3033L, X3036R, X3042L, and X3048L located at the northeast corner of the SH 119/SH 52 intersection adjacent to the IBM campus were delineated with IBM E Loop Road as the western limit for two reasons.
    1. LiDAR contours indicate this road is crowned.
    2. The *SH 119 at SH 52 (Mineral Road) Final Drainage Report* states runoff from the majority of the IBM campus is routed south in an underground storm system and therefore does not reach the project area.
        - The drainage report states the portion of the IBM campus not reaching the storm system is the parking lots on the east side of the IBM campus. Runoff from the parking lots on the east side of the IBM campus flows east towards SH 119 and thus reaches the project area.
        - The 5-year and 100-year flowrates reaching the project area from the IBM campus are 25 cfs and 30 cfs respectively.

**Results:**

**Table 2** summarizes the 5-year and 100-year peak flowrates associated with individual basins. **Table 3** summarizes the 5-year and 100-year flowrates for all design points where runoff leaves the project area.

***Table 2.*** *Peak Discharge Summary of Individual Basins*

| BASIN ID | AREA (acre) | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| X1016L | 10.65 | 3.3 | 27.0 |
| X1017L | 0.70 | 1.3 | 4.0 |
| X1018L | 1.91 | 0.6 | 5.2 |
| X1021R | 0.28 | 1.1 | 2.2 |
| X1029R | 101.56 | 28.5 | 142.5 |
| X1030R | 0.94 | 0.1 | 2.1 |
| X1032R | 0.36 | 0.1 | 1.3 |
| X1034R | 1.25 | 0.2 | 3.1 |
| X1047L | 4.98 | 1.1 | 12.3 |
| X1047LA | 0.16 | 0.4 | 1.1 |
| X1054R | 4.67 | 3.2 | 12.8 |
| X1056L | 1.42 | 1.2 | 5.8 |
| X1069R | 5.56 | 0.7 | 11.4 |
| X1077R | 2.79 | 0.3 | 6.1 |
| X1080R | 2.46 | 1.6 | 8.5 |
| X1082R | 0.20 | 0.0 | 0.7 |
| X1083R | 0.82 | 1.1 | 3.8 |
| X1088R | 2.87 | 1.2 | 8.1 |
| X2010R | 8.15 | 1.0 | 10.0 |
| X2019R | 4.76 | 0.3 | 6.2 |
| X2022R | 0.12 | 0.2 | 0.7 |
| X2022RA | 1.16 | 0.1 | 2.6 |
| X2031R | 3.60 | 0.6 | 8.0 |
| X2056R | 9.09 | 1.2 | 11.3 |
| X2060R | 5.16 | 5.7 | 19.3 |
| X2064R | 5.43 | 2.6 | 13.5 |
| X2079R | 3.14 | 1.2 | 7.5 |
| X2085R | 3.26 | 1.3 | 8.9 |
| X2090R | 4.38 | 1.1 | 9.7 |
| X2099R | 0.44 | 0.3 | 1.6 |
| X2100R | 4.37 | 1.1 | 8.8 |
| X3008L | 4.08 | 1.3 | 9.5 |
| X3008R | 2.61 | 1.5 | 6.3 |
| X3013L | 2.81 | 1.2 | 8.3 |
| X3023L | 10.96 | 3.7 | 21.4 |
| X3023R | 1.18 | 2.6 | 5.9 |
| X3029R | 13.74 | 4.9 | 27.0 |
| X3033R | 17.48 | 13.6 | 45.3 |
| X3033RA | 0.74 | 1.0 | 2.6 |
| X3036L | 24.91 | 12.0 | 39.9 |
| X3038R | 1.07 | 0.7 | 3.7 |
| X3042L | 2.30 | 0.9 | 5.3 |
| X3042R | 1.36 | 1.4 | 5.4 |
| X3048L | 22.96 | 3.5 | 31.3 |
| X3049R | 3.63 | 2.4 | 10.3 |
| X3052L | 0.61 | 0.7 | 2.8 |
| X4019R | 16.48 | 1.6 | 15.4 |
| X4019RA | 0.21 | 0.6 | 1.4 |
| X4021R | 0.35 | 1.0 | 2.3 |
| X4023R | 3.89 | 3.6 | 11.2 |
| X4028R | 2.91 | 1.9 | 10.8 |
| X4044R | 7.65 | 0.7 | 9.8 |
| X4054R | 4.90 | 1.0 | 8.5 |
| X4065R | 4.64 | 1.4 | 9.6 |
| X4076LA | 4.51 | 0.7 | 8.0 |
| X4076L | 0.60 | 0.4 | 1.8 |
| X4028R | 2.91 | 1.9 | 10.8 |
| X4082L | 2.95 | 0.8 | 6.9 |
| X4087L | 3.13 | 1.7 | 9.1 |
| X4091L | 2.40 | 2.5 | 9.3 |

***Table 2.*** *Peak Discharge Summary of Individual Basins (continued)*

| BASIN ID | AREA (acre) | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| X4096L | 0.92 | 1.2 | 3.8 |
| X4114L | 8.50 | 1.8 | 12.2 |
| X5006R | 1.44 | 1.1 | 5.1 |
| X5007R | 0.10 | 0.2 | 0.6 |
| X5011L | 8.78 | 2.3 | 15.3 |
| X5011R | 0.27 | 0.6 | 1.5 |
| X5013L | 3.08 | 1.6 | 8.0 |
| X5023R | 6.91 | 1.3 | 7.4 |
| X5033R | 7.15 | 1.2 | 8.9 |
| X5041R | 1.78 | 0.5 | 4.8 |
| X5045R | 0.92 | 0.3 | 2.0 |
| X5048R | 2.21 | 0.5 | 5.0 |
| X5052L | 1.93 | 0.7 | 4.2 |
| X5064R | 9.61 | 1.5 | 13.6 |
| X5066R | 4.10 | 0.3 | 6.2 |
| X5068R | 11.18 | 2.5 | 24.4 |
| X5075R | 9.68 | 2.8 | 21.6 |
| X5084R | 6.80 | 2.5 | 15.6 |

***Table 3.*** *Peak Discharge Summary of Design Points where Flow Leaves Project*

| Design Point | Contributing Basins | Description of Runoff Leaving Project Area | Q5 (cfs) | Q100 (cfs) |
|---|---|---|---|---|
| X1018L | X1016L, X1017L, X1018L, X1021R | Fourmile Creek | 5.3 | 35.4 |
| X1030R | X1029R, X1030R, X1032R | Ditch between NB CO 119 and BNSF Railroad | 28.6 | 144.0 |
| X1034R | X1034R | Poorly defined ditch outside (southeast) of BNSF Railroad | 0.2 | 3.1 |
| X1047L | X1047L | Boulder and Whiterock Irrigation Ditch | 1.1 | 12.3 |
| X1056L | X1054R, X1056L | Water Quality Extended Detention Basin North of Jay Road | 4.0 | 16.5 |
| X1069R | X1069R | Boulder and Whiterock Irrigation Ditch | 0.7 | 11.4 |
| X1082R | X1082R | Ditch between NB CO 119 and BNSF Railroad | 0.0 | 0.7 |
| X1083R | X1077R, X1080R, X1083R | Boulder and Whiterock Irrigation Ditch | 2.2 | 14.6 |
| X1088R | X1088R | City of Boulder and Others Irrigation Ditch | 1.2 | 8.1 |
| X2010R | X2010R | Ditch between NB CO 119 and BNSF Railroad | 1.0 | 10.0 |
| X2019R | X2019R | Ditch between NB CO 119 and BNSF Railroad | 0.3 | 6.2 |
| X2022RA | X2022RA | Ditch between NB CO 119 and BNSF Railroad | 0.1 | 2.6 |
| X2022R | X2022R | Ditch between NB CO 119 and BNSF Railroad | 0.2 | 0.7 |
| X2031R | X2031R | Boulder and Whiterock Irrigation Ditch | 0.6 | 8.0 |
| X2060R | X2056R, X2060R | Boulder Reservoir Spillway/ Boulder County Irrigation Ditch | 3.5 | 19.3 |
| X2064R | X2064R | Ditch between NB CO 119 and BNSF Railroad | 2.6 | 13.5 |
| X2079R | X2079R | City of Boulder and Northern Colorado Water Conservancy District Irrigation Ditch | 1.2 | 7.5 |
| X2085R | X2085R | Ditch between NB CO 119 and BNSF Railroad | 1.3 | 8.9 |
| X0290R | X2090R, X2099R, X2100R | Dry Creek | 2.3 | 18.5 |
| X3008L | X3008L | IBM and Others Irrigation Ditch | 1.3 | 9.5 |
| X3008R | X3008R | Ditch between NB CO 119 and BNSF Railroad | 1.5 | 6.3 |
| X3013L | X3013L | Ditch between NB CO 119 and BNSF Railroad | 1.2 | 8.3 |
| X3023R | X3023R | Inlet at CO 119 and SH 52 Intersection | 2.6 | 5.9 |
| X3029R | X3023L, X3029R, Offsite Flow From IBM Campus | Ditch between NB CO 119 and BNSF Railroad | 33.5 | 78.3 |
| X3033RA | X3033R, X3033RA | Ditch between NB CO 119 and BNSF Railroad | 14.4 | 47.4 |

***Table 3.*** *Peak Discharge Summary of Design Points where Flow Leaves Project (continued)*

| Design Point | Contributing Basins | Description of Runoff Leaving Project Area | Q5 (cfs) | Q10 0 (cfs) |
|---|---|---|---|---|
| X3038R | X3036L, X3038R | Ditch between NB CO 119 and BNSF Railroad | 12.3 | 41.4 |
| X3042R | X3042L, X3042R | Ditch between NB CO 119 and BNSF Railroad | 1.8 | 8.7 |
| X3049R | X3048L, X3049R | Ditch between NB CO 119 and BNSF Railroad | 4.8 | 37.0 |
| X3052L | X3052L | Ditch between NB CO 119 and BNSF Railroad | 0.7 | 2.8 |
| X4019R | X4019R | Point between NB CO 119 and BNSF Railroad | 1.6 | 15.4 |
| X4028R | X4019RA, X4021R, X4023R, X4028R | Water Quality Extended Detention Basin North of Niwot Road | 4.1 | 21.9 |
| X4044R | X4044R | Williamson Irrigation Ditch | 0.7 | 9.8 |
| X4054R | X4054R | Ditch between NB CO 119 and BNSF Railroad | 1.0 | 8.5 |
| X4065R | X4065R | Ditch between NB CO 119 and BNSF Railroad | 1.4 | 9.6 |
| X4076LA | X4076LA | Ditch outside and adjacent to SB CO 119 | 0.7 | 8.0 |
| X4076L | X4076L | Ditch outside and adjacent to SB CO 119 | 0.4 | 1.8 |
| X4082L | X4082L | Ditch outside and adjacent to SB CO 119 | 0.8 | 6.9 |
| X4087L | X4087L | Ditch outside and adjacent to SB CO 119 | 1.7 | 9.1 |
| X4091L | X4091L | Point outside of SB CO 119 | 2.5 | 9.3 |
| X4096L | X4096L | Point outside of SB CO 119 | 1.2 | 3.8 |
| X4114L | X4114L | Point outside of SB CO 119 near Lefthand Creek | 1.8 | 12.2 |
| X5006R | X5006R, X5007R | Storm system at existing underpass under NB CO 119 near Airport Road | 1.3 | 5.5 |
| X5011L | X5011L, X5011R | Lefthand Creek | 2.5 | 15.8 |
| X5013L | X5013L | Lefthand Creek | 1.6 | 8.0 |
| X5023R | X5023R | Ditch between NB CO 119 and BNSF Railroad | 1.3 | 7.4 |
| X5033R | X5033R | Lefthand Creek | 1.2 | 8.9 |
| X5041R | X5041R | Ditch between NB CO 119 and BNSF Railroad | 0.5 | 4.8 |
| X5048R | X5048R | Ditch between NB CO 119 and BNSF Railroad | 0.5 | 5.0 |
| X5064R | X5052L, X5064R | Ditch between NB CO 119 and BNSF Railroad | 1.9 | 16.5 |
| X5066R | X5066R | Ditch between NB CO 119 and BNSF Railroad | 0.3 | 6.2 |
| X5075R | X5075R, X5084R | Ditch between NB CO 119 and BNSF Railroad | 5.4 | 37.0 |

## Materials Included in this Calculation Packet:

1. Rational Method Calculations

**SH 119 Bikeway**
**Existing Hydrology Calculations - Rational Method**
**Muller Engineering Company, Inc.**

| | |
|---|---|
| CDOT Project Number: | N/A |
| Muller Project Number: | 21015 |

| | |
|---|---|
| Originator | ZDS |
| Date: | 2/2/2022 |
| Checker: | ACF |
| Date: | 3/1/2022 |

| Land Use Types | Percent Impervious |
|---|---|
| STREETS: PAVED | 100 |
| RESIDENTIAL: 0.25 ACRES OR LESS | 45 |
| UNDEVELOPED AREAS: GREENBELTS, AGRICULTURAL | 2 |
| SOLAR PANEL FIELD | 50 |
| STREETS: GRAVEL (PACKED) | 40 |
| IRRIGATION POND | 98 |
| BUSINESS: SUBURBAN AREAS | 75 |
| NO LAND USE DEFINED | 0 |

Land Use Types and Imperviousness Values from USDCM Volume 1 Table 6-3

## PERCENT IMPERVIOUS VALUES

| BASIN ID | TOTAL AREA | | STREETS: PAVED | | RESIDENTIAL: 0.25 ACRES OR LESS | | UNDEVELOPED AREAS: GREENBELTS, AGRICULTURAL | | SOLAR PANEL FIELD | | STREETS: GRAVEL (PACKED) | | IRRIGATION POND | | BUSINESS: SUBURBAN AREAS | | WEIGHTED PERCENT IMPERVIOUS | WEIGHTED PERCENT PERVIOUS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (sq ft) | (acre) | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | | |
| X1016L | 463,994 | 10.65 | 65,370 | 14 | | 0 | 398,624 | 86 | | 0 | | 0 | | 0 | | 0 | 16 | 84 |
| X1017L | 30,595 | 0.70 | 15,629 | 51 | | 0 | 14,966 | 49 | | 0 | | 0 | | 0 | | 0 | 52 | 48 |
| X1018L | 83,003 | 1.91 | 10,436 | 13 | | 0 | 72,567 | 87 | | 0 | | 0 | | 0 | | 0 | 14 | 86 |
| X1021R | 12,212 | 0.28 | 12,219 | 100 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 100 | 0 |
| X1029R | 4,423,755 | 101.56 | 61,081 | 1 | 1,969,817 | 45 | 2,392,857 | 54 | | 0 | | 0 | | 0 | | 0 | 23 | 77 |
| X1030R | 41,148 | 0.94 | | 0 | | 0 | 41,148 | 100 | | 0 | | 0 | | 0 | | 0 | 2 | 98 |
| X1032R | 15,708 | 0.36 | | 0 | | 0 | 15,708 | 100 | | 0 | | 0 | | 0 | | 0 | 2 | 98 |
| X1034R | 54,497 | 1.25 | | 0 | | 0 | 54,497 | 100 | | 0 | | 0 | | 0 | | 0 | 2 | 98 |
| X1047L | 217,001 | 4.98 | 8,906 | 4 | | 0 | 208,095 | 96 | | 0 | | 0 | | 0 | | 0 | 6 | 94 |
| X1047LA | 6,874 | 0.16 | 4,394 | 64 | | 0 | 2,480 | 36 | | 0 | | 0 | | 0 | | 0 | 65 | 35 |
| X1054R | 203,467 | 4.67 | 61,266 | 30 | | 0 | 142,201 | 70 | | 0 | | 0 | | 0 | | 0 | 32 | 68 |
| X1056L | 61,720 | 1.42 | 13,070 | 21 | | 0 | 48,650 | 79 | | 0 | | 0 | | 0 | | 0 | 23 | 77 |
| X1069R | 242,034 | 5.56 | 682 | 0 | | 0 | 240,582 | 99 | | 0 | 770 | 0 | | 0 | | 0 | 2 | 98 |
| X1077R | 121,454 | 2.79 | | 0 | | 0 | 121,454 | 100 | | 0 | | 0 | | 0 | | 0 | 2 | 98 |
| X1080R | 107,200 | 2.46 | 20,960 | 20 | | 0 | 86,240 | 80 | | 0 | | 0 | | 0 | | 0 | 21 | 79 |
| X1082R | 8,585 | 0.20 | | 0 | | 0 | 8,585 | 100 | | 0 | | 0 | | 0 | | 0 | 2 | 98 |
| X1083R | 35,855 | 0.82 | 14,489 | 40 | | 0 | 21,366 | 60 | | 0 | | 0 | | 0 | | 0 | 42 | 58 |
| X1088R | 125,017 | 2.87 | 16,864 | 13 | | 0 | 108,153 | 87 | | 0 | | 0 | | 0 | | 0 | 15 | 85 |
| X2010R | 354,896 | 8.15 | 19,778 | 6 | | 0 | 335,118 | 94 | | 0 | | 0 | | 0 | | 0 | 7 | 93 |
| X2019R | 207,452 | 4.76 | | 0 | | 0 | 207,452 | 100 | | 0 | | 0 | | 0 | | 0 | 2 | 98 |
| X2022R | 5,417 | 0.12 | 1,403 | 26 | | 0 | 4,014 | 74 | | 0 | | 0 | | 0 | | 0 | 27 | 73 |
| X2022RA | 50,741 | 1.16 | | 0 | | 0 | 50,741 | 100 | | 0 | | 0 | | 0 | | 0 | 2 | 98 |
| X2031R | 157,010 | 3.60 | 3,075 | 2 | | 0 | 153,935 | 98 | | 0 | | 0 | | 0 | | 0 | 4 | 96 |
| X2056R | 396,021 | 9.09 | 24,184 | 6 | | 0 | 371,837 | 94 | | 0 | | 0 | | 0 | | 0 | 8 | 92 |
| X2060R | 224,901 | 5.16 | 87,081 | 39 | | 0 | 137,820 | 61 | | 0 | | 0 | | 0 | | 0 | 40 | 60 |
| X2064R | 236,468 | 5.43 | 47,432 | 20 | | 0 | 189,036 | 80 | | 0 | | 0 | | 0 | | 0 | 22 | 78 |
| X2079R | 136,934 | 3.14 | 19,096 | 14 | | 0 | 117,838 | 86 | | 0 | | 0 | | 0 | | 0 | 16 | 84 |
| X2085R | 141,925 | 3.26 | 17,225 | 12 | | 0 | 124,700 | 88 | | 0 | | 0 | | 0 | | 0 | 14 | 86 |
| X2090R | 190,821 | 4.38 | 15,647 | 8 | | 0 | 175,174 | 92 | | 0 | | 0 | | 0 | | 0 | 10 | 90 |
| X2099R | 19,351 | 0.44 | 3,294 | 17 | | 0 | 16,057 | 83 | | 0 | | 0 | | 0 | | 0 | 19 | 81 |
| X2100R | 190,162 | 4.37 | 17,352 | 9 | | 0 | 172,810 | 91 | | 0 | | 0 | | 0 | | 0 | 11 | 89 |
| X3008L | 177,783 | 4.08 | 18,652 | 10 | | 0 | 159,131 | 90 | | 0 | | 0 | | 0 | | 0 | 12 | 88 |
| X3008R | 113,528 | 2.61 | 31,293 | 28 | | 0 | 82,235 | 72 | | 0 | | 0 | | 0 | | 0 | 29 | 71 |
| X3013L | 122,487 | 2.81 | 14,442 | 12 | | 0 | 108,045 | 88 | | 0 | | 0 | | 0 | | 0 | 14 | 86 |
| X3023L | 477,443 | 10.96 | 77,654 | 16 | | 0 | 399,789 | 84 | | 0 | | 0 | | 0 | | 0 | 18 | 82 |
| X3023R | 51,358 | 1.18 | 39,883 | 78 | | 0 | 11,475 | 22 | | 0 | | 0 | | 0 | | 0 | 78 | 22 |
| X3029R | 598,300 | 13.74 | 87,606 | 15 | | 0 | 472,688 | 79 | 38,006 | 6 | | 0 | | 0 | | 0 | 19 | 81 |
| X3033R | 761,254 | 17.48 | 22,582 | 3 | | 0 | 163,264 | 21 | 575,408 | 76 | | 0 | | 0 | | 0 | 41 | 59 |
| X3033RA | 32,407 | 0.74 | 18,185 | 56 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 56 | 44 |
| X3036L | 1,084,927 | 24.91 | 25,038 | 2 | | 0 | 243,587 | 22 | 791,991 | 73 | | 0 | 24,311 | 2 | | 0 | 41 | 59 |
| X3038R | 46,539 | 1.07 | 10,053 | 22 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 22 | 78 |
| X3042L | 100,199 | 2.30 | 16,780 | 17 | | 0 | 83,419 | 83 | | 0 | | 0 | | 0 | | 0 | 18 | 82 |
| X3042R | 59,219 | 1.36 | 19,736 | 33 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 33 | 67 |
| X3048L | 1,000,057 | 22.96 | 72,499 | 7 | | 0 | 927,558 | 93 | | 0 | | 0 | | 0 | | 0 | 9 | 91 |
| X3049R | 158,167 | 3.63 | 43,920 | 28 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 28 | 72 |
| X3052L | 26,432 | 0.61 | 8,607 | 33 | | 0 | 17,825 | 67 | | 0 | | 0 | | 0 | | 0 | 34 | 66 |
| X4019R | 717,656 | 16.48 | 42,932 | 6 | | 0 | 674,724 | 94 | | 0 | | 0 | | 0 | | 0 | 8 | 92 |
| X4019RA | 9,066 | 0.21 | 6,786 | 75 | | 0 | 2,280 | 25 | | 0 | | 0 | | 0 | | 0 | 75 | 25 |
| X4021R | 15,055 | 0.35 | 11,877 | 79 | | 0 | 3,178 | 21 | | 0 | | 0 | | 0 | | 0 | 79 | 21 |
| X4023R | 169,237 | 3.89 | 77,240 | 46 | | 0 | 91,997 | 54 | | 0 | | 0 | | 0 | | 0 | 47 | 53 |
| X4028R | 126,600 | 2.91 | 20,977 | 17 | | 0 | 105,623 | 83 | | 0 | | 0 | | 0 | | 0 | 18 | 82 |
| X4044R | 333,447 | 7.65 | 5,804 | 2 | | 0 | 327,643 | 98 | | 0 | | 0 | | 0 | | 0 | 4 | 96 |
| X4054R | 213,546 | 4.90 | 17,071 | 8 | | 0 | 196,475 | 92 | | 0 | | 0 | | 0 | | 0 | 10 | 90 |
| X4065R | 201,942 | 4.64 | 23,255 | 12 | | 0 | 178,687 | 88 | | 0 | | 0 | | 0 | | 0 | 13 | 87 |
| X4076LA | 196,620 | 4.51 | 9,681 | 5 | | 0 | 186,939 | 95 | | 0 | | 0 | | 0 | | 0 | 7 | 93 |
| X4076L | 26,055 | 0.60 | 7,128 | 27 | | 0 | 18,927 | 73 | | 0 | | 0 | | 0 | | 0 | 29 | 71 |
| X4082L | 128,471 | 2.95 | 11,315 | 9 | | 0 | 117,156 | 91 | | 0 | | 0 | | 0 | | 0 | 11 | 89 |
| X4087L | 136,429 | 3.13 | 25,554 | 19 | | 0 | 110,875 | 81 | | 0 | | 0 | | 0 | | 0 | 20 | 80 |
| X4091L | 104,657 | 2.40 | 35,538 | 34 | | 0 | 69,119 | 66 | | 0 | | 0 | | 0 | | 0 | 35 | 65 |
| X4096L | 39,945 | 0.92 | 16,462 | 41 | | 0 | 23,336 | 58 | | 0 | 147 | 0 | | 0 | | 0 | 43 | 57 |
| X4114L | 370,089 | 8.50 | 47,398 | 13 | | 0 | 322,691 | 87 | | 0 | | 0 | | 0 | | 0 | 15 | 85 |
| X5006R | 62,921 | 1.44 | 15,751 | 25 | | 0 | 47,170 | 75 | | 0 | | 0 | | 0 | | 0 | 27 | 73 |
| X5007R | 4,569 | 0.10 | 1,714 | 38 | | 0 | 2,855 | 62 | | 0 | | 0 | | 0 | | 0 | 39 | 61 |
| X5011L | 382,365 | 8.78 | 50,418 | 13 | | 0 | 331,947 | 87 | | 0 | | 0 | | 0 | | 0 | 15 | 85 |
| X5011R | 11,635 | 0.27 | 7,969 | 68 | | 0 | 3,666 | 32 | | 0 | | 0 | | 0 | | 0 | 69 | 31 |
| X5013L | 134,100 | 3.08 | 32,841 | 24 | | 0 | 101,259 | 76 | | 0 | | 0 | | 0 | | 0 | 26 | 74 |
| X5023R | 300,782 | 6.91 | 42,985 | 14 | | 0 | 257,797 | 86 | | 0 | | 0 | | 0 | | 0 | 16 | 84 |
| X5033R | 311,264 | 7.15 | 34,108 | 11 | | 0 | 277,156 | 89 | | 0 | | 0 | | 0 | | 0 | 13 | 87 |
| X5041R | 77,498 | 1.78 | 9,990 | 13 | | 0 | 67,508 | 87 | | 0 | | 0 | | 0 | | 0 | 15 | 85 |
| X5045R | 39,903 | 0.92 | 6,142 | 15 | | 0 | 33,761 | 85 | | 0 | | 0 | | 0 | | 0 | 17 | 83 |
| X5048R | 96,384 | 2.21 | 9,470 | 10 | | 0 | 86,914 | 90 | | 0 | | 0 | | 0 | | 0 | 12 | 88 |
| X5052L | 83,929 | 1.93 | 16,107 | 19 | | 0 | 67,822 | 81 | | 0 | | 0 | | 0 | | 0 | 21 | 79 |
| X5064R | 418,822 | 9.61 | 51,424 | 12 | | 0 | 367,398 | 88 | | 0 | | 0 | | 0 | | 0 | 14 | 86 |
| X5066R | 178,669 | 4.10 | 9,295 | 5 | | 0 | 169,374 | 95 | | 0 | | 0 | | 0 | | 0 | 7 | 93 |
| X5068R | 486,810 | 11.18 | 43,964 | 9 | | 0 | 442,846 | 91 | | 0 | | 0 | | 0 | | 0 | 11 | 89 |
| X5075R | 421,518 | 9.68 | 43,319 | 10 | | 0 | 378,199 | 90 | | 0 | | 0 | | 0 | | 0 | 12 | 88 |
| X5084R | 296,113 | 6.80 | 44,109 | 15 | | 0 | 252,004 | 85 | | 0 | | 0 | | 0 | | 0 | 17 | 83 |

**SH 119 Bikeway**
**Existing Hydrology Calculations - Rational Method**
**Muller Engineering Company, Inc.**
**CDOT Project Number:** N/A
**Muller Project Number:** 21015

**Originator** ZDS
**Date:** 2/2/2022
**Checker:** ACF
**Date:** 3/1/2022

# RUNOFF COEFFIECIENTS FOR 2, 5, 10, AND 100 YEAR STORM EVENTS

| BASIN ID | NRCS HYDROLOGIC SOIL GROUP[1] | | | | | | | | | | | | | | | | | | | | | | | | | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SOIL GROUP (%)[1] | | | SOIL GROUP A | | | | | | | SOIL GROUP B | | | | | | | SOIL GROUP C/D | | | | | | | | | | | | |
| | A | B | C/D | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | % | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | % | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | % | | | | | | |
| X1016L | | 100 | | | | | | | | 0 | 0.10 | 0.12 | 0.19 | 0.35 | 0.42 | 0.50 | 100 | | | | | | | 0 | 0.10 | 0.12 | 0.19 | 0.35 | 0.42 | 0.50 |
| X1017L | | 100 | | | | | | | | 0 | 0.39 | 0.42 | 0.48 | 0.58 | 0.62 | 0.67 | 100 | | | | | | | 0 | 0.39 | 0.42 | 0.48 | 0.58 | 0.62 | 0.67 |
| X1018L | | 90 | 10 | | | | | | | 0 | 0.09 | 0.10 | 0.17 | 0.34 | 0.41 | 0.49 | 90 | 0.09 | 0.15 | 0.24 | 0.40 | 0.46 | 0.54 | 10 | 0.09 | 0.11 | 0.18 | 0.35 | 0.41 | 0.50 |
| X1021R | | 80 | 20 | | | | | | | 0 | 0.84 | 0.86 | 0.87 | 0.88 | 0.89 | 0.90 | 80 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 | 20 | 0.84 | 0.86 | 0.87 | 0.88 | 0.89 | 0.90 |
| X1029R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.16 | 0.22 | 0.30 | 0.45 | 0.50 | 0.58 | 100 | 0.16 | 0.22 | 0.30 | 0.45 | 0.50 | 0.58 |
| X1030R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| X1032R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| X1034R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| X1047L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.04 | 0.08 | 0.18 | 0.35 | 0.42 | 0.51 | 100 | 0.04 | 0.08 | 0.18 | 0.35 | 0.42 | 0.51 |
| X1047LA | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.51 | 0.57 | 0.61 | 0.68 | 0.71 | 0.75 | 100 | 0.51 | 0.57 | 0.61 | 0.68 | 0.71 | 0.75 |
| X1054R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.23 | 0.29 | 0.37 | 0.50 | 0.55 | 0.61 | 100 | 0.23 | 0.29 | 0.37 | 0.50 | 0.55 | 0.61 |
| X1056L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.16 | 0.22 | 0.30 | 0.45 | 0.50 | 0.58 | 100 | 0.16 | 0.22 | 0.30 | 0.45 | 0.50 | 0.58 |
| X1069R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| X1077R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| X1080R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 100 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 |
| X1082R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| X1083R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.31 | 0.38 | 0.44 | 0.55 | 0.60 | 0.65 | 100 | 0.31 | 0.38 | 0.44 | 0.55 | 0.60 | 0.65 |
| X1088R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.10 | 0.16 | 0.24 | 0.40 | 0.47 | 0.55 | 100 | 0.10 | 0.16 | 0.24 | 0.40 | 0.47 | 0.55 |
| X2010R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.51 | 100 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.51 |
| X2019R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| X2022R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.19 | 0.26 | 0.33 | 0.47 | 0.53 | 0.60 | 100 | 0.19 | 0.26 | 0.33 | 0.47 | 0.53 | 0.60 |
| X2022RA | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| X2031R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.02 | 0.07 | 0.16 | 0.34 | 0.41 | 0.50 | 100 | 0.02 | 0.07 | 0.16 | 0.34 | 0.41 | 0.50 |
| X2056R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 | 100 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 |
| X2060R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.30 | 0.36 | 0.43 | 0.54 | 0.59 | 0.65 | 100 | 0.30 | 0.36 | 0.43 | 0.54 | 0.59 | 0.65 |
| X2064R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 100 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 |
| X2079R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.10 | 0.16 | 0.25 | 0.41 | 0.47 | 0.55 | 100 | 0.10 | 0.16 | 0.25 | 0.41 | 0.47 | 0.55 |
| X2085R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.09 | 0.15 | 0.23 | 0.40 | 0.46 | 0.54 | 100 | 0.09 | 0.15 | 0.23 | 0.40 | 0.46 | 0.54 |
| X2090R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.06 | 0.12 | 0.21 | 0.38 | 0.44 | 0.53 | 100 | 0.06 | 0.12 | 0.21 | 0.38 | 0.44 | 0.53 |
| X2099R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.13 | 0.19 | 0.27 | 0.42 | 0.48 | 0.56 | 100 | 0.13 | 0.19 | 0.27 | 0.42 | 0.48 | 0.56 |
| X2100R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 | 100 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 |
| X3008L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.08 | 0.14 | 0.22 | 0.39 | 0.45 | 0.53 | 100 | 0.08 | 0.14 | 0.22 | 0.39 | 0.45 | 0.53 |
| X3008R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.21 | 0.27 | 0.35 | 0.48 | 0.54 | 0.60 | 100 | 0.21 | 0.27 | 0.35 | 0.48 | 0.54 | 0.60 |
| X3013L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.09 | 0.15 | 0.23 | 0.39 | 0.46 | 0.54 | 100 | 0.09 | 0.15 | 0.23 | 0.39 | 0.46 | 0.54 |
| X3023L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.12 | 0.18 | 0.26 | 0.42 | 0.48 | 0.56 | 100 | 0.12 | 0.18 | 0.26 | 0.42 | 0.48 | 0.56 |
| X3023R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.63 | 0.68 | 0.71 | 0.76 | 0.78 | 0.80 | 100 | 0.63 | 0.68 | 0.71 | 0.76 | 0.78 | 0.80 |
| X3029R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.13 | 0.19 | 0.28 | 0.43 | 0.49 | 0.56 | 100 | 0.13 | 0.19 | 0.28 | 0.43 | 0.49 | 0.56 |
| X3033R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.31 | 0.37 | 0.44 | 0.55 | 0.59 | 0.65 | 100 | 0.31 | 0.37 | 0.44 | 0.55 | 0.59 | 0.65 |
| X3033RA | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.43 | 0.50 | 0.55 | 0.63 | 0.67 | 0.71 | 100 | 0.43 | 0.50 | 0.55 | 0.63 | 0.67 | 0.71 |
| X3036L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.31 | 0.37 | 0.44 | 0.55 | 0.60 | 0.65 | 100 | 0.31 | 0.37 | 0.44 | 0.55 | 0.60 | 0.65 |
| X3038R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 100 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 |
| X3042L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.12 | 0.19 | 0.27 | 0.42 | 0.48 | 0.56 | 100 | 0.12 | 0.19 | 0.27 | 0.42 | 0.48 | 0.56 |
| X3042R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.24 | 0.31 | 0.38 | 0.51 | 0.56 | 0.62 | 100 | 0.24 | 0.31 | 0.38 | 0.51 | 0.56 | 0.62 |
| X3048L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.06 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 | 100 | 0.06 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 |
| X3049R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.20 | 0.26 | 0.34 | 0.47 | 0.53 | 0.60 | 100 | 0.20 | 0.26 | 0.34 | 0.47 | 0.53 | 0.60 |
| X3052L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.25 | 0.31 | 0.38 | 0.51 | 0.56 | 0.62 | 100 | 0.25 | 0.31 | 0.38 | 0.51 | 0.56 | 0.62 |
| X4019R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 | 100 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 |
| X4019RA | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.60 | 0.65 | 0.69 | 0.74 | 0.76 | 0.79 | 100 | 0.60 | 0.65 | 0.69 | 0.74 | 0.76 | 0.79 |
| X4021R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.64 | 0.69 | 0.72 | 0.76 | 0.78 | 0.81 | 100 | 0.64 | 0.69 | 0.72 | 0.76 | 0.78 | 0.81 |
| X4023R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.35 | 0.42 | 0.48 | 0.58 | 0.62 | 0.68 | 100 | 0.35 | 0.42 | 0.48 | 0.58 | 0.62 | 0.68 |
| X4028R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.12 | 0.18 | 0.27 | 0.42 | 0.48 | 0.56 | 100 | 0.12 | 0.18 | 0.27 | 0.42 | 0.48 | 0.56 |
| X4044R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.02 | 0.07 | 0.16 | 0.34 | 0.41 | 0.50 | 100 | 0.02 | 0.07 | 0.16 | 0.34 | 0.41 | 0.50 |
| X4054R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.06 | 0.12 | 0.20 | 0.37 | 0.44 | 0.52 | 100 | 0.06 | 0.12 | 0.20 | 0.37 | 0.44 | 0.52 |
| X4065R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.09 | 0.14 | 0.23 | 0.39 | 0.46 | 0.54 | 100 | 0.09 | 0.14 | 0.23 | 0.39 | 0.46 | 0.54 |
| X4076LA | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.04 | 0.09 | 0.18 | 0.36 | 0.43 | 0.51 | 100 | 0.04 | 0.09 | 0.18 | 0.36 | 0.43 | 0.51 |
| X4076L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.21 | 0.27 | 0.35 | 0.48 | 0.53 | 0.60 | 100 | 0.21 | 0.27 | 0.35 | 0.48 | 0.53 | 0.60 |
| X4082L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 | 100 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 |
| X4087L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.14 | 0.20 | 0.28 | 0.43 | 0.49 | 0.57 | 100 | 0.14 | 0.20 | 0.28 | 0.43 | 0.49 | 0.57 |
| X4091L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.26 | 0.32 | 0.39 | 0.52 | 0.57 | 0.63 | 100 | 0.26 | 0.32 | 0.39 | 0.52 | 0.57 | 0.63 |
| X4096L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.32 | 0.38 | 0.45 | 0.56 | 0.60 | 0.66 | 100 | 0.32 | 0.38 | 0.45 | 0.56 | 0.60 | 0.66 |
| X4114L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.10 | 0.15 | 0.24 | 0.40 | 0.46 | 0.54 | 100 | 0.10 | 0.15 | 0.24 | 0.40 | 0.46 | 0.54 |
| X5006R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.19 | 0.25 | 0.33 | 0.47 | 0.52 | 0.59 | 100 | 0.19 | 0.25 | 0.33 | 0.47 | 0.52 | 0.59 |
| X5007R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.29 | 0.35 | 0.42 | 0.54 | 0.58 | 0.64 | 100 | 0.29 | 0.35 | 0.42 | 0.54 | 0.58 | 0.64 |
| X5011L | | 10 | 100 | | | | | | | 0 | 0.09 | 0.11 | 0.18 | 0.34 | 0.41 | 0.50 | 10 | 0.10 | 0.16 | 0.24 | 0.40 | 0.47 | 0.55 | 100 | 0.11 | 0.17 | 0.26 | 0.44 | 0.51 | 0.59 |
| X5011R | 10 | 90 | | 0.52 | 0.54 | 0.55 | 0.58 | 0.61 | 0.65 | 10 | 0.55 | 0.58 | 0.62 | 0.68 | 0.72 | 0.75 | 90 | | | | | | | 0 | 0.54 | 0.57 | 0.61 | 0.67 | 0.70 | 0.74 |
| X5013L | 10 | 90 | | 0.15 | 0.15 | 0.17 | 0.19 | 0.25 | 0.31 | 10 | 0.17 | 0.20 | 0.27 | 0.41 | 0.47 | 0.55 | 90 | | | | | | | 0 | 0.17 | 0.19 | 0.26 | 0.39 | 0.45 | 0.52 |
| X5023R | 60 | | 40 | 0.08 | 0.08 | 0.09 | 0.11 | 0.16 | 0.23 | 60 | | | | | | | 0 | 0.11 | 0.17 | 0.25 | 0.41 | 0.47 | 0.55 | 40 | 0.09 | 0.12 | 0.15 | 0.23 | 0.29 | 0.36 |
| X5033R | 50 | 10 | 40 | 0.06 | 0.06 | 0.07 | 0.09 | 0.13 | 0.21 | 50 | 0.08 | 0.09 | 0.16 | 0.33 | 0.40 | 0.49 | 10 | 0.08 | 0.14 | 0.23 | 0.39 | 0.46 | 0.54 | 40 | 0.07 | 0.10 | 0.14 | 0.23 | 0.29 | 0.37 |
| X5041R | | 100 | | | | | | | | 0 | 0.09 | 0.11 | 0.18 | 0.34 | 0.41 | 0.49 | 100 | | | | | | | 0 | 0.09 | 0.11 | 0.18 | 0.34 | 0.41 | 0.49 |
| X5045R | | 100 | | | | | | | | 0 | 0.11 | 0.13 | 0.20 | 0.36 | 0.42 | 0.51 | 100 | | | | | | | 0 | 0.11 | 0.13 | 0.20 | 0.36 | 0.42 | 0.51 |
| X5048R | | 100 | | | | | | | | 0 | 0.07 | 0.08 | 0.15 | 0.32 | 0.39 | 0.48 | 100 | | | | | | | 0 | 0.07 | 0.08 | 0.15 | 0.32 | 0.39 | 0.48 |
| X5052L | | 100 | | | | | | | | 0 | 0.13 | 0.16 | 0.23 | 0.38 | 0.44 | 0.52 | 100 | | | | | | | 0 | 0.13 | 0.16 | 0.23 | 0.38 | 0.44 | 0.52 |
| X5064R | | 100 | | | | | | | | 0 | 0.08 | 0.10 | 0.17 | 0.34 | 0.41 | 0.49 | 100 | | | | | | | 0 | 0.08 | 0.10 | 0.17 | 0.34 | 0.41 | 0.49 |
| X5066R | | 100 | | | | | | | | 0 | 0.04 | 0.05 | 0.11 | 0.29 | 0.37 | 0.46 | 100 | | | | | | | 0 | 0.04 | 0.05 | 0.11 | 0.29 | 0.37 | 0.46 |
| X5068R | | 60 | 40 | | | | | | | 0 | 0.06 | 0.08 | 0.14 | 0.32 | 0.39 | 0.48 | 60 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 | 40 | 0.07 | 0.10 | 0.17 | 0.34 | 0.41 | 0.50 |
| X5075R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.08 | 0.13 | 0.22 | 0.39 | 0.45 | 0.53 | 100 | 0.08 | 0.13 | 0.22 | 0.39 | 0.45 | 0.53 |
| X5084R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.11 | 0.17 | 0.25 | 0.41 | 0.47 | 0.55 | 100 | 0.11 | 0.17 | 0.25 | 0.41 | 0.47 | 0.55 |

Notes:
[1] Soil Group based on NRCS Soil Classification Map
[2] C Values obtained from USDCM Manual, March 2017, Chpt 6, Sec 2.5.1, Table 6-4

**SH 119 Bikeway**
**Existing Hydrology Calculations - Rational Method**
**Muller Engineering Company, Inc.**
**CDOT Project Number:** N/A
**Muller Project Number:** 21015

**Originator** ZDS
**Date:** 2/2/2022
**Checker:** ACF
**Date:** 3/1/2022

## TIME OF CONCENTRATION

| BASIN DATA | | | | INITIAL/OVERLAND TIME ($T_i$) | | | | | CHANNELIZED (TRAVEL) TIME ($T_t$) | | | | | | | | TOTAL $t_c$ | $T_c$ CHECK (Urbanized Basins) | | FINAL $t_c$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BASIN ID | AREA (acre) | $C_5$ | Basin Type | LENGTH $L_i$ (ft) | ELEV. START (ft) | ELEV. END (ft) | OVERLAND SLOPE ($S_i$) (ft/ft) | $t_i$ (min)[1] | LENGTH $L_t$ (ft) | ELEV. START (ft) | ELEV. END (ft) | CHANNELIZED SLOPE ($S_t$) (ft/ft) | CONVEYANCE COEFFICIENT Type | CONVEYANCE COEFFICIENT K | Velocity $V_t$ (ft/sec) | $t_t$ (min)[2] | $t_i + t_t$ (min.) | First Design Point | Maximum $t_c$ (min)[3] | $t_{minimum}$= 5 (Urban) $t_{minimum}$= 10 (Non-Urban) |
| X1016L | 10.65 | 0.12 | Non-Urban | 57 | 5329.8 | 5306.5 | 0.409 | 3.9 | 1050 | 5306.5 | 5287.5 | 0.018 | SP | 7 | 0.9 | 18.6 | 22.5 | No | N/A | 22.5 |
| X1017L | 0.70 | 0.42 | Urban | 23 | 5292.0 | 5291.5 | 0.022 | 4.5 | 171 | 5291.5 | 5285.5 | 0.035 | SP | 7 | 1.3 | 2.2 | 6.7 | No | N/A | 6.7 |
| X1018L | 1.91 | 0.11 | Non-Urban | 73 | 5294.2 | 5292.7 | 0.021 | 12.1 | 494 | 5292.7 | 5280.5 | 0.025 | SP | 7 | 1.1 | 7.5 | 19.5 | No | N/A | 19.5 |
| X1021R | 0.28 | 0.86 | Urban | 62 | 5296.50 | 5295.80 | 0.011 | 3.3 | 231 | 5295.80 | 5294.50 | 0.006 | P | 20 | 1.5 | 2.6 | 5.9 | No | N/A | 5.9 |
| X1029R | 101.56 | 0.22 | Non-Urban | 500 | 5373.0 | 5367.0 | 0.012 | 33.5 | 4814 | 5367.0 | 5284.0 | 0.017 | BG | 10 | 1.3 | 61.1 | 94.6 | Yes | 72.5 | 72.5 |
| X1030R | 0.94 | 0.05 | Non-Urban | 21 | 5295.3 | 5294.3 | 0.048 | 5.2 | 910 | 5294.3 | 5285.5 | 0.010 | SP | 7 | 0.7 | 22.0 | 27.2 | Yes | 42.3 | 27.2 |
| X1032R | 0.36 | 0.05 | Non-Urban | 33 | 5287.1 | 5283.7 | 0.103 | 5.0 | 159 | 5283.7 | 5282.5 | 0.008 | SP | 7 | 0.6 | 4.4 | 9.4 | Yes | 28.9 | 10.0 |
| X1034R | 1.25 | 0.05 | Non-Urban | 121 | 5291.8 | 5284.5 | 0.060 | 11.5 | 341 | 5284.5 | 5282.5 | 0.006 | SP | 7 | 0.5 | 10.6 | 22.1 | No | N/A | 22.1 |
| X1047L | 4.98 | 0.08 | Non-Urban | 127 | 5291.7 | 5284.5 | 0.057 | 11.7 | 773 | 5284.5 | 5268.0 | 0.021 | SP | 7 | 1.0 | 12.6 | 24.3 | No | N/A | 24.3 |
| X1047LA | 0.16 | 0.57 | Urban | 77 | 5285.1 | 5281.7 | 0.044 | 5.2 | 63 | 5281.7 | 5277.5 | 0.067 | SP | 7 | 1.8 | 0.6 | 5.8 | No | N/A | 5.8 |
| X1054R | 4.67 | 0.29 | Urban | 194 | 5283.8 | 5279.0 | 0.025 | 15.0 | 608 | 5279.0 | 5271.5 | 0.012 | SP | 7 | 0.8 | 13.0 | 28.1 | No | N/A | 28.1 |
| X1056L | 1.42 | 0.22 | Urban | 97 | 5278.2 | 5274.1 | 0.042 | 9.7 | 252 | 5274.1 | 5267.5 | 0.026 | P | 20 | 3.2 | 1.3 | 11.0 | No | N/A | 11.0 |
| X1069R | 5.56 | 0.05 | Non-Urban | 90 | 5276.5 | 5273.5 | 0.033 | 12.0 | 1251 | 5273.5 | 5244.5 | 0.023 | SP | 7 | 1.1 | 19.6 | 31.6 | No | N/A | 31.6 |
| X1077R | 2.79 | 0.05 | Non-Urban | 205 | 5253.3 | 5248.0 | 0.026 | 19.8 | 448 | 5248.0 | 5241.5 | 0.015 | SP | 7 | 0.8 | 8.9 | 28.7 | No | N/A | 28.7 |
| X1080R | 2.46 | 0.21 | Urban | 119 | 5248.0 | 5241.0 | 0.059 | 9.8 | 290 | 5241.0 | 5237.5 | 0.012 | SP | 7 | 0.8 | 6.3 | 16.1 | No | N/A | 16.1 |
| X1082R | 0.20 | 0.05 | Non-Urban | 52 | 5241.4 | 5237.7 | 0.071 | 7.1 | 50 | 5237.7 | 5235.5 | 0.044 | SP | 7 | 1.5 | 0.6 | 7.7 | No | N/A | 10.0 |
| X1083R | 0.82 | 0.38 | Urban | 195 | 5245.7 | 5236.0 | 0.050 | 10.7 | 38 | 5236.0 | 5235.5 | 0.013 | SP | 7 | 0.8 | 0.8 | 11.5 | No | N/A | 11.5 |
| X1088R | 2.87 | 0.16 | Non-Urban | 133 | 5241.1 | 5237.0 | 0.031 | 13.5 | 399 | 5237.0 | 5231.5 | 0.014 | SP | 7 | 0.8 | 8.1 | 21.6 | No | N/A | 21.6 |
| X2010R | 8.15 | 0.10 | Non-Urban | 449 | 5241.1 | 5230.0 | 0.025 | 28.5 | 2109 | 5230.0 | 5205.5 | 0.012 | SP | 7 | 0.8 | 46.6 | 75.1 | No | N/A | 75.1 |
| X2019R | 4.76 | 0.05 | Non-Urban | 500 | 5220.0 | 5210.3 | 0.019 | 34.0 | 1191 | 5210.3 | 5199.5 | 0.009 | SP | 7 | 0.7 | 29.8 | 63.8 | No | N/A | 63.8 |
| X2022R | 0.12 | 0.26 | Urban | 32 | 5201.5 | 5198.0 | 0.109 | 3.9 | 67 | 5198.0 | 5197.5 | 0.007 | SP | 7 | 0.6 | 1.8 | 5.7 | No | N/A | 5.7 |
| X2022RA | 1.16 | 0.05 | Non-Urban | 213 | 5202.5 | 5199.0 | 0.016 | 23.5 | 177 | 5199.0 | 5197.5 | 0.008 | SP | 7 | 0.6 | 4.6 | 28.0 | No | N/A | 28.0 |
| X2031R | 3.60 | 0.07 | Non-Urban | 158 | 5201.5 | 5195.6 | 0.037 | 15.2 | 849 | 5195.6 | 5175.0 | 0.024 | SP | 7 | 1.1 | 13.0 | 28.2 | No | N/A | 28.2 |
| X2056R | 9.09 | 0.10 | Non-Urban | 438 | 5182.0 | 5164.0 | 0.041 | 23.7 | 2024 | 5164.0 | 5145.5 | 0.009 | SP | 7 | 0.7 | 50.4 | 74.1 | No | N/A | 74.1 |
| X2060R | 5.16 | 0.36 | Urban | 175 | 5164.8 | 5156.0 | 0.050 | 10.3 | 433 | 5156.0 | 5147.0 | 0.021 | SP | 7 | 1.0 | 7.2 | 17.5 | No | N/A | 17.5 |
| X2064R | 5.43 | 0.21 | Urban | 269 | 5169.3 | 5163.0 | 0.023 | 19.8 | 724 | 5163.0 | 5149.0 | 0.019 | SP | 7 | 1.0 | 12.4 | 32.2 | Yes | 29.5 | 29.5 |
| X2079R | 3.14 | 0.16 | Non-Urban | 477 | 5169.2 | 5156.0 | 0.028 | 26.4 | 323 | 5156.0 | 5138.0 | 0.056 | SP | 7 | 1.7 | 3.3 | 29.7 | No | N/A | 29.7 |
| X2085R | 3.26 | 0.15 | Non-Urban | 97 | 5151.4 | 5140.1 | 0.116 | 7.5 | 520 | 5140.1 | 5136.5 | 0.007 | SP | 7 | 0.6 | 14.9 | 22.4 | No | N/A | 22.4 |
| X2090R | 4.38 | 0.12 | Non-Urban | 201 | 5152.1 | 5145.7 | 0.032 | 17.2 | 809 | 5145.7 | 5130.0 | 0.019 | SP | 7 | 1.0 | 13.8 | 31.0 | No | N/A | 31.0 |
| X2099R | 0.44 | 0.19 | Non-Urban | 141 | 5152.5 | 5148.0 | 0.032 | 13.3 | 76 | 5148.0 | 5145.5 | 0.033 | SP | 7 | 1.3 | 1.0 | 14.3 | No | N/A | 14.3 |
| X2100R | 4.37 | 0.12 | Non-Urban | 182 | 5170.2 | 5165.2 | 0.027 | 17.0 | 1048 | 5165.2 | 5148.5 | 0.016 | SP | 7 | 0.9 | 19.8 | 36.8 | No | N/A | 36.8 |
| X3008L | 4.08 | 0.14 | Non-Urban | 78 | 5175.0 | 5169.0 | 0.077 | 7.8 | 884 | 5169.0 | 5160.5 | 0.010 | SP | 7 | 0.7 | 21.5 | 29.3 | No | N/A | 29.3 |
| X3008R | 2.61 | 0.27 | Urban | 146 | 5170.2 | 5164.8 | 0.037 | 11.7 | 655 | 5164.8 | 5161.5 | 0.005 | SP | 7 | 0.5 | 22.0 | 33.7 | No | N/A | 33.7 |
| X3013L | 2.81 | 0.15 | Non-Urban | 48 | 5165.1 | 5162.0 | 0.065 | 6.4 | 507 | 5162.0 | 5157.5 | 0.009 | SP | 7 | 0.7 | 12.8 | 19.3 | No | N/A | 19.3 |
| X3023L | 10.96 | 0.18 | Non-Urban | 408 | 5165.2 | 5157.0 | 0.020 | 26.6 | 592 | 5157.0 | 5152.0 | 0.008 | SP | 7 | 0.6 | 15.3 | 41.9 | No | N/A | 41.9 |
| X3023R | 1.18 | 0.68 | Urban | 25 | 5162.2 | 5160.0 | 0.088 | 1.9 | 1070 | 5160.00 | 5155.2 | 0.004 | P | 20 | 1.3 | 13.3 | 15.2 | Yes | 26.1 | 15.2 |
| X3029R | 13.74 | 0.19 | Non-Urban | 346 | 5161.0 | 5154.0 | 0.020 | 24.1 | 1199 | 5154.0 | 5147.5 | 0.005 | GW | 15 | 1.1 | 18.1 | 42.2 | No | N/A | 42.2 |
| X3033R | 17.48 | 0.37 | Urban | 300 | 5161.0 | 5156.5 | 0.015 | 19.9 | 1301 | 5156.5 | 5144.5 | 0.009 | SP | 7 | 0.7 | 32.3 | 52.1 | Yes | 34.3 | 34.3 |
| X3033RA | 0.74 | 0.50 | Urban | 22 | 5155.4 | 5155.0 | 0.018 | 4.2 | 815 | 5155.00 | 5147.0 | 0.010 | SP | 7 | 0.7 | 19.6 | 23.8 | Yes | 24.6 | 23.8 |
| X3036L | 24.91 | 0.37 | Urban | 300 | 5160.5 | 5154.7 | 0.019 | 18.2 | 1950 | 5154.7 | 5140.0 | 0.008 | SP | 7 | 0.6 | 53.5 | 71.7 | No | N/A | 71.7 |
| X3038R | 1.07 | 0.21 | Urban | 31 | 5150.6 | 5148.3 | 0.074 | 4.6 | 511 | 5148.3 | 5142.0 | 0.012 | SP | 7 | 0.8 | 11.0 | 15.6 | No | N/A | 15.6 |
| X3042L | 2.30 | 0.19 | Non-Urban | 356 | 5148.2 | 5143.0 | 0.015 | 27.5 | 212 | 5143.0 | 5141.0 | 0.009 | SP | 7 | 0.7 | 5.2 | 32.7 | No | N/A | 32.7 |
| X3042R | 1.36 | 0.31 | Urban | 79 | 5148.3 | 5144.8 | 0.044 | 7.8 | 318 | 5144.80 | 5140.0 | 0.015 | SP | 7 | 0.9 | 6.2 | 13.9 | Yes | 23.5 | 13.9 |
| X3048L | 22.96 | 0.11 | Non-Urban | 488 | 5160.5 | 5152.0 | 0.017 | 32.9 | 1518 | 5152.0 | 5133.0 | 0.013 | SP | 7 | 0.8 | 32.3 | 65.2 | No | N/A | 65.2 |
| X3049R | 3.63 | 0.26 | Urban | 100 | 5144.7 | 5140.0 | 0.047 | 9.1 | 752 | 5140.0 | 5131.0 | 0.012 | SP | 7 | 0.8 | 16.4 | 25.4 | Yes | 30.2 | 25.4 |
| X3052L | 0.61 | 0.31 | Urban | 52 | 5137.5 | 5136.0 | 0.029 | 7.2 | 178 | 5136.0 | 5132.0 | 0.022 | SP | 7 | 1.0 | 2.8 | 10.0 | No | N/A | 10.0 |
| X4019R | 16.48 | 0.10 | Non-Urban | 304 | 5135.6 | 5130.0 | 0.018 | 25.7 | 3150 | 5130.0 | 5105.0 | 0.008 | SP | 7 | 0.6 | 84.2 | 109.9 | No | N/A | 109.9 |
| X4019RA | 0.21 | 0.65 | Urban | 73 | 5111.5 | 5110.5 | 0.014 | 6.2 | 53 | 5110.5 | 5107.7 | 0.053 | SP | 7 | 1.6 | 0.5 | 6.8 | No | N/A | 6.8 |
| X4021R | 0.35 | 0.69 | Urban | 62 | 5110.2 | 5109.0 | 0.019 | 4.7 | 136 | 5109.0 | 5106.5 | 0.018 | SP | 7 | 0.9 | 2.4 | 7.1 | No | N/A | 7.1 |
| X4023R | 3.89 | 0.42 | Urban | 241 | 5111.2 | 5109.0 | 0.009 | 19.7 | 487 | 5109.0 | 5103.5 | 0.011 | SP | 7 | 0.7 | 10.9 | 30.6 | No | N/A | 30.6 |
| X4028R | 2.91 | 0.18 | Non-Urban | 98 | 5108.5 | 5104.0 | 0.046 | 9.9 | 415 | 5104.0 | 5099.0 | 0.012 | P | 20 | 2.2 | 3.2 | 13.0 | No | N/A | 13.0 |
| X4044R | 7.65 | 0.07 | Non-Urban | 500 | 5105.0 | 5098.8 | 0.012 | 38.9 | 1244 | 5098.8 | 5085.0 | 0.011 | SP | 7 | 0.7 | 28.1 | 67.0 | No | N/A | 67.0 |
| X4054R | 4.90 | 0.12 | Non-Urban | 211 | 5094.7 | 5088.0 | 0.032 | 17.6 | 990 | 5088.0 | 5081.0 | 0.007 | SP | 7 | 0.6 | 28.0 | 45.7 | No | N/A | 45.7 |
| X4065R | 4.64 | 0.14 | Non-Urban | 243 | 5086.2 | 5082.0 | 0.017 | 22.5 | 727 | 5082.0 | 5070.0 | 0.017 | SP | 7 | 0.9 | 13.5 | 35.9 | No | N/A | 35.9 |
| X4076LA | 4.51 | 0.09 | Non-Urban | 167 | 5079.5 | 5073.0 | 0.039 | 15.0 | 1121 | 5073.0 | 5062.5 | 0.009 | SP | 7 | 0.7 | 27.6 | 42.6 | No | N/A | 42.6 |
| X4076L | 0.60 | 0.27 | Urban | 300 | 5074.8 | 5067.2 | 0.025 | 19.1 | 186 | 5067.2 | 5063.8 | 0.018 | SP | 7 | 0.9 | 3.3 | 22.3 | No | N/A | 22.3 |
| X4082L | 2.95 | 0.12 | Non-Urban | 119 | 5072.0 | 5066.0 | 0.050 | 11.3 | 673 | 5066.0 | 5060.0 | 0.009 | SP | 7 | 0.7 | 17.0 | 28.3 | No | N/A | 28.3 |
| X4087L | 3.13 | 0.20 | Urban | 85 | 5064.9 | 5060.5 | 0.052 | 8.7 | 481 | 5060.5 | 5057.0 | 0.007 | SP | 7 | 0.6 | 13.4 | 22.1 | Yes | 30.5 | 22.1 |
| X4091L | 2.40 | 0.32 | Urban | 123 | 5064.4 | 5058.0 | 0.052 | 9.0 | 222 | 5058.0 | 5056.5 | 0.007 | SP | 7 | 0.6 | 6.4 | 15.4 | No | N/A | 15.4 |
| X4096L | 0.92 | 0.38 | Urban | 177 | 5064.2 | 5059.0 | 0.029 | 12.1 | 105 | 5059.0 | 5058.0 | 0.010 | SP | 7 | 0.7 | 2.6 | 14.6 | No | N/A | 14.6 |
| X4114L | 8.50 | 0.15 | Non-Urban | 500 | 5063.2 | 5056.0 | 0.014 | 33.9 | 1490 | 5056.0 | 5036.0 | 0.013 | SP | 7 | 0.8 | 30.6 | 64.5 | No | N/A | 64.5 |
| X5006R | 1.44 | 0.25 | Urban | 51 | 5045.7 | 5041.20 | 0.088 | 5.3 | 644 | 5041.20 | 5029.00 | 0.019 | SP | 7 | 1.0 | 11.1 | 16.5 | Yes | 27.6 | 16.5 |
| X5007R | 0.10 | 0.35 | Urban | 34 | 5040.2 | 5039.2 | 0.029 | 5.5 | 69 | 5039.20 | 5034.00 | 0.075 | SP | 7 | 1.9 | 0.6 | 6.1 | Yes | 19.7 | 6.1 |
| X5011L | 8.78 | 0.17 | Non-Urban | 468 | 5048.1 | 5034.0 | 0.030 | 25.3 | 1223 | 5034.0 | 5022.5 | 0.009 | SP | 7 | 0.7 | 30.0 | 55.3 | No | N/A | 55.3 |
| X5011R | 0.27 | 0.57 | Urban | 120 | 5030.00 | 5028.00 | 0.017 | 8.8 | 32 | 5028.00 | 5025.50 | 0.078 | SP | 7 | 2.0 | 0.3 | 9.1 | Yes | 14.4 | 9.1 |
| X5013L | 3.08 | 0.19 | Urban | 300 | 5038.0 | 5024.0 | 0.047 | 17.0 | 224 | 5024.0 | 5022.5 | 0.007 | SP | 7 | 0.6 | 6.5 | 23.6 | No | N/A | 23.6 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X5023R | 6.91 | 0.12 | Non-Urban | 500 | 5029.1 | 5021.5 | 0.015 | 34.6 | 509 | 5021.5 | 5019.5 | 0.004 | SP | 7 | 0.4 | 19.3 | 53.9 | No | N/A | 53.9 |
| X5033R | 7.15 | 0.10 | Non-Urban | 500 | 5029.1 | 5021.3 | 0.016 | 35.0 | 619 | 5021.3 | 5005.5 | 0.026 | SP | 7 | 1.1 | 9.2 | 44.2 | No | N/A | 44.2 |
| X5041R | 1.78 | 0.11 | Non-Urban | 152 | 5020.2 | 5017.0 | 0.021 | 17.3 | 133 | 5017.0 | 5013.5 | 0.026 | SP | 7 | 1.1 | 2.0 | 19.3 | No | N/A | 19.3 |
| X5045R | 0.92 | 0.13 | Non-Urban | 212 | 5017.2 | 5015.5 | 0.008 | 27.5 | 174 | 5015.5 | 5010.0 | 0.032 | SP | 7 | 1.2 | 2.3 | 29.9 | No | N/A | 29.9 |
| X5048R | 2.21 | 0.08 | Non-Urban | 79 | 5018.9 | 5016.0 | 0.037 | 10.6 | 630 | 5016.0 | 5009.5 | 0.010 | SP | 7 | 0.7 | 14.8 | 25.4 | No | N/A | 25.4 |
| X5052L | 1.93 | 0.16 | Urban | 286 | 5016.0 | 5012.0 | 0.014 | 25.8 | 139 | 5012.0 | 5011.5 | 0.004 | SP | 7 | 0.4 | 5.5 | 31.3 | No | N/A | 31.3 |
| X5064R | 9.61 | 0.10 | Non-Urban | 386 | 5014.8 | 5009.4 | 0.014 | 31.7 | 961 | 5009.4 | 5001.5 | 0.008 | SP | 7 | 0.6 | 25.2 | 56.9 | No | N/A | 56.9 |
| X5066R | 4.10 | 0.05 | Non-Urban | 489 | 5012.2 | 5005.0 | 0.015 | 37.0 | 363 | 5005.0 | 5001.5 | 0.010 | SP | 7 | 0.7 | 8.8 | 45.8 | No | N/A | 45.8 |
| X5068R | 11.18 | 0.10 | Non-Urban | 90 | 5029.5 | 5023.5 | 0.067 | 9.2 | 1175 | 5023.5 | 5000.0 | 0.020 | SP | 7 | 1.0 | 19.8 | 29.0 | No | N/A | 29.0 |
| X5075R | 9.68 | 0.13 | Non-Urban | 47 | 5027.0 | 5025.0 | 0.043 | 7.4 | 1235 | 5025.0 | 5006.5 | 0.015 | SP | 7 | 0.9 | 24.0 | 31.4 | No | N/A | 31.4 |
| X5084R | 6.80 | 0.17 | Non-Urban | 354 | 5033.0 | 5020.5 | 0.035 | 20.8 | 507 | 5020.5 | 5014.5 | 0.012 | SP | 7 | 0.8 | 11.1 | 31.9 | No | N/A | 31.9 |

Notes:

1 $t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_o^{0.33}}$ USDCM Equation 6-3, August 2018

2 $t_t = \frac{Length}{60 * V_t}$ Where, V = K * $S^{0.5}$ and K = 2.5 (Heavy Meadows), 5 (Tillage / Field), 7 (Short Pasture / Lawns), 10 (Nearly Bare Ground), 15, (Grassed Waterway), 20 (Paved) - USDCM Equation 6-4 August 2018

3 $t_c = 26 - 17i \frac{L_t}{60(14i + 9)\sqrt{S_t}}$ USDCM Equation 6-5 August 2018

**SH 119 Bikeway**
**Existing Hydrology Calculations - Rational Method**
**Muller Engineering Company, Inc.**

**CDOT Project Number:** N/A

**Muller Project Number:** 21015

**Originator** ZDS
**Date:** 2/2/2022
**Checker:** ACF
**Date:** 3/1/2022

## INTENSITY VALUES

| Storm Event | 2-Year | 5-Year | 10-Year | 25-Year | 50-Year | 100-Year |
|---|---|---|---|---|---|---|
| One-Hour Point Rainfall Values (P1) (inches) | 1.01 | 1.44 | 1.73 | 2.09 | 2.42 | 2.74 |

Boulder County Storm Drainage Criteria Manual, NOAA Atlas 2 Vol 3 (Region 1, Boulder, CO)

## RATIONAL FLOWS

| BASIN ID | AREA (acre) | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | $I_2$ (in/hr) | $I_5$ (in/hr) | $I_{10}$ (in/hr) | $I_{25}$ (in/hr) | $I_{50}$ (in/hr) | $I_{100}$ (in/hr) | $Q_2$ (cfs) | $Q_5$ (cfs) | $Q_{10}$ (cfs) | $Q_{25}$ (cfs) | $Q_{50}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X1016L | 10.65 | 0.10 | 0.12 | 0.19 | 0.35 | 0.42 | 0.50 | 1.86 | 2.66 | 3.19 | 3.86 | 4.47 | 5.06 | 1.9 | 3.3 | 6.3 | 14.3 | 19.8 | 27.0 |
| X1017L | 0.70 | 0.39 | 0.42 | 0.48 | 0.58 | 0.62 | 0.67 | 3.15 | 4.49 | 5.39 | 6.51 | 7.54 | 8.54 | 0.9 | 1.3 | 1.8 | 2.6 | 3.3 | 4.0 |
| X1018L | 1.91 | 0.09 | 0.11 | 0.18 | 0.35 | 0.41 | 0.50 | 2.01 | 2.87 | 3.44 | 4.16 | 4.82 | 5.46 | 0.3 | 0.6 | 1.2 | 2.7 | 3.8 | 5.2 |
| X1021R | 0.28 | 0.84 | 0.86 | 0.87 | 0.88 | 0.89 | 0.90 | 3.28 | 4.68 | 5.62 | 6.79 | 7.86 | 8.90 | 0.8 | 1.1 | 1.4 | 1.7 | 2.0 | 2.2 |
| X1029R | 101.56 | 0.16 | 0.22 | 0.30 | 0.45 | 0.50 | 0.58 | 0.90 | 1.28 | 1.54 | 1.86 | 2.15 | 2.43 | 14.2 | 28.5 | 46.6 | 83.9 | 109.9 | 142.5 |
| X1030R | 0.94 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 1.68 | 2.39 | 2.87 | 3.47 | 4.02 | 4.55 | 0.0 | 0.1 | 0.4 | 1.1 | 1.5 | 2.1 |
| X1032R | 0.36 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 2.73 | 3.90 | 4.68 | 5.65 | 6.55 | 7.41 | 0.0 | 0.1 | 0.2 | 0.7 | 1.0 | 1.3 |
| X1034R | 1.25 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 1.88 | 2.69 | 3.23 | 3.90 | 4.51 | 5.11 | 0.0 | 0.2 | 0.6 | 1.6 | 2.3 | 3.1 |
| X1047L | 4.98 | 0.04 | 0.08 | 0.18 | 0.35 | 0.42 | 0.51 | 1.79 | 2.55 | 3.07 | 3.70 | 4.29 | 4.86 | 0.3 | 1.1 | 2.7 | 6.5 | 9.0 | 12.3 |
| X1047LA | 0.16 | 0.51 | 0.57 | 0.61 | 0.68 | 0.71 | 0.75 | 3.29 | 4.70 | 5.64 | 6.81 | 7.89 | 8.93 | 0.3 | 0.4 | 0.5 | 0.7 | 0.9 | 1.1 |
| X1054R | 4.67 | 0.23 | 0.29 | 0.37 | 0.50 | 0.55 | 0.61 | 1.65 | 2.35 | 2.82 | 3.41 | 3.95 | 4.47 | 1.7 | 3.2 | 4.8 | 7.9 | 10.1 | 12.8 |
| X1056L | 1.42 | 0.16 | 0.22 | 0.30 | 0.45 | 0.50 | 0.58 | 2.63 | 3.75 | 4.50 | 5.44 | 6.30 | 7.13 | 0.6 | 1.2 | 1.9 | 3.4 | 4.5 | 5.8 |
| X1069R | 5.56 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 1.54 | 2.19 | 2.63 | 3.18 | 3.68 | 4.17 | 0.1 | 0.7 | 2.2 | 5.9 | 8.3 | 11.4 |
| X1077R | 2.79 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 1.63 | 2.32 | 2.79 | 3.37 | 3.90 | 4.42 | 0.0 | 0.3 | 1.1 | 3.1 | 4.4 | 6.1 |
| X1080R | 2.46 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 2.22 | 3.16 | 3.80 | 4.59 | 5.32 | 6.02 | 0.8 | 1.6 | 2.7 | 4.9 | 6.5 | 8.5 |
| X1082R | 0.20 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 2.73 | 3.90 | 4.68 | 5.65 | 6.55 | 7.41 | 0.0 | 0.0 | 0.1 | 0.4 | 0.5 | 0.7 |
| X1083R | 0.82 | 0.31 | 0.38 | 0.44 | 0.55 | 0.60 | 0.65 | 2.58 | 3.68 | 4.42 | 5.33 | 6.18 | 6.99 | 0.7 | 1.1 | 1.6 | 2.4 | 3.0 | 3.8 |
| X1088R | 2.87 | 0.10 | 0.16 | 0.24 | 0.40 | 0.47 | 0.55 | 1.91 | 2.72 | 3.27 | 3.95 | 4.57 | 5.18 | 0.5 | 1.2 | 2.3 | 4.6 | 6.1 | 8.1 |
| X2010R | 8.15 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.51 | 0.88 | 1.25 | 1.50 | 1.81 | 2.10 | 2.38 | 0.3 | 1.0 | 2.3 | 5.3 | 7.3 | 10.0 |
| X2019R | 4.76 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 0.98 | 1.40 | 1.68 | 2.03 | 2.35 | 2.66 | 0.0 | 0.3 | 1.2 | 3.2 | 4.5 | 6.2 |
| X2022R | 0.12 | 0.19 | 0.26 | 0.33 | 0.47 | 0.53 | 0.60 | 3.30 | 4.70 | 5.65 | 6.82 | 7.90 | 8.95 | 0.1 | 0.2 | 0.2 | 0.4 | 0.5 | 0.7 |
| X2022RA | 1.16 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 1.65 | 2.35 | 2.82 | 3.41 | 3.95 | 4.47 | 0.0 | 0.1 | 0.5 | 1.3 | 1.9 | 2.6 |
| X2031R | 3.60 | 0.02 | 0.07 | 0.16 | 0.34 | 0.41 | 0.50 | 1.64 | 2.34 | 2.82 | 3.40 | 3.94 | 4.46 | 0.1 | 0.6 | 1.6 | 4.2 | 5.9 | 8.0 |
| X2056R | 9.09 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 | 0.88 | 1.26 | 1.51 | 1.83 | 2.12 | 2.40 | 0.4 | 1.2 | 2.6 | 6.0 | 8.3 | 11.3 |
| X2060R | 5.16 | 0.30 | 0.36 | 0.43 | 0.54 | 0.59 | 0.65 | 2.13 | 3.03 | 3.65 | 4.40 | 5.10 | 5.77 | 3.3 | 5.7 | 8.0 | 12.3 | 15.5 | 19.3 |
| X2064R | 5.43 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 1.60 | 2.28 | 2.74 | 3.31 | 3.83 | 4.34 | 1.3 | 2.6 | 4.3 | 7.9 | 10.4 | 13.5 |
| X2079R | 3.14 | 0.10 | 0.16 | 0.25 | 0.41 | 0.47 | 0.55 | 1.60 | 2.27 | 2.73 | 3.30 | 3.82 | 4.33 | 0.5 | 1.2 | 2.1 | 4.2 | 5.6 | 7.5 |
| X2085R | 3.26 | 0.09 | 0.15 | 0.23 | 0.40 | 0.46 | 0.54 | 1.87 | 2.67 | 3.20 | 3.87 | 4.48 | 5.07 | 0.6 | 1.3 | 2.5 | 5.0 | 6.7 | 8.9 |
| X2090R | 4.38 | 0.06 | 0.12 | 0.21 | 0.38 | 0.44 | 0.53 | 1.55 | 2.22 | 2.66 | 3.22 | 3.72 | 4.22 | 0.4 | 1.1 | 2.4 | 5.3 | 7.2 | 9.7 |
| X2099R | 0.44 | 0.13 | 0.19 | 0.27 | 0.42 | 0.48 | 0.56 | 2.34 | 3.34 | 4.01 | 4.85 | 5.61 | 6.36 | 0.1 | 0.3 | 0.5 | 0.9 | 1.2 | 1.6 |
| X2100R | 4.37 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 | 1.40 | 2.00 | 2.40 | 2.90 | 3.36 | 3.80 | 0.4 | 1.1 | 2.2 | 4.8 | 6.5 | 8.8 |
| X3008L | 4.08 | 0.08 | 0.14 | 0.22 | 0.39 | 0.45 | 0.53 | 1.61 | 2.29 | 2.75 | 3.32 | 3.85 | 4.36 | 0.5 | 1.3 | 2.5 | 5.3 | 7.1 | 9.5 |
| X3008R | 2.61 | 0.21 | 0.27 | 0.35 | 0.48 | 0.54 | 0.60 | 1.48 | 2.11 | 2.53 | 3.06 | 3.54 | 4.01 | 0.8 | 1.5 | 2.3 | 3.8 | 4.9 | 6.3 |
| X3013L | 2.81 | 0.09 | 0.15 | 0.23 | 0.39 | 0.46 | 0.54 | 2.03 | 2.89 | 3.47 | 4.19 | 4.85 | 5.50 | 0.5 | 1.2 | 2.3 | 4.7 | 6.3 | 8.3 |
| X3023L | 10.96 | 0.12 | 0.18 | 0.26 | 0.42 | 0.48 | 0.56 | 1.29 | 1.84 | 2.21 | 2.67 | 3.09 | 3.50 | 1.7 | 3.7 | 6.4 | 12.3 | 16.3 | 21.4 |
| X3023R | 1.18 | 0.63 | 0.68 | 0.71 | 0.76 | 0.78 | 0.80 | 2.28 | 3.25 | 3.91 | 4.72 | 5.46 | 6.18 | 1.7 | 2.6 | 3.3 | 4.2 | 5.0 | 5.9 |
| X3029R | 13.74 | 0.13 | 0.19 | 0.28 | 0.43 | 0.49 | 0.56 | 1.29 | 1.83 | 2.20 | 2.66 | 3.08 | 3.49 | 2.3 | 4.9 | 8.3 | 15.6 | 20.6 | 27.0 |
| X3033R | 17.48 | 0.31 | 0.37 | 0.44 | 0.55 | 0.59 | 0.65 | 1.46 | 2.09 | 2.51 | 3.03 | 3.50 | 3.97 | 7.8 | 13.6 | 19.1 | 29.1 | 36.4 | 45.3 |
| X3033RA | 0.74 | 0.43 | 0.50 | 0.55 | 0.63 | 0.67 | 0.71 | 1.81 | 2.58 | 3.10 | 3.74 | 4.34 | 4.91 | 0.6 | 1.0 | 1.3 | 1.8 | 2.2 | 2.6 |
| X3036L | 24.91 | 0.31 | 0.37 | 0.44 | 0.55 | 0.60 | 0.65 | 0.90 | 1.29 | 1.55 | 1.87 | 2.17 | 2.45 | 7.0 | 12.0 | 16.9 | 25.7 | 32.2 | 39.9 |
| X3038R | 1.07 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 2.25 | 3.21 | 3.86 | 4.66 | 5.40 | 6.11 | 0.4 | 0.7 | 1.2 | 2.2 | 2.9 | 3.7 |
| X3042L | 2.30 | 0.12 | 0.19 | 0.27 | 0.42 | 0.48 | 0.56 | 1.51 | 2.15 | 2.58 | 3.12 | 3.61 | 4.09 | 0.4 | 0.9 | 1.6 | 3.0 | 4.0 | 5.3 |
| X3042R | 1.36 | 0.24 | 0.31 | 0.38 | 0.51 | 0.56 | 0.62 | 2.37 | 3.38 | 4.06 | 4.91 | 5.68 | 6.44 | 0.8 | 1.4 | 2.1 | 3.4 | 4.3 | 5.4 |
| X3048L | 22.96 | 0.06 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 | 0.96 | 1.38 | 1.65 | 2.00 | 2.31 | 2.62 | 1.2 | 3.5 | 7.6 | 17.0 | 23.2 | 31.3 |
| X3049R | 3.63 | 0.20 | 0.26 | 0.34 | 0.47 | 0.53 | 0.60 | 1.74 | 2.48 | 2.99 | 3.61 | 4.18 | 4.73 | 1.2 | 2.4 | 3.7 | 6.2 | 8.0 | 10.3 |
| X3052L | 0.61 | 0.25 | 0.31 | 0.38 | 0.51 | 0.56 | 0.62 | 2.73 | 3.89 | 4.67 | 5.64 | 6.53 | 7.40 | 0.4 | 0.7 | 1.1 | 1.7 | 2.2 | 2.8 |
| X4019R | 16.48 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 | 0.67 | 0.95 | 1.15 | 1.38 | 1.60 | 1.81 | 0.5 | 1.6 | 3.6 | 8.3 | 11.4 | 15.4 |
| X4019RA | 0.21 | 0.60 | 0.65 | 0.69 | 0.74 | 0.76 | 0.79 | 3.14 | 4.48 | 5.38 | 6.50 | 7.52 | 8.52 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X4021R | 0.35 | 0.64 | 0.69 | 0.72 | 0.76 | 0.78 | 0.81 | 3.09 | 4.40 | 5.29 | 6.39 | 7.40 | 8.37 | 0.7 | 1.0 | 1.3 | 1.7 | 2.0 | 2.3 |
| X4023R | 3.89 | 0.35 | 0.42 | 0.48 | 0.58 | 0.62 | 0.68 | 1.57 | 2.23 | 2.68 | 3.24 | 3.75 | 4.25 | 2.2 | 3.6 | 5.0 | 7.3 | 9.1 | 11.2 |
| X4028R | 2.91 | 0.12 | 0.18 | 0.27 | 0.42 | 0.48 | 0.56 | 2.44 | 3.49 | 4.19 | 5.06 | 5.86 | 6.63 | 0.9 | 1.9 | 3.2 | 6.2 | 8.2 | 10.8 |
| X4044R | 7.65 | 0.02 | 0.07 | 0.16 | 0.34 | 0.41 | 0.50 | 0.95 | 1.35 | 1.62 | 1.96 | 2.27 | 2.57 | 0.1 | 0.7 | 2.0 | 5.1 | 7.1 | 9.8 |
| X4054R | 4.90 | 0.06 | 0.12 | 0.20 | 0.37 | 0.44 | 0.52 | 1.22 | 1.74 | 2.09 | 2.53 | 2.93 | 3.32 | 0.4 | 1.0 | 2.1 | 4.6 | 6.3 | 8.5 |
| X4065R | 4.64 | 0.09 | 0.14 | 0.23 | 0.39 | 0.46 | 0.54 | 1.42 | 2.03 | 2.43 | 2.94 | 3.41 | 3.86 | 0.6 | 1.4 | 2.6 | 5.4 | 7.2 | 9.6 |
| X4076LA | 4.51 | 0.04 | 0.09 | 0.18 | 0.36 | 0.43 | 0.51 | 1.28 | 1.82 | 2.19 | 2.64 | 3.06 | 3.47 | 0.2 | 0.7 | 1.8 | 4.3 | 5.9 | 8.0 |
| X4076L | 0.60 | 0.21 | 0.27 | 0.35 | 0.48 | 0.53 | 0.60 | 1.87 | 2.67 | 3.21 | 3.87 | 4.49 | 5.08 | 0.2 | 0.4 | 0.7 | 1.1 | 1.4 | 1.8 |
| X4082L | 2.95 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 | 1.64 | 2.34 | 2.81 | 3.40 | 3.93 | 4.45 | 0.3 | 0.8 | 1.7 | 3.8 | 5.2 | 6.9 |
| X4087L | 3.13 | 0.14 | 0.20 | 0.28 | 0.43 | 0.49 | 0.57 | 1.88 | 2.68 | 3.23 | 3.90 | 4.51 | 5.11 | 0.8 | 1.7 | 2.9 | 5.3 | 7.0 | 9.1 |
| X4091L | 2.40 | 0.26 | 0.32 | 0.39 | 0.52 | 0.57 | 0.63 | 2.26 | 3.22 | 3.87 | 4.68 | 5.42 | 6.13 | 1.4 | 2.5 | 3.7 | 5.8 | 7.4 | 9.3 |
| X4096L | 0.92 | 0.32 | 0.38 | 0.45 | 0.56 | 0.60 | 0.66 | 2.32 | 3.31 | 3.98 | 4.80 | 5.56 | 6.30 | 0.7 | 1.2 | 1.6 | 2.5 | 3.1 | 3.8 |
| X4114L | 8.50 | 0.10 | 0.15 | 0.24 | 0.40 | 0.46 | 0.54 | 0.97 | 1.39 | 1.67 | 2.01 | 2.33 | 2.64 | 0.8 | 1.8 | 3.4 | 6.8 | 9.2 | 12.2 |
| X5006R | 1.44 | 0.19 | 0.25 | 0.33 | 0.47 | 0.52 | 0.59 | 2.19 | 3.13 | 3.76 | 4.54 | 5.25 | 5.95 | 0.6 | 1.1 | 1.8 | 3.1 | 4.0 | 5.1 |
| X5007R | 0.10 | 0.29 | 0.35 | 0.42 | 0.54 | 0.58 | 0.64 | 3.24 | 4.62 | 5.55 | 6.70 | 7.76 | 8.79 | 0.1 | 0.2 | 0.2 | 0.4 | 0.5 | 0.6 |
| X5011L | 8.78 | 0.11 | 0.17 | 0.26 | 0.44 | 0.51 | 0.59 | 1.08 | 1.54 | 1.85 | 2.23 | 2.58 | 2.92 | 1.0 | 2.3 | 4.2 | 8.6 | 11.5 | 15.3 |
| X5011R | 0.27 | 0.54 | 0.57 | 0.61 | 0.67 | 0.70 | 0.74 | 2.83 | 4.04 | 4.85 | 5.86 | 6.79 | 7.69 | 0.4 | 0.6 | 0.8 | 1.1 | 1.3 | 1.5 |
| X5013L | 3.08 | 0.17 | 0.19 | 0.26 | 0.39 | 0.45 | 0.52 | 1.82 | 2.59 | 3.12 | 3.76 | 4.36 | 4.94 | 1.0 | 1.6 | 2.5 | 4.5 | 6.1 | 8.0 |
| X5023R | 6.91 | 0.09 | 0.12 | 0.15 | 0.23 | 0.29 | 0.36 | 1.10 | 1.56 | 1.88 | 2.27 | 2.63 | 2.97 | 0.7 | 1.3 | 2.0 | 3.6 | 5.2 | 7.4 |
| X5033R | 7.15 | 0.07 | 0.10 | 0.14 | 0.23 | 0.29 | 0.37 | 1.25 | 1.78 | 2.14 | 2.58 | 2.99 | 3.38 | 0.6 | 1.2 | 2.2 | 4.3 | 6.2 | 8.9 |
| X5041R | 1.78 | 0.09 | 0.11 | 0.18 | 0.34 | 0.41 | 0.49 | 2.03 | 2.89 | 3.47 | 4.19 | 4.86 | 5.50 | 0.3 | 0.5 | 1.1 | 2.5 | 3.5 | 4.8 |
| X5045R | 0.92 | 0.11 | 0.13 | 0.20 | 0.36 | 0.42 | 0.51 | 1.59 | 2.26 | 2.72 | 3.29 | 3.81 | 4.31 | 0.2 | 0.3 | 0.5 | 1.1 | 1.5 | 2.0 |
| X5048R | 2.21 | 0.07 | 0.08 | 0.15 | 0.32 | 0.39 | 0.48 | 1.74 | 2.49 | 2.99 | 3.61 | 4.18 | 4.73 | 0.3 | 0.5 | 1.0 | 2.6 | 3.6 | 5.0 |
| X5052L | 1.93 | 0.13 | 0.16 | 0.23 | 0.38 | 0.44 | 0.52 | 1.54 | 2.20 | 2.65 | 3.20 | 3.70 | 4.19 | 0.4 | 0.7 | 1.1 | 2.3 | 3.2 | 4.2 |
| X5064R | 9.61 | 0.08 | 0.10 | 0.17 | 0.34 | 0.41 | 0.49 | 1.06 | 1.51 | 1.81 | 2.19 | 2.53 | 2.87 | 0.9 | 1.5 | 3.0 | 7.1 | 9.9 | 13.6 |
| X5066R | 4.10 | 0.04 | 0.05 | 0.11 | 0.29 | 0.37 | 0.46 | 1.22 | 1.74 | 2.09 | 2.53 | 2.92 | 3.31 | 0.2 | 0.3 | 1.0 | 3.0 | 4.4 | 6.2 |
| X5068R | 11.18 | 0.07 | 0.10 | 0.17 | 0.34 | 0.41 | 0.50 | 1.62 | 2.31 | 2.77 | 3.35 | 3.87 | 4.39 | 1.2 | 2.5 | 5.3 | 12.8 | 17.8 | 24.4 |
| X5075R | 9.68 | 0.08 | 0.13 | 0.22 | 0.39 | 0.45 | 0.53 | 1.54 | 2.20 | 2.64 | 3.19 | 3.69 | 4.18 | 1.2 | 2.8 | 5.7 | 11.9 | 16.2 | 21.6 |
| X5084R | 6.80 | 0.11 | 0.17 | 0.25 | 0.41 | 0.47 | 0.55 | 1.53 | 2.18 | 2.62 | 3.16 | 3.66 | 4.14 | 1.1 | 2.5 | 4.5 | 8.9 | 11.8 | 15.6 |

Notes:

[1] $I = \frac{28.5 * P1}{(10 + T_c)^{0.786}}$ USDCM Equation 5-1, March 2017)

**SH 119 Bikeway**
**Existing Hydrology Calculations - Rational Method**
**Muller Engineering Company, Inc.**
**CDOT Project Number:** N/A
**Muller Project Number:** 21015

**Originator** ZDS
**Date:** 2/2/2022
**Checker:** ACF
**Date:** 3/1/2022

| STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE) 5-YEAR STORM EVENT | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | |
| DESIGN POINT | BASIN ID | AREA (acres) | $C_5$ | CA (acres) | $T_c$ (min) | $I_5$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_5$ | $I_5$ (in/hr) | Q (cfs) | DESCRIPTION |
| X1018L | X1016L | 10.65 | 0.12 | 1.23 | 22.53 | 2.66 | 3.3 | | | | | |
| | X1017L | 0.70 | 0.42 | 0.30 | 6.71 | 4.49 | 1.3 | | | | | |
| | X1018L | 1.91 | 0.11 | 0.21 | 19.54 | 2.87 | 0.6 | | | | | |
| | X1021R | 0.28 | 0.86 | 0.24 | 5.85 | 4.68 | 1.1 | | | | | |
| | | | | | | | | 22.5 | 1.98 | 2.66 | 5.3 | |
| X1030R | X1029R | 101.56 | 0.22 | 22.29 | 72.47 | 1.28 | 28.5 | | | | | |
| | X1032R | 0.36 | 0.05 | 0.02 | 10.00 | 3.90 | 0.1 | | | | | |
| | X1030R | 0.94 | 0.05 | 0.05 | 27.22 | 2.39 | 0.1 | | | | | |
| | | | | | | | | 72.5 | 22.36 | 1.28 | 28.6 | |
| X1056L | X1054R | 4.67 | 0.29 | 1.37 | 28.08 | 2.35 | 3.2 | | | | | |
| | X1056L | 1.42 | 0.22 | 0.31 | 11.01 | 3.75 | 1.2 | | | | | |
| | | | | | | | | 28.1 | 1.68 | 2.35 | 4.0 | |
| X1083R | X1077R | 2.79 | 0.05 | 0.14 | 28.67 | 2.32 | 0.3 | | | | | |
| | X1080R | 2.46 | 0.21 | 0.51 | 16.07 | 3.16 | 1.6 | | | | | |
| | X1083R | 0.82 | 0.38 | 0.31 | 11.54 | 3.68 | 1.1 | | | | | |
| | | | | | | | | 28.7 | 0.97 | 2.32 | 2.2 | |
| X2060R | X2056R | 9.09 | 0.10 | 0.91 | 74.10 | 1.26 | 1.2 | | | | | |
| | X2060R | 5.16 | 0.36 | 1.87 | 17.49 | 3.03 | 5.7 | | | | | |
| | | | | | | | | 74.1 | 2.79 | 1.26 | 3.5 | |
| X2090R | X2090R | 4.38 | 0.12 | 0.51 | 30.99 | 2.22 | 1.1 | | | | | |
| | X2099R | 0.44 | 0.19 | 0.08 | 14.33 | 3.34 | 0.3 | | | | | |
| | X2100R | 4.37 | 0.12 | 0.54 | 36.79 | 2.00 | 1.1 | | | | | |
| | | | | | | | | 36.8 | 1.14 | 2.00 | 2.3 | |
| X3029R | X3023L | 10.96 | 0.18 | 2.00 | 41.92 | 1.84 | 3.7 | | | | | |
| | X3029R | 13.74 | 0.19 | 2.67 | 42.21 | 1.83 | 4.9 | | | | | |
| | | | | | | | | 42.2 | 4.66 | 1.83 | 8.5 | |
| X3033RA | X3033R | 17.48 | 0.37 | 6.51 | 34.29 | 2.09 | 13.6 | | | | | |
| | X3033RA | 0.74 | 0.50 | 0.37 | 23.79 | 2.58 | 1.0 | | | | | |
| | | | | | | | | 34.3 | 6.88 | 2.09 | 14.4 | |
| X3038R | X3036L | 24.91 | 0.37 | 9.34 | 71.72 | 1.29 | 12.0 | | | | | |
| | X3038R | 1.07 | 0.21 | 0.23 | 15.56 | 3.21 | 0.7 | | | | | |
| | | | | | | | | 71.7 | 9.56 | 1.29 | 12.3 | |
| X3042L | X3042L | 2.30 | 0.19 | 0.43 | 32.67 | 2.15 | 0.9 | | | | | |
| | X3042R | 1.36 | 0.31 | 0.42 | 13.94 | 3.38 | 1.4 | | | | | |
| | | | | | | | | 32.7 | 0.85 | 2.15 | 1.8 | |
| X3049R | X3048L | 22.96 | 0.11 | 2.52 | 65.20 | 1.38 | 3.5 | | | | | |
| | X3049R | 3.63 | 0.26 | 0.95 | 25.44 | 2.48 | 2.4 | | | | | |
| | | | | | | | | 65.2 | 3.47 | 1.38 | 4.8 | |
| X4028R | X4019RA | 0.21 | 0.65 | 0.14 | 6.77 | 4.48 | 0.6 | | | | | |
| | X4021R | 0.35 | 0.69 | 0.24 | 7.13 | 4.40 | 1.0 | | | | | |
| | X4023R | 3.89 | 0.42 | 1.62 | 30.61 | 2.23 | 3.6 | | | | | |
| | X4028R | 2.91 | 0.18 | 0.54 | 13.05 | 3.49 | 1.9 | | | | | |
| | X4044R | 7.65 | 0.07 | 0.50 | 67.03 | 1.35 | 0.7 | | | | | |
| | | | | | | | | 67.0 | 3.03 | 1.35 | 4.1 | |
| X5006R | X5006R | 1.44 | 0.25 | 0.36 | 16.47 | 3.13 | 1.1 | | | | | |
| | X5007R | 0.10 | 0.35 | 0.04 | 6.11 | 4.62 | 0.2 | | | | | |
| | | | | | | | | 16.5 | 0.40 | 3.13 | 1.3 | |
| X5011L | X5011R | 0.27 | 0.57 | 0.15 | 9.10 | 4.04 | 0.6 | | | | | |
| | X5011L | 8.78 | 0.17 | 1.48 | 55.32 | 1.54 | 2.3 | | | | | |
| | | | | | | | | 55.3 | 1.63 | 1.54 | 2.5 | |
| X5064R | X5052L | 1.93 | 0.16 | 0.30 | 31.33 | 2.20 | 0.7 | | | | | |
| | X5064R | 9.61 | 0.10 | 0.98 | 56.94 | 1.51 | 1.5 | | | | | |
| | | | | | | | | 56.9 | 1.28 | 1.51 | 1.9 | |
| X5075R | X5084R | 6.80 | 0.17 | 1.16 | 31.91 | 2.18 | 2.5 | | | | | |
| | X5075R | 9.68 | 0.13 | 1.30 | 31.44 | 2.20 | 2.8 | | | | | |
| | | | | | | | | 31.9 | 2.46 | 2.18 | 5.4 | |

Notes:

1 $I = \frac{28.5 * P1}{(10 * T_c)^{0.786}}$ (UDFCD Equation 5-1, March 2017), Where P1 Values come from NOAA Atlas 2, Volume 8, Version 2

2 $Q_{tot} = I_{min}\left[\sum_{i=0}^{n}(CA)_i\right]$ Where: $I_{min}$ = Mininmum Intensity and CA = Effective CA

**SH 119 Bikeway**
**Existing Hydrology Calculations - Rational Method**
**Muller Engineering Company, Inc.**
**CDOT Project Number: N/A**
**Muller Project Number: 21015**

**Originator ZDS**
**Date: 2/2/2022**
**Checker: ACF**
**Date: 3/1/2022**

| STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE) 100-YEAR STORM EVENT | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DESIGN POINT | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | DESCRIPTION |
| | BASIN ID | AREA (acres) | $C_{100}$ | CA (acres) | $T_c$ (min) | $I_{100}$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_{100}$ | $I_{100}$ (in/hr) | Q (cfs) | |
| X1018L | X1016L | 10.65 | 0.50 | 5.33 | 22.53 | 5.06 | 27.0 | | | | | |
| | X1017L | 0.70 | 0.67 | 0.47 | 6.71 | 8.54 | 4.0 | | | | | |
| | X1018L | 1.91 | 0.50 | 0.95 | 19.54 | 5.46 | 5.2 | | | | | |
| | X1021R | 0.28 | 0.90 | 0.25 | 5.85 | 8.90 | 2.2 | | | | | |
| | | | | | | | | **22.5** | **7.00** | **5.06** | **35.4** | |
| X1030R | X1029R | 101.56 | 0.58 | 58.52 | 72.47 | 2.43 | 142.5 | | | | | |
| | X1032R | 0.36 | 0.49 | 0.18 | 10.00 | 7.41 | 1.3 | | | | | |
| | X1030R | 0.94 | 0.49 | 0.46 | 27.22 | 4.55 | 2.1 | | | | | |
| | | | | | | | | **72.5** | **59.16** | **2.43** | **144.0** | |
| X1056L | X1054R | 4.67 | 0.61 | 2.86 | 28.08 | 4.47 | 12.8 | | | | | |
| | X1056L | 1.42 | 0.58 | 0.82 | 11.01 | 7.13 | 5.8 | | | | | |
| | | | | | | | | **28.1** | **3.68** | **4.47** | **16.5** | |
| X1083R | X1077R | 2.79 | 0.49 | 1.37 | 28.67 | 4.42 | 6.1 | | | | | |
| | X1080R | 2.46 | 0.57 | 1.40 | 16.07 | 6.02 | 8.5 | | | | | |
| | X1083R | 0.82 | 0.65 | 0.54 | 11.54 | 6.99 | 3.8 | | | | | |
| | | | | | | | | **28.7** | **3.32** | **4.42** | **14.6** | |
| X2060R | X2056R | 9.09 | 0.52 | 4.70 | 74.10 | 2.40 | 11.3 | | | | | |
| | X2060R | 5.16 | 0.65 | 3.34 | 17.49 | 5.77 | 19.3 | | | | | |
| | | | | | | | | **74.1** | **8.04** | **2.40** | **19.3** | |
| X2090R | X2090R | 4.38 | 0.53 | 2.30 | 30.99 | 4.22 | 9.7 | | | | | |
| | X2099R | 0.44 | 0.56 | 0.25 | 14.33 | 6.36 | 1.6 | | | | | |
| | X2100R | 4.37 | 0.53 | 2.31 | 36.79 | 3.80 | 8.8 | | | | | |
| | | | | | | | | **36.8** | **4.86** | **3.80** | **18.5** | |
| X3029R | X3023L | 10.96 | 0.56 | 6.11 | 41.92 | 3.50 | 21.4 | | | | | |
| | X3029R | 13.74 | 0.56 | 7.74 | 42.21 | 3.49 | 27.0 | | | | | |
| | | | | | | | | **42.2** | **13.85** | **3.49** | **48.3** | |
| X3033RA | X3033R | 17.48 | 0.65 | 11.41 | 34.29 | 3.97 | 45.3 | | | | | |
| | X3033RA | 0.74 | 0.71 | 0.53 | 23.79 | 4.91 | 2.6 | | | | | |
| | | | | | | | | **34.3** | **11.94** | **3.97** | **47.4** | |
| X3038R | X3036L | 24.91 | 0.65 | 16.29 | 71.72 | 2.45 | 39.9 | | | | | |
| | X3038R | 1.07 | 0.57 | 0.61 | 15.56 | 6.11 | 3.7 | | | | | |
| | | | | | | | | **71.7** | **16.90** | **2.45** | **41.4** | |
| X3042R | X3042L | 2.30 | 0.56 | 1.29 | 32.67 | 4.09 | 5.3 | | | | | |
| | X3042R | 1.36 | 0.62 | 0.84 | 13.94 | 6.44 | 5.4 | | | | | |
| | | | | | | | | **32.7** | **2.13** | **4.09** | **8.7** | |
| X3049R | X3048L | 22.96 | 0.52 | 11.97 | 65.20 | 2.62 | 31.3 | | | | | |
| | X3049R | 3.63 | 0.60 | 2.17 | 25.44 | 4.73 | 10.3 | | | | | |
| | | | | | | | | **65.2** | **14.14** | **2.62** | **37.0** | |
| X4028R | X4019RA | 0.21 | 0.79 | 0.17 | 6.77 | 8.52 | 1.4 | | | | | |
| | X4021R | 0.35 | 0.81 | 0.28 | 7.13 | 8.37 | 2.3 | | | | | |
| | X4023R | 3.89 | 0.68 | 2.62 | 30.61 | 4.25 | 11.2 | | | | | |
| | X4028R | 2.91 | 0.56 | 1.62 | 13.05 | 6.63 | 10.8 | | | | | |
| | X4044R | 7.65 | 0.50 | 3.82 | 67.03 | 2.57 | 9.8 | | | | | |
| | | | | | | | | **67.0** | **8.51** | **2.57** | **21.9** | |
| X5006R | X5006R | 1.44 | 0.59 | 0.86 | 16.47 | 5.95 | 5.1 | | | | | |
| | X5007R | 0.10 | 0.64 | 0.07 | 6.11 | 8.79 | 0.6 | | | | | |
| | | | | | | | | **16.5** | **0.92** | **5.95** | **5.5** | |
| X5011L | X5011R | 0.27 | 0.74 | 0.20 | 9.10 | 7.69 | 1.5 | | | | | |
| | X5011L | 8.78 | 0.59 | 5.22 | 55.32 | 2.92 | 15.3 | | | | | |
| | | | | | | | | **55.3** | **5.42** | **2.92** | **15.8** | |
| X5068R | X5052L | 1.93 | 0.52 | 1.01 | 31.33 | 4.19 | 4.2 | | | | | |
| | X5064R | 9.61 | 0.49 | 4.73 | 56.94 | 2.87 | 13.6 | | | | | |
| | | | | | | | | **56.9** | **5.74** | **2.87** | **16.5** | |
| X5075R | X5084R | 6.80 | 0.55 | 3.75 | 31.91 | 4.14 | 15.6 | | | | | |
| | X5075R | 9.68 | 0.53 | 5.16 | 31.44 | 4.18 | 21.6 | | | | | |
| | | | | | | | | **31.9** | **8.92** | **4.14** | **37.0** | |

Notes:

1 $I = \frac{28.5 * P1}{(10 * T_c)^{0.786}}$ (UDFCD Equation 5-1, March 2017), Where P1 Values come from NOAA Atlas 2, Volume 8, Version 2

2 $Q_{tot} = I_{min}\left[\sum_{i=0}^{n}(CA)_i\right]$ Where: $I_{min}$ = Mininmum Intensity and CA = Effective CA

# Proposed Hydrology Calculations

# CALCULATION COVER SHEET

| Project Name: | CO 119 Bikeway | Project No. | 21015 (Muller) |
|---|---|---|---|
| Design Calculation: | Proposed Hydrology | Version: | 1 |
| Originator | ZDS | Date: | June 24, 2022 |
| Checker | EGS | Date: | June 28, 2022 |

Purpose:
Analyze the proposed hydrologic conditions and determine peak flowrates for the CO 119 Bikeway project.

References:

Criteria Manuals Used:

Colorado Department of Transportation (CDOT) *Drainage Design Manual,* 2019
Boulder County *Multimodal Transportation Standards (MTS)*, 2012
Boulder County *Storm Drainage Criteria Manual (SDCM)*, 2016

Referenced Data Sources:
CDOT, *Topographic Survey,* Received July 2021
CDOT, *SUE (QL C&D)*, Received December 2021
Boulder County, *LiDAR*, Accessed January 2022
United States Department of Agriculture Natural Resources Conservation Service (NRCS), *Web Soil Service for Hydrologic Soil Group*, Accessed January 2022
National Oceanic and Atmospheric Administration, *Point Frequency Data Server*, Accessed January 2022
Microsoft Corp., *Bing Maps Aerial*, Accessed January 2022
Alphabet Inc., *Google Earth Aerial*, June 2021 Imagery

Refer to the drainage report for the appendices referenced below:
Appendix A
Roadway Classification Table
Hydrologic and Hydraulic Criteria Table
Existing Basin Maps
Proposed Basin Maps
Hydrologic Soils Report (NRCS)
Point Precipitation Frequency Estimates (NOAA Atlas 14)

Refer to the Drainage Report for full citations of references.

## Criteria:

Runoff from existing basins for the proposed project was determined using CDOT and Boulder County drainage manuals. Refer to the Hydrologic Criteria Table in Appendix A of the Drainage Report for the complete comparison of analyzed criteria. Table 1 shows the applied criteria for this calculation packet.

*Table 1. Applied Hydrologic Criteria Table*

| Hydrologic Criteria | Applied Criteria |
|---|---|
| Design Frequency | |
| Cross Drainage | |
| Multi-lane Road (Urban) | 100-year |
| Multi-lane Road (Rural) | 50-year |
| Two Lane Road (Urban) | 100-year |
| Two Lane Road (Rural) | 25-year |
| Culvert Outlet Scour Protection | 10-year |
| Pedestrian Walkways and Bikeways | 5-year |
| Parallel Drainage | |
| Roadway Overtopping & Revetment | *Same as for cross drainage* |
| Side Drains | 10-year |
| Storm Drains | |
| Major Storm | 100-year |
| Minor Storm | 5-year |
| Channels | |
| Capacity | *Depends on roadway classification* |
| Lining | 10-year |
| Hydrologic Procedure Selection | |
| Hydrologic Peak Prediction Procedure | |
| Drainage Area | Rational Method (<200 ac)<br>CUHP and EPA-SWMM (>200 ac) |
| Time of Concentration (Tc) for Rational Method | |
| Min. Tc for urban areas | 5 min. |
| Min. Tc for non-urban areas | 10 min. |
| Max. Overland Flow Path Length (urban) | 300 ft |
| Max. Overland Flow Path Length (rural) | 500 ft |

## Background and Rationale:

- The project is located along CO 119 from Boulder, Colorado to Longmont, Colorado.
- Project improvements include:
    - Grading and constructing a bike path along CO 119 from Foothills Parkway in Boulder to Hover Street in Longmont. At-grade crossings, underpasses, and bridges will be designed for the bike path.

        - Supplementary improvements include:
            - Traffic support for intersections along CO 119 impacted by bike path.
            - Structural design of underpasses and bridges.
            - Landscaping improvements.
            - Lighting for underpasses and other locations.
            - Floodplain analysis.
            - Irrigation coordination.
- Drainage generally flows east through the project area, flow directions are not uniform throughout the project length, however.
- Design points (DP) for basins are located at the receiving point (stormwater ditches, stormwater pipes and culverts, stormwater area inlets, irrigation ditches, irrigation pipes and culverts, and streams and rivers) and where runoff leaves the project area.
- Basins were delineated using survey contours and topography provided by CDOT and LiDAR contours referenced from Boulder County along with the proposed bikeway and improvements associated with the separate CO 119 Mobility Improvements project.
- Basin IDs correspond with centerline stationing for the proposed alignments for the bike path using L and R for left and right designation. Basins with the same station and a greater offset were labeled with increasing alphabetical letters (i.e., the design point for P4019RA has a greater offset distance than P4019R).
- Basins were analyzed for peak discharge using rational method, then DPs with multiple contributing areas were routed to determine overall peak discharge leaving the project area.

## Assumptions/Givens:

### Rational Method Givens

- Hydrologic Soil Group HSG A, B, C, and D
- Rainfall precipitation values for a 1-hour storm duration for the 5-year event and 100-year event were taken from NOAA Atlas 2 per the Boulder County Storm Drainage Criteria Manual. Rainfall precipitation values for a 1-hour storm duration for the 2-year, 10-year, 25-year, and 50-year events were taken from NOAA Atlas 14 using the NOAA Precipitation Frequency Data Server.
- Land use types and percent imperviousness provided in (Table 6-3 of USDCM) used for this project are:
    - Streets: Paved, 100% imperviousness
    - Streets: Gravel (Packed), 40% imperviousness
    - Undeveloped Areas: Greenbelts, Agricultural, 2% imperviousness
    - Business: Suburban Areas, 75% imperviousness
    - Residential: 0.25 Acres or Less, 45% imperviousness
- USDCM Equations 6-3, 6-4, and 6-5 were used to calculate the time of concentration required to calculate intensity.
- The preliminary CO 119 Mobility Project proposed design was considered during basin delineations, land use inputs, and flow path elevations.
    - The majority of the CO 119 Bikeway project between STA 3000+00 and STA 3064+98 was omitted from basin delineations and subsequent hydrology calculations. The CO 119 Mobility Project includes a major reconstruction of the SH 52/CO 119 intersection

with other impacts to CO 119 through this portion of the project. As a result, the drainage design in this area is primarily influenced by the CO 119 Mobility Project rather than the CO 119 Bikeway Project. The only proposed basins delineated within this stretch of the project are for the bikeway underpass at SH 52.

  - The CO 119 Mobility Project involves widening CO 119 to include bus transit lanes and facilities and parking lots. At the time of these preliminary calculations, the drainage design for these elements was not completed. Therefore, proposed basins generally are conservative because they include a larger area than will likely drain to the basin's design point because drainage improvements with the CO 119 Mobility project will likely capture a portion of the large basin area. Refer to Basin P2059R for an example. Additionally, a basin was delineated for the Mobility Hub Jay Road Inlet, which is sometimes referred to by the abbreviated Basin ID "MHJRI".

Rational Method Assumptions

- The following land use types and percent imperviousness values were not taken from USDCM but were assumed:
  - Google Earth imagery indicates that solar panels are currently placed on the IBM property between the main IBM campus and CO 119. A 50% imperviousness was assumed for fields with solar panels.
  - Irrigation ponds were assumed to be 98% impervious.

General Assumptions

- Roadside ditches parallel to CO 119 coupled with the embankment of CO 119 prevent offsite flow from reaching the median of CO 119. Therefore, off-site basins were not analyzed except for areas where the proposed bike path is outside of the CO 119 median.
  - Three large watersheds (Fourmile Creek, Dry Creek, and Lefthand Creek) cross the proposed bike path design. Total flowrate values for these watersheds were provided via floodplain models from Boulder County. Local areas within the project site contributing to each of these watersheds were evaluated.
- Irrigation ownership data from Boulder County was used to aid basin delineations. Irrigation ownership data indicates roughly 35 irrigation systems crossing CO 119 (and subsequently the proposed bike path) within the project area. Irrigation ditches traversing CO 119 have not been assumed to flow full, and thus have capacity to intercept stormwater based on topography.

Results:

Table 2 summarizes the 5-year and 100-year peak flowrates associated with individual basins. Table 3 summarizes the 5-year and 100-year flowrates for all design points where runoff leaves the project area.

*Table 2. Peak Discharge Summary of Individual Basins*

| BASIN ID | AREA (acre) | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| P1000R | 1.41 | 0.2 | 2.9 |
| P1013R | 1.54 | 1.9 | 5.5 |
| P1016L | 8.85 | 1.3 | 15.8 |
| P1017L | 0.71 | 1.3 | 4.1 |
| P1018L | 1.27 | 0.6 | 4.3 |
| P1021R | 0.64 | 1.0 | 2.9 |
| P1021RA | 0.28 | 1.1 | 2.2 |
| P1029L | 99.22 | 26.5 | 137.3 |
| P1029R | 1.42 | 2.1 | 5.8 |
| P1030R | 0.76 | 0.1 | 1.7 |
| P1031L | 1.04 | 1.6 | 4.8 |
| P1031R | 0.74 | 1.5 | 4.6 |
| P1032R | 0.26 | 0.0 | 0.9 |
| P1034R | 0.70 | 0.2 | 1.9 |
| P1043R | 1.09 | 0.5 | 3.2 |
| P1044L | 2.33 | 0.5 | 6.7 |
| MHJRI | 0.44 | 1.5 | 3.1 |
| P1048L | 1.20 | 1.2 | 6.1 |
| P1053L | 2.12 | 3.5 | 8.4 |
| P1054R | 2.33 | 1.7 | 7.2 |
| P1056L | 1.17 | 1.4 | 5.5 |
| P1057L | 0.29 | 0.2 | 1.1 |
| P1058L | 0.05 | 0.0 | 0.2 |
| P1063R | 0.92 | 0.2 | 2.2 |
| P1067L | 2.85 | 0.9 | 7.0 |
| P1069R | 1.28 | 0.5 | 4.4 |
| P1076L | 1.06 | 0.3 | 3.1 |
| P1077R | 1.85 | 0.4 | 4.1 |
| P1080R | 1.59 | 0.5 | 4.4 |
| P1082L | 1.70 | 2.4 | 7.2 |
| P1082R | 0.20 | 0.1 | 0.7 |
| P1088R | 3.16 | 1.9 | 9.4 |
| P2010R | 3.20 | 0.7 | 5.1 |

| BASIN ID | AREA (acre) | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| P2021L | 7.83 | 0.8 | 7.6 |
| P2022L | 0.07 | 0.0 | 0.2 |
| P2022R | 3.00 | 0.9 | 5.2 |
| P2030L | 1.18 | 0.2 | 2.7 |
| P2031R | 2.36 | 1.1 | 7.0 |
| P2032L | 0.12 | 0.0 | 0.4 |
| P2049L | 1.75 | 0.2 | 3.2 |
| P2058L | 0.53 | 0.1 | 1.2 |
| P2059R | 9.82 | 3.4 | 17.7 |
| P2062L | 1.13 | 4.2 | 8.9 |
| P2063R | 0.23 | 0.5 | 1.4 |
| P2064R | 2.43 | 2.3 | 9.9 |
| P2066R | 2.26 | 1.9 | 7.9 |
| P2075L | 0.58 | 0.1 | 1.7 |
| P2077L | 0.37 | 0.3 | 1.5 |
| P2079L | 1.73 | 1.1 | 4.9 |
| P2084L | 0.80 | 0.2 | 2.4 |
| P2085L | 2.32 | 0.9 | 5.0 |
| P2085R | 2.57 | 1.6 | 7.6 |
| P2092R | 0.39 | 0.5 | 1.9 |
| P2093R | 1.69 | 0.7 | 4.3 |
| P2098R | 0.38 | 0.2 | 1.4 |
| P2100L | 1.09 | 0.3 | 2.5 |
| P2100R | 3.11 | 1.1 | 7.3 |
| P3021R | 0.20 | 0.8 | 1.6 |
| P3023R | 0.17 | 0.7 | 1.4 |
| P3042R | 0.97 | 1.0 | 4.0 |
| P3049L | 1.47 | 1.4 | 5.1 |
| P3049R | 2.24 | 2.0 | 7.2 |
| P3052R | 0.61 | 0.9 | 3.2 |
| P4018L | 13.69 | 2.0 | 14.6 |
| P4019R | 3.37 | 2.2 | 8.8 |
| P4019RA | 0.21 | 0.7 | 1.6 |

*Table 2. Peak Discharge Summary of Individual Basins (contd.)*

| BASIN ID | AREA (acre) | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| P4020R | 0.42 | 0.7 | 1.8 |
| P4021R | 0.35 | 1.1 | 2.4 |
| P4023R | 3.48 | 10.4 | 22.3 |
| P4028L | 0.63 | 1.1 | 2.9 |
| P4028R | 2.05 | 0.5 | 5.2 |
| P4040L | 1.46 | 0.2 | 2.8 |
| P4044R | 5.31 | 1.2 | 9.0 |
| P4053L | 1.86 | 0.2 | 3.4 |
| P4054R | 3.13 | 1.8 | 7.9 |
| P4060L | 1.21 | 0.1 | 1.9 |
| P4065R | 3.29 | 2.0 | 8.6 |
| P4074R | 2.84 | 1.6 | 6.8 |
| P4075L | 2.34 | 0.2 | 4.2 |
| P4076L | 0.09 | 0.1 | 0.4 |
| P4081L | 1.32 | 0.5 | 3.7 |
| P4081R | 1.63 | 1.2 | 4.5 |
| P4086R | 1.61 | 1.2 | 4.9 |
| P4087L | 1.38 | 0.8 | 4.5 |
| P4091L | 1.39 | 1.9 | 5.7 |
| P4091R | 1.01 | 0.7 | 3.5 |
| P4093L | 0.46 | 0.8 | 2.3 |
| P4095R | 0.45 | 0.6 | 1.9 |
| P4108R | 3.91 | 1.9 | 8.3 |
| P4114L | 3.63 | 0.8 | 6.2 |

| BASIN ID | AREA (acre) | $Q_5$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| P4117R | 2.27 | 1.6 | 5.8 |
| P5001L | 2.27 | 0.7 | 5.1 |
| P5006R | 1.44 | 1.3 | 5.3 |
| P5007R | 0.10 | 0.2 | 0.6 |
| P5011L | 5.52 | 2.0 | 10.7 |
| P5011R | 2.28 | 0.9 | 5.7 |
| P5013L | 3.08 | 1.7 | 8.4 |
| P5023L | 1.17 | 0.4 | 1.9 |
| P5023R | 5.73 | 1.0 | 6.3 |
| P5030L | 3.02 | 0.2 | 2.0 |
| P5033R | 4.16 | 1.4 | 6.2 |
| P5040L | 0.89 | 0.0 | 0.6 |
| P5041R | 0.93 | 0.7 | 2.2 |
| P5048L | 1.12 | 0.0 | 0.5 |
| P5048R | 2.60 | 2.0 | 5.9 |
| P5052L | 1.99 | 1.4 | 5.8 |
| P5064R | 6.82 | 2.1 | 12.5 |
| P5066L | 8.08 | 1.9 | 13.1 |
| P5066R | 2.57 | 0.5 | 5.0 |
| P5068R | 15.75 | 2.4 | 38.4 |
| P5076R | 1.57 | 1.9 | 6.9 |
| P5084L | 5.20 | 1.1 | 9.9 |
| P5084R | 1.44 | 4.6 | 9.2 |

*Table 3. Peak Discharge Summary of Design Points where Flow Leaves Project*

| Design Point | Contributing Basins | Description of Runoff Leaving Project Area | Q5 cfs) | Q100 (cfs) |
|---|---|---|---|---|
| P1017L | P1013R, P1016L, P1017L | Fourmile Creek | 3.3 | 21.5 |
| P1018L | P1018L, P1021R, P1021RA | Fourmile Creek | 2.3 | 8.6 |
| P1030R | P1029L, P1029R, P1030R, P1031L, P1031R, P1032R | Ditch between NB SH 119 and BNSF Railroad | 28.4 | 143.9 |
| P1034R | P1034R | Poorly defined ditch outside (southeast) of BNSF Railroad | 0.2 | 1.9 |
| P1044L | P1043R, P1044L | Boulder and Whiterock Irrigation Ditch | 0.9 | 9.4 |
| P1056L | Mobility Hub Jay Rd Inlet, P1048L, P1053L, P1054R, P1056L | Water Quality Extended Detention Basin North of Jay Road | 7.7 | 24.6 |
| P1069R | Mobility Hub Jay Rd Inlet, P1048L, P1053L, P1054R, P1056L, P1057L, P1067L, P1063R, P1069R | Boulder and Whiterock Irrigation Ditch | 8.5 | 35.3 |
| P1082L | P1076L, P1077R, P1080R, P1082L | Boulder and Whiterock Irrigation Ditch | 2.7 | 7.5 |
| P1082R | P1082R | Ditch between NB SH 119 and BNSF Railroad | 0.1 | 0.7 |
| P1088R | P1088R | City of Boulder and Others Irrigation Line | 1.9 | 9.4 |
| P2010R | P2010R | Ditch between NB SH 119 and BNSF Railroad | 0.7 | 5.1 |
| P2022R | P2021L, P2022L, P2022R | Ditch between NB SH 119 and BNSF Railroad | 1.3 | 10.8 |
| P2031R | P2030L, P2031R, P2032L | Boulder and Whiterock Irrigation Ditch | 1.1 | 8.7 |
| P2059R | P2049L, P2058L, P2059R, P2062L | Boulder Reservoir Spillway/ Boulder County Irrigation Ditch | 5.0 | 24.4 |
| P2064R | P2063R, P2064R, P2066R | Ditch between NB SH 119 and BNSF Railroad | 4.1 | 17.3 |
| P2079L | P2075L, P2077L, P2079L | City of Boulder and Northern Colorado Water Conservancy District Irrigation Line | 1.4 | 7.2 |
| P2085R | P2084L, P2085R | Ditch between NB SH 119 and BNSF Railroad | 1.8 | 9.7 |
| P2085L | P2085L, P2092R, P2093R, P2098R, P2100R, P2100L | Dry Creek | 3.0 | 19.2 |
| P3049R | P3049L, P3049R | Star Irrigation Ditch | 3.4 | 11.9 |
| P3052R | P3052R | Ditch between NB SH 119 and BNSF Railroad | 0.9 | 3.2 |

*Table 3. Peak Discharge Summary of Design Points where Flow Leaves Project (continued)*

| Design Point | Contributing Basins | Description of Runoff Leaving Project Area | Q5 (cfs) | Q100 (cfs) |
|---|---|---|---|---|
| P3052R | P3052R | Ditch between NB SH 119 and BNSF Railroad | 0.9 | 3.2 |
| P4028R | P4021R, P4023R, P4028L, P4028R | Water Quality Extended Detention Basin North of Niwot Road | 8.7 | 23.2 |
| P4044R | P4021R, P4023R, P4028L, P4028R, P4040L, P4044R | Williamson Irrigation Ditch | 7.0 | 26.4 |
| P4054R | P4053L, P4054R | Ditch between NB SH 119 and BNSF Railroad | 1.7 | 10.2 |
| P4065R | P4060L, P4065R | Williamson Irrigation Ditch | 1.5 | 8.2 |
| P4075L | P4075L | Ditch outside and adjacent to SH 119 | 0.2 | 4.2 |
| P4076L | P4074R, P4076L | Unkown Irrigation Line, potentially a secondary line of Williamson Irrigation Ditch | 1.7 | 7.0 |
| P4081L | P4081R, P4081L | Ditch outside and adjacent to SH 119 | 1.6 | 7.7 |
| P4087L | P4086R, P4087L | Ditch outside and adjacent to SB SH 119 | 1.6 | 8.7 |
| P4091L | P4091R, P4091L | Point outside of SB SH 119 | 2.7 | 9.2 |
| P4095R | P4093L, P4095R | Point outside of SB SH 119, potentially a secondary line of Williamson Irrigation Ditch | 1.3 | 3.8 |
| P4114L | P4108R, P4114L | Pont outside of SB SH 119 | 2.4 | 13.8 |
| P5001L | P4117R, P5001L | Point outside of SB SH 119 | 2.2 | 10.6 |
| P5006R | P5006R, P5007R | Storm system at existing underpass near Airport Road | 1.4 | 5.7 |
| P5011L | P5011R, P5011L | Lefthand Creek | 2.7 | 15.0 |
| P5013L | P5013L | Lefthand Creek | 1.7 | 8.4 |
| P5023R | P5023L, P5023R | Ditch between NB SH 119 and BNSF Railroad | 1.4 | 7.8 |
| P5033R | P5030L, P5033R | Lefthand Creek | 1.2 | 6.5 |
| P5041R | P5040L, P5041R | Ditch between NB SH 119 and BNSF Railroad | 0.6 | 2.4 |
| P5048R | P5048L, P5048R | Ditch between NB SH 119 and BNSF Railroad | 1.4 | 4.7 |
| P5064R | P5064R | Ditch between NB SH 119 and BNSF Railroad | 2.1 | 12.5 |
| P5066R | P5066R | Ditch between NB SH 119 and BNSF Railroad | 0.5 | 5.0 |
| P5068R | P5052L, P5066L, P5076R, P5068R, P5084L, P5084R | Holland Ditch | 9.2 | 56.6 |

Materials Included in this Calculation Packet:

1. Rational Method Calculations

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

| Land Use Types | Percent Impervious |
|---|---|
| STREETS: PAVED | 100 |
| RESIDENTIAL: 0.25 ACRES OR LESS | 45 |
| UNDEVELOPED AREAS: GREENBELTS, AGRICULTURAL | 2 |

Land Use Types and Imperviousness Values from USDCM Volume 1 Table 6-3

## PERCENT IMPERVIOUS VALUES

| BASIN ID | TOTAL AREA | | STREETS: PAVED | | RESIDENTIAL: 0.25 ACRES OR LESS | | UNDEVELOPED AREAS: GREENBELTS, AGRICULTURAL | | WEIGHTED PERCENT IMPERVIOUS | WEIGHTED PERCENT PERVIOUS |
|---|---|---|---|---|---|---|---|---|---|---|
| | (sq ft) | (acre) | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | | |
| P1000R | 61,634 | 1.41 | 4,758 | 8 | | 0 | 56,876 | 92 | 10 | 90 |
| P1013R | 67,164 | 1.54 | 37,000 | 55 | | 0 | 30,164 | 45 | 56 | 44 |
| P1016L | 385,526 | 8.85 | 34,879 | 9 | | 0 | 350,647 | 91 | 11 | 89 |
| P1017L | 30,748 | 0.71 | 15,782 | 51 | | 0 | 14,966 | 49 | 52 | 48 |
| P1018L | 55,282 | 1.27 | 7,028 | 13 | | 0 | 48,254 | 87 | 14 | 86 |
| P1021R | 27,818 | 0.64 | 13,126 | 47 | | 0 | 14,692 | 53 | 48 | 52 |
| P1021RA | 12,175 | 0.28 | 12,175 | 100 | | 0 | 0 | 0 | 100 | 0 |
| P1029L | 4,322,064 | 99.22 | 6,784 | 0 | 1,969,817 | 46 | 2,345,463 | 54 | 22 | 78 |
| P1029R | 61,807 | 1.42 | 34,743 | 56 | | 0 | 27,064 | 44 | 57 | 43 |
| P1030R | 33,240 | 0.76 | 0 | 0 | | 0 | 33,240 | 100 | 2 | 98 |
| P1031L | 45,261 | 1.04 | 21,989 | 49 | | 0 | 23,272 | 51 | 50 | 50 |
| P1031R | 32,343 | 0.74 | 14,680 | 45 | | 0 | 17,663 | 55 | 46 | 54 |
| P1032R | 11,285 | 0.26 | 0 | 0 | | 0 | 11,285 | 100 | 2 | 98 |
| P1034R | 30,466 | 0.70 | 2,789 | 9 | | 0 | 27,677 | 91 | 11 | 89 |
| P1043R | 47,432 | 1.09 | 5,877 | 12 | | 0 | 41,555 | 88 | 14 | 86 |
| P1044L | 101,570 | 2.33 | 3,148 | 3 | | 0 | 98,422 | 97 | 5 | 95 |
| Mobility Hub Jay Road Inlet | 19,113 | 0.44 | 19,113 | 100 | | 0 | 0 | 0 | 100 | 0 |
| P1048L | 52,350 | 1.20 | 10,230 | 20 | | 0 | 42,120 | 80 | 21 | 79 |
| P1053L | 92,203 | 2.12 | 65,508 | 71 | | 0 | 26,695 | 29 | 72 | 28 |
| P1054R | 101,448 | 2.33 | 27,235 | 27 | | 0 | 74,213 | 73 | 28 | 72 |
| P1056L | 50,851 | 1.17 | 15,696 | 31 | | 0 | 35,155 | 69 | 32 | 68 |
| P1057L | 12,427 | 0.29 | 2,430 | 20 | | 0 | 9,997 | 80 | 21 | 79 |
| P1058L | 2,104 | 0.05 | 0 | 0 | | 0 | 2,104 | 100 | 2 | 98 |
| P1063R | 39,917 | 0.92 | 732 | 2 | | 0 | 39,185 | 98 | 4 | 96 |
| P1067L | 124,252 | 2.85 | 12,017 | 10 | | 0 | 112,235 | 90 | 11 | 89 |
| P1069R | 55,715 | 1.28 | 3,449 | 6 | | 0 | 52,266 | 94 | 8 | 92 |
| P1076L | 46,204 | 1.06 | 1,872 | 4 | | 0 | 44,332 | 96 | 6 | 94 |
| P1077R | 80,690 | 1.85 | 4,881 | 6 | | 0 | 75,809 | 94 | 8 | 92 |
| P1080R | 69,050 | 1.59 | 5,198 | 8 | | 0 | 63,852 | 92 | 9 | 91 |
| P1082L | 74,084 | 1.70 | 36,603 | 49 | | 0 | 37,481 | 51 | 50 | 50 |
| P1082R | 8,595 | 0.20 | 396 | 5 | | 0 | 8,199 | 95 | 7 | 93 |
| P1088R | 137,450 | 3.16 | 30,802 | 22 | | 0 | 106,648 | 78 | 24 | 76 |
| P2010R | 139,279 | 3.20 | 16,199 | 12 | 0 | 0 | 123,080 | 88 | 13 | 87 |

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

| Land Use Types | Percent Impervious |
|---|---|
| STREETS: PAVED | 100 |
| RESIDENTIAL: 0.25 ACRES OR LESS | 45 |
| UNDEVELOPED AREAS: GREENBELTS, AGRICULTURAL | 2 |

Land Use Types and Imperviousness Values from USDCM Volume 1 Table 6-3

## PERCENT IMPERVIOUS VALUES

| BASIN ID | TOTAL AREA | | STREETS: PAVED | | RESIDENTIAL: 0.25 ACRES OR LESS | | UNDEVELOPED AREAS: GREENBELTS, AGRICULTURAL | | WEIGHTED PERCENT IMPERVIOUS | WEIGHTED PERCENT PERVIOUS |
|---|---|---|---|---|---|---|---|---|---|---|
| | (sq ft) | (acre) | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | | |
| P2021L | 341,127 | 7.83 | 23,196 | 7 | 0 | 0 | 317,931 | 93 | 9 | 91 |
| P2022L | 2,866 | 0.07 | 0 | 0 | 0 | 0 | 2,866 | 100 | 2 | 98 |
| P2022R | 130,684 | 3.00 | 21,286 | 16 | 0 | 0 | 109,398 | 84 | 18 | 82 |
| P2030L | 51,510 | 1.18 | 1,534 | 3 | 0 | 0 | 49,976 | 97 | 5 | 95 |
| P2031R | 102,855 | 2.36 | 14,328 | 14 | 0 | 0 | 88,528 | 86 | 16 | 84 |
| P2032L | 5,099 | 0.12 | 85 | 2 | 0 | 0 | 5,014 | 98 | 4 | 96 |
| P2049L | 76,390 | 1.75 | 803 | 1 | 0 | 0 | 75,587 | 99 | 3 | 97 |
| P2058L | 23,092 | 0.53 | 0 | 0 | 0 | 0 | 23,092 | 100 | 2 | 98 |
| P2059R | 427,969 | 9.82 | 83,898 | 20 | 0 | 0 | 344,071 | 80 | 21 | 79 |
| P2062L | 49,195 | 1.13 | 44,908 | 91 | 0 | 0 | 4,287 | 9 | 91 | 9 |
| P2064R | 105,905 | 2.43 | 28,981 | 27 | 0 | 0 | 76,924 | 73 | 29 | 71 |
| P2066R | 98,463 | 2.26 | 27,298 | 28 | 0 | 0 | 71,165 | 72 | 29 | 71 |
| P2063R | 10,207 | 0.23 | 4,818 | 47 | 0 | 0 | 5,389 | 53 | 48 | 52 |
| P2075L | 25,076 | 0.58 | 769 | 3 | 0 | 0 | 24,307 | 97 | 5 | 95 |
| P2077L | 16,160 | 0.37 | 2,841 | 18 | 0 | 0 | 13,319 | 82 | 19 | 81 |
| P2079L | 75,318 | 1.73 | 19,121 | 25 | 0 | 0 | 56,197 | 75 | 27 | 73 |
| P2084L | 35,033 | 0.80 | 1,863 | 5 | 0 | 0 | 33,170 | 95 | 7 | 93 |
| P2085R | 111,797 | 2.57 | 26,602 | 24 | 0 | 0 | 85,195 | 76 | 25 | 75 |
| P2085L | 101,216 | 2.32 | 16,541 | 16 | 0 | 0 | 84,675 | 84 | 18 | 82 |
| P2092R | 17,184 | 0.39 | 5,706 | 33 | 0 | 0 | 11,478 | 67 | 35 | 65 |
| P2093R | 73,728 | 1.69 | 9,813 | 13 | 0 | 0 | 63,915 | 87 | 15 | 85 |
| P2100L | 47,275 | 1.09 | 3,000 | 6 | 0 | 0 | 44,275 | 94 | 8 | 92 |
| P2100R | 135,561 | 3.11 | 19,288 | 14 | 0 | 0 | 116,273 | 86 | 16 | 84 |
| P2098R | 16,426 | 0.38 | 2,693 | 16 | 0 | 0 | 13,733 | 84 | 18 | 82 |
| P3021R | 8,688 | 0.20 | 8,688 | 100 | 0 | 0 | 0 | 0 | 100 | 0 |
| P3023R | 7,508 | 0.17 | 7,508 | 100 | 0 | 0 | 0 | 0 | 100 | 0 |
| P3042R | 42,275 | 0.97 | 13,029 | 31 | 0 | 0 | 29,246 | 69 | 32 | 68 |
| P3049L | 64,035 | 1.47 | 23,245 | 36 | 0 | 0 | 40,790 | 64 | 38 | 62 |
| P3049R | 97,628 | 2.24 | 36,139 | 37 | 0 | 0 | 61,489 | 63 | 38 | 62 |
| P3052R | 26,431 | 0.61 | 10,214 | 39 | 0 | 0 | 16,217 | 61 | 40 | 60 |
| P4018L | 596,253 | 13.69 | 68,375 | 11 | 0 | 0 | 527,878 | 89 | 13 | 87 |
| P4019R | 146,999 | 3.37 | 43,232 | 29 | 0 | 0 | 103,767 | 71 | 31 | 69 |
| P4019RA | 9,066 | 0.21 | 7,731 | 85 | 0 | 0 | 1,334 | 15 | 86 | 14 |

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

| Land Use Types | Percent Impervious |
|---|---|
| STREETS: PAVED | 100 |
| RESIDENTIAL: 0.25 ACRES OR LESS | 45 |
| UNDEVELOPED AREAS: GREENBELTS, AGRICULTURAL | 2 |

Land Use Types and Imperviousness Values from USDCM Volume 1 Table 6-3

PERCENT IMPERVIOUS VALUES

| BASIN ID | TOTAL AREA | | STREETS: PAVED | | RESIDENTIAL: 0.25 ACRES OR LESS | | UNDEVELOPED AREAS: GREENBELTS, AGRICULTURAL | | WEIGHTED PERCENT IMPERVIOUS | WEIGHTED PERCENT PERVIOUS |
|---|---|---|---|---|---|---|---|---|---|---|
| | (sq ft) | (acre) | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | | |
| P4020R | 18,097 | 0.42 | 10,505 | 58 | 0 | 0 | 7,592 | 42 | 59 | 41 |
| P4021R | 15,056 | 0.35 | 12,326 | 82 | 0 | 0 | 2,730 | 18 | 82 | 18 |
| P4023R | 151,399 | 3.48 | 132,698 | 88 | 0 | 0 | 18,701 | 12 | 88 | 12 |
| P4028R | 89,275 | 2.05 | 5,789 | 6 | 0 | 0 | 83,486 | 94 | 8 | 92 |
| P4040L | 63,688 | 1.46 | 431 | 1 | 0 | 0 | 63,257 | 99 | 3 | 97 |
| P4044R | 231,372 | 5.31 | 24,901 | 11 | 0 | 0 | 206,471 | 89 | 13 | 87 |
| P4053L | 80,884 | 1.86 | 190 | 0 | 0 | 0 | 80,694 | 100 | 2 | 98 |
| P4054R | 136,299 | 3.13 | 35,075 | 26 | 0 | 0 | 101,224 | 74 | 27 | 73 |
| P4060L | 52,733 | 1.21 | 94 | 0 | 0 | 0 | 52,640 | 100 | 2 | 98 |
| P4065R | 143,409 | 3.29 | 38,307 | 27 | 0 | 0 | 105,101 | 73 | 28 | 72 |
| P4074R | 123,870 | 2.84 | 35,609 | 29 | 0 | 0 | 88,261 | 71 | 30 | 70 |
| P4075L | 101,855 | 2.34 | 88 | 0 | 0 | 0 | 101,767 | 100 | 2 | 98 |
| P4076L | 3,977 | 0.09 | 725 | 18 | 0 | 0 | 3,253 | 82 | 20 | 80 |
| P4081L | 57,379 | 1.32 | 7,462 | 13 | 0 | 0 | 49,916 | 87 | 15 | 85 |
| P4081R | 71,026 | 1.63 | 23,209 | 33 | 0 | 0 | 47,817 | 67 | 34 | 66 |
| P4086R | 70,230 | 1.61 | 20,749 | 30 | 0 | 0 | 49,481 | 70 | 31 | 69 |
| P4087L | 59,967 | 1.38 | 9,503 | 16 | 0 | 0 | 50,465 | 84 | 18 | 82 |
| P4091L | 60,677 | 1.39 | 30,554 | 50 | 0 | 0 | 30,123 | 50 | 51 | 49 |
| P4091R | 43,938 | 1.01 | 10,042 | 23 | 0 | 0 | 33,896 | 77 | 24 | 76 |
| P4093L | 20,171 | 0.46 | 9,959 | 49 | 0 | 0 | 10,212 | 51 | 50 | 50 |
| P4095R | 19,774 | 0.45 | 8,844 | 45 | 0 | 0 | 10,930 | 55 | 46 | 54 |
| P4108R | 170,192 | 3.91 | 43,555 | 26 | 0 | 0 | 126,637 | 74 | 27 | 73 |
| P4114L | 157,955 | 3.63 | 14,169 | 9 | 0 | 0 | 143,785 | 91 | 11 | 89 |
| P4117R | 98,714 | 2.27 | 36,188 | 37 | 0 | 0 | 62,525 | 63 | 38 | 62 |
| P5006R | 62,881 | 1.44 | 18,304 | 29 | 0 | 0 | 44,577 | 71 | 31 | 69 |
| P5007R | 4,569 | 0.10 | 2,133 | 47 | 0 | 0 | 2,437 | 53 | 48 | 52 |
| P5011L | 240,492 | 5.52 | 47,197 | 20 | 0 | 0 | 193,295 | 80 | 21 | 79 |
| P5011R | 99,149 | 2.28 | 14,488 | 15 | 0 | 0 | 84,661 | 85 | 16 | 84 |
| P5013L | 134,100 | 3.08 | 36,023 | 27 | 0 | 0 | 98,077 | 73 | 28 | 72 |
| P5023R | 249,731 | 5.73 | 43,437 | 17 | 0 | 0 | 206,294 | 83 | 19 | 81 |
| P5023L | 51,051 | 1.17 | 13,889 | 27 | 0 | 0 | 37,161 | 73 | 29 | 71 |
| P5030L | 131,456 | 3.02 | 6,772 | 5 | 0 | 0 | 124,683 | 95 | 7 | 93 |
| P5033R | 181,335 | 4.16 | 35,151 | 19 | 0 | 0 | 146,184 | 81 | 21 | 79 |

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

| Land Use Types | Percent Impervious |
|---|---|
| STREETS: PAVED | 100 |
| RESIDENTIAL: 0.25 ACRES OR LESS | 45 |
| UNDEVELOPED AREAS: GREENBELTS, AGRICULTURAL | 2 |

Land Use Types and Imperviousness Values from USDCM Volume 1 Table 6-3

## PERCENT IMPERVIOUS VALUES

| BASIN ID | TOTAL AREA | | STREETS: PAVED | | RESIDENTIAL: 0.25 ACRES OR LESS | | UNDEVELOPED AREAS: GREENBELTS, AGRICULTURAL | | WEIGHTED PERCENT IMPERVIOUS | WEIGHTED PERCENT PERVIOUS |
|---|---|---|---|---|---|---|---|---|---|---|
| | (sq ft) | (acre) | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | (sq ft) | % of Basin [2] | | |
| P5040L | 38,574 | 0.89 | 687 | 2 | 0 | 0 | 37,886 | 98 | 4 | 96 |
| P5041R | 40,549 | 0.93 | 15,690 | 39 | 0 | 0 | 24,859 | 61 | 40 | 60 |
| P5048L | 48,649 | 1.12 | 0 | 0 | 0 | 0 | 48,649 | 100 | 2 | 98 |
| P5048R | 113,201 | 2.60 | 47,522 | 42 | 0 | 0 | 65,679 | 58 | 43 | 57 |
| P5052L | 86,807 | 1.99 | 23,991 | 28 | 0 | 0 | 62,816 | 72 | 29 | 71 |
| P5064R | 297,129 | 6.82 | 63,970 | 22 | 0 | 0 | 233,159 | 78 | 23 | 77 |
| P5066L | 351,919 | 8.08 | 62,163 | 18 | 0 | 0 | 289,756 | 82 | 19 | 81 |
| P5068R | 685,963 | 15.75 | 42,661 | 6 | 0 | 0 | 643,302 | 94 | 8 | 92 |
| P5076R | 68,599 | 1.57 | 27,770 | 40 | 0 | 0 | 40,829 | 60 | 42 | 58 |
| P5084R | 62,649 | 1.44 | 62,649 | 100 | 0 | 0 | 0 | 0 | 100 | 0 |
| P5084L | 226,563 | 5.20 | 16,432 | 7 | 0 | 0 | 210,131 | 93 | 9 | 91 |
| P5066R | 112,112 | 2.57 | 6,678 | 6 | 0 | 0 | 105,434 | 94 | 8 | 92 |
| P5001L | 99,055 | 2.27 | 9,769 | 10 | 0 | 0 | 89,287 | 90 | 12 | 88 |
| P4028L | 27,547 | 0.63 | 16,743 | 61 | 0 | 0 | 10,804 | 39 | 62 | 38 |

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## RUNOFF COEFFIECIENTS FOR 2, 5, 10, 25, 50, AND 100 YEAR STORM EVENTS

| BASIN ID | NRCS HYDROLOGIC SOIL GROUP[1] | | | | | | | | | | | | | | | | | | | | | | | | | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SOIL GROUP (%)[1] | | | SOIL GROUP A | | | | | | | SOIL GROUP B | | | | | | | SOIL GROUP C/D | | | | | | | | | | | | |
| | A | B | C/D | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | % | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | % | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | % | | | | | | |
| P1000R | | 100 | | | | | | | | 0 | 0.05 | 0.07 | 0.13 | 0.31 | 0.38 | 0.47 | 100 | | | | | | | 0 | 0.05 | 0.07 | 0.13 | 0.31 | 0.38 | 0.47 |
| P1013R | | 100 | | | | | | | | 0 | 0.43 | 0.46 | 0.51 | 0.60 | 0.64 | 0.69 | 100 | | | | | | | 0 | 0.43 | 0.46 | 0.51 | 0.60 | 0.64 | 0.69 |
| P1016L | | 100 | | | | | | | | 0 | 0.06 | 0.08 | 0.15 | 0.32 | 0.39 | 0.48 | 100 | | | | | | | 0 | 0.06 | 0.08 | 0.15 | 0.32 | 0.39 | 0.48 |
| P1017L | | 100 | | | | | | | | 0 | 0.39 | 0.42 | 0.48 | 0.58 | 0.62 | 0.67 | 100 | | | | | | | 0 | 0.39 | 0.42 | 0.48 | 0.58 | 0.62 | 0.67 |
| P1018L | | 25 | 75 | | | | | | | 0 | 0.09 | 0.10 | 0.17 | 0.34 | 0.41 | 0.49 | 25 | 0.09 | 0.15 | 0.24 | 0.40 | 0.46 | 0.54 | 75 | 0.09 | 0.14 | 0.22 | 0.38 | 0.45 | 0.53 |
| P1021R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.37 | 0.43 | 0.49 | 0.59 | 0.63 | 0.68 | 100 | 0.37 | 0.43 | 0.49 | 0.59 | 0.63 | 0.68 |
| P1021RA | | 25 | 75 | | | | | | | 0 | 0.84 | 0.86 | 0.87 | 0.88 | 0.89 | 0.90 | 25 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 | 75 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 |
| P1029L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 100 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 |
| P1029R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.44 | 0.50 | 0.55 | 0.64 | 0.67 | 0.72 | 100 | 0.44 | 0.50 | 0.55 | 0.64 | 0.67 | 0.72 |
| P1030R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| P1031L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.38 | 0.44 | 0.50 | 0.60 | 0.64 | 0.69 | 100 | 0.38 | 0.44 | 0.50 | 0.60 | 0.64 | 0.69 |
| P1031R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.35 | 0.42 | 0.48 | 0.58 | 0.62 | 0.67 | 100 | 0.35 | 0.42 | 0.48 | 0.58 | 0.62 | 0.67 |
| P1032R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| P1034R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 | 100 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 |
| P1043R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.09 | 0.15 | 0.24 | 0.40 | 0.46 | 0.54 | 100 | 0.09 | 0.15 | 0.24 | 0.40 | 0.46 | 0.54 |
| P1044L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.03 | 0.08 | 0.17 | 0.35 | 0.42 | 0.50 | 100 | 0.03 | 0.08 | 0.17 | 0.35 | 0.42 | 0.50 |
| Mobility Hub Jay Road Inlet | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 | 100 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 |
| P1048L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 100 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 |
| P1053L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.57 | 0.62 | 0.66 | 0.72 | 0.74 | 0.78 | 100 | 0.57 | 0.62 | 0.66 | 0.72 | 0.74 | 0.78 |
| P1054R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.20 | 0.27 | 0.34 | 0.48 | 0.53 | 0.60 | 100 | 0.20 | 0.27 | 0.34 | 0.48 | 0.53 | 0.60 |
| P1056L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.23 | 0.30 | 0.37 | 0.50 | 0.55 | 0.62 | 100 | 0.23 | 0.30 | 0.37 | 0.50 | 0.55 | 0.62 |
| P1057L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 100 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 |
| P1058L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| P1063R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.02 | 0.07 | 0.16 | 0.34 | 0.41 | 0.50 | 100 | 0.02 | 0.07 | 0.16 | 0.34 | 0.41 | 0.50 |
| P1067L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.07 | 0.13 | 0.22 | 0.38 | 0.45 | 0.53 | 100 | 0.07 | 0.13 | 0.22 | 0.38 | 0.45 | 0.53 |
| P1069R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 | 100 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 |
| P1076L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.04 | 0.08 | 0.18 | 0.35 | 0.42 | 0.51 | 100 | 0.04 | 0.08 | 0.18 | 0.35 | 0.42 | 0.51 |
| P1077R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 | 100 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 |
| P1080R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.06 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 | 100 | 0.06 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 |
| P1082L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.38 | 0.45 | 0.51 | 0.60 | 0.64 | 0.69 | 100 | 0.38 | 0.45 | 0.51 | 0.60 | 0.64 | 0.69 |
| P1082R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.04 | 0.09 | 0.18 | 0.36 | 0.42 | 0.51 | 100 | 0.04 | 0.09 | 0.18 | 0.36 | 0.42 | 0.51 |
| P1088R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.17 | 0.23 | 0.31 | 0.45 | 0.51 | 0.58 | 100 | 0.17 | 0.23 | 0.31 | 0.45 | 0.51 | 0.58 |
| P2010R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.09 | 0.14 | 0.23 | 0.39 | 0.46 | 0.54 | 100 | 0.09 | 0.14 | 0.23 | 0.39 | 0.46 | 0.54 |
| P2021L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.05 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 | 100 | 0.05 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 |
| P2022L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| P2022R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.12 | 0.18 | 0.26 | 0.42 | 0.48 | 0.56 | 100 | 0.12 | 0.18 | 0.26 | 0.42 | 0.48 | 0.56 |
| P2030L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.03 | 0.08 | 0.17 | 0.35 | 0.42 | 0.50 | 100 | 0.03 | 0.08 | 0.17 | 0.35 | 0.42 | 0.50 |
| P2031R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.10 | 0.16 | 0.25 | 0.41 | 0.47 | 0.55 | 100 | 0.10 | 0.16 | 0.25 | 0.41 | 0.47 | 0.55 |
| P2032L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.02 | 0.06 | 0.16 | 0.34 | 0.41 | 0.50 | 100 | 0.02 | 0.06 | 0.16 | 0.34 | 0.41 | 0.50 |
| P2049L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.02 | 0.06 | 0.15 | 0.34 | 0.41 | 0.50 | 100 | 0.02 | 0.06 | 0.15 | 0.34 | 0.41 | 0.50 |
| P2058L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| P2059R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 100 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 |
| P2062L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.75 | 0.78 | 0.81 | 0.83 | 0.84 | 0.86 | 100 | 0.75 | 0.78 | 0.81 | 0.83 | 0.84 | 0.86 |
| P2064R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.21 | 0.27 | 0.35 | 0.48 | 0.53 | 0.60 | 100 | 0.21 | 0.27 | 0.35 | 0.48 | 0.53 | 0.60 |
| P2066R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.21 | 0.27 | 0.35 | 0.48 | 0.54 | 0.60 | 100 | 0.21 | 0.27 | 0.35 | 0.48 | 0.54 | 0.60 |
| P2063R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.37 | 0.43 | 0.49 | 0.59 | 0.63 | 0.68 | 100 | 0.37 | 0.43 | 0.49 | 0.59 | 0.63 | 0.68 |
| P2075L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.03 | 0.08 | 0.17 | 0.35 | 0.42 | 0.50 | 100 | 0.03 | 0.08 | 0.17 | 0.35 | 0.42 | 0.50 |
| P2077L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.13 | 0.19 | 0.27 | 0.43 | 0.49 | 0.56 | 100 | 0.13 | 0.19 | 0.27 | 0.43 | 0.49 | 0.56 |
| P2079L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.19 | 0.26 | 0.33 | 0.47 | 0.52 | 0.59 | 100 | 0.19 | 0.26 | 0.33 | 0.47 | 0.52 | 0.59 |
| P2084L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.04 | 0.09 | 0.19 | 0.36 | 0.43 | 0.51 | 100 | 0.04 | 0.09 | 0.19 | 0.36 | 0.43 | 0.51 |
| P2085R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.18 | 0.24 | 0.32 | 0.46 | 0.52 | 0.59 | 100 | 0.18 | 0.24 | 0.32 | 0.46 | 0.52 | 0.59 |
| P2085L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.12 | 0.18 | 0.27 | 0.42 | 0.48 | 0.56 | 100 | 0.12 | 0.18 | 0.27 | 0.42 | 0.48 | 0.56 |
| P2092R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.25 | 0.32 | 0.39 | 0.51 | 0.56 | 0.63 | 100 | 0.25 | 0.32 | 0.39 | 0.51 | 0.56 | 0.63 |
| P2093R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.10 | 0.16 | 0.24 | 0.40 | 0.47 | 0.55 | 100 | 0.10 | 0.16 | 0.24 | 0.40 | 0.47 | 0.55 |
| P2100L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.05 | 0.10 | 0.19 | 0.37 | 0.43 | 0.52 | 100 | 0.05 | 0.10 | 0.19 | 0.37 | 0.43 | 0.52 |
| P2100R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.11 | 0.17 | 0.25 | 0.41 | 0.47 | 0.55 | 100 | 0.11 | 0.17 | 0.25 | 0.41 | 0.47 | 0.55 |
| P2098R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.12 | 0.18 | 0.27 | 0.42 | 0.48 | 0.56 | 100 | 0.12 | 0.18 | 0.27 | 0.42 | 0.48 | 0.56 |
| P3021R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 | 100 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 |
| P3023R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 | 100 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 |
| P3042R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.23 | 0.30 | 0.37 | 0.50 | 0.55 | 0.62 | 100 | 0.23 | 0.30 | 0.37 | 0.50 | 0.55 | 0.62 |
| P3049L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.28 | 0.34 | 0.41 | 0.53 | 0.58 | 0.64 | 100 | 0.28 | 0.34 | 0.41 | 0.53 | 0.58 | 0.64 |
| P3049R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.28 | 0.35 | 0.42 | 0.53 | 0.58 | 0.64 | 100 | 0.28 | 0.35 | 0.42 | 0.53 | 0.58 | 0.64 |
| P3052R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.30 | 0.36 | 0.43 | 0.54 | 0.59 | 0.65 | 100 | 0.30 | 0.36 | 0.43 | 0.54 | 0.59 | 0.65 |

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## RUNOFF COEFFIECIENTS FOR 2, 5, 10, 25, 50, AND 100 YEAR STORM EVENTS

| BASIN ID | NRCS HYDROLOGIC SOIL GROUP[1] | | | | | | | | | | | | | | | | | | | | | | | | | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SOIL GROUP (%)[1] | | | SOIL GROUP A | | | | | | | SOIL GROUP B | | | | | | | SOIL GROUP C/D | | | | | | | | | | | | |
| | A | B | C/D | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | % | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | % | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | % | | | | | | |
| P4018L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.09 | 0.14 | 0.23 | 0.39 | 0.46 | 0.54 | 100 | 0.09 | 0.14 | 0.23 | 0.39 | 0.46 | 0.54 |
| P4019R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.22 | 0.29 | 0.36 | 0.49 | 0.54 | 0.61 | 100 | 0.22 | 0.29 | 0.36 | 0.49 | 0.54 | 0.61 |
| P4019RA | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.70 | 0.74 | 0.77 | 0.80 | 0.81 | 0.83 | 100 | 0.70 | 0.74 | 0.77 | 0.80 | 0.81 | 0.83 |
| P4020R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.46 | 0.52 | 0.57 | 0.65 | 0.68 | 0.73 | 100 | 0.46 | 0.52 | 0.57 | 0.65 | 0.68 | 0.73 |
| P4021R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.67 | 0.71 | 0.74 | 0.78 | 0.80 | 0.82 | 100 | 0.67 | 0.71 | 0.74 | 0.78 | 0.80 | 0.82 |
| P4023R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.72 | 0.76 | 0.78 | 0.81 | 0.82 | 0.84 | 100 | 0.72 | 0.76 | 0.78 | 0.81 | 0.82 | 0.84 |
| P4028R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.05 | 0.10 | 0.19 | 0.37 | 0.43 | 0.52 | 100 | 0.05 | 0.10 | 0.19 | 0.37 | 0.43 | 0.52 |
| P4040L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.06 | 0.15 | 0.33 | 0.41 | 0.49 | 100 | 0.01 | 0.06 | 0.15 | 0.33 | 0.41 | 0.49 |
| P4044R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.08 | 0.14 | 0.22 | 0.39 | 0.45 | 0.54 | 100 | 0.08 | 0.14 | 0.22 | 0.39 | 0.45 | 0.54 |
| P4053L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| P4054R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.19 | 0.26 | 0.33 | 0.47 | 0.53 | 0.60 | 100 | 0.19 | 0.26 | 0.33 | 0.47 | 0.53 | 0.60 |
| P4060L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| P4065R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.20 | 0.27 | 0.34 | 0.48 | 0.53 | 0.60 | 100 | 0.20 | 0.27 | 0.34 | 0.48 | 0.53 | 0.60 |
| P4074R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.22 | 0.28 | 0.36 | 0.49 | 0.54 | 0.61 | 100 | 0.22 | 0.28 | 0.36 | 0.49 | 0.54 | 0.61 |
| P4075L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 100 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 |
| P4076L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.14 | 0.20 | 0.28 | 0.43 | 0.49 | 0.57 | 100 | 0.14 | 0.20 | 0.28 | 0.43 | 0.49 | 0.57 |
| P4081L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.10 | 0.16 | 0.24 | 0.40 | 0.47 | 0.54 | 100 | 0.10 | 0.16 | 0.24 | 0.40 | 0.47 | 0.54 |
| P4081R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.25 | 0.31 | 0.38 | 0.51 | 0.56 | 0.62 | 100 | 0.25 | 0.31 | 0.38 | 0.51 | 0.56 | 0.62 |
| P4086R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.22 | 0.29 | 0.36 | 0.49 | 0.54 | 0.61 | 100 | 0.22 | 0.29 | 0.36 | 0.49 | 0.54 | 0.61 |
| P4087L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.12 | 0.18 | 0.26 | 0.42 | 0.48 | 0.56 | 100 | 0.12 | 0.18 | 0.26 | 0.42 | 0.48 | 0.56 |
| P4091L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.39 | 0.46 | 0.51 | 0.61 | 0.64 | 0.69 | 100 | 0.39 | 0.46 | 0.51 | 0.61 | 0.64 | 0.69 |
| P4091R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.17 | 0.24 | 0.31 | 0.46 | 0.51 | 0.58 | 100 | 0.17 | 0.24 | 0.31 | 0.46 | 0.51 | 0.58 |
| P4093L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.38 | 0.45 | 0.50 | 0.60 | 0.64 | 0.69 | 100 | 0.38 | 0.45 | 0.50 | 0.60 | 0.64 | 0.69 |
| P4095R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.35 | 0.41 | 0.47 | 0.58 | 0.62 | 0.67 | 100 | 0.35 | 0.41 | 0.47 | 0.58 | 0.62 | 0.67 |
| P4108R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.19 | 0.26 | 0.33 | 0.47 | 0.53 | 0.60 | 100 | 0.19 | 0.26 | 0.33 | 0.47 | 0.53 | 0.60 |
| P4114L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 | 100 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 |
| P4117R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.28 | 0.35 | 0.41 | 0.53 | 0.58 | 0.64 | 100 | 0.28 | 0.35 | 0.41 | 0.53 | 0.58 | 0.64 |
| P5006R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.22 | 0.29 | 0.36 | 0.49 | 0.54 | 0.61 | 100 | 0.22 | 0.29 | 0.36 | 0.49 | 0.54 | 0.61 |
| P5007R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.36 | 0.43 | 0.49 | 0.59 | 0.63 | 0.68 | 100 | 0.36 | 0.43 | 0.49 | 0.59 | 0.63 | 0.68 |
| P5011L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 100 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 |
| P5011R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.11 | 0.17 | 0.25 | 0.41 | 0.47 | 0.55 | 100 | 0.11 | 0.17 | 0.25 | 0.41 | 0.47 | 0.55 |
| P5013L | | 100 | | | | | | | | 0 | 0.19 | 0.22 | 0.29 | 0.43 | 0.49 | 0.56 | 100 | | | | | | | 0 | 0.19 | 0.22 | 0.29 | 0.43 | 0.49 | 0.56 |
| P5023R | 50 | 50 | | 0.10 | 0.10 | 0.11 | 0.14 | 0.19 | 0.26 | 50 | 0.12 | 0.14 | 0.21 | 0.37 | 0.43 | 0.52 | 50 | | | | | | | 0 | 0.11 | 0.12 | 0.16 | 0.25 | 0.31 | 0.39 |
| P5023L | 50 | 50 | | 0.17 | 0.17 | 0.19 | 0.22 | 0.27 | 0.33 | 50 | 0.19 | 0.22 | 0.29 | 0.43 | 0.49 | 0.56 | 50 | | | | | | | 0 | 0.18 | 0.20 | 0.24 | 0.32 | 0.38 | 0.45 |
| P5030L | 100 | | | 0.03 | 0.03 | 0.03 | 0.04 | 0.08 | 0.16 | 100 | | | | | | | 0 | | | | | | | 0 | 0.03 | 0.03 | 0.03 | 0.04 | 0.08 | 0.16 |
| P5033R | 100 | | | 0.11 | 0.12 | 0.13 | 0.15 | 0.20 | 0.27 | 100 | | | | | | | 0 | | | | | | | 0 | 0.11 | 0.12 | 0.13 | 0.15 | 0.20 | 0.27 |
| P5040L | 100 | | | 0.01 | 0.01 | 0.02 | 0.02 | 0.06 | 0.14 | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.01 | 0.02 | 0.02 | 0.06 | 0.14 |
| P5041R | 100 | | | 0.25 | 0.27 | 0.28 | 0.31 | 0.36 | 0.42 | 100 | | | | | | | 0 | | | | | | | 0 | 0.25 | 0.27 | 0.28 | 0.31 | 0.36 | 0.42 |
| P5048L | 100 | | | 0.01 | 0.01 | 0.01 | 0.01 | 0.04 | 0.13 | 100 | | | | | | | 0 | | | | | | | 0 | 0.01 | 0.01 | 0.01 | 0.01 | 0.04 | 0.13 |
| P5048R | 100 | | | 0.28 | 0.29 | 0.31 | 0.34 | 0.39 | 0.45 | 100 | | | | | | | 0 | | | | | | | 0 | 0.28 | 0.29 | 0.31 | 0.34 | 0.39 | 0.45 |
| P5052L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.21 | 0.27 | 0.35 | 0.48 | 0.54 | 0.60 | 100 | 0.21 | 0.27 | 0.35 | 0.48 | 0.54 | 0.60 |
| P5064R | | 100 | | | | | | | | 0 | 0.15 | 0.17 | 0.24 | 0.39 | 0.46 | 0.53 | 100 | | | | | | | 0 | 0.15 | 0.17 | 0.24 | 0.39 | 0.46 | 0.53 |
| P5066L | | 100 | | | | | | | | 0 | 0.12 | 0.14 | 0.21 | 0.37 | 0.44 | 0.52 | 100 | | | | | | | 0 | 0.12 | 0.14 | 0.21 | 0.37 | 0.44 | 0.52 |
| P5068R | | 100 | | | | | | | | 0 | 0.04 | 0.06 | 0.12 | 0.30 | 0.37 | 0.46 | 100 | | | | | | | 0 | 0.04 | 0.06 | 0.12 | 0.30 | 0.37 | 0.46 |
| P5076R | | 100 | | | | | | | | 0 | 0.30 | 0.33 | 0.39 | 0.51 | 0.56 | 0.62 | 100 | | | | | | | 0 | 0.30 | 0.33 | 0.39 | 0.51 | 0.56 | 0.62 |
| P5084R | | 100 | | | | | | | | 0 | 0.84 | 0.86 | 0.87 | 0.88 | 0.89 | 0.90 | 100 | | | | | | | 0 | 0.84 | 0.86 | 0.87 | 0.88 | 0.89 | 0.90 |
| P5084L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.06 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 | 100 | 0.06 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 |
| P5066R | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 | 100 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 |
| P5001L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.07 | 0.13 | 0.22 | 0.38 | 0.45 | 0.53 | 100 | 0.07 | 0.13 | 0.22 | 0.38 | 0.45 | 0.53 |
| P4028L | | | 100 | | | | | | | 0 | | | | | | | 0 | 0.48 | 0.54 | 0.59 | 0.66 | 0.69 | 0.74 | 100 | 0.48 | 0.54 | 0.59 | 0.66 | 0.69 | 0.74 |

[1] Soil Group based on NRCS Soil Classification Map

[2] C Values obtained from USDCM Manual, March 2017, Chpt 6, Sec 2.5.1, Table 6-4

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

# TIME OF CONCENTRATION

| BASIN DATA | | | | INITIAL/OVERLAND TIME ($T_i$) | | | | | CHANNELIZED (TRAVEL) TIME ($T_t$) | | | | | | | | TOTAL $t_c$ | $T_c$ CHECK (Urbanized Basins) | | FINAL $t_c$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BASIN ID | AREA (acre) | $C_5$ | Basin Type | LENGTH $L_i$ (ft) | ELEV. START (ft) | ELEV. END (ft) | OVERLAND SLOPE ($S_i$) (ft/ft) | $t_i$ (min)[1] | LENGTH $L_t$ (ft) | ELEV. START (ft) | ELEV. END (ft) | CHANNELIZED SLOPE ($S_t$) (ft/ft) | CONVEYANCE COEFFICIENT Type | CONVEYANCE COEFFICIENT K | Velocity $V_t$ (ft/sec) | $t_t$ (min)[2] | $t_i + t_t$ (min.) | First Design Point | Maximum $t_c$ (min)[3] | $t_{minimum}$= 5 (Urban) $t_{minimum}$= 10 (Non-Urban) |
| P1000R | 1.41 | 0.07 | Non-Urban | 234 | 5331.40 | 5308.90 | 0.096 | 13.5 | 276 | 5308.90 | 5308.40 | 0.002 | SP | 7 | 0.3 | 15.4 | 29.0 | No | N/A | 29.0 |
| P1013R | 1.54 | 0.46 | Urban | 79 | 5308.00 | 5306.00 | 0.025 | 7.6 | 762 | 5306.00 | 5291.70 | 0.019 | SP | 7 | 1.0 | 13.2 | 20.8 | Yes | 22.0 | 20.8 |
| P1016L | 8.85 | 0.08 | Non-Urban | 500 | 5331.50 | 5296.00 | 0.071 | 21.6 | 705 | 5296.00 | 5287.50 | 0.012 | SP | 7 | 0.8 | 15.3 | 36.9 | No | N/A | 36.9 |
| P1017L | 0.71 | 0.42 | Urban | 23 | 5292.00 | 5291.30 | 0.030 | 4.0 | 171 | 5291.30 | 5285.80 | 0.032 | SP | 7 | 1.3 | 2.3 | 6.3 | Yes | 18.1 | 6.3 |
| P1018L | 1.27 | 0.14 | Non-Urban | 24 | 5297.20 | 5296.80 | 0.017 | 7.2 | 500 | 5296.80 | 5282.00 | 0.030 | SP | 7 | 1.2 | 6.9 | 14.1 | No | N/A | 14.1 |
| P1021R | 0.64 | 0.43 | Urban | 73 | 5294.20 | 5292.50 | 0.023 | 7.8 | 227 | 5292.50 | 5289.00 | 0.015 | SP | 7 | 0.9 | 4.4 | 12.2 | Yes | 19.7 | 12.2 |
| P1021RA | 0.28 | 0.86 | Urban | 63 | 5296.70 | 5296.00 | 0.011 | 3.4 | 232 | 5296.00 | 5294.00 | 0.009 | P | 20 | 1.9 | 2.1 | 5.5 | Yes | 10.8 | 5.5 |
| P1029L | 99.22 | 0.21 | Urban | 300 | 5373.00 | 5369.00 | 0.013 | 25.2 | 4754 | 5369.00 | 5285.00 | 0.018 | BG | 10 | 1.3 | 59.6 | 84.8 | Yes | 71.8 | 71.8 |
| P1029R | 1.42 | 0.50 | Urban | 73 | 5294.00 | 5292.00 | 0.027 | 6.6 | 533 | 5292.00 | 5285.00 | 0.013 | SP | 7 | 0.8 | 11.1 | 17.7 | Yes | 20.9 | 17.7 |
| P1030R | 0.76 | 0.05 | Non-Urban | 21 | 5295.70 | 5294.10 | 0.076 | 4.4 | 910 | 5294.10 | 5285.30 | 0.010 | SP | 7 | 0.7 | 22.0 | 26.5 | No | N/A | 26.5 |
| P1031L | 1.04 | 0.44 | Urban | 75 | 5292.50 | 5290.80 | 0.023 | 7.9 | 395 | 5290.80 | 5273.00 | 0.045 | SP | 7 | 1.5 | 4.4 | 12.3 | Yes | 19.5 | 12.3 |
| P1031R | 0.74 | 0.42 | Urban | 40 | 5292.30 | 5288.00 | 0.108 | 3.6 | 334 | 5288.00 | 5272.00 | 0.048 | P | 20 | 4.4 | 1.3 | 4.8 | Yes | 19.7 | 5.0 |
| P1032R | 0.26 | 0.05 | Non-Urban | 16 | 5285.00 | 5284.00 | 0.063 | 4.1 | 243 | 5284.00 | 5282.56 | 0.006 | SP | 7 | 0.5 | 7.5 | 11.7 | Yes | 31.3 | 11.7 |
| P1034R | 0.70 | 0.12 | Non-Urban | 110 | 5291.30 | 5284.60 | 0.061 | 10.2 | 340 | 5284.60 | 5282.80 | 0.005 | SP | 7 | 0.5 | 11.1 | 21.3 | No | N/A | 21.3 |
| P1043R | 1.09 | 0.15 | Non-Urban | 70 | 5289.20 | 5284.80 | 0.063 | 7.8 | 532 | 5284.80 | 5278.80 | 0.011 | SP | 7 | 0.7 | 11.9 | 19.7 | No | N/A | 19.7 |
| P1044L | 2.33 | 0.08 | Non-Urban | 39 | 5291.20 | 5289.80 | 0.036 | 7.6 | 733 | 5289.80 | 5268.00 | 0.030 | SP | 7 | 1.2 | 10.1 | 17.7 | No | N/A | 17.7 |
| Mobility Hub Jay Road Inlet | 0.44 | 0.86 | Urban | 71 | 5285.50 | 5284.90 | 0.008 | 3.9 | 530 | 5284.90 | 5279.50 | 0.010 | P | 20 | 2.0 | 4.4 | 8.3 | Yes | 12.8 | 8.3 |
| P1048L | 1.20 | 0.21 | Urban | 19 | 5282.62 | 5278.62 | 0.211 | 2.6 | 547 | 5278.62 | 5265.12 | 0.025 | P | 20 | 3.1 | 2.9 | 5.5 | Yes | 27.3 | 5.5 |
| P1053L | 2.12 | 0.62 | Urban | 245 | 5284.00 | 5277.60 | 0.026 | 9.8 | 515 | 5277.60 | 5272.10 | 0.011 | SP | 7 | 0.7 | 11.9 | 21.7 | No | N/A | 21.7 |
| P1054R | 2.33 | 0.27 | Urban | 55 | 5278.20 | 5274.00 | 0.076 | 5.7 | 453 | 5274.00 | 5271.83 | 0.005 | SP | 7 | 0.5 | 15.6 | 21.3 | No | N/A | 21.3 |
| P1056L | 1.17 | 0.30 | Urban | 74 | 5278.00 | 5274.60 | 0.046 | 7.5 | 278 | 5274.60 | 5268.00 | 0.024 | P | 20 | 3.1 | 1.5 | 9.0 | No | N/A | 9.0 |
| P1057L | 0.29 | 0.21 | Urban | 56 | 5274.00 | 5273.00 | 0.018 | 9.9 | 87 | 5273.00 | 5271.80 | 0.014 | SP | 7 | 0.8 | 1.8 | 11.7 | Yes | 23.4 | 11.7 |
| P1058L | 0.05 | 0.05 | Non-Urban | 26 | 5276.30 | 5273.20 | 0.119 | 4.3 | 90 | 5273.20 | 5273.00 | 0.002 | SP | 7 | 0.3 | 4.5 | 8.8 | No | N/A | 10.0 |
| P1063R | 0.92 | 0.07 | Non-Urban | 57 | 5275.00 | 5273.60 | 0.025 | 10.5 | 809 | 5273.60 | 5255.40 | 0.022 | SP | 7 | 1.0 | 12.8 | 23.3 | No | N/A | 23.3 |
| P1067L | 2.85 | 0.13 | Non-Urban | 70 | 5274.60 | 5268.00 | 0.094 | 7.0 | 1097 | 5268.00 | 5246.84 | 0.019 | SP | 7 | 1.0 | 18.8 | 25.8 | No | N/A | 25.8 |
| P1069R | 1.28 | 0.10 | Non-Urban | 25 | 5262.00 | 5259.00 | 0.120 | 4.0 | 567 | 5259.00 | 5244.00 | 0.026 | SP | 7 | 1.1 | 8.3 | 12.3 | No | N/A | 12.3 |
| P1076L | 1.06 | 0.08 | Non-Urban | 8 | 5254.40 | 5253.00 | 0.175 | 2.0 | 693 | 5253.00 | 5244.50 | 0.012 | SP | 7 | 0.8 | 14.9 | 16.9 | No | N/A | 16.9 |
| P1077R | 1.85 | 0.10 | Non-Urban | 161 | 5250.20 | 5248.00 | 0.014 | 20.7 | 436 | 5248.00 | 5241.50 | 0.015 | SP | 7 | 0.9 | 8.5 | 29.2 | No | N/A | 29.2 |
| P1080R | 1.59 | 0.11 | Non-Urban | 176 | 5246.20 | 5239.00 | 0.041 | 14.9 | 176 | 5239.00 | 5237.71 | 0.007 | SP | 7 | 0.6 | 4.9 | 19.8 | No | N/A | 19.8 |
| P1082L | 1.70 | 0.45 | Urban | 89 | 5248.00 | 5243.80 | 0.047 | 6.7 | 456 | 5243.80 | 5235.70 | 0.018 | SP | 7 | 0.9 | 8.1 | 14.8 | No | N/A | 14.8 |
| P1082R | 0.20 | 0.09 | Non-Urban | 52 | 5241.10 | 5237.80 | 0.063 | 7.2 | 50 | 5237.80 | 5235.33 | 0.049 | SP | 7 | 1.6 | 0.5 | 7.7 | No | N/A | 10.0 |
| P1088R | 3.16 | 0.23 | Urban | 202 | 5243.80 | 5236.00 | 0.039 | 14.3 | 347 | 5236.00 | 5231.60 | 0.013 | SP | 7 | 0.8 | 7.3 | 21.6 | No | N/A | 21.6 |
| P2010R | 3.20 | 0.14 | Non-Urban | 20 | 5235.50 | 5232.00 | 0.177 | 3.0 | 2245 | 5232.00 | 5206.00 | 0.012 | SP | 7 | 0.8 | 49.7 | 52.7 | No | N/A | 52.7 |
| P2021L | 7.83 | 0.11 | Non-Urban | 375 | 5241.20 | 5231.50 | 0.026 | 25.4 | 3243 | 5231.50 | 5199.50 | 0.010 | SP | 7 | 0.7 | 77.7 | 103.1 | No | N/A | 103.1 |
| P2022L | 0.07 | 0.05 | Non-Urban | 25 | 5202.00 | 5201.20 | 0.032 | 6.5 | 45 | 5201.20 | 5198.00 | 0.071 | SP | 7 | 1.9 | 0.4 | 6.9 | No | N/A | 10.0 |
| P2022R | 3.00 | 0.18 | Non-Urban | 55 | 5216.50 | 5215.00 | 0.027 | 8.8 | 1725 | 5215.00 | 5197.00 | 0.010 | SP | 7 | 0.7 | 40.2 | 49.0 | No | N/A | 49.0 |
| P2030L | 1.18 | 0.08 | Non-Urban | 83 | 5201.20 | 5199.70 | 0.018 | 13.8 | 735 | 5199.70 | 5187.20 | 0.017 | SP | 7 | 0.9 | 13.4 | 27.2 | No | N/A | 27.2 |
| P2031R | 2.36 | 0.16 | Non-Urban | 51 | 5200.82 | 5196.00 | 0.094 | 5.8 | 887 | 5196.00 | 5175.00 | 0.024 | SP | 7 | 1.1 | 13.7 | 19.5 | No | N/A | 19.5 |
| P2032L | 0.12 | 0.06 | Non-Urban | 20 | 5189.20 | 5185.70 | 0.178 | 3.2 | 211 | 5185.70 | 5181.00 | 0.022 | SP | 7 | 1.0 | 3.4 | 6.6 | No | N/A | 10.0 |
| P2049L | 1.75 | 0.06 | Non-Urban | 44 | 5182.20 | 5179.20 | 0.069 | 6.6 | 1610 | 5179.20 | 5155.00 | 0.015 | SP | 7 | 0.9 | 31.3 | 37.8 | No | N/A | 37.8 |
| P2058L | 0.53 | 0.05 | Non-Urban | 37 | 5161.00 | 5156.20 | 0.129 | 5.0 | 548 | 5156.20 | 5154.00 | 0.004 | SP | 7 | 0.4 | 20.6 | 25.5 | No | N/A | 25.5 |
| P2059R | 9.82 | 0.21 | Urban | 64 | 5181.50 | 5172.50 | 0.141 | 5.4 | 2053 | 5172.50 | 5147.00 | 0.012 | SP | 7 | 0.8 | 43.9 | 49.2 | Yes | 48.0 | 48.0 |
| P2062L | 1.13 | 0.78 | Urban | 63 | 5164.70 | 5161.70 | 0.047 | 2.7 | 283 | 5161.70 | 5158.50 | 0.011 | P | 20 | 2.1 | 2.2 | 4.9 | No | N/A | 5.0 |
| P2064R | 2.43 | 0.27 | Urban | 56 | 5168.20 | 5164.00 | 0.075 | 5.8 | 845 | 5164.00 | 5153.00 | 0.013 | P | 20 | 2.3 | 6.2 | 11.9 | No | N/A | 11.9 |
| P2066R | 2.26 | 0.27 | Urban | 95 | 5168.70 | 5166.00 | 0.028 | 10.3 | 565 | 5166.00 | 5143.00 | 0.041 | SP | 7 | 1.4 | 6.7 | 17.0 | Yes | 24.6 | 17.0 |
| P2063R | 0.23 | 0.43 | Urban | 20 | 5154.00 | 5153.50 | 0.025 | 4.0 | 342 | 5153.50 | 5142.00 | 0.034 | P | 20 | 3.7 | 1.6 | 5.5 | Yes | 19.8 | 5.5 |
| P2075L | 0.58 | 0.08 | Non-Urban | 82 | 5170.00 | 5168.00 | 0.024 | 12.5 | 260 | 5168.00 | 5161.30 | 0.026 | SP | 7 | 1.1 | 3.9 | 16.4 | No | N/A | 16.4 |
| P2077L | 0.37 | 0.19 | Non-Urban | 99 | 5165.20 | 5158.00 | 0.073 | 8.5 | 142 | 5158.00 | 5153.20 | 0.034 | SP | 7 | 1.3 | 1.8 | 10.3 | No | N/A | 10.3 |
| P2079L | 1.73 | 0.26 | Urban | 101 | 5168.50 | 5168.20 | 0.003 | 22.9 | 561 | 5168.20 | 5138.70 | 0.053 | SP | 7 | 1.6 | 5.8 | 28.7 | Yes | 24.6 | 24.6 |
| P2084L | 0.80 | 0.09 | Non-Urban | 33 | 5159.20 | 5153.20 | 0.182 | 4.0 | 689 | 5153.20 | 5141.70 | 0.017 | SP | 7 | 0.9 | 12.7 | 16.7 | No | N/A | 16.7 |

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

## TIME OF CONCENTRATION

| BASIN DATA | | | | INITIAL/OVERLAND TIME ($T_i$) | | | | | CHANNELIZED (TRAVEL) TIME ($T_t$) | | | | | | | | TOTAL $t_c$ | $T_c$ CHECK (Urbanized Basins) | | FINAL $t_c$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BASIN ID | AREA (acre) | $C_5$ | Basin Type | LENGTH $L_i$ (ft) | ELEV. START (ft) | ELEV. END (ft) | OVERLAND SLOPE ($S_i$) (ft/ft) | $t_i$ (min)[1] | LENGTH $L_t$ (ft) | ELEV. START (ft) | ELEV. END (ft) | CHANNELIZED SLOPE ($S_t$) (ft/ft) | CONVEYANCE COEFFICIENT Type | CONVEYANCE COEFFICIENT K | Velocity $V_t$ (ft/sec) | $t_t$ (min)[2] | $t_i + t_t$ (min.) | First Design Point | Maximum $t_c$ (min)[3] | $t_{minimum}$= 5 (Urban) $t_{minimum}$= 10 (Non-Urban) |
| P2085R | 2.57 | 0.24 | Urban | 67 | 5149.20 | 5140.50 | 0.129 | 5.5 | 540 | 5140.50 | 5137.20 | 0.006 | SP | 7 | 0.5 | 16.5 | 21.9 | Yes | 30.9 | 21.9 |
| P2085L | 2.32 | 0.18 | Non-Urban | 28 | 5152.20 | 5151.00 | 0.044 | 5.3 | 1114 | 5151.00 | 5142.00 | 0.008 | SP | 7 | 0.6 | 29.5 | 34.8 | No | N/A | 34.8 |
| P2092R | 0.39 | 0.32 | Urban | 90 | 5143.00 | 5139.00 | 0.044 | 8.2 | 96 | 5139.00 | 5134.00 | 0.052 | SP | 7 | 1.6 | 1.0 | 9.2 | No | N/A | 9.2 |
| P2093R | 1.69 | 0.16 | Non-Urban | 148 | 5150.50 | 5146.20 | 0.029 | 14.6 | 519 | 5146.20 | 5139.00 | 0.014 | SP | 7 | 0.8 | 10.5 | 25.1 | No | N/A | 25.1 |
| P2100L | 1.09 | 0.10 | Non-Urban | 37 | 5169.50 | 5166.20 | 0.090 | 5.3 | 1148 | 5166.20 | 5149.30 | 0.015 | SP | 7 | 0.8 | 22.5 | 27.8 | No | N/A | 27.8 |
| P2100R | 3.11 | 0.17 | Non-Urban | 55 | 5167.00 | 5164.50 | 0.046 | 7.6 | 1085 | 5164.50 | 5149.70 | 0.014 | SP | 7 | 0.8 | 22.1 | 29.7 | No | N/A | 29.7 |
| P2098R | 0.38 | 0.18 | Non-Urban | 92 | 5151.50 | 5148.50 | 0.033 | 10.8 | 114 | 5148.50 | 5146.50 | 0.018 | SP | 7 | 0.9 | 2.0 | 12.8 | No | N/A | 12.8 |
| P3021R | 0.20 | 0.86 | Urban | 8 | 5160.00 | 5156.00 | 0.500 | 0.3 | 347 | 5156.00 | 5143.50 | 0.036 | P | 20 | 3.8 | 1.5 | 1.9 | Yes | 10.3 | 5.0 |
| P3023R | 0.17 | 0.86 | Urban | 7 | 5150.50 | 5150.00 | 0.071 | 0.6 | 280 | 5150.00 | 5142.50 | 0.027 | P | 20 | 3.3 | 1.4 | 2.0 | Yes | 10.2 | 5.0 |
| P3042R | 0.97 | 0.30 | Urban | 70 | 5147.30 | 5144.00 | 0.047 | 7.3 | 272 | 5144.00 | 5140.00 | 0.015 | SP | 7 | 0.8 | 5.3 | 12.6 | Yes | 23.3 | 12.6 |
| P3049L | 1.47 | 0.34 | Urban | 48 | 5146.70 | 5144.00 | 0.056 | 5.4 | 737 | 5144.00 | 5132.00 | 0.016 | SP | 7 | 0.9 | 13.8 | 19.1 | No | N/A | 19.1 |
| P3049R | 2.24 | 0.35 | Urban | 70 | 5144.50 | 5141.00 | 0.050 | 6.6 | 752 | 5141.00 | 5131.00 | 0.013 | SP | 7 | 0.8 | 15.5 | 22.2 | No | N/A | 22.2 |
| P3052R | 0.61 | 0.36 | Urban | 68 | 5136.50 | 5133.00 | 0.051 | 6.4 | 45 | 5133.00 | 5132.00 | 0.022 | SP | 7 | 1.0 | 0.7 | 7.1 | No | N/A | 7.1 |
| P4018L | 13.69 | 0.14 | Non-Urban | 133 | 5135.50 | 5131.50 | 0.030 | 13.8 | 3046 | 5131.50 | 5107.50 | 0.008 | SP | 7 | 0.6 | 81.7 | 95.5 | No | N/A | 95.5 |
| P4019R | 3.37 | 0.29 | Urban | 266 | 5116.00 | 5108.00 | 0.030 | 16.6 | 530 | 5108.00 | 5105.00 | 0.006 | SP | 7 | 0.5 | 16.8 | 33.4 | Yes | 29.6 | 29.6 |
| P4019RA | 0.21 | 0.74 | Urban | 73 | 5111.70 | 5110.50 | 0.016 | 4.7 | 53 | 5110.50 | 5108.00 | 0.047 | SP | 7 | 1.5 | 0.6 | 5.3 | Yes | 11.6 | 5.3 |
| P4020R | 0.42 | 0.52 | Urban | 70 | 5105.00 | 5104.70 | 0.004 | 11.6 | 330 | 5104.70 | 5096.50 | 0.025 | SP | 7 | 1.1 | 5.0 | 16.6 | Yes | 18.0 | 16.6 |
| P4021R | 0.35 | 0.71 | Urban | 62 | 5110.50 | 5109.00 | 0.024 | 4.1 | 136 | 5109.00 | 5107.00 | 0.015 | SP | 7 | 0.8 | 2.7 | 6.8 | Yes | 12.9 | 6.8 |
| P4023R | 3.48 | 0.76 | Urban | 232 | 5110.50 | 5105.00 | 0.024 | 7.1 | 85 | 5105.00 | 5104.00 | 0.012 | SP | 7 | 0.8 | 1.9 | 9.0 | Yes | 11.7 | 9.0 |
| P4028R | 2.05 | 0.10 | Non-Urban | 149 | 5106.50 | 5103.00 | 0.024 | 16.5 | 323 | 5103.00 | 5099.00 | 0.012 | SP | 7 | 0.8 | 6.9 | 23.4 | No | N/A | 23.4 |
| P4040L | 1.46 | 0.06 | Non-Urban | 8 | 5104.50 | 5103.20 | 0.157 | 2.2 | 1293 | 5103.20 | 5092.00 | 0.009 | SP | 7 | 0.7 | 33.1 | 35.2 | No | N/A | 35.2 |
| P4044R | 5.31 | 0.14 | Non-Urban | 277 | 5104.20 | 5099.00 | 0.019 | 23.5 | 1104 | 5099.00 | 5086.00 | 0.012 | SP | 7 | 0.8 | 24.2 | 47.7 | No | N/A | 47.7 |
| P4053L | 1.86 | 0.05 | Non-Urban | 24 | 5094.00 | 5092.00 | 0.084 | 4.6 | 1254 | 5092.00 | 5082.00 | 0.008 | SP | 7 | 0.6 | 33.4 | 38.0 | No | N/A | 38.0 |
| P4054R | 3.13 | 0.26 | Urban | 292 | 5091.50 | 5087.50 | 0.014 | 23.4 | 660 | 5087.50 | 5081.00 | 0.010 | SP | 7 | 0.7 | 15.8 | 39.3 | Yes | 30.0 | 30.0 |
| P4060L | 1.21 | 0.05 | Non-Urban | 497 | 5087.50 | 5082.50 | 0.010 | 42.1 | 293 | 5082.50 | 5078.00 | 0.015 | SP | 7 | 0.9 | 5.6 | 47.7 | No | N/A | 47.7 |
| P4065R | 3.29 | 0.27 | Urban | 286 | 5084.50 | 5082.00 | 0.009 | 26.6 | 723 | 5082.00 | 5070.00 | 0.017 | SP | 7 | 0.9 | 13.4 | 40.0 | Yes | 28.4 | 28.4 |
| P4074R | 2.84 | 0.28 | Urban | 193 | 5076.70 | 5073.20 | 0.018 | 16.9 | 994 | 5073.20 | 5064.20 | 0.009 | SP | 7 | 0.7 | 24.9 | 41.7 | Yes | 34.0 | 34.0 |
| P4075L | 2.34 | 0.05 | Non-Urban | 24 | 5081.00 | 5078.20 | 0.118 | 4.1 | 1458 | 5078.20 | 5063.00 | 0.010 | SP | 7 | 0.7 | 34.0 | 38.1 | No | N/A | 38.1 |
| P4076L | 0.09 | 0.20 | Non-Urban | 27 | 5069.20 | 5064.50 | 0.174 | 3.3 | 19 | 5064.50 | 5063.50 | 0.052 | SP | 7 | 1.6 | 0.2 | 3.5 | No | N/A | 10.0 |
| P4081L | 1.32 | 0.16 | Non-Urban | 27 | 5066.20 | 5064.70 | 0.056 | 5.0 | 597 | 5064.70 | 5060.20 | 0.008 | SP | 7 | 0.6 | 16.4 | 21.4 | No | N/A | 21.4 |
| P4081R | 1.63 | 0.31 | Urban | 214 | 5072.20 | 5065.00 | 0.034 | 13.9 | 576 | 5065.00 | 5060.20 | 0.008 | SP | 7 | 0.6 | 15.0 | 29.0 | Yes | 27.9 | 27.9 |
| P4086R | 1.61 | 0.29 | Urban | 141 | 5064.20 | 5060.00 | 0.030 | 12.2 | 385 | 5060.00 | 5057.00 | 0.008 | SP | 7 | 0.6 | 10.4 | 22.5 | Yes | 26.2 | 22.5 |
| P4087L | 1.38 | 0.18 | Non-Urban | 33 | 5066.70 | 5062.00 | 0.141 | 4.0 | 505 | 5062.00 | 5057.00 | 0.010 | SP | 7 | 0.7 | 12.1 | 16.1 | No | N/A | 16.1 |
| P4091L | 1.39 | 0.46 | Urban | 119 | 5064.20 | 5058.00 | 0.052 | 7.4 | 223 | 5058.00 | 5057.20 | 0.004 | SP | 7 | 0.4 | 8.9 | 16.2 | No | N/A | 16.2 |
| P4091R | 1.01 | 0.24 | Urban | 93 | 5063.50 | 5058.00 | 0.059 | 8.4 | 204 | 5058.00 | 5057.20 | 0.004 | SP | 7 | 0.4 | 7.8 | 16.2 | No | N/A | 16.2 |
| P4093L | 0.46 | 0.45 | Urban | 65 | 5062.80 | 5061.00 | 0.028 | 6.8 | 160 | 5061.00 | 5059.00 | 0.013 | SP | 7 | 0.8 | 3.4 | 10.2 | Yes | 18.9 | 10.2 |
| P4095R | 0.45 | 0.41 | Urban | 190 | 5064.20 | 5059.00 | 0.027 | 12.3 | 107 | 5059.00 | 5058.00 | 0.009 | SP | 7 | 0.7 | 2.7 | 14.9 | Yes | 19.4 | 14.9 |
| P4108R | 3.91 | 0.26 | Non-Urban | 443 | 5063.50 | 5057.00 | 0.015 | 28.2 | 1391 | 5057.00 | 5043.00 | 0.010 | SP | 7 | 0.7 | 33.0 | 61.2 | Yes | 39.5 | 39.5 |
| P4114L | 3.63 | 0.12 | Non-Urban | 68 | 5062.00 | 5060.00 | 0.029 | 10.2 | 1759 | 5060.00 | 5036.00 | 0.014 | SP | 7 | 0.8 | 35.8 | 46.0 | No | N/A | 46.0 |
| P4117R | 2.27 | 0.35 | Urban | 136 | 5051.00 | 5046.00 | 0.037 | 10.3 | 916 | 5046.00 | 5040.50 | 0.006 | SP | 7 | 0.5 | 28.2 | 38.5 | Yes | 33.3 | 33.3 |
| P5006R | 1.44 | 0.29 | Urban | 46 | 5045.70 | 5041.70 | 0.086 | 4.9 | 641 | 5041.70 | 5029.00 | 0.020 | SP | 7 | 1.0 | 10.8 | 15.7 | Yes | 26.5 | 15.7 |
| P5007R | 0.10 | 0.43 | Urban | 34 | 5040.50 | 5039.20 | 0.038 | 4.6 | 68 | 5039.20 | 5034.00 | 0.076 | SP | 7 | 1.9 | 0.6 | 5.2 | Yes | 18.1 | 5.2 |
| P5011L | 5.52 | 0.21 | Urban | 106 | 5043.00 | 5038.00 | 0.047 | 9.9 | 1489 | 5038.00 | 5023.00 | 0.010 | SP | 7 | 0.7 | 35.3 | 45.2 | Yes | 43.0 | 43.0 |
| P5011R | 2.28 | 0.17 | Non-Urban | 18 | 5041.50 | 5041.00 | 0.028 | 5.1 | 1034 | 5041.00 | 5027.00 | 0.014 | SP | 7 | 0.8 | 21.2 | 26.3 | No | N/A | 26.3 |
| P5013L | 3.08 | 0.22 | Urban | 298 | 5037.70 | 5024.00 | 0.046 | 16.6 | 197 | 5024.00 | 5023.00 | 0.005 | SP | 7 | 0.5 | 6.6 | 23.2 | Yes | 24.7 | 23.2 |
| P5023R | 5.73 | 0.12 | Non-Urban | 405 | 5026.20 | 5021.50 | 0.012 | 33.8 | 509 | 5021.50 | 5020.00 | 0.003 | SP | 7 | 0.4 | 22.4 | 56.2 | No | N/A | 56.2 |
| P5023L | 1.17 | 0.20 | Urban | 74 | 5030.00 | 5025.00 | 0.067 | 7.5 | 873 | 5025.00 | 5021.50 | 0.004 | SP | 7 | 0.4 | 32.8 | 40.3 | Yes | 38.8 | 38.8 |
| P5030L | 3.02 | 0.03 | Non-Urban | 82 | 5029.00 | 5023.00 | 0.073 | 9.1 | 687 | 5023.00 | 5020.00 | 0.004 | SP | 7 | 0.5 | 24.8 | 33.8 | No | N/A | 33.8 |
| P5033R | 4.16 | 0.12 | Urban | 136 | 5019.50 | 5013.20 | 0.046 | 12.5 | 385 | 5013.20 | 5006.20 | 0.018 | SP | 7 | 0.9 | 6.8 | 19.3 | Yes | 26.4 | 19.3 |
| P5040L | 0.89 | 0.01 | Non-Urban | 175 | 5019.00 | 5017.00 | 0.011 | 24.8 | 30 | 5017.00 | 5014.00 | 0.098 | SP | 7 | 2.2 | 0.2 | 25.1 | No | N/A | 25.1 |

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

## TIME OF CONCENTRATION

| BASIN DATA | | | | INITIAL/OVERLAND TIME ($T_i$) | | | | | CHANNELIZED (TRAVEL) TIME ($T_t$) | | | | | | | | TOTAL $t_c$ | $T_c$ CHECK (Urbanized Basins) | | FINAL $t_c$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BASIN ID | AREA (acre) | $C_5$ | Basin Type | LENGTH $L_i$ (ft) | ELEV. START (ft) | ELEV. END (ft) | OVERLAND SLOPE ($S_i$) (ft/ft) | $t_i$ (min)[1] | LENGTH $L_t$ (ft) | ELEV. START (ft) | ELEV. END (ft) | CHANNELIZED SLOPE ($S_t$) (ft/ft) | CONVEYANCE COEFFICIENT Type | CONVEYANCE COEFFICIENT K | Velocity $V_t$ (ft/sec) | $t_t$ (min)[2] | $t_i + t_t$ (min.) | First Design Point | Maximum $t_c$ (min)[3] | $t_{minimum}$= 5 (Urban) $t_{minimum}$= 10 (Non-Urban) |
| P5041R | 0.93 | 0.27 | Urban | 96 | 5019.20 | 5017.50 | 0.018 | 12.2 | 258 | 5017.50 | 5014.00 | 0.014 | SP | 7 | 0.8 | 5.3 | 17.4 | Yes | 21.7 | 17.4 |
| P5048L | 1.12 | 0.01 | Non-Urban | 120 | 5016.50 | 5016.00 | 0.004 | 28.8 | 445 | 5016.00 | 5011.00 | 0.011 | SP | 7 | 0.7 | 10.0 | 38.8 | No | N/A | 38.8 |
| P5048R | 2.60 | 0.29 | Urban | 85 | 5019.00 | 5015.50 | 0.041 | 8.4 | 584 | 5015.50 | 5009.00 | 0.011 | SP | 7 | 0.7 | 13.2 | 21.6 | Yes | 24.8 | 21.6 |
| P5052L | 1.99 | 0.27 | Urban | 84 | 5016.00 | 5013.50 | 0.030 | 9.6 | 260 | 5013.50 | 5013.00 | 0.002 | SP | 7 | 0.3 | 14.1 | 23.7 | Yes | 28.6 | 23.7 |
| P5064R | 6.82 | 0.17 | Urban | 64 | 5016.00 | 5011.00 | 0.078 | 6.8 | 1258 | 5011.00 | 5002.00 | 0.007 | SP | 7 | 0.6 | 35.4 | 42.2 | Yes | 42.3 | 42.2 |
| P5066L | 8.08 | 0.14 | Non-Urban | 93 | 5016.00 | 5011.00 | 0.054 | 9.5 | 1286 | 5011.00 | 5003.00 | 0.006 | SP | 7 | 0.6 | 38.8 | 48.4 | No | N/A | 48.4 |
| P5068R | 15.75 | 0.06 | Non-Urban | 31 | 5027.00 | 5025.00 | 0.065 | 5.7 | 5000 | 5025.00 | 1786.36 | 0.648 | SP | 7 | 5.6 | 14.8 | 20.5 | No | N/A | 20.5 |
| P5076R | 1.57 | 0.33 | Urban | 81 | 5026.50 | 5024.50 | 0.025 | 9.2 | 398 | 5024.50 | 5011.00 | 0.034 | P | 20 | 3.7 | 1.8 | 11.0 | Yes | 21.3 | 11.0 |
| P5084R | 1.44 | 0.86 | Urban | 51 | 5027.00 | 5025.00 | 0.039 | 2.0 | 457 | 5025.00 | 5017.50 | 0.016 | SP | 7 | 0.9 | 8.5 | 10.5 | Yes | 11.6 | 10.5 |
| P5084L | 5.20 | 0.11 | Non-Urban | 340 | 5032.00 | 5021.00 | 0.032 | 22.4 | 510 | 5021.00 | 5018.00 | 0.006 | SP | 7 | 0.5 | 15.8 | 38.2 | No | N/A | 38.2 |
| P5066R | 2.57 | 0.10 | Non-Urban | 308 | 5009.70 | 5005.00 | 0.015 | 27.6 | 363 | 5005.00 | 5002.00 | 0.008 | SP | 7 | 0.6 | 9.5 | 37.1 | No | N/A | 37.1 |
| P5001L | 2.27 | 0.13 | Non-Urban | 106 | 5043.50 | 5038.00 | 0.052 | 10.5 | 667 | 5038.00 | 5033.50 | 0.007 | SP | 7 | 0.6 | 19.4 | 29.8 | No | N/A | 29.8 |
| P4028L | 0.63 | 0.54 | Non-Urban | 69 | 5108.70 | 5105.20 | 0.051 | 4.9 | 301 | 5105.20 | 5103.70 | 0.005 | SP | 7 | 0.5 | 10.1 | 15.0 | No | N/A | 15.0 |

[1] $t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{{S_o}^{0.33}}$ USDCM Equation 6-3, August 2018

[2] $t_t = \frac{Length}{60 * V_t}$ Where $V_t = K * S^{0.5}$ and K = 2.5 (Heavy Meadows), 5 (Tillage / Field), 7 (Short Pasture / Lawns), 10 (Nearly Bare Ground), 15, (Grassed Waterway), 20 (Paved) - USDCM Equation 6-4 August 2018

[3] $t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)_{\sqrt{}}}$ USDCM Equation 6-5 August 2018

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

| INTENSITY VALUES | | | | | | |
|---|---|---|---|---|---|---|
| Storm Event | 2-Year | 5-Year | 10-Year | 25-Year | 50-Year | 100-Year |
| One-Hour Point Rainfall Values (P1) (inches) | 0.79 | 1.40 | 1.35 | 1.81 | 2.23 | 2.70 |

5-Year: Boulder County Storm Drainage Criteria Manual, NOAA Atlas 2 Vol 3 (Region 1, Boulder, CO)
All other Events: NOAA Atlas 14, Volume 8, Version 2 (Region 1, Boulder, CO)

## RATIONAL FLOWS

| BASIN ID | AREA (acre) | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | $I_2$ (in/hr) | $I_5$ (in/hr) | $I_{10}$ (in/hr) | $I_{25}$ (in/hr) | $I_{50}$ (in/hr) | $I_{100}$ (in/hr) | $Q_2$ (cfs) | $Q_5$ (cfs) | $Q_{10}$ (cfs) | $Q_{25}$ (cfs) | $Q_{50}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1000R | 1.41 | 0.05 | 0.07 | 0.13 | 0.31 | 0.38 | 0.47 | 1.27 | 2.24 | 2.16 | 2.90 | 3.57 | 4.33 | 0.1 | 0.2 | 0.4 | 1.3 | 1.9 | 2.9 |
| P1013R | 1.54 | 0.43 | 0.46 | 0.51 | 0.60 | 0.64 | 0.69 | 1.52 | 2.70 | 2.60 | 3.48 | 4.29 | 5.20 | 1.0 | 1.9 | 2.0 | 3.2 | 4.2 | 5.5 |
| P1016L | 8.85 | 0.06 | 0.08 | 0.15 | 0.32 | 0.39 | 0.48 | 1.09 | 1.94 | 1.87 | 2.51 | 3.09 | 3.74 | 0.6 | 1.3 | 2.4 | 7.0 | 10.6 | 15.8 |
| P1017L | 0.71 | 0.39 | 0.42 | 0.48 | 0.58 | 0.62 | 0.67 | 2.51 | 4.44 | 4.29 | 5.75 | 7.08 | 8.57 | 0.7 | 1.3 | 1.5 | 2.3 | 3.1 | 4.1 |
| P1018L | 1.27 | 0.09 | 0.14 | 0.22 | 0.38 | 0.45 | 0.53 | 1.85 | 3.27 | 3.16 | 4.23 | 5.21 | 6.31 | 0.2 | 0.6 | 0.9 | 2.1 | 3.0 | 4.3 |
| P1021R | 0.64 | 0.37 | 0.43 | 0.49 | 0.59 | 0.63 | 0.68 | 1.97 | 3.49 | 3.37 | 4.52 | 5.56 | 6.74 | 0.5 | 1.0 | 1.1 | 1.7 | 2.2 | 2.9 |
| P1021RA | 0.28 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 | 2.62 | 4.64 | 4.47 | 6.00 | 7.39 | 8.94 | 0.6 | 1.1 | 1.1 | 1.5 | 1.8 | 2.2 |
| P1029L | 99.22 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 0.71 | 1.25 | 1.21 | 1.62 | 1.99 | 2.41 | 10.5 | 26.5 | 35.1 | 70.8 | 98.9 | 137.3 |
| P1029R | 1.42 | 0.44 | 0.50 | 0.55 | 0.64 | 0.67 | 0.72 | 1.66 | 2.93 | 2.83 | 3.79 | 4.67 | 5.66 | 1.0 | 2.1 | 2.2 | 3.4 | 4.5 | 5.8 |
| P1030R | 0.76 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 1.33 | 2.36 | 2.28 | 3.05 | 3.76 | 4.56 | 0.0 | 0.1 | 0.3 | 0.8 | 1.2 | 1.7 |
| P1031L | 1.04 | 0.38 | 0.44 | 0.50 | 0.60 | 0.64 | 0.69 | 1.97 | 3.48 | 3.35 | 4.50 | 5.54 | 6.71 | 0.8 | 1.6 | 1.7 | 2.8 | 3.7 | 4.8 |
| P1031R | 0.74 | 0.35 | 0.42 | 0.48 | 0.58 | 0.62 | 0.67 | 2.68 | 4.75 | 4.58 | 6.14 | 7.56 | 9.16 | 0.7 | 1.5 | 1.6 | 2.6 | 3.5 | 4.6 |
| P1032R | 0.26 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 2.01 | 3.56 | 3.43 | 4.60 | 5.67 | 6.86 | 0.0 | 0.0 | 0.1 | 0.4 | 0.6 | 0.9 |
| P1034R | 0.70 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 | 1.51 | 2.66 | 2.57 | 3.44 | 4.24 | 5.14 | 0.1 | 0.2 | 0.4 | 0.9 | 1.3 | 1.9 |
| P1043R | 1.09 | 0.09 | 0.15 | 0.24 | 0.40 | 0.46 | 0.54 | 1.57 | 2.77 | 2.67 | 3.58 | 4.42 | 5.35 | 0.2 | 0.5 | 0.7 | 1.6 | 2.2 | 3.2 |
| P1044L | 2.33 | 0.03 | 0.08 | 0.17 | 0.35 | 0.42 | 0.50 | 1.66 | 2.93 | 2.83 | 3.79 | 4.67 | 5.66 | 0.1 | 0.5 | 1.1 | 3.1 | 4.5 | 6.7 |
| Mobility Hub Jay Road Inlet | 0.44 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 | 2.29 | 4.06 | 3.91 | 5.25 | 6.47 | 7.83 | 0.8 | 1.5 | 1.5 | 2.0 | 2.5 | 3.1 |
| P1048L | 1.20 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 2.62 | 4.64 | 4.47 | 5.99 | 7.38 | 8.94 | 0.5 | 1.2 | 1.5 | 3.2 | 4.4 | 6.1 |
| P1053L | 2.12 | 0.57 | 0.62 | 0.66 | 0.72 | 0.74 | 0.78 | 1.49 | 2.64 | 2.54 | 3.41 | 4.20 | 5.09 | 1.8 | 3.5 | 3.6 | 5.2 | 6.6 | 8.4 |
| P1054R | 2.33 | 0.20 | 0.27 | 0.34 | 0.48 | 0.53 | 0.60 | 1.51 | 2.66 | 2.57 | 3.44 | 4.24 | 5.14 | 0.7 | 1.7 | 2.0 | 3.8 | 5.3 | 7.2 |
| P1056L | 1.17 | 0.23 | 0.30 | 0.37 | 0.50 | 0.55 | 0.62 | 2.23 | 3.94 | 3.80 | 5.09 | 6.28 | 7.60 | 0.6 | 1.4 | 1.6 | 3.0 | 4.0 | 5.5 |
| P1057L | 0.29 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 2.01 | 3.55 | 3.42 | 4.59 | 5.66 | 6.85 | 0.1 | 0.2 | 0.3 | 0.6 | 0.8 | 1.1 |
| P1058L | 0.05 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 2.14 | 3.79 | 3.65 | 4.90 | 6.03 | 7.30 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 |
| P1063R | 0.92 | 0.02 | 0.07 | 0.16 | 0.34 | 0.41 | 0.50 | 1.43 | 2.54 | 2.45 | 3.28 | 4.04 | 4.89 | 0.0 | 0.2 | 0.4 | 1.0 | 1.5 | 2.2 |
| P1067L | 2.85 | 0.07 | 0.13 | 0.22 | 0.38 | 0.45 | 0.53 | 1.35 | 2.40 | 2.31 | 3.10 | 3.82 | 4.62 | 0.3 | 0.9 | 1.4 | 3.4 | 4.9 | 7.0 |
| P1069R | 1.28 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 | 1.97 | 3.48 | 3.36 | 4.50 | 5.54 | 6.71 | 0.1 | 0.5 | 0.8 | 2.1 | 3.1 | 4.4 |
| P1076L | 1.06 | 0.04 | 0.08 | 0.18 | 0.35 | 0.42 | 0.51 | 1.69 | 3.00 | 2.89 | 3.88 | 4.78 | 5.78 | 0.1 | 0.3 | 0.5 | 1.4 | 2.1 | 3.1 |
| P1077R | 1.85 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 | 1.26 | 2.23 | 2.15 | 2.89 | 3.56 | 4.31 | 0.1 | 0.4 | 0.8 | 1.9 | 2.8 | 4.1 |
| P1080R | 1.59 | 0.06 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 | 1.57 | 2.77 | 2.67 | 3.58 | 4.41 | 5.34 | 0.1 | 0.5 | 0.9 | 2.1 | 3.1 | 4.4 |
| P1082L | 1.70 | 0.38 | 0.45 | 0.51 | 0.60 | 0.64 | 0.69 | 1.81 | 3.20 | 3.08 | 4.14 | 5.10 | 6.17 | 1.2 | 2.4 | 2.6 | 4.2 | 5.5 | 7.2 |
| P1082R | 0.20 | 0.04 | 0.09 | 0.18 | 0.36 | 0.42 | 0.51 | 2.14 | 3.79 | 3.65 | 4.90 | 6.03 | 7.30 | 0.0 | 0.1 | 0.1 | 0.3 | 0.5 | 0.7 |
| P1088R | 3.16 | 0.17 | 0.23 | 0.31 | 0.45 | 0.51 | 0.58 | 1.49 | 2.64 | 2.55 | 3.42 | 4.21 | 5.10 | 0.8 | 1.9 | 2.5 | 4.9 | 6.8 | 9.4 |
| P2010R | 3.20 | 0.09 | 0.14 | 0.23 | 0.39 | 0.46 | 0.54 | 0.87 | 1.54 | 1.49 | 2.00 | 2.46 | 2.98 | 0.2 | 0.7 | 1.1 | 2.5 | 3.6 | 5.1 |
| P2021L | 7.83 | 0.05 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 | 0.55 | 0.97 | 0.94 | 1.25 | 1.55 | 1.87 | 0.2 | 0.8 | 1.4 | 3.6 | 5.3 | 7.6 |
| P2022L | 0.07 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 2.14 | 3.79 | 3.65 | 4.90 | 6.03 | 7.30 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 |
| P2022R | 3.00 | 0.12 | 0.18 | 0.26 | 0.42 | 0.48 | 0.56 | 0.91 | 1.62 | 1.56 | 2.09 | 2.58 | 3.12 | 0.3 | 0.9 | 1.2 | 2.6 | 3.7 | 5.2 |
| P2030L | 1.18 | 0.03 | 0.08 | 0.17 | 0.35 | 0.42 | 0.50 | 1.31 | 2.33 | 2.24 | 3.01 | 3.70 | 4.48 | 0.0 | 0.2 | 0.4 | 1.2 | 1.8 | 2.7 |
| P2031R | 2.36 | 0.10 | 0.16 | 0.25 | 0.41 | 0.47 | 0.55 | 1.58 | 2.79 | 2.69 | 3.61 | 4.45 | 5.38 | 0.4 | 1.1 | 1.6 | 3.5 | 4.9 | 7.0 |
| P2032L | 0.12 | 0.02 | 0.06 | 0.16 | 0.34 | 0.41 | 0.50 | 2.14 | 3.79 | 3.65 | 4.90 | 6.03 | 7.30 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 |
| P2049L | 1.75 | 0.02 | 0.06 | 0.15 | 0.34 | 0.41 | 0.50 | 1.08 | 1.91 | 1.84 | 2.47 | 3.04 | 3.68 | 0.0 | 0.2 | 0.5 | 1.5 | 2.2 | 3.2 |
| P2058L | 0.53 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 1.36 | 2.41 | 2.32 | 3.12 | 3.84 | 4.65 | 0.0 | 0.1 | 0.2 | 0.5 | 0.8 | 1.2 |

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

| INTENSITY VALUES | | | | | | |
|---|---|---|---|---|---|---|
| Storm Event | 2-Year | 5-Year | 10-Year | 25-Year | 50-Year | 100-Year |
| One-Hour Point Rainfall Values (P1) (inches) | 0.79 | 1.40 | 1.35 | 1.81 | 2.23 | 2.70 |

5-Year: Boulder County Storm Drainage Criteria Manual, NOAA Atlas 2 Vol 3 (Region 1, Boulder, CO)
All other Events: NOAA Atlas 14, Volume 8, Version 2 (Region 1, Boulder, CO)

RATIONAL FLOWS

| BASIN ID | AREA (acre) | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | $I_2$ (in/hr) | $I_5$ (in/hr) | $I_{10}$ (in/hr) | $I_{25}$ (in/hr) | $I_{50}$ (in/hr) | $I_{100}$ (in/hr) | $Q_2$ (cfs) | $Q_5$ (cfs) | $Q_{10}$ (cfs) | $Q_{25}$ (cfs) | $Q_{50}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P2059R | 9.82 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 0.93 | 1.64 | 1.58 | 2.12 | 2.61 | 3.16 | 1.3 | 3.4 | 4.5 | 9.1 | 12.7 | 17.7 |
| P2062L | 1.13 | 0.75 | 0.78 | 0.81 | 0.83 | 0.84 | 0.86 | 2.68 | 4.75 | 4.58 | 6.14 | 7.56 | 9.16 | 2.3 | 4.2 | 4.2 | 5.8 | 7.2 | 8.9 |
| P2064R | 2.43 | 0.21 | 0.27 | 0.35 | 0.48 | 0.53 | 0.60 | 1.99 | 3.52 | 3.40 | 4.55 | 5.61 | 6.79 | 1.0 | 2.3 | 2.9 | 5.3 | 7.3 | 9.9 |
| P2066R | 2.26 | 0.21 | 0.27 | 0.35 | 0.48 | 0.54 | 0.60 | 1.69 | 2.99 | 2.89 | 3.87 | 4.77 | 5.78 | 0.8 | 1.9 | 2.3 | 4.2 | 5.8 | 7.9 |
| P2063R | 0.23 | 0.37 | 0.43 | 0.49 | 0.59 | 0.63 | 0.68 | 2.61 | 4.62 | 4.46 | 5.98 | 7.37 | 8.92 | 0.2 | 0.5 | 0.5 | 0.8 | 1.1 | 1.4 |
| P2075L | 0.58 | 0.03 | 0.08 | 0.17 | 0.35 | 0.42 | 0.50 | 1.72 | 3.05 | 2.94 | 3.94 | 4.85 | 5.88 | 0.0 | 0.1 | 0.3 | 0.8 | 1.2 | 1.7 |
| P2077L | 0.37 | 0.13 | 0.19 | 0.27 | 0.43 | 0.49 | 0.56 | 2.11 | 3.74 | 3.61 | 4.84 | 5.96 | 7.21 | 0.1 | 0.3 | 0.4 | 0.8 | 1.1 | 1.5 |
| P2079L | 1.73 | 0.19 | 0.26 | 0.33 | 0.47 | 0.52 | 0.59 | 1.39 | 2.46 | 2.37 | 3.18 | 3.92 | 4.75 | 0.5 | 1.1 | 1.4 | 2.6 | 3.6 | 4.9 |
| P2084L | 0.80 | 0.04 | 0.09 | 0.19 | 0.36 | 0.43 | 0.51 | 1.71 | 3.02 | 2.91 | 3.90 | 4.81 | 5.82 | 0.1 | 0.2 | 0.4 | 1.1 | 1.7 | 2.4 |
| P2085R | 2.57 | 0.18 | 0.24 | 0.32 | 0.46 | 0.52 | 0.59 | 1.48 | 2.62 | 2.53 | 3.39 | 4.18 | 5.06 | 0.7 | 1.6 | 2.1 | 4.0 | 5.5 | 7.6 |
| P2085L | 2.32 | 0.12 | 0.18 | 0.27 | 0.42 | 0.48 | 0.56 | 1.13 | 2.01 | 1.94 | 2.60 | 3.20 | 3.87 | 0.3 | 0.9 | 1.2 | 2.5 | 3.6 | 5.0 |
| P2092R | 0.39 | 0.25 | 0.32 | 0.39 | 0.51 | 0.56 | 0.63 | 2.21 | 3.91 | 3.77 | 5.06 | 6.23 | 7.55 | 0.2 | 0.5 | 0.6 | 1.0 | 1.4 | 1.9 |
| P2093R | 1.69 | 0.10 | 0.16 | 0.24 | 0.40 | 0.47 | 0.55 | 1.38 | 2.44 | 2.35 | 3.15 | 3.88 | 4.70 | 0.2 | 0.7 | 1.0 | 2.2 | 3.1 | 4.3 |
| P2100L | 1.09 | 0.05 | 0.10 | 0.19 | 0.37 | 0.43 | 0.52 | 1.30 | 2.30 | 2.21 | 2.97 | 3.66 | 4.43 | 0.1 | 0.3 | 0.5 | 1.2 | 1.7 | 2.5 |
| P2100R | 3.11 | 0.11 | 0.17 | 0.25 | 0.41 | 0.47 | 0.55 | 1.25 | 2.21 | 2.13 | 2.86 | 3.52 | 4.26 | 0.4 | 1.1 | 1.7 | 3.6 | 5.2 | 7.3 |
| P2098R | 0.38 | 0.12 | 0.18 | 0.27 | 0.42 | 0.48 | 0.56 | 1.93 | 3.41 | 3.29 | 4.41 | 5.44 | 6.59 | 0.1 | 0.2 | 0.3 | 0.7 | 1.0 | 1.4 |
| P3021R | 0.20 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 | 2.68 | 4.75 | 4.58 | 6.14 | 7.56 | 9.16 | 0.4 | 0.8 | 0.8 | 1.1 | 1.3 | 1.6 |
| P3023R | 0.17 | 0.83 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 | 2.68 | 4.75 | 4.58 | 6.14 | 7.56 | 9.16 | 0.4 | 0.7 | 0.7 | 0.9 | 1.2 | 1.4 |
| P3042R | 0.97 | 0.23 | 0.30 | 0.37 | 0.50 | 0.55 | 0.62 | 1.94 | 3.44 | 3.32 | 4.45 | 5.48 | 6.64 | 0.4 | 1.0 | 1.2 | 2.2 | 2.9 | 4.0 |
| P3049L | 1.47 | 0.28 | 0.34 | 0.41 | 0.53 | 0.58 | 0.64 | 1.59 | 2.82 | 2.72 | 3.64 | 4.49 | 5.44 | 0.6 | 1.4 | 1.6 | 2.8 | 3.8 | 5.1 |
| P3049R | 2.24 | 0.28 | 0.35 | 0.42 | 0.53 | 0.58 | 0.64 | 1.47 | 2.61 | 2.51 | 3.37 | 4.15 | 5.03 | 0.9 | 2.0 | 2.3 | 4.0 | 5.4 | 7.2 |
| P3052R | 0.61 | 0.30 | 0.36 | 0.43 | 0.54 | 0.59 | 0.65 | 2.42 | 4.28 | 4.13 | 5.53 | 6.82 | 8.25 | 0.4 | 0.9 | 1.1 | 1.8 | 2.4 | 3.2 |
| P4018L | 13.69 | 0.09 | 0.14 | 0.23 | 0.39 | 0.46 | 0.54 | 0.58 | 1.02 | 0.99 | 1.33 | 1.63 | 1.98 | 0.7 | 2.0 | 3.1 | 7.1 | 10.2 | 14.6 |
| P4019R | 3.37 | 0.22 | 0.29 | 0.36 | 0.49 | 0.54 | 0.61 | 1.25 | 2.21 | 2.14 | 2.86 | 3.53 | 4.27 | 0.9 | 2.2 | 2.6 | 4.8 | 6.5 | 8.8 |
| P4019RA | 0.21 | 0.70 | 0.74 | 0.77 | 0.80 | 0.81 | 0.83 | 2.64 | 4.67 | 4.50 | 6.03 | 7.44 | 9.00 | 0.4 | 0.7 | 0.7 | 1.0 | 1.3 | 1.6 |
| P4020R | 0.42 | 0.46 | 0.52 | 0.57 | 0.65 | 0.68 | 0.73 | 1.71 | 3.03 | 2.92 | 3.91 | 4.82 | 5.84 | 0.3 | 0.7 | 0.7 | 1.1 | 1.4 | 1.8 |
| P4021R | 0.35 | 0.67 | 0.71 | 0.74 | 0.78 | 0.80 | 0.82 | 2.46 | 4.35 | 4.19 | 5.62 | 6.92 | 8.38 | 0.6 | 1.1 | 1.1 | 1.5 | 1.9 | 2.4 |
| P4023R | 3.48 | 0.72 | 0.76 | 0.78 | 0.81 | 0.82 | 0.84 | 2.23 | 3.94 | 3.80 | 5.10 | 6.28 | 7.61 | 5.6 | 10.4 | 10.3 | 14.4 | 18.0 | 22.3 |
| P4028R | 2.05 | 0.05 | 0.10 | 0.19 | 0.37 | 0.43 | 0.52 | 1.43 | 2.53 | 2.44 | 3.27 | 4.03 | 4.88 | 0.2 | 0.5 | 1.0 | 2.5 | 3.6 | 5.2 |
| P4040L | 1.46 | 0.01 | 0.06 | 0.15 | 0.33 | 0.41 | 0.49 | 1.13 | 1.99 | 1.92 | 2.58 | 3.18 | 3.85 | 0.0 | 0.2 | 0.4 | 1.3 | 1.9 | 2.8 |
| P4044R | 5.31 | 0.08 | 0.14 | 0.22 | 0.39 | 0.45 | 0.54 | 0.93 | 1.65 | 1.59 | 2.13 | 2.62 | 3.17 | 0.4 | 1.2 | 1.9 | 4.4 | 6.3 | 9.0 |
| P4053L | 1.86 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 1.07 | 1.90 | 1.83 | 2.46 | 3.03 | 3.67 | 0.0 | 0.2 | 0.5 | 1.5 | 2.3 | 3.4 |
| P4054R | 3.13 | 0.19 | 0.26 | 0.33 | 0.47 | 0.53 | 0.60 | 1.24 | 2.20 | 2.12 | 2.84 | 3.50 | 4.23 | 0.7 | 1.8 | 2.2 | 4.2 | 5.8 | 7.9 |
| P4060L | 1.21 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 0.93 | 1.65 | 1.59 | 2.13 | 2.62 | 3.18 | 0.0 | 0.1 | 0.3 | 0.9 | 1.3 | 1.9 |
| P4065R | 3.29 | 0.20 | 0.27 | 0.34 | 0.48 | 0.53 | 0.60 | 1.28 | 2.27 | 2.19 | 2.93 | 3.61 | 4.37 | 0.8 | 2.0 | 2.5 | 4.6 | 6.3 | 8.6 |
| P4074R | 2.84 | 0.22 | 0.28 | 0.36 | 0.49 | 0.54 | 0.61 | 1.15 | 2.04 | 1.96 | 2.63 | 3.24 | 3.93 | 0.7 | 1.6 | 2.0 | 3.7 | 5.0 | 6.8 |
| P4075L | 2.34 | 0.01 | 0.05 | 0.15 | 0.33 | 0.40 | 0.49 | 1.07 | 1.90 | 1.83 | 2.46 | 3.03 | 3.67 | 0.0 | 0.2 | 0.6 | 1.9 | 2.9 | 4.2 |
| P4076L | 0.09 | 0.14 | 0.20 | 0.28 | 0.43 | 0.49 | 0.57 | 2.14 | 3.79 | 3.65 | 4.90 | 6.03 | 7.30 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 |
| P4081L | 1.32 | 0.10 | 0.16 | 0.24 | 0.40 | 0.47 | 0.54 | 1.50 | 2.66 | 2.56 | 3.44 | 4.24 | 5.13 | 0.2 | 0.5 | 0.8 | 1.8 | 2.6 | 3.7 |
| P4081R | 1.63 | 0.25 | 0.31 | 0.38 | 0.51 | 0.56 | 0.62 | 1.30 | 2.29 | 2.21 | 2.97 | 3.65 | 4.42 | 0.5 | 1.2 | 1.4 | 2.5 | 3.3 | 4.5 |
| P4086R | 1.61 | 0.22 | 0.29 | 0.36 | 0.49 | 0.54 | 0.61 | 1.46 | 2.58 | 2.49 | 3.34 | 4.12 | 4.98 | 0.5 | 1.2 | 1.5 | 2.7 | 3.6 | 4.9 |

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

| INTENSITY VALUES | | | | | | |
|---|---|---|---|---|---|---|
| Storm Event | 2-Year | 5-Year | 10-Year | 25-Year | 50-Year | 100-Year |
| One-Hour Point Rainfall Values (P1) (inches) | 0.79 | 1.40 | 1.35 | 1.81 | 2.23 | 2.70 |

5-Year: Boulder County Storm Drainage Criteria Manual, NOAA Atlas 2 Vol 3 (Region 1, Boulder, CO)
All other Events: NOAA Atlas 14, Volume 8, Version 2 (Region 1, Boulder, CO)

## RATIONAL FLOWS

| BASIN ID | AREA (acre) | $C_2$ | $C_5$ | $C_{10}$ | $C_{25}$ | $C_{50}$ | $C_{100}$ | $I_2$ (in/hr) | $I_5$ (in/hr) | $I_{10}$ (in/hr) | $I_{25}$ (in/hr) | $I_{50}$ (in/hr) | $I_{100}$ (in/hr) | $Q_2$ (cfs) | $Q_5$ (cfs) | $Q_{10}$ (cfs) | $Q_{25}$ (cfs) | $Q_{50}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P4087L | 1.38 | 0.12 | 0.18 | 0.26 | 0.42 | 0.48 | 0.56 | 1.74 | 3.07 | 2.96 | 3.97 | 4.89 | 5.93 | 0.3 | 0.8 | 1.1 | 2.3 | 3.2 | 4.5 |
| P4091L | 1.39 | 0.39 | 0.46 | 0.51 | 0.61 | 0.64 | 0.69 | 1.73 | 3.06 | 2.95 | 3.96 | 4.88 | 5.90 | 0.9 | 1.9 | 2.1 | 3.3 | 4.4 | 5.7 |
| P4091R | 1.01 | 0.17 | 0.24 | 0.31 | 0.46 | 0.51 | 0.58 | 1.73 | 3.07 | 2.96 | 3.97 | 4.89 | 5.92 | 0.3 | 0.7 | 0.9 | 1.8 | 2.5 | 3.5 |
| P4093L | 0.46 | 0.38 | 0.45 | 0.50 | 0.60 | 0.64 | 0.69 | 2.12 | 3.76 | 3.63 | 4.86 | 5.99 | 7.25 | 0.4 | 0.8 | 0.8 | 1.4 | 1.8 | 2.3 |
| P4095R | 0.45 | 0.35 | 0.41 | 0.47 | 0.58 | 0.62 | 0.67 | 1.80 | 3.18 | 3.07 | 4.12 | 5.07 | 6.14 | 0.3 | 0.6 | 0.7 | 1.1 | 1.4 | 1.9 |
| P4108R | 3.91 | 0.19 | 0.26 | 0.33 | 0.47 | 0.53 | 0.60 | 1.05 | 1.86 | 1.79 | 2.40 | 2.96 | 3.59 | 0.8 | 1.9 | 2.3 | 4.4 | 6.1 | 8.3 |
| P4114L | 3.63 | 0.07 | 0.12 | 0.21 | 0.38 | 0.45 | 0.53 | 0.95 | 1.69 | 1.63 | 2.18 | 2.68 | 3.25 | 0.2 | 0.8 | 1.2 | 3.0 | 4.3 | 6.2 |
| P4117R | 2.27 | 0.28 | 0.35 | 0.41 | 0.53 | 0.58 | 0.64 | 1.17 | 2.06 | 1.99 | 2.67 | 3.29 | 3.98 | 0.7 | 1.6 | 1.9 | 3.2 | 4.3 | 5.8 |
| P5006R | 1.44 | 0.22 | 0.29 | 0.36 | 0.49 | 0.54 | 0.61 | 1.75 | 3.11 | 2.99 | 4.01 | 4.95 | 5.99 | 0.6 | 1.3 | 1.5 | 2.8 | 3.9 | 5.3 |
| P5007R | 0.10 | 0.36 | 0.43 | 0.49 | 0.59 | 0.63 | 0.68 | 2.66 | 4.71 | 4.54 | 6.09 | 7.50 | 9.08 | 0.1 | 0.2 | 0.2 | 0.4 | 0.5 | 0.6 |
| P5011L | 5.52 | 0.15 | 0.21 | 0.29 | 0.44 | 0.50 | 0.57 | 0.99 | 1.76 | 1.70 | 2.27 | 2.80 | 3.39 | 0.8 | 2.0 | 2.7 | 5.5 | 7.7 | 10.7 |
| P5011R | 2.28 | 0.11 | 0.17 | 0.25 | 0.41 | 0.47 | 0.55 | 1.34 | 2.37 | 2.29 | 3.07 | 3.78 | 4.57 | 0.3 | 0.9 | 1.3 | 2.9 | 4.1 | 5.7 |
| P5013L | 3.08 | 0.19 | 0.22 | 0.29 | 0.43 | 0.49 | 0.56 | 1.44 | 2.54 | 2.45 | 3.29 | 4.05 | 4.90 | 0.8 | 1.7 | 2.2 | 4.3 | 6.1 | 8.4 |
| P5023R | 5.73 | 0.11 | 0.12 | 0.16 | 0.25 | 0.31 | 0.39 | 0.84 | 1.48 | 1.43 | 1.91 | 2.36 | 2.85 | 0.5 | 1.0 | 1.3 | 2.8 | 4.2 | 6.3 |
| P5023L | 1.17 | 0.18 | 0.20 | 0.24 | 0.32 | 0.38 | 0.45 | 1.06 | 1.88 | 1.81 | 2.43 | 2.99 | 3.62 | 0.2 | 0.4 | 0.5 | 0.9 | 1.3 | 1.9 |
| P5030L | 3.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.08 | 0.16 | 1.16 | 2.04 | 1.97 | 2.64 | 3.26 | 3.94 | 0.1 | 0.2 | 0.2 | 0.4 | 0.8 | 2.0 |
| P5033R | 4.16 | 0.11 | 0.12 | 0.13 | 0.15 | 0.20 | 0.27 | 1.59 | 2.81 | 2.71 | 3.63 | 4.47 | 5.41 | 0.7 | 1.4 | 1.4 | 2.3 | 3.8 | 6.2 |
| P5040L | 0.89 | 0.01 | 0.01 | 0.02 | 0.02 | 0.06 | 0.14 | 1.38 | 2.44 | 2.35 | 3.15 | 3.88 | 4.70 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.6 |
| P5041R | 0.93 | 0.25 | 0.27 | 0.28 | 0.31 | 0.36 | 0.42 | 1.67 | 2.95 | 2.85 | 3.82 | 4.70 | 5.70 | 0.4 | 0.7 | 0.7 | 1.1 | 1.6 | 2.2 |
| P5048L | 1.12 | 0.01 | 0.01 | 0.01 | 0.01 | 0.04 | 0.13 | 1.06 | 1.88 | 1.81 | 2.43 | 2.99 | 3.62 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.5 |
| P5048R | 2.60 | 0.28 | 0.29 | 0.31 | 0.34 | 0.39 | 0.45 | 1.50 | 2.65 | 2.55 | 3.42 | 4.22 | 5.10 | 1.1 | 2.0 | 2.0 | 3.0 | 4.3 | 5.9 |
| P5052L | 1.99 | 0.21 | 0.27 | 0.35 | 0.48 | 0.54 | 0.60 | 1.42 | 2.52 | 2.43 | 3.25 | 4.01 | 4.85 | 0.6 | 1.4 | 1.7 | 3.1 | 4.3 | 5.8 |
| P5064R | 6.82 | 0.15 | 0.17 | 0.24 | 0.39 | 0.46 | 0.53 | 1.01 | 1.78 | 1.72 | 2.30 | 2.84 | 3.44 | 1.0 | 2.1 | 2.9 | 6.2 | 8.9 | 12.5 |
| P5066L | 8.08 | 0.12 | 0.14 | 0.21 | 0.37 | 0.44 | 0.52 | 0.92 | 1.63 | 1.57 | 2.11 | 2.60 | 3.15 | 0.9 | 1.9 | 2.7 | 6.3 | 9.2 | 13.1 |
| P5068R | 15.75 | 0.04 | 0.06 | 0.12 | 0.30 | 0.37 | 0.46 | 1.54 | 2.72 | 2.62 | 3.52 | 4.33 | 5.25 | 1.1 | 2.4 | 5.1 | 16.6 | 25.5 | 38.4 |
| P5076R | 1.57 | 0.30 | 0.33 | 0.39 | 0.51 | 0.56 | 0.62 | 2.06 | 3.64 | 3.51 | 4.71 | 5.80 | 7.02 | 1.0 | 1.9 | 2.2 | 3.8 | 5.1 | 6.9 |
| P5084R | 1.44 | 0.84 | 0.86 | 0.87 | 0.88 | 0.89 | 0.90 | 2.10 | 3.72 | 3.59 | 4.81 | 5.92 | 7.17 | 2.5 | 4.6 | 4.5 | 6.1 | 7.6 | 9.2 |
| P5084L | 5.20 | 0.06 | 0.11 | 0.20 | 0.37 | 0.44 | 0.52 | 1.07 | 1.90 | 1.83 | 2.45 | 3.02 | 3.66 | 0.3 | 1.1 | 1.9 | 4.7 | 6.9 | 9.9 |
| P5066R | 2.57 | 0.05 | 0.10 | 0.19 | 0.36 | 0.43 | 0.52 | 1.09 | 1.93 | 1.86 | 2.50 | 3.08 | 3.73 | 0.1 | 0.5 | 0.9 | 2.3 | 3.4 | 5.0 |
| P5001L | 2.27 | 0.07 | 0.13 | 0.22 | 0.38 | 0.45 | 0.53 | 1.25 | 2.20 | 2.13 | 2.85 | 3.51 | 4.25 | 0.2 | 0.7 | 1.1 | 2.5 | 3.6 | 5.1 |
| P4028L | 0.63 | 0.48 | 0.54 | 0.59 | 0.66 | 0.69 | 0.74 | 1.79 | 3.17 | 3.06 | 4.10 | 5.06 | 6.12 | 0.5 | 1.1 | 1.1 | 1.7 | 2.2 | 2.9 |

[1] $I = \frac{28.5 * P1}{(10 + T_d)^{0.786}}$ USDCM Equation 5-1, (March 2017) where $T_d = T_c$ USDCM Chapter 6 Section 2.5 (August 2018)

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Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE)
5-YEAR STORM EVENT

| DESIGN POINT | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASIN ID | AREA (acres) | $C_5$ | CA (acres) | $T_c$ (min) | $I_5$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_5$ | $I_5$ (in/hr) | Q (cfs) | |
| P1017L | P1013R | 1.54 | 0.46 | 0.71 | 20.83 | 2.70 | 1.9 | | | | | |
| | P1016L | 8.85 | 0.08 | 0.68 | 36.92 | 1.94 | 1.3 | | | | | |
| | | | | | | | | 36.92 | 1.39 | 1.94 | 2.7 | |
| | P1017L | 0.71 | 0.42 | 0.30 | 6.32 | 4.44 | 1.3 | | | | | |
| | | | | | | | | 36.9 | 1.69 | 1.94 | 3.3 | |
| P1018L | P1021RA | 0.28 | 0.86 | 0.24 | 5.46 | 4.64 | 1.1 | | | | | |
| | P1021R | 0.64 | 0.43 | 0.27 | 12.17 | 3.49 | 1.0 | | | | | |
| | P1018L | 1.27 | 0.14 | 0.18 | 14.08 | 3.27 | 0.6 | | | | | |
| | | | | | | | | 14.1 | 0.69 | 3.27 | 2.3 | |
| P1030R | P1029L | 99.22 | 0.21 | 21.17 | 71.79 | 1.25 | 26.5 | | | | | |
| | P1029R | 1.42 | 0.50 | 0.71 | 17.68 | 2.93 | 2.1 | | | | | |
| | P1030R | 0.76 | 0.05 | 0.04 | 26.47 | 2.36 | 0.1 | | | | | |
| | P1031L | 1.04 | 0.44 | 0.46 | 12.29 | 3.48 | 1.6 | | | | | |
| | P1031R | 0.74 | 0.42 | 0.31 | 5.00 | 4.75 | 1.5 | | | | | |
| | P1032R | 0.26 | 0.05 | 0.01 | 11.65 | 3.56 | 0.0 | | | | | |
| | | | | | | | | 71.8 | 22.70 | 1.25 | 28.4 | |
| P1044L | P1043R | 1.09 | 0.15 | 0.16 | 19.74 | 2.77 | 0.5 | | | | | |
| | P1044L | 2.33 | 0.08 | 0.18 | 17.69 | 2.93 | 0.5 | | | | | |
| | | | | | | | | 19.7 | 0.34 | 2.77 | 0.9 | |
| P1056L | Mobility Hub Jay Road Inlet | 0.44 | 0.86 | 0.38 | 8.32 | 4.06 | 1.5 | | | | | |
| | P1048L | 1.20 | 0.21 | 0.25 | 5.47 | 4.64 | 1.2 | | | | | |
| | P1053L | 2.12 | 0.62 | 1.32 | 21.70 | 2.64 | 3.5 | | | | | |
| | P1054R | 2.33 | 0.27 | 0.62 | 21.29 | 2.66 | 1.7 | | | | | |
| | P1056L | 1.17 | 0.30 | 0.35 | 9.02 | 3.94 | 1.4 | | | | | |
| | | | | | | | | 21.7 | 2.91 | 2.64 | 7.7 | |
| P1069R | Mobility Hub Jay Road Inlet | 0.44 | 0.86 | 0.38 | 8.32 | 4.06 | 1.5 | | | | | |
| | P1048L | 1.20 | 0.21 | 0.25 | 5.47 | 4.64 | 1.2 | | | | | |
| | P1053L | 2.12 | 0.62 | 1.32 | 21.70 | 2.64 | 3.5 | | | | | |
| | P1054R | 2.33 | 0.27 | 0.62 | 21.29 | 2.66 | 1.7 | | | | | |
| | P1056L | 1.17 | 0.30 | 0.35 | 9.02 | 3.94 | 1.4 | | | | | |
| | P1057L | 0.29 | 0.21 | 0.06 | 11.71 | 3.55 | 0.2 | | | | | |
| | P1067L | 2.85 | 0.13 | 0.37 | 25.80 | 2.40 | 0.9 | | | | | |
| | P1063R | 0.92 | 0.07 | 0.06 | 23.32 | 2.54 | 0.2 | | | | | |
| | P1069R | 1.28 | 0.10 | 0.13 | 12.27 | 3.48 | 0.5 | | | | | |
| | | | | | | | | 25.8 | 3.53 | 2.40 | 8.5 | |
| P1082L | P1076L | 1.06 | 0.08 | 0.09 | 16.92 | 3.00 | 0.3 | | | | | |
| | P1077R | 1.85 | 0.10 | 0.19 | 29.17 | 2.23 | 0.4 | | | | | |
| | P1080R | 1.59 | 0.11 | 0.18 | 19.76 | 2.77 | 0.5 | | | | | |
| | P1082L | 1.70 | 0.45 | 0.76 | 14.80 | 3.20 | 2.4 | | | | | |
| | | | | | | | | 29.2 | 1.21 | 2.23 | 2.7 | |
| P2022R | P2021L | 7.83 | 0.11 | 0.83 | 103.10 | 0.97 | 0.8 | | | | | |
| | P2022L | 0.07 | 0.05 | 0.00 | 10.00 | 3.79 | 0.0 | | | | | |
| | P2022R | 3.00 | 0.18 | 0.55 | 48.98 | 1.62 | 0.9 | | | | | |
| | | | | | | | | 103.1 | 1.38 | 0.97 | 1.3 | |
| P2031R | P2030L | 1.18 | 0.08 | 0.09 | 27.21 | 2.33 | 0.2 | | | | | |
| | P2031R | 2.36 | 0.16 | 0.39 | 19.50 | 2.79 | 1.1 | | | | | |
| | P2032L | 0.12 | 0.06 | 0.01 | 10.00 | 3.79 | 0.0 | | | | | |
| | | | | | | | | 27.2 | 0.48 | 2.33 | 1.1 | |

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Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

## STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE)
## 5-YEAR STORM EVENT

| DESIGN POINT | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASIN ID | AREA (acres) | $C_5$ | CA (acres) | $T_c$ (min) | $I_5$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_5$ | $I_5$ (in/hr) | Q (cfs) | |
| P2059R | P2058L | 0.53 | 0.05 | 0.03 | 25.54 | 2.41 | 0.1 | | | | | |
| | P2049L | 1.75 | 0.06 | 0.10 | 37.82 | 1.91 | 0.2 | | | | | |
| | P2059R | 9.82 | 0.21 | 2.05 | 48.04 | 1.64 | 3.4 | | | | | |
| | P2062L | 1.13 | 0.78 | 0.89 | 5.00 | 4.75 | 4.2 | | | | | |
| | | | | | | | | 48.0 | 3.07 | 1.64 | 5.0 | |
| P2064R | P2063R | 0.23 | 0.43 | 0.10 | 5.51 | 4.62 | 0.5 | | | | | |
| | P2064R | 2.43 | 0.27 | 0.66 | 11.93 | 3.52 | 2.3 | | | | | |
| | P2066R | 2.26 | 0.27 | 0.62 | 16.96 | 2.99 | 1.9 | | | | | |
| | | | | | | | | 17.0 | 1.38 | 2.99 | 4.1 | |
| P2079L | P2075L | 0.58 | 0.08 | 0.04 | 16.39 | 3.05 | 0.1 | | | | | |
| | P2077L | 0.37 | 0.19 | 0.07 | 10.32 | 3.74 | 0.3 | | | | | |
| | P2079L | 1.73 | 0.26 | 0.44 | 24.63 | 2.46 | 1.1 | | | | | |
| | | | | | | | | 24.6 | 0.56 | 2.46 | 1.4 | |
| P2085R | P2084L | 0.80 | 0.09 | 0.08 | 16.69 | 3.02 | 0.2 | | | | | |
| | P2085R | 2.57 | 0.24 | 0.62 | 21.91 | 2.62 | 1.6 | | | | | |
| | | | | | | | | 21.9 | 0.70 | 2.62 | 1.8 | |
| P2085L | P2085L | 2.32 | 0.18 | 0.42 | 34.85 | 2.01 | 0.9 | | | | | |
| | P2092R | 0.39 | 0.32 | 0.13 | 9.19 | 3.91 | 0.5 | | | | | |
| | P2093R | 1.69 | 0.16 | 0.27 | 25.05 | 2.44 | 0.7 | | | | | |
| | P2098R | 0.38 | 0.18 | 0.07 | 12.82 | 3.41 | 0.2 | | | | | |
| | P2100R | 3.11 | 0.17 | 0.52 | 29.70 | 2.21 | 1.1 | | | | | |
| | P2100L | 1.09 | 0.10 | 0.11 | 27.81 | 2.30 | 0.3 | | | | | |
| | | | | | | | | 34.8 | 1.51 | 2.01 | 3.0 | |
| P3049R | P3049L | 1.47 | 0.34 | 0.50 | 19.12 | 2.82 | 1.4 | | | | | |
| | P3049R | 2.24 | 0.35 | 0.78 | 22.17 | 2.61 | 2.0 | | | | | |
| | | | | | | | | 22.2 | 1.29 | 2.61 | 3.4 | |
| P4028R | P4021R | 0.35 | 0.71 | 0.25 | 6.78 | 4.35 | 1.1 | | | | | |
| | P4023R | 3.48 | 0.76 | 2.63 | 9.00 | 3.94 | 10.4 | | | | | |
| | P4028L | 0.63 | 0.54 | 0.34 | 15.04 | 3.17 | 1.1 | | | | | |
| | P4028R | 2.05 | 0.10 | 0.21 | 23.43 | 2.53 | 0.5 | | | | | |
| | | | | | | | | 23.4 | 3.43 | 2.53 | 8.7 | |
| P4044R | P4021R | 0.35 | 0.71 | 0.25 | 6.78 | 4.35 | 1.1 | | | | | |
| | P4023R | 3.48 | 0.76 | 2.63 | 9.00 | 3.94 | 10.4 | | | | | |
| | P4028L | 0.63 | 0.54 | 0.34 | 15.04 | 3.17 | 1.1 | | | | | |
| | P4028R | 2.05 | 0.10 | 0.21 | 23.43 | 2.53 | 0.5 | | | | | |
| | P4040L | 1.46 | 0.06 | 0.08 | 35.25 | 1.99 | 0.2 | | | | | |
| | P4044R | 5.31 | 0.14 | 0.73 | 47.74 | 1.65 | 1.2 | | | | | |
| | | | | | | | | 47.7 | 4.24 | 1.65 | 7.0 | |
| P4054R | P4053L | 1.86 | 0.05 | 0.10 | 38.02 | 1.90 | 0.2 | | | | | |
| | P4054R | 3.13 | 0.26 | 0.81 | 30.03 | 2.20 | 1.8 | | | | | |
| | | | | | | | | 38.0 | 0.91 | 1.90 | 1.7 | |
| P4065R | P4060L | 1.21 | 0.05 | 0.06 | 47.70 | 1.65 | 0.1 | | | | | |
| | P4065R | 3.29 | 0.27 | 0.88 | 28.44 | 2.27 | 2.0 | | | | | |
| | | | | | | | | 47.7 | 0.94 | 1.65 | 1.5 | |
| P4076L | P4074R | 2.84 | 0.28 | 0.80 | 34.03 | 2.04 | 1.6 | | | | | |
| | P4076L | 0.09 | 0.20 | 0.02 | 10.00 | 3.79 | 0.1 | | | | | |
| | | | | | | | | 34.0 | 0.82 | 2.04 | 1.7 | |
| P4081L | P4081R | 1.63 | 0.31 | 0.51 | 27.86 | 2.29 | 1.2 | | | | | |
| | P4081L | 1.32 | 0.16 | 0.21 | 21.36 | 2.66 | 0.5 | | | | | |
| | | | | | | | | 27.9 | 0.72 | 2.29 | 1.6 | |
| P4087L | P4086R | 1.61 | 0.29 | 0.47 | 22.53 | 2.58 | 1.2 | | | | | |
| | P4087L | 1.38 | 0.18 | 0.25 | 16.10 | 3.07 | 0.8 | | | | | |
| | | | | | | | | 22.5 | 0.71 | 2.58 | 1.8 | |
| P4091L | P4091L | 1.39 | 0.46 | 0.64 | 16.22 | 3.06 | 1.9 | | | | | |
| | P4091R | 1.01 | 0.24 | 0.24 | 16.15 | 3.07 | 0.7 | | | | | |
| | | | | | | | | 16.2 | 0.87 | 3.06 | 2.7 | |

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Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

**STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE)**
**5-YEAR STORM EVENT**

| DESIGN POINT | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASIN ID | AREA (acres) | $C_5$ | CA (acres) | $T_c$ (min) | $I_5$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_5$ | $I_5$ (in/hr) | Q (cfs) | |
| P4095R | P4093L | 0.46 | 0.45 | 0.21 | 10.18 | 3.76 | 0.8 | | | | | |
| | P4095R | 0.45 | 0.41 | 0.19 | 14.95 | 3.18 | 0.6 | | | | | |
| | | | | | | | | 14.9 | 0.39 | 3.18 | 1.3 | |
| P4114L | P4108R | 3.91 | 0.26 | 1.00 | 39.46 | 1.86 | 1.9 | | | | | |
| | P4114L | 3.63 | 0.12 | 0.45 | 46.02 | 1.69 | 0.8 | | | | | |
| | | | | | | | | 46.0 | 1.45 | 1.69 | 2.4 | |
| P5001L | P4117R | 2.27 | 0.35 | 0.78 | 33.33 | 2.06 | 1.6 | | | | | |
| | P5001L | 2.27 | 0.13 | 0.30 | 29.81 | 2.20 | 0.7 | | | | | |
| | | | | | | | | 33.3 | 1.08 | 2.06 | 2.2 | |
| P5006R | P5006R | 1.44 | 0.29 | 0.41 | 15.75 | 3.11 | 1.3 | | | | | |
| | P5007R | 0.10 | 0.43 | 0.04 | 5.16 | 4.71 | 0.2 | | | | | |
| | | | | | | | | 15.7 | 0.46 | 3.11 | 1.4 | |
| P5011L | P5011R | 2.28 | 0.17 | 0.38 | 26.28 | 2.37 | 0.9 | | | | | |
| | P5011L | 5.52 | 0.21 | 1.15 | 43.04 | 1.76 | 2.0 | | | | | |
| | | | | | | | | 43.0 | 1.54 | 1.76 | 2.7 | |
| P5023R | P5023L | 1.17 | 0.20 | 0.23 | 38.80 | 1.88 | 0.4 | | | | | |
| | P5023R | 5.73 | 0.12 | 0.70 | 56.15 | 1.48 | 1.0 | | | | | |
| | | | | | | | | 56.2 | 0.93 | 1.48 | 1.4 | |
| P5033R | P5030L | 3.02 | 0.03 | 0.09 | 33.83 | 2.04 | 0.2 | | | | | |
| | P5033R | 4.16 | 0.12 | 0.49 | 19.29 | 2.81 | 1.4 | | | | | |
| | | | | | | | | 33.8 | 0.58 | 2.04 | 1.2 | |
| P5041R | P5040L | 0.89 | 0.01 | 0.01 | 25.07 | 2.44 | 0.0 | | | | | |
| | P5041R | 0.93 | 0.27 | 0.25 | 17.44 | 2.95 | 0.7 | | | | | |
| | | | | | | | | 25.1 | 0.26 | 2.44 | 0.6 | |
| P5048R | P5048L | 1.12 | 0.01 | 0.01 | 38.83 | 1.88 | 0.0 | | | | | |
| | P5048R | 2.60 | 0.29 | 0.76 | 21.56 | 2.65 | 2.0 | | | | | |
| | | | | | | | | 38.8 | 0.77 | 1.88 | 1.4 | |
| P5068R | P5052L | 1.99 | 0.27 | 0.55 | 23.66 | 2.52 | 1.4 | | | | | |
| | P5066L | 8.08 | 0.14 | 1.16 | 48.38 | 1.63 | 1.9 | | | | | |
| | P5068R | 15.75 | 0.06 | 0.88 | 20.46 | 2.72 | 2.4 | | | | | |
| | P5084R | 1.44 | 0.86 | 1.24 | 10.47 | 3.72 | 4.6 | | | | | |
| | P5084L | 5.20 | 0.11 | 0.57 | 38.19 | 1.90 | 1.1 | | | | | |
| | P5084R | 1.44 | 0.86 | 1.24 | 10.47 | 3.72 | 4.6 | | | | | |
| | | | | | | | | 48.4 | 5.63 | 1.63 | 9.2 | |

Notes:

1 $I = \frac{28.5 * P1}{(10 * T_d)^{0.786}}$ USDCM Equation 5-1, (March 2017) where P Values come from NOAA Atlas 2, Volume 8, Version 2 and Td = Tc USDCM Chapter 6 Section 2.5 (August 2018)

2 $Q_{tot} = I_{min}\left[\sum_{i=0}^{n}(CA)_i\right]$ Where: $I_{min}$ = Minimum Intensity and CA = Effective CA

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Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

| STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE) 10-YEAR STORM EVENT | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | |
| DESIGN POINT | BASIN ID | AREA (acres) | $C_{10}$ | CA (acres) | $T_c$ (min) | $I_{10}$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_{10}$ | $I_{10}$ (in/hr) | Q (cfs) | DESCRIPTION |
| P1017L | P1013R | 1.54 | 0.51 | 0.79 | 20.83 | 2.60 | 2.0 | | | | | |
| | P1016L | 8.85 | 0.15 | 1.28 | 36.92 | 1.87 | 2.4 | | | | | |
| | | | | | | | | 36.9 | 2.07 | 1.87 | 3.9 | |
| | P1017L | 0.71 | 0.48 | 0.34 | 6.32 | 4.29 | 1.5 | | | | | |
| | | | | | | | | 36.9 | 2.41 | 1.87 | 4.5 | |
| P1018L | P1021RA | 0.28 | 0.87 | 0.24 | 5.46 | 4.47 | 1.1 | | | | | |
| | P1021R | 0.64 | 0.49 | 0.31 | 12.17 | 3.37 | 1.1 | | | | | |
| | P1018L | 1.27 | 0.22 | 0.28 | 14.08 | 3.16 | 0.9 | | | | | |
| | | | | | | | | 14.1 | 0.59 | 3.16 | 1.9 | |
| P1030R | P1029L | 99.22 | 0.29 | 29.07 | 71.79 | 1.21 | 35.1 | | | | | |
| | P1029R | 1.42 | 0.55 | 0.79 | 17.68 | 2.83 | 2.2 | | | | | |
| | P1030R | 0.76 | 0.15 | 0.11 | 26.47 | 2.28 | 0.3 | | | | | |
| | P1031L | 1.04 | 0.50 | 0.52 | 12.29 | 3.35 | 1.7 | | | | | |
| | P1031R | 0.74 | 0.48 | 0.35 | 5.00 | 4.58 | 1.6 | | | | | |
| | P1032R | 0.26 | 0.15 | 0.04 | 11.65 | 3.43 | 0.1 | | | | | |
| | | | | | | | | 71.8 | 30.88 | 1.21 | 37.3 | |
| P1044R | P1043R | 1.09 | 0.24 | 0.26 | 19.74 | 2.67 | 0.7 | | | | | |
| | P1044L | 2.33 | 0.17 | 0.39 | 17.69 | 2.83 | 1.1 | | | | | |
| | | | | | | | | 19.7 | 0.65 | 2.67 | 1.7 | |
| P1056L | Mobility Hub Jay Road Inlet | 0.44 | 0.87 | 0.38 | 8.32 | 3.91 | 1.5 | | | | | |
| | P1048L | 1.20 | 0.29 | 0.35 | 5.47 | 4.47 | 1.5 | | | | | |
| | P1053L | 2.12 | 0.66 | 1.40 | 21.70 | 2.54 | 3.6 | | | | | |
| | P1054R | 2.33 | 0.34 | 0.80 | 21.29 | 2.57 | 2.0 | | | | | |
| | P1056L | 1.17 | 0.37 | 0.43 | 9.02 | 3.80 | 1.6 | | | | | |
| | | | | | | | | 21.7 | 3.36 | 2.54 | 8.5 | |
| P1069R | Mobility Hub Jay Road Inlet | 0.44 | 0.87 | 0.38 | 8.32 | 3.91 | 1.5 | | | | | |
| | P1048L | 1.20 | 0.29 | 0.35 | 5.47 | 4.47 | 1.5 | | | | | |
| | P1053L | 2.12 | 0.66 | 1.40 | 21.70 | 2.54 | 3.6 | | | | | |
| | P1054R | 2.33 | 0.34 | 0.80 | 21.29 | 2.57 | 2.0 | | | | | |
| | P1056L | 1.17 | 0.37 | 0.43 | 9.02 | 3.80 | 1.6 | | | | | |
| | P1057L | 0.29 | 0.29 | 0.08 | 11.71 | 3.42 | 0.3 | | | | | |
| | P1067L | 2.85 | 0.22 | 0.62 | 25.80 | 2.31 | 1.4 | | | | | |
| | P1063R | 0.92 | 0.16 | 0.15 | 23.32 | 2.45 | 0.4 | | | | | |
| | P1069R | 1.28 | 0.19 | 0.25 | 12.27 | 3.36 | 0.8 | | | | | |
| | | | | | | | | 25.8 | 4.45 | 2.31 | 10.3 | |
| P1082L | P1076L | 1.06 | 0.18 | 0.19 | 16.92 | 2.89 | 0.5 | | | | | |
| | P1077R | 1.85 | 0.19 | 0.35 | 29.17 | 2.15 | 0.8 | | | | | |
| | P1080R | 1.59 | 0.20 | 0.32 | 19.76 | 2.67 | 0.9 | | | | | |
| | P1082L | 1.70 | 0.51 | 0.86 | 14.80 | 3.08 | 2.6 | | | | | |
| | | | | | | | | 29.2 | 1.72 | 2.15 | 3.7 | |
| P2022R | P2021L | 7.83 | 0.20 | 1.54 | 103.10 | 0.94 | 1.4 | | | | | |
| | P2022L | 0.07 | 0.15 | 0.01 | 10.00 | 3.65 | 0.0 | | | | | |
| | P2022R | 3.00 | 0.26 | 0.79 | 48.98 | 1.56 | 1.2 | | | | | |
| | | | | | | | | 103.1 | 2.34 | 0.94 | 2.2 | |
| P2031R | P2030L | 1.18 | 0.17 | 0.20 | 27.21 | 2.24 | 0.4 | | | | | |
| | P2031R | 2.36 | 0.25 | 0.59 | 19.50 | 2.69 | 1.6 | | | | | |
| | P2032L | 0.12 | 0.16 | 0.02 | 10.00 | 3.65 | 0.1 | | | | | |
| | | | | | | | | 27.2 | 0.80 | 2.24 | 1.8 | |

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Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator: ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE)
10-YEAR STORM EVENT

| DESIGN POINT | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASIN ID | AREA (acres) | $C_{10}$ | CA (acres) | $T_c$ (min) | $I_{10}$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_{10}$ | $I_{10}$ (in/hr) | Q (cfs) | |
| P2059R | P2058L | 0.53 | 0.15 | 0.08 | 25.54 | 2.32 | 0.2 | | | | | |
| | P2049L | 1.75 | 0.15 | 0.27 | 37.82 | 1.84 | 0.5 | | | | | |
| | P2059R | 9.82 | 0.29 | 2.84 | 48.04 | 1.58 | 4.5 | | | | | |
| | P2062L | 1.13 | 0.81 | 0.91 | 5.00 | 4.58 | 4.2 | | | | | |
| | | | | | | | | 48.0 | 4.10 | 1.58 | 6.5 | |
| P2064R | P2063R | 0.23 | 0.49 | 0.11 | 5.51 | 4.46 | 0.5 | | | | | |
| | P2064R | 2.43 | 0.35 | 0.84 | 11.93 | 3.40 | 2.9 | | | | | |
| | P2066R | 2.26 | 0.35 | 0.79 | 16.96 | 2.89 | 2.3 | | | | | |
| | | | | | | | | 17.0 | 1.74 | 2.89 | 5.0 | |
| P2079L | P2075L | 0.58 | 0.17 | 0.10 | 16.39 | 2.94 | 0.3 | | | | | |
| | P2077L | 0.37 | 0.27 | 0.10 | 10.32 | 3.61 | 0.4 | | | | | |
| | P2079L | 1.73 | 0.33 | 0.57 | 24.63 | 2.37 | 1.4 | | | | | |
| | | | | | | | | 24.6 | 0.77 | 2.37 | 1.8 | |
| P2085R | P2084L | 0.80 | 0.19 | 0.15 | 16.69 | 2.91 | 0.4 | | | | | |
| | P2085R | 2.57 | 0.32 | 0.82 | 21.91 | 2.53 | 2.1 | | | | | |
| | | | | | | | | 21.9 | 0.97 | 2.53 | 2.5 | |
| P2085L | P2085L | 2.32 | 0.27 | 0.62 | 34.85 | 1.94 | 1.2 | | | | | |
| | P2092R | 0.39 | 0.39 | 0.15 | 9.19 | 3.77 | 0.6 | | | | | |
| | P2093R | 1.69 | 0.24 | 0.41 | 25.05 | 2.35 | 1.0 | | | | | |
| | P2098R | 0.38 | 0.27 | 0.10 | 12.82 | 3.29 | 0.3 | | | | | |
| | P2100R | 3.11 | 0.25 | 0.78 | 29.70 | 2.13 | 1.7 | | | | | |
| | P2100L | 1.09 | 0.19 | 0.21 | 27.81 | 2.21 | 0.5 | | | | | |
| | | | | | | | | 34.8 | 2.27 | 1.94 | 4.4 | |
| P3049R | P3049L | 1.47 | 0.41 | 0.60 | 19.12 | 2.72 | 1.6 | | | | | |
| | P3049R | 2.24 | 0.42 | 0.93 | 22.17 | 2.51 | 2.3 | | | | | |
| | | | | | | | | 22.2 | 1.53 | 2.51 | 3.9 | |
| P4028R | P4021R | 0.35 | 0.74 | 0.26 | 6.78 | 4.19 | 1.1 | | | | | |
| | P4023R | 3.48 | 0.78 | 2.72 | 9.00 | 3.80 | 10.3 | | | | | |
| | P4028L | 0.63 | 0.59 | 0.37 | 15.04 | 3.06 | 1.1 | | | | | |
| | P4028R | 2.05 | 0.19 | 0.40 | 23.43 | 2.44 | 1.0 | | | | | |
| | | | | | | | | 23.4 | 3.74 | 2.44 | 9.1 | |
| P4044R | P4021R | 0.35 | 0.74 | 0.26 | 6.78 | 4.19 | 1.1 | | | | | |
| | P4023R | 3.48 | 0.78 | 2.72 | 9.00 | 3.80 | 10.3 | | | | | |
| | P4028L | 0.63 | 0.59 | 0.37 | 15.04 | 3.06 | 1.1 | | | | | |
| | P4028R | 2.05 | 0.19 | 0.40 | 23.43 | 2.44 | 1.0 | | | | | |
| | P4040L | 1.46 | 0.15 | 0.22 | 35.25 | 1.92 | 0.4 | | | | | |
| | P4044R | 5.31 | 0.22 | 1.19 | 47.74 | 1.59 | 1.9 | | | | | |
| | | | | | | | | 47.7 | 5.16 | 1.59 | 8.2 | |
| P4054R | P4053L | 1.86 | 0.15 | 0.28 | 38.02 | 1.83 | 0.5 | | | | | |
| | P4054R | 3.13 | 0.33 | 1.04 | 30.03 | 2.12 | 2.2 | | | | | |
| | | | | | | | | 38.0 | 1.32 | 1.83 | 2.4 | |
| P4065R | P4060L | 1.21 | 0.15 | 0.18 | 47.70 | 1.59 | 0.3 | | | | | |
| | P4065R | 3.29 | 0.34 | 1.12 | 28.44 | 2.19 | 2.5 | | | | | |
| | | | | | | | | 47.7 | 1.30 | 1.59 | 2.1 | |
| P4076L | P4074R | 2.84 | 0.36 | 1.01 | 34.03 | 1.96 | 2.0 | | | | | |
| | P4076L | 0.09 | 0.28 | 0.03 | 10.00 | 3.65 | 0.1 | | | | | |
| | | | | | | | | 34.0 | 1.04 | 1.96 | 2.0 | |
| P4081L | P4081R | 1.63 | 0.38 | 0.63 | 27.86 | 2.21 | 1.4 | | | | | |
| | P4081L | 1.32 | 0.24 | 0.32 | 21.36 | 2.56 | 0.8 | | | | | |
| | | | | | | | | 27.9 | 0.94 | 2.21 | 2.1 | |
| P4087L | P4086R | 1.61 | 0.36 | 0.58 | 22.53 | 2.49 | 1.5 | | | | | |
| | P4087L | 1.38 | 0.26 | 0.36 | 16.10 | 2.96 | 1.1 | | | | | |
| | | | | | | | | 22.5 | 0.94 | 2.49 | 2.3 | |
| P4091L | P4091L | 1.39 | 0.51 | 0.71 | 16.22 | 2.95 | 2.1 | | | | | |
| | P4091R | 1.01 | 0.31 | 0.32 | 16.15 | 2.96 | 0.9 | | | | | |
| | | | | | | | | 16.2 | 1.03 | 2.95 | 3.0 | |

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Muller Project Number: 21015

Originator ZDS/TPS
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Checker: EGS
Date: 6/28/2022

STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE)
10-YEAR STORM EVENT

| DESIGN POINT | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASIN ID | AREA (acres) | $C_{10}$ | CA (acres) | $T_c$ (min) | $I_{10}$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_{10}$ | $I_{10}$ (in/hr) | Q (cfs) | |
| P4095R | P4093L | 0.46 | 0.50 | 0.23 | 10.18 | 3.63 | 0.8 | | | | | |
| | P4095R | 0.45 | 0.47 | 0.21 | 14.95 | 3.07 | 0.7 | | | | | |
| | | | | | | | | 14.9 | 0.45 | 3.07 | 1.4 | |
| P4114L | P4108R | 3.91 | 0.33 | 1.30 | 39.46 | 1.79 | 2.3 | | | | | |
| | P4114L | 3.63 | 0.21 | 0.77 | 46.02 | 1.63 | 1.2 | | | | | |
| | | | | | | | | 46.0 | 2.07 | 1.63 | 3.4 | |
| P5001L | P4117R | 2.27 | 0.41 | 0.94 | 33.33 | 1.99 | 1.9 | | | | | |
| | P5001L | 2.27 | 0.22 | 0.50 | 29.81 | 2.13 | 1.1 | | | | | |
| | | | | | | | | 33.3 | 1.43 | 1.99 | 2.8 | |
| P5006R | P5006R | 1.44 | 0.36 | 0.52 | 15.75 | 2.99 | 1.5 | | | | | |
| | P5007R | 0.10 | 0.49 | 0.05 | 5.16 | 4.54 | 0.2 | | | | | |
| | | | | | | | | 15.7 | 0.57 | 2.99 | 1.7 | |
| P5011L | P5011R | 2.28 | 0.25 | 0.58 | 26.28 | 2.29 | 1.3 | | | | | |
| | P5011L | 5.52 | 0.29 | 1.60 | 43.04 | 1.70 | 2.7 | | | | | |
| | | | | | | | | 43.0 | 2.17 | 1.70 | 3.7 | |
| P5023R | P5023L | 1.17 | 0.24 | 0.28 | 38.80 | 1.81 | 0.5 | | | | | |
| | P5023R | 5.73 | 0.16 | 0.93 | 56.15 | 1.43 | 1.3 | | | | | |
| | | | | | | | | 56.2 | 1.21 | 1.43 | 1.7 | |
| P5033R | P5030L | 3.02 | 0.03 | 0.10 | 33.83 | 1.97 | 0.2 | | | | | |
| | P5033R | 4.16 | 0.13 | 0.53 | 19.29 | 2.71 | 1.4 | | | | | |
| | | | | | | | | 33.8 | 0.63 | 1.97 | 1.2 | |
| P5041R | P5040L | 0.89 | 0.02 | 0.01 | 25.07 | 2.35 | 0.0 | | | | | |
| | P5041R | 0.93 | 0.28 | 0.26 | 17.44 | 2.85 | 0.7 | | | | | |
| | | | | | | | | 25.1 | 0.27 | 2.35 | 0.6 | |
| P5048R | P5048L | 1.12 | 0.01 | 0.01 | 38.83 | 1.81 | 0.0 | | | | | |
| | P5048R | 2.60 | 0.31 | 0.80 | 21.56 | 2.55 | 2.0 | | | | | |
| | | | | | | | | 38.8 | 0.81 | 1.81 | 1.5 | |
| P5068R | P5052L | 1.99 | 0.35 | 0.69 | 23.66 | 2.43 | 1.7 | | | | | |
| | P5066L | 8.08 | 0.21 | 1.72 | 48.38 | 1.57 | 2.7 | | | | | |
| | P5068R | 15.75 | 0.12 | 1.93 | 20.46 | 2.62 | 5.1 | | | | | |
| | P5084R | 1.44 | 0.87 | 1.25 | 10.47 | 3.59 | 4.5 | | | | | |
| | P5084L | 5.20 | 0.20 | 1.04 | 38.19 | 1.83 | 1.9 | | | | | |
| | P5084R | 1.44 | 0.87 | 1.25 | 10.47 | 3.59 | 4.5 | | | | | |
| | | | | | | | | 48.4 | 7.88 | 1.57 | 12.4 | |

Notes:

1 $I = \frac{28.5 * P1}{(10 * T_d)^{0.786}}$ USDCM Equation 5-1, (March 2017) where P Values come from NOAA Atlas 2, Volume 8, Version 2 and Td = Tc USDCM Chapter 6 Section 2.5 (August 2018)

2 $Q_{tot} = I_{min}\left[\sum_{i=0}^{n}(CA)_i\right]$ Where: $I_{min}$ = Minimum Intensity and CA = Effective CA

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Originator ZDS/TPS
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STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE)
100-YEAR STORM EVENT

| DESIGN POINT | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASIN ID | AREA (acres) | $C_{100}$ | CA (acres) | $T_c$ (min) | $I_{100}$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_{100}$ | $I_{100}$ (in/hr) | Q (cfs) | |
| P1017L | P1013R | 1.54 | 0.69 | 1.06 | 20.83 | 5.20 | 5.5 | | | | | |
| | P1016L | 8.85 | 0.48 | 4.22 | 36.92 | 3.74 | 15.8 | | | | | |
| | | | | | | | | 36.9 | 5.28 | 3.74 | 19.7 | |
| | P1017L | 0.71 | 0.67 | 0.47 | 6.32 | 8.57 | 4.1 | | | | | |
| | | | | | | | | 36.9 | 5.76 | 3.74 | 21.5 | |
| P1018L | P1021RA | 0.28 | 0.89 | 0.25 | 5.46 | 8.94 | 2.2 | | | | | |
| | P1021R | 0.64 | 0.68 | 0.44 | 12.17 | 6.74 | 2.9 | | | | | |
| | P1018L | 1.27 | 0.53 | 0.67 | 14.08 | 6.31 | 4.3 | | | | | |
| | | | | | | | | 14.1 | 1.36 | 6.31 | 8.6 | |
| P1030R | P1029L | 99.22 | 0.57 | 56.87 | 71.79 | 2.41 | 137.3 | | | | | |
| | P1029R | 1.42 | 0.72 | 1.02 | 17.68 | 5.66 | 5.8 | | | | | |
| | P1030R | 0.76 | 0.49 | 0.38 | 26.47 | 4.56 | 1.7 | | | | | |
| | P1031L | 1.04 | 0.69 | 0.71 | 12.29 | 6.71 | 4.8 | | | | | |
| | P1031R | 0.74 | 0.67 | 0.50 | 5.00 | 9.16 | 4.6 | | | | | |
| | P1032R | 0.26 | 0.49 | 0.13 | 11.65 | 6.86 | 0.9 | | | | | |
| | | | | | | | | 71.8 | 59.61 | 2.41 | 143.9 | |
| P1044R | P1043R | 1.09 | 0.54 | 0.59 | 19.74 | 5.35 | 3.2 | | | | | |
| | P1044L | 2.33 | 0.50 | 1.18 | 17.69 | 5.66 | 6.7 | | | | | |
| | | | | | | | | 19.7 | 1.77 | 5.35 | 9.4 | |
| P1056L | Mobility Hub Jay Road Inlet | 0.44 | 0.89 | 0.39 | 8.32 | 7.83 | 3.1 | | | | | |
| | P1048L | 1.20 | 0.57 | 0.69 | 5.47 | 8.94 | 6.1 | | | | | |
| | P1053L | 2.12 | 0.78 | 1.65 | 21.70 | 5.09 | 8.4 | | | | | |
| | P1054R | 2.33 | 0.60 | 1.40 | 21.29 | 5.14 | 7.2 | | | | | |
| | P1056L | 1.17 | 0.62 | 0.72 | 9.02 | 7.60 | 5.5 | | | | | |
| | | | | | | | | 21.7 | 4.84 | 5.09 | 24.6 | |
| P1069R | Mobility Hub Jay Road Inlet | 0.44 | 0.89 | 0.39 | 8.32 | 7.83 | 3.1 | | | | | |
| | P1048L | 1.20 | 0.57 | 0.69 | 5.47 | 8.94 | 6.1 | | | | | |
| | P1053L | 2.12 | 0.78 | 1.65 | 21.70 | 5.09 | 8.4 | | | | | |
| | P1054R | 2.33 | 0.60 | 1.40 | 21.29 | 5.14 | 7.2 | | | | | |
| | P1056L | 1.17 | 0.62 | 0.72 | 9.02 | 7.60 | 5.5 | | | | | |
| | P1057L | 0.29 | 0.57 | 0.16 | 11.71 | 6.85 | 1.1 | | | | | |
| | P1067L | 2.85 | 0.53 | 1.51 | 25.80 | 4.62 | 7.0 | | | | | |
| | P1063R | 0.92 | 0.50 | 0.46 | 23.32 | 4.89 | 2.2 | | | | | |
| | P1069R | 1.28 | 0.52 | 0.66 | 12.27 | 6.71 | 4.4 | | | | | |
| | | | | | | | | 25.8 | 7.64 | 4.62 | 35.3 | |
| P1082L | P1076L | 1.06 | 0.51 | 0.54 | 16.92 | 2.89 | 1.6 | | | | | |
| | P1077R | 1.85 | 0.52 | 0.96 | 29.17 | 2.15 | 2.1 | | | | | |
| | P1080R | 1.59 | 0.52 | 0.83 | 19.76 | 2.67 | 2.2 | | | | | |
| | P1082L | 1.70 | 0.69 | 1.17 | 14.80 | 3.08 | 3.6 | | | | | |
| | | | | | | | | 29.2 | 3.50 | 2.15 | 7.5 | |
| P2022R | P2021L | 7.83 | 0.52 | 4.07 | 103.10 | 1.87 | 7.6 | | | | | |
| | P2022L | 0.07 | 0.49 | 0.03 | 10.00 | 7.30 | 0.2 | | | | | |
| | P2022R | 3.00 | 0.56 | 1.67 | 48.98 | 3.12 | 5.2 | | | | | |
| | | | | | | | | 103.1 | 5.77 | 1.87 | 10.8 | |
| P2031R | P2030L | 1.18 | 0.50 | 0.60 | 27.21 | 4.48 | 2.7 | | | | | |
| | P2031R | 2.36 | 0.55 | 1.29 | 19.50 | 5.38 | 7.0 | | | | | |
| | P2032L | 0.12 | 0.50 | 0.06 | 10.00 | 7.30 | 0.4 | | | | | |
| | | | | | | | | 27.2 | 1.95 | 4.48 | 8.7 | |

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Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE)
100-YEAR STORM EVENT

| DESIGN POINT | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASIN ID | AREA (acres) | $C_{100}$ | CA (acres) | $T_c$ (min) | $I_{100}$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_{100}$ | $I_{100}$ (in/hr) | Q (cfs) | |
| P2059R | P2058L | 0.53 | 0.49 | 0.26 | 25.54 | 4.65 | 1.2 | | | | | |
| | P2049L | 1.75 | 0.50 | 0.87 | 37.82 | 3.68 | 3.2 | | | | | |
| | P2059R | 9.82 | 0.57 | 5.61 | 48.04 | 3.16 | 17.7 | | | | | |
| | P2062L | 1.13 | 0.86 | 0.97 | 5.00 | 9.16 | 8.9 | | | | | |
| | | | | | | | | 48.0 | 7.71 | 3.16 | 24.4 | |
| P2064R | P2063R | 0.23 | 0.68 | 0.16 | 5.51 | 8.92 | 1.4 | | | | | |
| | P2064R | 2.43 | 0.60 | 1.46 | 11.93 | 6.79 | 9.9 | | | | | |
| | P2066R | 2.26 | 0.60 | 1.36 | 16.96 | 5.78 | 7.9 | | | | | |
| | | | | | | | | 17.0 | 2.99 | 5.78 | 17.3 | |
| P2079L | P2075L | 0.58 | 0.50 | 0.29 | 16.39 | 5.88 | 1.7 | | | | | |
| | P2077L | 0.37 | 0.56 | 0.21 | 10.32 | 7.21 | 1.5 | | | | | |
| | P2079L | 1.73 | 0.59 | 1.03 | 24.63 | 4.75 | 4.9 | | | | | |
| | | | | | | | | 24.6 | 1.53 | 4.75 | 7.2 | |
| P2085R | P2084L | 0.80 | 0.51 | 0.41 | 16.69 | 5.82 | 2.4 | | | | | |
| | P2085R | 2.57 | 0.59 | 1.51 | 21.91 | 5.06 | 7.6 | | | | | |
| | | | | | | | | 21.9 | 1.92 | 5.06 | 9.7 | |
| P2085L | P2085L | 2.32 | 0.56 | 1.30 | 34.85 | 3.87 | 5.0 | | | | | |
| | P2092R | 0.39 | 0.63 | 0.25 | 9.19 | 7.55 | 1.9 | | | | | |
| | P2093R | 1.69 | 0.55 | 0.92 | 25.05 | 4.70 | 4.3 | | | | | |
| | P2098R | 0.38 | 0.56 | 0.21 | 12.82 | 6.59 | 1.4 | | | | | |
| | P2100R | 3.11 | 0.55 | 1.71 | 29.70 | 4.26 | 7.3 | | | | | |
| | P2100L | 1.09 | 0.52 | 0.56 | 27.81 | 4.43 | 2.5 | | | | | |
| | | | | | | | | 34.8 | 4.95 | 3.87 | 19.2 | |
| P3049R | P3049L | 1.47 | 0.64 | 0.94 | 19.12 | 5.44 | 5.1 | | | | | |
| | P3049R | 2.24 | 0.64 | 1.44 | 22.17 | 5.03 | 7.2 | | | | | |
| | | | | | | | | 22.2 | 2.37 | 5.03 | 11.9 | |
| P4028R | P4021R | 0.35 | 0.82 | 0.28 | 6.78 | 8.38 | 2.4 | | | | | |
| | P4023R | 3.48 | 0.84 | 2.93 | 9.00 | 7.61 | 22.3 | | | | | |
| | P4028L | 0.63 | 0.74 | 0.47 | 15.04 | 6.12 | 2.9 | | | | | |
| | P4028R | 2.05 | 0.52 | 1.06 | 23.43 | 4.88 | 5.2 | | | | | |
| | | | | | | | | 23.4 | 4.75 | 4.88 | 23.2 | |
| P4044R | P4021R | 0.35 | 0.82 | 0.28 | 6.78 | 8.38 | 2.4 | | | | | |
| | P4023R | 3.48 | 0.84 | 2.93 | 9.00 | 7.61 | 22.3 | | | | | |
| | P4028L | 0.63 | 0.74 | 0.47 | 15.04 | 6.12 | 2.9 | | | | | |
| | P4028R | 2.05 | 0.52 | 1.06 | 23.43 | 4.88 | 5.2 | | | | | |
| | P4040L | 1.46 | 0.49 | 0.72 | 35.25 | 3.85 | 2.8 | | | | | |
| | P4044R | 5.31 | 0.54 | 2.84 | 47.74 | 3.17 | 9.0 | | | | | |
| | | | | | | | | 47.7 | 8.31 | 3.17 | 26.4 | |
| P4054R | P4053L | 1.86 | 0.49 | 0.92 | 38.02 | 3.67 | 3.4 | | | | | |
| | P4054R | 3.13 | 0.60 | 1.86 | 30.03 | 4.23 | 7.9 | | | | | |
| | | | | | | | | 38.0 | 2.78 | 3.67 | 10.2 | |
| P4065R | P4060L | 1.21 | 0.49 | 0.60 | 47.70 | 3.18 | 1.9 | | | | | |
| | P4065R | 3.29 | 0.60 | 1.97 | 28.44 | 4.37 | 8.6 | | | | | |
| | | | | | | | | 47.7 | 2.57 | 3.18 | 8.2 | |
| P4076L | P4074R | 2.84 | 0.61 | 1.73 | 34.03 | 3.93 | 6.8 | | | | | |
| | P4076L | 0.09 | 0.57 | 0.05 | 10.00 | 7.30 | 0.4 | | | | | |
| | | | | | | | | 34.0 | 1.78 | 3.93 | 7.0 | |
| P4081L | P4081R | 1.63 | 0.62 | 1.02 | 27.86 | 4.42 | 4.5 | | | | | |
| | P4081L | 1.32 | 0.54 | 0.72 | 21.36 | 5.13 | 3.7 | | | | | |
| | | | | | | | | 27.9 | 1.73 | 4.42 | 7.7 | |
| P4087L | P4086R | 1.61 | 0.61 | 0.98 | 22.53 | 4.98 | 4.9 | | | | | |
| | P4087L | 1.38 | 0.56 | 0.77 | 16.10 | 5.93 | 4.5 | | | | | |
| | | | | | | | | 22.5 | 1.75 | 4.98 | 8.7 | |
| P4091L | P4091R | 1.01 | 0.58 | 0.59 | 16.15 | 5.92 | 3.5 | | | | | |
| | P4091L | 1.39 | 0.69 | 0.97 | 16.22 | 5.90 | 5.7 | | | | | |
| | | | | | | | | 16.2 | 1.56 | 5.90 | 9.2 | |

CO 119 Bikeway
Proposed Hydrology Calculations - Rational Method
Muller Engineering Company, Inc.
Muller Project Number: 21015

Originator ZDS/TPS
Date: 6/24/2022
Checker: EGS
Date: 6/28/2022

STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE)
100-YEAR STORM EVENT

| DESIGN POINT | DIRECT RUNOFF FROM BASIN | | | | | | | TOTAL RUNOFF | | | | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASIN ID | AREA (acres) | $C_{100}$ | CA (acres) | $T_c$ (min) | $I_{100}$ (in/hr) | Q (cfs) | $T_c$ (min) | Effective $CA_{100}$ | $I_{100}$ (in/hr) | Q (cfs) | |
| P4095R | P4093L | 0.46 | 0.69 | 0.32 | 10.18 | 7.25 | 2.3 | | | | | |
| | P4095R | 0.45 | 0.67 | 0.31 | 14.95 | 6.14 | 1.9 | | | | | |
| | | | | | | | | 14.9 | 0.62 | 6.14 | 3.8 | |
| P4114L | P4108R | 3.91 | 0.60 | 2.32 | 39.46 | 3.59 | 8.3 | | | | | |
| | P4114L | 3.63 | 0.53 | 1.92 | 46.02 | 3.25 | 6.2 | | | | | |
| | | | | | | | | 46.0 | 4.24 | 3.25 | 13.8 | |
| P5001L | P4117R | 2.27 | 0.64 | 1.45 | 33.33 | 3.98 | 5.8 | | | | | |
| | P5001L | 2.27 | 0.53 | 1.21 | 29.81 | 4.25 | 5.1 | | | | | |
| | | | | | | | | 33.3 | 2.66 | 3.98 | 10.6 | |
| P5006R | P5006R | 1.44 | 0.61 | 0.88 | 15.75 | 5.99 | 5.3 | | | | | |
| | P5007R | 0.10 | 0.68 | 0.07 | 5.16 | 9.08 | 0.6 | | | | | |
| | | | | | | | | 15.7 | 0.95 | 5.99 | 5.7 | |
| P5011L | P5011R | 2.28 | 0.55 | 1.25 | 26.28 | 4.57 | 5.7 | | | | | |
| | P5011L | 5.52 | 0.57 | 3.15 | 43.04 | 3.39 | 10.7 | | | | | |
| | | | | | | | | 43.0 | 4.41 | 3.39 | 15.0 | |
| P5023R | P5023L | 1.17 | 0.45 | 0.52 | 38.80 | 3.62 | 1.9 | | | | | |
| | P5023R | 5.73 | 0.39 | 2.22 | 56.15 | 2.85 | 6.3 | | | | | |
| | | | | | | | | 56.2 | 2.74 | 2.85 | 7.8 | |
| P5033R | P5030L | 3.02 | 0.16 | 0.50 | 33.83 | 3.94 | 2.0 | | | | | |
| | P5033R | 4.16 | 0.27 | 1.14 | 19.29 | 5.41 | 6.2 | | | | | |
| | | | | | | | | 33.8 | 1.64 | 3.94 | 6.5 | |
| P5041R | P5040L | 0.89 | 0.14 | 0.12 | 25.07 | 4.70 | 0.6 | | | | | |
| | P5041R | 0.93 | 0.42 | 0.39 | 17.44 | 5.70 | 2.2 | | | | | |
| | | | | | | | | 25.1 | 0.52 | 4.70 | 2.4 | |
| P5048R | P5048L | 1.12 | 0.13 | 0.14 | 38.83 | 3.62 | 0.5 | | | | | |
| | P5048R | 2.60 | 0.45 | 1.16 | 21.56 | 5.10 | 5.9 | | | | | |
| | | | | | | | | 38.8 | 1.30 | 3.62 | 4.7 | |
| P5068R | P5052L | 1.99 | 0.60 | 1.20 | 23.66 | 4.85 | 5.8 | | | | | |
| | P5066L | 8.08 | 0.52 | 4.17 | 48.38 | 3.15 | 13.1 | | | | | |
| | P5068R | 15.75 | 0.46 | 7.31 | 20.46 | 5.25 | 38.4 | | | | | |
| | P5084R | 1.44 | 0.90 | 1.29 | 10.47 | 7.17 | 9.2 | | | | | |
| | P5084L | 5.20 | 0.52 | 2.71 | 38.19 | 3.66 | 9.9 | | | | | |
| | P5084R | 1.44 | 0.90 | 1.29 | 10.47 | 7.17 | 9.2 | | | | | |
| | | | | | | | | 48.4 | 17.97 | 3.15 | 56.6 | |

Notes:

1 $I = \frac{28.5 * P1}{(10 * T_d)^{0.786}}$ USDCM Equation 5-1, (March 2017) where P Values come from NOAA Atlas 2, Volume 8, Version 2 and Td = Tc USDCM Chapter 6 Section 2.5 (August 2018)

2 $Q_{tot} = I_{min}\left[\sum_{i=0}^{n}(CA)_i\right]$ Where: $I_{min}$ = Minimum Intensity and CA = Effective CA

# APPENDIX C

## Hydraulics

Proposed Hydraulics Calculations

# CALCULATION COVER SHEET

| Project Name: | CO 119 Bikeway | Project No. | 21015 (Muller) |
|---|---|---|---|
| Design Calculation: | Proposed Hydraulics | Version: | 1 |
| Originator | ZDS | Date: | June 23, 2022 |
| Checker | EGS | Date: | June 24, 2022 |

Purpose:
Determine if proposed ditches, inlets, and pipes have sufficient capacity and meet criteria for the CO 119 Bikeway project.

References:

Criteria Manuals Used:

Colorado Department of Transportation (CDOT) *Drainage Design Manual,* 2019
Boulder County *Multimodal Transportation Standards (MTS)*, 2012
Boulder County *Storm Drainage Criteria Manual (SDCM)*, 2016

Referenced Data Sources:
Proposed OpenRoads Designer Model, Otak Inc.
Proposed OpenRoads Designer Model, Muller Engineering Company
Boulder County, *LiDAR*, Accessed January 2022
Colorado Department of Transportation*, Drainage Design Manual,* 2019

Software Used:
Bentley FlowMaster V8i (SELECTseries 1), *Bentley Systems Inc*., November 2009
Bentely OpenRoads Designer CE 2021, *Bentley Systems Inc*.
MHFD v5.01, Mile High Flood District. April 2021

Refer to the drainage report for the appendices referenced below:
Appendix A
Hydrologic and Hydraulic Criteria Table
Proposed Basin Maps

Appendix B
Proposed Hydrology Calculation Packet

Criteria:

The ditches for the proposed project have been designed to meet CDOT and Boulder County Criteria. For this project, the 5-year event was used as the design storm for pipes and inlets, the 10-year event was used as the design storm for ditches, and the 100-year event was the major storm. Refer to the Hydrologic and Hydraulic Criteria Tables in Appendix A of the Drainage Report for the complete criteria list.

Background and Rationale:

- Ditches
    - Preliminary stage ditch sizing calculations presented in this calculation packet estimate the required depth of proposed ditches. These calculations use one set of average or representative parameters (longitudinal slope, Manning's roughness coefficient, and ditch geometry) which have been applied to estimate the required depth of all proposed ditches.
        - The longitudinal slope used is 0.01
        - The Manning's roughness coefficient used is 0.035
            - Represents a grass-lined ditch
        - The ditch geometry used is a V-ditch with 3:1 (H:V) side slopes
            - Taken from the proposed bikeway typical section
        - The peak flowrates of basins computed in the *Proposed Hydrology Calculation Packet* were compared to the FlowMaster outputs computed above to estimate the appropriate ditch depth. The average 10-year peak flowrate within a basin is 1.7 cfs. The average 100-year peak basin flowrate is 6.5 cfs.
    - Final stage ditch size calculations will include detailed freeboard, Froude Number, velocity, and capacity calculations on an individual basis for all proposed and existing ditches.
- Inlets
    - Two categories of proposed inlets were analyzed: Type C inlets at upstream end of bikeway crossing pipes and Type 13 inlets located at bikeway underpasses.
        1. Type C inlets at upstream end of bikeway crossing pipes
            a. The capacity of Type C inlets placed at the upstream end of pipes crossing the bikeway were analyzed using nomograph data. Please refer to the attachments for detailed information.
                i. A 1' ponding depth was assumed. Constructing a 1' ponding area appears to be feasible with the bikeway design.
            b. The capacity result was compared to 5-year and 100-year peak flowrate for basins with a Type C inlet at the outlet of the basin to determine if a Type C inlet has sufficient capacity to intercept flow.
            c. Three representative locations were used in the analysis (please refer to the Proposed Hydrology Calculation Packet for more information on basin flowrates):
                i. P1063R, P2049L, P4117R.
                    1. Avg. 5-year basin flowrate = 0.5 cfs
                    2. Max. 5-year basin flowrate = 1.0 cfs
                    3. Avg. 100-year basin flowrate = 3.0 cfs
                    4. Max 100-year basin flowrate = 3.7 cfs
        2. Type 13 inlets at bikeway underpasses
            a. Type 13 valley grate inlets are placed at underpasses where the proposed bikeway transects an existing road. Two Type 13 inlets are located in a sump at the lowest point of the underpass and two Type 13 inlets are located on-grade.

b. The inlets at the 63rd St underpass (I2063L, I2063R, I2065L, and I2065R) were analyzed. The 63rd St underpass is relatively representative of all underpasses.
    a. Inlets I2063L and I2063R are in sump condition.
    b. Inlets I2065L and I2065R are on grade.
    c. The 5-year and 100-year flowrates from basin P2066R were assigned to each inlet as appropriate. Please refer to the *Proposed Hydrology Calculation Packet* for more information.
c. The allowable spread width for the minor storm was assigned as the shoulder.
d. The allowable spread width for the major storm was assigned as the shoulder plus bikeway lane.
    i. Per the underpass typical section, there is a 2 ft shoulder and a 12 ft bikeway path.
e. The capacity result was compared to 5-year and 100-year peak flowrate for basins with a Type 13 inlet at the outlet of the basin to determine if a Type 13 inlet has sufficient capacity to intercept flow.

- Pipes
    - Two categories of proposed pipes were analyzed: 1) Pipe networks at bikeway underpasses 2) Single crossing pipes under bikeway.
        1. Pipe networks at bikeway underpasses
            a. Proposed 15" plastic pipes will convey flow from inlets at the bikeway underpasses to a proposed pump station which will return flow to the ground surface.
            b. A complete design and analysis of proposed pump stations will be completed with final design.
            c. At the preliminary stage, the 15" plastic pipes which drain by gravity were analyzed. Pump characteristics are preliminary.
            d. OpenRoads Designer Drainage and Utilities functions were used to analyze proposed pipe networks.
                i. The system at the proposed 63rd Street was analyzed. This underpass is representative of all other underpass locations in terms of receiving flowrate and pipe network design.
                ii. The StormCAD unlimited license was used for computations.
                iii. 5-year and 100-year flowrates to the system were taken from *Proposed Hydrology Calculation Packet* from Basins P2063R and P2066R. Flowrates were applied to inlets I2063L, I2063R, I2065L, and I2065R. Capture efficiency of inlets was ignored as a conservative estimate for pipe calculations. Please refer to the attachments for a schematic showing the layout of the system.
        2. Single crossing pipes under bikeway.
            a. The standard method of conveying flow across the proposed bikeway at a low-point or existing ditch crossing is via an 18" RCP.

b. Bentley FlowMaster was used to evaluate the capacity of an 18” RCP.
c. The capacity result was compared to the 5-year and 100-year peak flowrates of eight representative basins with an 18” RCP at the basin outlet to determine if an 18” RCP is sufficient.
d. The following parameters were used for the Bentley FlowMaster calculation:
   i. Manning’s n = 0.013
   ii. Pipe Slope = 1%
e. The following basins were used in the analysis (please refer to the *Proposed Hydrology Calculation Packet* for more information on basin flowrates):
   i. P1043R, P1053L, P2049L, P4040L, P4060L, P4093L, P4108R.
      1. Avg. 5-year basin flowrate = 1.1 cfs
      2. Max. 5-year basin flowrate = 3.5 cfs
      3. Avg. 100-year basin flowrate = 4.6 cfs
      4. Max 100-year basin flowrate = 8.4 cfs

Results:

<u>Ditches</u>

The resulting FlowMaster outputs are:

- A 6” ditch has capacity for 1.2 cfs
- A 12” ditch has capacity for 7.8 cfs
- A 18” ditch has capacity for 22.8 cfs

Please refer to the attachments for detailed FlowMaster calculation reports.

Therefore, a 6” ditch is generally sufficient for conveying the 10-year event for a wide range of basins. A 12” ditch is sufficient for conveying the 10-year and 100-year events for the majority of basins.

<u>Inlets</u>

<u>Type C inlets:</u>

The capacity of a Type C inlet with 1’ of ponding depth is 12.5 cfs per the CDOT nomograph. Therefore, a Type C inlet is generally sufficient for capturing the design flowrate.

<u>Type 13 inlets:</u>

MHFD Inlet results show a Type 13 inlet does not have sufficient capture capacity as currently designed. Underpass inlet design will be reevaluated with the final design. Final design will likely include double Type 13 inlets (instead of singles) and trench drains which are not represented in these calculations. Please refer to Table 2 below for results summary.

*Table 2. Inlet Results Summary*

| Inlet ID | Inlet Type | Minor Storm: 5-year | | | | | Major Storm: 100-year | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Design Flow (cfs) | Capture % | Bypass Flow (cfs) | Captured Flow (cfs) | Spread or Depth Criteria Violated? | Design Flow (cfs) | Capture % | Bypass Flow (cfs) | Captured Flow (cfs) | Spread or Depth Criteria Violated? |
| I2063L and I2063R | Type 13 Valley | 1.0 | N/A | | 1.0 | Yes, spread = 5.5 ft | 4.0 | N/A | | 4.0 | No |
| I2065L and I2065R | Type 13 Valley | 1.0 | 66% | 0.3 | 0.7 | Yes | 4.0 | 49% | 2.1 | 1.9 | No |

<u>Pipes</u>

<u>Underpass storm network:</u>

The 5-year HGL is contained within the system upstream of the pump. The 100-year HGL is not contained within pipe S2065L upstream of the pump. Please refer to the attachments for a profile view of the 5-year and 100-year HGL. The profile view extends from I2065L to the Flared End-Section at the ground surface. Table 3 shows velocity and flow depth results for the 5-year event. Table 4 shows velocity and flow depth results for the 100-year event.

*Table 3. 5-Year Underpass Storm Network Results*

| Label | Flow (cfs) | Velocity (ft/s) | Hydraulic Grade Line (In) (ft) | Hydraulic Grade Line (Out) (ft) | Depth (In) (ft) | Depth (Out) (ft) |
|---|---|---|---|---|---|---|
| Pr. S2065L 15" | 1.0 | 7.2 | 5,140.43 | 5,139.19 | 0.39 | 0.76 |
| Pr. S2063L 15" | 0.25 | 2.87 | 5,139.28 | 5,139.27 | 0.19 | 0.57 |
| Pr. S2063R 15" | 0.5 | 1.23 | 5,139.26 | 5,139.19 | 0.57 | 0.76 |
| Pr. S2065R 15" | 2.5 | 10.1 | 5,139.07 | 5,137.35 | 0.63 | 0.34 |

*Table 4. 100-Year Underpass Storm Network Results*

| Label | Flow (cfs) | Velocity (ft/s) | Hydraulic Grade Line (In) (ft) | Hydraulic Grade Line (Out) (ft) | Depth (In) (ft) | Depth (Out) (ft) |
|---|---|---|---|---|---|---|
| Pr. S2065L 15" | 4 | 10.74 | 5,140.85 | 5,140.08 | 0.81 | 1.65 |
| Pr. S2063L 15" | 0.7 | 3.89 | 5,140.27 | 5,140.26 | 1.18 | 1.57 |
| Pr. S2063R 15" | 1.4 | 1.14 | 5,140.25 | 5,140.08 | 1.56 | 1.65 |
| Pr. S2065R 15" | 9.4 | 13.78 | 5,139.60 | 5,137.80 | 1.17 | 0.79 |

<u>Standard bikeway crossing pipes:</u>

The capacity of an 18" RCP is 10.5 cfs. Please refer to the attachments for a detailed FlowMaster calculation report.

The capacity of 10.5 cfs indicates that an 18” RCP is sufficient for conveying the 5-year and 100-year design flowrates.

Materials Included in this Calculation Packet:

1. Ditches - FlowMaster Ditch Results
2. Inlets - CDOT Nomagraph
3. Inlets - MHFD Inlet Results
4. Pipes – Underpass storm network layout schematic
5. Pipes – OpenRoads Designer HGL Profiles
6. Pipes – FlowMaster 18” RCP Results

# FlowMaster Ditch Results

# Worksheet for 6 in. V Ditch Check

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.035 | |
| Channel Slope | 0.01000 | ft/ft |
| Normal Depth | 0.50 | ft |
| Left Side Slope | 3.00 | ft/ft (H:V) |
| Right Side Slope | 3.00 | ft/ft (H:V) |

## Results

| | | |
|---|---|---|
| Discharge | 1.22 | ft³/s |
| Flow Area | 0.75 | ft² |
| Wetted Perimeter | 3.16 | ft |
| Hydraulic Radius | 0.24 | ft |
| Top Width | 3.00 | ft |
| Critical Depth | 0.40 | ft |
| Critical Slope | 0.03274 | ft/ft |
| Velocity | 1.63 | ft/s |
| Velocity Head | 0.04 | ft |
| Specific Energy | 0.54 | ft |
| Froude Number | 0.57 | |
| Flow Type | Subcritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Downstream Velocity | Infinity | ft/s |
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 0.50 | ft |
| Critical Depth | 0.40 | ft |
| Channel Slope | 0.01000 | ft/ft |
| Critical Slope | 0.03274 | ft/ft |

# Worksheet for 12 in. V Ditch Check

## Project Description

| | | |
|---|---|---|
| Friction Method | Manning Formula | |
| Solve For | Discharge | |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.035 | |
| Channel Slope | 0.01000 | ft/ft |
| Normal Depth | 1.00 | ft |
| Left Side Slope | 3.00 | ft/ft (H:V) |
| Right Side Slope | 3.00 | ft/ft (H:V) |

## Results

| | | |
|---|---|---|
| Discharge | 7.75 | $ft^3/s$ |
| Flow Area | 3.00 | $ft^2$ |
| Wetted Perimeter | 6.32 | ft |
| Hydraulic Radius | 0.47 | ft |
| Top Width | 6.00 | ft |
| Critical Depth | 0.84 | ft |
| Critical Slope | 0.02559 | ft/ft |
| Velocity | 2.58 | ft/s |
| Velocity Head | 0.10 | ft |
| Specific Energy | 1.10 | ft |
| Froude Number | 0.64 | |
| Flow Type | Subcritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Downstream Velocity | Infinity | ft/s |
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 1.00 | ft |
| Critical Depth | 0.84 | ft |
| Channel Slope | 0.01000 | ft/ft |
| Critical Slope | 0.02559 | ft/ft |

# Worksheet for 18 in. V Ditch Check

## Project Description

| | | | |
|---|---|---|---|
| Friction Method | Manning Formula | | |
| Solve For | Discharge | | |

## Input Data

| | | | |
|---|---|---|---|
| Roughness Coefficient | | 0.035 | |
| Channel Slope | | 0.01000 | ft/ft |
| Normal Depth | | 1.50 | ft |
| Left Side Slope | | 3.00 | ft/ft (H:V) |
| Right Side Slope | | 3.00 | ft/ft (H:V) |

## Results

| | | | |
|---|---|---|---|
| Discharge | | 22.84 | $ft^3/s$ |
| Flow Area | | 6.75 | $ft^2$ |
| Wetted Perimeter | | 9.49 | ft |
| Hydraulic Radius | | 0.71 | ft |
| Top Width | | 9.00 | ft |
| Critical Depth | | 1.29 | ft |
| Critical Slope | | 0.02215 | ft/ft |
| Velocity | | 3.38 | ft/s |
| Velocity Head | | 0.18 | ft |
| Specific Energy | | 1.68 | ft |
| Froude Number | | 0.69 | |
| Flow Type | Subcritical | | |

## GVF Input Data

| | | | |
|---|---|---|---|
| Downstream Depth | | 0.00 | ft |
| Length | | 0.00 | ft |
| Number Of Steps | | 0 | |

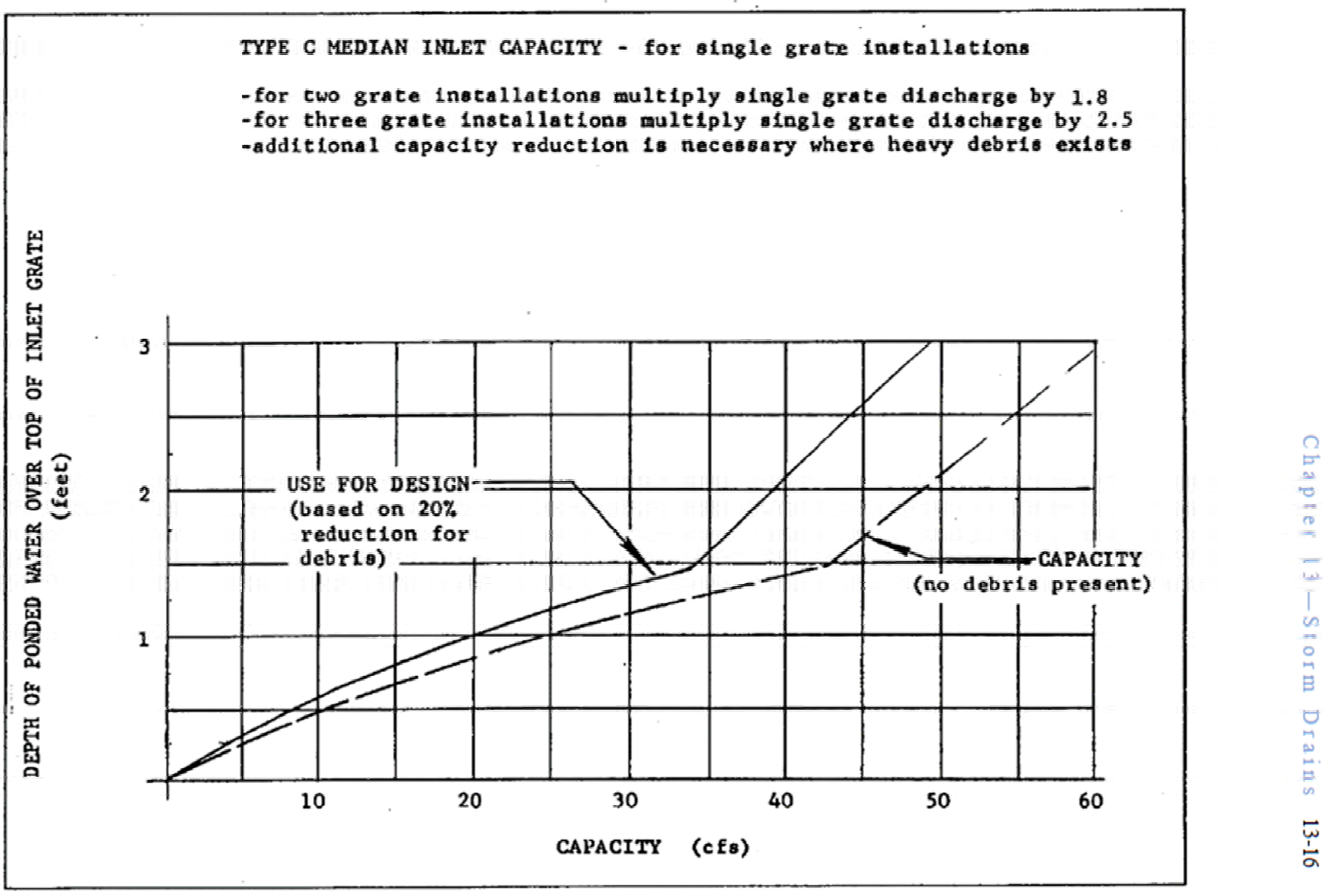
## GVF Output Data

| | | | |
|---|---|---|---|
| Upstream Depth | | 0.00 | ft |
| Profile Description | | | |
| Profile Headloss | | 0.00 | ft |
| Downstream Velocity | | Infinity | ft/s |
| Upstream Velocity | | Infinity | ft/s |
| Normal Depth | | 1.50 | ft |
| Critical Depth | | 1.29 | ft |
| Channel Slope | | 0.01000 | ft/ft |
| Critical Slope | | 0.02215 | ft/ft |

# CDOT Nomograph

| | | | |
|---|---|---|---|
| **SH 119 Bikeway** | | | |
| **Type C/D Area Inlet Capacity Calculations** | | **By:** | **ZDS** |
| **Muller Engineering Company, Inc.** | | **Date:** | **6/23/2022** |
| **CDOT Project Number:** | **None** | **CHECKED BY:** | |
| **Muller Project Number:** | | **DATE:** | |

**CDOT Drainage Design Manual (2019) Chapter 13 Appendix A: Design Nomograph 13-16 for Type C/D Area Inlet Capacities**




| | |
|---|---|
| Inlet Type: | Type C |
| Depth of Ponding: | 1.00 ft |
| Inlet Capacity (no clogging)[1]: | 25 cfs |
| Inlet Multiplication Factor: | 1 |
| Clogging Reduction Factor[2]: | 0.5 |
| | |
| **Inlet Design Capacity:** | **12.5 cfs** |

Notes:
1. Clogging from debris taken into consideration with the clogging reduction factor; therefore, the capacity with no debris present is used.
2. Inlet clogging factor taken from the Urban Drainage and Flood Control District "Hydraulic Capacity of CDOT Type C and D Area Inlets" Report Revised March 5, 2012.

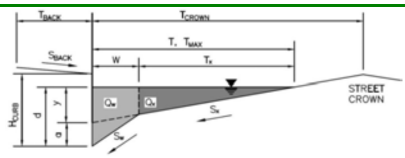
# MHFD Inlet

*MHFD-Inlet, Version 5.01 (April 2021)*

# ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

**(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)**

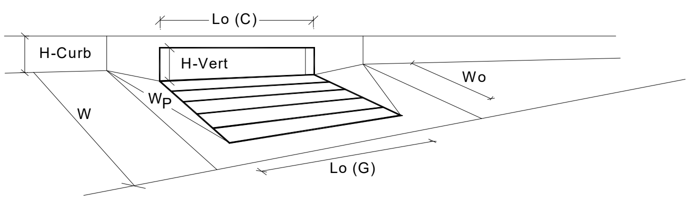
**Project:** **SH 119 Bikeway**
**Inlet ID:** **I2063R-I2063L**




| Gutter Geometry: | | | | |
|---|---|---|---|---|
| Maximum Allowable Width for Spread Behind Curb | $T_{BACK}$ = | 0.0 | | ft |
| Side Slope Behind Curb (leave blank for no conveyance credit behind curb) | $S_{BACK}$ = | | | ft/ft |
| Manning's Roughness Behind Curb (typically between 0.012 and 0.020) | $n_{BACK}$ = | | | |
| Height of Curb at Gutter Flow Line | $H_{CURB}$ = | 12.00 | | inches |
| Distance from Curb Face to Street Crown | $T_{CROWN}$ = | 14.0 | | ft |
| Gutter Width | W = | 2.00 | | ft |
| Street Transverse Slope | $S_X$ = | 0.015 | | ft/ft |
| Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft) | $S_W$ = | 0.167 | | ft/ft |
| Street Longitudinal Slope - Enter 0 for sump condition | $S_O$ = | 0.000 | | ft/ft |
| Manning's Roughness for Street Section (typically between 0.012 and 0.020) | $n_{STREET}$ = | 0.013 | | |
| | | Minor Storm | Major Storm | |
| Max. Allowable Spread for Minor & Major Storm | $T_{MAX}$ = | 2.0 | 14.0 | ft |
| Max. Allowable Depth at Gutter Flowline for Minor & Major Storm | $d_{MAX}$ = | 12.0 | 12.0 | inches |
| Check boxes are not applicable in SUMP conditions | | ☐ | ☐ | |
| | | Minor Storm | Major Storm | |
| MINOR STORM Allowable Capacity is based on Depth Criterion | | | | |
| MAJOR STORM Allowable Capacity is based on Depth Criterion | **$Q_{allow}$ =** | **SUMP** | **SUMP** | **cfs** |

# INLET IN A SUMP OR SAG LOCATION

*MHFD-Inlet, Version 5.01 (April 2021)*



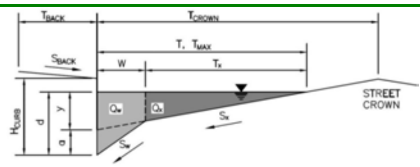

| Design Information (Input) | CDOT/Denver 13 Valley Grate | | MINOR | MAJOR | |
|---|---|---|---|---|---|
| Type of Inlet | | Type = | CDOT/Denver 13 Valley Grate | | |
| Local Depression (additional to continuous gutter depression 'a' from above) | | $a_{local}$ = | 2.00 | 2.00 | inches |
| Number of Unit Inlets (Grate or Curb Opening) | | No = | 1 | 1 | |
| Water Depth at Flowline (outside of local depression) | | Ponding Depth = | 4.0 | 6.2 | inches |
| Grate Information | | | MINOR | MAJOR | ☐ Override Depths |
| Length of a Unit Grate | | $L_o$ (G) = | 3.00 | 3.00 | feet |
| Width of a Unit Grate | | $W_o$ = | 1.73 | 1.73 | feet |
| Area Opening Ratio for a Grate (typical values 0.15-0.90) | | $A_{ratio}$ = | 0.43 | 0.43 | |
| Clogging Factor for a Single Grate (typical value 0.50 - 0.70) | | $C_f$ (G) = | 0.50 | 0.50 | |
| Grate Weir Coefficient (typical value 2.15 - 3.60) | | $C_w$ (G) = | 3.30 | 3.30 | |
| Grate Orifice Coefficient (typical value 0.60 - 0.80) | | $C_o$ (G) = | 0.60 | 0.60 | |
| Curb Opening Information | | | MINOR | MAJOR | |
| Length of a Unit Curb Opening | | $L_o$ (C) = | N/A | N/A | feet |
| Height of Vertical Curb Opening in Inches | | $H_{vert}$ = | N/A | N/A | inches |
| Height of Curb Orifice Throat in Inches | | $H_{throat}$ = | N/A | N/A | inches |
| Angle of Throat (see USDCM Figure ST-5) | | Theta = | N/A | N/A | degrees |
| Side Width for Depression Pan (typically the gutter width of 2 feet) | | $W_p$ = | N/A | N/A | feet |
| Clogging Factor for a Single Curb Opening (typical value 0.10) | | $C_f$ (C) = | N/A | N/A | |
| Curb Opening Weir Coefficient (typical value 2.3-3.7) | | $C_w$ (C) = | N/A | N/A | |
| Curb Opening Orifice Coefficient (typical value 0.60 - 0.70) | | $C_o$ (C) = | N/A | N/A | |
| Total Inlet Interception Capacity (assumes clogged condition) | | **$Q_a$ =** | **0.7** | **2.3** | **cfs** |
| **WARNING: Inlet Capacity less than Q Peak for Minor and Major Storms** | | $Q_{PEAK\ REQUIRED}$ = | 1.0 | 4.0 | cfs |

*MHFD-Inlet, Version 5.01 (April 2021)*

# ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

**(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)**

**Project: SH 119 Bikeway**
**Inlet ID: I2065L-I2065R**

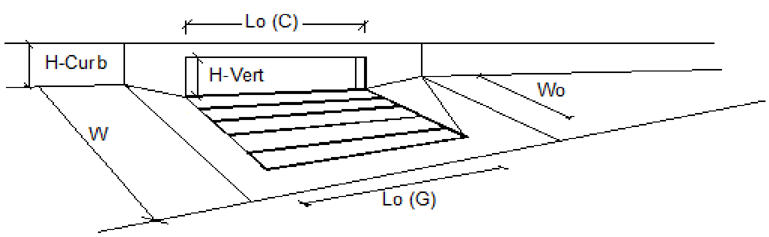



| Gutter Geometry: | | | | |
|---|---|---|---|---|
| Maximum Allowable Width for Spread Behind Curb | $T_{BACK}$ = | 0.0 | | ft |
| Side Slope Behind Curb (leave blank for no conveyance credit behind curb) | $S_{BACK}$ = | | | ft/ft |
| Manning's Roughness Behind Curb (typically between 0.012 and 0.020) | $n_{BACK}$ = | | | |
| Height of Curb at Gutter Flow Line | $H_{CURB}$ = | 12.00 | | inches |
| Distance from Curb Face to Street Crown | $T_{CROWN}$ = | 14.0 | | ft |
| Gutter Width | W = | 2.00 | | ft |
| Street Transverse Slope | $S_X$ = | 0.015 | | ft/ft |
| Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft) | $S_W$ = | 0.167 | | ft/ft |
| Street Longitudinal Slope - Enter 0 for sump condition | $S_O$ = | 0.020 | | ft/ft |
| Manning's Roughness for Street Section (typically between 0.012 and 0.020) | $n_{STREET}$ = | 0.013 | | |
| | | Minor Storm | Major Storm | |
| Max. Allowable Spread for Minor & Major Storm | $T_{MAX}$ = | 2.0 | 14.0 | ft |
| Max. Allowable Depth at Gutter Flowline for Minor & Major Storm | $d_{MAX}$ = | 12.0 | 12.0 | inches |
| Allow Flow Depth at Street Crown (check box for yes, leave blank for no) | | ☐ | ☐ | |
| | | Minor Storm | Major Storm | |
| MINOR STORM Allowable Capacity is based on Spread Criterion | | | | |
| MAJOR STORM Allowable Capacity is based on Spread Criterion | **$Q_{allow}$ =** | **2.0** | **10.0** | **cfs** |

**Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'**
**Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'**

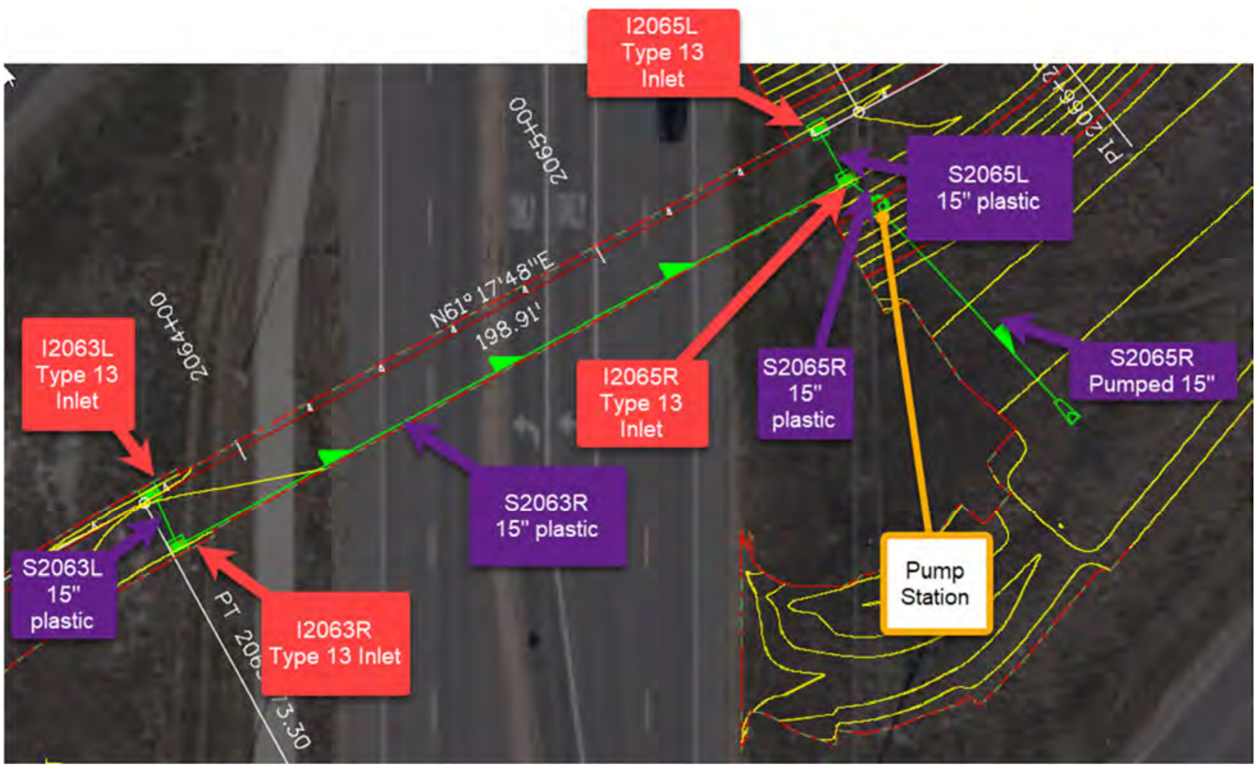
# INLET ON A CONTINUOUS GRADE

*MHFD-Inlet, Version 5.01 (April 2021)*

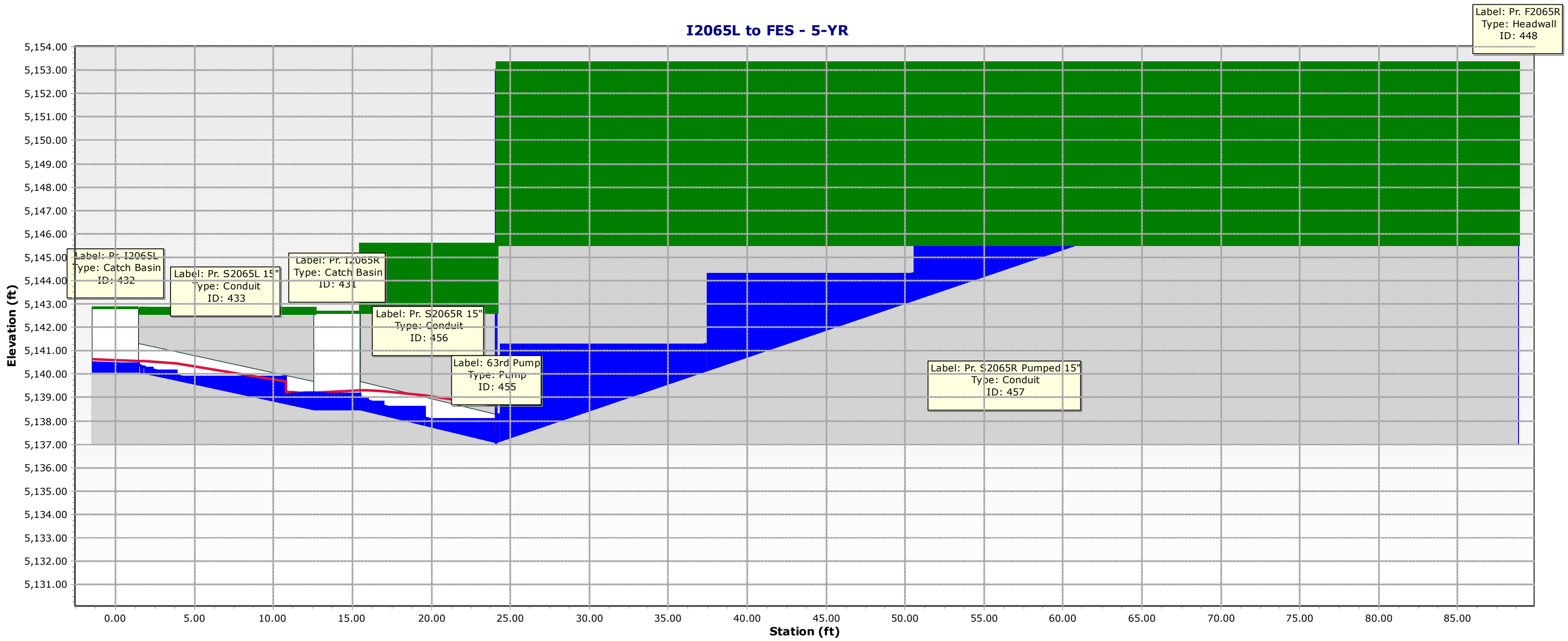


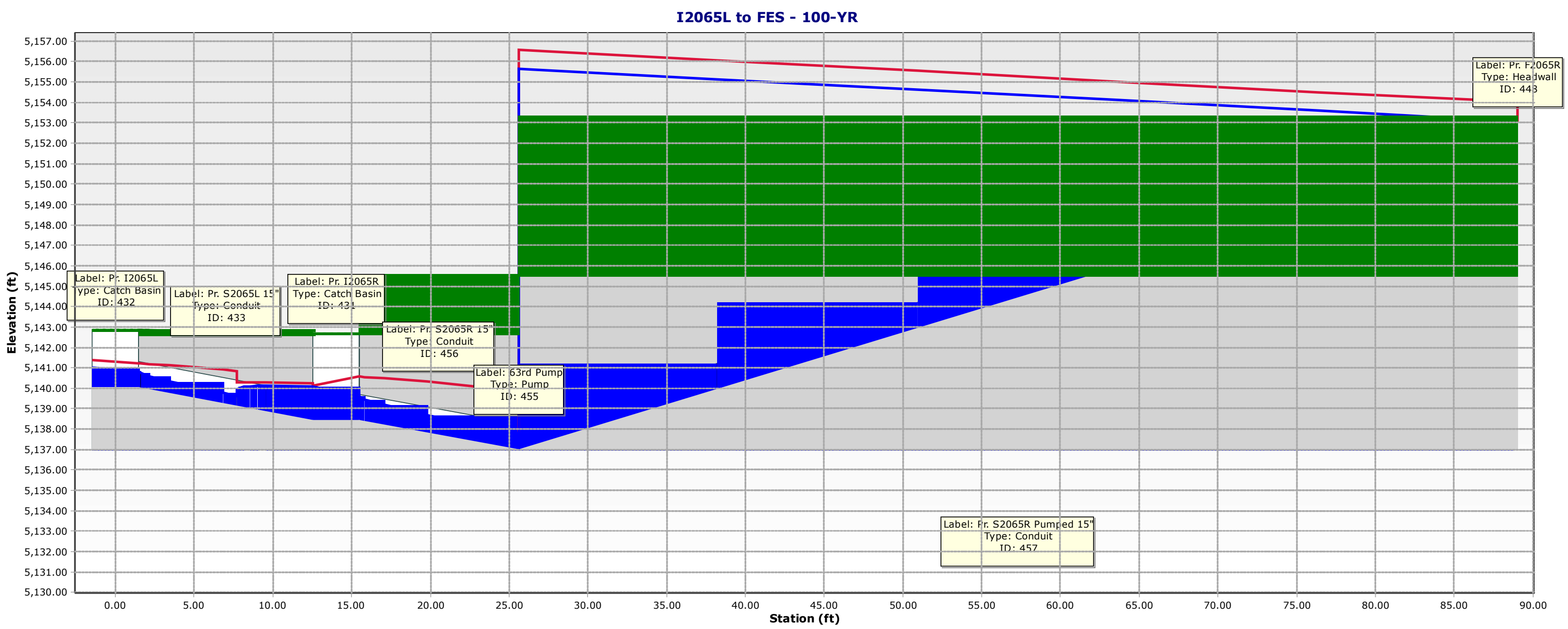

| Design Information (Input) | CDOT/Denver 13 Valley Grate | | MINOR | MAJOR | |
|---|---|---|---|---|---|
| Type of Inlet | | Type = | CDOT/Denver 13 Valley Grate | | |
| Local Depression (additional to continuous gutter depression 'a') | | $a_{LOCAL}$ = | 2.0 | 2.0 | inches |
| Total Number of Units in the Inlet (Grate or Curb Opening) | | No = | 1 | 1 | |
| Length of a Single Unit Inlet (Grate or Curb Opening) | | $L_o$ = | 3.00 | 3.00 | ft |
| Width of a Unit Grate (cannot be greater than W, Gutter Width) | | $W_o$ = | 1.73 | 1.73 | ft |
| Clogging Factor for a Single Unit Grate (typical min. value = 0.5) | | $C_f$-G = | 0.50 | 0.50 | |
| Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1) | | $C_f$-C = | N/A | N/A | |
| **Street Hydraulics: OK - Q < Allowable Street Capacity'** | | | MINOR | MAJOR | |
| Design Discharge for Half of Street (from *Inlet Management*) | | $Q_o$ = | 1.0 | 4.0 | cfs |
| Water Spread Width | | T = | 1.6 | 7.5 | ft |
| Water Depth at Flowline (outside of local depression) | | d = | 3.2 | 5.0 | inches |
| Water Depth at Street Crown (or at $T_{MAX}$) | | $d_{CROWN}$ = | 0.0 | 0.0 | inches |
| Ratio of Gutter Flow to Design Flow | | $E_o$ = | 1.010 | 0.870 | |
| Discharge outside the Gutter Section W, carried in Section $T_x$ | | $Q_x$ = | 0.0 | 0.5 | cfs |
| Discharge within the Gutter Section W | | $Q_w$ = | 1.0 | 3.5 | cfs |
| Discharge Behind the Curb Face | | $Q_{BACK}$ = | 0.0 | 0.0 | cfs |
| Flow Area within the Gutter Section W | | $A_W$ = | 0.19 | 0.50 | sq ft |
| Velocity within the Gutter Section W | | $V_W$ = | 5.3 | 7.0 | fps |
| Water Depth for Design Condition | | $d_{LOCAL}$ = | 5.2 | 7.0 | inches |
| Summary | | | MINOR | MAJOR | |
| Total Inlet Interception Capacity | | **Q =** | **0.7** | **1.9** | **cfs** |
| Total Inlet Carry-Over Flow (flow bypassing inlet) | | **$Q_b$ =** | **0.3** | **2.1** | **cfs** |
| Capture Percentage = $Q_a/Q_o$ = | | **C% =** | **66** | **49** | **%** |

# Underpass Storm Network Graphic


I2065L
Type 13
Inlet
S2065L
15" plastic
S2065R
Pumped 15"
N61° 17'48"E
198.91'
2065+00
2064+00
I2063L
Type 13
Inlet
I2065R
Type 13
Inlet
S2065R
15"
plastic
S2063R
15" plastic
Pump
Station
S2063L
15"
plastic
I2063R
Type 13 Inlet

# OpenRoads Designer Drainage and Utilities HGL Profiles


I2065L to FES - 5-YR
Elevation (ft)
Station (ft)
Label: Pr. I2065L
Type: Catch Basin
ID: 432
Label: Pr. S2065L 15"
Type: Conduit
ID: 433
Label: Pr. I2065R
Type: Catch Basin
ID: 431
Label: Pr. S2065R 15"
Type: Conduit
ID: 456
Label: 63rd Pump
Type: Pump
ID: 455
Label: Pr. S2065R Pumped 15"
Type: Conduit
ID: 457
Label: Pr. F2065R
Type: Headwall
ID: 448
5,154.00
5,153.00
5,152.00
5,151.00
5,150.00
5,149.00
5,148.00
5,147.00
5,146.00
5,145.00
5,144.00
5,143.00
5,142.00
5,141.00
5,140.00
5,139.00
5,138.00
5,137.00
5,136.00
5,135.00
5,134.00
5,133.00
5,132.00
5,131.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
85.00


I2065L to FES - 100-YR
Elevation (ft)
Station (ft)
5,157.00
5,156.00
5,155.00
5,154.00
5,153.00
5,152.00
5,151.00
5,150.00
5,149.00
5,148.00
5,147.00
5,146.00
5,145.00
5,144.00
5,143.00
5,142.00
5,141.00
5,140.00
5,139.00
5,138.00
5,137.00
5,136.00
5,135.00
5,134.00
5,133.00
5,132.00
5,131.00
5,130.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
85.00
90.00
Label: Pr. I2065L Type: Catch Basin ID: 432
Label: Pr. S2065L 15" Type: Conduit ID: 433
Label: Pr. I2065R Type: Catch Basin ID: 431
Label: Pr. S2065R 15" Type: Conduit ID: 456
Label: 63rd Pump Type: Pump ID: 455
Label: Pr. F2065R Type: Headwall ID: 443
Label: Pr. S2065R Pumped 15" Type: Conduit ID: 457

# FlowMaster 18" RCP Result

# Worksheet for 18" RCP

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.013 | |
| Channel Slope | 0.01000 | ft/ft |
| Normal Depth | 1.50 | ft |
| Diameter | 1.50 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 10.50 | ft³/s |
| Flow Area | 1.77 | ft² |
| Wetted Perimeter | 4.71 | ft |
| Hydraulic Radius | 0.38 | ft |
| Top Width | 0.00 | ft |
| Critical Depth | 1.25 | ft |
| Percent Full | 100.0 | % |
| Critical Slope | 0.00977 | ft/ft |
| Velocity | 5.94 | ft/s |
| Velocity Head | 0.55 | ft |
| Specific Energy | 2.05 | ft |
| Froude Number | 0.00 | |
| Maximum Discharge | 11.30 | ft³/s |
| Discharge Full | 10.50 | ft³/s |
| Slope Full | 0.01000 | ft/ft |
| Flow Type | SubCritical | |

## GVF Input Data

| | | |
|---|---|---|
| Downstream Depth | 0.00 | ft |
| Length | 0.00 | ft |
| Number Of Steps | 0 | |

## GVF Output Data

| | | |
|---|---|---|
| Upstream Depth | 0.00 | ft |
| Profile Description | | |
| Profile Headloss | 0.00 | ft |
| Average End Depth Over Rise | 0.00 | % |
| Normal Depth Over Rise | 100.00 | % |
| Downstream Velocity | Infinity | ft/s |

# Worksheet for 18" RCP

## GVF Output Data

| | | |
|---|---|---|
| Upstream Velocity | Infinity | ft/s |
| Normal Depth | 1.50 | ft |
| Critical Depth | 1.25 | ft |
| Channel Slope | 0.01000 | ft/ft |
| Critical Slope | 0.00977 | ft/ft |