CO 119 SAFETY AND MOBILITY IMPROVEMENTS PROJECT

PRELIMINARY DRAINAGE REPORT

August 2022

Prepared for:

Colorado Department of Transportation

Region 4 Boulder Residency

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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 Safety and Mobility Improvements Project was prepared by me or under my direct supervision in accordance with the provisions of the *Boulder County Storm Drainage Criteria Manual* and the *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 the Colorado Department of Transportation (CDOT) Region 4, has prepared the following drainage report for the CO 119 Safety and Mobility Improvements 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 project is located along Colorado State Highway 119 (CO 119) in Boulder County, Colorado. The proposed improvements are located primarily at five intersections along the CO 119 corridor. The project traverses unincorporated Boulder County, and the City of Boulder. The south end of the project is just east of 47th Street and the north end of the project is near Airport Road. Please refer to **Figure 1**.

Figure 1. ***Vicinity Map***

The project is specifically located in Sections 2, 3, 10, 15, and 16 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 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 agricultural land and railroad property. Suburban development, industrial development, and commercial development occurs beyond the immediate undeveloped land in all directions.

The project area is entirely located in 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 and the City of Boulder owns property adjacent to the southbound CO 119 lanes through the majority of the project area.

Table 1. *Existing Site Information*

Legal Description	Townships 1 and 2 North, Range 69 and 70 West of the Sixth Meridian
City and County	Unincorporated Boulder County, and City of Boulder, in Boulder County, Colorado
Adjacent Land Use	Undeveloped, agricultural, residential development, commercial development, industrial development
Major Drainageways	Fourmile Canyon Creek, Boulder Creek, Dry Creek No. 2, and Left Hand Creek
Irrigation Facilities	Boulder and Whiterock, City of Boulder, IBM, Williamson, and others
Hydrologic Soil Group	C and D, except a small number of basins with partial areas of A and B
Topography	Gently sloping terrain with considerable wetlands and high groundwater

1.2 Project Description and Intent

The CO 119 Safety and Mobility Improvements project generally consists of Bus Rapid Transit (BRT) / queue jump modifications and Park-and-Ride facilities along CO 119. It includes improvements at five intersections: Jay Road, 63rd Street, CO 52, Niwot Road, and Airport Road. Two new Regional Transportation District (RTD) Park-and-Ride facilities are proposed, one at 63rd Street and one at Niwot Road. This project will also include a realignment of the CO 119 and CO 52 intersection.

A concurrent design is underway by Boulder County for a 12-foot paved bikeway (the Bikeway project) along CO 119 from Boulder to Longmont. The added pavement from the Bikeway project was included in the evaluation of proposed facilities and outfalls for the Safety and Mobility project, assuming the two projects are constructed concurrently.

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 project.

CO 119 Bikeway Preliminary Drainage Report (Muller Engineering Company, 2022). This report presented the drainage design for the Bikeway project, primarily within the median of CO 119. Bikeway drainage design included a draft version of the preliminary CO 119 Safety and Mobility project, based on the status of design available at the time.

Final Drainage Report – Front Range Health and Wellness Center (Park Engineering Consultants, 2016). This report described a development north of the project area.

Hydrology and Hydraulics Report for the Intersections of SH 119 at Jay Road and SH 119 at Niwot Road (Fellsburg, Holt, and Ullevig, 2012). This report described improvements to the intersections of CO 119 at Jay Road and CO 119 at Niwot Road. The report focused on water quality requirements associated with these two projects. Culverts that were designed to convey flows to the water quality ponds were designed for the 2-year event for water quality treatment. The report also described the Boulder and Whiterock irrigation channel through the intersection at Jay Road.

Vojta Farm Final Stormwater Report (Drexel, Barell, and Company, 2008). This report describes a residential development at the intersection of 47th Street and Jay Road in the City of Boulder. The development is within an offsite basin which drains to a culvert on CO 119 associated with Boulder County's Bikeway project currently under design.

Preliminary Drainage Design Report – SH 119 at 63rd Street Intersection Improvements Project (SEH, 2008). The report included evaluation of extension of an existing 10 x 6 concrete box culvert, and other drainage facilities for the intersection.

SH 119 at SH 52 (Mineral Road) Final Drainage Report (Muller Engineering Company, 2005). This report presented proposed CO 52 and CO 119 intersection improvements which were not ultimately constructed. The report included information about the drainage patterns for the IBM Campus and offsite areas.

1.4 Floodplain

The floodplain administrator for the project area is Boulder County. There are two jurisdictions for the regulatory agency that administers Federal Emergency Management Administration (FEMA) permitting. Northeast of 71st Street, the regulatory agency is the Colorado Water Conservation Board (CWCB). This part of the project generally drains to Left Hand Creek, and includes the Niwot Road and Airport Road intersections. Southwest of 71st Street, the regulatory agency is the Mile High Flood District (MHFD). This part of the project drains to Dry Creek No. 2, Boulder Creek, or Fourmile Canyon Creek and includes Jay Road, 63rd Street, and CO 52.

The project includes proposed work within one FEMA regulated flood hazard area, for Left Hand Creek, in the vicinity of Airport Road. A second flood hazard area, for Dry Creek No. 2, is located within the project extents but has no planned impacts. Fourmile Canyon Creek is south of the project limit. Appendix A contains regulatory mapping for streams within the project limit.

1.4.1 Left Hand Creek

Mapping for Left Hand Creek is currently best represented by the Colorado Hazard Mapping Program (CHAMP) model. The primary purpose of CHAMP was to identify flood risks in northeast Colorado following the 2013 flood event. Currently-published FEMA mapping does not incorporate the CHAMP results and does not represent the effective condition.

Left Hand Creek runs parallel to CO 119 near Airport Road and crosses CO 119 north of Airport Road. The project includes minor widening into the median near Airport Road that will encroach into the floodplain.

Required floodplain modeling and permitting for Left Hand Creek will be coordinated with the Bikeway project; the Bikeway includes impacts at Airport Road and at the CO 119/Left Hand Creek crossing area. Modeling and permitting will be presented in a separate memorandum.

1.4.2 Dry Creek No. 2

Dry Creek is designated “No. 2” by Boulder County as one of several Dry Creek streams in the county. In the vicinity of the project, Dry Creek No. 2 is in a FEMA-designated special flood hazard area Zone A, defined as an area that presents a 1% annual chance of flooding and does not have base flood elevations. The Mobility project does not include any proposed impacts within the regulatory hazard area. The Bikeway project does have proposed impacts; modeling and permitting will be performed as part of that project.

1.5 Relationship to CO 119 Bikeway Project

The CO 119 Safety and Mobility Improvements project is currently on roughly the same design schedule as the CO 119 Bikeway project. The project improvements include the following:

- 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 associated with the bike path.

The drainage design and analysis described in this drainage report is based on the assumption that the CO 119 Bikeway project will be constructed in a similar timeframe as the CO 119 Mobility project. The drainage design and analysis of the CO 119 Mobility project includes Bikeway project as part of the overall proposed design. The bikeway is not included in existing conditions evaluations.

2 DRAINAGE 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 No. 2, and Left Hand Creek.

At the south end of the project, 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 No. 2. Runoff from Monarch Road to the north limit of the project area drains to Left Hand Creek. Boulder Creek, Dry Creek No. 2, and Left Hand Creek are tributaries to the St. Vrain River.

2.1.2 Offsite Area

Offsite area within the Fourmile Canyon Creek, Boulder Creek, and Dry Creek No. 2 watersheds generally flows east toward southbound CO 119. Offsite area within the Left Hand Creek watershed generally flows northeast toward the creek.

2.2 Sub Basin Description

Smaller areas draining to the four major creeks were broken down into sub basins (hereafter referred to simply as “basins”). The design point (or outlet) of basins is a hydraulic facility such as a ditch, culvert, inlet, water quality pond, or creek. In several areas, the flow does not concentrate to a single discharge point and the design point is taken as the right-of-way line, representing a distributed outfall or sheet flow.

Basins were delineated using surveyed topography provided by CDOT and LiDAR contours referenced from Boulder County. Proposed basins incorporated the proposed site grading and proposed infrastructure.

2.3 Historic Drainage Patterns

The northbound and southbound lanes of CO 119 are typically cross-sloped to drain to the outside of the highway, with occasional super-elevated sections where roadway runoff from southbound and/or northbound 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 typically 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 southbound CO 119. The ditch and culvert system may be intended for stormwater conveyance, irrigation supply flow conveyance, irrigation return flow conveyance, or a combination of these.

Muller has developed mapping irrigation routes from Boulder County and other resources. Based the existing drainage patterns, discussion with local agencies, and discussion with irrigation personnel, irrigation ditches are an important part of the area drainage pattern. The irrigation ditches and cross culverts are often placed near the lowest point of a contributing basin with no other drainage system to convey stormwater. Ditches currently convey local runoff away from the site and ultimately to existing wetlands, drainageways, and streams. There are also downstream water users on many of the ditches.

The proposed design is intended to maintain the existing drainage patterns, including the interaction with irrigation ditches. Ongoing communications with irrigators will continue, including requests for irrigation flow rates. Irrigation flow rates were not included in the preliminary drainage design. If design irrigation flow rates are identified and are to be delivered during flood events, those flow rates will be incorporated in the hydrologic and hydraulic evaluations.

3 DRAINAGE DESIGN CRITERIA

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

- Boulder County Storm Drainage Criteria Manual (SDCM), 2016
- 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 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 (<160 ac) CUHP and EPA-SWMM (>160 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 160 acres and the Rational Method was used calculate peak flowrates. See the Existing and Proposed Hydrology Calculation Packets included in Appendix B for full procedures and calculations.

Proposed basin delineation considered grading and new impervious areas from the CO 119 Bikeway project. A significant increase in pavement within the median of CO 119 is associated with the CO 119 Bikeway project.

Rainfall data was taken from NOAA Atlas 14. In 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. Chapter 5 of the Mile High Flood District *USDCM Volume 1* (2017) has adopted NOAA Atlas 14 as its rainfall data source.

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 curb and gutter, inlets, storm drain, manholes, culverts, and roadside ditches to meet the criteria identified in Table 3. Preliminary hydraulic calculations used Bentley FlowMaster and HY-8 to analyze cross culverts and storm drain systems. See the proposed hydraulic calculations included in Appendix C for full procedures and calculations.

Table 3. *Applied Hydraulic Criteria*

Hydraulic Criteria	Applied Criteria
Street Capacity	
Spread Width (Arterials)	
Minor Event (10-year) > 45 mph	10 feet clear each way
Major Event (100-year) > 45 mph	10 feet clear in the center
Allowable Depth at Panline (Arterials)	
Minor Event (10-year) > 45 mph	Follow Spread Criteria
Major Event (100-year) > 45 mph	Follow Spread 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. $\leq$ D $\leq$ 60 in.	1.7
60 in. < D < 84 in.	1.5
84 in. $\leq$ D < 120 in.	1.2
120 in. $\leq$ 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) 1.0% (riprap-lined) 0.5% (natural) while V>7 fps and Froude # < 0.8 if flow depth exceeds 1 ft
Min. Longitudinal Slope	0.2% (grass-lined and riprap-lined) Match adjacent for natural

4 DRAINAGE DESIGN AND ANALYSIS

4.1 Proposed Drainage Design

The proposed drainage design consists of the following elements:

- Existing culverts impacted by the road realignments/widenings will be extended or replaced to maintain existing drainage patterns.
- Ditching will be provided as needed to align drainageways with the proposed culverts and storm drains.
- Inlets will be placed to collect flow along proposed curb and gutter. During final design, the inlet types and placements will be verified in coordination with the roadway design. Streets with barrier-type guardrails will incorporate gutters where possible so that Type 16 inlets may be installed. If gutters cannot be incorporated in front of the barriers, vane grate inlets will be utilized. Type R curb inlets and Type C area inlets are also proposed where applicable to the site configuration. Inlet, ditch, and street capacities will be evaluated at final design.
- At the Park-and-Ride facilities, area drainage will be directed to new detention ponds to the extent possible. Hydraulic design at the Park-and-Ride facilities is presented in a separate memorandum, the *RTD Park-n-Ride Niwot Road and 63rd Street CO 119 Safety and Mobility Improvement – Preliminary Drainage Report* (RTD, August 2022).
- At two existing Permanent Water Quality (PWQ) ponds, the outlet structures will be modified/replaced to accommodate hydrologic and hydraulic changes in the pond function caused by the project.
- One new Permanent Water Quality (PWQ) pond is proposed south of Airport Road. Culverts will be placed to convey roadway runoff from the outer roadside ditches, under CO 119, to a new pond footprint in the median. The outfall of the pond will extend in the median to a downstream ditch crossing that currently receives both existing outer roadside ditches.

4.2 Hydrologic Analysis

4.2.1 General

Overall, there are no changes to historic drainage patterns. On a smaller scale, the site grading resulted in intermediate adjustments of several basins from one outfall to another adjacent outfall along the same overall drainageway. A discussion follows the key design point data below.

Proposed drainage structures typically depend on single basins and did not require detailed routing.

4.2.2 Key Design Points

To compare the overall downstream impact of the project, basins were grouped into key design points based on the receiving waters/outfalls. The basin groupings are related to the key design points in various ways – in some cases, they enter the same point from different directions, and in some cases they are separated by some distance upstream from the common outfall. The basin groupings at key design points were simply added together and no detailed routing was performed. This method is conservative for estimating the increase in flow, and ensures areas of concentrated runoff aren't overlooked.

Detailed routing of flows between basins could be performed to refine the flow rate for final design. A flow routing procedure would need to be performed for both the existing and the proposed and may not significantly change the conclusions for the overall change in flow rate.

Table 4 provides a comparison of existing and proposed flowrates at these key design points.

4.2.3 Discussion on Drainage Pattern Adjustments between Outfalls

DP 247R, DP 249R, and DP 250R1

DP 247R, DP 249R, and DP 250R1 are located along the reach of CO 52 that is being realigned further south. As a result of the roadway realignment, some of the drainage area that originally contributed to DP 247R will now be situated on the north side of the realigned CO 52 and as such it will flow to DP 249R and DP 250R1. The south and north sides of CO 52 are ultimately connected by two irrigation crossings, and the area ultimately drains to Dry Creek No. 2.

DP 258R and DP 267C

Southbound CO 119 is proposed to be relocated further west in the vicinity of CO 52, which may result in adjustments between adjacent outfalls. This area will be revisited in final design ensure the design mimics existing drainage patterns. An existing culvert extends from the southwest corner of the intersection under CO 52 to the northwest side of the intersection. The preliminary replacement of this culvert resulted in an outfall in the median, due to the relocation of the southbound 119 to the west. The proposed culvert alignment may be adjusted in the next design phase to better restore the drainage patterns in this area.

DP 309C and DP 333C

At Niwot Road, existing flow from south of Niwot exits to the east of CO 119 at the ditch identified as I-D-36 (DP 309C). From this point, the existing flow continues north towards DP 333C based on site observations and survey available at the time of design.

The proposed design reroutes the flow from the southwest side of Niwot to pass through the existing CDOT water quality pond north of Niwot Road before exiting to the east at the ditch identified as I-D-31 (DP 333C). The reroute also mitigates a conflict between the proposed

bikeway underpass and the existing ditch alignment. Based on site visits and discussions with irrigation owner representatives, there are no water users between I-D-36 and I-D-31.

Table 4. *Existing and Proposed Flowrate Comparison*

Key Design Point	Contributing Basins		Major Storm Q_{100} (cfs)			Receiving Water Description
	Existing	Proposed	Existing	Proposed	Δ Flow	
DP042R	X042R	P042R	3.6	5.0	1.4	I-S-3 (Fourmile Canyon Creek)
DP049R	X049L, X049R, X049C, X050C, X054C	P049C, P049L, P051L, P053C, P050C, P049R, P054C	21.2	24.2	3.0	I-D-3
DP064C	X064C, X062L, X063R	P064C, P062L, P063R, P061C	28.9	29.1	0.2	I-D-5
DP069R	X069R	P069R	4.3	4.3	0.0	I-D-7
DP076R	X076R	P076R	3.0	3	0.0	I-D-8
DP086R	X073C, X074R, X063C, X086R, X084L	P086R, P084L, P073C, P070C, P071C, P068C, P065C, P064L, P074R, P067C	44.9	61.0	16.1	I-D-9
DP178R	X175L, X176C, X172C, X184L, X180C, X178R	P175L, P175C, P172C, P175R, P177R, P177C, P177L, P184L, P178C, P179C, P179C1, P180C, P178R, P181C, RTD	205.7	210.7	5.0	I-D-17
DP201L	X194C, X195L, X193R, X201L	P191C, P192C, P194C, P195L, P193R, P201L	25.7	27.9	0	I-D-19
DP216C	X200C, X200R, X216C, X222L	P200C, P200R, P216C, P222L	21.9	22.9	2.2	Dry Creek No. 2
DP234C	X234L, X234C	P234L, P234C	14.0	14.5	0.5	I-D-22
DP247R	X247R	P246R2	14.3	14.0	-0.3	Existing Ditch Under 71st
DP249R	X238L, X238C, X242R, X249R	P238L, P238C, P242R, P246R1, P249R	19.9	27.2	7.3	I-D-23
DP250R2	X246R, X250R2	P245R, P250R2	19.6	19.7	0.1	Dry Creek No. 2
DP250R1	X250R1	P250R1	4.5	5.0	0.5	I-D-24

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

Key Design Point	Contributing Basins		Major Storm Q_{100} (cfs)			Receiving Water Description
	Existing	Proposed	Existing	Proposed	Δ Flow	
DP258R	X255L, X258R, X248R, X249C, X248L	P258R, P248R, P255L	57.0	22.2	-34.8	I-D-25
DP257L	X256L	P257L	2.0	2.0	0	I-D-26
DP267C	X263C, X261L, X267C, X267L, X258C, X258L	P242C, P243C, P244L, P245L1, P246L1, P246L2, P245L2, P252C, P246C, P248C2, P263C2, P263C1, P263L, P247R1, P250C, P247R2, P248C1, P267C, P268L, P265C	70.9	111.3	40.4	I-D-29
DP275C	X273L, X275C	P273L, P275C	37.7	41.5	3.8	I-D-30
DP276L	X276C, X276L	P276L, P276C	6.1	6.1	0	I-D-35
DP309C	X305L, X306R, X309C	P306R, P309C	32.9	18.9	-14.0	I-D-36
DP333C	X333C, X317C, X313C, X311C, X331L, X329R, X321R, X326L	P333C, P317C, P318C, P331L, P314R, P321R, P329R, P326L, P310C, P307C, P307L, RTD	53.9	71.1	17.2	I-D-31
DP343C	X335L, X343C	P335L, P343C	11.4	12.0	0.6	I-D-32
DP398C	X397L, X397C1, X397C2, X397R, X398C	P397R, P397C1, P397C2, P397L, P398C	28.2	29.2	1	Proposed Pond(1)
DP414C	X414C	P414C	4.9	4.9	0	Existing Storm System Under NB CO 119 at Airport Rd
DP416C	X416C, X429C	P416C, P429C	22.6	24.5	1.9	Left Hand Creek

Note 1. Pond to be designed to detain the water quality capture volume. Ancillary attenuation of 100-year peak flow to be computed at next design phase (approximately 6 cfs reduction expected based on preliminary footprint).

4.3 Hydraulic Analysis

4.3.1 Ditches

4.3.1.1 Capacity

Proposed ditches adjacent to the project were sized similar to existing ditches and will be evaluated at final design.

4.3.1.2 Other Criteria

Longitudinal slope will be subject to proposed grading for the roadway and existing terrain. A minimum 3:1 (H:V) side slope is anticipated to be feasible in most locations for proposed ditches. Final slopes, freeboard, and Froude numbers will be presented for proposed ditches at final design.

4.3.2 Inlets

4.3.2.1 Capacity

Inlets were placed using preliminary engineering judgement. Inlet capacities will be verified at final design, and adjustments to the number and placement of inlets will be made as necessary.

4.3.2.2 Other Criteria

The applied spread and depth criteria will be evaluated in final design.

4.3.3 Pipes

4.3.3.1 Capacity

Results indicate proposed pipes will have sufficient capacity for the 100-year design storm utilizing slopes from 0.5% to 2%. Pipe profiles showing final pipe slopes and hydraulic grade lines will be developed at final design. Calculations are presented in Appendix C.

4.3.3.2 Criteria

All criteria in Table 3 will be evaluated on the final profiles.

4.3.4 Riprap

Riprap is placed at the outfall of proposed pipes. The selected dimensions and size of riprap is similar to CDOT M-Standard 601-12 and a detail is provided on the plans.

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 Phase I MS4 permit (COS000005) covers state and interstate highways and their rights-of-way within urbanized boundaries, as defined by CDPHE and Boulder County's Statewide General Permit. Boulder County is regulated by the statewide General Phase II permit (COR0900000). Because the entire project is within existing or proposed CDOT right-of-way, it will be regulated under the CDOT permit. This approach was confirmed through meetings with water quality permitting specialists from CDOT and Boulder County.

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 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 the applicable MS4 permit. PWQ triggers, criteria, and proposed treatment totals are presented in the *Overall Project Water Quality Approach Memorandum* provided in Appendix D.

The following PWQ improvements are proposed:

- Two existing ponds will be modified to mitigate impacts from the project. The existing ponds are extended detention basins that manage the WQCV for previous CDOT projects constructed under a previous MS4 permit.
    - One existing pond is outside of the area triggered by the current MS4 permit at Jay Road.
    - The other pond is in the Left Hand Creek drainage area, north of Niwot Road, and will provide treatment in excess of the previous project criteria. The excess treatment to be directed to the existing pond will partially meet treatment criteria triggered by the current MS4 permit for the project.
- Two full spectrum detention basins will be constructed, one with each Park-and-Ride facility, in accordance with Boulder County stormwater detention criteria. The Park-and-Ride detention ponds will be maintained by RTD under a maintenance agreement with CDOT.
    - One detention pond is at 63rd Street, which is outside of the area triggered by the current MS4 permit, and will provide excess PWQ.
    - The other pond is in the Left Hand Creek drainage area, at Niwot Road, and will partially meet treatment criteria triggered by the current MS4 permit for the project.
- Approximately one new extended detention basin water quality pond will be constructed to manage the WQCV in the Left Hand Creek drainage area to meet remaining treatment acreage triggered by the current CDOT MS4 permit for the project.

Hydraulic calculations for the full spectrum detention basins are provided in RTD's drainage report. Hydraulic calculations for the modified existing ponds and the new PWQ pond will be presented at final design.

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 Safety and Mobility Improvements Project is in accordance with the CDOT Drainage Design Criteria Manual and the Boulder County Storm Drainage Criteria Manual.

6.2 Drainage Concept

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

1. Drainage design assumes the CO 119 Bikeway project is constructed concurrently. Bikeway features are not included in the existing conditions evaluation. They are included in the proposed conditions evaluation and therefore the results quantify impacts due to both projects together.

2. Historic drainage patterns will be maintained.

3. Culverts, inlets, and ditches are intended to manage flow spread on the proposed improvements.

4. Permanent water quality will be provided for applicable areas in accordance with the MS4 criteria.

.

7 REFERENCES

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

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

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

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

Muller Engineering Company, *CO 119 Bikeway Preliminary Drainage Report,* July 2022

Park Engineering Consultants, *Final Drainage Report – Front Range Health and Wellness Center*, 2016

RTD, *RTD Park-n-Ride Niwot Road and 63rd Street CO 119 Safety and Mobility Improvement – Preliminary Drainage Report,* August 2022

SEH, *Preliminary Drainage Design Report – SH 119 at 63rd Street Intersection Improvements Project*, 2008

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

APPENDIX A

Maps and References

Roadway Criteria Table

Hydrologic Criteria Table

Hydraulic Criteria Table

Existing Basin Maps

Proposed Basin Maps

Hydrologic Soils Report (NRCS)

Point Precipitation Data (NOAA Atlas 14)

FEMA and CHAMP Flood Zone Maps

APPENDIX B

Hydrology

Existing Hydrology Calculations

Proposed Hydrology Calculations

APPENDIX C

Hydraulics

Proposed Pipe Hydraulic Calculations

Proposed Culvert Hydraulic Calculations

APPENDIX D

Water Quality

Overall Project Water Quality Approach Memorandum

APPENDIX A

Maps and References

Roadway Criteria Table

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Roadway Classification Table

Roadway Classification Table		
Roadway Name	**Project Recommendation for Roadway Classification (per CDOT C-Plan Database and 2018 Boulder County Road Map)**	**Applied Hydraulic Classification (Interstate, Arterial, Collector)[1]**
SH 119	Principal Arterial / Freeway Expressway	Arterial
47th St	Collector	Collector
Jay Rd	Major Arterial	Arterial
55th St	Local	Collector
63rd St	Collector	Collector
IBM Dr	Local	Collector
SH 52 (Mineral Rd)	Principal Arterial	Arterial
Monarch Rd	Collector	Collector
Niwot Rd	Collector	Collector
Oxford Rd	Local	Collector
N 83rd St	Collector	Collector
Airport Rd	Principal Arterial	Arterial
S Fordham St	Local	Collector
Hover St	Principal Arterial	Arterial

1. Hydraulic Classification applied based on roadway classification, engineering judgment, and conservatism.

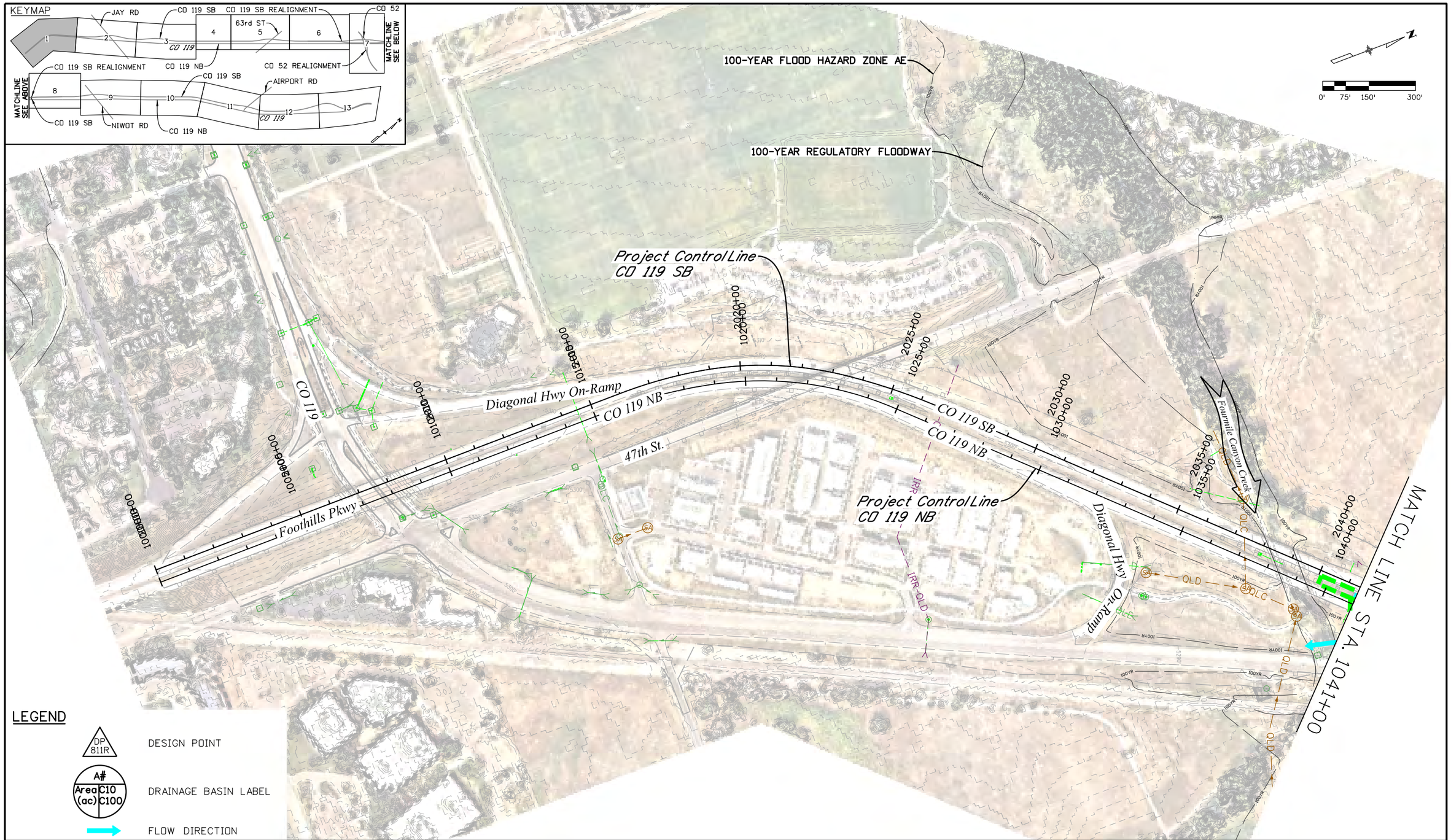
Hydrologic Criteria Table

SH 119 Mobility Hydrologic Design Criteria							
Hydrologic Criteria	**CDOT**		**MHFD**		**Boulder County**		**Applied Criteria**
	CDOT Drainage Design Manual (2019)		Urban Storm Drainage Criteria Manual (USDCM)		Multimodal Transportation Standards (MTS) [2012] or Storm Drainage Criteria Manual (SDCM) [2016]		
Data Collection							
Data Source							
Rainfall	NOAA, Flood Studies/Master Plans, USGS, or CDOT Maintenance	CH 6 Appendix A			Boulder County Point Rainfall Depths	Section 500 (SDCM) 5-year: 500-1 100-year: 500-3	Boulder County Point Rainfall Depths for 5-year and 100-year storm events. NOAA data for other storm events.
Soils	USGS NRCS						NRCS
Design Frequency							
Cross Drainage							
Multi-lane Road (Urban)	100-year	Table 7.2	-	-	Minor: 5-year 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		2-year	Chapter 10, Section 3.2	5-year	5.7.4 (MTS)	5-year
Parallel Drainage							
Roadway Overtopping & Revetment	*Same as for cross drainage*	Table 7.2	-		Minor: 5-year 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	Chapter 7	100-year	Section 3, 304 and Section 9 (SDCM)	100-year
Minor Storm	2 to 5-year		2 to 5-year	Chapter 7	5-year		5-year
Channels							
Capacity	*Refer to Parallel or Cross Drainage*	Ch. 8.4	-		Minor: 5-year 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) CUHP (most desireable), NRCS TR55, Snyder's Unit Hydrograph, SCS Synthetic Unit Hydrograph, others (>200 ac)	Ch. 7.4.1	-		Rational Method (not to exceed 90 ac)	Section 6, 602 (SDCM)	Rational Method (<160 ac) CUHP and EPA-SWMM (>160 ac)
Time of Concentration (Tc) for Rational Method							
Min. Tc for urban areas	5 min.	Ch. 7.4.5	5 min.	2.4.4	5 min.	Section 6, 602.2	5 min.
Min. Tc for non-urban areas	10 min.		10 min.		10 min.		10 min.
Max. Overland Flow Path Length (urban)	300 ft		300 ft		300 ft	Section 6, Table 600-1	300 ft
Max. Overland Flow Path Length (rural)	500 ft		500 ft		500 ft		500 ft

Hydraulic Criteria Table

SH 119 Mobility 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)		
Street Capacity							
Spread Width (Arterials)							
Minor Event (10-year) > 45 MPH	Shoulder or 4-ft from flowline	Table 13.1	10 feet clear each way	Table 900-1 (SDCM)			10 feet clear each way
Major Event (100-year) > 45 MPH	Building foundations must not be flooded	Ch. 13.2.2	10 feet clear in center	Table 900-1 (SDCM)			10 feet clear in center
Allowable Depth at Panline (Arterials)							
Minor Event (10-year) > 45 MPH	follow spread criteria	CH 13.3.2	Follow spread criteria	Table 900-1 (SDCM)			Follow spread criteria
Major Event (100-year) > 45 MPH	18 in. / 6 in. at crown	CH 13.3.2	Follow spread criteria	Table 900-1 (SDCM)			Follow spread criteria
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) 1.0% (riprap-lined) 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) 1.0% (riprap-lined) 0.5% (natural) while V>7 fps and Froude # < 0.8 if flow depth exceeds 1 ft
Min. Longitudinal Slope	0.2% (grass-lined and riprap-lined) Match adjacent for natural		-	-	-	-	0.2% (grass-lined and riprap-lined) Match adjacent for natural

Existing Basin Map



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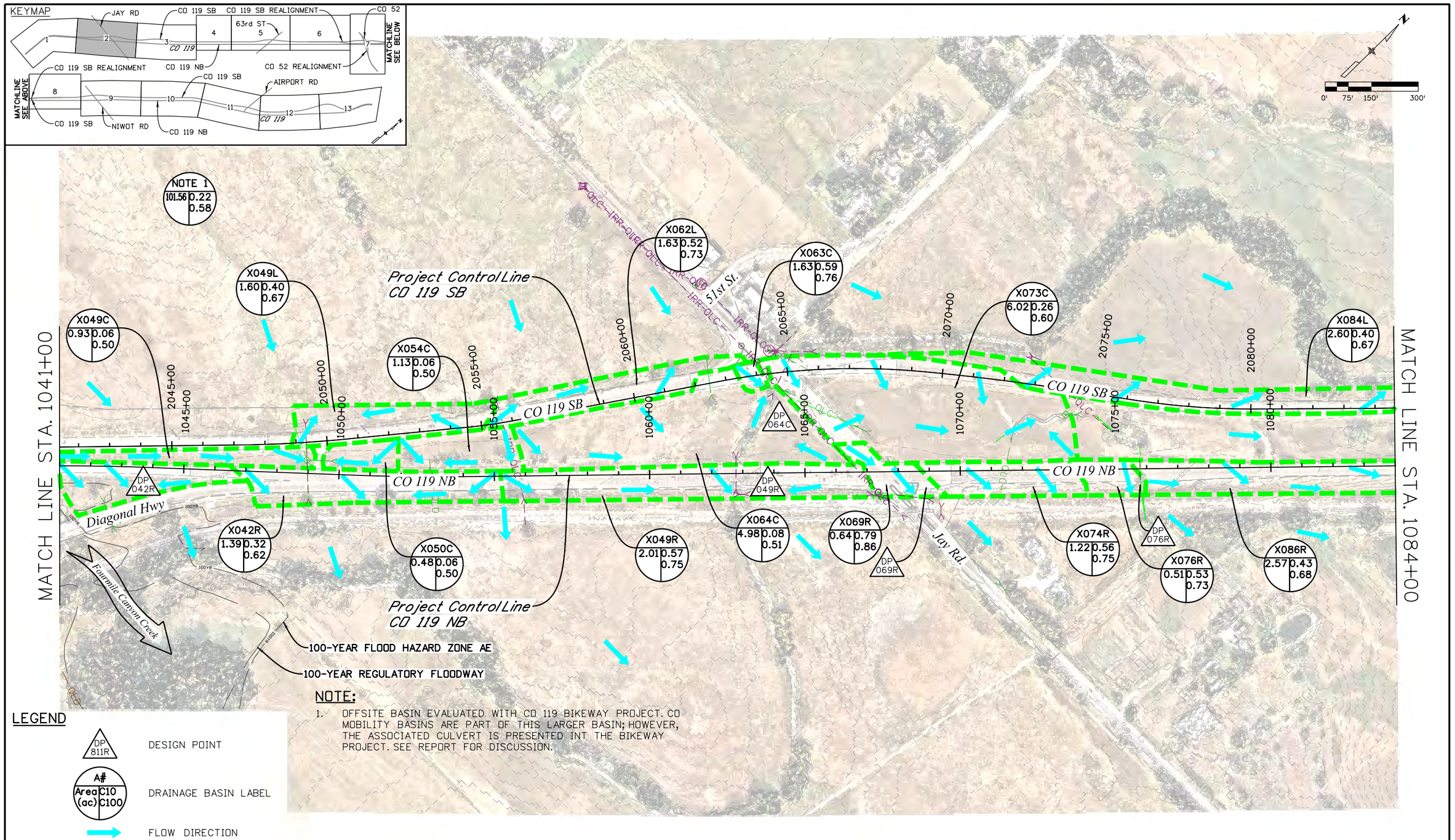

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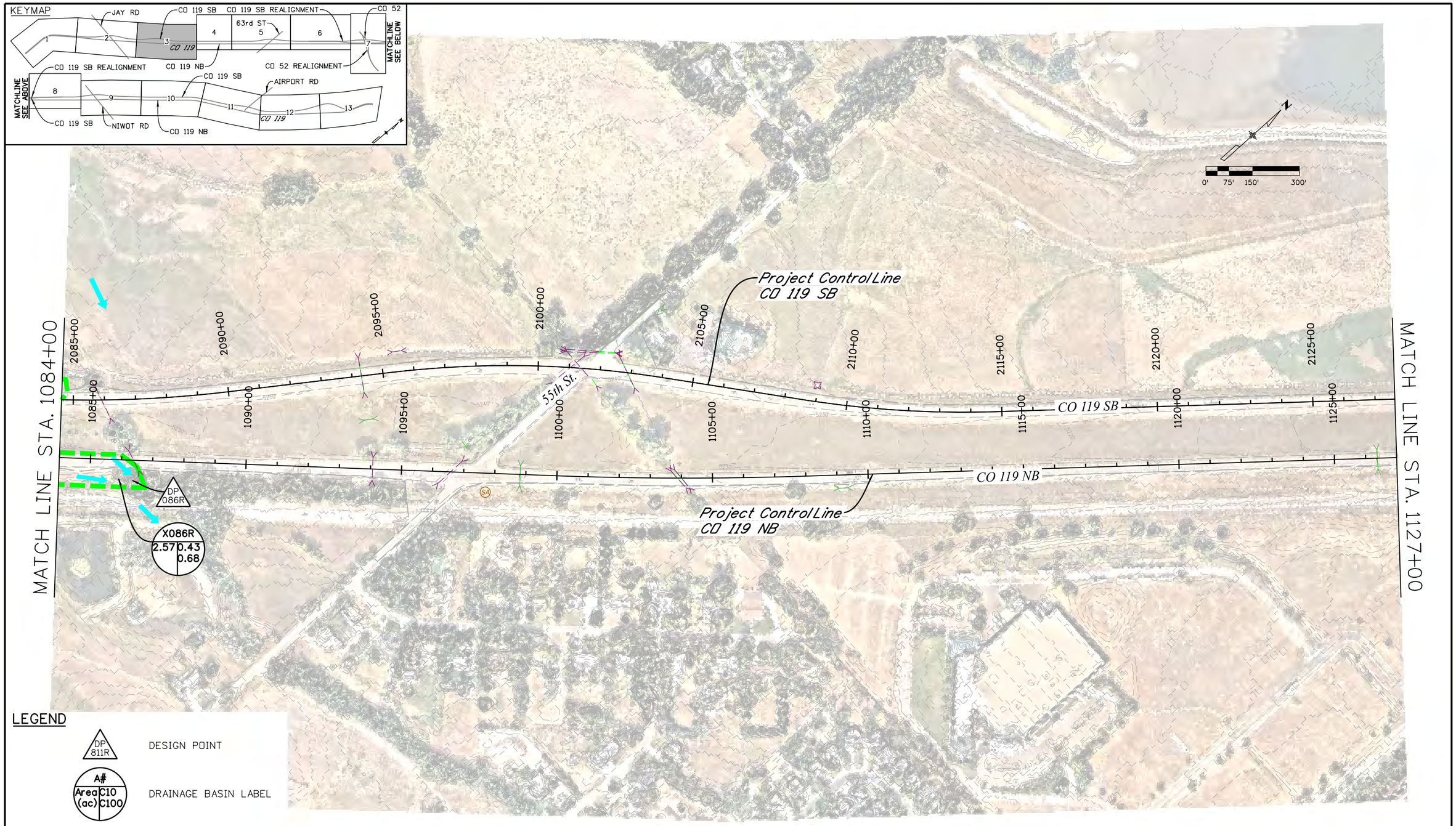

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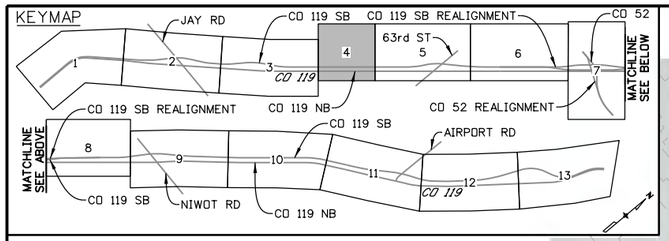

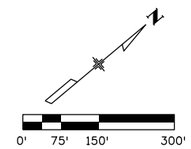

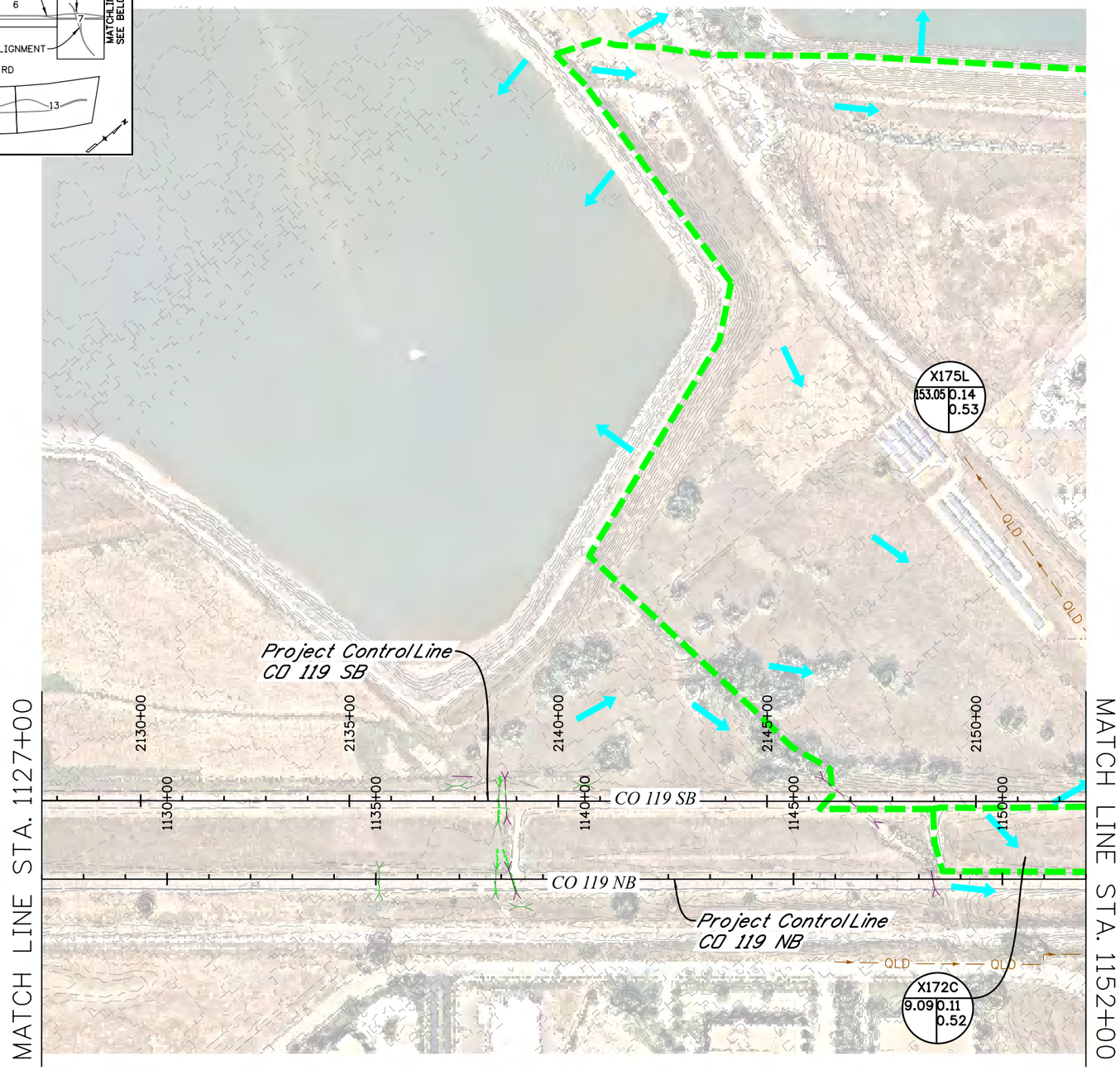

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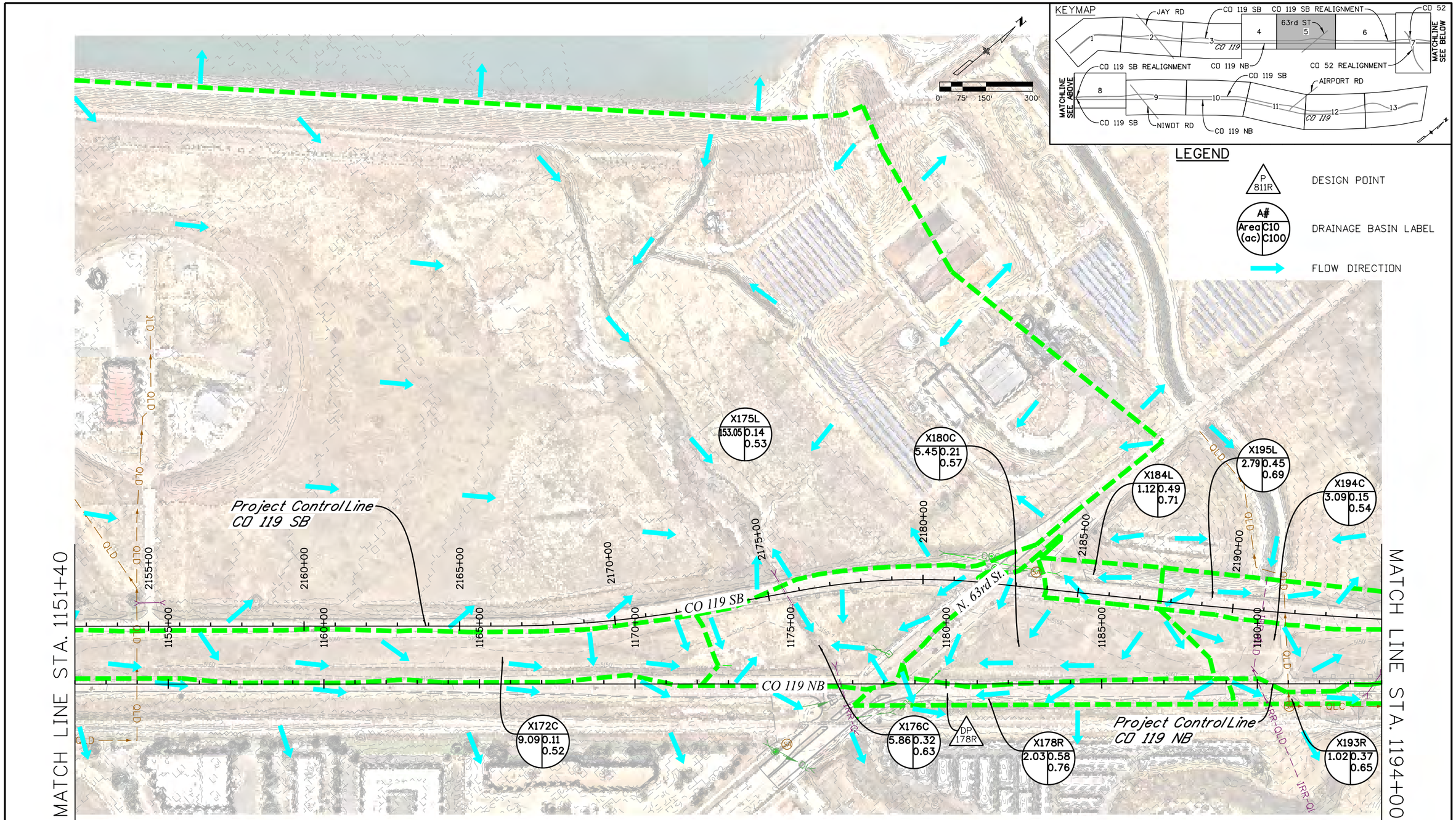

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EXISTING DRAINAGE BASIN MAP
STA. 1194+00 TO STA. 1237+00

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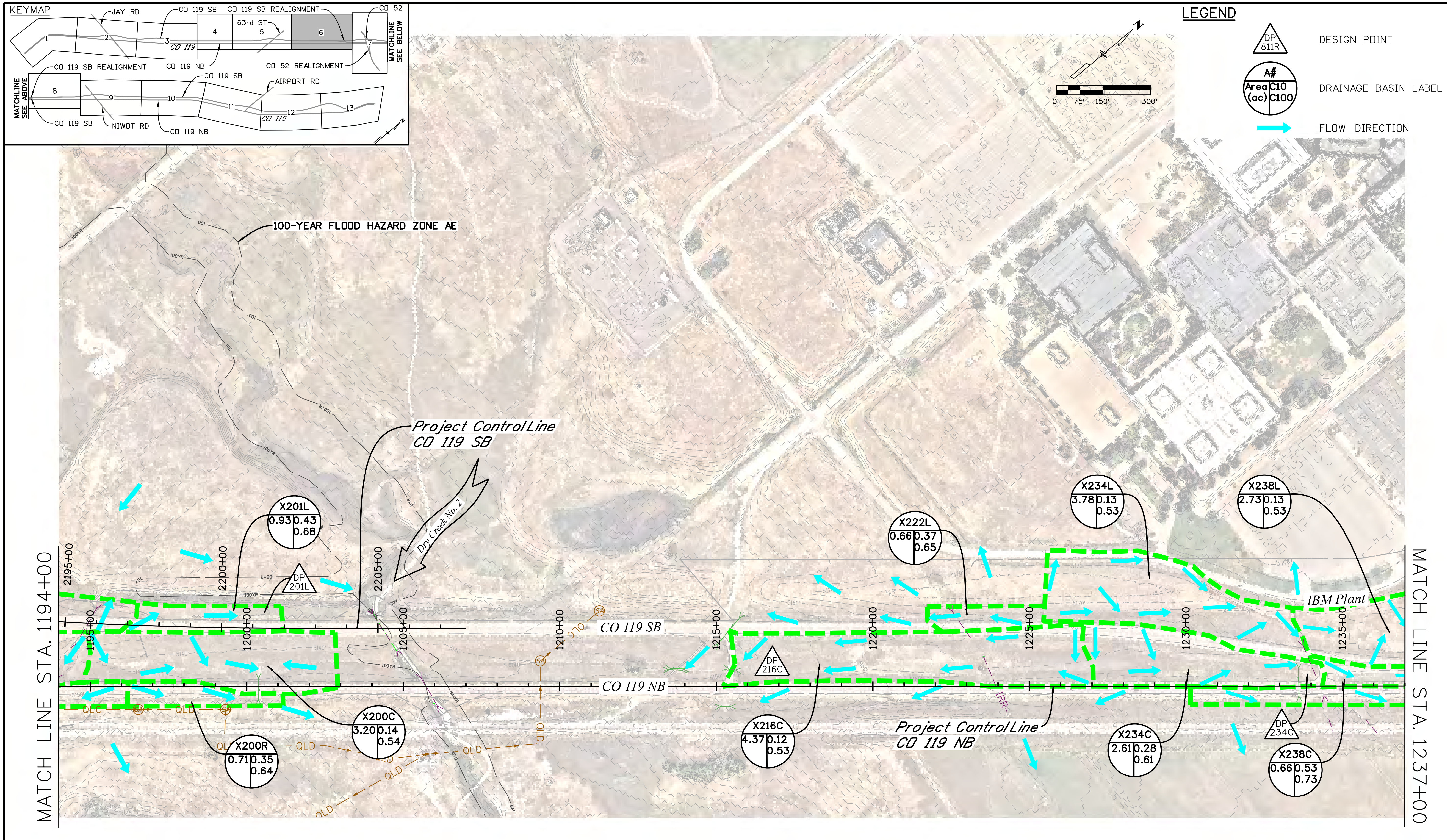

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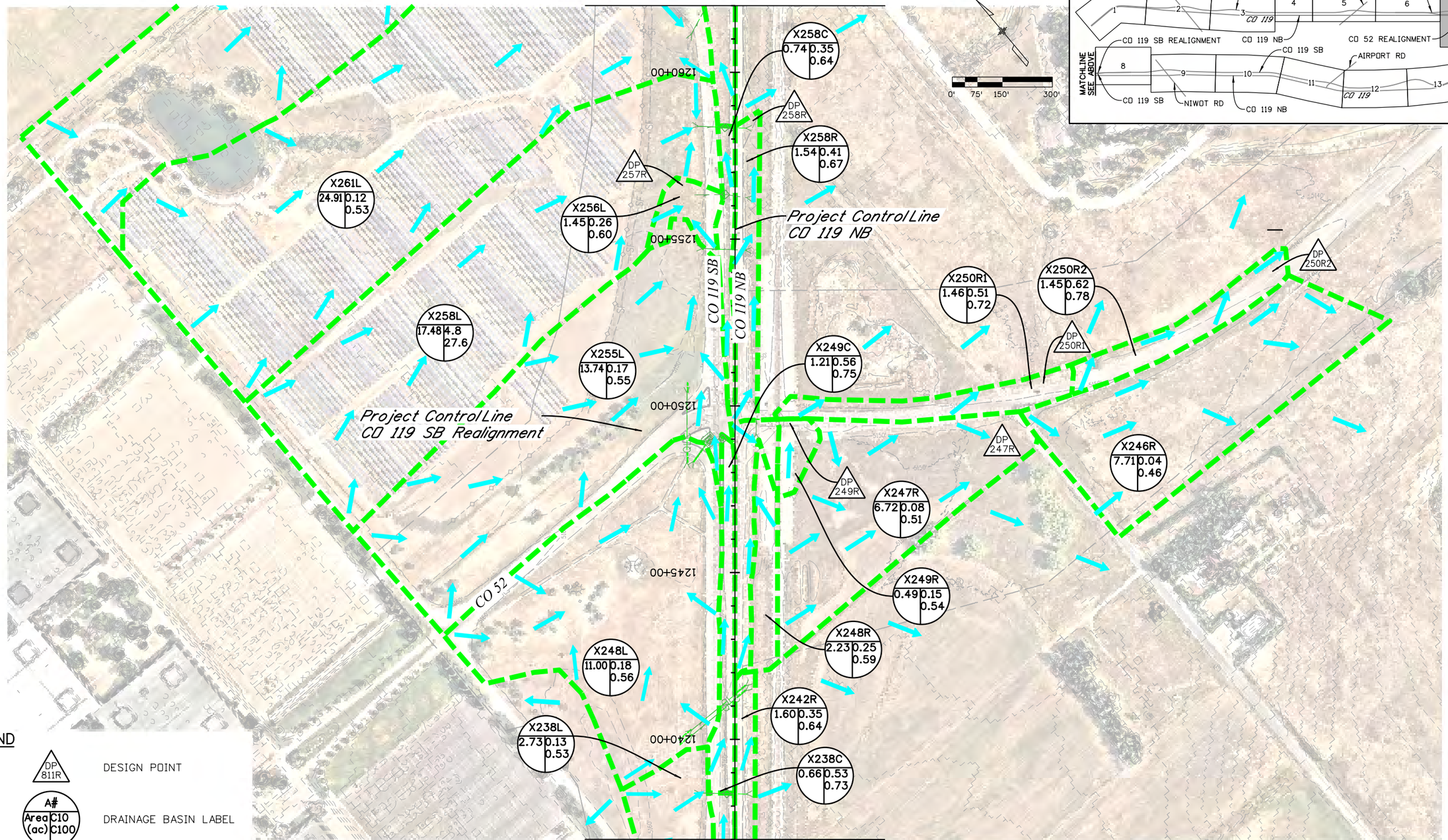

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EXISTING DRAINAGE BASIN MAP
STA. 1237+00 TO STA. 1262+00

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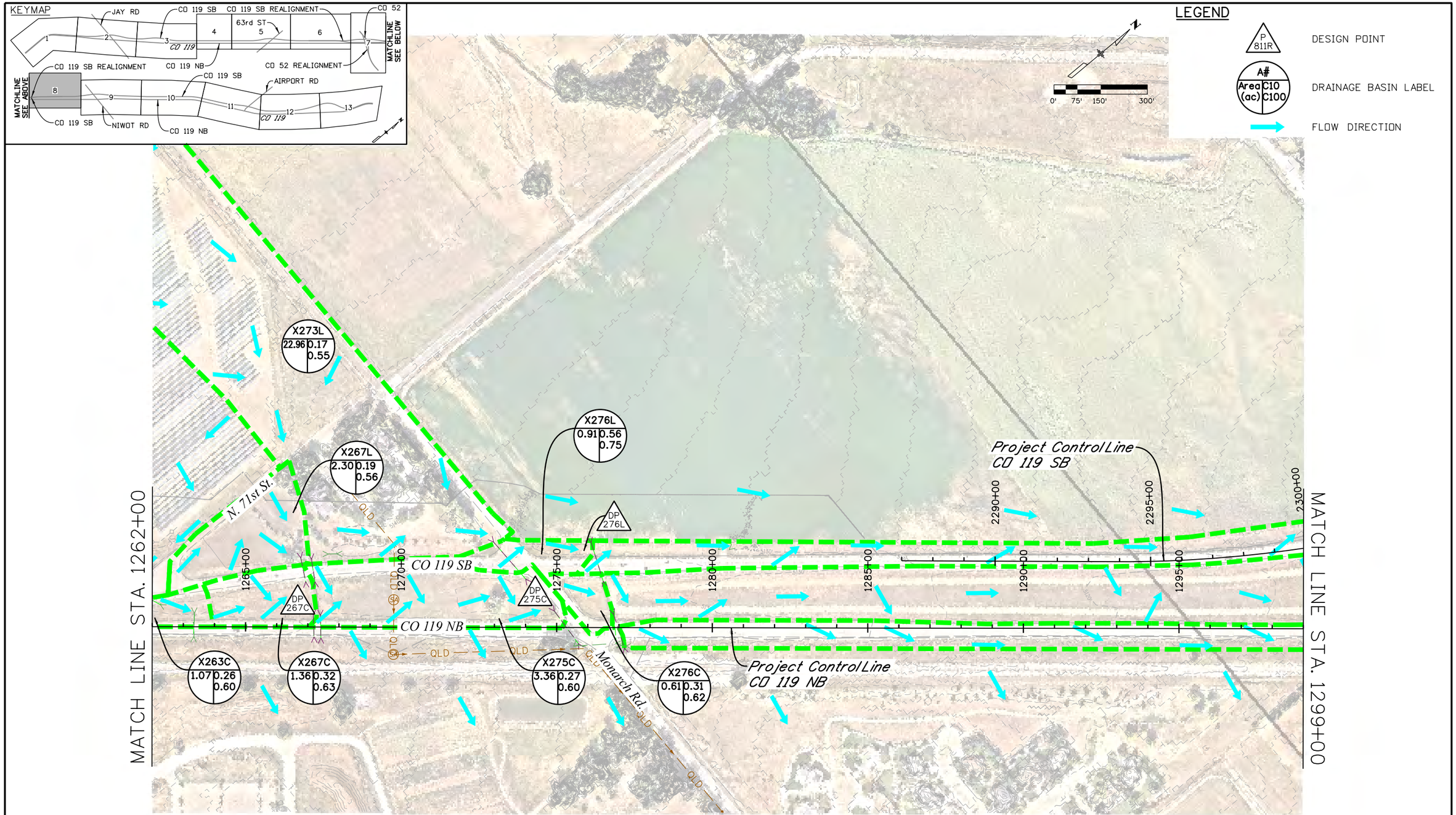

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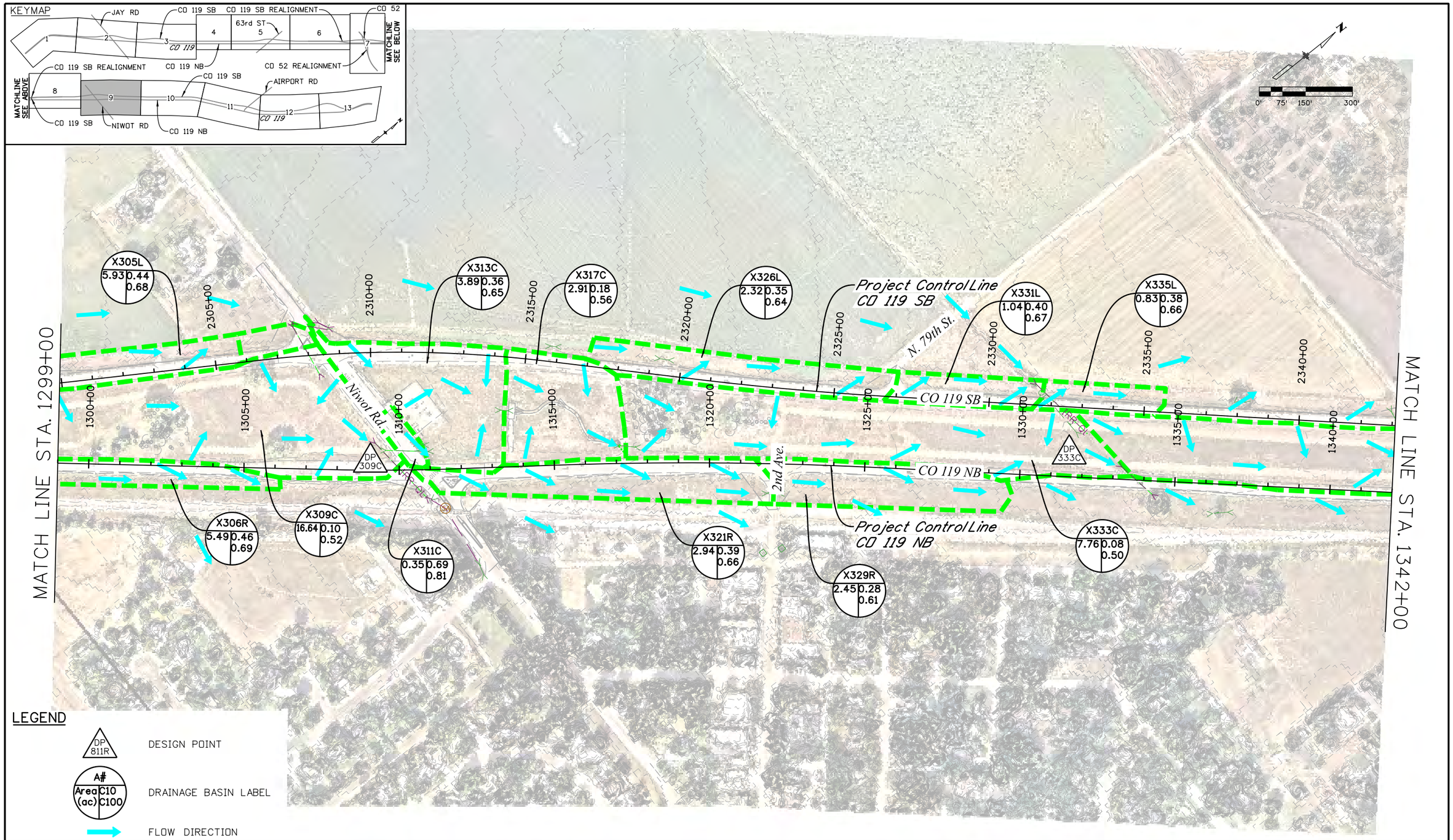

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EXISTING DRAINAGE BASIN MAP
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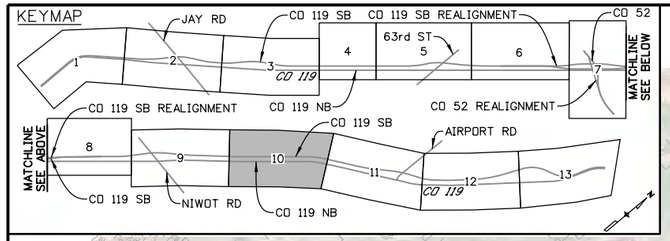

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Revised:
Void:

CO 119 MOBILITY
EXISTING DRAINAGE BASIN MAP
STA. 1342+00 TO STA. 1385+00

Designer: EPT
Detailer: LMR
Sheet Subset: EX DRBAS
Structure Numbers:
Subset Sheets: 10 of 13

Project No./Code
STA 1191-033
21497
Sheet Number

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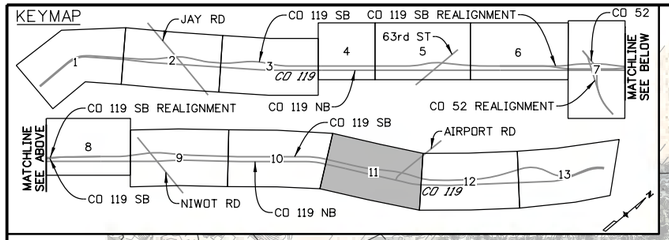
KEYMAP



LEGEND

DP 811R — DESIGN POINT

A# / Area (ac) / C10 / C100 — DRAINAGE BASIN LABEL

FLOW DIRECTION

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_EX_Basins_11.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
EXISTING DRAINAGE BASIN MAP
STA. 1385+00 TO STA. 1428+00

Designer: EPT
Detailer: LMR
Structure Numbers:
Sheet Subset: EX DRBAS
Subset Sheets: 11 of 13

Project No./Code: STA 1191-033
21497
Sheet Number

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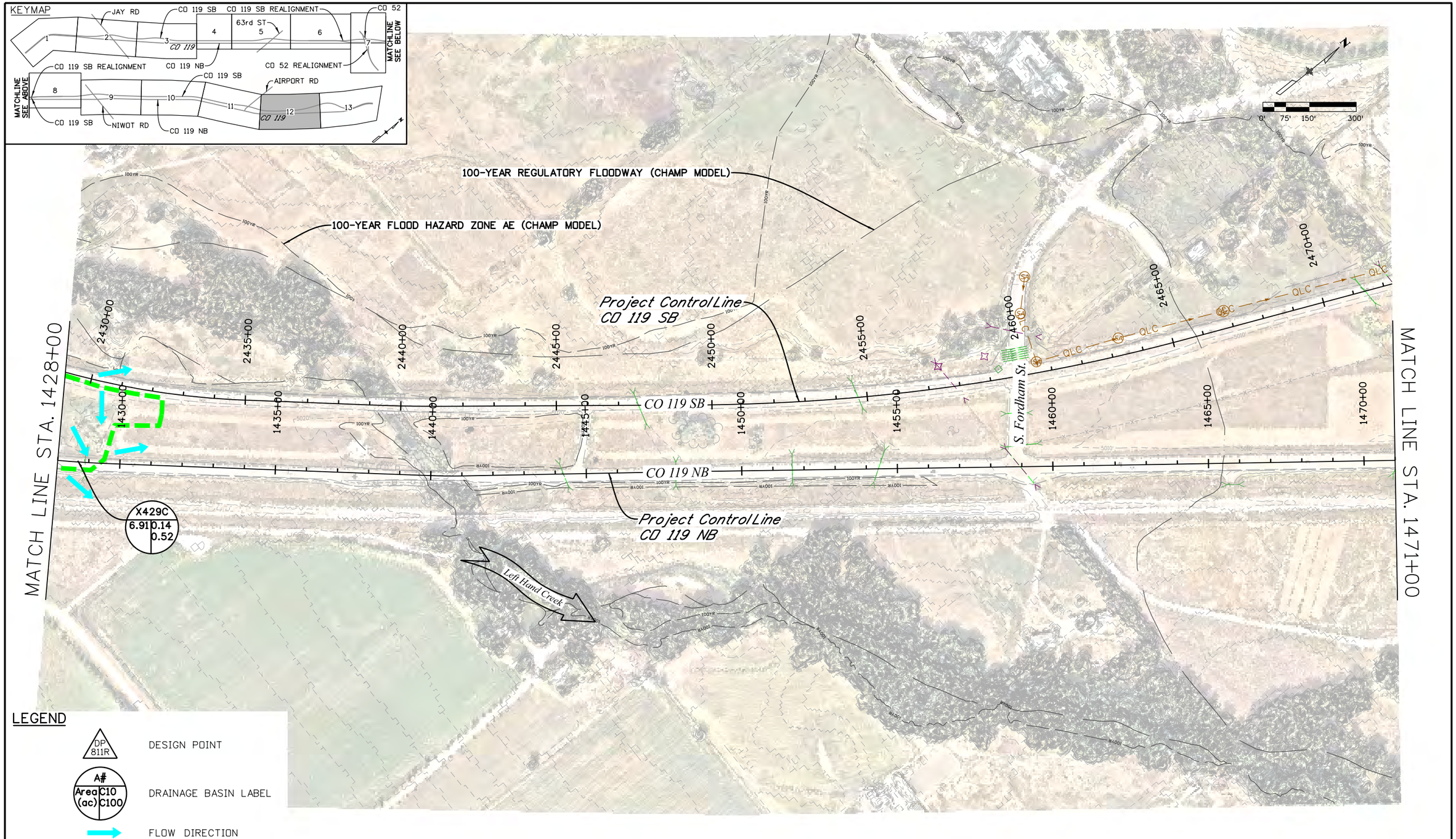

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_EX_Basins_12.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
1050 Lee Hill Road
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Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
EXISTING DRAINAGE BASIN MAP
STA. 1428+00 TO STA. 1471+00

Designer: EPT
Detailer: LMR
Sheet Subset: EX DRBAS
Structure Numbers:
Subset Sheets: 12 of 13

Project No./Code
STA 1191-033
21497
Sheet Number

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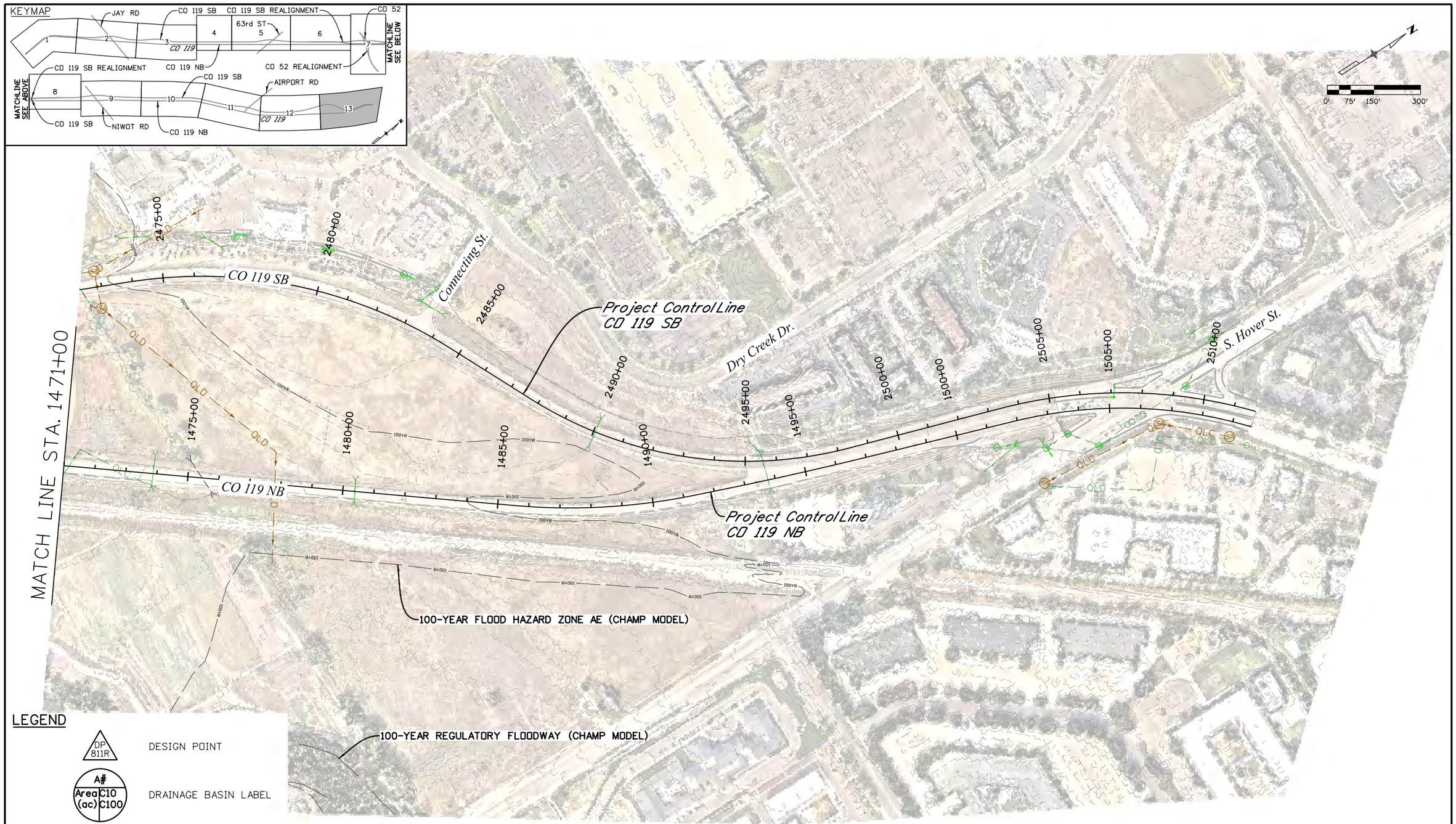

LEGEND

DP 811R — DESIGN POINT

A# / Area (ac) / C10 / C100 — DRAINAGE BASIN LABEL

FLOW DIRECTION

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_EX_Basins_13.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions		
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Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
EXISTING DRAINAGE BASIN MAP
STA. 1471+00 TO STA. 1509+61

Designer: EPT
Detailer: LMR
Sheet Subset: EX DRBAS
Structure Numbers:
Subset Sheets: 13 of 13

Project No./Code: STA 1191-033
21497
Sheet Number

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Proposed Basin Map

KEYMAP

JAY RD · CO 119 SB · CO 119 SB REALIGNMENT · 63rd ST · CO 52 · CO 119 · CO 119 NB · CO 52 REALIGNMENT · MATCHLINE SEE BELOW · MATCHLINE SEE ABOVE · CO 119 SB REALIGNMENT · CO 119 SB · AIRPORT RD · CO 119 · CO 119 SB · NIWOT RD · CO 119 NB

100-YEAR FLOOD HAZARD ZONE AE

100-YEAR REGULATORY FLOODWAY

0' 75' 150' 300'

Project ControlLine CO 119 SB

Project ControlLine CO 119 NB

CO 119 NB · CO 119 SB · CO 119 NB · Diagonal Hwy On-Ramp · Diagonal Hwy On-Ramp · 47th St. · Foothills Pkwy · Fourmile Canyon Creek · IRR · IRR-QLD · QLD · QLDC · MATCH LINE STA. 1041+00

LEGEND

DP 811R — DESIGN POINT

A# / Area (ac) / C10 / C100 — DRAINAGE BASIN LABEL

FLOW DIRECTION

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_PR_Basins_01.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions

Date:	Comments	Init.

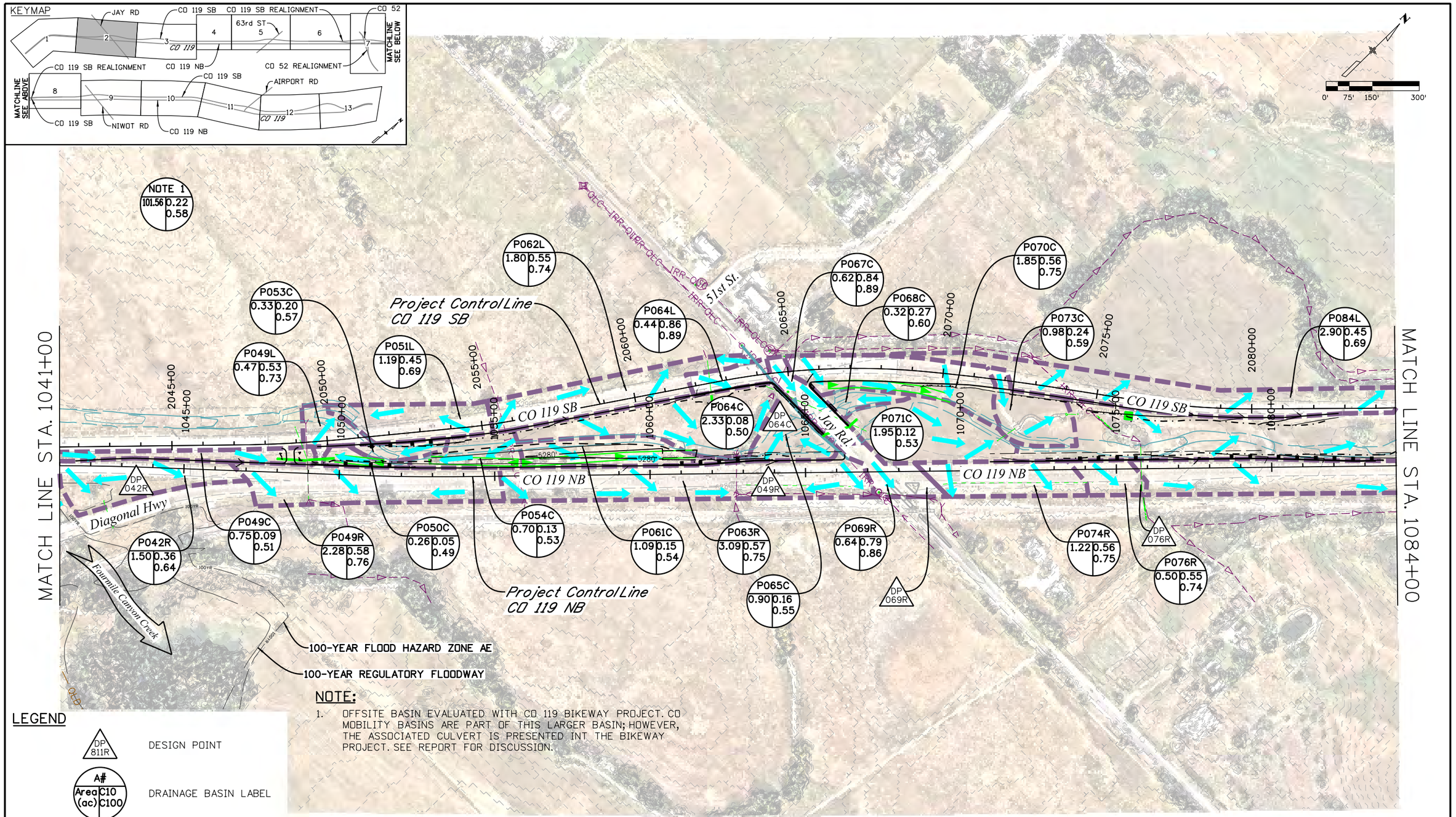
Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
PROPOSED DRAINAGE BASIN MAP
STA. 1000+00 TO STA. 1041+00

Designer: EPT
Detailer: LMR
Sheet Subset: PR DRBAS
Structure Numbers:
Subset Sheets: 1 of 13

Project No./Code
STA 1191-033
21497
Sheet Number



NOTE:

1. OFFSITE BASIN EVALUATED WITH CO 119 BIKEWAY PROJECT. CO MOBILITY BASINS ARE PART OF THIS LARGER BASIN; HOWEVER, THE ASSOCIATED CULVERT IS PRESENTED INT THE BIKEWAY PROJECT. SEE REPORT FOR DISCUSSION.

LEGEND

- DP 811R — DESIGN POINT
- A# / Area (ac) / C10 / C100 — DRAINAGE BASIN LABEL
- FLOW DIRECTION

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_PR_Basins_02.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
PROPOSED DRAINAGE BASIN MAP
STA. 1041+00 TO STA. 1084+00

Designer: EPT
Detailer: LMR
Structure Numbers:
Sheet Subset: PR DRBAS
Subset Sheets: 2 of 13

Project No./Code
STA 1191-033
21497
Sheet Number

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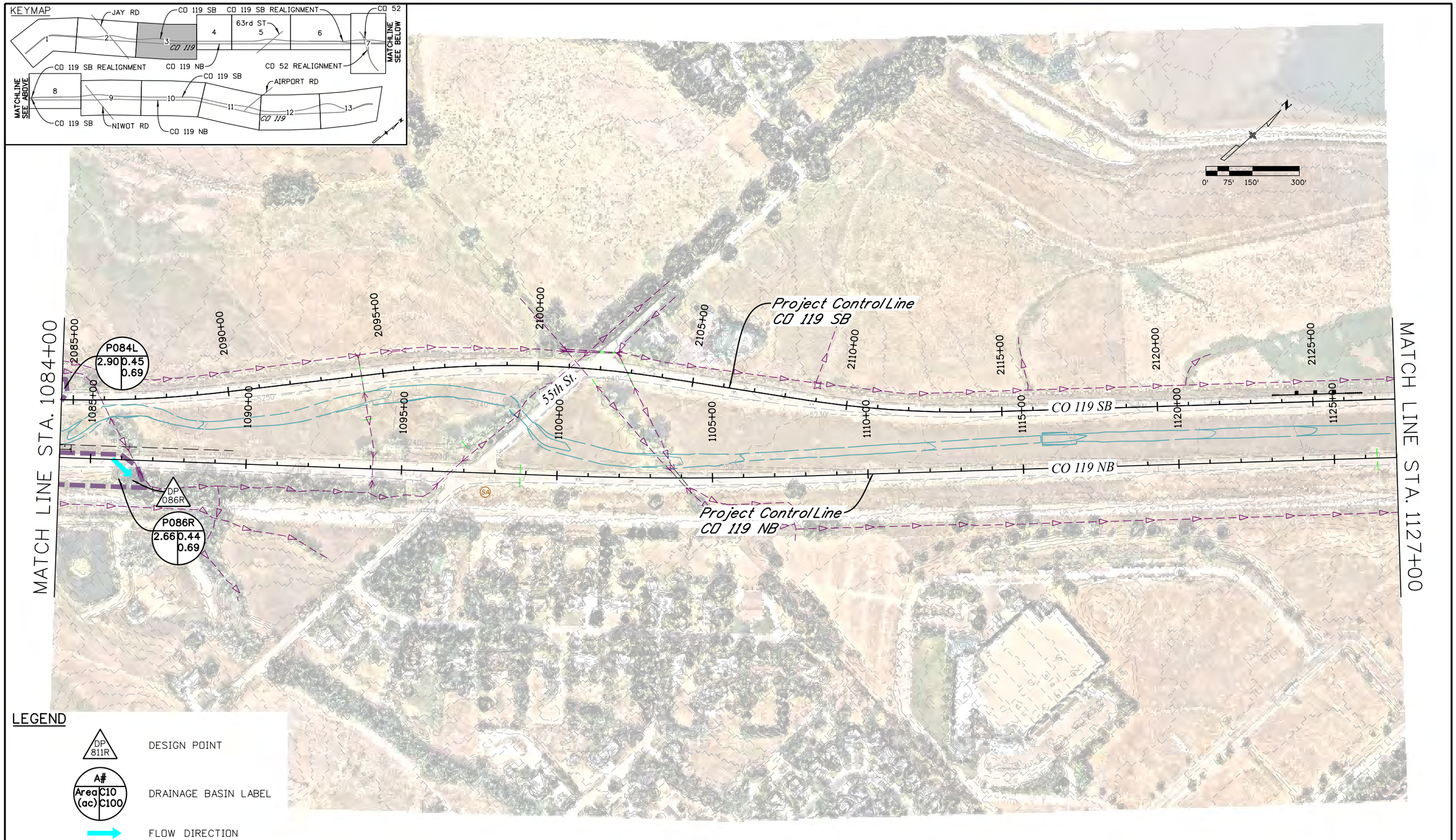

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_PR_Basins_03.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions		
Date:	Comments	Init.

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1050 Lee Hill Road
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FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
PROPOSED DRAINAGE BASIN MAP
STA. 1084+00 TO STA. 1127+00

Designer: EPT
Detailer: LMR
Structure Numbers:
Sheet Subset: PR DRBAS
Subset Sheets: 3 of 13

Project No./Code
STA 1191-033
21497
Sheet Number

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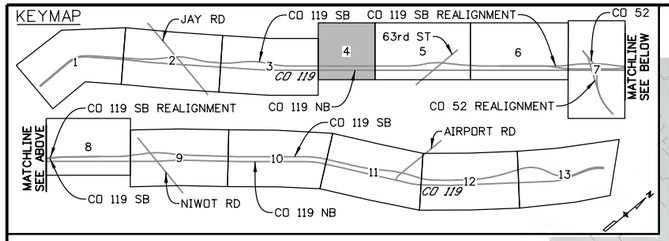

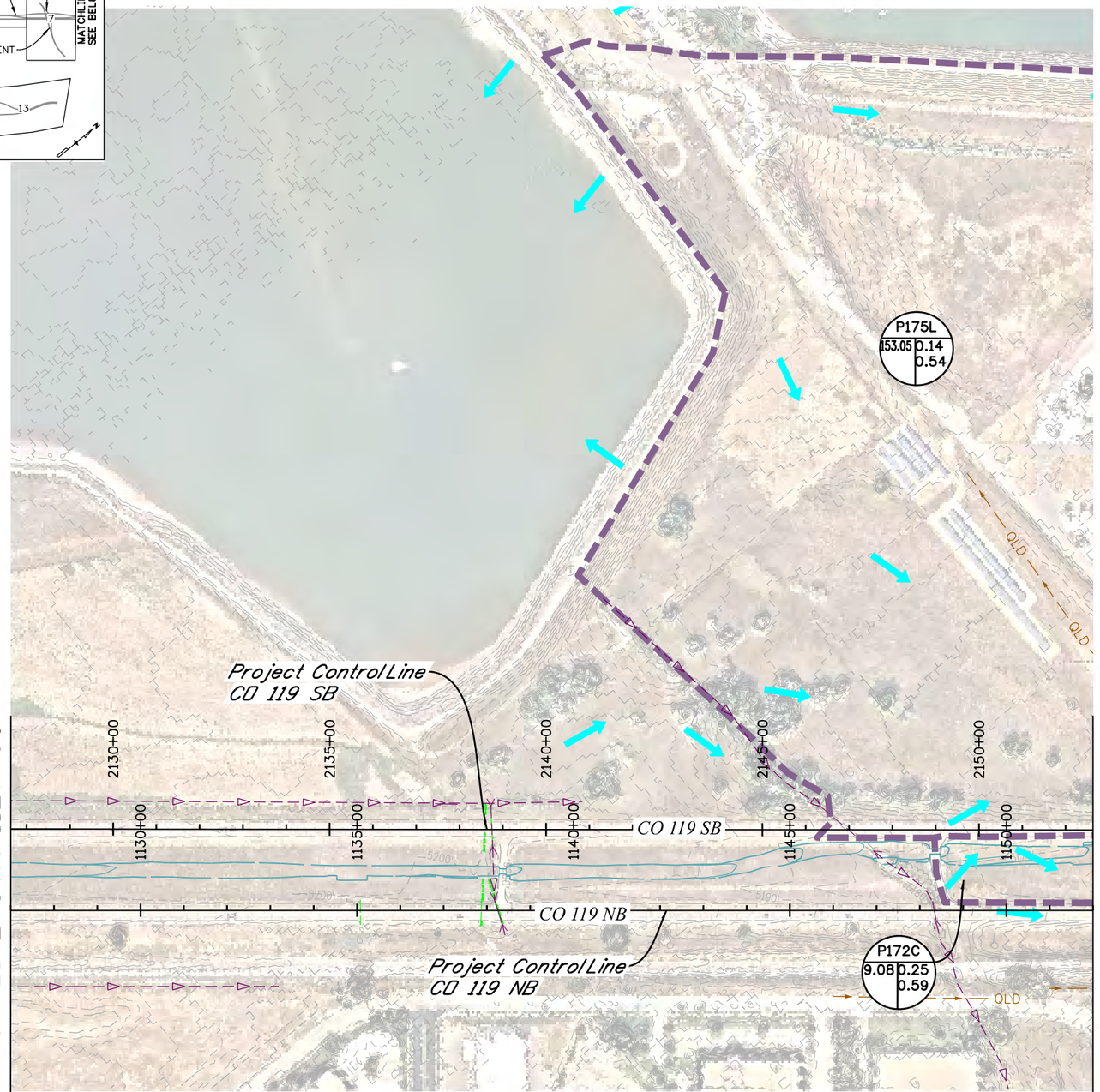

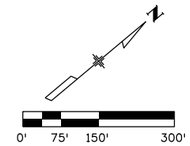

LEGEND

DP 811R — DESIGN POINT

A# / Area (ac) / C10 / C100 — DRAINAGE BASIN LABEL

FLOW DIRECTION

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_PR_Basins_04.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
PROPOSED DRAINAGE BASIN MAP
STA. 1127+00 TO STA. 1152+00

Designer: EPT
Detailer: LMR
Sheet Subset: PR DRBAS
Structure Numbers:
Subset Sheets: 4 of 13

Project No./Code
STA 1191-033
21497
Sheet Number

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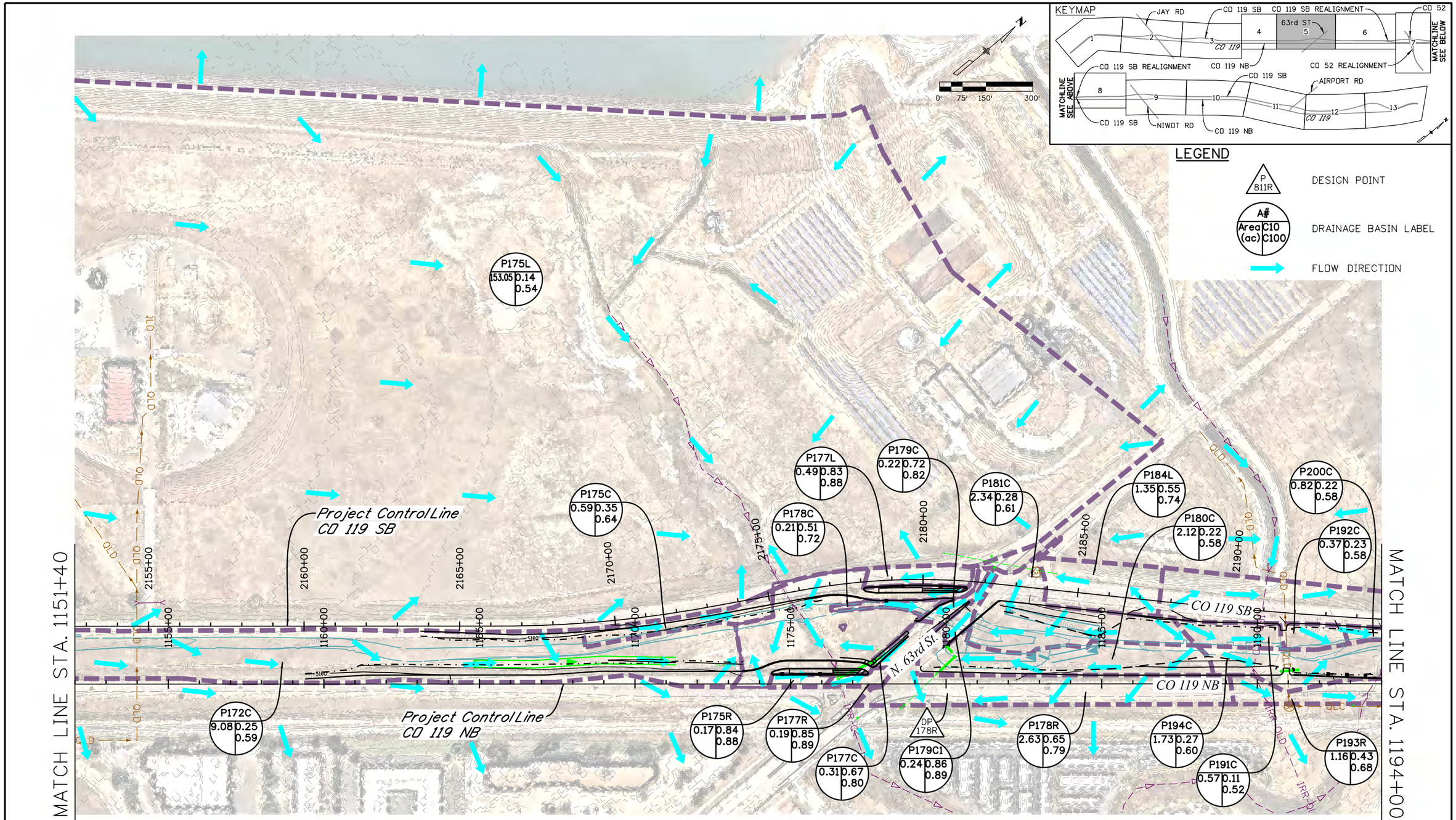
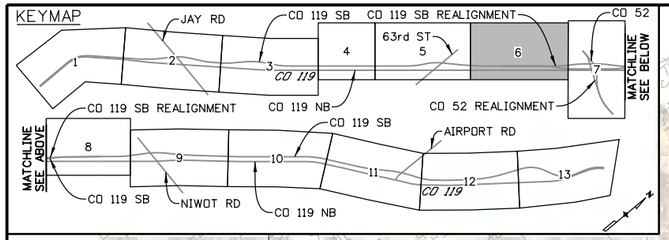


All seals for this set of drawings are applied to the cover page(s)	Print Date: 8/9/2022 File Name: 21497_HY_BAS_PR_Basins_05.dgn Horiz. Scale: Vert. Scale: As Noted Unit Information MULLER ENGINEERING COMPANY		Sheet Revisions Date: / Comments / Init.	Colorado Department of Transportation 1050 Lee Hill Road Boulder, CO 80302 Phone: 303-546-5676 FAX: 303-444-0751 Region 4 DM	As Constructed No Revisions: Revised: Void:	CO 119 MOBILITY PROPOSED DRAINAGE BASIN MAP STA. 1194+00 TO STA. 1237+00 Designer: EPT / Structure Numbers: Detailer: LMR Sheet Subset: PR DRBAS / Subset Sheets: 5 of 13	Project No./Code STA 1191-033 21497 Sheet Number

KEYMAP



LEGEND

DP 811R — DESIGN POINT

A# / Area (ac) / C10 / C100 — DRAINAGE BASIN LABEL

FLOW DIRECTION

0' 75' 150' 300'

100-YEAR FLOOD HAZARD ZONE AE

Project Control Line CO 119 SB

Project Control Line CO 119 NB

Dry Creek No. 2

CO 119 SB

CO 119 NB

IBM Plant

MATCH LINE STA. 1194+00

MATCH LINE STA. 1237+00

P195L 2.88 0.47 0.70

P201L 0.99 0.46 0.70

P200C 0.82 0.22 0.58

DP 201L

P193R 1.16 0.43 0.68

P194C 1.73 0.27 0.60

P200R 2.54 0.26 0.60

P222L 0.72 0.39 0.66

P216C 4.17 0.20 0.57

DP 216C

P234L 3.68 0.24 0.59

P238L 0.98 0.05 0.49

P238L1 1.18 0.46 0.70

P234C 2.18 0.32 0.63

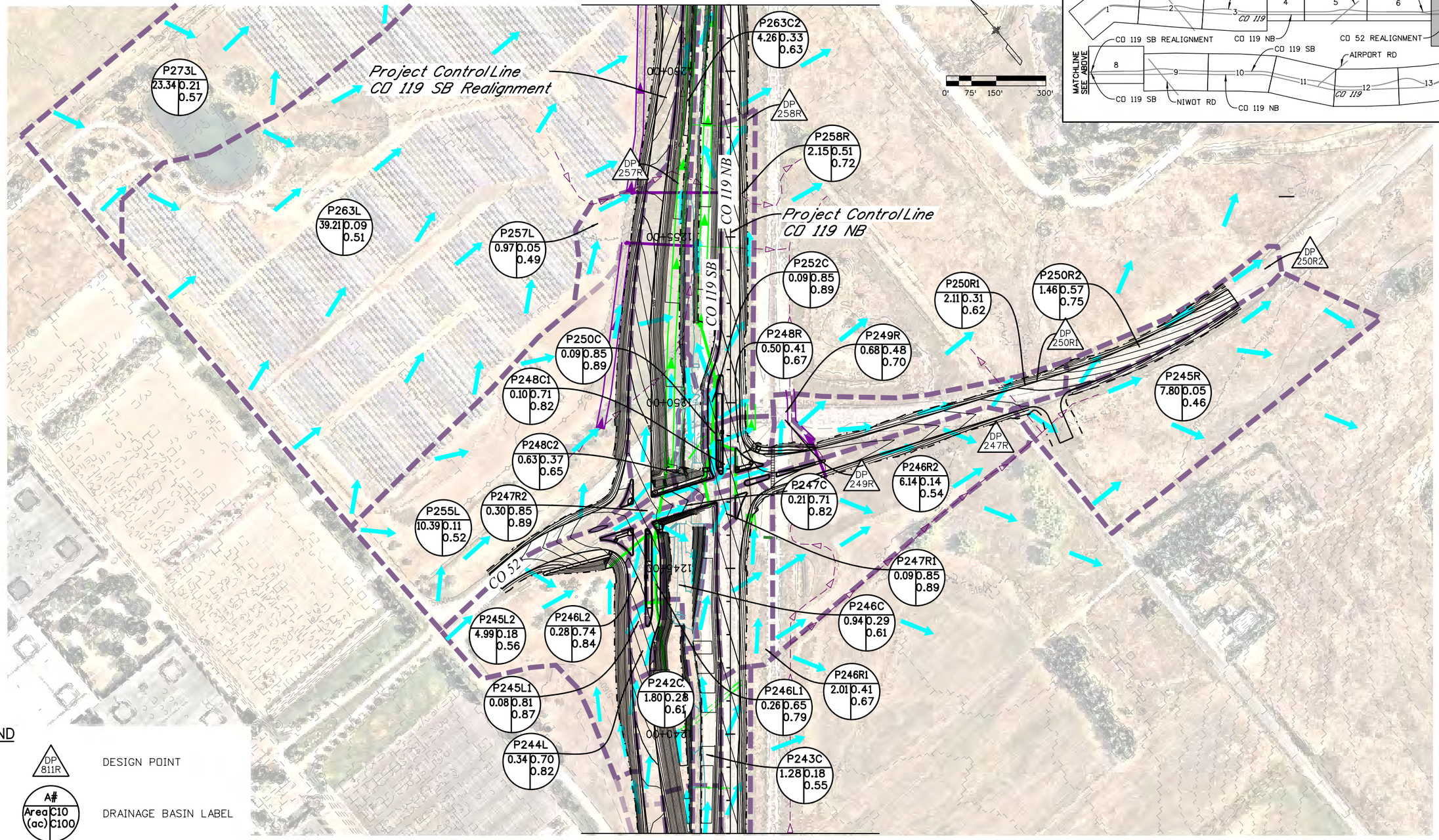
DP 234C

P242R 2.33 0.53 0.73

P238C 0.92 0.25 0.59

All seals for this set of drawings are applied to the cover page(s)	Print Date: 8/9/2022 File Name: 21497_HY_BAS_PR_Basins_06.dgn Horiz. Scale: Vert. Scale: As Noted Unit Information MULLER ENGINEERING COMPANY	Sheet Revisions Date / Comments / Init.	Colorado Department of Transportation 1050 Lee Hill Road Boulder, CO 80302 Phone: 303-546-5676 FAX: 303-444-0751 Region 4 DM	As Constructed No Revisions: Revised: Void:	CO 119 MOBILITY PROPOSED DRAINAGE BASIN MAP STA. 1194+00 TO STA. 1237+00 Designer: EPT Detailer: LMR Sheet Subset: PR DRBAS Structure Numbers Subset Sheets: 6 of 13	Project No./Code STA 1191-033 21497 Sheet Number

MATCH LINE STA. 1262+00



MATCH LINE STA. 1237+00

LEGEND

- DP 811R — DESIGN POINT
- A# / Area (ac) / C10 / C100 — DRAINAGE BASIN LABEL
- FLOW DIRECTION

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_PR_Basins_07.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
PROPOSED DRAINAGE BASIN MAP
STA. 1237+00 TO STA. 1262+00

Designer: EPT
Detailer: LMR
Sheet Subset: PR DRBAS
Structure Numbers:
Subset Sheets: 7 of 13

Project No./Code: STA 1191-033
21497
Sheet Number

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KEYMAP

JAY RD
CO 119 SB
CO 119 SB REALIGNMENT
63rd ST
CO 52
CO 119
CO 119 NB
CO 52 REALIGNMENT
MATCHLINE SEE BELOW
MATCHLINE SEE ABOVE
AIRPORT RD
NIWOT RD

LEGEND

DESIGN POINT

DRAINAGE BASIN LABEL

FLOW DIRECTION

0' 75' 150' 300'

MATCH LINE STA. 1262+00

MATCH LINE STA. 1299+00

CO 119 SB

CO 119 NB

N. 71st St.

Monarch Rd.

QLD

Project Control Line
CO 119 SB

Project Control Line
CO 119 NB

P273L 23.34 0.21 0.57

P263L 39.21 0.09 0.51

P268L 2.36 0.29 0.61

P276L 0.92 0.56 0.75

DP 276L

P307L 6.59 0.45 0.69

DP 267C

DP 275C

P265C 0.22 0.16 0.55

P263C1 2.71 0.81 0.55

P267C 0.94 0.30 0.61

P275C 3.33 0.30 0.61

P276C 0.61 0.32 0.63

P307C 5.79 0.11 0.52

1265+00 1270+00 1275+00 1280+00 1285+00 1290+00 1295+00 2290+00 2295+00 2300+00

All seals for this set of drawings are applied to the cover page(s)	Print Date: 8/9/2022 File Name: 21497_HY_BAS_PR_Basins_08.dgn Horiz. Scale: Vert. Scale: As Noted Unit Information MULLER ENGINEERING COMPANY	Sheet Revisions Date: Comments: Init.	Colorado Department of Transportation 1050 Lee Hill Road Boulder, CO 80302 Phone: 303-546-5676 FAX: 303-444-0751 Region 4 DM	As Constructed No Revisions: Revised: Void:	CO 119 MOBILITY PROPOSED DRAINAGE BASIN MAP STA. 1262+00 TO STA. 1299+00 Designer: EPT Detailer: LMR Sheet Subset: PR DRBAS Structure Numbers Subset Sheets: 8 of 13	Project No./Code STA 1191-033 21497 Sheet Number

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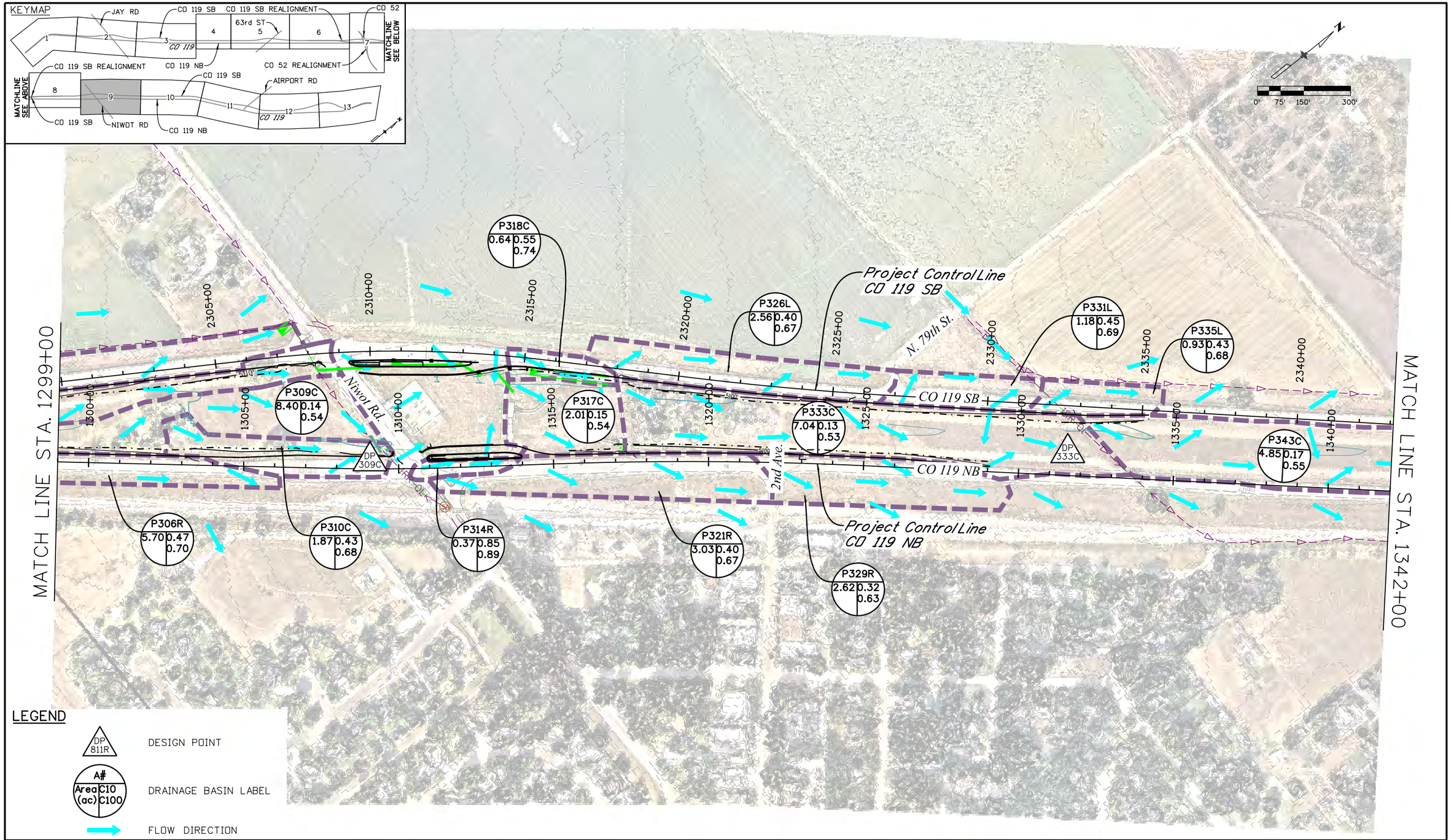

LEGEND

DP 811R — DESIGN POINT

A# / Area (ac) / C10 / C100 — DRAINAGE BASIN LABEL

FLOW DIRECTION

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_PR_Basins_09.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
PROPOSED DRAINAGE BASIN MAP
STA. 1299+00 TO STA. 1342+00

Designer: EPT | Structure Numbers:
Detailer: LMR
Sheet Subset: PR DRBAS | Subset Sheets: 9 of 13

Project No./Code
STA 1191-033
21497
Sheet Number

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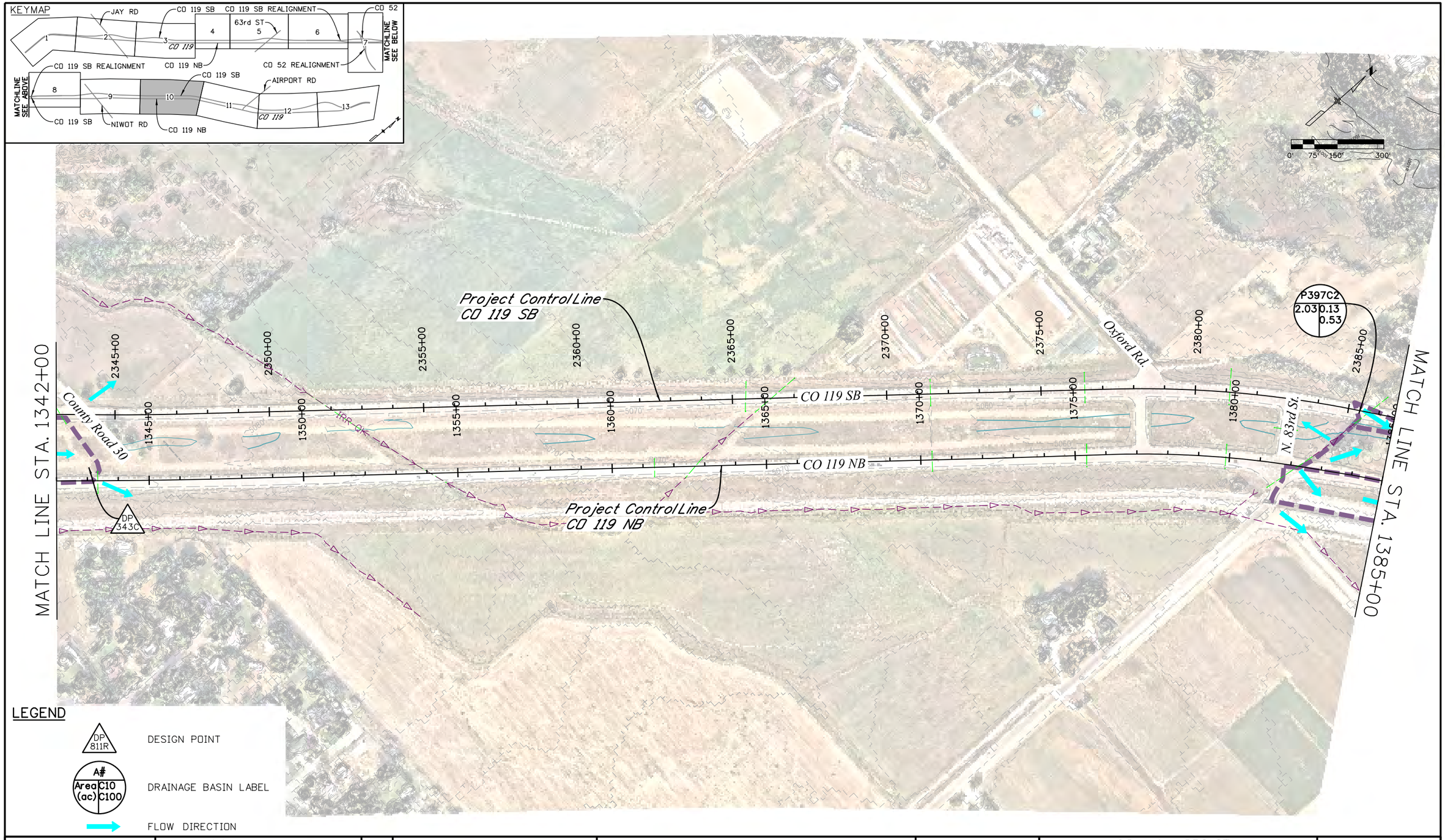


All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_PR_Basins_10.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions		
Date:	Comments	Init.

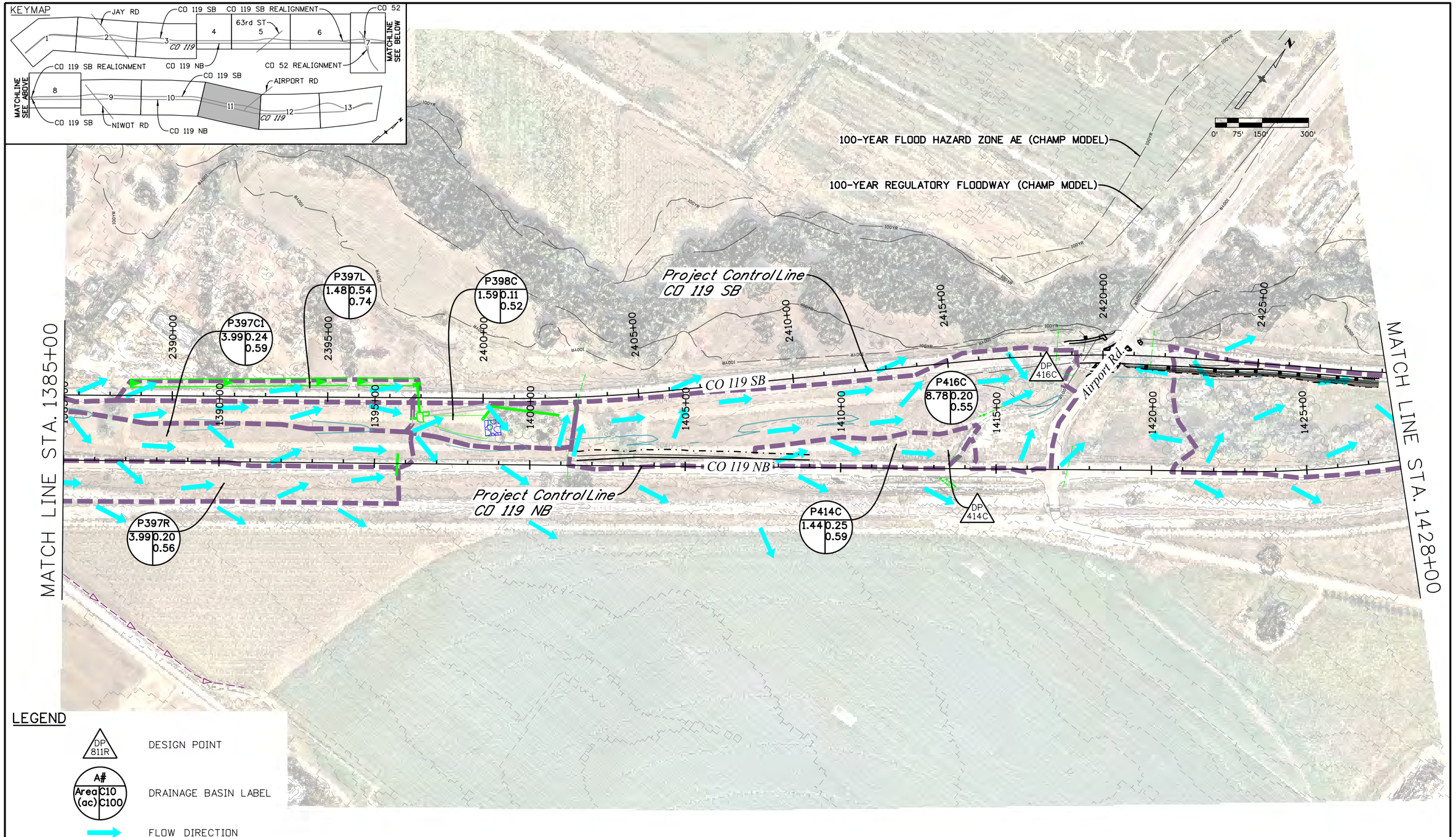
Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
PROPOSED DRAINAGE BASIN MAP
STA. 1342+00 TO STA. 1385+00

Designer: EPT
Detailer: LMR
Sheet Subset: PR DRBAS
Structure Numbers:
Subset Sheets: 10 of 13

Project No./Code: STA 1191-033
21497
Sheet Number



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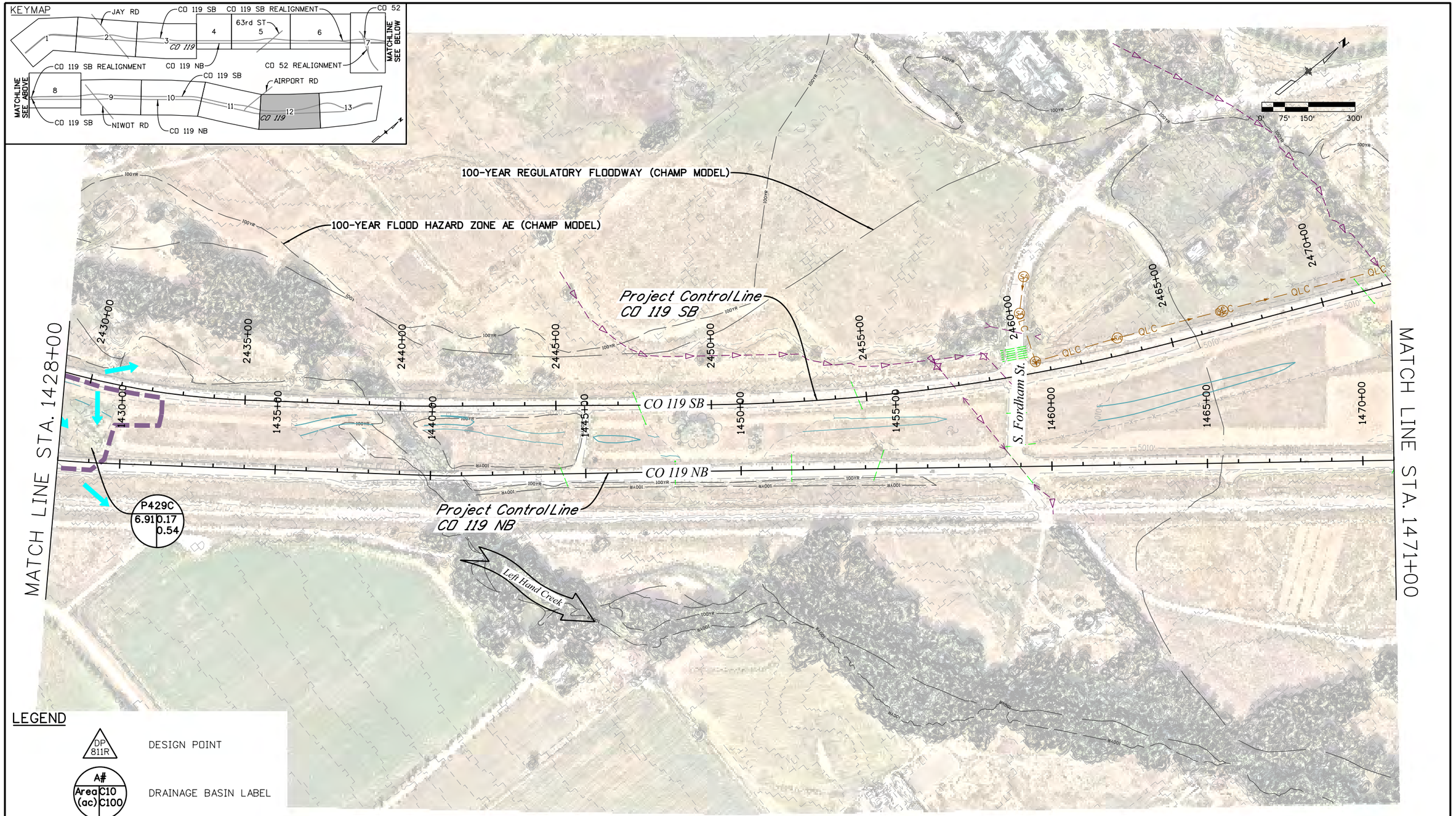
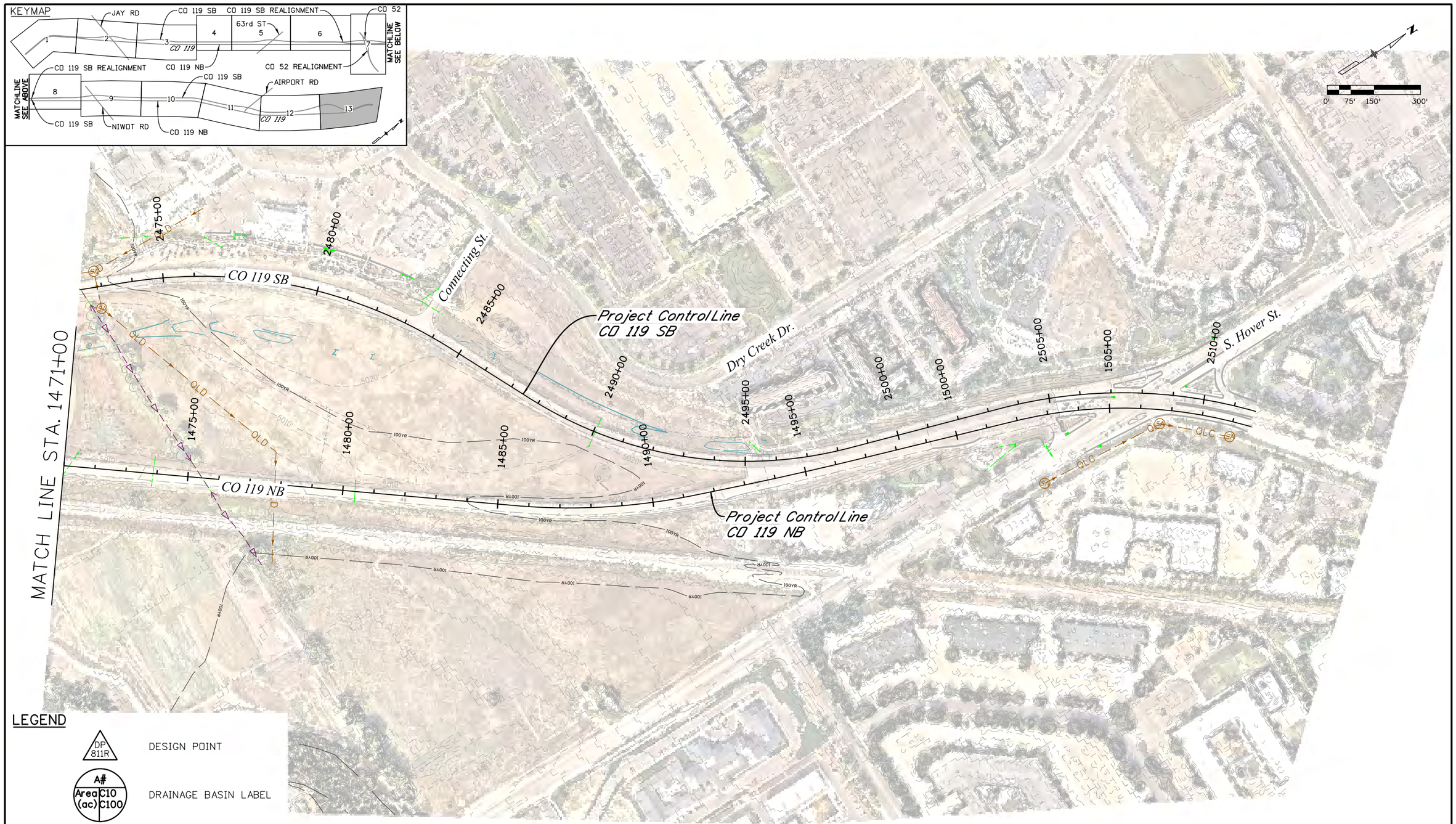


All seals for this set of drawings are applied to the cover page(s)	Print Date: 8/9/2022 File Name: 21497_HY_BAS_PR_Basins_12.dgn Horiz. Scale: Vert. Scale: As Noted Unit Information MULLER ENGINEERING COMPANY	Sheet Revisions Date / Comments / Init.	Colorado Department of Transportation 1050 Lee Hill Road Boulder, CO 80302 Phone: 303-546-5676 FAX: 303-444-0751 Region 4 DM	As Constructed No Revisions: Revised: Void:	CO 119 MOBILITY PROPOSED DRAINAGE BASIN MAP STA. 1428+00 TO STA. 1471+00 Designer: EPT Detailer: LMR Sheet Subset: PR DRBAS Structure Numbers Subset Sheets: 12 of 13	Project No./Code STA 1191-033 21497 Sheet Number



LEGEND

- DP 811R — DESIGN POINT
- A# / Area / C10 / C100 (ac) — DRAINAGE BASIN LABEL
- FLOW DIRECTION

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_BAS_PR_Basins_13.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

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Date:	Comments	Init.

Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
PROPOSED DRAINAGE BASIN MAP
STA. 1471+00 TO STA. 1509+61

Designer: EPT
Detailer: LMR
Sheet Subset: PR DRBAS
Structure Numbers:
Subset Sheets: 13 of 13

Project No./Code
STA 1191-033
21497
Sheet Number

Hydrologic Soils Report (NRCS)

United States Department of Agriculture

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

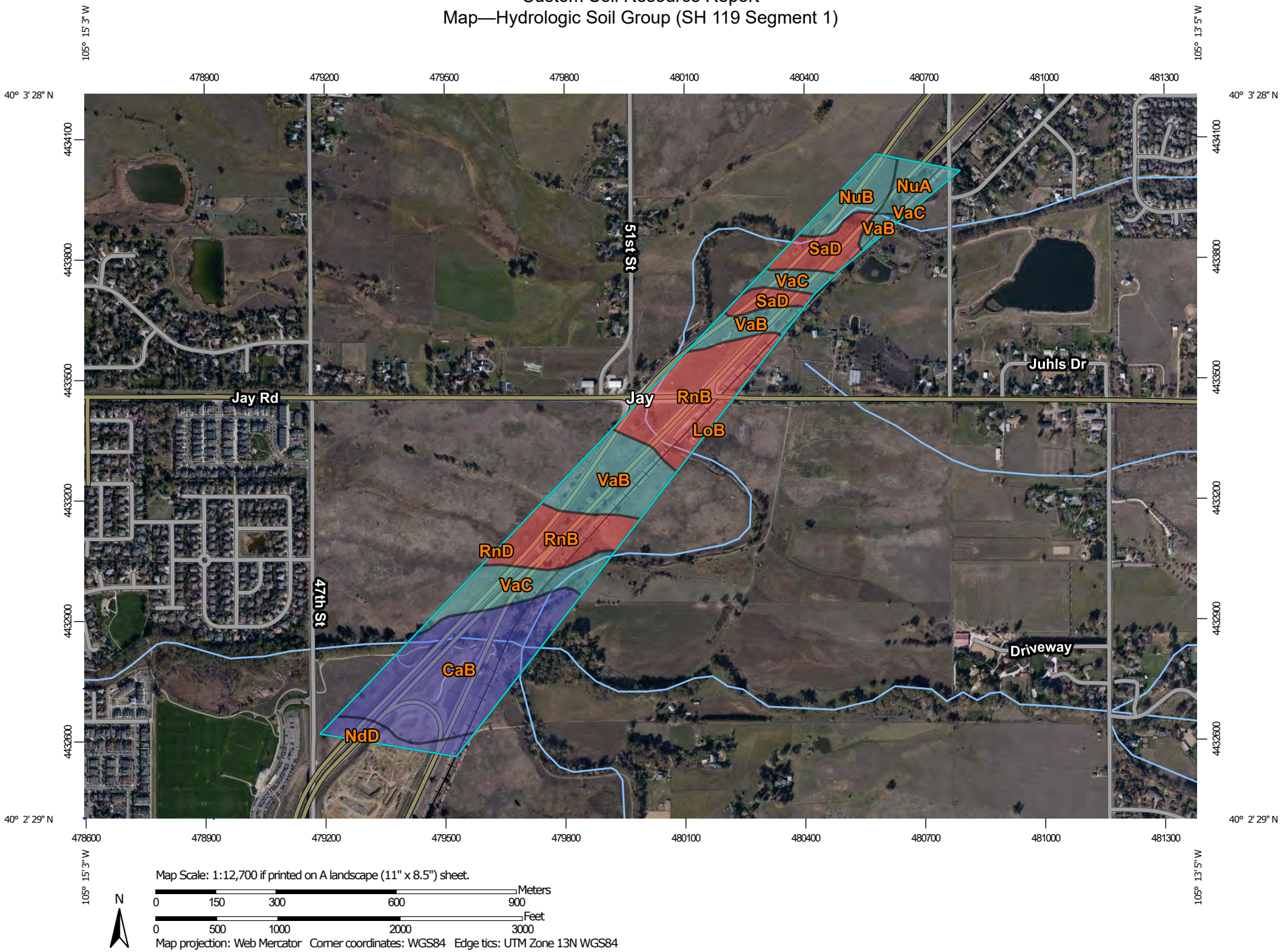
January 27, 2022

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.

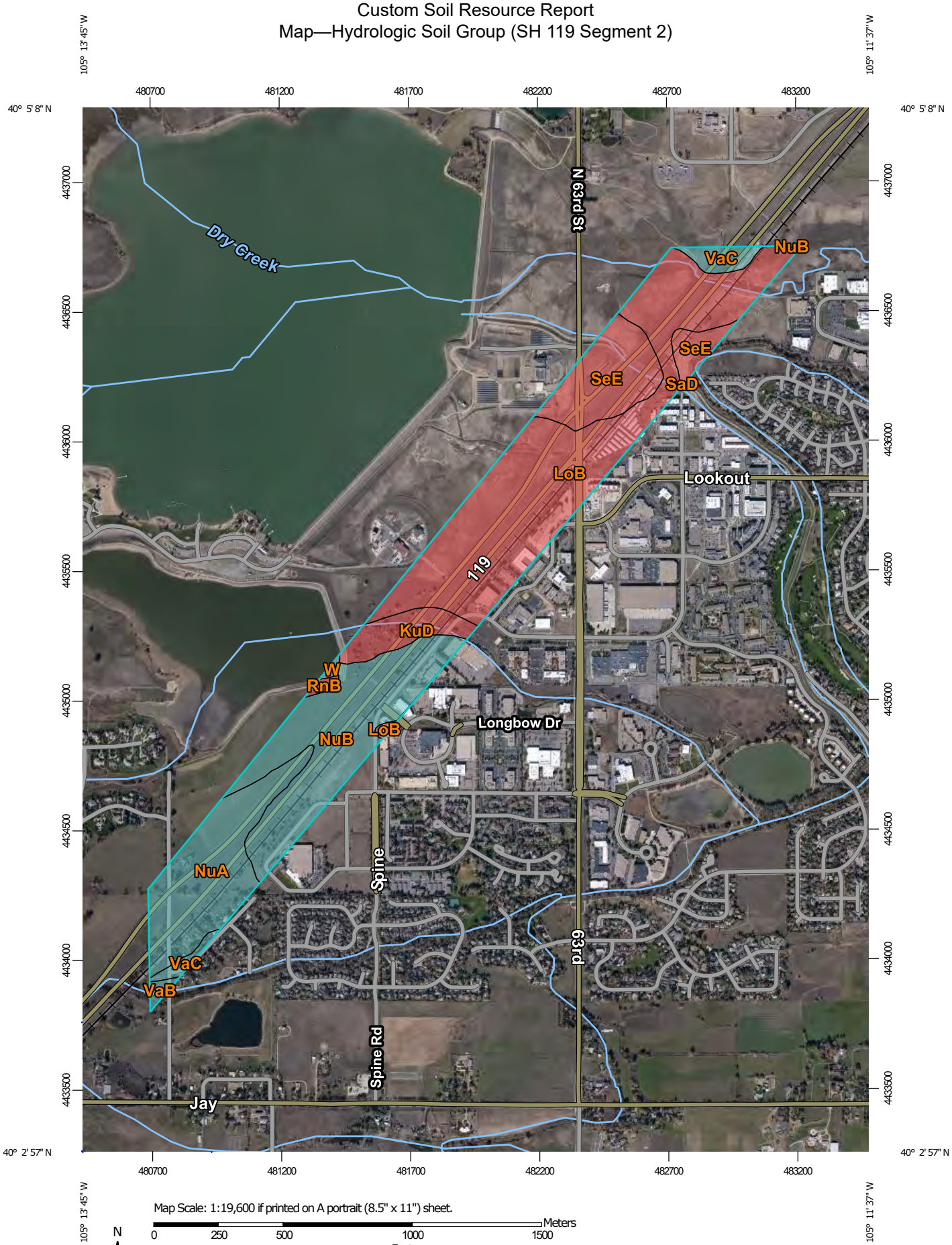
Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over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



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



Custom Soil Resource Report
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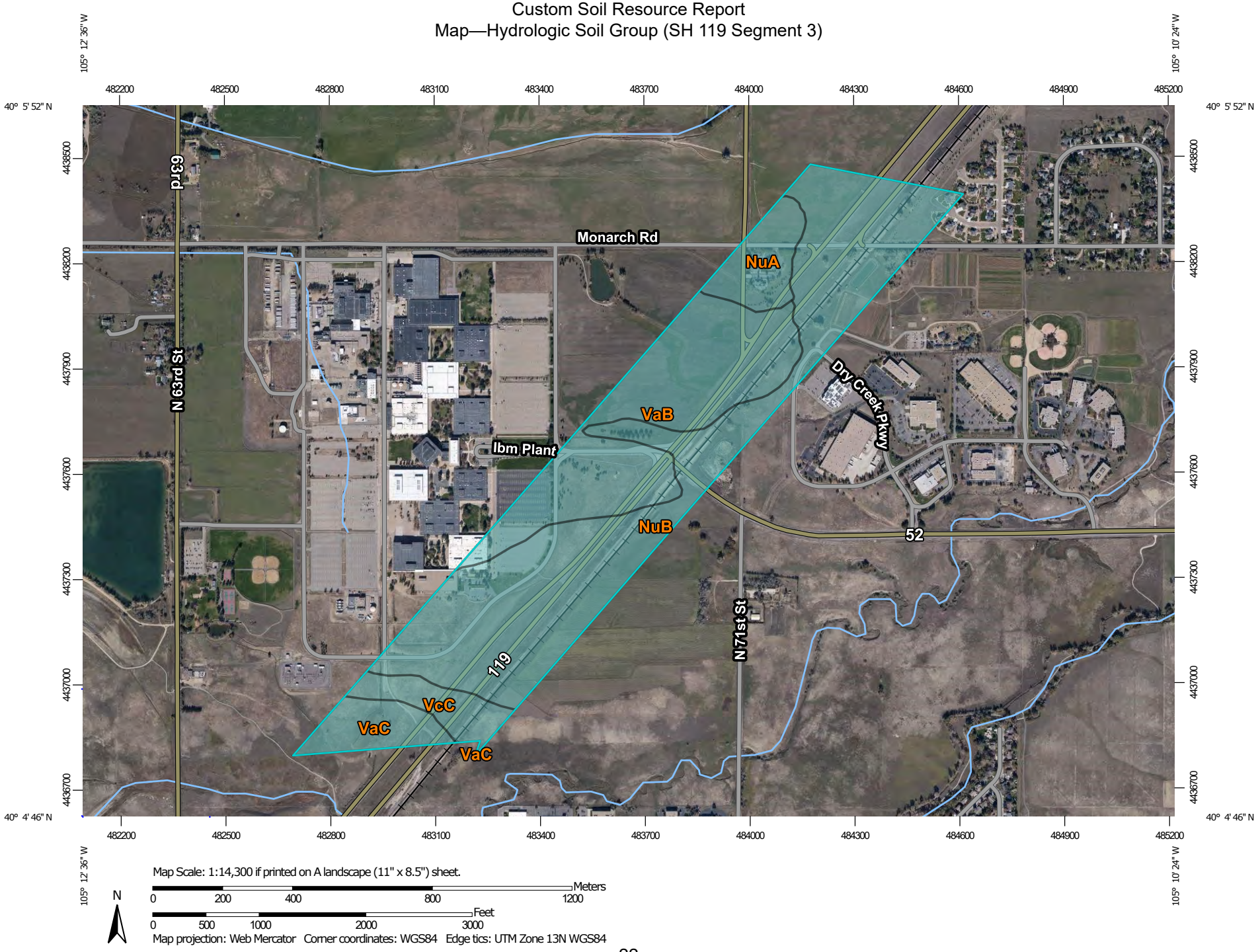

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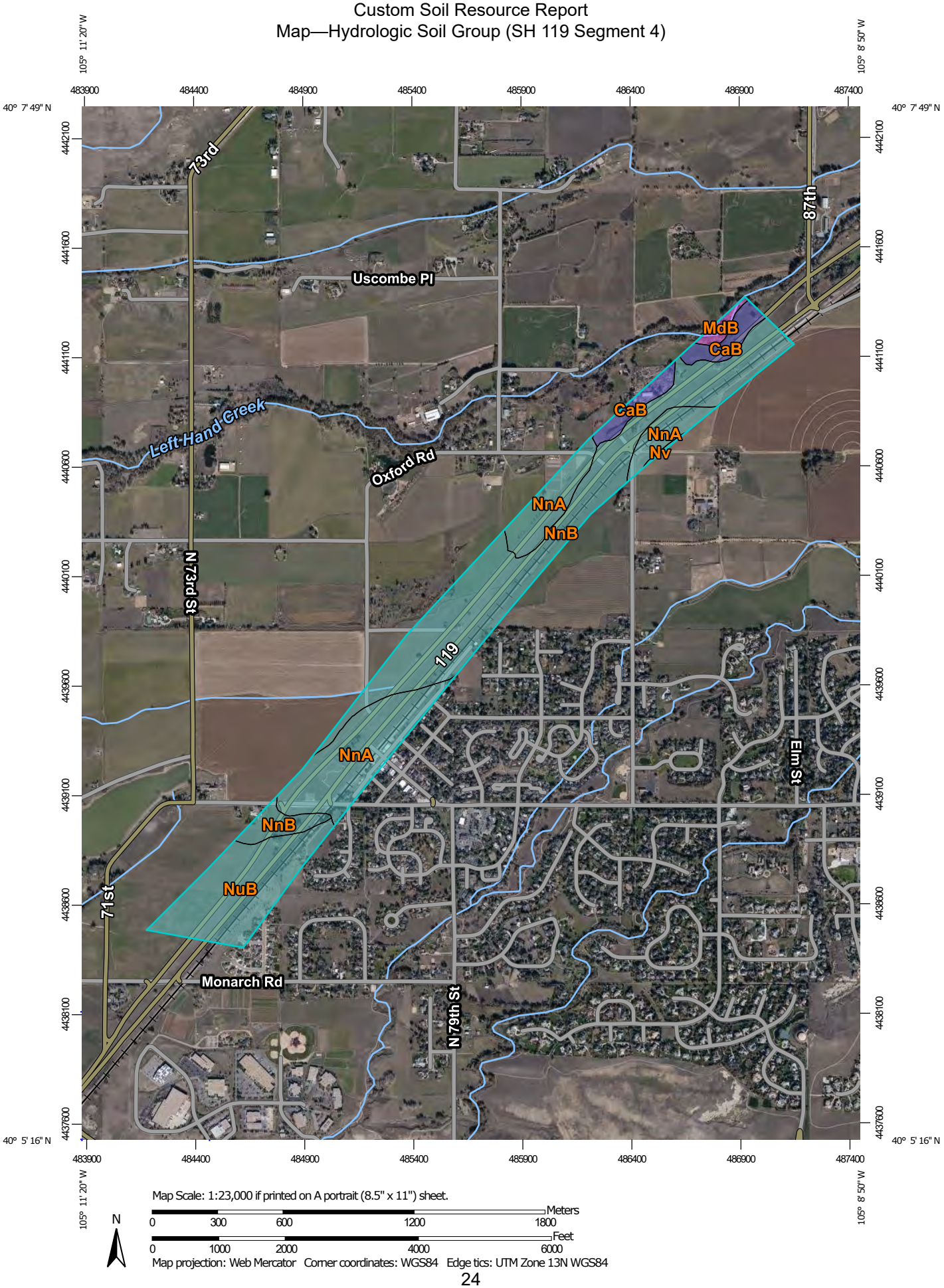

Custom Soil Resource Report
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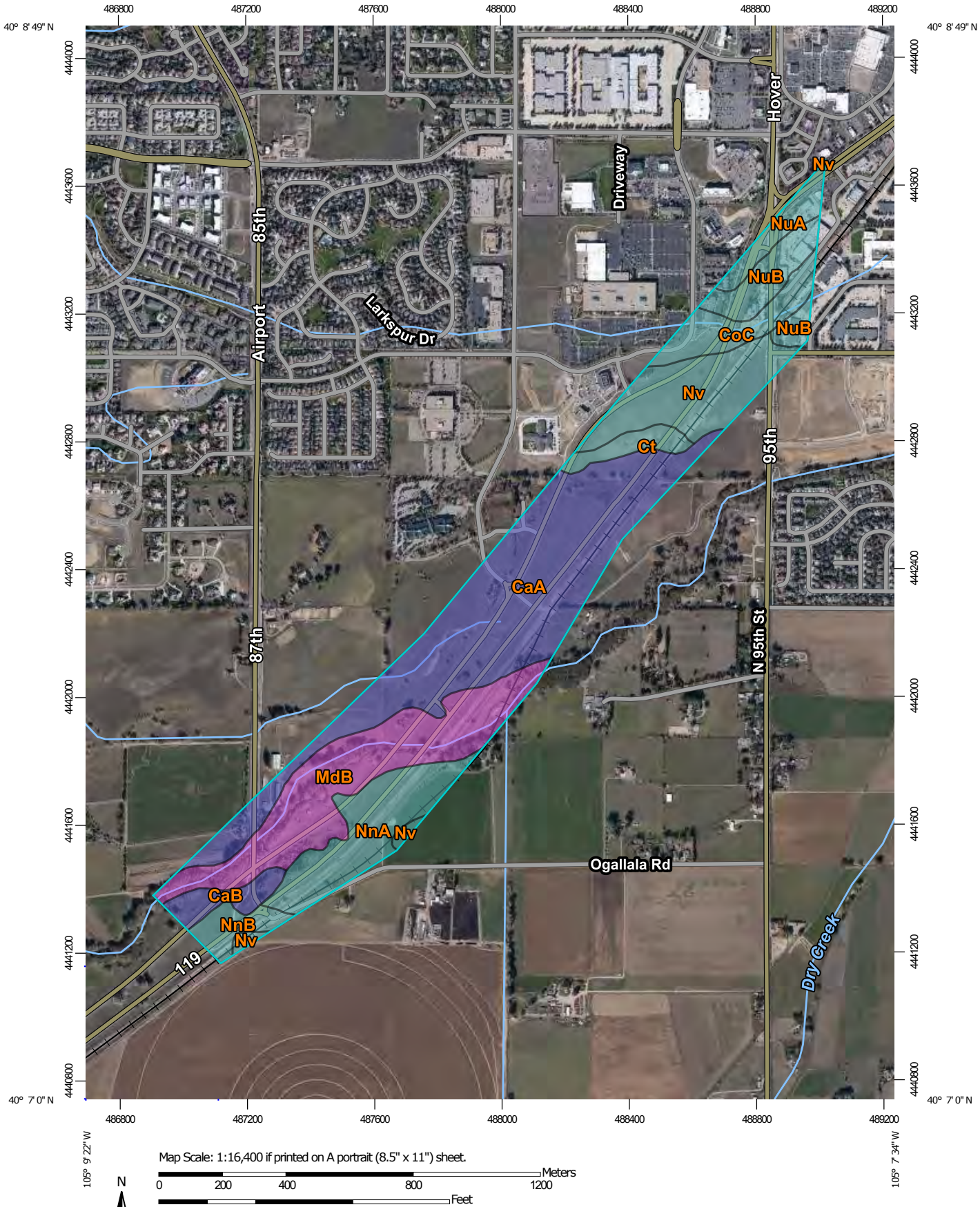
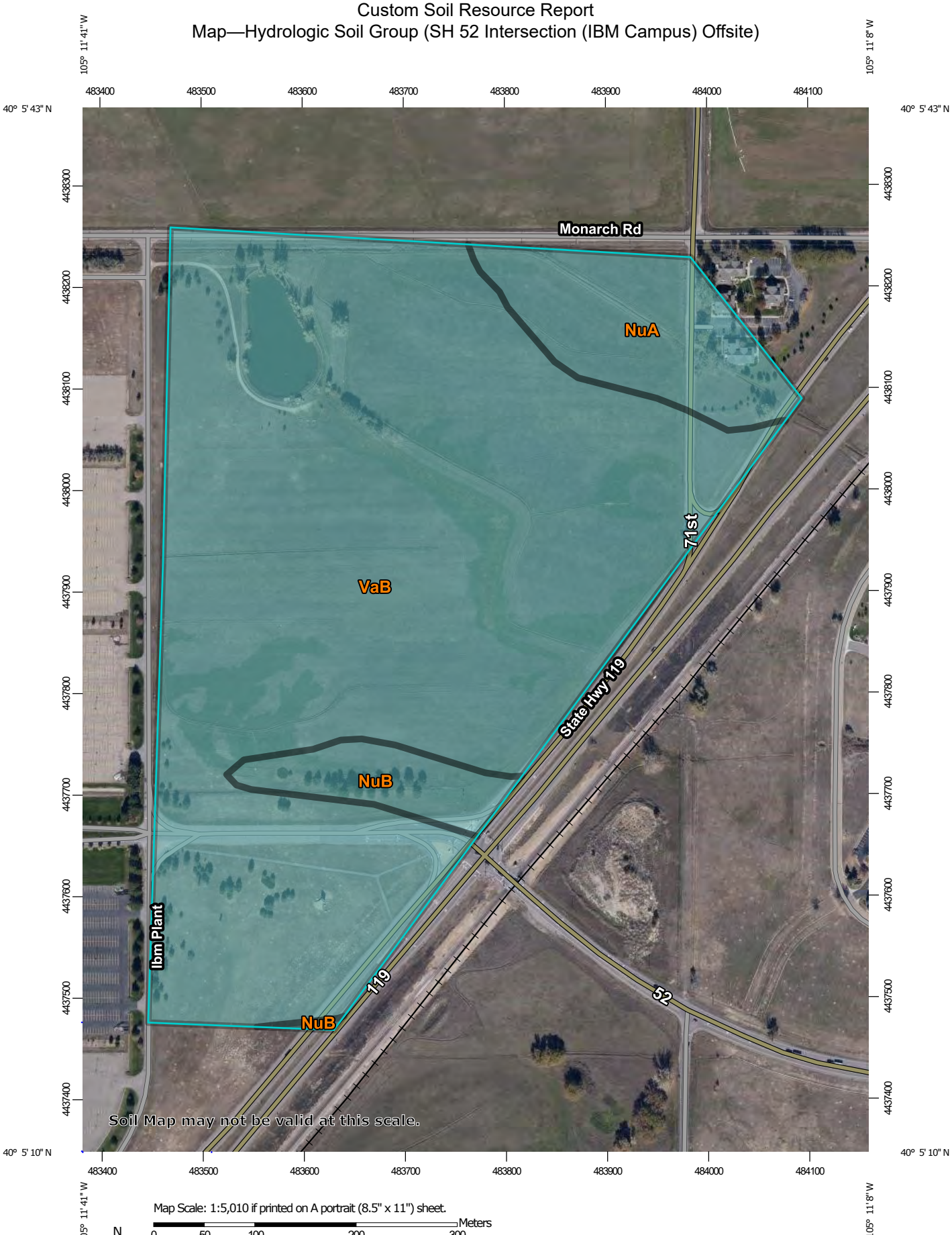
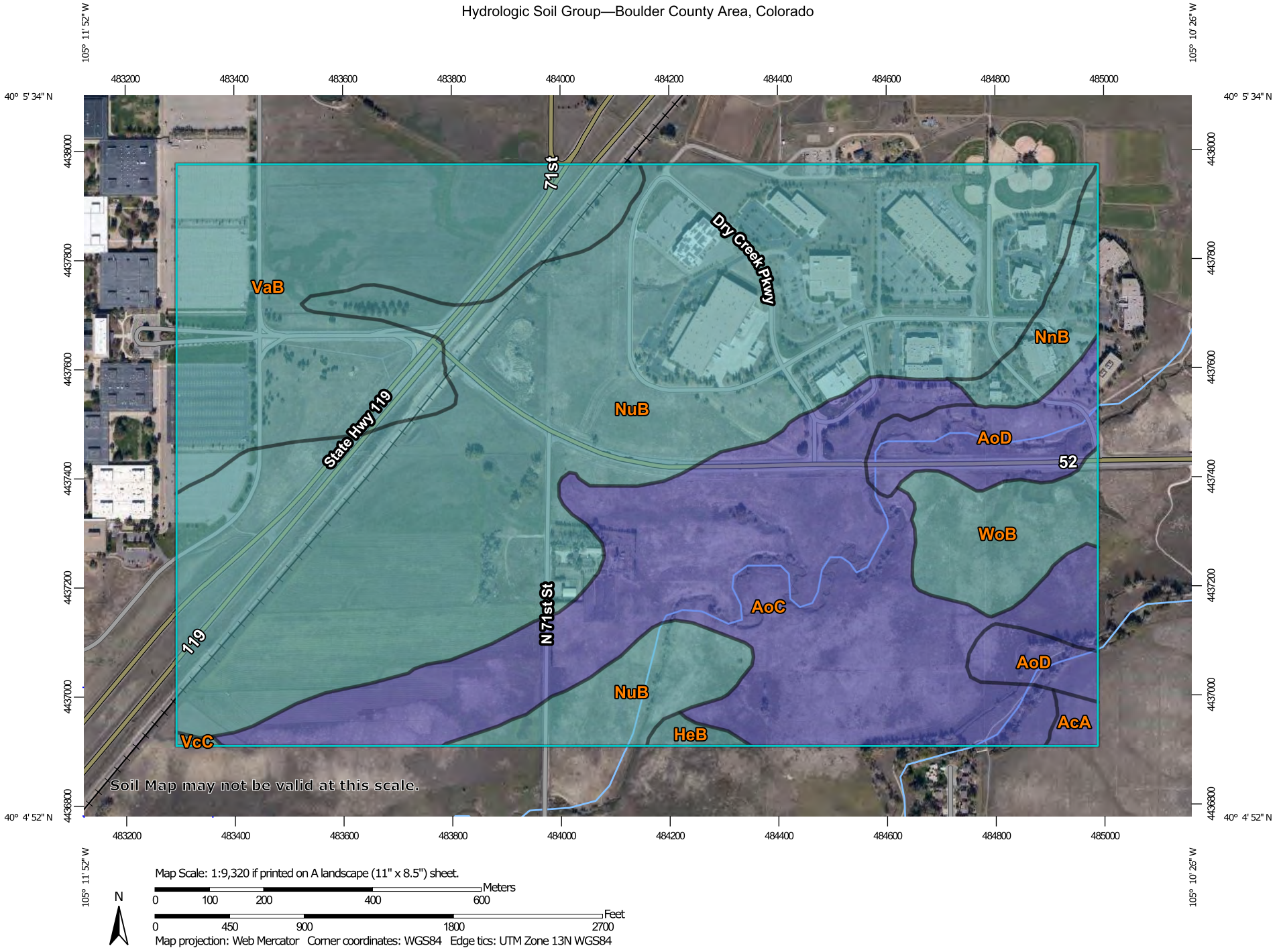


Custom Soil Resource Report
Map—Hydrologic Soil Group (SH 52 Intersection (IBM Campus) Offsite)




Hydrologic Soil Group—Boulder County Area, Colorado
105° 11' 52" W
105° 10' 26" W
40° 5' 34" N
40° 4' 52" N
483200
483400
483600
483800
484000
484200
484400
484600
484800
485000
4438000
4437800
4437600
4437400
4437200
4437000
4436800
71st
Dry Creek Pkwy
State Hwy 119
N 71st St
119
52
VaB
NnB
NuB
AoD
WoB
AoC
AcA
HeB
VcC
Soil Map may not be valid at this scale.
Map Scale: 1:9,320 if printed on A landscape (11" x 8.5") sheet.
N
Meters
0 100 200 400 600
Feet
0 450 900 1800 2700
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.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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.

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

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.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

NOAA Atlas 14 Rainfall Data

NOAA Atlas 14, Volume 8, Version 2
Location name: Longmont, Colorado, USA*
Latitude: 40.1016°, Longitude: -105.1761°
Elevation: 5110.5 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.218** (0.176-0.272)	**0.265** (0.213-0.331)	**0.359** (0.288-0.450)	**0.453** (0.361-0.571)	**0.608** (0.477-0.825)	**0.748** (0.565-1.02)	**0.904** (0.655-1.26)	**1.08** (0.744-1.54)	**1.34** (0.881-1.96)	**1.56** (0.985-2.27)
10-min	**0.319** (0.257-0.399)	**0.387** (0.312-0.485)	**0.525** (0.421-0.659)	**0.664** (0.529-0.836)	**0.891** (0.699-1.21)	**1.10** (0.827-1.49)	**1.32** (0.959-1.84)	**1.58** (1.09-2.26)	**1.96** (1.29-2.87)	**2.28** (1.44-3.33)
15-min	**0.389** (0.314-0.486)	**0.472** (0.380-0.591)	**0.640** (0.514-0.803)	**0.809** (0.645-1.02)	**1.09** (0.852-1.47)	**1.34** (1.01-1.82)	**1.61** (1.17-2.25)	**1.93** (1.33-2.75)	**2.39** (1.57-3.50)	**2.78** (1.76-4.06)
30-min	**0.529** (0.427-0.661)	**0.641** (0.516-0.802)	**0.867** (0.695-1.09)	**1.10** (0.872-1.38)	**1.47** (1.15-1.99)	**1.81** (1.37-2.46)	**2.18** (1.58-3.04)	**2.61** (1.80-3.73)	**3.24** (2.13-4.74)	**3.76** (2.38-5.50)
60-min	**0.652** (0.525-0.814)	**0.791** (0.637-0.990)	**1.07** (0.859-1.34)	**1.35** (1.08-1.71)	**1.81** (1.42-2.46)	**2.23** (1.68-3.03)	**2.69** (1.95-3.74)	**3.21** (2.21-4.58)	**3.98** (2.62-5.81)	**4.61** (2.92-6.74)
2-hr	**0.774** (0.629-0.958)	**0.941** (0.764-1.17)	**1.28** (1.03-1.59)	**1.61** (1.29-2.01)	**2.16** (1.71-2.89)	**2.65** (2.02-3.56)	**3.19** (2.33-4.40)	**3.81** (2.65-5.38)	**4.71** (3.13-6.82)	**5.46** (3.50-7.91)
3-hr	**0.847** (0.692-1.04)	**1.03** (0.841-1.27)	**1.40** (1.13-1.72)	**1.76** (1.42-2.18)	**2.34** (1.86-3.12)	**2.86** (2.19-3.83)	**3.44** (2.53-4.71)	**4.10** (2.87-5.75)	**5.05** (3.38-7.27)	**5.85** (3.77-8.42)
6-hr	**1.02** (0.840-1.24)	**1.23** (1.01-1.50)	**1.65** (1.35-2.02)	**2.05** (1.67-2.52)	**2.70** (2.16-3.55)	**3.28** (2.53-4.33)	**3.91** (2.90-5.29)	**4.62** (3.27-6.41)	**5.66** (3.83-8.05)	**6.52** (4.25-9.29)
12-hr	**1.27** (1.05-1.53)	**1.52** (1.26-1.83)	**2.00** (1.65-2.41)	**2.45** (2.01-2.98)	**3.17** (2.55-4.10)	**3.80** (2.95-4.94)	**4.48** (3.35-5.98)	**5.25** (3.74-7.18)	**6.35** (4.33-8.92)	**7.26** (4.78-10.2)
24-hr	**1.51** (1.26-1.80)	**1.84** (1.54-2.20)	**2.43** (2.03-2.92)	**2.97** (2.46-3.58)	**3.79** (3.05-4.80)	**4.47** (3.49-5.72)	**5.20** (3.91-6.82)	**5.99** (4.30-8.07)	**7.11** (4.89-9.85)	**8.01** (5.34-11.2)
2-day	**1.70** (1.44-2.01)	**2.14** (1.81-2.54)	**2.89** (2.42-3.43)	**3.53** (2.95-4.21)	**4.45** (3.59-5.52)	**5.18** (4.07-6.52)	**5.94** (4.50-7.66)	**6.74** (4.87-8.93)	**7.83** (5.43-10.7)	**8.68** (5.85-12.0)
3-day	**1.86** (1.58-2.18)	**2.31** (1.95-2.71)	**3.07** (2.59-3.61)	**3.72** (3.12-4.40)	**4.66** (3.77-5.74)	**5.41** (4.27-6.75)	**6.18** (4.70-7.92)	**6.99** (5.09-9.21)	**8.10** (5.66-11.0)	**8.97** (6.09-12.3)
4-day	**2.00** (1.70-2.33)	**2.43** (2.07-2.85)	**3.18** (2.69-3.73)	**3.82** (3.22-4.51)	**4.76** (3.87-5.84)	**5.51** (4.37-6.86)	**6.29** (4.81-8.03)	**7.11** (5.21-9.34)	**8.25** (5.79-11.1)	**9.14** (6.23-12.5)
7-day	**2.34** (2.00-2.71)	**2.75** (2.35-3.19)	**3.47** (2.96-4.04)	**4.10** (3.47-4.79)	**5.02** (4.13-6.12)	**5.77** (4.62-7.13)	**6.56** (5.06-8.31)	**7.39** (5.46-9.63)	**8.55** (6.06-11.5)	**9.47** (6.52-12.8)
10-day	**2.62** (2.25-3.02)	**3.04** (2.61-3.51)	**3.76** (3.22-4.35)	**4.39** (3.73-5.10)	**5.31** (4.38-6.43)	**6.06** (4.87-7.43)	**6.84** (5.31-8.61)	**7.67** (5.70-9.93)	**8.82** (6.29-11.8)	**9.74** (6.74-13.1)
20-day	**3.38** (2.93-3.86)	**3.86** (3.35-4.41)	**4.67** (4.03-5.35)	**5.36** (4.60-6.16)	**6.33** (5.26-7.54)	**7.10** (5.76-8.58)	**7.89** (6.18-9.79)	**8.71** (6.53-11.1)	**9.82** (7.07-12.9)	**10.7** (7.48-14.3)
30-day	**3.99** (3.48-4.52)	**4.56** (3.97-5.17)	**5.49** (4.77-6.25)	**6.27** (5.41-7.16)	**7.33** (6.11-8.64)	**8.15** (6.64-9.76)	**8.98** (7.06-11.0)	**9.81** (7.39-12.4)	**10.9** (7.91-14.2)	**11.8** (8.29-15.6)
45-day	**4.74** (4.15-5.33)	**5.44** (4.77-6.13)	**6.58** (5.74-7.43)	**7.49** (6.50-8.51)	**8.72** (7.29-10.2)	**9.65** (7.88-11.4)	**10.5** (8.33-12.8)	**11.4** (8.66-14.3)	**12.6** (9.16-16.3)	**13.4** (9.54-17.7)
60-day	**5.37** (4.72-6.02)	**6.20** (5.45-6.96)	**7.53** (6.59-8.47)	**8.59** (7.48-9.70)	**9.98** (8.36-11.6)	**11.0** (9.03-13.0)	**12.0** (9.51-14.5)	**13.0** (9.86-16.2)	**14.2** (10.4-18.2)	**15.1** (10.8-19.8)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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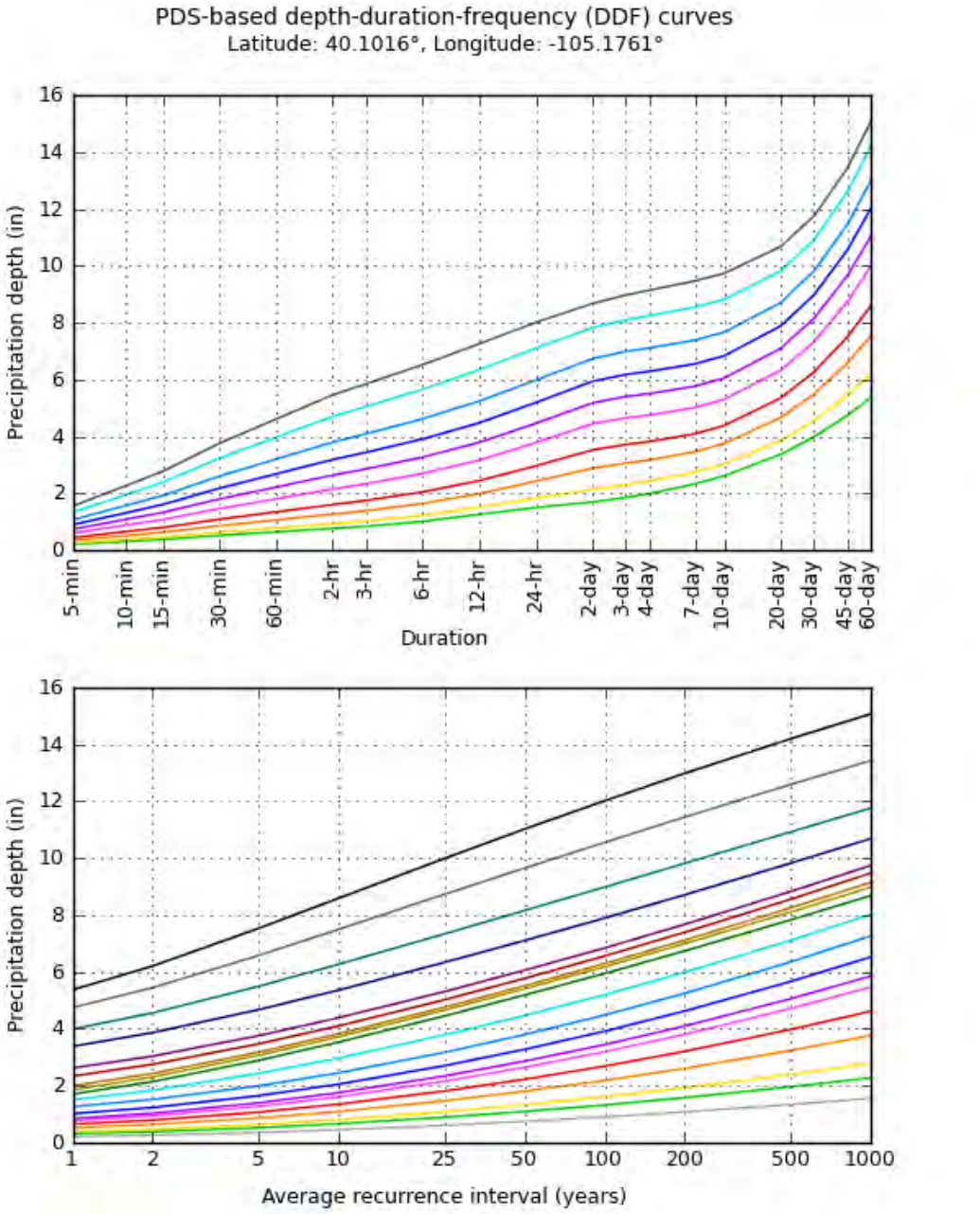
PF graphical



NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Thu Jan 27 19:41:55 2022

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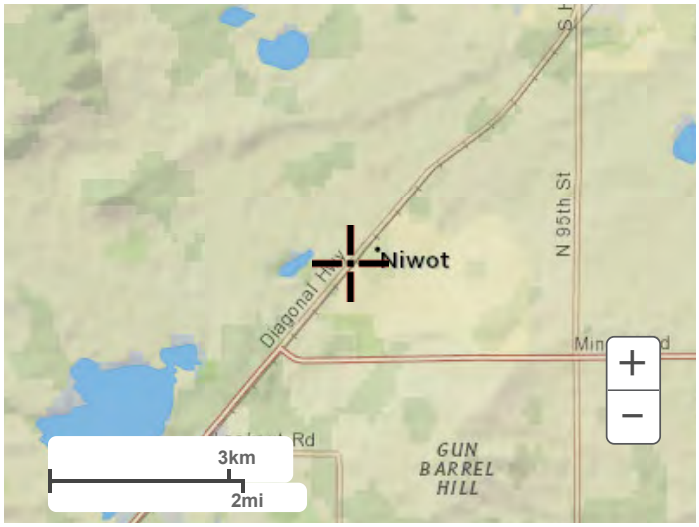
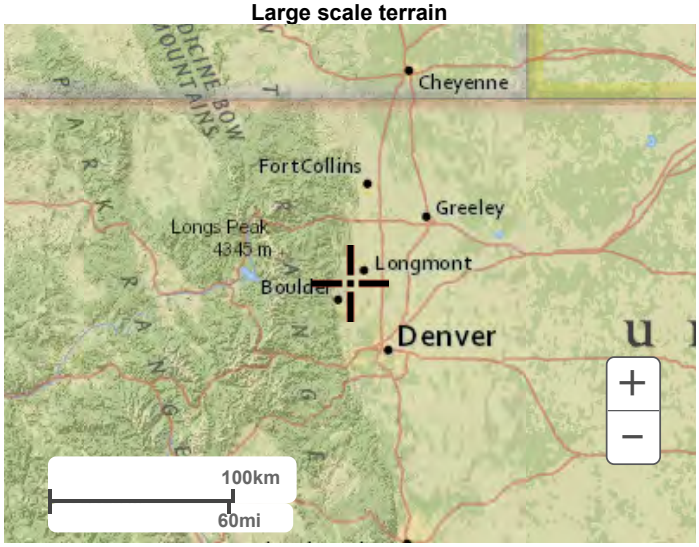
Maps & aerials

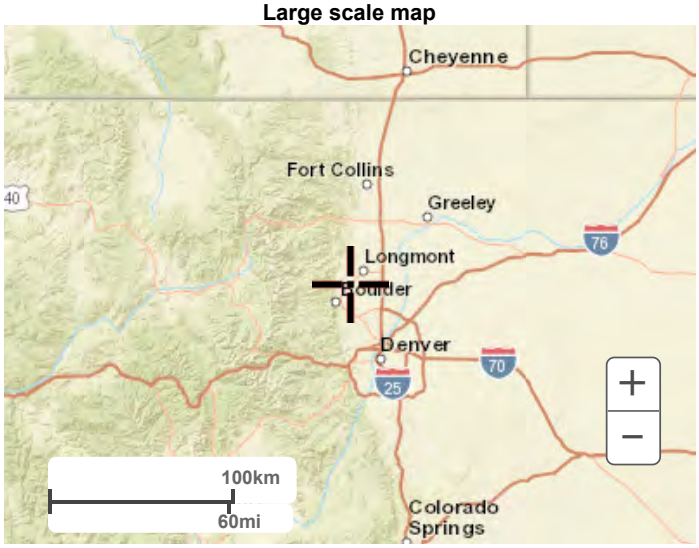
Small scale terrain



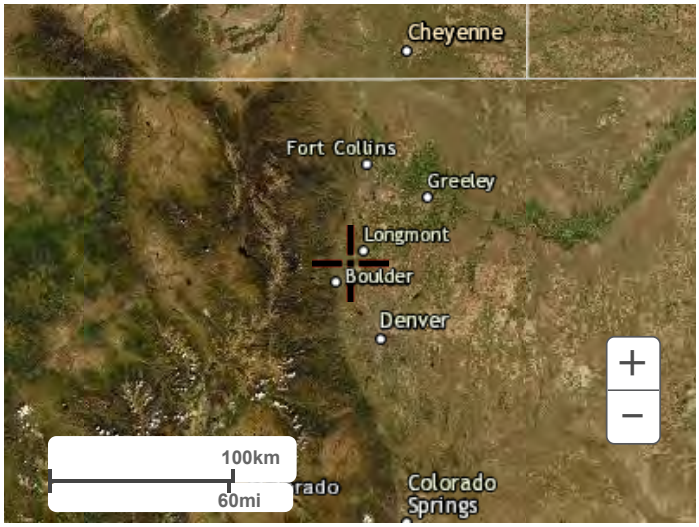
Large scale terrain



Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

FEMA Flood Zone Maps

(Order: Dry Creek, Lefthand Canyon Creek)

National Flood Hazard Layer FIRMette

FEMA

105°12'24"W 40°5'1"N

105°11'46"W 40°4'33"N

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

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
- 20.2 / 17.5 Cross Sections with 1% Annual Chance / Water Surface Elevation
- Coastal Transect
- 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

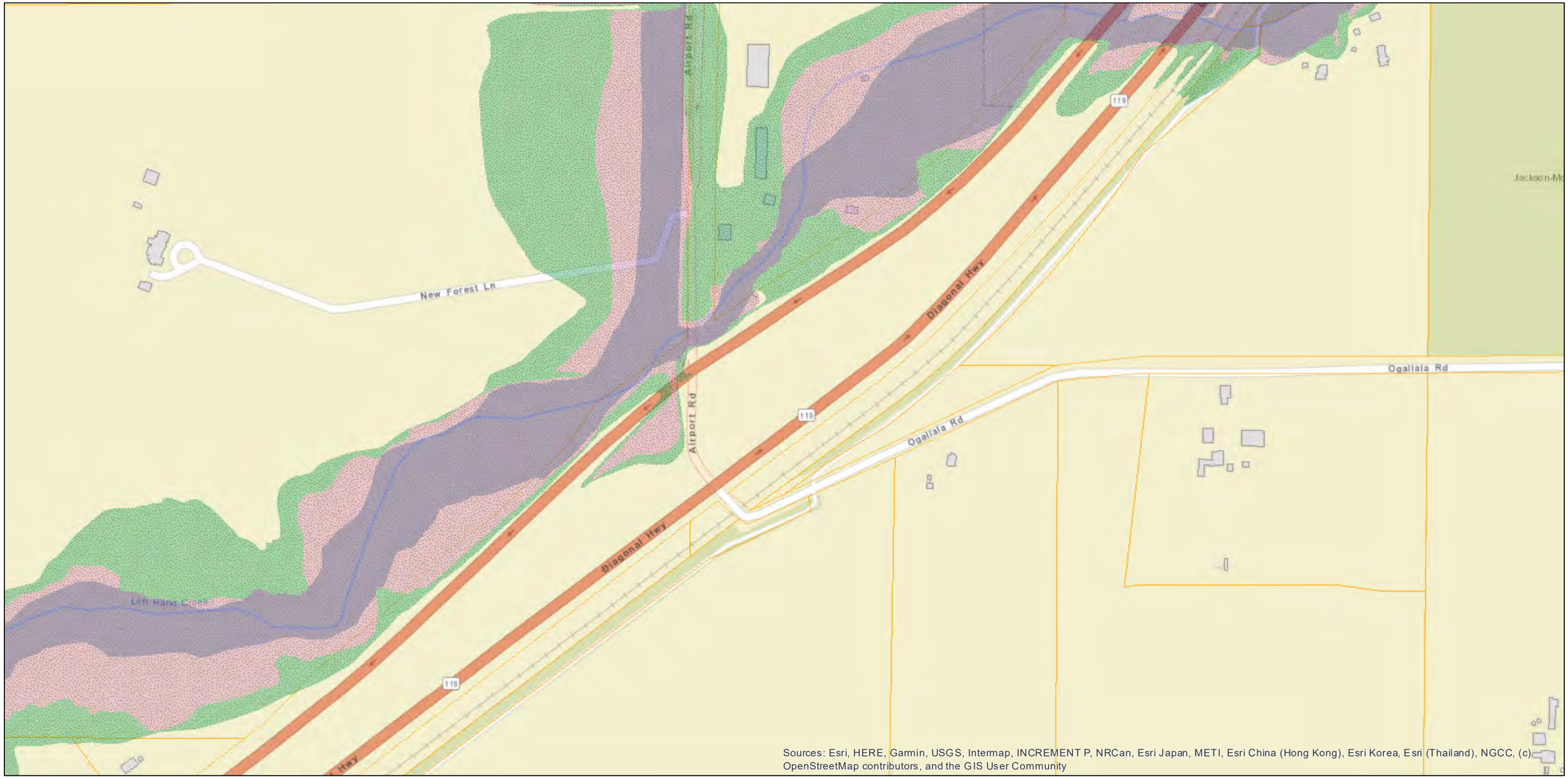
The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

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 4:15 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.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Left Hand Creek CHAMP Zones



Boulder County

Boulder County Regulatory Flood Risk Zones

- Floodway (Boulder County)
- 100-Year Floodplain - Zones AE, A, AO, and AH (Boulder County)
- 500-Year Floodplain - Zone X500 (Boulder County)

Flood Risk Zones (FEMA)

FEMA Regulatory Flood Risk Zones

- Floodway (FEMA)
- 100-Year Floodplain - Zones AE, A, AO and AH (FEMA)
- 500-Year Floodplain - Zone X500 (FEMA)

Assessor Parcels

N
W E
S

0 0.0325 0.065 0.13 mi

APPENDIX B

Hydrology

Existing Hydrology Calculations

Proposed Hydrology Calculations

Existing Hydrology Calculations

CALCULATION COVER SHEET

Project Name:	CO 119 Safety & Mobility Improvements Project	**Project No.**	20-069.01 (Muller)/ 21497 (CDOT)
Design Calculation:	Existing Hydrology	**Version:**	1
Originator	MAK	**Date:**	July 6, 2022
Checker	ZDS/EPT	**Date:**	August 8, 2022

Purpose:

Analyze the existing hydrologic conditions and determine peak flowrates for the CO 119 Safety & Mobility Improvements Project.

References:

Criteria Manuals Used:

Colorado Department of Transportation (CDOT) *Drainage Design Manual,* 2019
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
NOAA Atlas 14 Point Precipitation Frequency Estimates (Longmont, Colorado)
Urban Drainage and Flood Control District (UDFCD). *Urban Storm Drainage Criteria Manual (USDCM)* Vol. 1 (2016)

Previous Reports:

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 the most conservative hydrologic criteria between 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 System	100-Year
Minor System	5-year
Hydrologic Procedure Selection	
Hydrologic Peak Prediction Procedure	
Drainage Area	Rational Method (<160 ac) CUHP and EPA-SWMM (>160 ac)
Time of Concentration	
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:
  - Bus Rapid Transit (BRT)/queue jump modifications at five intersections on CO 119 (Jay Road, 63rd Street, CO 52, Niwot Road, and Airport Road)
  - New Regional Transportation District (RTD) Park-and-Ride facilities at two intersections (63rd Street and Niwot Road)
- Drainage generally flows east through the project area; however, flow directions are not uniform throughout the project length.
- 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 alignment for CO 119 Northbound. L was designated for basin design points to the left of the median (southbound CO 119 and further west), C was designated for basins in the median, and R was used for basins to the right of the median (northbound CO 119 and further east). Basins with the same station and a greater offset were labeled with increasing numbers (i.e., the design point for X250R1 has a greater offset distance than X250R).
- Land use designation was based on survey and aerial imagery.
- Basins were analyzed for peak discharge using rational method, and no DP's have multiple contributing areas.

Assumptions/Givens:

Rational Method Givens

- Hydrologic Soil Group HSG A, B, C, and D – Taken from USDA NRCS Web Soil Survey.
- Rainfall precipitation values for a 1-hour storm duration were taken from NOAA Atlas 14 for a point located in the project area.
- Land use types and percent imperviousness provided in (Volume 1 Table 6-3 of USDCM) used for this project are:
    - Streets: Paved, 100% imperviousness
    - Undeveloped Areas: Lawns, Clayey Soil, 2% imperviousness
    - Business: Suburban Areas, 75% imperviousness
- USDCM Equations 6-3, 6-4, and 6-5 were used to calculate the time of concentration required to calculate intensity.
- Basins were delineated up to CDOT ROW boundaries, as this is the limit of impact for this project.

Rational Method Assumptions

- The following land use types and percent imperviousness values were not taken from USDCM but were assumed:
    - Irrigation ponds were assumed to be 100% impervious
    - Solar panels were assumed to be 10% impervious because they are disconnected from the ground, allowing runoff to reach the pervious surface below the panels.

Results:

Table 2 summarizes the 5-year and 100-year peak flowrates associated with the existing basins. Refer to the rational spreadsheet for calculations and analysis of all basins.

- Basin X175L contains the Boulder water treatment plant emergency discharge channel. Boulder County indicated that the emergency discharge could be as high as 37 cfs. The water treatment discharge was added to the 100-year storm event flow rate but was not assumed to coincide with smaller return frequency events.
- Basin X305L was delineated up to the CDOT ROW boundary on the west side of CO 119 in order to compare pre- and post-project flows at the design point; additional offsite flows that drain into an irrigation ditch towards X305L were not quantified. The offsite ditch flow would depend on runoff along the ditch network upstream, ditch operations, and upstream facility sizing. These items are not in the scope of this project and do not impact sizing of any project features. Therefore, only the change in flow was computed using the area within ROW.

Table 2. *Peak Discharge Summary of Individual Basins*

BASIN ID	AREA (acre)	Q_5 (cfs)	Q_{100} (cfs)
X042R	1.39	0.7	3.6
X049L	1.60	1.4	5.7
X049C	0.93	0.1	2.1
X049R	2.01	2.7	9.0
X050C	0.48	0.1	1.5
X054C	1.13	0.2	2.9
X062L	1.63	1.7	6.1
X063R	2.85	3.2	10.8
X063C	0.16	0.3	1.1
X064C	4.98	0.8	12.0
X069R	0.64	1.6	4.3
X073C	6.02	2.4	14.1
X074R	1.22	2.2	7.3
X076R	0.51	0.9	3.0
X084L	2.60	3.4	14.2
X086R	2.57	2.1	8.2
X172C	9.09	0.9	11.1
X175L	153.05	14.9	146.5
X176C	5.86	4.2	20.6
X178R	2.03	3.2	10.6
X180C	5.45	1.8	12.0
X184L	1.12	1.3	4.9
X193R	1.02	1.0	4.5
X194C	3.09	0.8	6.9
X195L	2.79	2.9	11.0

BASIN ID	AREA (acre)	Q_5 (cfs)	Q_{100} (cfs)
X200C	3.20	0.9	8.6
X200R	0.71	0.5	2.1
X201L	0.93	0.8	3.3
X216C	4.37	0.8	8.6
X222L	0.66	0.6	2.6
X234L	3.78	0.8	7.9
X234C	2.61	1.1	6.1
X238L	2.73	0.8	7.9
X238C	0.66	0.9	3.0
X242R	1.60	1.6	7.3
X248L	11.00	2.8	21.4
X248R	2.23	1.0	6.0
X249C	1.21	1.6	5.2
X249R	0.49	0.2	1.7
X247R	6.72	0.9	14.3
X250R1	1.46	1.3	4.5
X250R2	1.45	2.0	6.3
X246R	7.71	0.4	13.3
X255L	13.74	2.5	20.2
X256L	0.69	0.3	2.0
X258L	16.79	1.5	26.1
X258C	0.74	0.5	2.3
X258R	1.54	1.0	4.2
X261L	24.91	2.5	27.4

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

BASIN ID	AREA (acre)	Q_5 (cfs)	Q_{100} (cfs)
X267L	2.30	0.7	4.9
X263C	1.07	0.6	3.7
X267C	1.36	1.3	6.5
X273L	22.96	3.3	27.5
X275C	3.63	1.9	10.2
X276L	0.91	1.0	3.5
X276C	0.61	0.5	2.6
X305L	5.93	2.2	8.7
X306R	5.49	2.3	8.9
X309C	16.64	1.2	15.3
X311C	0.35	0.8	2.3
X313C	3.89	2.2	10.0
X317C	2.91	1.1	8.8
X321R	2.94	1.6	6.7
X326L	2.32	1.3	6.0
X329R	2.45	1.1	5.8
X331L	1.04	1.0	4.3
X333C	7.76	0.6	10.0
X335L	0.83	0.7	3.0
X343C	4.90	0.8	8.4
X397L	1.48	1.2	4.0
X397C1	3.99	1.0	7.1
X397C2	2.03	0.2	3.6
X397R	3.99	1.1	7.9
X398C	1.59	0.2	5.6
X414C	1.44	0.8	4.9
X416C	8.78	1.4	12.9
X429C	6.91	1.0	9.7

*37 cfs added to 100-year storm flow for the Boulder water treatment plant emergency discharge channel

Materials Included in this Calculation Packet:

1. Rational Method Calculations

SH 119 Mobility
Basin Calculations - Rational Method
Muller Engineering Company, Inc.
CDOT Project Number: 21497
Muller Project Number: 20-069.01

Originator MAK
Date: 7/19/2022
Checker: ZDS/EPT
Date: 8/8/2022

Land Use Types	Percent Impervious
STREETS: PAVED	100
LAWNS, CLAYEY SOIL	2
BUSINESS: SUBURBAN AREAS	75
IRRIGATION POND	100
SOLAR PANELS	10

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

STATION	BASIN ID	PERCENT IMPERVIOUS VALUES													
		TOTAL AREA		STREETS: PAVED		LAWNS, CLAYEY SOIL		BUSINESS: SUBURBAN AREAS		IRRIGATION POND		SOLAR PANELS		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]		
	X042R	60,532	1.39	22,276	37	38,256	63		0		0		0	38	62
	X049L	69,903	1.60	30,619	44	39,284	56		0		0		0	45	55
	X049C	40,304	0.93	415	1	39,889	99		0		0		0	3	97
	X049R	87,500	2.01	56,084	64	31,416	36		0		0		0	65	35
	X050C	21,077	0.48	208	1	20,869	99		0		0		0	3	97
	X054C	49,222	1.13	803	2	48,420	98		0		0		0	4	96
	X062L	70,917	1.63	41,292	58	29,625	42		0		0		0	59	41
	X063R	124,222	2.85	78,002	63	46,220	37		0		0		0	64	36
	X063C	6,875	0.16	4,614	67	2,261	33		0		0		0	68	32
	X064C	217,002	4.98	8,897	4	208,105	96		0		0		0	6	94
	X069R	27,838	0.64	25,459	91	2,379	9		0		0		0	92	8
	X073C	262,096	6.02	67,659	26	194,437	74		0		0		0	27	73
	X074R	53,232	1.22	33,834	64	19,398	36		0		0		0	64	36
	X076R	22,316	0.51	13,212	59	9,104	41		0		0		0	60	40
	X084L	113,391	2.60	49,324	43	64,067	57		0		0		0	45	55
	X086R	112,025	2.57	52,762	47	59,263	53		0		0		0	48	52
	X172C	396,021	9.09	29,805	8	366,216	92		0		0		0	9	91
	X175L	6,666,795	153.05	220,025	3	5,646,738	85	636,979	10		0	163,053	2	12	88
	X176C	255,367	5.86	86,927	34	168,440	66		0		0		0	35	65
	X178R	88,433	2.03	58,485	66	29,948	34		0		0		0	67	33
	X180C	237,506	5.45	47,955	20	189,551	80		0		0		0	22	78
	X184L	49,003	1.12	26,523	54	22,480	46		0		0		0	55	45
	X193R	44,475	1.02	17,510	39	26,965	61		0		0		0	41	59
	X194C	134,430	3.09	16,471	12	117,959	88		0		0		0	14	86
	X195L	121,522	2.79	60,725	50	60,797	50		0		0		0	51	49
	X200C	139,512	3.20	14,913	11	124,599	89		0		0		0	12	88
	X200R	30,839	0.71	11,631	38	19,208	62		0		0		0	39	61
	X201L	40,374	0.93	19,143	47	21,231	53		0		0		0	48	52
	X216C	190,162	4.37	17,357	9	172,805	91		0		0		0	11	89
	X222L	28,754	0.66	11,355	39	17,399	61		0		0		0	41	59
	X234L	164,724	3.78	15,720	10	149,004	90		0		0		0	11	89
	X234C	113,528	2.61	32,318	28	81,210	72		0		0		0	30	70
	X238L	118,993	2.73	11,474	10	107,519	90		0		0		0	11	89
	X238C	28,921	0.66	17,245	60	11,676	40		0		0		0	60	40
	X242R	69,744	1.60	25,626	37	44,119	63		0		0		0	38	62
	X248L	479,134	11.00	78,921	16	400,213	84		0		0		0	18	82
	X248R	97,051	2.23	24,415	25	72,636	75		0		0		0	27	73
	X249C	52,634	1.21	33,436	64	19,198	36		0		0		0	64	36
	X249R	21,324	0.49	2,638	12	18,686	88		0		0		0	14	86
	X247R	292,552	6.72	10,961	4	281,591	96		0		0		0	6	94
	X250R1	63,501	1.46	36,530	58	26,971	42		0		0		0	58	42
	X250R2	63,006	1.45	44,777	71	18,229	29		0		0		0	72	28
	X246R	335,857	7.71	6,143	2	329,714	98		0		0		0	4	96
	X255L	598,300	13.74	88,003	15	510,297	85		0		0		0	16	84
	X256L	29,993	0.69	7,804	26	22,189	74		0		0		0	27	73
	X258L	731,260	16.79	21,435	3	709,825	97		0		0		0	5	95
	X258C	32,407	0.74	12,211	38	20,196	62		0		0		0	39	61
	X258R	66,929	1.54	30,079	45	36,850	55		0		0		0	46	54

	X261L	1,084,927	**24.91**	25,303	**2**	993,147	**92**		**0**	66,477	**6**		**0**	10	90
	X267L	100,199	**2.30**	16,865	**17**	83,334	**83**		**0**		**0**		**0**	18	82
	X263C	46,539	**1.07**	11,939	**26**	34,600	**74**		**0**		**0**		**0**	27	73
	X267C	59,219	**1.36**	19,736	**33**	39,483	**67**		**0**		**0**		**0**	35	65
	X273L	1,000,057	**22.96**	78,418	**8**	835,575	**84**	86,064	**9**		**0**		**0**	16	84
	X275C	158,167	**3.63**	43,920	**28**	114,247	**72**		**0**		**0**		**0**	29	71
	X276L	39,537	**0.91**	24,975	**63**	14,562	**37**		**0**		**0**		**0**	64	36
	X276C	26,432	**0.61**	8,607	**33**	17,825	**67**		**0**		**0**		**0**	34	66
	X305L	258,447	**5.93**	123,659	**48**	134,788	**52**		**0**		**0**		**0**	49	51
	X306R	239,183	**5.49**	120,610	**50**	118,573	**50**		**0**		**0**		**0**	51	49
	X309C	724,636	**16.64**	46,593	**6**	678,043	**94**		**0**		**0**		**0**	8	92
	X311C	15,056	**0.35**	11,877	**79**	3,179	**21**		**0**		**0**		**0**	79	21
	X313C	169,237	**3.89**	65,448	**39**	103,789	**61**		**0**		**0**		**0**	40	60
	X317C	126,600	**2.91**	20,639	**16**	105,961	**84**		**0**		**0**		**0**	18	82
	X321R	128,231	**2.94**	53,616	**42**	74,615	**58**		**0**		**0**		**0**	43	57
	X326L	100,948	**2.32**	37,839	**37**	63,109	**63**		**0**		**0**		**0**	39	61
	X329R	106,575	**2.45**	30,688	**29**	75,887	**71**		**0**		**0**		**0**	30	70
	X331L	45,458	**1.04**	19,881	**44**	25,577	**56**		**0**		**0**		**0**	45	55
	X333C	337,922	**7.76**	10,278	**3**	327,644	**97**		**0**		**0**		**0**	5	95
	X335L	36,133	**0.83**	14,808	**41**	21,325	**59**		**0**		**0**		**0**	42	58
	X343C	213,546	**4.90**	17,932	**8**	195,614	**92**		**0**		**0**		**0**	10	90
	X397L	64,434	**1.48**	39,609	**61**	24,825	**39**		**0**		**0**		**0**	62	38
	X397C1	173,662	**3.99**	30,068	**17**	143,594	**83**		**0**		**0**		**0**	19	81
	X397C2	88,389	**2.03**	4,135	**5**	84,254	**95**		**0**		**0**		**0**	7	93
	X397R	173,889	**3.99**	31,093	**18**	142,796	**82**		**0**		**0**		**0**	20	80
	X398C	69,215	**1.59**	0	**0**	69,215	**100**		**0**		**0**		**0**	2	98
	X414C	62,921	**1.44**	15,751	**25**	47,170	**75**		**0**		**0**		**0**	27	73
	X416C	382,365	**8.78**	50,418	**13**	331,947	**87**		**0**		**0**		**0**	15	85
	X429C	300,782	**6.91**	42,985	**14**	257,797	**86**		**0**		**0**		**0**	16	84

SH 119 Mobility
Basin Calculations - Rational Method
Muller Engineering Company, Inc.
CDOT Project Number: 21497
Muller Project Number: 20-069.01

Originator MAK
Date: 7/19/2022
Checker: ZDS/EPT
Date: 8/8/2022

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

STATION	BASIN ID	NRCS HYDROLOGIC SOIL GROUP[1]																														
		SOIL GROUP (%)[1]			SOIL GROUP A							SOIL GROUP B							SOIL GROUP C/D							C_2	C_5	C_{10}	C_{25}	C_{50}	C_{100}
		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}	%						
00+00	X042R		50	50							0	0.27	0.30	0.37	0.49	0.54	0.60	50	0.28	0.35	0.41	0.53	0.58	0.64	50	0.28	0.32	0.39	0.51	0.56	0.62
00+00	X049L			100							0							0	0.34	0.40	0.46	0.57	0.61	0.67	100	0.34	0.40	0.46	0.57	0.61	0.67
00+00	X049C			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
00+00	X049R			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
00+00	X050C			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
00+00	X054C			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
00+00	X062L			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
00+00	X063R			100							0							0	0.50	0.56	0.60	0.67	0.70	0.74	100	0.50	0.56	0.60	0.67	0.70	0.74
00+00	X063C			100							0							0	0.54	0.59	0.63	0.70	0.73	0.76	100	0.54	0.59	0.63	0.70	0.73	0.76
00+00	X064C			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
00+00	X069R			100							0							0	0.75	0.79	0.81	0.83	0.84	0.86	100	0.75	0.79	0.81	0.83	0.84	0.86
00+00	X073C			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
00+00	X074R			100							0							0	0.51	0.56	0.61	0.68	0.71	0.75	100	0.51	0.56	0.61	0.68	0.71	0.75
00+00	X076R			100							0							0	0.47	0.53	0.58	0.66	0.69	0.73	100	0.47	0.53	0.58	0.66	0.69	0.73
00+00	X084L			100							0							0	0.34	0.40	0.46	0.57	0.61	0.67	100	0.34	0.40	0.46	0.57	0.61	0.67
00+00	X086R			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
00+00	X172C			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
00+00	X175L			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
00+00	X176C			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
00+00	X178R			100							0							0	0.53	0.58	0.63	0.69	0.72	0.76	100	0.53	0.58	0.63	0.69	0.72	0.76
00+00	X180C			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
00+00	X184L			100							0							0	0.42	0.49	0.54	0.63	0.66	0.71	100	0.42	0.49	0.54	0.63	0.66	0.71
00+00	X193R			100							0							0	0.30	0.37	0.43	0.55	0.59	0.65	100	0.30	0.37	0.43	0.55	0.59	0.65
00+00	X194C			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
00+00	X195L			100							0							0	0.39	0.45	0.51	0.60	0.64	0.69	100	0.39	0.45	0.51	0.60	0.64	0.69
00+00	X200C			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
00+00	X200R			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
00+00	X201L			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
00+00	X216C			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
00+00	X222L			100							0							0	0.30	0.37	0.43	0.55	0.59	0.65	100	0.30	0.37	0.43	0.55	0.59	0.65
00+00	X234L			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
00+00	X234C			100							0							0	0.21	0.28	0.35	0.49	0.54	0.61	100	0.21	0.28	0.35	0.49	0.54	0.61
00+00	X238L			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
00+00	X238C			100							0							0	0.47	0.53	0.58	0.66	0.69	0.73	100	0.47	0.53	0.58	0.66	0.69	0.73
00+00	X242R			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
00+00	X248L			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
00+00	X248R			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
00+00	X249C			100							0							0	0.51	0.56	0.61	0.68	0.71	0.75	100	0.51	0.56	0.61	0.68	0.71	0.75
00+00	X249R			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
00+00	X247R			100							0							0	0.03	0.08	0.17	0.35	0.42	0.51	100	0.03	0.08	0.17	0.35	0.42	0.51
00+00	X250R1			100							0							0	0.45	0.51	0.56	0.65	0.68	0.72	100	0.45	0.51	0.56	0.65	0.68	0.72
00+00	X250R2			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
00+00	X246R		65	35							0	0.02	0.02	0.09	0.27	0.35	0.44	65	0.02	0.07	0.16	0.34	0.41	0.50	35	0.02	0.04	0.11	0.30	0.37	0.46
00+00	X255L			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
00+00	X256L			100							0							0	0.19	0.26	0.34	0.47	0.53	0.60	100	0.19	0.26	0.34	0.47	0.53	0.60
00+00	X258L			100							0							0	0.03	0.07	0.17	0.35	0.42	0.50	100	0.03	0.07	0.17	0.35	0.42	0.50
00+00	X258C			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
00+00	X258R			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
00+00	X261L			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
00+00	X267L			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
00+00	X263C			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
00+00	X267C			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
00+00	X273L			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
00+00	X275C			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
00+00	X276L			100							0							0	0.50	0.56	0.60	0.68	0.71	0.75	100	0.50	0.56	0.60	0.68	0.71	0.75
00+00	X276C			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
00+00	X305L			100							0							0	0.37	0.44	0.49	0.59	0.63	0.68	100	0.37	0.44	0.49	0.59	0.63	0.68
00+00	X306R			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
00+00	X309C			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
00+00	X311C			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
00+00	X313C			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
00+00	X317C			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
00+00	X321R			100							0							0	0.32	0.39	0.45	0.56	0.60	0.66	100	0.32	0.39	0.45	0.56	0.60	0.66
00+00	X326L			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
00+00	X329R			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

00+00	X331L			100							0							0	0.34	0.40	0.46	0.57	0.61	0.67	100	0.34	0.40	0.46	0.57	0.61	0.67
00+00	X333C			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
00+00	X335L			100							0							0	0.31	0.38	0.44	0.56	0.60	0.66	100	0.31	0.38	0.44	0.56	0.60	0.66
00+00	X343C			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
00+00	X397L		20	80							0	0.48	0.51	0.56	0.64	0.68	0.72	20	0.49	0.55	0.59	0.67	0.70	0.74	80	0.49	0.54	0.59	0.66	0.69	0.74
00+00	X397C1			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
00+00	X397C2		5	95							0	0.03	0.04	0.11	0.29	0.36	0.46	5	0.04	0.09	0.18	0.36	0.43	0.51	95	0.04	0.09	0.18	0.35	0.42	0.51
00+00	X397R			100							0							0	0.13	0.20	0.28	0.43	0.49	0.56	100	0.13	0.20	0.28	0.43	0.49	0.56
00+00	X398C		10	90							0	0.01	0.01	0.07	0.26	0.34	0.44	10	0.01	0.05	0.15	0.33	0.40	0.49	90	0.01	0.05	0.14	0.32	0.40	0.49
00+00	X414C			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
00+00	X416C	5	20	75	0.07	0.08	0.08	0.10	0.15	0.23	5	0.09	0.11	0.18	0.34	0.41	0.50	20	0.10	0.16	0.24	0.40	0.47	0.55	75	0.10	0.14	0.22	0.38	0.44	0.52
00+00	X429C		60	40							0	0.10	0.12	0.19	0.35	0.42	0.50	60	0.11	0.17	0.25	0.41	0.47	0.55	40	0.10	0.14	0.21	0.37	0.44	0.52

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 Mobility
Basin Calculations - Rational Method
Muller Engineering Company, Inc.
CDOT Project Number: 21497
Muller Project Number: 20-069.01

Originator MAK
Date: 7/19/2022
Checker: ZDS/EPT
Date: 8/8/2022

TIME OF CONCENTRATION

STATION	BASIN DATA				INITIAL/OVERLAND TIME (T_i)					CHANNELIZED (TRAVEL) TIME (T_t)								TOTAL t_c	T_c CHECK (Urbanized Basins)		FINAL t_c	REMARKS
	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)	
00+00	X042R	1.39	0.32	Urban	71	5290.00	5289.00	0.014	10.5	758	5289.00	5283.00	0.008	SP	7	0.6	20.3	30.8	No	N/A	30.8	
00+00	X049L	1.60	0.40	Urban	83	5292.50	5290.00	0.030	8.0	545	5290.00	5283.50	0.012	SP	7	0.8	11.9	19.8	No	N/A	19.8	
00+00	X049C	0.93	0.06	Non-Urban	21	5295.20	5293.90	0.061	4.8	910	5293.90	5285.40	0.009	SP	7	0.7	22.4	27.2	No	N/A	27.2	
00+00	X049R	2.01	0.57	Urban	70	5286.50	5285.50	0.014	7.2	360	5285.50	5282.00	0.010	SP	7	0.7	8.7	15.9	No	N/A	15.9	
00+00	X050C	0.48	0.06	Non-Urban	74	5292.10	5284.00	0.109	7.4	196	5284.00	5283.00	0.005	SP	7	0.5	6.6	13.9	No	N/A	13.9	
00+00	X054C	1.13	0.06	Non-Urban	121	5291.50	5284.80	0.055	11.7	292	5284.80	5283.00	0.006	SP	7	0.5	8.9	20.6	No	N/A	20.6	
00+00	X062L	1.63	0.52	Urban	89	5292.00	5290.00	0.022	7.6	689	5290.00	5279.50	0.015	SP	7	0.9	13.3	20.9	No	N/A	20.9	
00+00	X063R	2.85	0.56	Urban	72	5286.50	5286.00	0.007	9.4	746	5286.00	5270.00	0.021	SP	7	1.0	12.1	21.5	No	N/A	21.5	
00+00	X063C	0.16	0.59	Urban	81	5285.00	5281.00	0.049	4.9	59	5281.00	5278.00	0.051	SP	7	1.6	0.6	5.5	No	N/A	5.5	
00+00	X064C	4.98	0.08	Non-Urban	127	5291.50	5285.00	0.051	12.1	773	5285.00	5268.00	0.022	SP	7	1.0	12.4	24.5	No	N/A	24.5	
00+00	X069R	0.64	0.79	Urban	242	5279.00	5276.00	0.012	8.2	10	5276.00	5275.50	0.050	SP	7	1.6	0.1	8.3	No	N/A	8.3	
00+00	X073C	6.02	0.26	Urban	194	5283.50	5279.00	0.023	16.0	867	5279.00	5267.50	0.013	SP	7	0.8	17.9	33.9	No	N/A	33.9	
00+00	X074R	1.22	0.56	Urban	100	5276.50	5274.50	0.020	7.7	14	5274.50	5274.00	0.036	SP	7	1.3	0.2	7.9	No	N/A	7.9	
00+00	X076R	0.51	0.53	Urban	88	5274.00	5272.00	0.023	7.4	40	5272.00	5268.60	0.085	SP	7	2.0	0.3	7.7	No	N/A	7.7	
00+00	X084L	2.60	0.40	Urban	92	5274.50	5270.00	0.049	7.2	10	5270.00	5269.00	0.100	SP	7	2.2	0.1	7.2	No	N/A	7.2	
00+00	X086R	2.57	0.43	Urban	101	5273.00	5271.00	0.020	9.7	1060	5271.00	5242.00	0.027	SP	7	1.2	15.3	25.0	No	N/A	25.0	
00+00	X172C	9.09	0.11	Non-Urban	438	5182.00	5164.00	0.041	23.4	2024	5164.00	5146.00	0.009	SP	7	0.7	51.1	74.5	No	N/A	74.5	
00+00	X175L	153.05	0.14	Non-Urban	500	5209.00	5197.00	0.024	29.1	3811	5197.00	5148.00	0.013	SP	7	0.8	80.0	109.2	No	N/A	109.2	
00+00	X176C	5.86	0.32	Urban	175	5165.00	5156.00	0.051	10.8	433	5156.00	5147.00	0.021	SP	7	1.0	7.2	17.9	No	N/A	17.9	
00+00	X178R	2.03	0.58	Urban	77	5156.00	5152.00	0.052	4.8	251	5152.00	5150.00	0.008	SP	7	0.6	6.7	11.5	No	N/A	11.5	
00+00	X180C	5.45	0.21	Non-Urban	321	5170.00	5163.00	0.022	22.2	724	5163.00	5150.00	0.018	SP	7	0.9	12.9	35.0	No	N/A	35.0	
00+00	X184L	1.12	0.49	Urban	70	5170.00	5169.00	0.014	8.2	329	5169.00	5164.00	0.015	SP	7	0.9	6.4	14.6	Yes	19.3	14.6	
00+00	X193R	1.02	0.37	Urban	64	5159.00	5157.00	0.031	7.3	412	5157.00	5139.00	0.044	SP	7	1.5	4.7	12.0	No	N/A	12.0	
00+00	X194C	3.09	0.15	Non-Urban	500	5170.00	5156.00	0.028	27.3	361	5156.00	5138.00	0.050	SP	7	1.6	3.8	31.2	No	N/A	31.2	
00+00	X195L	2.79	0.45	Urban	72	5170.00	5169.00	0.014	8.9	618	5169.00	5150.00	0.031	SP	7	1.2	8.4	17.3	No	N/A	17.3	
00+00	X200C	3.20	0.14	Non-Urban	99	5151.00	5140.00	0.111	7.8	520	5140.00	5136.00	0.008	SP	7	0.6	14.1	21.9	No	N/A	21.9	
00+00	X200R	0.71	0.35	Non-Urban	361	5147.50	5143.00	0.012	23.8	139	5143.00	5140.00	0.022	SP	7	1.0	2.3	26.0	No	N/A	26.0	
00+00	X201L	0.93	0.43	Urban	98	5148.50	5145.00	0.036	7.8	438	5145.00	5142.00	0.007	SP	7	0.6	12.6	20.4	No	N/A	20.4	
00+00	X216C	4.37	0.12	Non-Urban	182	5170.00	5165.00	0.027	17.0	1048	5165.00	5149.00	0.015	SP	7	0.9	20.2	37.2	No	N/A	37.2	
00+00	X222L	0.66	0.37	Urban	117	5170.00	5167.00	0.026	10.4	295	5167.00	5161.50	0.019	SP	7	1.0	5.1	15.6	No	N/A	15.6	
00+00	X234L	3.78	0.13	Non-Urban	94	5176.00	5167.00	0.096	8.1	884	5167.00	5161.00	0.007	SP	7	0.6	25.5	33.6	No	N/A	33.6	
00+00	X234C	2.61	0.28	Urban	146	5170.00	5165.00	0.034	11.9	655	5165.00	5162.00	0.005	SP	7	0.5	23.0	35.0	No	N/A	35.0	
00+00	X238L	2.73	0.13	Non-Urban	48	5165.00	5162.00	0.063	6.6	507	5162.00	5157.00	0.010	SP	7	0.7	12.2	18.8	No	N/A	18.8	
00+00	X238C	0.66	0.53	Urban	53	5165.00	5164.00	0.019	6.1	381	5164.00	5160.00	0.010	SP	7	0.7	8.9	14.9	No	N/A	14.9	
00+00	X242R	1.60	0.35	Urban	104	5164.00	5160.00	0.038	8.9	92	5160.00	5158.00	0.022	SP	7	1.0	1.5	10.4	No	N/A	10.4	
00+00	X248L	11.00	0.18	Non-Urban	408	5166.00	5157.00	0.022	25.7	592	5157.00	5152.00	0.008	SP	7	0.6	15.3	41.1	No	N/A	41.1	
00+00	X248R	2.23	0.25	Urban	59	5160.00	5157.00	0.051	6.9	689	5157.00	5152.00	0.007	SP	7	0.6	19.3	26.1	No	N/A	26.1	
00+00	X249C	1.21	0.56	Urban	53	5164.00	5160.00	0.075	3.6	1071	5160.00	5155.00	0.005	P	20	1.4	13.1	16.7	Yes	29.6	16.7	
00+00	X249R	0.49	0.15	Non-Urban	58	5155.00	5154.00	0.017	10.9	159	5154.00	5150.00	0.025	SP	7	1.1	2.4	13.3	No	N/A	13.3	
00+00	X247R	6.72	0.08	Non-Urban	24	5157.00	5155.00	0.083	4.5	982	5155.00	5147.00	0.008	SP	7	0.6	25.9	30.4	No	N/A	30.4	
00+00	X250R1	1.46	0.51	Urban	107	5155.00	5149.50	0.051	6.4	572	5149.50	5147.50	0.003	SP	7	0.4	23.1	29.4	No	N/A	29.4	
00+00	X250R2	1.45	0.62	Urban	80	5149.00	5144.00	0.063	4.2	524	5144.00	5139.50	0.009	SP	7	0.6	13.5	17.7	No	N/A	17.7	
00+00	X246R	7.71	0.04	Non-Urban	207	5152.00	5145.00	0.034	18.4	970	5145.00	5130.00	0.015	SP	7	0.9	18.6	37.0	No	N/A	37.0	
00+00	X255L	13.74	0.17	Non-Urban	346	5161.00	5156.00	0.014	27.7	1199	5156.00	5147.50	0.007	SP	7	0.6	33.9	61.6	No	N/A	61.6	
00+00	X256L	0.69	0.26	Urban	216	5151.00	5149.00	0.009	22.9	20	5149.00	5148.90	0.005	SP	7	0.5	0.7	23.6	No	N/A	23.6	
00+00	X258L	16.79	0.07	Non-Urban	305	5161.00	5156.00	0.016	27.5	1301	5156.00	5145.00	0.008	SP	7	0.6	33.7	61.1	Yes	49.5	49.5	
00+00	X258C	0.74	0.35	Urban	22	5155.50	5155.00	0.023	4.8	815	5155.00	5147.00	0.010	SP	7	0.7	19.6	24.4	Yes	28.9	24.4	
00+00	X258R	1.54	0.41	Urban	98	5155.00	5152.00	0.031	8.5	835	5152.00	5146.00	0.007	SP	7	0.6	23.5	31.9	No	N/A	31.9	
00+00	X261L	24.91	0.12	Non-Urban	297	5161.00	5154.00	0.024	23.0	1950	5154.00	5144.00	0.005	SP	7	0.5	64.8	87.8	No	N/A	87.8	
00+00	X267L	2.30	0.19	Non-Urban	356	5148.00	5144.00	0.011	29.9	212	5144.00	5142.00	0.009	SP	7	0.7	5.2	35.1	No	N/A	35.1	
00+00	X263C	1.07	0.26	Urban	31	5150.00	5148.00	0.065	4.6	511	5148.00	5143.00	0.010	SP	7	0.7	12.3	16.9	No	N/A	16.9	
00+00	X267C	1.36	0.32	Urban	79	5148.00	5145.00	0.038	8.1	79	5145.00	5140.00	0.063	SP	7	1.8	0.7	8.8	No	N/A	8.8	
00+00	X273L	22.96	0.17	Non-Urban	488	5161.00	5152.00	0.018	30.4	2051	5152.00	5134.00	0.009	SP	7	0.7	52.1	82.6	No	N/A	82.6	
00+00	X275C	3.63	0.27	Non-Urban	100	5145.00	5140.00	0.050	8.8	752	5140.00	5131.00	0.012	SP	7	0.8	16.4	25.1	No	N/A	25.1	
00+00	X276L	0.91	0.56	Non-Urban	312	5139.50	5136.00	0.011	16.6	194	5136.00	5134.00	0.010	SP	7	0.7	4.5	21.2	No	N/A	21.2	
00+00	X276C	0.61	0.31	Urban	58	5137.00	5136.00	0.017	9.0	178	5136.00	5132.00	0.022	SP	7	1.0	2.8	11.9	No	N/A	11.9	
00+00	X305L	5.93	0.44	Urban	115	5136.00	5133.00	0.026	9.4	2856	5133.00	5110.00	0.008	SP	7	0.6	75.8	85.1	No	N/A	85.1	
00+00	X306R	5.49	0.46	Non-Urban	500	5133.50	5130.00	0.007	29.2	2000	5130.00	5108.00	0.011	SP	7	0.7	45.4	74.6	No	N/A	74.6	

00+00	X309C	16.64	0.10	Non-Urban	304	5135.50	5130.00	0.018	25.8	3162	5130.00	5105.00	0.008	SP	7	0.6	84.7	110.5	No	N/A	110.5	
00+00	X311C	0.35	0.69	Urban	62	5110.00	5109.00	0.016	5.0	136	5109.00	5106.00	0.022	SP	7	1.0	2.2	7.2	No	N/A	7.2	
00+00	X313C	3.89	0.36	Urban	241	5111.00	5109.00	0.008	22.0	487	5109.00	5104.00	0.010	SP	7	0.7	11.4	33.4	No	N/A	33.4	
00+00	X317C	2.91	0.18	Non-Urban	98	5108.00	5104.00	0.041	10.3	410	5104.00	5099.00	0.012	SP	7	0.8	8.8	19.2	No	N/A	19.2	
00+00	X321R	2.94	0.39	Urban	254	5110.00	5106.00	0.016	17.7	937	5106.00	5098.00	0.009	SP	7	0.6	24.1	41.8	No	N/A	41.8	
00+00	X326L	2.32	0.35	Urban	43	5105.00	5102.00	0.070	4.7	940	5102.00	5096.00	0.006	SP	7	0.6	28.0	32.7	No	N/A	32.7	
00+00	X329R	2.45	0.28	Urban	172	5101.50	5096.00	0.032	13.2	682	5096.00	5092.00	0.006	SP	7	0.5	21.2	34.4	No	N/A	34.4	
00+00	X331L	1.04	0.40	Urban	81	5099.00	5096.00	0.037	7.4	414	5096.00	5088.00	0.019	SP	7	1.0	7.1	14.4	No	N/A	14.4	
00+00	X333C	7.76	0.08	Non-Urban	498	5105.00	5098.00	0.014	36.9	1248	5098.00	5085.00	0.010	SP	7	0.7	29.1	66.0	No	N/A	66.0	
00+00	X335L	0.83	0.38	Urban	85	5096.00	5090.00	0.071	6.3	376	5090.00	5088.00	0.005	SP	7	0.5	12.3	18.6	No	N/A	18.6	
00+00	X343C	4.90	0.12	Non-Urban	211	5095.00	5088.00	0.033	17.3	990	5088.00	5081.00	0.007	SP	7	0.6	28.0	45.4	No	N/A	45.4	
00+00	X397L	1.48	0.54	Urban	70	5060.10	5058.50	0.023	6.4	1207	5058.50	5048.00	0.009	SP	7	0.7	30.8	37.3	No	N/A	37.3	
00+00	X397C1	3.99	0.19	Non-Urban	185	5063.50	5059.30	0.023	17.0	1284	5059.30	5046.50	0.010	SP	7	0.7	30.6	47.7	No	N/A	47.7	
00+00	X397C2	2.03	0.09	Non-Urban	98	5062.40	5060.00	0.024	13.5	1211	5060.00	5046.00	0.012	SP	7	0.8	26.8	40.3	No	N/A	40.3	
00+00	X397R	3.99	0.20	Non-Urban	61	5063.30	5062.00	0.021	9.9	1333	5062.00	5048.00	0.011	SP	7	0.7	31.0	40.9	No	N/A	40.9	
00+00	X398C	1.59	0.05	Non-Urban	36	5048.00	5045.80	0.061	6.3	31	5045.80	5045.00	0.026	SP	7	1.1	0.5	6.7	No	N/A	10.0	
00+00	X414C	1.44	0.25	Urban	61	5045.50	5041.80	0.061	6.6	643	5041.80	5029.00	0.020	SP	7	1.0	10.9	17.4	No	N/A	17.4	
00+00	X416C	8.78	0.14	Non-Urban	468	5048.00	5034.00	0.030	26.0	1223	5034.00	5023.00	0.009	SP	7	0.7	30.7	56.7	No	N/A	56.7	
00+00	X429C	6.91	0.14	Non-Urban	499	5029.00	5021.00	0.016	33.2	509	5021.00	5020.00	0.002	SP	7	0.3	27.3	60.6	No	N/A	60.6	

Notes:

[1] $t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S^{0.33}}$ 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] $t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$ USDCM Equation 6-5 August 2018

SH 119 Mobility
Basin Calculations - Rational Method
Muller Engineering Company, Inc.
CDOT Project Number: 21497
Muller Project Number: 20-069.01

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	1.07	1.35	1.81	2.23	2.69

NOAA Atlas 14, Volume 8, Version 2 (Longmont, CO)

Originator MAK
Date: 7/19/2022
Checker: ZDS/EPT
Date: 8/8/2022

STATION	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)
00+00	X042R	1.39	0.28	0.32	0.39	0.51	0.56	0.62	1.22	1.65	2.08	2.79	3.44	4.15	0.5	0.7	1.1	2.0	2.7	3.6
00+00	X049L	1.60	0.34	0.40	0.46	0.57	0.61	0.67	1.56	2.11	2.67	3.57	4.40	5.31	0.8	1.4	2.0	3.3	4.3	5.7
00+00	X049C	0.93	0.02	0.06	0.15	0.34	0.41	0.50	1.31	1.78	2.24	3.01	3.70	4.47	0.0	0.1	0.3	0.9	1.4	2.1
00+00	X049R	2.01	0.51	0.57	0.61	0.68	0.71	0.75	1.75	2.37	2.98	4.00	4.93	5.95	1.8	2.7	3.7	5.5	7.0	9.0
00+00	X050C	0.48	0.02	0.06	0.15	0.34	0.41	0.50	1.86	2.52	3.17	4.26	5.24	6.33	0.0	0.1	0.2	0.7	1.0	1.5
00+00	X054C	1.13	0.02	0.06	0.16	0.34	0.41	0.50	1.53	2.07	2.62	3.51	4.32	5.22	0.0	0.2	0.5	1.3	2.0	2.9
00+00	X062L	1.63	0.46	0.52	0.57	0.65	0.68	0.73	1.52	2.06	2.60	3.48	4.29	5.18	1.1	1.7	2.4	3.7	4.8	6.1
00+00	X063R	2.85	0.50	0.56	0.60	0.67	0.70	0.74	1.50	2.02	2.55	3.42	4.22	5.09	2.1	3.2	4.4	6.6	8.5	10.8
00+00	X063C	0.16	0.54	0.59	0.63	0.70	0.73	0.76	2.61	3.54	4.46	5.98	7.37	8.89	0.2	0.3	0.4	0.7	0.8	1.1
00+00	X064C	4.98	0.04	0.08	0.18	0.35	0.42	0.51	1.40	1.89	2.38	3.19	3.93	4.74	0.2	0.8	2.1	5.6	8.3	12.0
00+00	X069R	0.64	0.75	0.79	0.81	0.83	0.84	0.86	2.29	3.10	3.91	5.25	6.47	7.80	1.1	1.6	2.0	2.8	3.5	4.3
00+00	X073C	6.02	0.19	0.26	0.33	0.47	0.53	0.60	1.15	1.56	1.97	2.64	3.25	3.92	1.3	2.4	4.0	7.5	10.3	14.1
00+00	X074R	1.22	0.51	0.56	0.61	0.68	0.71	0.75	2.33	3.16	3.98	5.34	6.58	7.94	1.4	2.2	3.0	4.4	5.7	7.3
00+00	X076R	0.51	0.47	0.53	0.58	0.66	0.69	0.73	2.35	3.18	4.02	5.38	6.63	8.00	0.6	0.9	1.2	1.8	2.3	3.0
00+00	X084L	2.60	0.34	0.40	0.46	0.57	0.61	0.67	2.40	3.25	4.10	5.50	6.78	8.18	2.1	3.4	4.9	8.1	10.8	14.2
00+00	X086R	2.57	0.37	0.43	0.49	0.59	0.63	0.68	1.38	1.87	2.35	3.16	3.89	4.69	1.3	2.1	3.0	4.8	6.3	8.2
00+00	X172C	9.09	0.06	0.11	0.20	0.37	0.44	0.52	0.69	0.93	1.18	1.58	1.94	2.34	0.4	0.9	2.2	5.3	7.8	11.1
00+00	X175L	153.05	0.08	0.14	0.22	0.39	0.45	0.53	0.53	0.71	0.90	1.20	1.48	1.79	6.4	14.9	30.8	71.6	103.0	146.5
00+00	X176C	5.86	0.26	0.32	0.39	0.52	0.57	0.63	1.65	2.23	2.81	3.77	4.64	5.60	2.5	4.2	6.5	11.4	15.4	20.6
00+00	X178R	2.03	0.53	0.58	0.63	0.69	0.72	0.76	2.03	2.74	3.46	4.63	5.71	6.89	2.2	3.2	4.4	6.5	8.4	10.6
00+00	X180C	5.45	0.15	0.21	0.29	0.44	0.50	0.57	1.13	1.53	1.93	2.59	3.19	3.85	0.9	1.8	3.1	6.2	8.7	12.0
00+00	X184L	1.12	0.42	0.49	0.54	0.63	0.66	0.71	1.82	2.46	3.10	4.16	5.13	6.19	0.9	1.3	1.9	2.9	3.8	4.9
00+00	X193R	1.02	0.30	0.37	0.43	0.55	0.59	0.65	1.99	2.69	3.39	4.55	5.61	6.76	0.6	1.0	1.5	2.5	3.4	4.5
00+00	X194C	3.09	0.09	0.15	0.24	0.40	0.46	0.54	1.21	1.64	2.07	2.78	3.42	4.13	0.3	0.8	1.5	3.4	4.9	6.9
00+00	X195L	2.79	0.39	0.45	0.51	0.60	0.64	0.69	1.68	2.27	2.86	3.84	4.73	5.70	1.8	2.9	4.1	6.5	8.5	11.0
00+00	X200C	3.20	0.08	0.14	0.22	0.39	0.45	0.54	1.48	2.00	2.53	3.39	4.18	5.04	0.4	0.9	1.8	4.2	6.1	8.6
00+00	X200R	0.71	0.29	0.35	0.42	0.54	0.58	0.64	1.35	1.82	2.30	3.08	3.80	4.58	0.3	0.5	0.7	1.2	1.6	2.1
00+00	X201L	0.93	0.37	0.43	0.49	0.59	0.63	0.68	1.54	2.08	2.63	3.52	4.34	5.23	0.5	0.8	1.2	1.9	2.5	3.3
00+00	X216C	4.37	0.07	0.12	0.21	0.38	0.45	0.53	1.09	1.47	1.86	2.49	3.07	3.70	0.3	0.8	1.7	4.1	6.0	8.6
00+00	X222L	0.66	0.30	0.37	0.43	0.55	0.59	0.65	1.76	2.39	3.01	4.04	4.97	6.00	0.4	0.6	0.9	1.5	1.9	2.6
00+00	X234L	3.78	0.07	0.13	0.22	0.38	0.45	0.53	1.16	1.57	1.98	2.65	3.27	3.94	0.3	0.8	1.6	3.8	5.5	7.9
00+00	X234C	2.61	0.21	0.28	0.35	0.49	0.54	0.61	1.13	1.53	1.93	2.59	3.19	3.85	0.6	1.1	1.8	3.3	4.5	6.1
00+00	X238L	2.73	0.07	0.13	0.22	0.38	0.45	0.53	1.61	2.17	2.74	3.68	4.53	5.47	0.3	0.8	1.6	3.8	5.6	7.9
00+00	X238C	0.66	0.47	0.53	0.58	0.66	0.69	0.73	1.80	2.43	3.07	4.12	5.07	6.12	0.6	0.9	1.2	1.8	2.3	3.0

00+00	X242R	1.60	0.28	0.35	0.41	0.53	0.58	0.64	2.11	2.85	3.60	4.82	5.94	7.17	0.9	1.6	2.4	4.1	5.5	7.3
00+00	X248L	11.00	0.12	0.18	0.27	0.42	0.48	0.56	1.02	1.39	1.75	2.34	2.89	3.48	1.4	2.8	5.1	10.8	15.3	21.4
00+00	X248R	2.23	0.19	0.25	0.33	0.47	0.52	0.59	1.34	1.82	2.29	3.08	3.79	4.57	0.6	1.0	1.7	3.2	4.4	6.0
00+00	X249C	1.21	0.51	0.56	0.61	0.68	0.71	0.75	1.71	2.31	2.91	3.90	4.81	5.80	1.0	1.6	2.1	3.2	4.1	5.2
00+00	X249R	0.49	0.09	0.15	0.24	0.40	0.46	0.54	1.90	2.57	3.24	4.34	5.35	6.46	0.1	0.2	0.4	0.8	1.2	1.7
00+00	X247R	6.72	0.03	0.08	0.17	0.35	0.42	0.51	1.23	1.67	2.10	2.82	3.47	4.19	0.3	0.9	2.5	6.6	9.8	14.3
00+00	X250R1	1.46	0.45	0.51	0.56	0.65	0.68	0.72	1.26	1.70	2.14	2.87	3.54	4.27	0.8	1.3	1.8	2.7	3.5	4.5
00+00	X250R2	1.45	0.57	0.62	0.66	0.72	0.74	0.78	1.66	2.24	2.83	3.79	4.67	5.64	1.4	2.0	2.7	4.0	5.0	6.3
00+00	X246R	7.71	0.02	0.04	0.11	0.30	0.37	0.46	1.09	1.48	1.87	2.50	3.08	3.72	0.2	0.4	1.6	5.7	8.8	13.3
00+00	X255L	13.74	0.11	0.17	0.25	0.41	0.47	0.55	0.79	1.06	1.34	1.80	2.21	2.67	1.2	2.5	4.7	10.1	14.4	20.2
00+00	X256L	0.69	0.19	0.26	0.34	0.47	0.53	0.60	1.42	1.93	2.43	3.26	4.02	4.85	0.2	0.3	0.6	1.1	1.5	2.0
00+00	X258L	16.79	0.03	0.07	0.17	0.35	0.42	0.50	0.91	1.23	1.55	2.08	2.56	3.09	0.4	1.5	4.4	12.1	17.9	26.1
00+00	X258C	0.74	0.29	0.35	0.42	0.54	0.58	0.64	1.40	1.89	2.38	3.20	3.94	4.75	0.3	0.5	0.7	1.3	1.7	2.3
00+00	X258R	1.54	0.35	0.41	0.47	0.58	0.62	0.67	1.20	1.62	2.04	2.74	3.37	4.07	0.6	1.0	1.5	2.4	3.2	4.2
00+00	X261L	24.91	0.06	0.12	0.21	0.38	0.44	0.53	0.61	0.83	1.05	1.41	1.73	2.09	1.0	2.5	5.4	13.2	19.1	27.4
00+00	X267L	2.30	0.12	0.19	0.27	0.42	0.48	0.56	1.13	1.53	1.93	2.58	3.18	3.84	0.3	0.7	1.2	2.5	3.5	4.9
00+00	X263C	1.07	0.19	0.26	0.33	0.47	0.53	0.60	1.70	2.29	2.90	3.88	4.78	5.77	0.3	0.6	1.0	2.0	2.7	3.7
00+00	X267C	1.36	0.25	0.32	0.39	0.51	0.56	0.63	2.25	3.04	3.83	5.14	6.33	7.64	0.8	1.3	2.0	3.6	4.8	6.5
00+00	X273L	22.96	0.11	0.17	0.25	0.41	0.47	0.55	0.64	0.87	1.10	1.47	1.81	2.18	1.6	3.3	6.3	13.8	19.6	27.5
00+00	X275C	3.63	0.21	0.27	0.35	0.48	0.54	0.60	1.37	1.86	2.35	3.15	3.87	4.67	1.0	1.9	3.0	5.5	7.5	10.2
00+00	X276L	0.91	0.50	0.56	0.60	0.68	0.71	0.75	1.51	2.04	2.58	3.46	4.26	5.14	0.7	1.0	1.4	2.1	2.7	3.5
00+00	X276C	0.61	0.25	0.31	0.38	0.51	0.56	0.62	1.99	2.70	3.40	4.57	5.62	6.78	0.3	0.5	0.8	1.4	1.9	2.6
00+00	X305L	5.93	0.37	0.44	0.49	0.59	0.63	0.68	0.63	0.85	1.07	1.44	1.77	2.14	1.4	2.2	3.1	5.1	6.6	8.7
00+00	X306R	5.49	0.39	0.46	0.51	0.61	0.64	0.69	0.69	0.93	1.18	1.58	1.94	2.34	1.5	2.3	3.3	5.3	6.9	8.9
00+00	X309C	16.64	0.05	0.10	0.19	0.37	0.43	0.52	0.52	0.71	0.89	1.19	1.47	1.77	0.4	1.2	2.9	7.3	10.6	15.3
00+00	X311C	0.35	0.64	0.69	0.72	0.76	0.78	0.81	2.41	3.26	4.11	5.51	6.79	8.19	0.5	0.8	1.0	1.5	1.8	2.3
00+00	X313C	3.89	0.30	0.36	0.43	0.54	0.59	0.65	1.16	1.57	1.99	2.66	3.28	3.96	1.3	2.2	3.3	5.6	7.5	10.0
00+00	X317C	2.91	0.12	0.18	0.27	0.42	0.48	0.56	1.59	2.15	2.72	3.64	4.49	5.41	0.6	1.1	2.1	4.4	6.3	8.8
00+00	X321R	2.94	0.32	0.39	0.45	0.56	0.60	0.66	1.01	1.37	1.73	2.32	2.86	3.44	1.0	1.6	2.3	3.8	5.1	6.7
00+00	X326L	2.32	0.29	0.35	0.42	0.54	0.58	0.64	1.18	1.60	2.01	2.70	3.33	4.01	0.8	1.3	2.0	3.4	4.5	6.0
00+00	X329R	2.45	0.22	0.28	0.36	0.49	0.54	0.61	1.14	1.55	1.95	2.62	3.22	3.89	0.6	1.1	1.7	3.1	4.3	5.8
00+00	X331L	1.04	0.34	0.40	0.46	0.57	0.61	0.67	1.83	2.47	3.12	4.18	5.15	6.22	0.6	1.0	1.5	2.5	3.3	4.3
00+00	X333C	7.76	0.03	0.08	0.17	0.35	0.42	0.50	0.75	1.01	1.28	1.71	2.11	2.55	0.2	0.6	1.7	4.6	6.8	10.0
00+00	X335L	0.83	0.31	0.38	0.44	0.56	0.60	0.66	1.62	2.19	2.76	3.70	4.56	5.50	0.4	0.7	1.0	1.7	2.3	3.0
00+00	X343C	4.90	0.06	0.12	0.21	0.38	0.44	0.53	0.96	1.30	1.64	2.20	2.71	3.27	0.3	0.8	1.7	4.1	5.9	8.4
00+00	X397L	1.48	0.49	0.54	0.59	0.66	0.69	0.74	1.09	1.47	1.86	2.49	3.07	3.70	0.8	1.2	1.6	2.4	3.1	4.0
00+00	X397C1	3.99	0.13	0.19	0.27	0.43	0.49	0.56	0.93	1.26	1.59	2.13	2.62	3.17	0.5	1.0	1.7	3.6	5.1	7.1
00+00	X397C2	2.03	0.04	0.09	0.18	0.35	0.42	0.51	1.04	1.40	1.77	2.37	2.92	3.52	0.1	0.2	0.6	1.7	2.5	3.6
00+00	X397R	3.99	0.13	0.20	0.28	0.43	0.49	0.56	1.03	1.39	1.75	2.35	2.89	3.49	0.5	1.1	1.9	4.0	5.6	7.9
00+00	X398C	1.59	0.01	0.05	0.14	0.32	0.40	0.49	2.14	2.89	3.65	4.90	6.03	7.28	0.0	0.2	0.8	2.5	3.8	5.6
00+00	X414C	1.44	0.19	0.25	0.33	0.47	0.52	0.59	1.67	2.26	2.85	3.82	4.70	5.68	0.5	0.8	1.4	2.6	3.6	4.9
00+00	X416C	8.78	0.10	0.14	0.22	0.38	0.44	0.52	0.83	1.12	1.42	1.90	2.34	2.82	0.7	1.4	2.8	6.3	9.0	12.9
00+00	X429C	6.91	0.10	0.14	0.21	0.37	0.44	0.52	0.79	1.07	1.36	1.82	2.24	2.70	0.6	1.0	2.0	4.7	6.8	9.7
		446.61																		

Notes:

[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)

Proposed Hydrology Calculations

CALCULATION COVER SHEET

Project Name:	CO 119 Safety and Mobility Improvements Project	**Project No.**	20-069.01 (Muller)/ 21497 (CDOT)
Design Calculation:	Proposed Hydrology	**Version:**	1
Originator	ELW	**Date:**	July 25, 2022
Checker	ZDS	**Date:**	August 8, 2022

Purpose:

Analyze the proposed hydrologic conditions and determine peak flowrates for the CO 119 Safety and Mobility Improvements Project.

References:

Criteria Manuals Used:

Colorado Department of Transportation (CDOT) *Drainage Design Manual,* 2019
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
NOAA Atlas 14 Point Precipitation Frequency Estimates (Longmont, Colorado)
Mile High Flood District (MHFD). *Urban Storm Drainage Criteria Manual (USDCM)* Vol. 1 (2016)

Previous Reports:

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
Proposed Basin Maps

Appendix B
Existing Hydrology Calculation Packet

Refer to the Drainage Report for full citations of references.

Criteria:

Runoff from proposed basins for the proposed project was determined using the most conservative hydrologic criteria between 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 System	100-Year
Minor System	5-year
Hydrologic Procedure Selection	
Hydrologic Peak Prediction Procedure	
Drainage Area	Rational Method (<160 ac) CUHP and EPA-SWMM (>160 ac)
Time of Concentration	
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:
  - Bus Rapid Transit (BRT)/queue jump modifications at five intersections on CO 119 (Jay Road, 63rd Street, CO 52, Niwot Road, and Airport Road)
  - New Regional Transportation District (RTD) Park-and-Ride facilities at two intersections (63rd Street and Niwot Road)
  - Realignment of the CO 119 and CO 52 intersection
- Drainage generally flows east through the project area; however, flow directions are not uniform throughout the project length.
- Design points (DP) for basins are located at the receiving point (stormwater ditches, stormwater pipes and culverts, stormwater inlets, irrigation ditches, irrigation pipes and culverts, and streams and rivers) and where runoff leaves the project area beyond CDOT Right-of-Way (ROW).
- Basins were delineated using survey contours and topography provided by CDOT and LiDAR contours referenced from Boulder County and the preliminary roadway design.

- Basin ID's correspond with centerline stationing for the proposed alignment for CO 119 Northbound. L was designated for basin design points to the left of the median (southbound CO 119 and further west), C was designated for basins in the median, and R was used for basins to the right of the median (northbound CO 119 and further east). Basins with the same station and a greater offset were labeled with increasing numbers (i.e., the design point for P250R1 has a greater offset distance than P250R).
- Land use designation was based on survey, aerial imagery, and the preliminary roadway design.
- Basins were analyzed for peak discharge using rational method, and no DP's have multiple contributing areas.
- Generally, runoff from contributing offsite areas is not relevant because the northbound and southbound lanes of CO 119 will be expanded from the inside lanes toward the median. The elevated embankments for northbound and southbound CO 119 lanes generally separate offsite flow from the project area. However, understanding offsite runoff is necessary for the drainage design at some locations. These locations are discussed in this calculation packet.
- Potential sidewalk designs were included in measuring impervious area in case these are implemented at a later stage of the project.
- The complementary CO 119 Bikeway Project design was considered in delineating basins and measuring land use inputs and flow paths.
- In basins where the bike path shoulder for the CO 119 Bikeway Project will be installed, impervious area was measured shoulder to shoulder to be conservative in the calculations.
- Basin delineations and hydrology calculations for DPs associated with proposed parking lots at the CO 119 and 63rd Street intersection and CO 119 and Niwot Road intersection are undertaken by the Regional Transportation District. Basin delineations and hydrology calculations for these areas are not included in this calculation packet.

Assumptions/Givens:

Rational Method Givens

- Hydrologic Soil Group HSG A, B, C, and D – Taken from USDA NRCS Web Soil Survey.
- Rainfall precipitation values for a 1-hour storm duration were taken from NOAA Atlas 14 for a point located in the project area.
- Land use types and percent imperviousness (provided in Volume 1 Table 6-3 of USDCM) used for this project are:
    - Streets: Paved, 100% imperviousness
    - Undeveloped Areas: Lawns, Clayey Soil, 2% imperviousness
    - Business: Suburban Areas, 75% imperviousness
- USDCM Equations 6-3, 6-4, and 6-5 were used to calculate the time of concentration required to calculate intensity.

General Assumptions/Directives

- Basin P175L was delineated and incorporated in both the existing and proposed hydrology calculations to quantify runoff to the existing 10'x6' concrete box culvert downstream of Boulder Reservoir. The concrete box culvert is slightly south of the CO 119 and 63rd Street intersection. The concrete box culvert will be extended underneath the proposed RTD parking lot.
- The western and southern basin boundaries for basin P245R were delineated in accordance with the existing basin X246R. The boundary is an arbitrary line downstream of the project. The purpose of these basins is to estimate sheet flow that exits the project from CO 52 and 71st Street.
- Runoff from an offsite basin reaches the southwest corner of the CO 119 and Niwot Road intersection. An irrigation diversion structure directs runoff to a culvert crossing Niwot Road to the north, and has an overflow weir that can direct larger flows to a 30" CSP crossing SB CO 119 to the east. Field observations and comments from irrigation owners suggest irrigation baseflow is routed north under Niwot Road and runoff only reaches the 30" CSP crossing SB CO 119 during large storm events which exceed the normal operation of the diversion structure. An offsite basin was delineated to understand the contributing area to the southwest corner of the intersection which is roughly 144 acres. Peak flowrates for the offsite basin will be calculated in the final design phase if necessary. The overflow estimate will require survey of the weir dimensions and elevations, which was not available during preliminary design.
- As discussed in the *SH 119 at SH 52 (Mineral Road) Final Drainage Report,* runoff from the majority of the IBM Campus at the CO 52 and CO 119 intersection is routed south in a storm drain system which outfalls into a detention pond south of the IBM Campus. The detention pond outfalls into Dry Creek just upstream of CO 119 and there are no improvements proposed at the Dry Creek/CO 119 crossing for the CO 119 Safety and Mobility Project. Therefore, runoff from the majority of the IBM Campus does not reach the project area. However, runoff from parking lots on the east side of the IBM Campus does reach the project area. A series of culverts conveys runoff south to a roadside ditch parallel to IBM Road. Flow within the roadside ditch passes under IBM Loop Road via a 30" equivalent culvert. The report states that this culvert is significantly undersized for conveying peak flowrates for the 5-year and 100-year storms. Subsequently, inadvertent detention occurs on the IBM property due to the undersized culvert. Downstream of the culvert, the IBM Road roadside ditch conveys 25 cfs in the 5-year storm and 30 cfs in the 100-year storm. These flowrates reach the project area at approximately Station 2255. A proposed pipe (an extension of an existing pipe) will convey runoff across northbound and southbound CO 119.

Rational Method Assumptions

- The following land use types and percent imperviousness values were not taken from USDCM but were assumed:
    - Irrigation ponds were assumed to be 100% impervious
    - Solar panels were assumed to be 10% impervious because they are disconnected from the ground, allowing runoff to reach the pervious surface below the panels.

Results:

Table 2 summarizes the 5-year and 100-year peak flowrates associated with the proposed basins. Refer to the rational spreadsheet for calculations and analysis of all basins.

Table 2. *Peak Discharge Summary of Individual Basins*

BASIN ID	AREA (acre)	Q_5 (cfs)	Q_{100} (cfs)
P042R	1.50	1.1	5.0
P049L	0.47	0.9	3.1
P049R	2.28	3.2	10.4
P049C	0.75	0.1	1.7
P050C	0.26	0.0	0.9
P051L	1.19	1.1	4.4
P053C	0.33	0.2	1.6
P054C	0.70	0.2	2.1
P061C	1.09	0.3	3.0
P062L	1.80	2.1	7.3
P063R	3.09	3.9	12.7
P064L	0.44	1.2	3.2
P064C	2.33	0.4	6.1
P065C	0.90	0.4	3.6
P067C	0.62	1.8	4.8
P068C	0.32	0.3	1.5
P069R	0.64	1.6	4.3
P070C	1.85	2.2	7.2
P071C	1.95	0.5	5.0
P073C	0.98	0.6	3.6
P074R	1.22	2.2	7.3
P076R	0.50	0.9	3.0
P084L	2.90	4.2	16.3
P086R	2.66	2.2	8.5
P172C	9.08	2.0	12.2
P175R	0.17	0.4	1.2
P175C	0.59	0.4	1.9
P175L	153.05	15.2	147.0
P177R	0.19	0.6	1.6
P177L	0.49	1.5	3.9

BASIN ID	AREA (acre)	Q_5 (cfs)	Q_{100} (cfs)
P177C	0.31	0.7	2.0
P178R	2.63	4.5	13.8
P178C	0.21	0.4	1.3
P179C	0.22	0.5	1.6
P179C1	0.24	0.7	2.0
P180C	2.12	0.8	5.4
P181C	2.34	1.4	7.8
P184L	1.35	1.7	5.9
P191C	0.57	0.1	1.6
P192C	0.37	0.3	1.6
P193R	1.16	1.2	4.8
P194C	1.73	1.0	5.6
P195L	2.88	2.9	10.9
P200C	0.82	0.4	2.5
P200R	2.54	1.3	7.6
P201L	0.99	0.9	3.4
P216C	4.17	1.3	9.7
P222L	0.72	0.7	3.1
P234C	2.18	1.1	5.5
P234L	3.68	1.5	9.0
P238C	0.92	0.4	2.3
P238L	0.98	0.1	2.7
P238L1	1.18	1.2	4.7
P242C	1.80	1.1	6.0
P242R	2.33	3.7	12.8
P243C	1.28	0.4	3.3
P244L	0.34	0.9	2.5
P245L1	0.08	0.2	0.6
P245L2	4.99	1.8	14.2
P245R	7.80	0.6	14.3

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

BASIN ID	AREA (acre)	Q_5 (cfs)	Q_{100} (cfs)
P246C	0.94	0.9	4.6
P246L1	0.26	0.6	1.7
P246L2	0.28	0.7	2.1
P246R1	2.01	1.6	6.5
P246R2	6.14	1.5	14.0
P247C	0.21	0.5	1.3
P247R1	0.09	0.3	0.7
P247R2	0.30	0.9	2.5
P248R	0.50	0.6	2.6
P248C1	0.10	0.3	0.8
P248C2	0.63	0.6	2.9
P249R	0.68	0.8	2.9
P250R1	2.11	1.0	5.0
P250R2	1.46	1.6	5.4
P250C	0.09	0.3	0.7
P252C	0.09	0.3	0.7
P255L	10.39	1.1	13.1
P257L	0.97	0.1	2.0
P258R	2.15	1.8	6.5
P263C1	2.71	0.7	5.4
P263C2	4.26	1.5	7.1
P263L	39.21	3.0	44.3
P265C	0.22	0.1	0.8
P267C	0.94	0.8	4.1
P268L	2.36	1.2	6.3
P273L	23.34	4.7	32.3

BASIN ID	AREA (acre)	Q_5 (cfs)	Q_{100} (cfs)
P275C	3.33	1.8	9.2
P276L	0.92	1.1	3.7
P276C	0.61	0.5	2.4
P306R	5.70	2.8	10.4
P307L	6.59	2.4	9.5
P307C	5.79	0.6	6.5
P309C	8.40	0.9	8.5
P310C	1.87	1.0	4.1
P314R	0.37	1.1	2.9
P317C	2.01	0.7	6.5
P318C	0.64	0.9	2.9
P321R	3.03	1.8	7.4
P326L	2.56	1.7	6.9
P329R	2.62	1.3	6.6
P331L	1.18	1.3	5.0
P333C	7.04	0.9	9.7
P335L	0.93	0.9	3.4
P343C	4.85	1.1	8.6
P397L	1.48	1.2	4.0
P397C1	3.99	1.2	7.5
P397C2	2.03	0.4	3.8
P397R	3.99	1.1	7.9
P398C	1.59	0.5	6.0
P414C	1.44	0.8	4.9
P416C	8.78	2.0	13.9
P429C	6.91	1.3	10.6

Materials Included in this Calculation Packet:

1. Rational Method Calculations

SH 119 Mobility - 63rd Ave Proposed Basins
Basin Calculations - Rational Method
Muller Engineering Company, Inc.
CDOT Project Number: 21497
Muller Project Number: 20-069.01

Originator: ELW
Date: 7/20/2022
Checker: ZDS
Date: 8/1/2022

Land Use Types	Percent Impervious
STREETS: PAVED	100
LAWNS, CLAYEY SOIL	2
IRRIGATION POND	100
BUSINESS: SUBURBAN AREAS	75
SOLAR PANELS	10
NO LAND USE DEFINED	0
NO LAND USE DEFINED	0
NO LAND USE DEFINED	0

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

STATION	BASIN ID	TOTAL AREA		STREETS: PAVED		LAWNS, CLAYEY SOIL		IRRIGATION POND		BUSINESS: SUBURBAN AREAS		SOLAR PANELS		WEIGHTED PERCENT IMPERVIOUS	WEIGHTED PERCENT PERVIOUS
		PERCENT IMPERVIOUS VALUES													
		(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]		
	P042R	65,255	1.50	27,257	42	37,998	58		0		0		0	43	57
	P049L	20,272	0.47	12,164	60	8,108	40		0		0		0	61	39
	P049R	99,405	2.28	65,719	66	33,686	34		0		0		0	67	33
	P049C	32,537	0.75	1,469	5	31,068	95		0		0		0	6	94
	P050C	11,122	0.26	24	0	11,099	100		0		0		0	2	98
	P051L	51,663	1.19	25,367	49	26,296	51		0		0		0	50	50
	P053C	14,459	0.33	2,749	19	11,710	81		0		0		0	21	79
	P054C	30,435	0.70	3,153	10	27,282	90		0		0		0	12	88
	P061C	47,348	1.09	5,844	12	41,504	88		0		0		0	14	86
	P062L	78,366	1.80	48,785	62	29,581	38		0		0		0	63	37
	P063R	134,770	3.09	87,514	65	47,256	35		0		0		0	66	34
	P064L	19,244	0.44	19,244	100	0	0		0		0		0	100	0
	P064C	101,538	2.33	3,157	3	98,381	97		0		0		0	5	95
	P065C	39,006	0.90	5,363	14	33,643	86		0		0		0	15	85
	P067C	27,115	0.62	26,697	98	418	2		0		0		0	98	2
	P068C	13,999	0.32	3,853	28	10,146	72		0		0		0	29	71
	P069R	27,838	0.64	25,459	91	2,379	9		0		0		0	92	8
	P070C	80,431	1.85	51,387	64	29,045	36		0		0		0	65	35
	P071C	84,868	1.95	7,672	9	77,196	91		0		0		0	11	89
	P073C	42,900	0.98	9,956	23	32,944	77		0		0		0	25	75
	P074R	53,284	1.22	33,887	64	19,397	36		0		0		0	64	36
	P076R	21,761	0.50	13,475	62	8,286	38		0		0		0	63	37
	P084L	126,167	2.90	62,298	49	63,869	51		0		0		0	50	50
	P086R	115,826	2.66	56,310	49	59,516	51		0		0		0	50	50
	P172C	395,634	9.08	96,174	24	299,460	76		0		0		0	26	74
	P175R	7,467	0.17	7,291	98	176	2		0		0		0	98	2
	P175C	25,658	0.59	9,689	38	15,969	62		0		0		0	39	61
	P175L	6,666,795	153.05	242,779	4	5,623,984	84		0	636,979	10	163,053	2	13	87
	P177R	8,370	0.19	8,368	100	2	0		0		0		0	100	0
	P177L	21,559	0.49	20,853	97	706	3		0		0		0	97	3
	P177C	13,502	0.31	10,397	77	3,105	23		0		0		0	77	23
	P178R	114,702	2.63	86,026	75	28,676	25		0		0		0	75	25
	P178C	9,310	0.21	5,318	57	3,993	43		0		0		0	58	42
	P179C	9,723	0.22	8,049	83	1,674	17		0		0		0	83	17
	P179C1	10,417	0.24	10,417	100	0	0		0		0		0	100	0
	P180C	92,149	2.12	19,312	21	72,837	79		0		0		0	23	77
	P181C	102,119	2.34	29,186	29	72,933	71		0		0		0	30	70
	P184L	58,664	1.35	36,184	62	22,480	38		0		0		0	62	38
	P191C	24,643	0.57	1,663	7	22,980	93		0		0		0	9	91
	P192C	15,935	0.37	3,632	23	12,303	77		0		0		0	24	76
	P193R	50,694	1.16	23,646	47	27,049	53		0		0		0	48	52
	P194C	75,418	1.73	20,665	27	54,754	73		0		0		0	29	71
	P195L	125,513	2.88	64,613	51	60,900	49		0		0		0	52	48
	P200C	35,877	0.82	7,496	21	28,381	79		0		0		0	22	78
	P200R	110,704	2.54	29,370	27	81,333	73		0		0		0	28	72

	P201L	43,099	**0.99**	21,867	**51**	21,232	**49**		**0**		**0**		**0**	52	48
	P216C	181,738	**4.17**	33,389	**18**	148,350	**82**		**0**		**0**		**0**	20	80
	P222L	31,376	**0.72**	13,308	**42**	18,067	**58**		**0**		**0**		**0**	44	56
	P234C	94,948	**2.18**	31,631	**33**	63,317	**67**		**0**		**0**		**0**	35	65
	P234L	160,486	**3.68**	37,438	**23**	123,049	**77**		**0**		**0**		**0**	25	75
	P238C	40,144	**0.92**	9,943	**25**	30,202	**75**		**0**		**0**		**0**	26	74
	P238L	42,549	**0.98**	120	**0**	42,429	**100**		**0**		**0**		**0**	2	98
	P238L1	51,450	**1.18**	26,271	**51**	25,179	**49**		**0**		**0**		**0**	52	48
	P242C	78,193	**1.80**	22,619	**29**	55,574	**71**		**0**		**0**		**0**	30	70
	P242R	101,393	**2.33**	60,091	**59**	41,303	**41**		**0**		**0**		**0**	60	40
	P243C	55,720	**1.28**	8,665	**16**	47,056	**84**		**0**		**0**		**0**	17	83
	P244L	14,935	**0.34**	12,070	**81**	2,865	**19**		**0**		**0**		**0**	81	19
	P245L1	3,527	**0.08**	3,321	**94**	206	**6**		**0**		**0**		**0**	94	6
	P245L2	217,379	**4.99**	34,178	**16**	183,201	**84**		**0**		**0**		**0**	17	83
	P245R	339,852	**7.80**	13,731	**4**	326,121	**96**		**0**		**0**		**0**	6	94
	P246C	41,129	**0.94**	12,192	**30**	28,937	**70**		**0**		**0**		**0**	31	69
	P246L1	11,418	**0.26**	8,522	**75**	2,896	**25**		**0**		**0**		**0**	75	25
	P246L2	12,080	**0.28**	10,307	**85**	1,774	**15**		**0**		**0**		**0**	86	14
	P246R1	87,518	**2.01**	38,757	**44**	48,761	**56**		**0**		**0**		**0**	45	55
	P246R2	267,494	**6.14**	29,749	**11**	237,745	**89**		**0**		**0**		**0**	13	87
	P247C	9,242	**0.21**	7,573	**82**	1,669	**18**		**0**		**0**		**0**	82	18
	P247R1	3,980	**0.09**	3,976	**100**	4	**0**		**0**		**0**		**0**	100	0
	P247R2	13,136	**0.30**	13,104	**100**	32	**0**		**0**		**0**		**0**	100	0
	P248R	21,635	**0.50**	9,774	**45**	11,861	**55**		**0**		**0**		**0**	46	54
	P248C1	4,533	**0.10**	3,743	**83**	790	**17**		**0**		**0**		**0**	83	17
	P248C2	27,610	**0.63**	10,889	**39**	16,721	**61**		**0**		**0**		**0**	41	59
	P249R	29,676	**0.68**	15,699	**53**	13,977	**47**		**0**		**0**		**0**	54	46
	P250R1	92,112	**2.11**	30,113	**33**	61,999	**67**		**0**		**0**		**0**	34	66
	P250R2	63,398	**1.46**	41,062	**65**	22,337	**35**		**0**		**0**		**0**	65	35
	P250C	3,865	**0.09**	3,860	**100**	5	**0**		**0**		**0**		**0**	100	0
	P252C	3,931	**0.09**	3,891	**99**	40	**1**		**0**		**0**		**0**	99	1
	P255L	452,389	**10.39**	34,086	**8**	418,304	**92**		**0**		**0**		**0**	9	91
	P257L	42,411	**0.97**	0	**0**	42,411	**100**		**0**		**0**		**0**	2	98
	P258R	93,558	**2.15**	53,181	**57**	40,377	**43**		**0**		**0**		**0**	58	42
	P263C1	117,881	**2.71**	18,159	**15**	99,722	**85**		**0**		**0**		**0**	17	83
	P263C2	185,651	**4.26**	63,270	**34**	122,381	**66**		**0**		**0**		**0**	35	65
	P263L	1,708,200	**39.21**	50,345	**3**	1,633,770	**96**	24,085	**1**		**0**		**0**	6	94
	P265C	9,675	**0.22**	1,295	**13**	8,381	**87**		**0**		**0**		**0**	15	85
	P267C	41,006	**0.94**	12,433	**30**	28,573	**70**		**0**		**0**		**0**	32	68
	P268L	102,662	**2.36**	30,485	**30**	72,177	**70**		**0**		**0**		**0**	31	69
	P273L	1,016,697	**23.34**	96,162	**9**	792,080	**78**	42,391	**4**	86,064	**8**		**0**	22	78
	P275C	144,956	**3.33**	44,060	**30**	100,896	**70**		**0**		**0**		**0**	32	68
	P276L	39,953	**0.92**	25,401	**64**	14,551	**36**		**0**		**0**		**0**	64	36
	P276C	26,468	**0.61**	8,898	**34**	17,570	**66**		**0**		**0**		**0**	35	65
	P306R	248,202	**5.70**	129,525	**52**	118,677	**48**		**0**		**0**		**0**	53	47
	P307L	287,069	**6.59**	140,763	**49**	146,305	**51**		**0**		**0**		**0**	50	50
	P307C	252,348	**5.79**	19,430	**8**	232,919	**92**		**0**		**0**		**0**	10	90
	P309C	365,960	**8.40**	41,971	**11**	323,989	**89**		**0**		**0**		**0**	13	87
	P310C	81,469	**1.87**	38,888	**48**	42,581	**52**		**0**		**0**		**0**	49	51
	P314R	16,296	**0.37**	16,259	**100**	37	**0**		**0**		**0**		**0**	100	0
	P317C	87,391	**2.01**	10,932	**13**	76,460	**87**		**0**		**0**		**0**	14	86
	P318C	28,052	**0.64**	17,418	**62**	10,634	**38**		**0**		**0**		**0**	63	37
	P321R	131,896	**3.03**	57,279	**43**	74,617	**57**		**0**		**0**		**0**	45	55
	P326L	111,407	**2.56**	48,432	**43**	62,975	**57**		**0**		**0**		**0**	45	55
	P329R	114,076	**2.62**	38,189	**33**	75,887	**67**		**0**		**0**		**0**	35	65
	P331L	51,368	**1.18**	25,791	**50**	25,577	**50**		**0**		**0**		**0**	51	49
	P333C	306,876	**7.04**	28,813	**9**	278,063	**91**		**0**		**0**		**0**	11	89
	P335L	40,708	**0.93**	19,383	**48**	21,325	**52**		**0**		**0**		**0**	49	51
	P343C	211,438	**4.85**	31,665	**15**	179,774	**85**		**0**		**0**		**0**	17	83
	P397L	64,434	**1.48**	39,609	**61**	24,825	**39**		**0**		**0**		**0**	62	38
	P397C1	173,662	**3.99**	40,780	**23**	132,882	**77**		**0**		**0**		**0**	25	75
	P397C2	88,389	**2.03**	8,381	**9**	80,008	**91**		**0**		**0**		**0**	11	89
	P397R	173,889	**3.99**	31,093	**18**	142,796	**82**		**0**		**0**		**0**	20	80
	P398C	69,215	**1.59**	5,616	**8**	63,599	**92**		**0**		**0**		**0**	10	90
	P414C	62,921	**1.44**	15,751	**25**	47,170	**75**		**0**		**0**		**0**	27	73
	P416C	382,365	**8.78**	74,237	**19**	308,128	**81**		**0**		**0**		**0**	21	79

	P429C	300,782	**6.91**	55,338	**18**	245,444	**82**		**0**		**0**		**0**	20	80

SH 119 Mobility - 63rd Ave Proposed Basins
Basin Calculations - Rational Method
Muller Engineering Company, Inc.
CDOT Project Number: 21497
Muller Project Number: 20-069.01

Originator ELW
Date: 7/20/2022
Checker: ZDS
Date: 8/1/2022

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

STATION	BASIN ID	NRCS HYDROLOGIC SOIL GROUP[1]										C_2	C_5	C_{10}	C_{25}	C_{50}	C_{100}
		SOIL GROUP (%)[1]			SOIL GROUP C/D												
		A	B	C/D	C_2	C_5	C_{10}	C_{25}	C_{50}	C_{100}	%						
00+00	P042R		70	30	0.32	0.39	0.45	0.56	0.60	0.66	30	0.32	0.36	0.42	0.53	0.58	0.64
00+00	P049L			100	0.47	0.53	0.58	0.66	0.69	0.73	100	0.47	0.53	0.58	0.66	0.69	0.73
00+00	P049R			100	0.53	0.58	0.63	0.69	0.72	0.76	100	0.53	0.58	0.63	0.69	0.72	0.76
00+00	P049C			100	0.04	0.09	0.18	0.35	0.42	0.51	100	0.04	0.09	0.18	0.35	0.42	0.51
00+00	P050C			100	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
00+00	P051L			100	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
00+00	P053C			100	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
00+00	P054C			100	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
00+00	P061C			100	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
00+00	P062L			100	0.49	0.55	0.60	0.67	0.70	0.74	100	0.49	0.55	0.60	0.67	0.70	0.74
00+00	P063R			100	0.52	0.57	0.62	0.69	0.71	0.75	100	0.52	0.57	0.62	0.69	0.71	0.75
00+00	P064L			100	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
00+00	P064C			100	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
00+00	P065C			100	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
00+00	P067C			100	0.82	0.84	0.86	0.87	0.88	0.89	100	0.82	0.84	0.86	0.87	0.88	0.89
00+00	P068C			100	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
00+00	P069R			100	0.75	0.79	0.81	0.83	0.84	0.86	100	0.75	0.79	0.81	0.83	0.84	0.86
00+00	P070C			100	0.51	0.56	0.61	0.68	0.71	0.75	100	0.51	0.56	0.61	0.68	0.71	0.75
00+00	P071C			100	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
00+00	P073C			100	0.17	0.24	0.32	0.46	0.51	0.59	100	0.17	0.24	0.32	0.46	0.51	0.59
00+00	P074R			100	0.51	0.56	0.61	0.68	0.71	0.75	100	0.51	0.56	0.61	0.68	0.71	0.75
00+00	P076R			100	0.49	0.55	0.60	0.67	0.70	0.74	100	0.49	0.55	0.60	0.67	0.70	0.74
00+00	P084L			100	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
00+00	P086R			100	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
00+00	P172C			100	0.18	0.25	0.32	0.46	0.52	0.59	100	0.18	0.25	0.32	0.46	0.52	0.59
00+00	P175R			100	0.81	0.84	0.85	0.87	0.87	0.88	100	0.81	0.84	0.85	0.87	0.87	0.88
00+00	P175C			100	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
00+00	P175L			100	0.08	0.14	0.23	0.39	0.46	0.54	100	0.08	0.14	0.23	0.39	0.46	0.54
00+00	P177R			100	0.83	0.85	0.87	0.88	0.88	0.89	100	0.83	0.85	0.87	0.88	0.88	0.89
00+00	P177L			100	0.80	0.83	0.85	0.86	0.87	0.88	100	0.80	0.83	0.85	0.86	0.87	0.88
00+00	P177C			100	0.62	0.67	0.71	0.75	0.77	0.80	100	0.62	0.67	0.71	0.75	0.77	0.80
00+00	P178R			100	0.61	0.65	0.69	0.74	0.76	0.79	100	0.61	0.65	0.69	0.74	0.76	0.79
00+00	P178C			100	0.45	0.51	0.56	0.64	0.68	0.72	100	0.45	0.51	0.56	0.64	0.68	0.72

00+00	P179C			100	0.67	0.72	0.75	0.78	0.80	0.82	100	0.67	0.72	0.75	0.78	0.80	0.82
00+00	P179C1			100	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
00+00	P180C			100	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
00+00	P181C			100	0.22	0.28	0.35	0.49	0.54	0.61	100	0.22	0.28	0.35	0.49	0.54	0.61
00+00	P184L			100	0.49	0.55	0.59	0.67	0.70	0.74	100	0.49	0.55	0.59	0.67	0.70	0.74
00+00	P191C			100	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
00+00	P192C			100	0.17	0.23	0.31	0.46	0.51	0.58	100	0.17	0.23	0.31	0.46	0.51	0.58
00+00	P193R			100	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
00+00	P194C			100	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
00+00	P195L			100	0.40	0.47	0.52	0.61	0.65	0.70	100	0.40	0.47	0.52	0.61	0.65	0.70
00+00	P200C			100	0.16	0.22	0.30	0.44	0.50	0.58	100	0.16	0.22	0.30	0.44	0.50	0.58
00+00	P200R			100	0.20	0.26	0.34	0.48	0.53	0.60	100	0.20	0.26	0.34	0.48	0.53	0.60
00+00	P201L			100	0.40	0.46	0.51	0.61	0.65	0.70	100	0.40	0.46	0.51	0.61	0.65	0.70
00+00	P216C			100	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
00+00	P222L			100	0.33	0.39	0.45	0.56	0.61	0.66	100	0.33	0.39	0.45	0.56	0.61	0.66
00+00	P234C			100	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
00+00	P234L			100	0.17	0.24	0.32	0.46	0.51	0.59	100	0.17	0.24	0.32	0.46	0.51	0.59
00+00	P238C			100	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
00+00	P238L			100	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
00+00	P238L1			100	0.40	0.46	0.52	0.61	0.65	0.70	100	0.40	0.46	0.52	0.61	0.65	0.70
00+00	P242C			100	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
00+00	P242R			100	0.47	0.53	0.58	0.66	0.69	0.73	100	0.47	0.53	0.58	0.66	0.69	0.73
00+00	P243C			100	0.12	0.18	0.26	0.42	0.48	0.55	100	0.12	0.18	0.26	0.42	0.48	0.55
00+00	P244L			100	0.66	0.70	0.73	0.77	0.79	0.82	100	0.66	0.70	0.73	0.77	0.79	0.82
00+00	P245L1			100	0.78	0.81	0.83	0.85	0.85	0.87	100	0.78	0.81	0.83	0.85	0.85	0.87
00+00	P245L2			100	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
00+00	P245R		85	15	0.04	0.08	0.18	0.35	0.42	0.51	15	0.03	0.05	0.12	0.30	0.37	0.46
00+00	P246C			100	0.22	0.29	0.36	0.49	0.55	0.61	100	0.22	0.29	0.36	0.49	0.55	0.61
00+00	P246L1			100	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
00+00	P246L2			100	0.70	0.74	0.77	0.80	0.81	0.84	100	0.70	0.74	0.77	0.80	0.81	0.84
00+00	P246R1			100	0.34	0.41	0.47	0.57	0.62	0.67	100	0.34	0.41	0.47	0.57	0.62	0.67
00+00	P246R2			100	0.08	0.14	0.23	0.39	0.46	0.54	100	0.08	0.14	0.23	0.39	0.46	0.54
00+00	P247C			100	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
00+00	P247R1			100	0.83	0.85	0.87	0.88	0.88	0.89	100	0.83	0.85	0.87	0.88	0.88	0.89
00+00	P247R2			100	0.83	0.85	0.87	0.88	0.88	0.89	100	0.83	0.85	0.87	0.88	0.88	0.89
00+00	P248R			100	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
00+00	P248C1			100	0.67	0.71	0.75	0.78	0.80	0.82	100	0.67	0.71	0.75	0.78	0.80	0.82
00+00	P248C2			100	0.30	0.37	0.43	0.55	0.59	0.65	100	0.30	0.37	0.43	0.55	0.59	0.65
00+00	P249R			100	0.41	0.48	0.53	0.62	0.66	0.70	100	0.41	0.48	0.53	0.62	0.66	0.70
00+00	P250R1			100	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
00+00	P250R2			100	0.52	0.57	0.62	0.69	0.71	0.75	100	0.52	0.57	0.62	0.69	0.71	0.75
00+00	P250C			100	0.83	0.85	0.87	0.88	0.88	0.89	100	0.83	0.85	0.87	0.88	0.88	0.89
00+00	P252C			100	0.82	0.85	0.86	0.87	0.88	0.89	100	0.82	0.85	0.86	0.87	0.88	0.89
00+00	P255L			100	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
00+00	P257L			100	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

00+00	P258R			100	0.45	0.51	0.56	0.64	0.68	0.72	100	0.45	0.51	0.56	0.64	0.68	0.72
00+00	P263C1			100	0.11	0.18	0.26	0.41	0.48	0.55	100	0.11	0.18	0.26	0.41	0.48	0.55
00+00	P263C2			100	0.26	0.33	0.39	0.52	0.57	0.63	100	0.26	0.33	0.39	0.52	0.57	0.63
00+00	P263L			100	0.04	0.09	0.18	0.35	0.42	0.51	100	0.04	0.09	0.18	0.35	0.42	0.51
00+00	P265C			100	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
00+00	P267C			100	0.23	0.30	0.37	0.50	0.55	0.61	100	0.23	0.30	0.37	0.50	0.55	0.61
00+00	P268L			100	0.22	0.29	0.36	0.49	0.55	0.61	100	0.22	0.29	0.36	0.49	0.55	0.61
00+00	P273L			100	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
00+00	P275C			100	0.23	0.30	0.37	0.50	0.55	0.61	100	0.23	0.30	0.37	0.50	0.55	0.61
00+00	P276L			100	0.51	0.56	0.61	0.68	0.71	0.75	100	0.51	0.56	0.61	0.68	0.71	0.75
00+00	P276C			100	0.26	0.32	0.39	0.51	0.56	0.63	100	0.26	0.32	0.39	0.51	0.56	0.63
00+00	P306R			100	0.41	0.47	0.53	0.62	0.65	0.70	100	0.41	0.47	0.53	0.62	0.65	0.70
00+00	P307L			100	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
00+00	P307C			100	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
00+00	P309C			100	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
00+00	P310C			100	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
00+00	P314R			100	0.83	0.85	0.87	0.88	0.88	0.89	100	0.83	0.85	0.87	0.88	0.88	0.89
00+00	P317C			100	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
00+00	P318C			100	0.49	0.55	0.60	0.67	0.70	0.74	100	0.49	0.55	0.60	0.67	0.70	0.74
00+00	P326L			100	0.34	0.40	0.46	0.57	0.61	0.67	100	0.34	0.40	0.46	0.57	0.61	0.67
00+00	P329R			100	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
00+00	P331L			100	0.39	0.45	0.51	0.61	0.64	0.69	100	0.39	0.45	0.51	0.61	0.64	0.69
00+00	P333C			100	0.07	0.13	0.21	0.38	0.45	0.53	100	0.07	0.13	0.21	0.38	0.45	0.53
00+00	P335L			100	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
00+00	P343C			100	0.11	0.17	0.26	0.41	0.47	0.55	100	0.11	0.17	0.26	0.41	0.47	0.55
00+00	P397L		20	80	0.49	0.55	0.59	0.67	0.70	0.74	80	0.49	0.54	0.59	0.66	0.69	0.74
00+00	P397C1			100	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
00+00	P397C2		5	95	0.07	0.13	0.22	0.38	0.45	0.53	95	0.07	0.13	0.21	0.38	0.45	0.53
00+00	P397R			100	0.13	0.20	0.28	0.43	0.49	0.56	100	0.13	0.20	0.28	0.43	0.49	0.56
00+00	P398C		10	90	0.06	0.12	0.21	0.37	0.44	0.52	90	0.06	0.11	0.20	0.37	0.44	0.52
00+00	P414C			100	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
00+00	P416C	5	10	85	0.14	0.21	0.29	0.44	0.50	0.57	85	0.14	0.20	0.27	0.42	0.48	0.55
00+00	P429C		60	40	0.14	0.20	0.28	0.43	0.49	0.57	40	0.13	0.17	0.24	0.40	0.46	0.54

[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 Mobility - 63rd Ave Proposed Basins
Basin Calculations - Rational Method
Muller Engineering Company, Inc.
CDOT Project Number: 21497
Muller Project Number: 20-069.01

Originator ELW
Date: 7/20/2022
Checker: ZDS
Date: 8/1/2022

TIME OF CONCENTRATION

STATION	BASIN DATA				INITIAL/OVERLAND TIME (T_i)					CHANNELIZED (TRAVEL) TIME (T_t)								TOTAL t_c	T_c CHECK (Urbanized Basins)		FINAL t_c	REMARKS
	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)	
00+00	P042R	1.50	0.36	Urban	81	5290.40	5289.20	0.015	10.6	478	5289.20	5282.40	0.014	SP	7	0.8	9.6	20.2	No	N/A	20.2	
00+00	P049L	0.47	0.53	Urban	95	5291.80	5281.80	0.106	4.6	137	5281.80	5277.00	0.035	P	20	3.7	0.6	5.2	Yes	16.4	5.2	
00+00	P049R	2.28	0.58	Urban	81	5287.00	5285.00	0.025	6.2	360	5285.00	5282.00	0.008	SP	7	0.6	9.4	15.6	No	N/A	15.6	
00+00	P049C	0.75	0.09	Non-Urban	22	5295.20	5293.90	0.059	4.8	910	5293.90	5285.40	0.009	SP	7	0.7	22.4	27.2	Yes	40.8	27.2	
00+00	P050C	0.26	0.05	Non-Urban	16	5287.30	5284.50	0.175	2.9	241	5284.50	5283.00	0.006	SP	7	0.6	7.3	10.2	Yes	31.1	10.2	
00+00	P051L	1.19	0.45	Urban	99	5292.20	5291.95	0.003	18.5	381	5291.95	5277.00	0.039	SP	7	1.4	4.6	23.1	Yes	19.5	19.5	
00+00	P053C	0.33	0.20	Urban	33	5292.40	5287.90	0.137	3.9	223	5287.90	5278.00	0.044	SP	7	1.5	2.5	6.4	Yes	24.0	6.4	
00+00	P054C	0.70	0.13	Non-Urban	104	5291.90	5284.50	0.071	9.3	290	5284.50	5282.50	0.007	SP	7	0.6	8.3	17.6	No	N/A	17.6	
00+00	P061C	1.09	0.15	Non-Urban	66	5289.50	5283.50	0.091	6.7	651	5283.50	5276.00	0.012	SP	7	0.8	14.4	21.2	No	N/A	21.2	
00+00	P062L	1.80	0.55	Urban	84	5292.20	5290.00	0.026	6.6	687	5290.00	5278.00	0.017	SP	7	0.9	12.4	19.0	No	N/A	19.0	
00+00	P063R	3.09	0.57	Urban	80	5287.00	5285.00	0.025	6.3	747	5285.00	5270.00	0.020	SP	7	1.0	12.6	18.8	No	N/A	18.8	
00+00	P064L	0.44	0.86	Urban	71	5285.20	5285.00	0.003	5.7	231	5285.00	5281.50	0.015	P	20	2.5	1.6	7.2	Yes	10.4	7.2	
00+00	P064C	2.33	0.08	Non-Urban	39	5291.90	5289.50	0.062	6.3	926	5289.50	5267.50	0.024	SP	7	1.1	14.3	20.6	No	N/A	20.6	
00+00	P065C	0.90	0.16	Non-Urban	26	5283.00	5276.00	0.273	2.9	408	5276.00	5267.00	0.022	SP	7	1.0	6.5	9.4	No	N/A	10.0	
00+00	P067C	0.62	0.84	Urban	180	5283.90	5279.90	0.022	4.8	165	5279.90	5278.20	0.010	P	20	2.0	1.4	6.1	Yes	10.4	6.1	
00+00	P068C	0.32	0.27	Urban	65	5273.70	5271.40	0.035	7.9	178	5271.40	5265.00	0.036	P	20	3.8	0.8	8.7	Yes	22.3	8.7	
00+00	P069R	0.64	0.79	Urban	242	5279.00	5276.00	0.012	8.2	10	5276.00	5275.50	0.050	SP	7	1.6	0.1	8.3	No	N/A	8.3	
00+00	P070C	1.85	0.56	Urban	151	5284.00	5277.70	0.042	7.4	515	5277.70	5273.10	0.009	SP	7	0.7	13.0	20.4	No	N/A	20.4	
00+00	P071C	1.95	0.12	Non-Urban	61	5278.50	5273.90	0.075	7.1	461	5273.90	5271.80	0.005	SP	7	0.5	16.3	23.3	No	N/A	23.3	
00+00	P073C	0.98	0.24	Urban	92	5278.50	5274.70	0.041	9.3	300	5274.70	5267.50	0.024	SP	7	1.1	4.6	14.0	No	N/A	14.0	
00+00	P074R	1.22	0.56	Urban	100	5276.50	5274.40	0.021	7.6	14	5274.40	5274.20	0.014	SP	7	0.8	0.3	7.9	No	N/A	7.9	
00+00	P076R	0.50	0.55	Urban	88	5274.00	5272.00	0.023	7.1	40	5272.00	5268.60	0.085	SP	7	2.0	0.3	7.4	No	N/A	7.4	
00+00	P084L	2.90	0.45	Urban	105	5275.00	5269.70	0.050	7.1	10	5269.70	5269.60	0.010	SP	7	0.7	0.2	7.3	No	N/A	7.3	
00+00	P086R	2.66	0.44	Urban	101	5273.20	5271.10	0.021	9.4	1068	5271.10	5243.60	0.026	SP	7	1.1	15.8	25.3	No	N/A	25.3	
00+00	P172C	9.08	0.25	Non-Urban	440	5182.20	5164.00	0.041	20.2	2107	5164.00	5148.00	0.008	SP	7	0.6	57.6	77.8	No	N/A	77.8	
00+00	P175R	0.17	0.84	Urban	43	5154.60	5154.20	0.009	3.2	199	5154.20	5154.00	0.001	P	20	0.6	5.2	8.4	No	N/A	8.4	
00+00	P175C	0.59	0.35	Urban	31	5161.00	5156.50	0.148	3.1	537	5156.50	5154.00	0.005	SP	7	0.5	18.8	21.8	No	N/A	21.8	
00+00	P175L	153.05	0.14	Non-Urban	500	5209.00	5197.00	0.024	29.0	3811	5197.00	5148.00	0.013	SP	7	0.8	80.0	109.1	No	N/A	109.1	
00+00	P177R	0.19	0.85	Urban	38	5154.80	5154.10	0.019	2.2	52	5154.10	5153.90	0.004	P	20	1.2	0.7	2.9	Yes	9.6	5.0	
00+00	P177L	0.49	0.83	Urban	135	5164.90	5160.20	0.035	3.8	200	5160.20	5157.60	0.013	P	20	2.3	1.5	5.2	No	N/A	5.2	
00+00	P177C	0.31	0.67	Urban	114	5157.50	5154.30	0.028	5.9	155	5154.30	5153.10	0.008	P	20	1.8	1.5	7.4	Yes	14.3	7.4	
00+00	P178R	2.63	0.65	Urban	122	5156.00	5152.00	0.033	6.0	251	5152.00	5150.00	0.008	SP	7	0.6	6.7	12.7	No	N/A	12.7	
00+00	P178C	0.21	0.51	Urban	23	5153.20	5153.00	0.009	5.2	270	5153.00	5142.00	0.041	P	20	4.0	1.1	6.4	Yes	17.4	6.4	
00+00	P179C	0.22	0.72	Urban	179	5164.50	5158.00	0.036	6.1	84	5158.00	5155.50	0.030	P	20	3.4	0.4	6.5	Yes	12.3	6.5	
00+00	P179C1	0.24	0.86	Urban	211	5164.00	5158.00	0.028	4.6	84	5158.00	5154.80	0.038	P	20	3.9	0.4	4.9	Yes	9.3	5.0	
00+00	P180C	2.12	0.22	Urban	125	5168.00	5157.50	0.084	8.8	709	5157.50	5152.00	0.008	SP	7	0.6	19.2	28.0	No	N/A	28.0	
00+00	P181C	2.34	0.28	Urban	140	5170.00	5168.00	0.014	15.6	691	5168.00	5143.00	0.036	P	20	3.8	3.0	18.6	Yes	25.5	18.6	
00+00	P184L	1.35	0.55	Urban	90	5170.00	5169.00	0.011	9.2	270	5169.00	5166.50	0.009	SP	7	0.7	6.7	15.8	No	N/A	15.8	
00+00	P191C	0.57	0.11	Non-Urban	110	5169.80	5168.20	0.015	16.6	259	5168.20	5160.00	0.032	SP	7	1.2	3.5	20.0	No	N/A	20.0	
00+00	P192C	0.37	0.23	Urban	105	5165.20	5157.00	0.078	8.1	121	5157.00	5153.50	0.029	SP	7	1.2	1.7	9.8	Yes	22.8	9.8	
00+00	P193R	1.16	0.43	Urban	211	5161.00	5156.00	0.024	13.3	222	5156.00	5139.00	0.077	SP	7	1.9	1.9	15.2	No	N/A	15.2	
00+00	P194C	1.73	0.27	Urban	222	5168.00	5156.80	0.050	13.1	506	5156.80	5138.00	0.037	SP	7	1.3	6.2	19.3	No	N/A	19.3	
00+00	P195L	2.88	0.47	Urban	72	5170.00	5169.50	0.007	10.9	618	5169.50	5150.00	0.032	SP	7	1.2	8.3	19.2	No	N/A	19.2	
00+00	P200C	0.82	0.22	Urban	114	5159.50	5152.00	0.066	9.1	605	5152.00	5142.00	0.017	SP	7	0.9	11.2	20.3	No	N/A	20.3	
00+00	P200R	2.54	0.26	Urban	69	5148.90	5140.00	0.129	5.4	530	5140.00	5137.00	0.006	SP	7	0.5	16.8	22.2	No	N/A	22.2	
00+00	P201L	0.99	0.46	Urban	98	5148.80	5144.00	0.049	6.8	444	5144.00	5142.00	0.005	SP	7	0.5	15.8	22.5	No	N/A	22.5	
00+00	P216C	4.17	0.20	Urban	155	5173.30	5164.50	0.057	11.4	1048	5164.50	5148.60	0.015	SP	7	0.9	20.3	31.7	No	N/A	31.7	
00+00	P222L	0.72	0.39	Urban	117	5172.10	5167.00	0.044	8.5	295	5167.00	5161.40	0.019	SP	7	1.0	5.1	13.6	Yes	21.0	13.6	
00+00	P234C	2.18	0.32	Urban	117	5173.30	5164.60	0.074	7.9	660	5164.60	5162.00	0.004	SP	7	0.4	25.0	32.9	No	N/A	32.9	
00+00	P234L	3.68	0.24	Urban	95	5174.00	5167.00	0.074	7.8	778	5167.00	5161.80	0.007	SP	7	0.6	22.7	30.5	No	N/A	30.5	
00+00	P238C	0.92	0.25	Urban	136	5168.00	5161.40	0.049	10.6	648	5161.40	5157.50	0.006	SP	7	0.5	19.9	30.5	Yes	32.5	30.5	
00+00	P238L	0.98	0.05	Non-Urban	41	5176.00	5168.00	0.197	4.5	719	5168.00	5156.60	0.016	SP	7	0.9	13.6	18.1	No	N/A	18.1	
00+00	P238L1	1.18	0.46	Urban	81	5174.10	5166.00	0.100	4.9	302	5166.00	5165.00	0.003	SP	7	0.4	12.5	17.4	Yes	22.5	17.4	
00+00	P242C	1.80	0.28	Urban	297	5171.00	5154.00	0.057	14.3	145	5154.00	5153.00	0.007	SP	7	0.6	4.2	18.5	Yes	23.0	18.5	
00+00	P242R	2.33	0.53	Urban	134	5165.00	5160.00	0.037	7.7	92	5160.00	5158.00	0.022	SP	7	1.0	1.5	9.2	No	N/A	9.2	
00+00	P243C	1.28	0.18	Non-Urban	92	5158.30	5157.40	0.010	16.2	286	5157.40	5156.00	0.005	SP	7	0.5	9.7	25.9	No	N/A	25.9	
00+00	P244L	0.34	0.70	Urban	60	5168.90	5166.50	0.040	3.5	209	5166.50	5164.00	0.012	P	20	2.2	1.6	5.1	Yes	13.8	5.1	
00+00	P245L1	0.08	0.81	Urban	55	5167.00	5165.60	0.025	2.9	63	5165.60	5165.10	0.008	P	20	1.8	0.6	3.5	Yes	10.5	5.0	

00+00	P245L2	4.99	0.18	Non-Urban	48	5166.00	5165.00	0.021	9.1	623	5165.00	5156.00	0.014	SP	7	0.8	12.3	21.4	Yes	30.6	21.4	
00+00	P245R	7.80	0.05	Non-Urban	146	5151.50	5145.00	0.044	14.1	988	5145.00	5130.00	0.015	SP	7	0.9	19.1	33.1	No	N/A	33.1	
00+00	P246C	0.94	0.29	Urban	25	5156.90	5156.50	0.016	6.3	355	5156.50	5143.80	0.036	P	20	3.8	1.6	7.9	Yes	23.1	7.9	
00+00	P246L1	0.26	0.65	Urban	53	5165.00	5164.00	0.019	4.8	171	5164.00	5163.00	0.006	P	20	1.5	1.9	6.6	Yes	15.1	6.6	
00+00	P246L2	0.28	0.74	Urban	54	5166.80	5165.30	0.028	3.5	185	5165.30	5163.50	0.010	P	20	2.0	1.6	5.0	Yes	12.9	5.0	
00+00	P246R1	2.01	0.41	Urban	118	5161.10	5157.00	0.035	9.0	531	5157.00	5153.00	0.008	SP	7	0.6	14.6	23.6	No	N/A	23.6	
00+00	P246R2	6.14	0.14	Non-Urban	24	5157.00	5155.00	0.084	4.2	973	5155.00	5147.00	0.008	SP	7	0.6	25.6	29.7	No	N/A	29.7	
00+00	P247C	0.21	0.71	Urban	165	5164.50	5162.10	0.015	8.0	178	5162.10	5159.00	0.017	P	20	2.6	1.1	9.1	Yes	13.1	9.1	
00+00	P247R1	0.09	0.85	Urban	76	5158.80	5157.50	0.017	3.2	60	5157.50	5157.20	0.005	P	20	1.4	0.7	4.0	Yes	9.6	5.0	
00+00	P247R2	0.30	0.85	Urban	30	5165.00	5164.50	0.017	2.0	363	5164.50	5158.20	0.017	P	20	2.6	2.3	4.3	Yes	11.0	5.0	
00+00	P248R	0.50	0.41	Urban	59	5157.20	5156.00	0.020	7.5	43	5156.00	5154.50	0.035	SP	7	1.3	0.5	8.0	No	N/A	8.0	
00+00	P248C1	0.10	0.71	Urban	69	5158.00	5156.70	0.019	4.7	64	5156.70	5156.40	0.005	P	20	1.4	0.8	5.4	Yes	12.7	5.4	
00+00	P248C2	0.63	0.37	Urban	109	5151.00	5148.20	0.026	10.1	186	5148.20	5143.00	0.028	P	20	3.3	0.9	11.1	Yes	20.3	11.1	
00+00	P249R	0.68	0.48	Urban	82	5160.00	5158.50	0.018	8.3	435	5158.50	5150.00	0.020	SP	7	1.0	7.4	15.8	No	N/A	15.8	
00+00	P250R1	2.11	0.31	Urban	264	5154.50	5152.00	0.009	23.5	438	5152.00	5148.70	0.008	SP	7	0.6	12.0	35.5	No	N/A	35.5	
00+00	P250R2	1.46	0.57	Urban	80	5150.00	5145.80	0.052	4.9	725	5145.80	5139.30	0.009	SP	7	0.7	18.2	23.2	No	N/A	23.2	
00+00	P250C	0.09	0.85	Urban	19	5158.00	5157.80	0.010	1.9	80	5157.80	5157.30	0.006	P	20	1.6	0.8	2.8	Yes	9.8	5.0	
00+00	P252C	0.09	0.85	Urban	28	5157.90	5157.00	0.032	1.7	131	5157.00	5156.10	0.007	P	20	1.7	1.3	3.0	Yes	10.3	5.0	
00+00	P255L	10.39	0.11	Non-Urban	350	5161.00	5155.00	0.017	27.9	1104	5155.00	5151.00	0.004	SP	7	0.4	43.7	71.6	No	N/A	71.6	
00+00	P257L	0.97	0.05	Non-Urban	285	5154.00	5149.00	0.018	26.6	107	5149.00	5148.20	0.007	SP	7	0.6	3.0	29.5	No	N/A	29.5	
00+00	P258R	2.15	0.51	Urban	122	5156.90	5154.00	0.024	8.9	867	5154.00	5146.00	0.009	SP	7	0.7	21.5	30.4	No	N/A	30.4	
00+00	P263C1	2.71	0.18	Non-Urban	27	5157.00	5154.00	0.112	3.9	1292	5154.00	5144.00	0.008	SP	7	0.6	35.0	38.9	No	N/A	38.9	
00+00	P263C2	4.26	0.33	Urban	247	5165.00	5153.00	0.049	13.0	1559	5153.00	5144.00	0.006	SP	7	0.5	48.8	61.9	No	N/A	61.9	
00+00	P263L	39.21	0.09	Non-Urban	297	5161.00	5154.00	0.024	23.8	1787	5154.00	5144.00	0.006	SP	7	0.5	56.9	80.7	No	N/A	80.7	
00+00	P265C	0.22	0.16	Non-Urban	40	5148.10	5146.00	0.053	6.2	165	5146.00	5145.00	0.006	SP	7	0.5	5.1	11.3	No	N/A	11.3	
00+00	P267C	0.94	0.30	Urban	31	5147.00	5144.70	0.075	4.2	328	5144.70	5140.40	0.013	SP	7	0.8	6.8	11.0	No	N/A	11.0	
00+00	P268L	2.36	0.29	Urban	287	5149.00	5143.00	0.021	19.4	237	5143.00	5142.00	0.004	SP	7	0.5	8.7	28.1	No	N/A	28.1	
00+00	P273L	23.34	0.21	Urban	300	5161.00	5152.00	0.030	19.3	2010	5152.00	5135.00	0.008	SP	7	0.6	52.0	71.4	No	N/A	71.4	
00+00	P275C	3.33	0.30	Urban	29	5146.20	5146.00	0.007	8.7	928	5146.00	5132.00	0.015	SP	7	0.9	18.0	26.7	No	N/A	26.7	
00+00	P276L	0.92	0.56	Urban	277	5139.50	5136.00	0.013	14.9	218	5136.00	5133.00	0.014	SP	7	0.8	4.4	19.3	No	N/A	19.3	
00+00	P276C	0.61	0.32	Urban	58	5137.00	5136.00	0.017	8.9	194	5136.00	5134.00	0.010	SP	7	0.7	4.5	13.5	No	N/A	13.5	
00+00	P306R	5.70	0.47	Urban	300	5133.50	5129.90	0.012	18.5	2000	5129.90	5108.00	0.011	SP	7	0.7	45.5	64.0	No	N/A	64.0	
00+00	P307L	6.59	0.45	Urban	115	5136.60	5133.40	0.028	9.0	3021	5133.40	5108.00	0.008	SP	7	0.6	78.4	87.5	No	N/A	87.5	
00+00	P307C	5.79	0.11	Non-Urban	18	5137.00	5134.20	0.155	3.1	3114	5134.20	5109.00	0.008	SP	7	0.6	82.4	85.5	No	N/A	85.5	
00+00	P309C	8.40	0.14	Non-Urban	201	5135.50	5131.00	0.022	18.8	3127	5131.00	5106.20	0.008	SP	7	0.6	83.6	102.3	No	N/A	102.3	
00+00	P310C	1.87	0.43	Urban	128	5112.10	5109.00	0.024	10.1	613	5109.00	5108.00	0.002	SP	7	0.3	36.1	46.3	No	N/A	46.3	
00+00	P314R	0.37	0.85	Urban	85	5111.10	5109.50	0.019	3.3	290	5109.50	5107.00	0.009	P	20	1.9	2.6	5.9	No	N/A	5.9	
00+00	P317C	2.01	0.15	Non-Urban	94	5106.00	5103.70	0.025	12.3	416	5103.70	5099.00	0.011	P	20	2.1	3.3	15.6	No	N/A	15.6	
00+00	P318C	0.64	0.55	Urban	30	5106.00	5105.30	0.023	4.1	306	5105.30	5104.00	0.004	SP	7	0.5	11.2	15.2	No	N/A	15.2	
00+00	P321R	3.03	0.40	Urban	170	5110.40	5108.60	0.011	16.2	937	5108.60	5099.00	0.010	SP	7	0.7	22.0	38.2	No	N/A	38.2	
00+00	P326L	2.56	0.40	Urban	43	5105.80	5102.00	0.088	4.1	940	5102.00	5096.00	0.006	SP	7	0.6	28.0	32.1	No	N/A	32.1	
00+00	P329R	2.62	0.32	Urban	187	5102.00	5099.00	0.016	16.5	694	5099.00	5092.00	0.010	SP	7	0.7	16.5	32.9	No	N/A	32.9	
00+00	P331L	1.18	0.45	Urban	97	5099.00	5096.00	0.031	7.9	414	5096.00	5088.00	0.019	SP	7	1.0	7.1	15.0	No	N/A	15.0	
00+00	P333C	7.04	0.13	Non-Urban	477	5104.00	5097.60	0.013	34.8	1241	5097.60	5085.00	0.010	SP	7	0.7	29.3	64.2	No	N/A	64.2	
00+00	P335L	0.93	0.43	Urban	107	5096.20	5090.00	0.058	7.0	385	5090.00	5088.00	0.005	SP	7	0.5	12.7	19.7	No	N/A	19.7	
00+00	P343C	4.85	0.17	Non-Urban	202	5094.00	5088.10	0.029	16.7	1024	5088.10	5081.50	0.006	SP	7	0.6	30.4	47.1	No	N/A	47.1	
00+00	P397L	1.48	0.54	Urban	70	5060.10	5058.50	0.023	6.4	1207	5058.50	5048.00	0.009	SP	7	0.7	30.8	37.3	No	N/A	37.3	
00+00	P397C1	3.99	0.24	Urban	185	5063.50	5059.30	0.023	16.1	1284	5059.30	5046.50	0.010	SP	7	0.7	30.6	46.8	No	N/A	46.8	
00+00	P397C2	2.03	0.13	Non-Urban	98	5062.40	5060.00	0.024	13.0	1211	5060.00	5046.00	0.012	SP	7	0.8	26.8	39.8	No	N/A	39.8	
00+00	P397R	3.99	0.20	Non-Urban	61	5063.30	5062.00	0.021	9.9	1333	5062.00	5048.00	0.011	SP	7	0.7	31.0	40.9	No	N/A	40.9	
00+00	P398C	1.59	0.11	Non-Urban	36	5048.00	5045.80	0.061	5.9	31	5045.80	5045.00	0.026	SP	7	1.1	0.5	6.3	No	N/A	10.0	
00+00	P414C	1.44	0.25	Urban	61	5045.50	5041.80	0.060	6.6	643	5041.80	5029.00	0.020	SP	7	1.0	10.8	17.5	No	N/A	17.5	
00+00	P416C	8.78	0.20	Non-Urban	468	5048.00	5034.00	0.030	24.5	1220	5034.00	5023.00	0.009	SP	7	0.7	30.6	55.1	No	N/A	55.1	
00+00	P429C	6.91	0.17	Non-Urban	499	5029.40	5021.30	0.016	32.0	509	5021.30	5020.00	0.003	SP	7	0.4	24.0	56.0	No	N/A	56.0	

[1] $t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S^{0.33}}$ 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] $t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_r}}$ USDCM Equation 6-5 August 2018

SH 119 Mobility - 63rd Ave Proposed Basins
Basin Calculations - Rational Method
Muller Engineering Company, Inc.
CDOT Project Number: 21497
Muller Project Number: 20-069.01

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	1.07	1.35	1.81	2.23	2.69

NOAA Atlas 14, Volume 8, Version 2 (Longmont, CO)

Originator ELW
Date: 7/20/2022
Checker: ZDS
Date: 8/1/2022

STATION	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)
00+00	P042R	1.50	0.32	0.36	0.42	0.53	0.58	0.64	1.55	2.10	2.64	3.54	4.37	5.27	0.7	1.1	1.7	2.8	3.8	5.0
00+00	P049L	0.47	0.47	0.53	0.58	0.66	0.69	0.73	2.66	3.59	4.54	6.08	7.49	9.04	0.6	0.9	1.2	1.9	2.4	3.1
00+00	P049R	2.28	0.53	0.58	0.63	0.69	0.72	0.76	1.76	2.38	3.01	4.03	4.96	5.99	2.1	3.2	4.3	6.4	8.2	10.4
00+00	P049C	0.75	0.04	0.09	0.18	0.35	0.42	0.51	1.31	1.78	2.24	3.01	3.71	4.47	0.0	0.1	0.3	0.8	1.2	1.7
00+00	P050C	0.26	0.01	0.05	0.15	0.33	0.40	0.49	2.12	2.87	3.62	4.86	5.98	7.22	0.0	0.0	0.1	0.4	0.6	0.9
00+00	P051L	1.19	0.38	0.45	0.50	0.60	0.64	0.69	1.58	2.13	2.69	3.61	4.45	5.36	0.7	1.1	1.6	2.6	3.4	4.4
00+00	P053C	0.33	0.14	0.20	0.28	0.43	0.49	0.57	2.50	3.38	4.27	5.72	7.05	8.50	0.1	0.2	0.4	0.8	1.2	1.6
00+00	P054C	0.70	0.08	0.13	0.22	0.39	0.45	0.53	1.66	2.25	2.83	3.80	4.68	5.65	0.1	0.2	0.4	1.0	1.5	2.1
00+00	P061C	1.09	0.09	0.15	0.24	0.40	0.46	0.54	1.51	2.04	2.58	3.46	4.26	5.14	0.2	0.3	0.7	1.5	2.1	3.0
00+00	P062L	1.80	0.49	0.55	0.60	0.67	0.70	0.74	1.60	2.16	2.73	3.66	4.50	5.43	1.4	2.1	2.9	4.4	5.7	7.3
00+00	P063R	3.09	0.52	0.57	0.62	0.69	0.71	0.75	1.61	2.17	2.74	3.68	4.53	5.46	2.6	3.9	5.2	7.8	10.0	12.7
00+00	P064L	0.44	0.83	0.86	0.87	0.88	0.88	0.89	2.41	3.26	4.11	5.51	6.78	8.18	0.9	1.2	1.6	2.1	2.6	3.2
00+00	P064C	2.33	0.03	0.08	0.17	0.35	0.42	0.50	1.53	2.07	2.61	3.50	4.31	5.20	0.1	0.4	1.0	2.8	4.2	6.1
00+00	P065C	0.90	0.10	0.16	0.25	0.41	0.47	0.55	2.14	2.89	3.65	4.90	6.03	7.28	0.2	0.4	0.8	1.8	2.5	3.6
00+00	P067C	0.62	0.82	0.84	0.86	0.87	0.88	0.89	2.53	3.43	4.32	5.79	7.14	8.61	1.3	1.8	2.3	3.1	3.9	4.8
00+00	P068C	0.32	0.21	0.27	0.35	0.48	0.53	0.60	2.25	3.05	3.85	5.16	6.36	7.67	0.1	0.3	0.4	0.8	1.1	1.5
00+00	P069R	0.64	0.75	0.79	0.81	0.83	0.84	0.86	2.29	3.10	3.92	5.25	6.47	7.80	1.1	1.6	2.0	2.8	3.5	4.3
00+00	P070C	1.85	0.51	0.56	0.61	0.68	0.71	0.75	1.54	2.08	2.63	3.53	4.34	5.24	1.4	2.2	3.0	4.4	5.7	7.2
00+00	P071C	1.95	0.07	0.12	0.21	0.38	0.45	0.53	1.43	1.94	2.44	3.28	4.04	4.87	0.2	0.5	1.0	2.4	3.5	5.0
00+00	P073C	0.98	0.17	0.24	0.32	0.46	0.51	0.59	1.86	2.51	3.17	4.25	5.23	6.31	0.3	0.6	1.0	1.9	2.7	3.6
00+00	P074R	1.22	0.51	0.56	0.61	0.68	0.71	0.75	2.34	3.16	3.99	5.35	6.59	7.95	1.4	2.2	3.0	4.4	5.7	7.3
00+00	P076R	0.50	0.49	0.55	0.60	0.67	0.70	0.74	2.38	3.22	4.07	5.45	6.72	8.10	0.6	0.9	1.2	1.8	2.3	3.0
00+00	P084L	2.90	0.38	0.45	0.50	0.60	0.64	0.69	2.40	3.24	4.09	5.49	6.76	8.15	2.7	4.2	6.0	9.6	12.5	16.3
00+00	P086R	2.66	0.38	0.44	0.50	0.60	0.64	0.69	1.37	1.85	2.34	3.14	3.86	4.66	1.4	2.2	3.1	5.0	6.5	8.5
00+00	P172C	9.08	0.18	0.25	0.32	0.46	0.52	0.59	0.67	0.91	1.14	1.53	1.89	2.28	1.1	2.0	3.4	6.4	8.9	12.2
00+00	P175R	0.17	0.81	0.84	0.85	0.87	0.87	0.88	2.28	3.09	3.90	5.22	6.44	7.76	0.3	0.4	0.6	0.8	1.0	1.2
00+00	P175C	0.59	0.29	0.35	0.42	0.54	0.58	0.64	1.49	2.01	2.54	3.40	4.19	5.05	0.3	0.4	0.6	1.1	1.4	1.9
00+00	P175L	153.05	0.08	0.14	0.23	0.39	0.46	0.54	0.53	0.71	0.90	1.20	1.48	1.79	6.6	15.2	31.1	72.0	103.5	147.0
00+00	P177R	0.19	0.83	0.85	0.87	0.88	0.88	0.89	2.68	3.63	4.58	6.14	7.56	9.12	0.4	0.6	0.8	1.0	1.3	1.6
00+00	P177L	0.49	0.80	0.83	0.85	0.86	0.87	0.88	2.65	3.59	4.52	6.07	7.47	9.02	1.0	1.5	1.9	2.6	3.2	3.9
00+00	P177C	0.31	0.62	0.67	0.71	0.75	0.77	0.80	2.39	3.23	4.08	5.47	6.74	8.13	0.5	0.7	0.9	1.3	1.6	2.0
00+00	P178R	2.63	0.61	0.65	0.69	0.74	0.76	0.79	1.94	2.62	3.30	4.43	5.46	6.59	3.1	4.5	6.0	8.7	11.0	13.8
00+00	P178C	0.21	0.45	0.51	0.56	0.64	0.68	0.72	2.51	3.39	4.28	5.73	7.06	8.52	0.2	0.4	0.5	0.8	1.0	1.3
00+00	P179C	0.22	0.67	0.72	0.75	0.78	0.80	0.82	2.49	3.37	4.26	5.71	7.03	8.48	0.4	0.5	0.7	1.0	1.3	1.6
00+00	P179C1	0.24	0.83	0.86	0.87	0.88	0.88	0.89	2.68	3.63	4.58	6.14	7.56	9.12	0.5	0.7	1.0	1.3	1.6	2.0
00+00	P180C	2.12	0.16	0.22	0.30	0.45	0.50	0.58	1.29	1.75	2.21	2.96	3.64	4.40	0.4	0.8	1.4	2.8	3.9	5.4
00+00	P181C	2.34	0.22	0.28	0.35	0.49	0.54	0.61	1.62	2.19	2.76	3.70	4.56	5.50	0.8	1.4	2.3	4.2	5.8	7.8
00+00	P184L	1.35	0.49	0.55	0.59	0.67	0.70	0.74	1.75	2.37	2.99	4.00	4.93	5.95	1.2	1.7	2.4	3.6	4.6	5.9
00+00	P191C	0.57	0.05	0.11	0.20	0.37	0.44	0.52	1.55	2.10	2.65	3.56	4.38	5.29	0.0	0.1	0.3	0.7	1.1	1.6
00+00	P192C	0.37	0.17	0.23	0.31	0.46	0.51	0.58	2.16	2.92	3.68	4.93	6.08	7.33	0.1	0.3	0.4	0.8	1.1	1.6
00+00	P193R	1.16	0.36	0.43	0.49	0.59	0.63	0.68	1.78	2.41	3.04	4.08	5.03	6.07	0.8	1.2	1.7	2.8	3.7	4.8
00+00	P194C	1.73	0.21	0.27	0.35	0.48	0.53	0.60	1.58	2.14	2.70	3.63	4.47	5.39	0.6	1.0	1.6	3.0	4.1	5.6
00+00	P195L	2.88	0.40	0.47	0.52	0.61	0.65	0.70	1.59	2.15	2.71	3.63	4.48	5.40	1.8	2.9	4.1	6.4	8.4	10.9

00+00	P200C	0.82	0.16	0.22	0.30	0.44	0.50	0.58	1.54	2.09	2.63	3.53	4.35	5.25	0.2	0.4	0.6	1.3	1.8	2.5
00+00	P200R	2.54	0.20	0.26	0.34	0.48	0.53	0.60	1.47	1.99	2.51	3.37	4.15	5.01	0.7	1.3	2.2	4.1	5.6	7.6
00+00	P201L	0.99	0.40	0.46	0.51	0.61	0.65	0.70	1.46	1.97	2.49	3.34	4.11	4.96	0.6	0.9	1.3	2.0	2.6	3.4
00+00	P216C	4.17	0.14	0.20	0.28	0.43	0.49	0.57	1.20	1.63	2.05	2.75	3.39	4.09	0.7	1.3	2.4	4.9	6.9	9.7
00+00	P222L	0.72	0.33	0.39	0.45	0.56	0.61	0.66	1.88	2.54	3.21	4.30	5.30	6.40	0.4	0.7	1.1	1.7	2.3	3.1
00+00	P234C	2.18	0.25	0.32	0.39	0.51	0.56	0.63	1.18	1.59	2.01	2.69	3.31	4.00	0.6	1.1	1.7	3.0	4.1	5.5
00+00	P234L	3.68	0.17	0.24	0.32	0.46	0.51	0.59	1.23	1.66	2.10	2.81	3.47	4.18	0.8	1.5	2.4	4.8	6.6	9.0
00+00	P238C	0.92	0.19	0.25	0.33	0.47	0.52	0.59	1.23	1.66	2.10	2.81	3.47	4.18	0.2	0.4	0.6	1.2	1.7	2.3
00+00	P238L	0.98	0.01	0.05	0.15	0.33	0.40	0.49	1.64	2.22	2.80	3.75	4.62	5.57	0.0	0.1	0.4	1.2	1.8	2.7
00+00	P238L1	1.18	0.40	0.46	0.52	0.61	0.65	0.70	1.67	2.26	2.85	3.83	4.71	5.69	0.8	1.2	1.7	2.8	3.6	4.7
00+00	P242C	1.80	0.22	0.28	0.36	0.49	0.54	0.61	1.62	2.19	2.77	3.71	4.57	5.52	0.6	1.1	1.8	3.3	4.4	6.0
00+00	P242R	2.33	0.47	0.53	0.58	0.66	0.69	0.73	2.21	2.98	3.77	5.05	6.22	7.50	2.4	3.7	5.1	7.7	10.0	12.8
00+00	P243C	1.28	0.12	0.18	0.26	0.42	0.48	0.55	1.35	1.83	2.31	3.09	3.81	4.60	0.2	0.4	0.8	1.6	2.3	3.3
00+00	P244L	0.34	0.66	0.70	0.73	0.77	0.79	0.82	2.67	3.61	4.55	6.10	7.51	9.06	0.6	0.9	1.1	1.6	2.0	2.5
00+00	P245L1	0.08	0.78	0.81	0.83	0.85	0.85	0.87	2.68	3.63	4.58	6.14	7.56	9.12	0.2	0.2	0.3	0.4	0.5	0.6
00+00	P245L2	4.99	0.12	0.18	0.26	0.42	0.48	0.56	1.50	2.03	2.56	3.44	4.23	5.11	0.9	1.8	3.3	7.1	10.1	14.2
00+00	P245R	7.80	0.03	0.05	0.12	0.30	0.37	0.46	1.17	1.58	2.00	2.68	3.30	3.98	0.3	0.6	1.8	6.2	9.5	14.3
00+00	P246C	0.94	0.22	0.29	0.36	0.49	0.55	0.61	2.34	3.16	3.99	5.35	6.59	7.94	0.5	0.9	1.4	2.5	3.4	4.6
00+00	P246L1	0.26	0.60	0.65	0.69	0.74	0.76	0.79	2.47	3.35	4.22	5.66	6.98	8.41	0.4	0.6	0.8	1.1	1.4	1.7
00+00	P246L2	0.28	0.70	0.74	0.77	0.80	0.81	0.84	2.68	3.62	4.57	6.13	7.55	9.11	0.5	0.7	1.0	1.4	1.7	2.1
00+00	P246R1	2.01	0.34	0.41	0.47	0.57	0.62	0.67	1.42	1.93	2.43	3.26	4.02	4.85	1.0	1.6	2.3	3.8	5.0	6.5
00+00	P246R2	6.14	0.08	0.14	0.23	0.39	0.46	0.54	1.25	1.69	2.13	2.85	3.52	4.24	0.6	1.5	3.0	6.9	9.9	14.0
00+00	P247C	0.21	0.67	0.71	0.74	0.78	0.80	0.82	2.22	3.00	3.79	5.08	6.25	7.54	0.3	0.5	0.6	0.8	1.1	1.3
00+00	P247R1	0.09	0.83	0.85	0.87	0.88	0.88	0.89	2.68	3.63	4.58	6.14	7.56	9.12	0.2	0.3	0.4	0.5	0.6	0.7
00+00	P247R2	0.30	0.83	0.85	0.87	0.88	0.88	0.89	2.68	3.63	4.58	6.14	7.56	9.12	0.7	0.9	1.2	1.6	2.0	2.5
00+00	P248R	0.50	0.35	0.41	0.47	0.58	0.62	0.67	2.32	3.14	3.96	5.31	6.54	7.89	0.4	0.6	0.9	1.5	2.0	2.6
00+00	P248C1	0.10	0.67	0.71	0.75	0.78	0.80	0.82	2.62	3.55	4.48	6.00	7.39	8.92	0.2	0.3	0.3	0.5	0.6	0.8
00+00	P248C2	0.63	0.30	0.37	0.43	0.55	0.59	0.65	2.06	2.78	3.51	4.70	5.79	6.99	0.4	0.6	1.0	1.6	2.2	2.9
00+00	P249R	0.68	0.41	0.48	0.53	0.62	0.66	0.70	1.75	2.37	2.99	4.01	4.95	5.97	0.5	0.8	1.1	1.7	2.2	2.9
00+00	P250R1	2.11	0.25	0.31	0.38	0.51	0.56	0.62	1.12	1.52	1.91	2.57	3.16	3.81	0.6	1.0	1.6	2.8	3.7	5.0
00+00	P250R2	1.46	0.52	0.57	0.62	0.69	0.71	0.75	1.44	1.94	2.45	3.29	4.05	4.89	1.1	1.6	2.2	3.3	4.2	5.4
00+00	P250C	0.09	0.83	0.85	0.87	0.88	0.88	0.89	2.68	3.63	4.58	6.14	7.56	9.12	0.2	0.3	0.4	0.5	0.6	0.7
00+00	P252C	0.09	0.82	0.85	0.86	0.87	0.88	0.89	2.68	3.63	4.58	6.14	7.56	9.12	0.2	0.3	0.4	0.5	0.6	0.7
00+00	P255L	10.39	0.06	0.11	0.20	0.37	0.44	0.52	0.71	0.96	1.21	1.62	2.00	2.41	0.4	1.1	2.5	6.3	9.1	13.1
00+00	P257L	0.97	0.01	0.05	0.15	0.33	0.40	0.49	1.25	1.70	2.14	2.87	3.53	4.26	0.0	0.1	0.3	0.9	1.4	2.0
00+00	P258R	2.15	0.45	0.51	0.56	0.64	0.68	0.72	1.23	1.67	2.10	2.82	3.47	4.19	1.2	1.8	2.5	3.9	5.0	6.5
00+00	P263C1	2.71	0.11	0.18	0.26	0.41	0.48	0.55	1.06	1.43	1.81	2.43	2.99	3.61	0.3	0.7	1.3	2.7	3.9	5.4
00+00	P263C2	4.26	0.26	0.33	0.39	0.52	0.57	0.63	0.78	1.06	1.34	1.79	2.21	2.66	0.9	1.5	2.2	3.9	5.3	7.1
00+00	P263L	39.21	0.04	0.09	0.18	0.35	0.42	0.51	0.65	0.88	1.11	1.49	1.84	2.22	0.9	3.0	7.8	20.7	30.6	44.3
00+00	P265C	0.22	0.10	0.16	0.24	0.40	0.47	0.55	2.04	2.76	3.48	4.67	5.75	6.93	0.0	0.1	0.2	0.4	0.6	0.8
00+00	P267C	0.94	0.23	0.30	0.37	0.50	0.55	0.61	2.06	2.79	3.52	4.72	5.81	7.01	0.4	0.8	1.2	2.2	3.0	4.1
00+00	P268L	2.36	0.22	0.29	0.36	0.49	0.55	0.61	1.29	1.74	2.20	2.95	3.63	4.38	0.7	1.2	1.9	3.4	4.7	6.3
00+00	P273L	23.34	0.15	0.21	0.29	0.44	0.50	0.57	0.71	0.96	1.21	1.63	2.00	2.42	2.5	4.7	8.2	16.7	23.3	32.3
00+00	P275C	3.33	0.23	0.30	0.37	0.50	0.55	0.61	1.33	1.79	2.26	3.04	3.74	4.51	1.0	1.8	2.8	5.0	6.8	9.2
00+00	P276L	0.92	0.51	0.56	0.61	0.68	0.71	0.75	1.58	2.14	2.70	3.62	4.46	5.38	0.7	1.1	1.5	2.3	2.9	3.7
00+00	P276C	0.61	0.26	0.32	0.39	0.51	0.56	0.63	1.89	2.55	3.22	4.32	5.32	6.41	0.3	0.5	0.8	1.3	1.8	2.4
00+00	P306R	5.70	0.41	0.47	0.53	0.62	0.65	0.70	0.76	1.03	1.31	1.75	2.16	2.60	1.8	2.8	3.9	6.1	8.0	10.4
00+00	P307L	6.59	0.38	0.45	0.50	0.60	0.64	0.69	0.62	0.83	1.05	1.41	1.74	2.10	1.6	2.4	3.5	5.6	7.3	9.5
00+00	P307C	5.79	0.06	0.11	0.20	0.37	0.44	0.52	0.63	0.85	1.07	1.43	1.77	2.13	0.2	0.6	1.3	3.1	4.5	6.5
00+00	P309C	8.40	0.09	0.14	0.23	0.39	0.46	0.54	0.55	0.75	0.94	1.26	1.55	1.87	0.4	0.9	1.8	4.2	6.0	8.5
00+00	P310C	1.87	0.37	0.43	0.49	0.59	0.63	0.68	0.95	1.28	1.62	2.17	2.68	3.23	0.7	1.0	1.5	2.4	3.2	4.1
00+00	P314R	0.37	0.83	0.85	0.87	0.88	0.88	0.89	2.56	3.46	4.36	5.85	7.21	8.69	0.8	1.1	1.4	1.9	2.4	2.9
00+00	P317C	2.01	0.09	0.15	0.24	0.40	0.46	0.54	1.76	2.39	3.01	4.03	4.97	6.00	0.3	0.7	1.4	3.2	4.6	6.5
00+00	P318C	0.64	0.49	0.55	0.60	0.67	0.70	0.74	1.78	2.41	3.04	4.08	5.02	6.06	0.6	0.9	1.2	1.8	2.3	2.9

00+00	P321R	3.03	0.34	0.40	0.46	0.57	0.61	0.67	1.07	1.45	1.83	2.45	3.02	3.65	1.1	1.8	2.6	4.2	5.6	7.4
00+00	P326L	2.56	0.34	0.40	0.46	0.57	0.61	0.67	1.19	1.61	2.04	2.73	3.36	4.06	1.0	1.7	2.4	4.0	5.3	6.9
00+00	P329R	2.62	0.25	0.32	0.39	0.51	0.56	0.63	1.17	1.59	2.00	2.69	3.31	3.99	0.8	1.3	2.0	3.6	4.9	6.6
00+00	P331L	1.18	0.39	0.45	0.51	0.61	0.64	0.69	1.80	2.43	3.06	4.11	5.06	6.11	0.8	1.3	1.8	2.9	3.8	5.0
00+00	P333C	7.04	0.07	0.13	0.21	0.38	0.45	0.53	0.76	1.03	1.30	1.75	2.15	2.60	0.4	0.9	2.0	4.7	6.8	9.7
00+00	P335L	0.93	0.37	0.43	0.49	0.59	0.63	0.68	1.57	2.12	2.68	3.59	4.42	5.34	0.5	0.9	1.2	2.0	2.6	3.4
00+00	P343C	4.85	0.11	0.17	0.26	0.41	0.47	0.55	0.94	1.27	1.60	2.15	2.65	3.19	0.5	1.1	2.0	4.3	6.1	8.6
00+00	P397L	1.48	0.49	0.54	0.59	0.66	0.69	0.74	1.09	1.47	1.86	2.49	3.07	3.70	0.8	1.2	1.6	2.4	3.1	4.0
00+00	P397C1	3.99	0.18	0.24	0.32	0.46	0.52	0.59	0.94	1.28	1.61	2.16	2.66	3.21	0.7	1.2	2.0	3.9	5.5	7.5
00+00	P397C2	2.03	0.07	0.13	0.21	0.38	0.45	0.53	1.04	1.41	1.78	2.39	2.94	3.55	0.2	0.4	0.8	1.8	2.7	3.8
00+00	P397R	3.99	0.13	0.20	0.28	0.43	0.49	0.56	1.03	1.39	1.75	2.35	2.89	3.49	0.5	1.1	1.9	4.0	5.6	7.9
00+00	P398C	1.59	0.06	0.11	0.20	0.37	0.44	0.52	2.14	2.89	3.65	4.90	6.03	7.28	0.2	0.5	1.2	2.9	4.2	6.0
00+00	P414C	1.44	0.19	0.25	0.33	0.47	0.52	0.59	1.67	2.26	2.85	3.82	4.70	5.67	0.5	0.8	1.3	2.6	3.6	4.9
00+00	P416C	8.78	0.14	0.20	0.27	0.42	0.48	0.55	0.85	1.14	1.44	1.94	2.39	2.88	1.1	2.0	3.5	7.1	10.0	13.9
00+00	P429C	6.91	0.13	0.17	0.24	0.40	0.46	0.54	0.84	1.13	1.43	1.92	2.36	2.85	0.8	1.3	2.4	5.3	7.5	10.6

[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)

APPENDIX C

Hydraulics

Pipe Material Selection Report

Proposed Pipe Hydraulic Calculations

Proposed Culvert Hydraulic Calculations

Pipe Material Selection Report

MULLER ENGINEERING COMPANY

MEMORANDUM

Project:	CO 119 Safety and Mobility Improvements Project
To:	Colorado Department of Transportation, Region 4
From:	Emily Tyler, P.E. Muller Engineering Company
Date:	August 5, 2022
Subject:	Pipe Material Selection Report

INTRODUCTION

The Colorado Department of Transportation (CDOT) is proposing Bus Rapid Transit (BRT)/queue jump modifications on CO 119 between Foothills Parkway in Boulder and Hover Street in Longmont. It includes improvements at five intersections (Jay Road, 63rd Street, SH 52, Niwot Road, and Airport Road), and new Regional Transportation District (RTD) Park-and-Ride facilities at two intersections (63rd St and Niwot Road).

In compliance with the *CDOT Pipe Material Selection Guide* (Guide) dated April 30, 2015, this memorandum is intended to establish the acceptable drainage pipe materials for the project. The proposed drainage improvements for this project include storm drain inlets, manholes, and pipes. Laboratory test results provided by GeoCal on July 5, 2022 are the basis for this analysis. This memo will be updated based on additional soil samples collected, analyzed, and discussed in the Final Geotechnical Investigation and Pavement Design Report when it becomes available.

APPLICATION

All proposed storm drain pipe will be evaluated per CDOT's Guide except where existing pipe is being extended. The proposed project will add approximately 3,400 linear feet of 18-inch, 21-inch, 24-inch, and 36-inch storm drain pipe.

ABRASION LEVEL

- Pipe Velocities – The storm drain pipe velocities in the 5-year storm event are 5 fps or less.
- Estimated Bed Load – Bed load for this project is assumed to be minor with some silt and sand from the tributary area as a result of roadway sanding activities during the winter months.
- Abrasion Level – Based on the 5-year pipe velocities and the bed load, abrasion level 2 applies to the proposed project.

CORROSION LEVEL

GeoCal completed the necessary soil sample testing at sixteen test holes along the project corridor. Sulfate, Chloride, pH, and resistivity test results from these test holes are summarized in the following table.

Boring Number	Soil Properties			
	Sulfates, SO4 (%)	Chloride, Cl (%)	pH	Resistivity, R (Ohm-cm)
B-1	1.52	.0651	8.4	300
B-2	0.70	0.0372	8.3	160
P-5	0.03	-	-	-
P-6	0.31	-	-	-
P-10	0.42	-	-	-
P-13	0.13	0.0261	8.0	100
P-15	0.05	-	-	-
P-16D	0.00	-	-	-
P-17	Not Detected	0.0186	7.6	1,600
P-20D	0.00	-	-	-
P-25	0.10	0.0774	7.6	450
PP-9	0.10	-	-	-
PP-11	0.05	0.0582	7.	450
PP-12	0.09	-	-	-
PP-22	0.20	-	-	-
PP-28	0.07	0.0240	7.9	1,200

Based on the soil properties identified and using Table 1 in CDOT's Guide, the project site has a corrosion resistance level of CR6.

SELECTION OF PIPE MATERIAL TYPE

For storm drain pipes, CDOT allows the use of reinforced concrete pipe (RCP), polyethylene (PE), polypropylene (PP), steel reinforced polyethylene (SRPE), or polyvinyl chloride pipe (PVC) in accordance with CDOT Standard Plans M-603-2, M603-4, and M-603-5. Per Figure 2 of CDOT's Guide, an Abrasion Level of 2 and a Corrosion Level of 6 results in the selection of **Class 10 Drainage Pipe**: which consists of RCP, PP, SRPE, PE and PVC as allowed by Table 624-1 in CDOT's Specifications. According to the Guide, metal pipes are not allowed for the project. All end sections shall be concrete as specified in M-603-10.

Exceptions to Class 10 for this project are as follows:

- Fill height may impact allowable materials. See next section for fill height verification.
- If reinforced concrete pipe (RCP) is used for the project, sulfate resistance (class 2) shall be used per the revised section 624 of the CDOT specifications manual, Table 601-2 of the CDOT specifications and the test results discussed above.
- When a pipe is to be extended, the same pipe material and size shall be used.

FILL HEIGHT VERIFICATION

Pursuant to CDOT M Standards M-603-4, a minimum cover of 12 inches is required for all PE, SRPE and PP pipes with a dimeter less than 60 inches (minimum cover defined as top of pipe to bottom of pavement). HDPE, SRPE and PP pipes with a diameter of 60 inches require a minimum cover of 24 inches. Per M-603-5, a minimum cover of 24 inches is required for all PVC pipe (minimum cover defined as top of pipe to bottom of pavement). For reinforced concrete pipes, the minimum cover pursuant to CDOT M Standard M-603-2 is 12 inches (measured from the top of pipe to bottom of pavement) unless otherwise specified by the manufacturer.

EXCEPTIONS TO POLICY

No exceptions are requested.

DOCUMENTATION

A copy of the geotechnical report has been attached. Both the geotechnical report and this pipe selection report will be placed in the project file as documentation regarding pipe material type selection.

Project #: **G22.1970.002**

TABLE 2
SUMMARY OF LABORATORY CHEMICAL TEST RESULTS

Client: **Muller Engineering**

Project Name: **SH119 Mobility Hub**

Sample Location		Natural Moisture Content (%)	Natural Dry Density (pcf)	Laboratory Resistivity (ohm-cm)	pH	Water Soluble Chlorides (%)	Water Soluble Sulfates (%)	AASHTO Class. (Group Index)	CR	Soil or Bedrock Description
Boring No.	Depth (feet)									
B-1	4	28.0	92	300	8.4	0.0651	1.52		CR5	
B-2	9	21.4	102	160	8.3	0.0372	0.70		CR4	
P-5	1	14.2	86	-	-	-	0.03			
P-6	1	12.2	115	-	-	-	0.31			
P-10	1	8.9	112	-	-	-	0.42			
P-13	1-5	-	-	100	8.0	0.0261	0.13		CR2	
P-15	1	11.7	113	-	-	-	0.05			
P-16D	1	12.6	113	-	-	-	0.00			
P-17	1-5	-	-	1,600	7.6	0.0186	Not Detected		CR0	
P-20D	1	15.2	114	-	-	-	0.00			
P-25	4	14.7	111	-	-	-	0.22			
	1-5	-	-	450	7.6	0.0774	0.10		CR1	
PP-9	1	-	-	-	-	-	0.10			
PP-11	1-5	-	-	450	7.9	0.0582	0.05		CR1	
PP-12	1	6.0	124	-	-	-	0.09			
PP-22	1	13.0	108	-	-	-	0.20			
PP-28	1-5	-	-	1,200	7.9	0.0240	0.07		CR1	

Proposed Pipe Hydraulics Calculations

CALCULATION COVER SHEET

Project Name:	CO 119 Safety and Mobility Improvements Project	**Project No.**	20069.01 (Muller)/ 21642 (CDOT)
Design Calculation:	Pipe Hydraulics	**Version:**	1
Originator	ZDS	**Date:**	July 26, 2022
Checker	ELW	**Date:**	August 4, 2022

Purpose:

The purpose of this calculation packet is to evaluate the proposed storm drain pipes and culverts capacity compared to receiving flow at a preliminary design level.

References:

Criteria Manuals Used:

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

Software used:

Bentley FlowMaster V8i (2009)

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

Refer to the Drainage Report for full citations of references.

Criteria:

Storm drain pipes and culverts for the proposed project have been designed to meet CDOT and Boulder County criteria. Per the Hydrology Criteria Table included in the Drainage Report in Appendix A, culverts crossing northbound or southbound CO 119 shall be designed for the 100-year event. Storm drain pipes shall be designed for the 5-year event but also evaluated for the 100-year event. **Table 1** shows applied hydraulic criteria.

Table 1. *Applied Hydraulic Criteria Table*

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
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

Directives:

- The project requires new storm drain pipes and culverts due to grading changes associated with the following improvements:
  - Adding bus transit facilities at the intersections of CO 119 with Jay Road, 63rd Street, CO 52, and Niwot Road
  - Regional Transportation District Park-N-Ride facilities at 63rd Street and Niwot Road
  - Water quality ponds
- Pipe IDs listed in **Table 2** correspond to the proposed project stationing for CO 119.
- Pipes were analyzed as concrete, with a Manning's Roughness coefficient of 0.013.
- Flow (Q) values were taken from proposed hydrology calculations. Culverts or storm drain pipes receiving runoff from multiple basins were evaluated based on the sum of flowrates from the multiple contributing basins.
  - Pipe design flowrates do not consider inlet capture efficiencies. In reality, the design flowrates for storm drain pipes presented in **Table 2** in some case are lower than the flowrates stated in this calculation packet due to incomplete capture by inlets.
  - Irrigation baseflow was not included in the design flowrates, as indicated in **Table 2**.
  - Offsite runoff from the IBM campus reaching the proposed culvert ("S255L") was considered in **Table 2**.

Results:

Table 2 provides a summary of proposed pipes compared to the design flowrate. Bentley Flowmaster was used to determine the capacity of a pipe at the specified diameter and slope. The default slope was 0.5% and the slope was increased to either 1.0% or 2.0% as necessary.

Table 2. *Pipe and Culvert Summary Table*

Pipe ID	Size	Slope (%)	Capacity (cfs)	Contributing Basin(s)	$\sum Q_5$ (cfs)	$\sum Q_{100}$ (cfs)	Irrigation Conveyance(1)
S049C	18"	0.5	7.4	P049C	0.1	1.7	No
S050C	18"	0.5	7.4	P050C	0.0	0.9	No
S054C	18"	0.5	7.4	P054C	0.2	2.1	No
S062L[2]	30"x19"	0.5	16.0	P062L, Offsite Area	2.1	7.3	Yes
S064L	18"	0.5	7.4	P064L	1.2	3.2	No
S067C	18"	1.0	10.5	P064L, P067C	3.0	8.0	No
S175R	18"	0.5	7.4	P175R	0.4	1.2	No
S177R	18"	0.5	7.4	P177R, P177C	1.3	3.6	No
S177C	18"	0.5	7.4	P177C	0.7	2.0	No
S179C	18"	0.5	7.4	P179C	0.5	1.6	No
S179C1	18"	0.5	7.4	P179C1, P179C	1.3	3.5	No
S180C[2]	21"	0.5	11.2	P178C, P179C1, P179C, P180C	2.5	10.2	No
S191C	18"	0.5	7.4	1/3 of P194C	0.3	1.8	No
S234L[2]	30"	0.5	29.0	P234L	0.8	4.7	Yes
S238C[2]	24"	0.5	16.0	P238C, P238L	0.5	5.0	No
S242C	18"	0.5	7.4	P242C	1.1	6.0	No
S244L	18"	0.5	7.4	P244L	0.9	2.5	No
S245L1	18"	0.5	7.4	P245L1	0.2	0.6	No
S245T	24"	0.5	16.0	P242C, P244L, P245L1	2.2	9.2	No
S245L2	36"	0.5	47.2	P245L2	1.8	14.2	No
S246L1	18"	0.5	7.4	P246L1	0.6	1.7	No
S246L2	36"	0.5	47.2	P245L2, P246L2	2.5	16.3	No
S246C	18"	1.0	10.5	P246C, P248C2	1.5	7.5	No

CALCULATION COVER SHEET **CO 119 Safety and Mobility Improvements Project**
August 2, 2022 **Pipe Hydraulics**

Pipe ID	Size	Slope (%)	Capacity (cfs)	Contributing Basin(s)	$\sum Q_5$ (cfs)	$\sum Q_{100}$ (cfs)	Irrigation Conveyance
S246T	36"	0.5	47.2	P242C, P244L, P245L1, P245L2, P246L1, P246L2, P246C, P248C2	6.8	34.6	No
S247C	18"	0.5	7.4	P247C	0.5	1.3	No
S247R2	18"	0.5	7.4	P247C, P247R2	1.4	3.8	No
S247R1	18"	0.5	7.4	P247R1	0.3	0.7	No
S248C1	18"	0.5	7.4	P247R1, P248C1	0.6	1.5	No
S250C	18"	0.5	7.4	P250C, P247R1, P248C1	0.9	2.2	No
S250T	24"	0.5	16.0	P247C, P247R1, P247R2, P248C1, P250C	2.2	6.0	No
S252C	18"	0.5	7.4	P252C	0.3	0.7	No
S252T	24"	0.5	16.0	P247C, P247R1, P247R2, P248C1, P250C, P252C	2.5	6.7	No
S255L[2]	24"	0.5	16.0	P255L and Offsite Flow	26.0	43.1	Yes
S257L[2]	24"	0.5	16.0	P257L	0.1	2.0	Yes
S263L	36"	0.5	47.2	P263L	3.0	44.3	No
S307C	24"	0.5	16.0	P307L, P307C	3.0	16.0	No
S314C	18"	0.5	7.4	None (minimal contrib. area)	0.0	0.3	No
S397L	24"	0.5	16.0	P397L	1.2	4.0	No
S397C2	18"	0.5	7.4	P397C2	0.4	3.8	No
S397R	18"	1.0	10.5	P397R	1.1	7.9	No
S400C[3]	24"	2.0	32.0	1/2 of P398C, P397L, P397C1, P397C2, P397R	4.1 (without detention)	26.2 (without detention)	No

Note 1. Irrigation status for information only; no irrigation baseflows are included in the flows presented in this table.

Note 2. Sized to match existing pipe either as a direct extension of an existing pipe, or as a replacement of an irrigation pipe.

Note 3. S400C will be sized based on the attenuated 100 year flow considering the detention volume of the proposed pond; an emergency overflow spillway is proposed to convey the peak 100 year inflow with no detention.

Materials Included in Calculation Packet:

Flowmaster Calculations

Pipe Sizing Report

Circular Pipe (21497_FIR_Pipe_Sizing.fm8) Report

Label	Roughness Coefficient	Channel Slope (ft/ft)	Diameter (ft)	Velocity (ft/s)	Percent Full (%)
18" RCP @ 0.5%	0.013	0.00500	1.50	4.20	100.0
18" RCP @ 1.0%	0.013	0.01000	1.50	5.94	100.0
18" RCP @ 2.0%	0.013	0.02000	1.50	8.41	100.0
24" RCP @ 0.5%	0.013	0.00500	2.00	5.09	100.0
24" RCP @ 1.0%	0.013	0.01000	2.00	7.20	100.0
21" RCP @ 0.5%	0.013	0.00500	1.75	4.66	100.0
30" RCP @ 0.5%	0.013	0.00500	2.50	5.91	100.0
36" RCP @ 0.5%	0.013	0.00500	3.00	6.67	100.0
24" RCP @ 2.0%	0.013	0.02000	2.00	10.18	100.0
30" RCP @ 2.0%	0.013	0.02000	2.50	11.82	100.0

Proposed Culvert Hydraulics Calculations

CALCULATION COVER SHEET

Project Name:	CO 119 Safety & Mobility Improvements Project	**Project No.**	20-069.01 (Muller)/ 21497 (CDOT)
Design Calculation:	Proposed Hydraulics - Culverts	**Version:**	1
Originator	ELW	**Date:**	August 8, 2022
Checker	MAK	**Date:**	August 9, 2022

Purpose:

Analyze and design culverts for adequate capacity to meet hydraulic criteria for the CO 119 Safety & Mobility Improvements Project.

References:

Criteria Manuals Used:

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

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

Software used:

HY-8 Version 7.50

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

Refer to the Drainage Report for full citations of references.

Criteria:

The storm drain system for the proposed project was designed using the hydraulic criteria from the CDOT Drainage Design Manual and the Boulder County Storm Drainage Criteria Manual (SDCM). 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.

Directives:

- The project requires the extension of the existing 10'x6' concrete box culvert downstream of Boulder Reservoir. The concrete box culvert is slightly south of the CO 119 and 63rd Street intersection and will be extended underneath the proposed RTD parking lot.
- Tailwater elevation was set based on the approximate groundwater elevation indicated by the wetland survey.
- Overtopping elevation was based on the elevation of the existing west edge of southbound CO 119. The low area of southbound CO 119 was approximated using a constant roadway elevation with a length of 300 feet for the overtopping weir. The length has no effect on hydraulic computations unless overtopping occurs.
- Culvert S175C is made of concrete with a Manning's roughness coefficient of 0.012.

- A Square Edge with Headwall inlet configuration was used to approximate entrance loss.
- The source of flow for culvert S175C comes from the proposed basin P175L as well as the Boulder water treatment plant emergency discharge channel, which lies within basin P175L. Refer to the Proposed Hydrology Calculation Packet in Appendix B of the Drainage Report for more information. This flow is applicable for the inlet control condition. Additional flow enters the culvert at storm drain connections downstream of the inlet and the total flow will be evaluated at final design.
- Culvert S175C is a double broken-back. Because culvert is inlet controlled, the break elevation has minimal impact on hydraulics.

Table 1. *Applied Culvert Hydraulic Criteria Table*

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
Culvert Headwater to Depth Ratio	
D < 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

Results:

Results for the 100-year storm are shown in **Table 2**. The velocity listed in **Table 2** is the outlet velocity.

Table 2. *Culvert summary table for 100-year results*

Culvert ID	Size	Slope (%)	100-year				
			Design flow (cfs)	Velocity (fps)	Flow Depth (ft)	Headwater Depth (ft)	Headwater to Depth Ratio
S175C	10’ span x 6’ rise	0.6%	184.0	4.0	4.6	3.72	0.62

Materials included in this calculation packet:

1. HY-8 Calculations (input data and results)

HY-8 Culvert Analysis Report

Table 1 - Culvert Summary Table: S175C

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	5148.00	0.000	1.200	0-NF	0.000	0.000	4.600	4.600	0.000	0.000
18.40	18.40	5149.51	0.806	2.708	1-S1t	0.000	0.472	4.600	4.600	0.400	0.000
36.80	36.80	5149.53	1.279	2.732	1-S1t	0.000	0.749	4.600	4.600	0.800	0.000
55.20	55.20	5149.57	1.676	2.773	1-S1t	0.000	0.982	4.600	4.600	1.200	0.000
73.60	73.60	5149.63	2.030	2.830	1-S1t	0.000	1.189	4.600	4.600	1.600	0.000
92.00	92.00	5149.71	2.356	2.906	1-S1t	0.000	1.380	4.600	4.600	2.000	0.000
110.40	110.40	5149.80	2.660	3.002	1-S1t	0.000	1.558	4.600	4.600	2.400	0.000
128.80	128.80	5149.92	2.948	3.123	1-S1t	0.000	1.727	4.600	4.600	2.800	0.000
147.20	147.20	5150.08	3.216	3.278	1-S1t	0.000	1.727	4.600	4.600	3.200	0.000
165.60	165.60	5150.34	3.470	3.539	1-S1t	0.000	1.727	4.600	4.600	3.600	0.000
184.00	184.00	5150.52	3.716	1.448	1-JS1t	0.000	1.757	4.600	4.600	4.000	0.000

****

Double Broken-back Culvert

Inlet Elevation (invert): 5146.80 ft

Upper Break Elevation (invert): 5145.50 ft

Lower Break Elevation (invert): 5144.90 ft

Culvert Length: 571.21 ft

Upper Culvert Section Slope: 0.0119

Steep Culvert Section Slope: 0.0024

Runout Culvert Section Slope: 0.0070

****

Site Data - S175C

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 5146.80 ft

Upper Break Station: 109.10 ft

Upper Break Elevation: 5145.50 ft

Lower Break Station: 357.00 ft

Lower Break Elevation: 5144.90 ft

Outlet Station: 571.20 ft

Outlet Elevation: 5143.40 ft

Number of Barrels: 1

Tailwater Channel Data - S175C

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 5148.00 ft

Roadway Data for Crossing: S175C

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 300.00 ft

Crest Elevation: 5157.00 ft

Roadway Surface: Paved

Roadway Top Width: 50.00 ft

Culvert Data Summary - S175C

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 6.00 ft

Upper & Middle Section Material: Concrete

Lower Section Material: Concrete

Embedment: 0.00 in

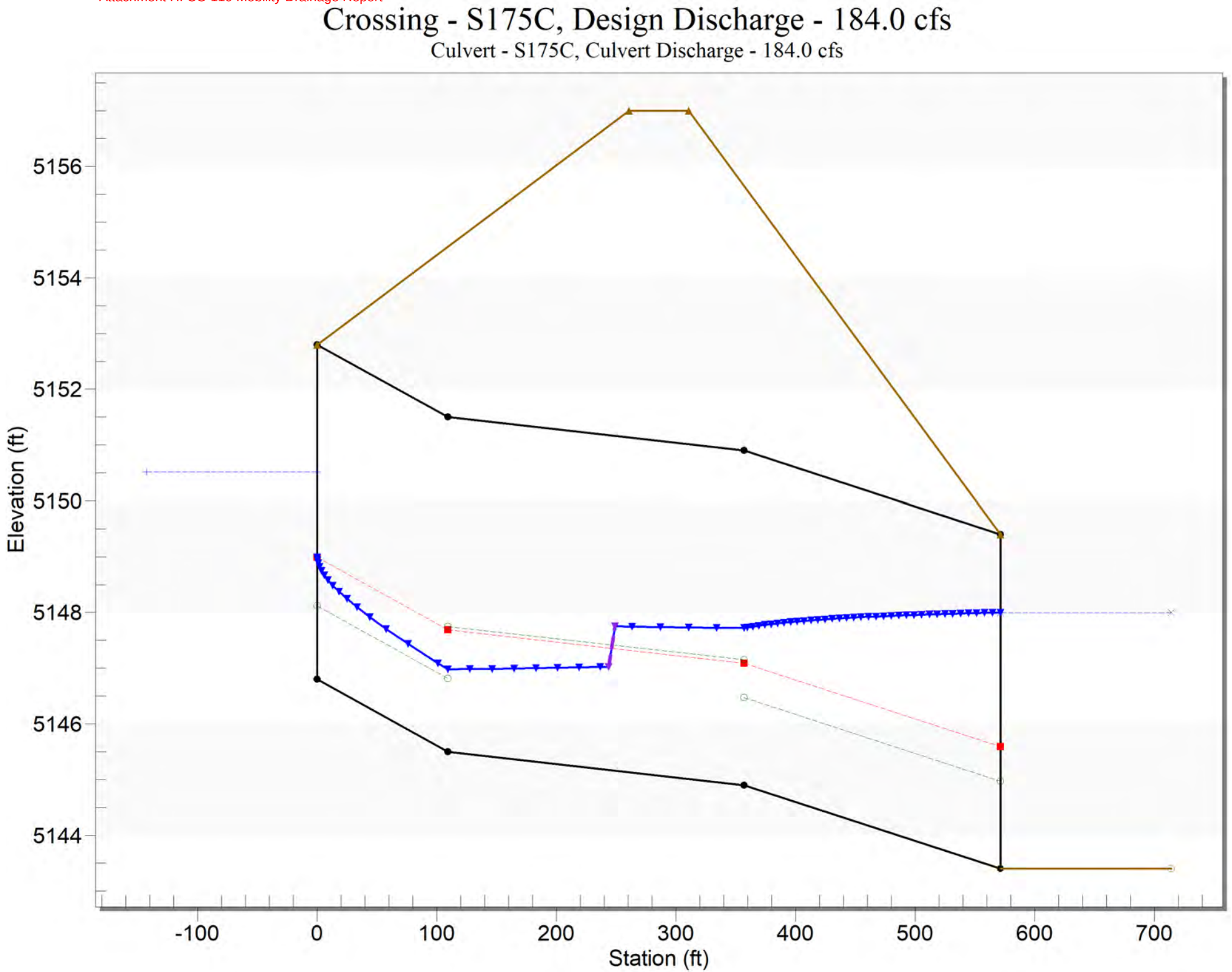
Upper & Middle Section Manning's n: 0.0120

Lower Section Manning's n: 0.0120

Culvert Type: Double Broken-back

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: None


Crossing - S175C, Design Discharge - 184.0 cfs
Culvert - S175C, Culvert Discharge - 184.0 cfs
Elevation (ft)
5156
5154
5152
5150
5148
5146
5144
-100
0
100
200
300
400
500
600
700
Station (ft)

APPENDIX D

Water Quality

Overall Project Water Quality Approach Memorandum

Water Quality Approach Memorandum

MEMORANDUM

Project: CO 119 Safety and Mobility Improvements

To: Colorado Department of Transportation, Region 4

From: Emily Tyler, PE, Muller Engineering Company Inc.

Date: August 9, 2022

Subject: Overall Project Water Quality Approach

Purpose

The purpose of this technical memorandum is to document the conceptual water quality design approach that will be applied to the Colorado State Highway (CO) 119 Safety and Mobility Improvements project.

This memorandum presents the water quality requirements for the project, a conceptual design of the proposed treatment areas, and conceptual plans to illustrate the extent of water quality facilities.

Background

Project Background

The proposed project generally consists of Bus Rapid Transit (BRT)/queue jump modifications on CO 119 between Foothills Parkway in Boulder and Hover Street in Longmont. It includes improvements at five intersections (Jay Road, 63rd Street, SH 52, Niwot Road, and Airport Road), and new Regional Transportation District (RTD) Park-and-Ride facilities at two intersections (63rd St and Niwot Rd).

This corridor was identified as the top candidate for future BRT through the Northwest Area Mobility Study (NAMS) completed in 2014 by RTD and other northwest area stakeholders. An RTD Planning and Environmental Linkage Study (PEL) was completed and approved by FHWA and FTA in 2019 and presents the vision for CO 119, including regional BRT, managed express lanes, and a commuter bikeway. Boulder County is currently in the process of design for the corridor bikeway. Managed express lanes are not in the current scope of work for the corridor and were not included in this water quality concept.

Project Authorities

These improvements will be designed and implemented in accordance with CDOT and the American Association of State Highway and Transportation Officials (AASHTO) Highway Design Standards, in cooperation with the City of Boulder and Boulder County.

MS4 Background

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 regulates sources of pollution from pipes and drainages (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 Phase I MS4 permit (COS000005) covers state and interstate highways and their rights-of-way within urbanized boundaries, as defined by CDPHE and Boulder County's Statewide General Permit. Boulder County is regulated by the statewide General Phase II permit (COR0900000). Because the entire project is within existing or proposed CDOT right-of-way, it will be regulated under the CDOT permit. This approach was confirmed through meetings with water quality permitting specialists from CDOT and Boulder County.

The guidelines for stormwater management, the reduction of flows from development sites, and pollution control measures are outlined in the CDOT's Permanent Water Quality Section of the Drainage Design Manual, dated 6/30/2021.

Project Approach and Criteria

MS4 Permanent Water Quality Criteria

In accordance with CDOT's *Drainage Design Manual* Chapter 16, *Permanent Water Quality*, Section 16.2.2.4.2 *Applicability, Triggers and Area Treated*, Permanent Water Quality (PWQ) Control Measures (CMs) are generally required on a project if it first meets all of the following conditions:

1. Within CDOT's MS4 boundary, in part or in whole
2. Land disturbance equal to or greater than 1 acre
3. Impervious area increase of 20% or more

If these three conditions are met plus one of the following conditions, PWQ CMs are required for the project.

4. Drains to a 303(d) listed segment for a CDOT Pollutant of Concern
5. Drains to the Cherry Creek Reservoir
6. Is part of an EA or EIS

All three of the first conditions are met: The project lies in the CDOT MS4 boundary; it disturbs more than 1 acre; and imperviousness is increased by more than 20%.

Therefore, the trigger for WQ depends on one of the last three conditions (items 4 through 6). Each trigger is evaluated below.

303(d)

The project covers several separate drainage basins. Stream segment identification is shown in **Table 1** below, as delineated by CDPHE. The complete list of roadway Pollutants of Concern is provided in CDOT's MS4 permit. This evaluation shows that two of the intersections drain to a 303(d) listed segment for a CDOT Pollutant of Concern. The other three intersections do not meet this trigger.

Cherry Creek

The project does not drain to the Cherry Creek Reservoir.

EA or EIS

The project is anticipated to be a Categorical Exclusion for Environment Assessment, which would mean that it will not be part of an EA or EIS. If the project becomes part of an EA or EIS, this condition will trigger a requirement for PWQ CMs within the project boundary according to CDOT's Drainage Design Manual.

Table 1. Stream Segment Environmental Concerns

Segment	Description	303d Listing (2021)	Discussion
COSPBO11	Fourmile Canyon Creek	Not listed	Less than 0.1 acre of the new pavement south of Jay Rd drains to this basin.
COSPBO11_A	Tributaries to Boulder Creek	Not listed	Includes Jay Rd.
COSPBO09_A	Boulder Creek	Ammonia, Arsenic, E. Coli	Downstream of Jay Rd area(1); Listed analytes are not roadway pollutants of concern.
COSPSV06b_A	Dry Creek No. 2	Not listed; however, online 2022 CDPHE map displays stream symbology red similar to 303(d)	Includes 63rd St and SH 52.
COSPSV05_A	Left Hand Creek	Copper (dissolved) Manganese (dissolved)	**Roadway pollutants of concern.** Includes Niwot Rd and Airport Rd.

Note 1: Part of the Jay Road improvements appear to drain to a tributary with no CDPHE segment, that ultimately would discharge to Boulder Creek about two miles downstream. This small tributary is intercepted by a larger irrigation channel before reaching Boulder Creek.

Table 2. Summary of PWQ Triggers(2) (Proposed)

Site	Existing Paved Acres	Proposed Paved Acres	Increase in Acres	Required Treatment(3)	303d Status for Roadway Pollutants of Concern
Jay Road	11.8	13.5	1.7 (15%)	0	Not Listed
63rd St	12.1	15.4	3.3 (27%)	0	Not Listed
CO 52	14.0	17.3(1)	3.3 (23%)	0	Not Listed
Niwot Rd	10.3	13.8	3.5 (34%)	**3.2 ac**	**303d Listed**
Airport Rd	6.6	6.7	0.1 (2%)	**0.1 ac**	**303d Listed**

Note 1: The project is anticipated to remove 4.8 acres of pavement for demolition of the old SH 52 intersection. Removal of that pavement is required and the area will be revegetated. Removal of pavement was considered in the post-project impervious area measurement.
Note 2: Project is not EA/EIS or Cherry Creek.
Note 3: 90% of the new impervious area meeting the 303(d) trigger; see Summary of Water Quality Criteria section of this memorandum.

Existing Permanent Water Quality Already Constructed

The project footprint contains PWQ CMs that were constructed under an earlier permit. The treatment that was constructed under the previous permit must be maintained as part of the current project.

Table 3. Summary of Existing PWQ

Site	PWQ Required (2012 Report)	PWQ Provided	Notes
Jay Road	3.9	4.0 reported	2.9 ac EDB reported 1.7 ac EDB existing (1) 1.1 ac media filter drain reported
Niwot Road	2.9	3.7 reported	Report did not account for a 30 inch irrigation pipe that diverts flow away from the EDB; to be modified with current project.

Note 1: Measurement of existing impervious area draining to the pond is presented in the Preliminary Drainage Report for CO 119 Safety and Mobility Project (Muller, 2022); see existing hydrology calculations for contributing basins.

BMP Selection Criteria

Based on the 303(d) trigger above, only the portion of the project that discharges to the stream segment listed for a roadway pollutant of concern is required to meet one of the following control measure design standards.

1. WQCV Standard: Provide treatment and/or infiltration from impervious surfaces with a surface area equal to or greater than 90% of the of the new impervious surface area located within the portion of the project discharging runoff to the 303(d) – listed segment of a roadway pollutant of concern. A minimum detention time of 12 hours is also required.
2. Runoff Reduction Standard: Control measure required to infiltrate, evaporate, or evapotranspire a quantity of water equal to or greater than 60% of what the calculated WQCV would be if all new impervious area from the applicable portion of the priority development project discharged without infiltration.
3. Pollutant Removal Standard: Control measure required to treat at a minimum the 80th percentile storm event. The control measure(s) shall be designed to treat to an expected median effluent concentration for a total of suspended solids (TSS) of 30 mg/L from impervious surfaces with a surface area equal to or greater than 90% of the new impervious surface area located within the portion of the project discharging runoff to the 303(d) – listed segment for a roadway pollutant of concern.

Summary of Water Quality Criteria

The following criteria and information will be used in the design of water quality facilities.

Table 4. Water Quality Criteria

Water Quality Feature	Criteria
Impervious Area Treated	• WQCV Standard: 90% of the increase in impervious area • Treatment is provided by drainage basin based on the receiving stream segment
Storage volume	• 120% WQCV (20% of WQCV volume is for sedimentation)
Detainment Time	• 40 hours
Grading	• Vegetated embankments, 3H:1V side slopes minimum, 4H:1V preferred • Riprap embankments, 2H:1V side slopes minimum • 2% pond bottom cross slope minimum • 1% trickle channel longitudinal slope
Emergency spillway	• 100-year flood
Maintenance access	• 8 feet or wider stabilized surface • 10% longitudinal slope or flatter • Large maintenance equipment access to the forebay

Proposed Design

The project area includes up to five proposed permanent water quality ponds. Proposed treatment is summarized in Tables 5 and 6.

- Two existing ponds will be modified to mitigate impacts from the project. The existing ponds are extended detention basins that detain the WQCV for previous CDOT projects constructed under a previous MS4 permit. One existing pond is at Jay Road which is outside of the area triggered by the current MS4 permit. The other basin is in the Left Hand Creek drainage area, north of Niwot Road, and will provide treatment in excess of the previous project criteria. The excess treatment to be directed to the existing pond will meet or partially meet treatment criteria triggered by the current MS4 permit for the project.
- Two full spectrum detention basins will be constructed, one with each Park-and-Ride facility, in accordance with Boulder County stormwater detention criteria. The Park-and-Ride detention ponds will be maintained by RTD under a maintenance agreement with CDOT. One detention pond is at 63rd Street, which is outside of the area triggered by the current MS4 permit, and will provide excess PWQ. The other basin is in the Left Hand Creek drainage area, at Niwot Road, and will partially meet treatment criteria triggered by the current MS4 permit for the project.
- One new extended detention basin water quality pond will be constructed in the Left Hand Creek drainage area, if needed to meet remaining treatment acreage triggered by the current CDOT MS4 permit for the project.

Table 5. PWQ Summary – Left Hand Creek 303d Trigger Area

Project Area	Required Treatment	Proposed Treatment
Existing Niwot Road PWQ	2.9 acres *(previous project requirement)*	• 4.1 acres: existing CDOT PWQ EDB as modified by the current project • Additional treatment Option 1: Up to 3.3 acres: additional diversion from south may or may not be feasible. Continue investigation of grades during final design.
Proposed Project PWQ	3.3 acres *(90% of the new 3.6 acres)*	• 1.0 acres: Boulder County full spectrum detention with PWQ at the proposed Niwot Park and Ride • Additional treatment Option 2: Up to 2.3 acres: Proposed CDOT PWQ EDB between Niwot and Left Hand Creek, if needed
Totals	**6.2 acres**	**7.4 (Option 2) to 8.4 acres (Option 1)**

Note 1: For PWQ reporting purposes, the treatment area is based on tributary roadway pavement and does not include credit for proposed concrete bikeway areas. EDB hydraulic design will be based on detailed actual land use imperviousness and basin hydrology.

Table 6. PWQ Summary – Other Areas not triggered by the current CDOT MS4 Permit

Project Area	Required Treatment	Proposed Treatment
Jay Rd	2.8 acres (match existing treatment)	• 2.3 acres(1): existing EDB with new tributary pavement added (outlet structure to be modified to provide 40 hour proposed drain time) • 1.1 acres: existing media filter drains not to be disturbed by the project **Total provided at Jay Rd: 3.4 acres**
63rd St	0 acres	• 1.2 acres: Boulder County full spectrum detention at the proposed 63rd Park and Ride • TBD: Additional contributing areas from surrounding bus platforms and roadways **Total provided at 63rd St: 1.2 acres plus additional contributing areas to be determined**

Note 1: For PWQ reporting purposes, the treatment area is based on tributary roadway pavement and does not include credit for proposed concrete bikeway areas. EDB hydraulic design will be based on detailed actual land use imperviousness and basin hydrology.

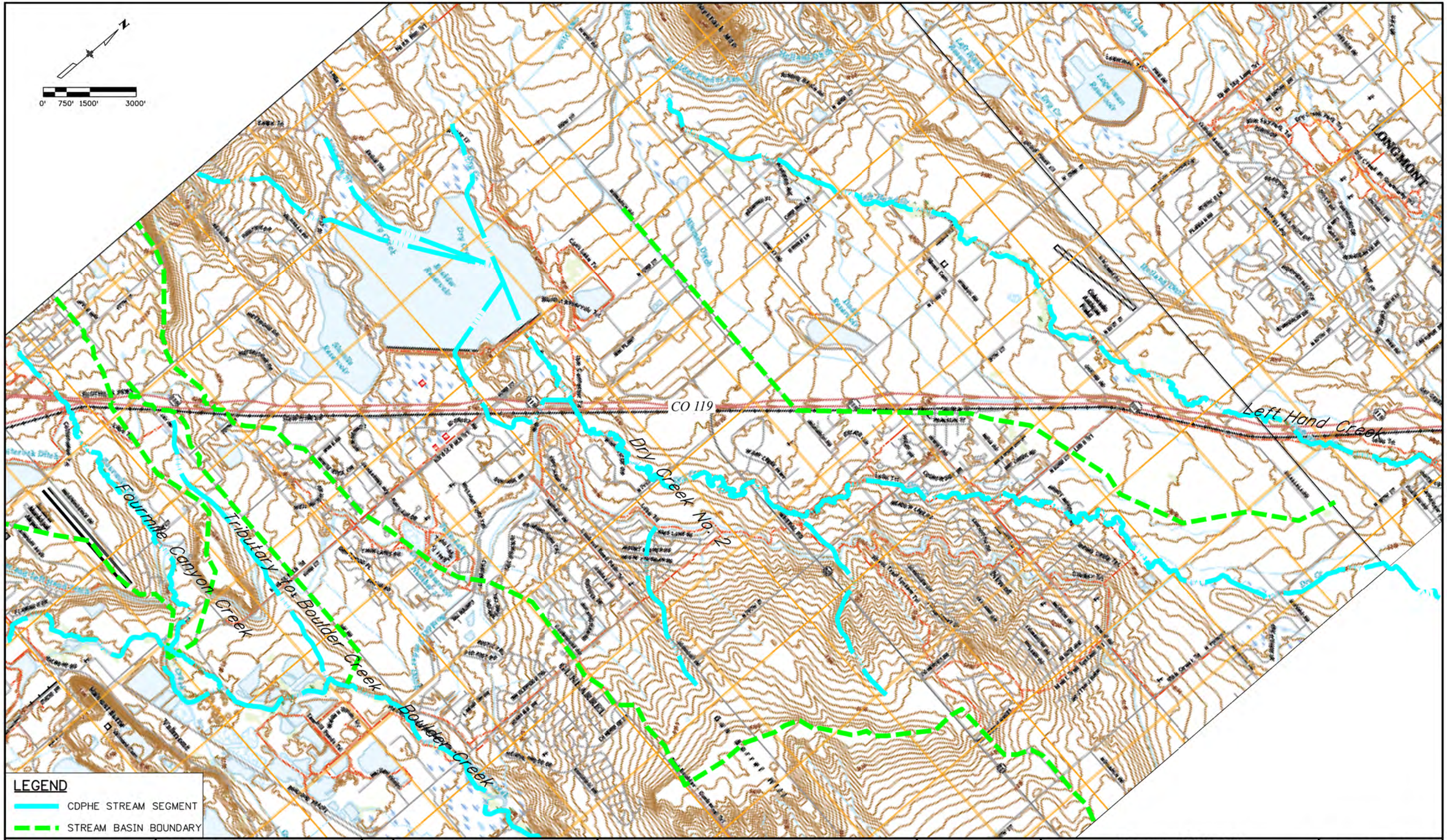
Conclusion

Based on the evaluation of permanent water quality needs for the project, PWQ CMs are required within the Left Hand Creek drainage basin. In addition, PWQ is being provided at existing facilities and at areas of full spectrum detention related to the Boulder County Storm Drainage Criteria Manual.

The location and configuration of permanent water quality facilities has been selected to optimize treatment and maintenance while meeting CDOT's MS4 permit. Up to five extended detention basin (EDBs) are proposed to meet permanent water quality requirements. This includes two existing CDOT PWQ EDBs, two new Boulder County full spectrum detention basins with PWQ, and one new CDOT PWQ EDB.

Attachments

Overall Watershed Map
Water Quality Maps



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Unit Information

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CO 119 MOBILITY
OVERALL WATERSHED MAP

Designer: EPT
Detailer: LMR
Sheet Subset: EOVDRBAS
Structure Numbers:
Subset Sheets: 1 of 1

Project No./Code
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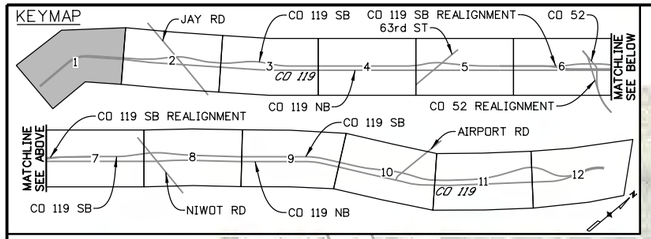
Sheet Number

KEYMAP



BEGINNING OF PROJECT ALIGNMENT
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NO NEW PAVEMENT ON THIS PART OF THE ALIGNMENT

Fourmile Canyon Creek

Project Control Line
CO 119 SB

Project Control Line
CO 119 NB

CO 119
Diagonal Hwy On-Ramp
47th St.
Foothills Pkwy
CO 119 NB
CO 119 SB
CO 119 NB
CO 119 SB
Diagonal Hwy On-Ramp
CO 119 NB
CO 119 SB

1015+00
1020+00
1025+00
1030+00
1035+00
1040+00
2020+00
2025+00
2030+00
2035+00
2040+00

MATCH LINE STA. 1041+00

0' 75' 150' 300'

LEGEND

- CDPHE STREAM SEGMENT
- STREAM BASIN BOUNDARY
- INCREASE IN PAVEMENT
- REMOVAL (AT CO 52)
- PROPOSED TREATMENT

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CO 119 MOBILITY
WATER QUALITY PLAN
STA. 1000+00 TO STA. 1041+00

Designer: EPT
Detailer: LMR
Sheet Subset: WQ
Structure Numbers:
Subset Sheets: 1 of 12

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21497
Sheet Number

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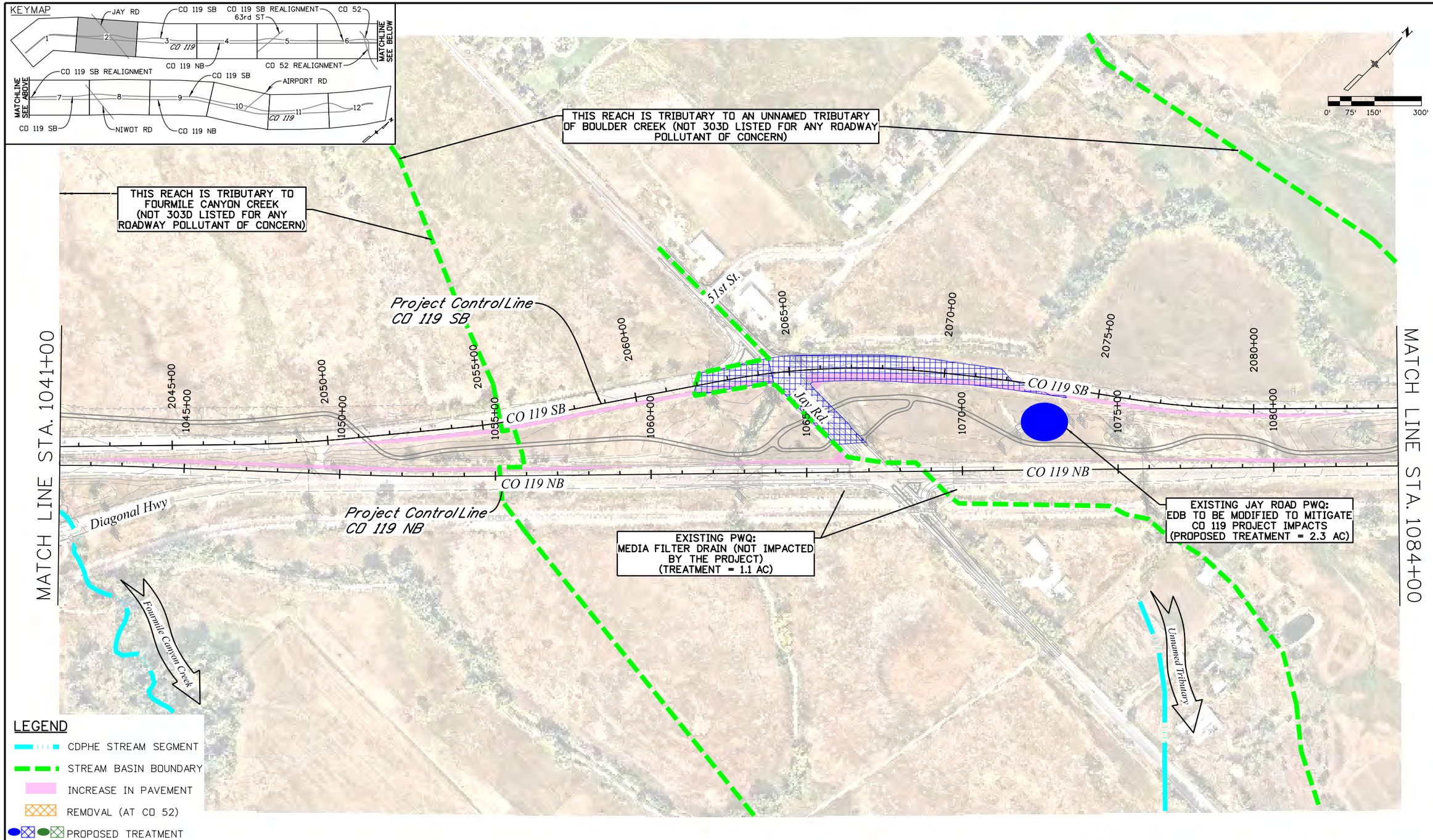

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CO 119 MOBILITY
WATER QUALITY PLAN
STA. 1041+00 TO STA. 1084+00

Designer: EPT
Detailer: LMR
Sheet Subset: WQ
Structure Numbers:
Subset Sheets: 2 of 12

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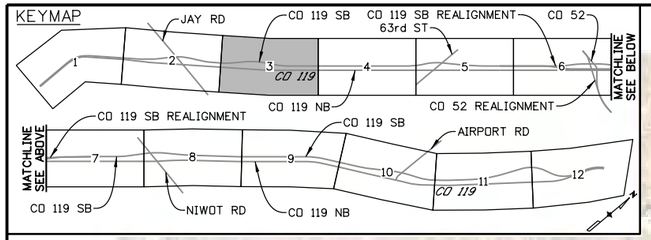

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(NOT 303D LISTED FOR ANY ROADWAY
POLLUTANT OF CONCERN)
NO NEW PAVEMENT PROPOSED ON THIS SHEET

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CO 119 SB

MATCH LINE STA. 1084+00

MATCH LINE STA. 1127+00

2085+00 2090+00 2095+00 2100+00 2105+00 2110+00 2115+00 2120+00 2125+00

1085+00 1090+00 1095+00 1100+00 1105+00 1110+00 1115+00 1120+00 1125+00

55th St.

CO 119 SB

CO 119 NB

Project Control Line
CO 119 NB

0' 75' 150' 300'

LEGEND

- CDPHE STREAM SEGMENT
- STREAM BASIN BOUNDARY
- INCREASE IN PAVEMENT
- REMOVAL (AT CO 52)
- PROPOSED TREATMENT

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CO 119 MOBILITY
WATER QUALITY PLAN
STA. 1840+00 TO STA. 1127+00

Designer: EPT
Detailer: LMR
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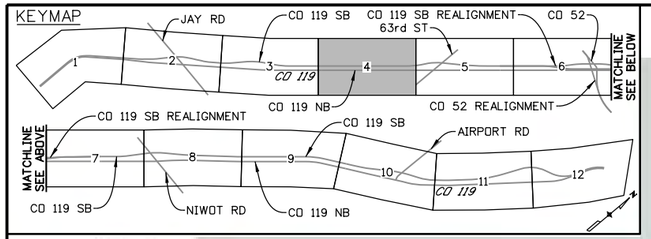

LEGEND

- CDPHE STREAM SEGMENT
- STREAM BASIN BOUNDARY
- INCREASE IN PAVEMENT
- REMOVAL (AT CO 52)
- PROPOSED TREATMENT

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CO 119 MOBILITY
WATER QUALITY PLAN
STA. 11270+00 TO STA. 1170+00

Designer: EPT
Detailer: LMR
Sheet Subset: WQ
Structure Numbers:
Subset Sheets: 4 of 12

Project No./Code
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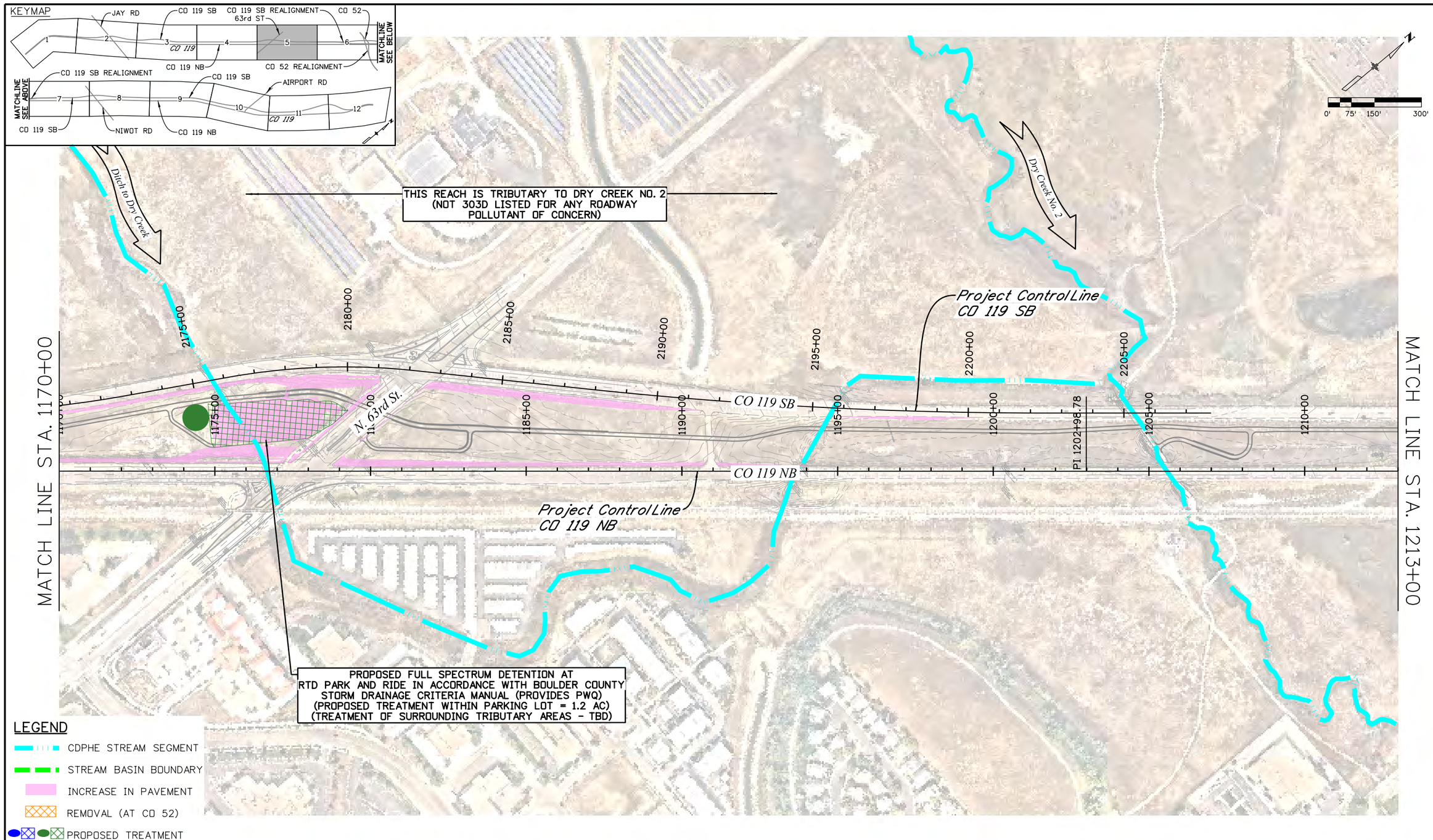

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CO 119 MOBILITY
WATER QUALITY PLAN
STA. 1170+00 TO STA. 1213+00

Designer: EPT
Detailer: LMR
Sheet Subset: WQ
Structure Numbers:
Subset Sheets: 5 of 12

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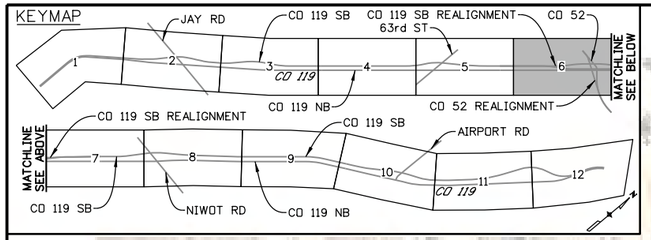

LEGEND

- CDPHE STREAM SEGMENT
- STREAM BASIN BOUNDARY
- INCREASE IN PAVEMENT
- REMOVAL (AT CO 52)
- PROPOSED TREATMENT

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STA. 1213+00 TO STA. 1256+00

Designer: EPT
Detailer: LMR
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Structure Numbers:
Subset Sheets: 6 of 12

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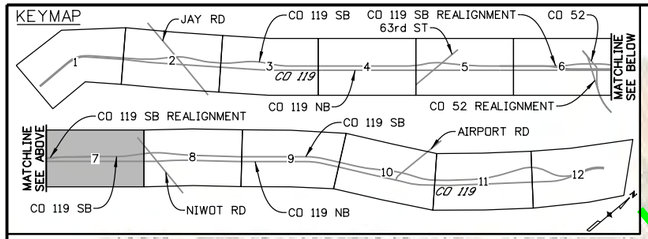

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CO 119 MOBILITY
WATER QUALITY PLAN
STA. 1256+00 TO STA. 1299+00

Designer: EPT
Detailer: LMR
Sheet Subset: WQ
Structure Numbers:
Subset Sheets: 7 of 12

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Sheet Number

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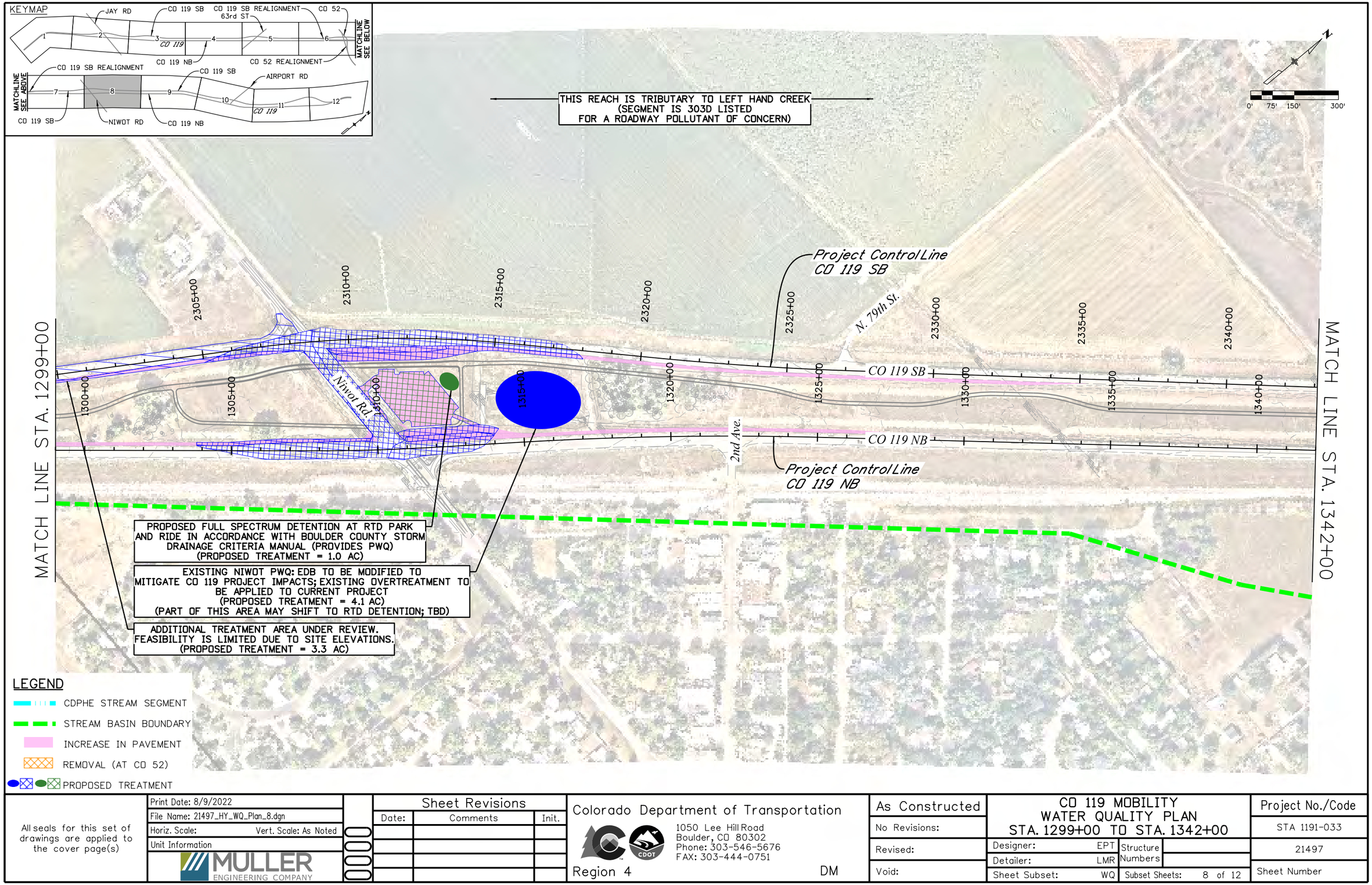

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CO 119 MOBILITY
WATER QUALITY PLAN
STA. 1299+00 TO STA. 1342+00

Designer: EPT
Detailer: LMR
Sheet Subset: WQ
Structure Numbers:
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Project No./Code
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Sheet Number

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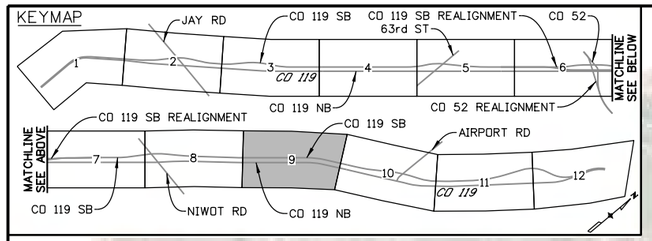

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File Name: 21497_HY_WQ_Plan_9.dgn
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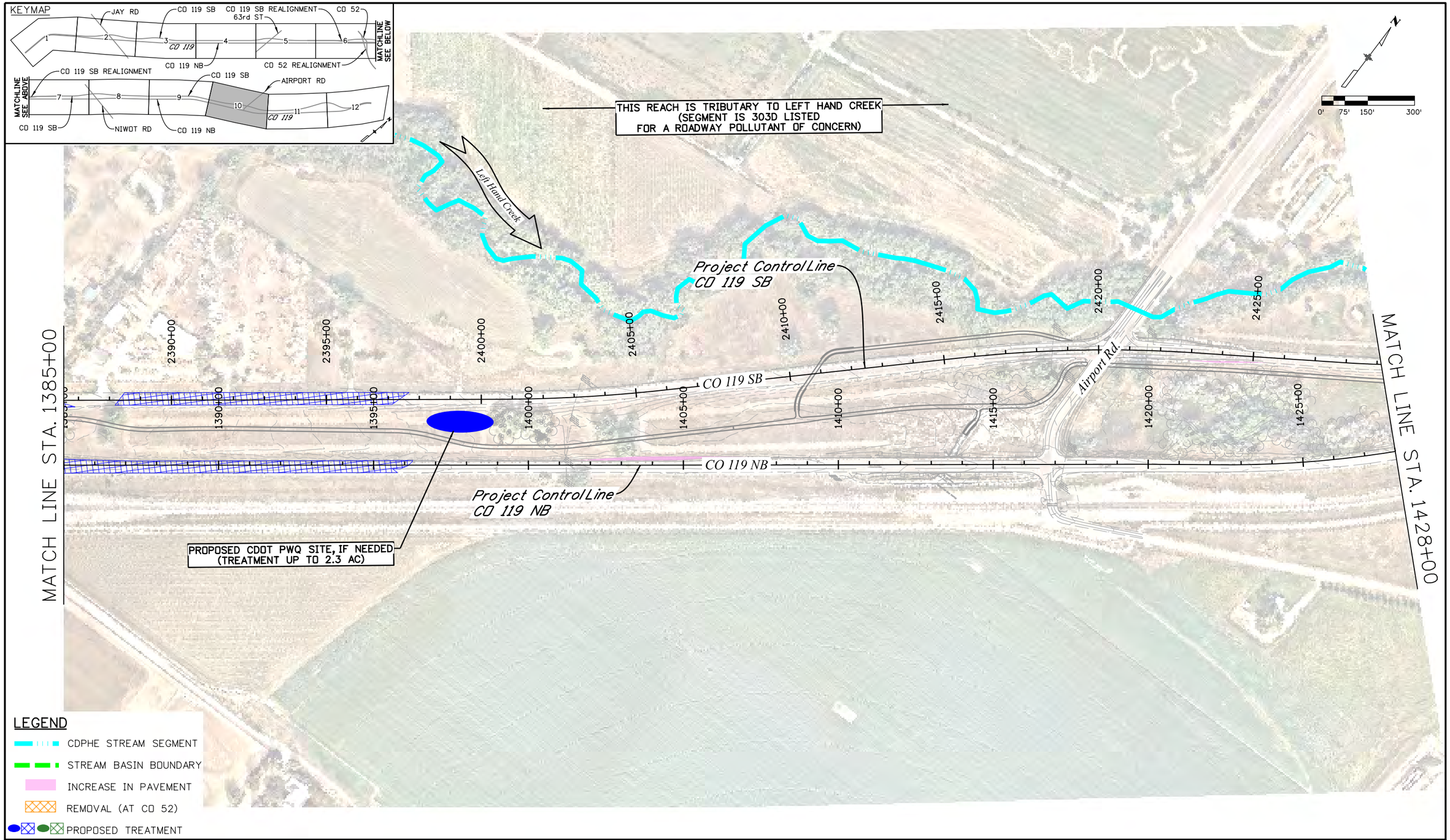
CO 119 MOBILITY
WATER QUALITY PLAN
STA. 1342+00 TO STA. 1385+00

Designer: EPT
Detailer: LMR
Sheet Subset: WQ
Structure Numbers:
Subset Sheets: 9 of 12

Project No./Code
STA 1191-033
21497
Sheet Number



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STA. 1385+00 TO STA. 1428+00

Designer: EPT
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Structure Numbers:
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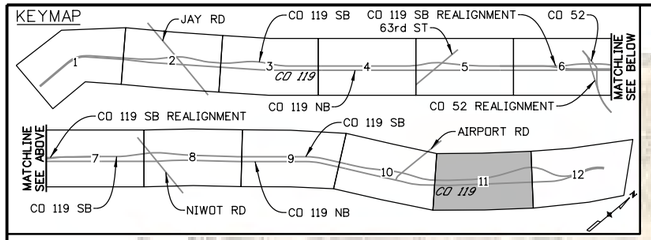
Project No./Code
STA 1191-033
21497
Sheet Number

KEYMAP



THIS REACH IS TRIBUTARY TO LEFT HAND CREEK
(SEGMENT IS 303D LISTED
FOR A ROADWAY POLLUTANT OF CONCERN)

NO NEW PAVEMENT PROPOSED ON THIS SHEET
(SEE PREVIOUS SHEETS FOR PAVEMENT IN THIS BASIN)

0' 75' 150' 300'

MATCH LINE STA. 1428+00

2430+00 2435+00 2440+00 2445+00 2450+00 2455+00 2460+00 2465+00 2470+00

1430+00 1435+00 1440+00 1445+00 1450+00 1455+00 1460+00 1465+00 1470+00

CO 119 SB

CO 119 NB

Project Control Line
CO 119 SB

Project Control Line
CO 119 NB

S. Fordham St.

MATCH LINE STA. 1471+00

Left Hand Creek

LEGEND

- CDPHE STREAM SEGMENT
- STREAM BASIN BOUNDARY
- INCREASE IN PAVEMENT
- REMOVAL (AT CO 52)
- PROPOSED TREATMENT

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/9/2022
File Name: 21497_HY_WQ_Plan_11.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

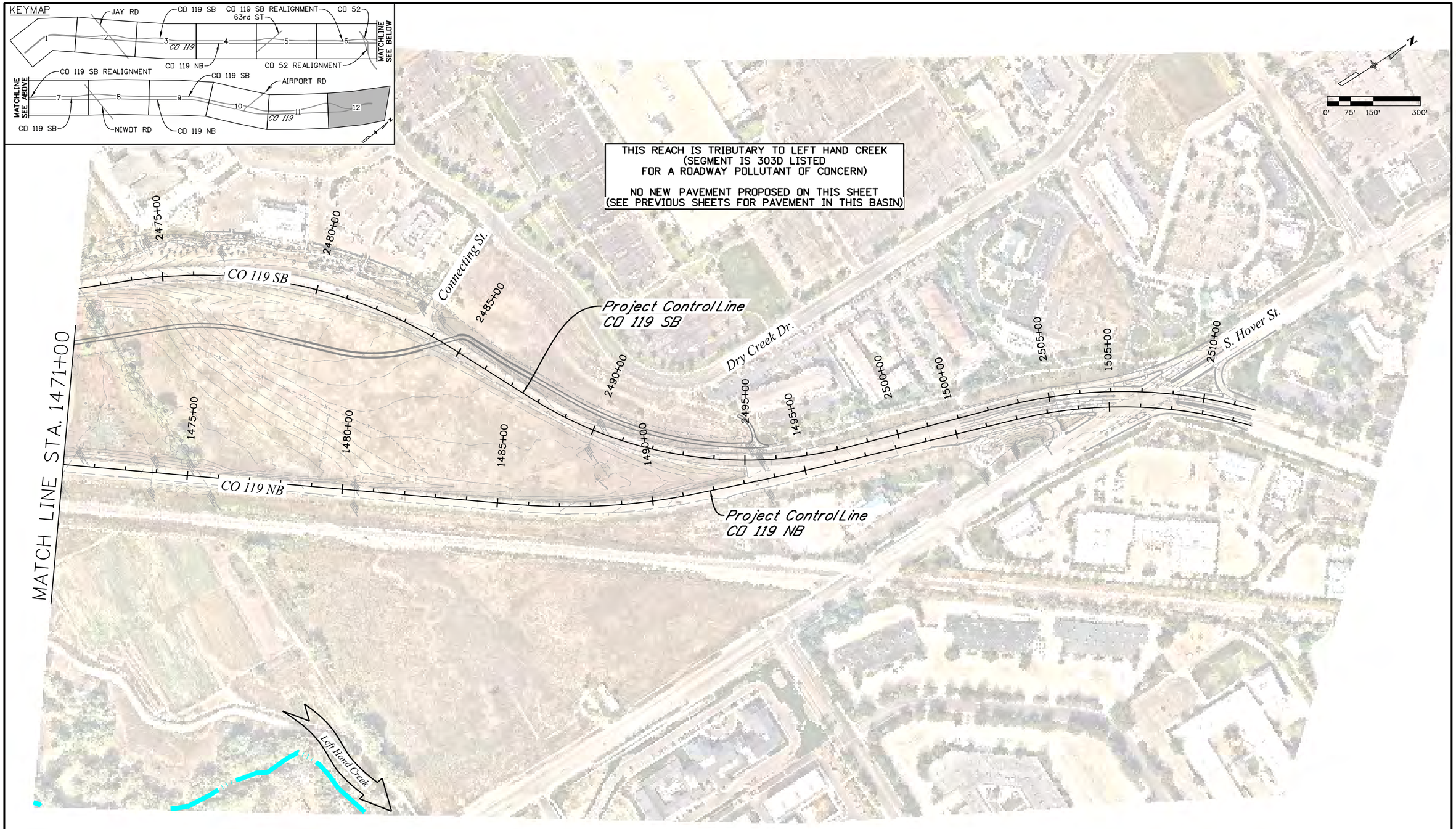
As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
WATER QUALITY PLAN
STA. 1428+00 TO STA. 1471+00

Designer: EPT
Detailer: LMR
Sheet Subset: WQ
Structure Numbers:
Subset Sheets: 11 of 12

Project No./Code
STA 1191-033
21497
Sheet Number

LRotella 1:19:51 PM pw:\\mullereng-pw.bentley.com:mullereng-pw-01\Documents\2020 Projects\20-069.01 CO 119 Mobility Improvements\01 Pre-Construction\Hydraulics\Water Quality\21497_HY_WQ_Plan_11.dgn



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Print Date: 8/9/2022
File Name: 21497_HY_WQ_Plan_12.dgn
Horiz. Scale: Vert. Scale: As Noted
Unit Information

MULLER ENGINEERING COMPANY

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
1050 Lee Hill Road
Boulder, CO 80302
Phone: 303-546-5676
FAX: 303-444-0751
Region 4 DM

As Constructed
No Revisions:
Revised:
Void:

CO 119 MOBILITY
WATER QUALITY PLAN
STA. 1471+00 TO STA. 1509+61

Designer: EPT
Detailer: LMR
Structure Numbers:
Sheet Subset: WQ
Subset Sheets: 12 of 12

Project No./Code
STA 1191-033
21497
Sheet Number

LRotella 1:20:33 PM pw:\\mullereng-pw.bentley.com:mullereng-pw-01\Documents\2020 Projects\20-069.01 CO 119 Mobility Improvements\01 Pre-Construction\Hydraulics\Water Quality\21497_HY_WQ_Plan_12.dgn