PHASE III DRAINAGE REPORT

ADVANCE AUTO PARTS

Castle Pines, Colorado

City of Castle Pines Project No. SIP-2026-002

Prepared for:

Advance Stores Company, Inc.
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Prepared by:

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August 5, 2026

Project No. 25013

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ENGINEER CERTIFICATIONS

I affirm that this report and plan for the phase III drainage design of Advance Auto Parts was prepared by me (or under my direct supervision) in accordance with the provisions of the Douglas County Drainage Design and Technical Criteria for the owners thereof. I understand that the City of Castle Pines does not and will not assume liability for drainage facilities designed by others.

_____

Brian Krombein, PE
Colorado Registered Professional Engineer No. 34294
For and on behalf of Vermilion Peak Engineering LLC

OWNER / DEVELOPER'S STATEMENT:

Advance Stores Company, Inc. hereby certifies that the drainage facilities for Advance Auto Parts shall be constructed according to the design presented in this report. I understand that the City of Castle Pines does not and will not assume liability for the drainage facilities designed and/or certified by my engineer and that the City of Castle Pines reviews drainage plans pursuant to Colorado Revised Statutes, Title 30, Article 28; but cannot, on behalf of Advance Stores Company, Inc., guarantee that final drainage design review will absolve Advance Stores Company, Inc. and/or their successors and/or assigns of future liability for improper design. I further understand that approval of the final plat does not imply approval of my engineer's drainage design.

Advance Stores Company, Inc.

_____

Authorized Signature

CITY OF CASTLE PINES APPROVALS:

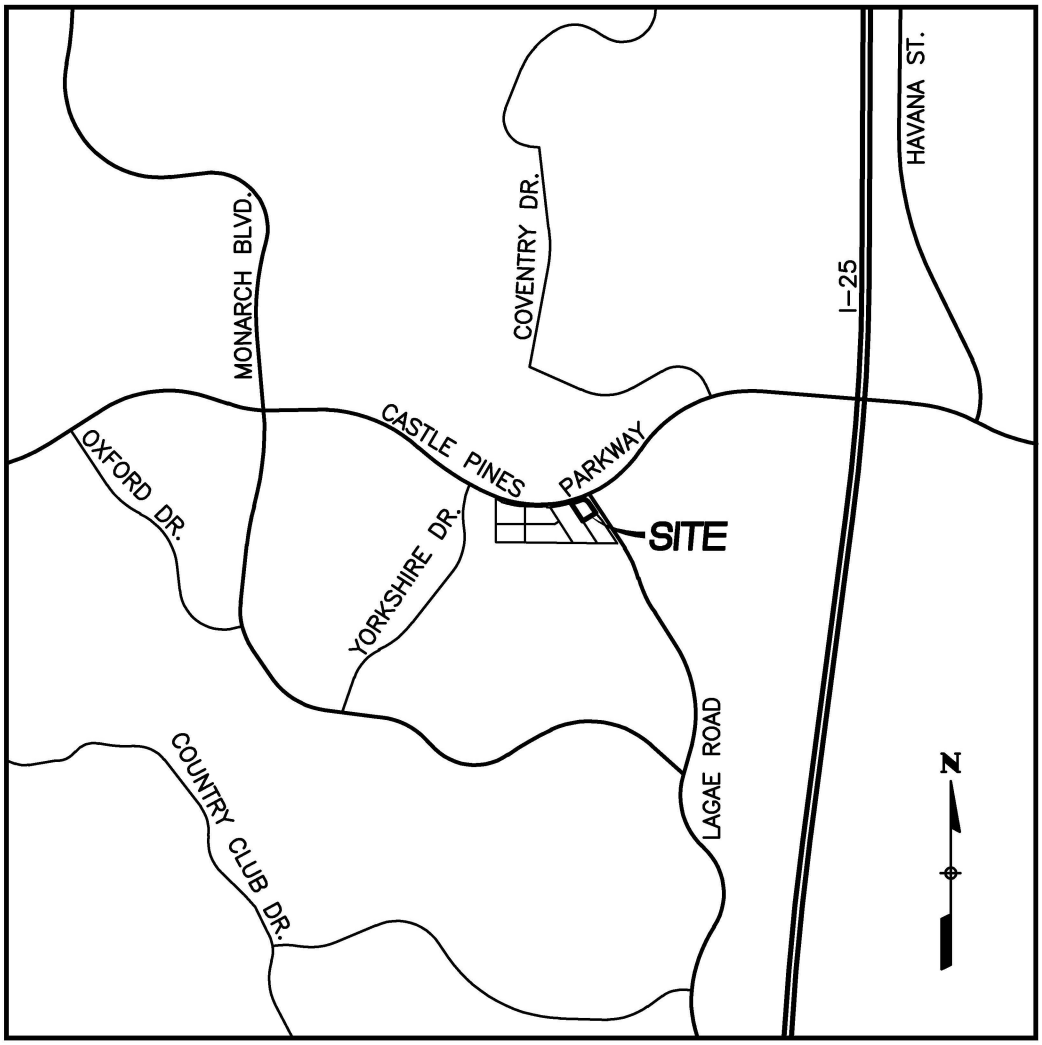
_____

Public Works Date

1.0 GENERAL LOCATION AND DESCRIPTION

Site Location

Advance Auto Parts is a 0.71-acre parcel located at the southwest corner of the intersection of Castle Pines Parkway and Lagae Road in the City of Castle Pines, Colorado. The site lies in the SW ¼ of Section 3, Township 7 South, Range 67 West of the 6th Principal Meridian. It is platted as Lot 5, Lagae Family Trust Minor Development. The site is bounded on the east by Lagae Road, on the north by Castle Pines Parkway, on the west by a stormwater detention facility in Tract A, Lagae Family Trust Minor Development and on the south by Lot 6 (vacant commercial).



VICINITY MAP

SCALE: 1"=2000'

Description of Property

Historically, the site consists of undeveloped land covered by native grasses and weeds. It has recently been overlot graded and revegetated with native grasses in anticipation of the development of the entire Lagae Family Trust parcel. Based upon a visual inspection of the site it is estimated that approximately 80% of the ground is currently vegetated.

A private drive containing water and sewer mains is located along the south boundary.

The National Resource Conservation Service soil survey of the Castle Rock, Colorado area, identifies the soil in the project area as Fondis clay loam, 3 to 9 percent slopes and Fondix-Kutch association. Both of these soils belong to hydrologic type C.

According to FEMA Flood Insurance Rate Map 08035C0160G, dated September 4, 2020 this property lies in Zone X, which is defined as "areas determined to be outside the 0.2% annual chance floodplain".

The property is tributary to the Beverly Hills Tributary which is part of the Happy Canyon Creek Watershed. Minor and major basin drainage patterns are more fully discussed in Section 2.0.

According to "Preliminary Geotechnical Study for Carmel Castle Pines Apartments", prepared by AG Wassenaar, Inc. on July 10, 2014 groundwater was not encountered to a depth of 35 feet at the boring within the Advance Auto Parts site. At this same boring bedrock was encountered at a depth of 4.5 feet. The site has since been overlot graded and sanitary and storm sewer has been installed to a depth of 8 feet. Therefore, we do not anticipate groundwater nor bedrock having any impact on the Advance Auto Parts development.

Proposed Land Use

The proposed development consists of a 6,912 sf retail building with an associated patio, parking lot and landscaped areas. The project site will be accessed through the private drive along the south edge of the property. This private drive connects to both Castle Pines Parkway and Lagae Road.

2.0 DRAINAGE BASINS AND SUB-BASINS

Major Drainage Basins

The project site is located in the Happy Canyon Creek drainage basin. In the existing condition runoff drains either westerly to the adjacent regional detention facility or to public storm inlets just outside the NE corner of the property. All runoff eventually drains easterly through public storm sewer which outfalls to the Beverly Hills tributary which drains to Happy Canyon Creek.

The project site is not affected by any offsite drainage basins.

Existing drainage studies affecting the project site include "Phase III Drainage Report for Lagae Family Trust, Douglas County, Colorado", prepared by Rick Engineering Company, most recently revised on May 13, 2020 (Rick Engineering Study).

Minor Drainage Basins

The intent of this report is to verify that the design of the Advance Auto Parts development meets the Douglas County drainage design criteria. As such, the calculations provided include onsite drainage design including proposed storm sewer. Specific calculations for determining the sizes and types of onsite storm sewer features are provided in the appendix of this report.

The project site has been divided into 5 onsite sub-basins for this drainage analysis. See the drainage plan at the rear of this report for a depiction of each basin.

Basin A (0.16 acres) contains the proposed building. It will drain through a roof drain system which will connect to the existing storm sewer outfall to the adjacent detention area west of the site. The 5-year and 100-year runoff rates at Design Point 1 will be 0.5 cfs and 1.1 cfs, respectively.

Basin B (0.10 acres) contains the north portion of the parking lot. Runoff will drain to a single Type 13 valley inlet in a 6" sump at Design Point 2. The 5-year and 100-year runoff

rates at Design Point 2 will be 0.3 cfs and 0.7 cfs, respectively. Collected flows will drain through private storm sewer to the existing outfall to the adjacent detention facility.

Basin C (0.17 acres) contains the south portion of the parking lot. Runoff will drain to a single Type 13 valley inlet in a 6" sump at Design Point 3. The 5-year and 100-year runoff rates at Design Point 3 will be 0.5 cfs and 1.1 cfs, respectively. Collected flows will drain through private storm sewer to the existing outfall to the adjacent detention facility.

Basin D (0.05 acres) contains a narrow, landscaped strip of land along the west boundary which will sheetflow directly to the adjacent extended detention basin. This roughly matches the basin delineation in the Rick Engineering Study where it is shown as being a portion of Basin 2D. The 5-year and 100-year runoff rates at Design Point 3 will be 0.0 cfs and 0.2 cfs, respectively.

Basin E (0.24 acres) contains the landscaped slopes along the north, south and east edges of the property plus the existing paved access drive along the south edge of the property. These areas will drain to the gutter of the surrounding roadway which carry flows to an existing, 15' Type R inlet in a sump on the west side of Lagae Road, just south of Castle Pines Parkway. The proposed 5-year and 100-year runoff rates at Design Point 4 will be 0.4 cfs and 1.2 cfs, respectively.

3.0 DRAINAGE DESIGN CRITERIA

Regulations

This drainage study has been prepared to meet the requirements of the City of Castle Pines as set forth in the "Douglas County Storm Drainage Design and Technical Criteria Manual" (Reference 1), and the "Urban Storm Drainage Criteria Manual" (Reference 2).

Drainage Studies, Master Plans, Site Constraints

The drainage design for all of Lagae Family Trust Minor Development was designed by Rick Engineering Company in the report titled, ""Phase III Drainage Report for Lagae Family Trust, Douglas County, Colorado", revised May 13, 2020 (Rick Engineering Study).

The drainage basins delineated in the Rick Engineering Study do not exactly match up with the proposed conditions. The Rick Engineering Study assumed that a significant offsite area to the south would drain into the project site (Basin 2C). Due to the steep drive aisle up into the site this offsite area will actually drain easterly to Lagae Road. The other onsite drainage basins will generally match the basin delineations in the Rick Engineering Study, though that study combined Lot 5 areas with portions of the adjacent lots.

The Rick Engineering Study calculations for EDB-2 assumed that a tributary area of 1.1 acres with an imperviousness of 45% will be served by this detention basin. In our proposed condition only 0.51 acres with an imperviousness of 81% are tributary to EDB-2. This reduces the required pond volume from 4,051 cf to 2,483 cf which is a 39% reduction in volume. We have provided an updated MHFD-Detention spreadsheet in the appendix to this report. This spreadsheet shows that runoff will be over-detained but will still meet State of Colorado requirements for release times during the 5-year storm. It also indicates that the 100-year release rate will be reduced from 1.1 cfs to 0.1 cfs. This will offset some of the excess 0.59 acres which will now drain to Lagae Road rather than EDB-2.

Overall, we conclude that the proposed drainage concept is similar to the basin assumptions of the Rick Engineering Study and that no modifications to the EDB-2 outlet control structure are necessary.

Hydrology

The Rational Method was used to calculate peak runoff rates for the sub-basins during the 5-year and 100-year storm events. Basin imperviousness was obtained from Table 6-3 (MHFD), runoff coefficients were obtained from Table 6-5 (MHFD), rainfall intensities were obtained from IDF curve data calculated using NOAA Atlas 14 data for the site location. The 1-hour point rainfall depths are 1.12" during the 5-year storm and 2.31" during the 100-year storm. Runoff velocities were obtained from Equation 6-4 (MHFD). Times of concentration were determined using form SF-2 and runoff flow rates were determined using form SF-3. Runoff tables and calculations can be found in the appendix of this report.

Hydraulics

Specific hydraulic calculations for determining the sizes and type of onsite storm sewer features are included in Appendix B at the rear of this report. In compliance with Douglas

County Design Criteria, the storm sewer system has been sized to collect runoff from the 100-year (and smaller) events, ponding depths within sumps will not exceed 6 inches . Inlet sizing has been determined using the UD-Inlet software provided by MHFD. The existing storm sewer was designed in the Rick Engineering Report. Proposed flowrates will be less than the storm sewer was designed to carry.

Water Quality Enhancement

Per county criteria, stormwater detention and the water quality capture volume must be provided for this development. Both of these items are provided in the regional detention facility located in Tract A, immediately west of the project site. The design of this facility is provided in the Rick Engineering Study. Applicable references have been included in Appendix D at the rear of this report. No additional, onsite detention or water quality improvements are required for development of the Advance Auto Parts site.

4.0 STORMWATER MANAGEMENT FACILITY DESIGN

Stormwater Conveyance Facilities

A layout of the storm sewer system is shown on the Phase III Drainage Plan, located at the rear of this report. The majority of the proposed development, including the building and most drive aisles, will drain to proposed or existing storm sewer within the development. A small portion of the site will drain directly to Lagae Road in approximately the same condition as anticipated in the Rick Engineering Study. We do not foresee these uncollected flows having any detrimental impacts on downstream storm drainage infrastructure.

The existing storm sewer system will convey runoff collected at Design Points 1, 2 and 3 to the regional detention facility in Tract A. Specific hydraulic calculations for determining the sizes and type of storm sewer features are provided in the appendix of this report.

Stormwater Storage Facilities

As mentioned above, stormwater detention is provided in an offsite facility.

Water Quality Enhancement Best Management Practices

As mentioned above, the water quality capture volume is provided in an offsite facility.

Floodplain Modification

No modifications or grading is proposed within any floodplains.

Additional Permitting Requirements

N/A

5.0 CONCLUSIONS

Compliance With Standards

The proposed drainage design is in conformance with the Douglas County Storm Drainage Design and Technical Criteria Manual and the Urban Storm Drainage Criteria Manual.

The proposed storm sewer has been designed to accept fully developed runoff from the project site. Calculations located in Appendix C show the parameters used to make this determination.

Detention and water quality volumes for this site are provided in an existing, offsite facility.

Variances

No variances related to drainage design have been requested for the proposed development.

Drainage Concept

Runoff generated onsite will be directed away from the building and toward onsite and offsite storm inlets. Collected flows from nearly all proposed impervious areas will be piped to the regional detention facility in Tract A in conformance with the Rick Engineering Study. Runoff from the landscaped slopes along the north and east boundaries will drain to an existing, offsite storm inlet in compliance with the Rick Engineering Study.

6.0 REFERENCES

1. Douglas County Storm Drainage Design and Technical Criteria Manual, July 8, 2008.

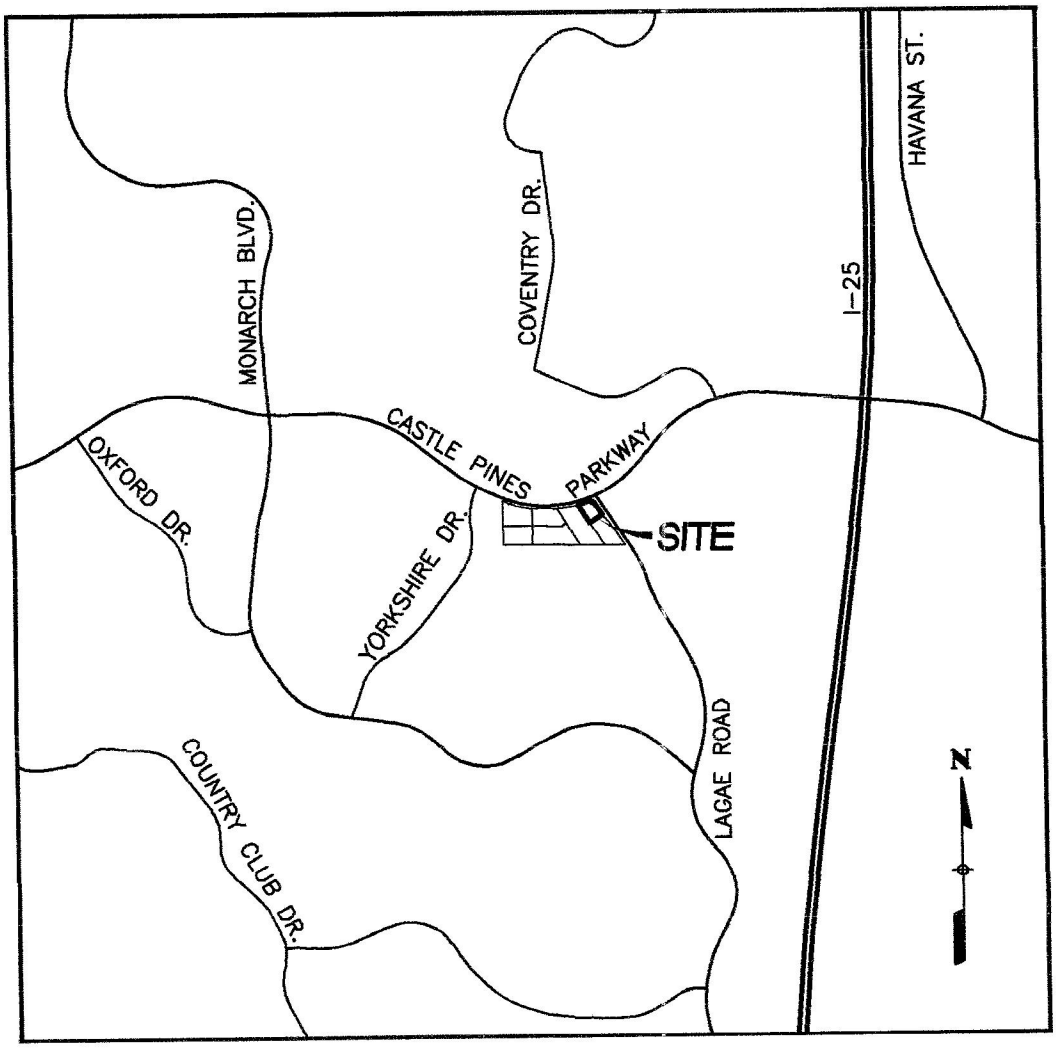
2. Urban Storm Drainage Criteria Manual, Mile High Flood District, Volume 1 - August 2018, Volume 2 - September 2017 Volume 3 - November 2019.

3. FEMA Flood Insurance Rate Map 08035C0160G, September 4, 2020.

4. United States Department of Agriculture – Web Soil Survey, May 10, 2021, Soil Map – Castle Rock Area, Colorado; http://websoilsurvey.nrcs.usda.gov/app/

5. Preliminary Geotechnical Study for Carmel Castle Pines Apartments, AG Wassenaar, Inc., July 10, 2014.

6. Phase III Drainage Report for Lagae Family Trust, Douglas County, Colorado, Rick Engineering Company, revised May 13, 2020.



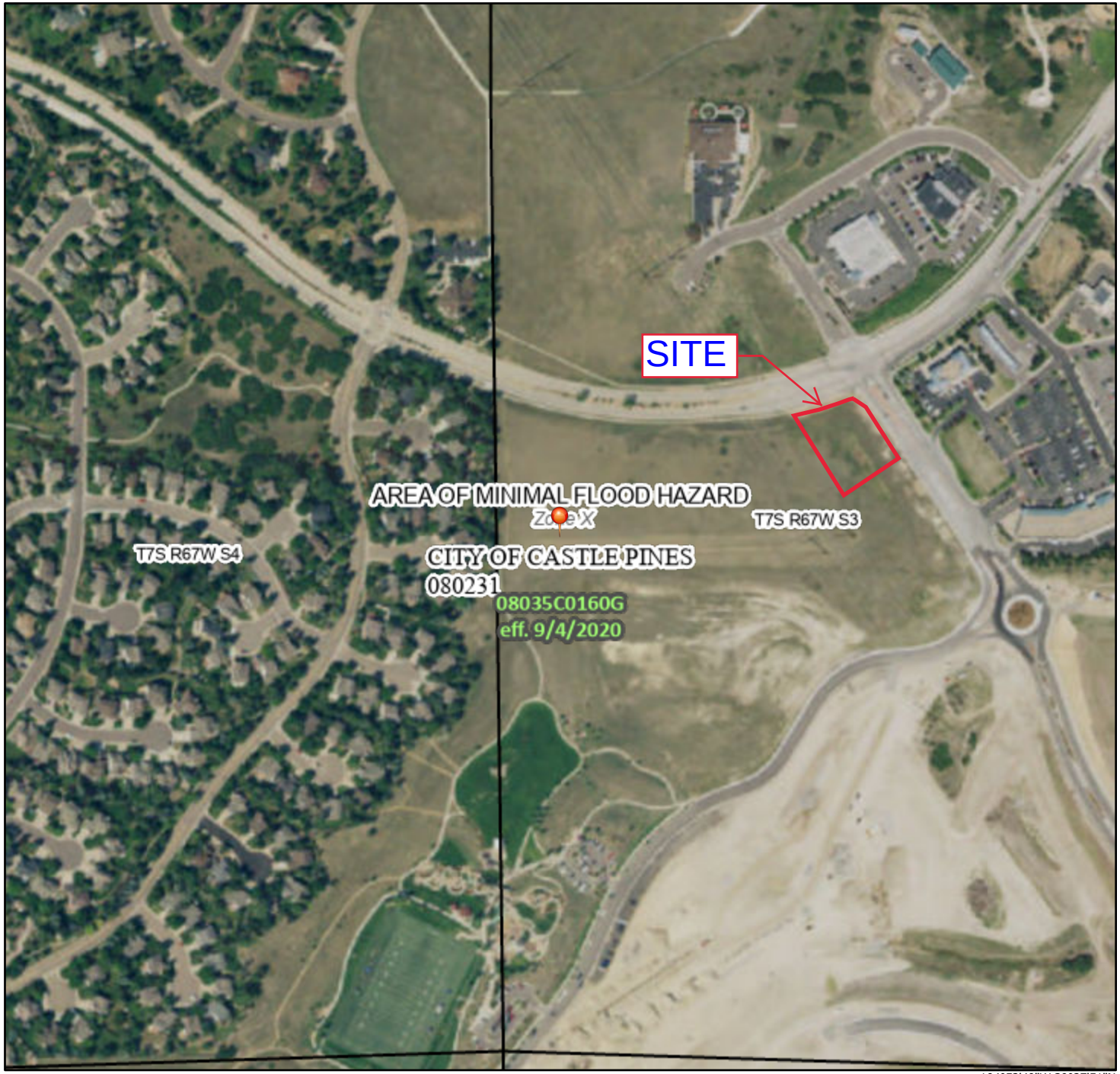
VICINITY MAP

SCALE: 1"=2000'

National Flood Hazard Layer FIRMette

FEMA

104°53'27"W 39°28'19"N



104°52'49"W 39°27'51"N

Feet

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

1:6,000

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

Legend

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

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

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

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

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

OTHER FEATURES
- 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 2/4/2021 at 3:48 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.

Soil Map—Castle Rock Area, Colorado

Map Scale: 1:595 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 5 10 20 30

Feet
0 25 50 100 150

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 Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

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: Castle Rock Area, Colorado
Survey Area Data: Version 13, Jun 5, 2020

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

Date(s) aerial images were photographed: Jul 24, 2018—Nov 19, 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.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
FoD	Fondis clay loam, 3 to 9 percent slopes	0.5	67.8%
Fu	Fondis-Kutch association	0.2	32.2%
Totals for Area of Interest		**0.8**	**100.0%**

Castle Rock Area, Colorado

FoD—Fondis clay loam, 3 to 9 percent slopes

Map Unit Setting

National map unit symbol: jqyp
Elevation: 5,500 to 6,800 feet
Mean annual precipitation: 15 to 19 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 120 to 135 days
Farmland classification: Not prime farmland

Map Unit Composition

Fondis and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fondis

Setting

Landform: Buttes, ridges, mesas
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits over coarse-silty outwash derived from arkose

Typical profile

H1 - 0 to 7 inches: clay loam
H2 - 7 to 24 inches: clay
H3 - 24 to 60 inches: sandy clay loam

Properties and qualities

Slope: 3 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: High (about 9.4 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C

Ecological site: R049XY208CO - Clayey Foothill DRAFT (1-2018)
MLRA 49
Hydric soil rating: No

Minor Components

Kutch
Percent of map unit: 5 percent
Hydric soil rating: No

Englewood
Percent of map unit: 5 percent
Hydric soil rating: No

Denver
Percent of map unit: 4 percent
Hydric soil rating: No

Aquic haplustolls
Percent of map unit: 1 percent
Landform: Swales
Hydric soil rating: Yes

Data Source Information

Soil Survey Area: Castle Rock Area, Colorado
Survey Area Data: Version 13, Jun 5, 2020

Castle Rock Area, Colorado

Fu—Fondis-Kutch association

Map Unit Setting

National map unit symbol: jqyq
Elevation: 5,500 to 6,800 feet
Mean annual precipitation: 15 to 19 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 120 to 135 days
Farmland classification: Not prime farmland

Map Unit Composition

Fondis and similar soils: 50 percent
Kutch and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fondis

Setting

Landform: Valley sides, draws
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits over coarse-silty outwash derived from arkose

Typical profile

H1 - 0 to 7 inches: loam
H2 - 7 to 24 inches: clay
H3 - 24 to 60 inches: sandy clay loam

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C

Ecological site: R049XY208CO - Clayey Foothill DRAFT (1-2018) MLRA 49
Hydric soil rating: No

Description of Kutch

Setting

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-textured residuum weathered from calcareous shale

Typical profile

H1 - 0 to 6 inches: sandy loam
H2 - 6 to 32 inches: clay
H3 - 32 to 36 inches: weathered bedrock

Properties and qualities

Slope: 5 to 40 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Newlin

Percent of map unit: 5 percent
Hydric soil rating: No

Bresser

Percent of map unit: 5 percent
Hydric soil rating: No

Hilly gravelly land

Percent of map unit: 4 percent
Hydric soil rating: No

Aquic haplustolls

Percent of map unit: 1 percent

Landform: Swales
Hydric soil rating: Yes

Data Source Information

Soil Survey Area: Castle Rock Area, Colorado
Survey Area Data: Version 13, Jun 5, 2020

APPENDIX A

Hydrologic Computations

2.4.1 Initial or Overland Flow Time

The initial or overland flow time, t_i, may be calculated using Equation 6-3:

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_o^{0.33}} \qquad \text{Equation 6-3}$$

Where:

t_i = overland (initial) flow time (minutes)
C_5 = runoff coefficient for 5-year frequency (from Table 6-4)
L_i = length of overland flow (ft)
S_o = average slope along the overland flow path (ft/ft).

Equation 6-3 is adequate for distances up to 300 feet in urban areas and 500 feet in rural areas. Note that in a highly urbanized catchment, the overland flow length is typically shorter than 300 feet due to effective man-made drainage systems that collect and convey runoff.

2.4.2 Channelized Flow Time

The channelized flow time (travel time) is calculated using the hydraulic properties of the conveyance element. The channelized flow time, t_t, is estimated by dividing the length of conveyance by the velocity. The following equation, Equation 6-4 (Guo 2013), can be used to determine the flow velocity in conjunction with Table 6-2 for the conveyance factor.

$$t_t = \frac{L_t}{60K\sqrt{S_o}} = \frac{L_t}{60V_t} \qquad \text{Equation 6-4}$$

Where:

t_t = channelized flow time (travel time, min)
L_t = waterway length (ft)
S_o = waterway slope (ft/ft)
V_t = travel time velocity (ft/sec) = $K\sqrt{S_o}$
K = NRCS conveyance factor (see Table 6-2).

Table 6-2. NRCS Conveyance factors, K

Type of Land Surface	Conveyance Factor, K
Heavy meadow	2.5
Tillage/field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

The time of concentration, t_c, is the sum of the initial (overland) flow time, t_i, and the channelized flow time, t_t, as per Equation 6-2.

2.4.3 First Design Point Time of Concentration in Urban Catchments

Equation 6-4 was solely determined by the waterway characteristics and using a set of empirical formulas. A calibration study between the Rational Method and the Colorado Urban Hydrograph Procedure (CUHP) suggests that the time of concentration shall be the lesser of the values calculated by Equation 6-2 and Equation 6-5 (Guo and Urbonas 2013).

$$t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}} \qquad \text{Equation 6-5}$$

Where:

t_c = minimum time of concentration for first design point when less than t_c from Equation 6-1.
L_t = length of channelized flow path (ft)
i = imperviousness (expressed as a decimal)
S_t = slope of the channelized flow path (ft/ft).

Equation 6-5 is the regional time of concentration that warrants the best agreement on peak flow predictions between the Rational Method and CUHP when the imperviousness of the tributary area is greater than 20 percent. It was developed using the UDFCD database that includes 295 sample urban catchments under 2-, 5-, 10-, 50, and 100-yr storm events (MacKenzie 2010). It suggests that both initial flow time and channelized flow velocity are directly related to the catchment's imperviousness (Guo and MacKenzie 2013).

The first design point is defined as a node where surface runoff enters the storm drain system. For example, all inlets are "first design points" because inlets are designed to accept flow into the storm drain.

Typically, but not always, Equation 6-5 will result in a lesser time of concentration at the first design point and will govern in an urbanized watershed. For subsequent design points, add the travel time for each relevant segment downstream.

2.4.4 Minimum Time of Concentration

Use a minimum t_c value of 5 minutes for urbanized areas and a minimum t_c value of 10 minutes for areas that are not considered urban. Use minimum values even when calculations result in a lesser time of concentration.

2.4.5 Common Errors in Calculating Time of Concentration

A common mistake in urbanized areas is to assume travel velocities that are too slow. Another common error is to not check the runoff peak resulting from only part of the catchment. Sometimes a lower portion of the catchment or a highly impervious area produces a larger peak than that computed for the whole catchment. This error is most often encountered when the catchment is long or the upper portion contains grassy open land and the lower portion is more developed.

Site-specific conditions may vary from the representative values presented in this chapter. The engineer is responsible for assuring that the selected imperviousness values represent the imperviousness of the catchment or the proposed development. During master planning or in early stages of design, select imperviousness values that are unlikely to be exceeded as final design plans are developed to avoid the need to increase the size of infrastructure during later design stages.

TABLE 6-2. RECOMMENDED IMPERVIOUSNESS BY LAND USE

LAND USE/DENSITY	IMPERVIOUSNESS
Residential	
Single-family Housing (SFH) – Rural (0 – 3 du/ac)	35%
SFH – Low & Medium-density (3 – 5 du/ac)	55%
SFH – High-density (5 - 20 du/ac)	65%
Manufactured Housing (>= 10 du/ac)	65%
Multi-family Housing (MFH) – Medium-density (5 – 20 du/ac)	65%
MFH – High-density MFH (>20 du/ac)	70%
Commercial	
Commercial – Low-density	65%
Commercial – Medium- to High-density	80%
Commercial – Urban Core	90%
Industrial/Institutional	
Schools	55%
Office/institutional	65%
Industrial Areas	75%
Solar Fields, Gravel Cover[1,2]	60%
Solar Fields, Grass Cover[1,2]	45%
Parks and Open Space	
Open Space, Undisturbed Native Grasses	5%
Community Parks	25%
Neighborhood Parks	15%
Golf Courses	30%
Cemeteries	25%

Note: Recommended imperviousness values shown in the table are the minimum imperviousness values for a specific land use. It is the engineer's responsibility to select imperviousness values that appropriately reflect the actual density of the proposed development.

[1] Use these values at the master planning scale or when the specific layout of panels is not known. Use values from the surface type (Table 6-3) at the site planning and design stage when panel width, panel spacing, and panel orientation relative to contours are known.

[2] Assumes 1:1 ratio of panels to aisles. See MHFD's technical memorandum regarding *Determination of Solar Panel Field Runoff Coefficients and Imperviousness Values* for additional information on procedures to reflect other impervious areas such as roads and pads that may be part of a solar field and layouts with wider inter-panel spacing.

TABLE 6-3. RECOMMENDED IMPERVIOUSNESS BY SURFACE TYPES

SURFACE TYPES		IMPERVIOUSNESS
Roadways and Paved Streets		95%
Concrete Driveways and Walks		95%
Roofs		95%
Gravel	No Traffic (Pedestrian Use)	40%
	Low-traffic Areas (Maintenance Paths and Substations)	60%
	High-traffic Areas (Roadways and Parking)	80%
Disturbed Soil (Including Lawns, Managed/Active Turf, Landscaped Areas with Water-Wise Vegetation, and Uncompacted Gravel/Mulch Planting Beds)		20%
Undisturbed or Decompacted Soil (Native Grasses and Open Space Areas)		5%
Artificial Turfs[1]	Landscape Applications (without Subgrade Drainage Layer)	25% – 45%
	Sport Fields (with Underdrain Pipe System)	60% – 80%
Water Surfaces (Lakes/Reservoirs/Irrigation Ponds)		100%
Solar Fields[2]	Grass Cover (Varies with Panel Orientation Relative to Ground Contours)	10% – 45%
	Gravel Cover (Varies with Panel Orientation Relative to Ground Contours)	50% – 75%
Historic Flow Analysis, Greenbelts, Agricultural		5%
Newly Graded Areas		65%
Stormwater Control Measures[3]	Retention Ponds & Constructed Wetland Ponds	100%
	Rooftop Systems – Blue Roofs	95%
	Rooftop Systems – Green Roofs (extensive)	65%
	Rooftop Systems – Green Roofs (intensive)	50%
	Permeable Pavement – CGP/PGP/RGP	55%
	Permeable Pavement – PICP	45%
	Extended Detention Basins	25%
	Receiving Pervious Areas (incl. Grass Buffers & Grass Swales)	20%
	Bioretention & Sand Filters	10%

[1] Consult with the manufacturer to get a recommended value.

[2] Assumes 1:1 ratio of panels to aisles. See MHFD's technical memorandum regarding *Determination of Solar Panel Field Runoff Coefficients and Imperviousness Values* for additional information on procedures for determining percent imperviousness based on panel width, panel spacing, and panel orientation relative to ground contours and how to reflect other impervious areas such as roads and pads that may be part of a solar field and layouts with wider inter-panel spacing.

[3] See MHFD's technical memorandum regarding *Evaluation of Percent Imperviousness for Stormwater Control Measures* for background information.

TABLE 6-8. RUNOFF COEFFICIENTS, *C*, NRCS HSG C/D

TOTAL OR EFFECTIVE % IMPERVIOUS	NRCS HSG C/D						
	WQE & 2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.05	0.15	0.33	0.40	0.49	0.59
5%	0.03	0.08	0.17	0.35	0.42	0.50	0.60
10%	0.06	0.12	0.21	0.38	0.44	0.52	0.62
15%	0.10	0.16	0.24	0.40	0.47	0.55	0.64
20%	0.14	0.20	0.28	0.43	0.49	0.57	0.65
25%	0.18	0.24	0.32	0.46	0.52	0.59	0.67
30%	0.22	0.28	0.35	0.49	0.54	0.61	0.68
35%	0.26	0.32	0.39	0.52	0.57	0.63	0.70
40%	0.30	0.36	0.43	0.54	0.59	0.65	0.71
45%	0.34	0.40	0.46	0.57	0.62	0.67	0.73
50%	0.38	0.44	0.50	0.60	0.64	0.69	0.75
55%	0.43	0.48	0.54	0.63	0.66	0.71	0.76
60%	0.47	0.52	0.57	0.66	0.69	0.73	0.78
65%	0.51	0.56	0.61	0.68	0.71	0.75	0.79
70%	0.56	0.61	0.65	0.71	0.74	0.77	0.81
75%	0.60	0.65	0.68	0.74	0.76	0.79	0.82
80%	0.65	0.69	0.72	0.77	0.79	0.81	0.84
85%	0.69	0.73	0.76	0.80	0.81	0.83	0.86
90%	0.74	0.77	0.79	0.82	0.84	0.85	0.87
95%	0.79	0.81	0.83	0.85	0.86	0.87	0.89
100%	0.84	0.86	0.87	0.88	0.89	0.89	0.90

NOAA Atlas 14, Volume 8, Version 2
Location name: Castle Rock, Colorado, USA*
Latitude: 39.469°, Longitude: -104.883°
Elevation: 6445 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	**0.230** (0.187-0.285)	**0.290** (0.237-0.360)	**0.393** (0.319-0.489)	**0.480** (0.387-0.601)	**0.605** (0.471-0.788)	**0.704** (0.534-0.930)	**0.806** (0.589-1.09)	**0.913** (0.637-1.27)	**1.06** (0.708-1.52)	**1.17** (0.762-1.71)
10-min	**0.336** (0.274-0.417)	**0.425** (0.346-0.528)	**0.575** (0.467-0.716)	**0.703** (0.567-0.880)	**0.886** (0.689-1.15)	**1.03** (0.782-1.36)	**1.18** (0.862-1.60)	**1.34** (0.933-1.86)	**1.55** (1.04-2.23)	**1.72** (1.12-2.50)
15-min	**0.410** (0.334-0.508)	**0.518** (0.422-0.644)	**0.701** (0.569-0.873)	**0.857** (0.692-1.07)	**1.08** (0.841-1.41)	**1.26** (0.954-1.66)	**1.44** (1.05-1.95)	**1.63** (1.14-2.28)	**1.89** (1.26-2.72)	**2.09** (1.36-3.05)
30-min	**0.534** (0.436-0.663)	**0.678** (0.552-0.841)	**0.918** (0.745-1.14)	**1.12** (0.906-1.40)	**1.41** (1.10-1.84)	**1.65** (1.25-2.17)	**1.88** (1.38-2.55)	**2.13** (1.49-2.97)	**2.46** (1.65-3.54)	**2.73** (1.77-3.97)
60-min	**0.683** (0.557-0.847)	**0.844** (0.688-1.05)	**1.12** (0.910-1.40)	**1.36** (1.10-1.71)	**1.72** (1.34-2.25)	**2.01** (1.52-2.66)	**2.31** (1.69-3.14)	**2.63** (1.84-3.68)	**3.07** (2.06-4.43)	**3.42** (2.23-4.99)
2-hr	**0.831** (0.683-1.02)	**1.01** (0.829-1.24)	**1.32** (1.08-1.64)	**1.60** (1.30-1.99)	**2.02** (1.60-2.64)	**2.37** (1.82-3.12)	**2.74** (2.02-3.70)	**3.13** (2.21-4.35)	**3.68** (2.49-5.26)	**4.12** (2.70-5.95)
3-hr	**0.946** (0.780-1.16)	**1.13** (0.929-1.38)	**1.46** (1.19-1.79)	**1.76** (1.43-2.17)	**2.21** (1.76-2.87)	**2.59** (2.00-3.41)	**3.00** (2.23-4.05)	**3.45** (2.45-4.78)	**4.08** (2.78-5.82)	**4.60** (3.03-6.60)
6-hr	**1.16** (0.966-1.41)	**1.37** (1.14-1.67)	**1.75** (1.45-2.13)	**2.10** (1.72-2.57)	**2.63** (2.10-3.39)	**3.07** (2.39-4.01)	**3.56** (2.66-4.75)	**4.08** (2.92-5.61)	**4.83** (3.32-6.82)	**5.44** (3.62-7.74)
12-hr	**1.41** (1.18-1.70)	**1.68** (1.40-2.03)	**2.15** (1.79-2.60)	**2.57** (2.12-3.12)	**3.19** (2.56-4.06)	**3.70** (2.89-4.76)	**4.24** (3.20-5.60)	**4.83** (3.48-6.54)	**5.64** (3.90-7.87)	**6.30** (4.22-8.87)
24-hr	**1.70** (1.44-2.04)	**2.02** (1.70-2.42)	**2.57** (2.15-3.08)	**3.05** (2.54-3.67)	**3.74** (3.02-4.69)	**4.30** (3.38-5.46)	**4.88** (3.70-6.37)	**5.50** (3.99-7.37)	**6.36** (4.42-8.76)	**7.03** (4.75-9.81)
2-day	**2.03** (1.72-2.41)	**2.37** (2.01-2.81)	**2.95** (2.49-3.51)	**3.46** (2.90-4.13)	**4.19** (3.40-5.20)	**4.78** (3.78-6.01)	**5.39** (4.12-6.96)	**6.04** (4.42-8.01)	**6.94** (4.86-9.46)	**7.64** (5.20-10.6)
3-day	**2.21** (1.88-2.60)	**2.58** (2.19-3.04)	**3.21** (2.72-3.80)	**3.75** (3.16-4.46)	**4.53** (3.69-5.59)	**5.15** (4.09-6.44)	**5.79** (4.44-7.42)	**6.46** (4.74-8.51)	**7.38** (5.20-10.0)	**8.10** (5.54-11.1)
4-day	**2.34** (2.00-2.75)	**2.74** (2.34-3.22)	**3.41** (2.90-4.02)	**3.99** (3.37-4.72)	**4.80** (3.92-5.89)	**5.45** (4.34-6.78)	**6.12** (4.70-7.80)	**6.81** (5.01-8.92)	**7.75** (5.48-10.4)	**8.48** (5.83-11.6)
7-day	**2.68** (2.30-3.13)	**3.12** (2.68-3.64)	**3.85** (3.29-4.51)	**4.48** (3.81-5.27)	**5.37** (4.41-6.54)	**6.07** (4.87-7.50)	**6.80** (5.26-8.60)	**7.55** (5.59-9.81)	**8.57** (6.10-11.5)	**9.36** (6.48-12.7)
10-day	**3.01** (2.59-3.50)	**3.47** (2.98-4.03)	**4.23** (3.63-4.93)	**4.88** (4.16-5.72)	**5.81** (4.80-7.04)	**6.55** (5.28-8.05)	**7.31** (5.68-9.20)	**8.10** (6.03-10.5)	**9.18** (6.56-12.2)	**10.0** (6.96-13.5)
20-day	**3.99** (3.46-4.60)	**4.51** (3.91-5.19)	**5.37** (4.64-6.20)	**6.09** (5.24-7.07)	**7.12** (5.92-8.53)	**7.93** (6.43-9.63)	**8.75** (6.85-10.9)	**9.60** (7.20-12.3)	**10.8** (7.75-14.1)	**11.6** (8.16-15.6)
30-day	**4.79** (4.17-5.48)	**5.39** (4.70-6.18)	**6.39** (5.54-7.34)	**7.21** (6.22-8.33)	**8.35** (6.96-9.92)	**9.24** (7.52-11.1)	**10.1** (7.95-12.5)	**11.0** (8.30-14.0)	**12.2** (8.84-15.9)	**13.1** (9.24-17.4)
45-day	**5.75** (5.04-6.56)	**6.52** (5.70-7.44)	**7.75** (6.75-8.86)	**8.75** (7.58-10.0)	**10.1** (8.42-11.9)	**11.1** (9.06-13.3)	**12.1** (9.52-14.8)	**13.0** (9.86-16.4)	**14.3** (10.4-18.5)	**15.2** (10.8-20.1)
60-day	**6.54** (5.74-7.43)	**7.48** (6.56-8.50)	**8.96** (7.84-10.2)	**10.1** (8.82-11.6)	**11.7** (9.77-13.7)	**12.8** (10.5-15.2)	**13.9** (11.0-16.9)	**15.0** (11.3-18.7)	**16.3** (11.8-20.9)	**17.2** (12.2-22.6)

[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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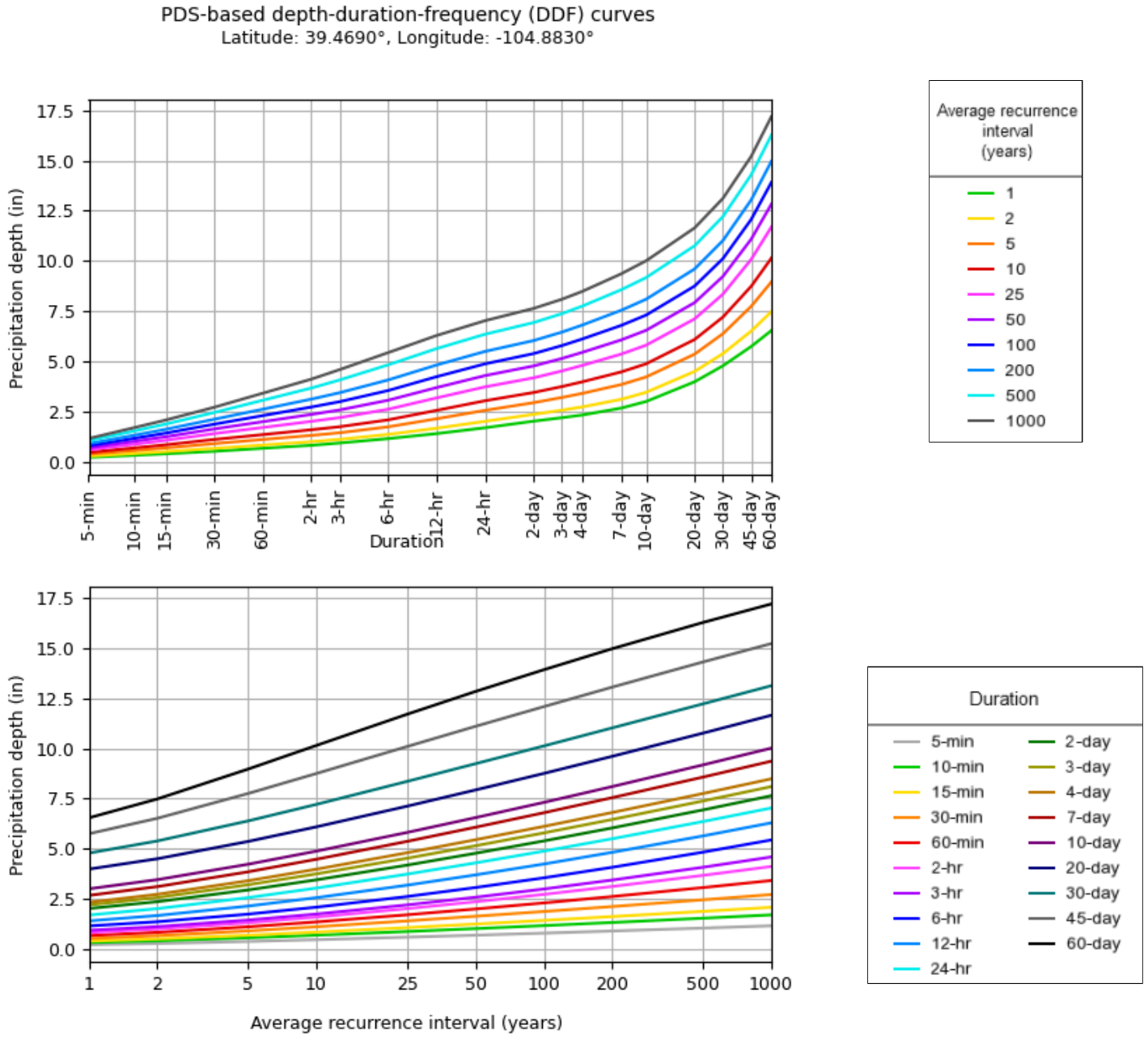
PF graphical



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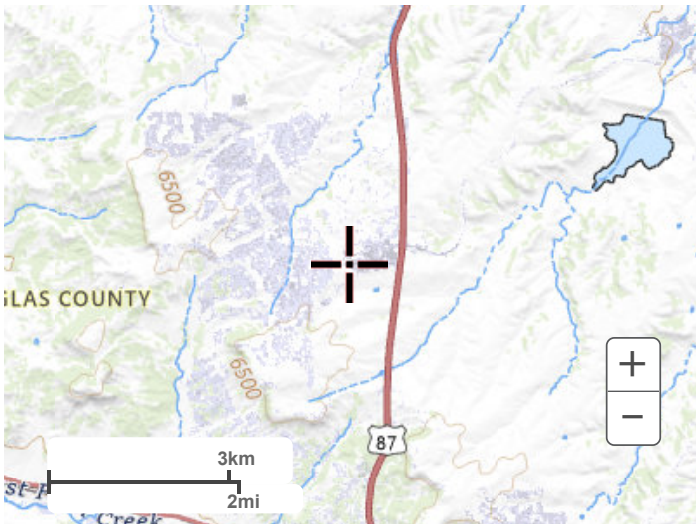
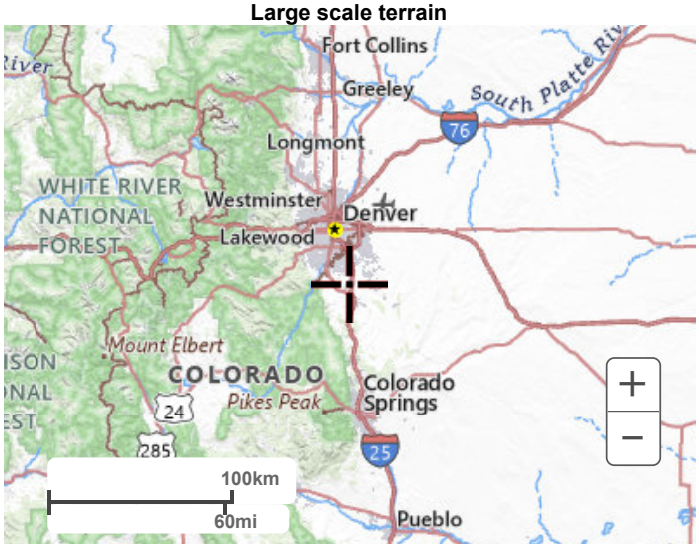
Maps & aerials

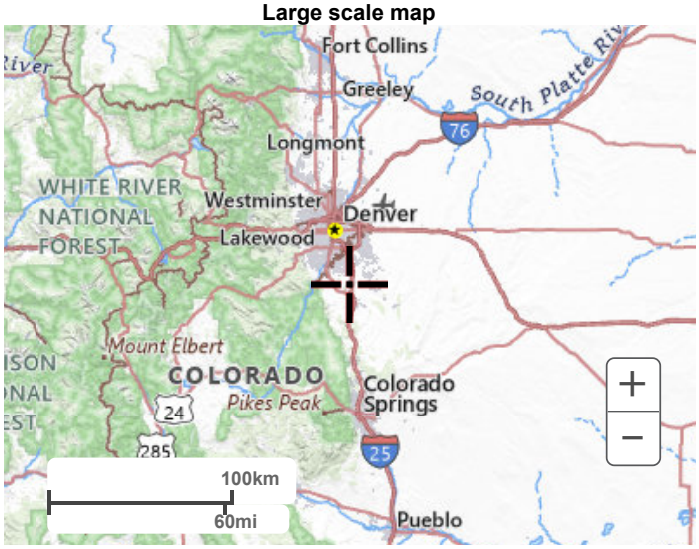
Small scale terrain



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

IDF Curve Data

5-Year Storm

i = 1 hour point rainfall = 1.12 inches

Duration	Rainfall Intensity = $(28.5 * i/(10+d)^{0.786}$
5	3.8
6	3.6
7	3.4
8	3.3
9	3.2
10	3.0

100-Year Storm

i = 1 hour point rainfall = 2.31 inches

Duration	Rainfall Intensity = $(28.5 * i/(10+d)^{0.786}$
5	7.8
6	7.4
7	7.1
8	6.8
9	6.5
10	6.2

COMPOSITE BASIN COEFFICIENTS

Subdivision Lagae Family Trust Minor Development, Lot 5
Location Castle Pines Parkway & Lagae Road

Project Name: Advance Auto Parts
Project No. 25013
Calculated By: BK
Checked By: BK
Date: 6/8/26

Total Area Basin A: 0.16 acres

Land Use	Imp.	Area	% Imp.	C_5	C_{100}
Parking Lot/Roadway	95	0.00	0	* use Table RO-5 to	
Rooftop	95	0.16	95	obtain coeffecient	
Landscape/Open Space	20	0.00	0	values.	
TOTAL		**0.16**	**95**	**0.81**	**0.87**

Total Area Basin B: 0.10 acres

Land Use	Imp.	Area	% Imp.	C_5	C_{100}
Parking Lot/Roadway	95	0.10	95	* use Table RO-5 to	
Rooftop	95	0.00	0	obtain coeffecient	
Landscape/Open Space	20	0.00	0	values.	
TOTAL		**0.10**	**95**	**0.81**	**0.87**

Total Area Basin C: 0.17 acres

Land Use	Imp.	Area	% Imp.	C_5	C_{100}
Parking Lot/Roadway	95	0.16	89	* use Table RO-5 to	
Rooftop	95	0.00	0	obtain coeffecient	
Landscape/Open Space	20	0.01	1	values.	
TOTAL		**0.17**	**91**	**0.78**	**0.86**

Note: impervious values were obtained from Table RO-3 (UDFCD Manual)

Total Area Basin D: 0.05 acres

Land Use	Imp.	Area	% Imp.	C_5	C_{100}
Parking Lot/Roadway	95	0.00	0	* use Table RO-5 to	
Rooftop	95	0.00	0	obtain coeffecient	
Landscape/Open Space	20	0.05	20	values.	
TOTAL		**0.05**	**20**	**0.20**	**0.57**

Total Area Basin E: 0.24 acres

Land Use	Imp.	Area	% Imp.	C_5	C_{100}
Parking Lot/Roadway	95	0.08	32	* use Table RO-5 to	
Rooftop	95	0.00	0	obtain coeffecient	
Landscape/Open Space	20	0.16	13	values.	
TOTAL		**0.24**	**45**	**0.40**	**0.67**

Entire Site: 0.72 acres

Land Use	Imp.	Area	% Imp.
Parking Lot/Roadway	95	0.34	45
Rooftop	95	0.16	21
Landscape/Open Space	20	0.22	6
TOTAL		**0.72**	**72**

STANDARD FORM SF-2
TIME OF CONCENTRATION

Subdivision Lagae Family Trust Minor Development, Lot 5
Location Castle Pines Parkway & Lagae Road

Project Name: Advance Auto Parts
Project No. 25013
Calculated By: BK
Checked By: BK
Date: 6/8/26

SUB-BASIN DATA			INITIAL/OVERLAND (T_i)			TRAVEL TIME (T_t)				Tc CHECK (URBANIZED BASINS)			FINAL
BASIN ID	D.A. (AC)	C_5	L (FT)	S (%)	T_i (MIN)	L (FT)	S (%)	VEL. (FPS)	T_t (MIN)	COMP. T_c (MIN)	TOTAL LENGTH(FT)	MIN. T_c (MIN)	T_c (MIN)
A	0.16	0.81	96	2.0	4.1	15	2.0	2.8	0.1	4.2	111.0	10.4	5.0
B	0.10	0.81	38	2.0	2.6	36	1.0	2.0	0.3	2.9	74.0	9.0	5.0
C	0.17	0.78	30	2.0	2.5	40	1.9	2.8	0.2	2.8	70.0	9.0	5.0
D	0.05	0.20	10	33.0	1.6	150	1.0	2.0	1.3	2.9	160.0	9.0	5.0
E	0.24	0.40	40	5.0	4.7	210	3.3	3.5	1.0	5.7	250.0	9.1	5.7

NOTES:

$T_i = (.395*(1.1 - C_5)*(L)^{0.5})/(S^{0.33})$

T_t=L/60V (Velocity From Fig. 6-4)

Tc Check = $(26-17i) + L/\{60(14i + 9)\sqrt{S}\}$

STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision Lagae Family Trust Minor Development, Lot 5
Location Castle Pines Parkway & Lagae Road
Design Storm 5 Year

Project Name: Advance Auto Parts
Project No. 25013
Calculated By: BK
Checked By:
Date: 6/8/26

		DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			
STREET	Design Point	Area Desig.	Area (Ac)	Runoff Coeff.	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (min)	COMMENTS
Building	1	A	0.16	0.81	5.0	0.13	3.8	0.5													Roof drain system to storm sewer
North portion of parking lot	2	B	0.10	0.81	5.0	0.08	3.8	0.3													Single Type 13 valley inlet in 6" sump
South portion of parking lot	3	C	0.17	0.78	5.0	0.13	3.8	0.5													Single Type 13 valley inlet in 6" sump
West edge of site	4	D	0.05	0.20	5.0	0.01	3.8	0.0													Sheetflows to adjacent detention
North, south, east edges of site	5	E	0.24	0.40	5.7	0.10	3.7	0.4													Sheetflows to surrounding roads + Existing 10' Type R inlet in sump

STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision Lagae Family Trust Minor Development, Lot 5
Location Castle Pines Parkway & Lagae Road
Design Storm 100 Year

Project Name: Advance Auto Parts
Project No. 25013
Calculated By: BK
Checked By:
Date: 6/8/26

		DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			
STREET	Design Point	Area Desig.	Area (Ac)	Runoff Coeff.	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (min)	COMMENTS
Building	1	A	0.16	0.87	5.0	0.14	7.8	1.1													Roof drain system to storm sewer
North portion of parking lot	2	B	0.10	0.87	5.0	0.09	7.8	0.7													Single Type 13 valley inlet in 6" sump
South portion of parking lot	3	C	0.17	0.86	5.0	0.15	7.8	1.1													Single Type 13 valley inlet in 6" sump
West edge of site	4	D	0.05	0.57	5.0	0.03	7.8	0.2													Sheetflows to adjacent detention
North, south and east edges of site	5	E	0.24	0.67	5.7	0.16	7.6	1.2													Sheetflows to surrounding roads + Existing 10' Type R inlet in sump

APPENDIX B

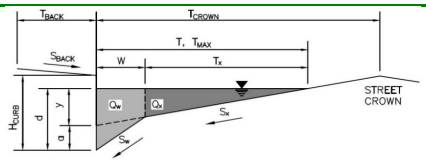
Hydraulic Computations

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

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

Project: **Advance Auto Parts - Castle Pines**

Inlet ID: **DP 2**



Gutter Geometry:

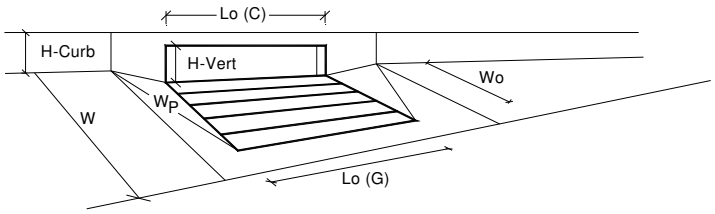
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	11.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.016	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	38.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	11.0	11.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is not applicable to Sump Condition				
MAJOR STORM Allowable Capacity is not applicable to Sump Condition	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT/Denver 13 Valley Grate)	Type =	CDOT/Denver 13 Valley Grate		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	2.00	2.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	4.2	4.2	inches
Grate Information		MINOR	MAJOR	☐ Override Depths
Length of a Unit Grate	L_o (G) =	3.00	3.00	feet
Width of a Unit Grate	W_o =	1.73	1.73	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	0.43	0.43	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	0.50	0.50	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	3.30	3.30	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	0.60	0.60	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	N/A	N/A	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	N/A	N/A	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	N/A	N/A	inches
Angle of Throat	Theta =	N/A	N/A	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	N/A	N/A	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	N/A	N/A	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	N/A	N/A	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	N/A	N/A	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	0.37	0.37	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	N/A	N/A	ft
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	0.65	0.65	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	N/A	N/A	
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	N/A	N/A	

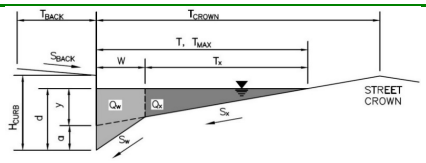
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**1.1**	**1.1**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)	$Q_{PEAK\ REQUIRED}$ =	0.3	0.7	cfs

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

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

Project: **Advance Auto Parts - Castle Pines**

Inlet ID: **DP 3**



Gutter Geometry:

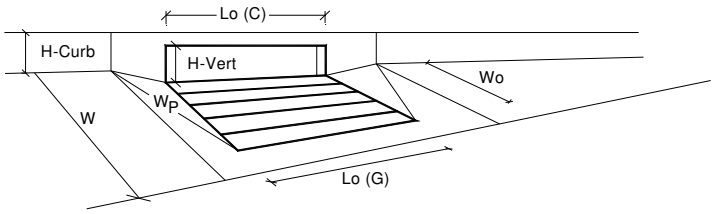
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	29.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.050	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.016	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	31.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.018	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	31.0	31.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is not applicable to Sump Condition				
MAJOR STORM Allowable Capacity is not applicable to Sump Condition	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)

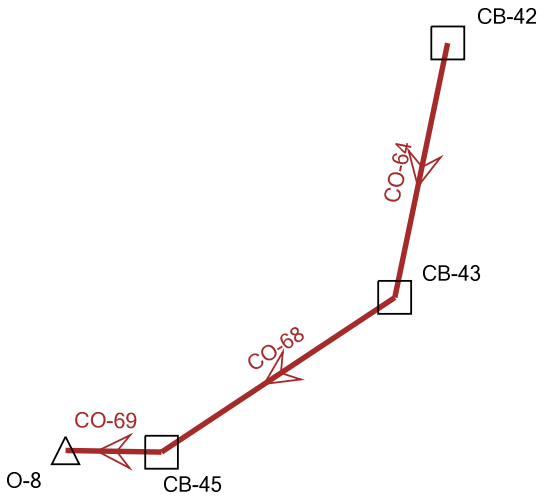


Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT/Denver 13 Valley Grate)	Type =	CDOT/Denver 13 Valley Grate		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	2.00	2.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	6.0	6.0	inches
Grate Information		MINOR	MAJOR	☐ Override Depths
Length of a Unit Grate	L_o (G) =	3.00	3.00	feet
Width of a Unit Grate	W_o =	1.73	1.73	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	0.43	0.43	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	0.50	0.50	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	3.30	3.30	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	0.60	0.60	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	N/A	N/A	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	N/A	N/A	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	N/A	N/A	inches
Angle of Throat	Theta =	N/A	N/A	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	N/A	N/A	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	N/A	N/A	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	N/A	N/A	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	N/A	N/A	

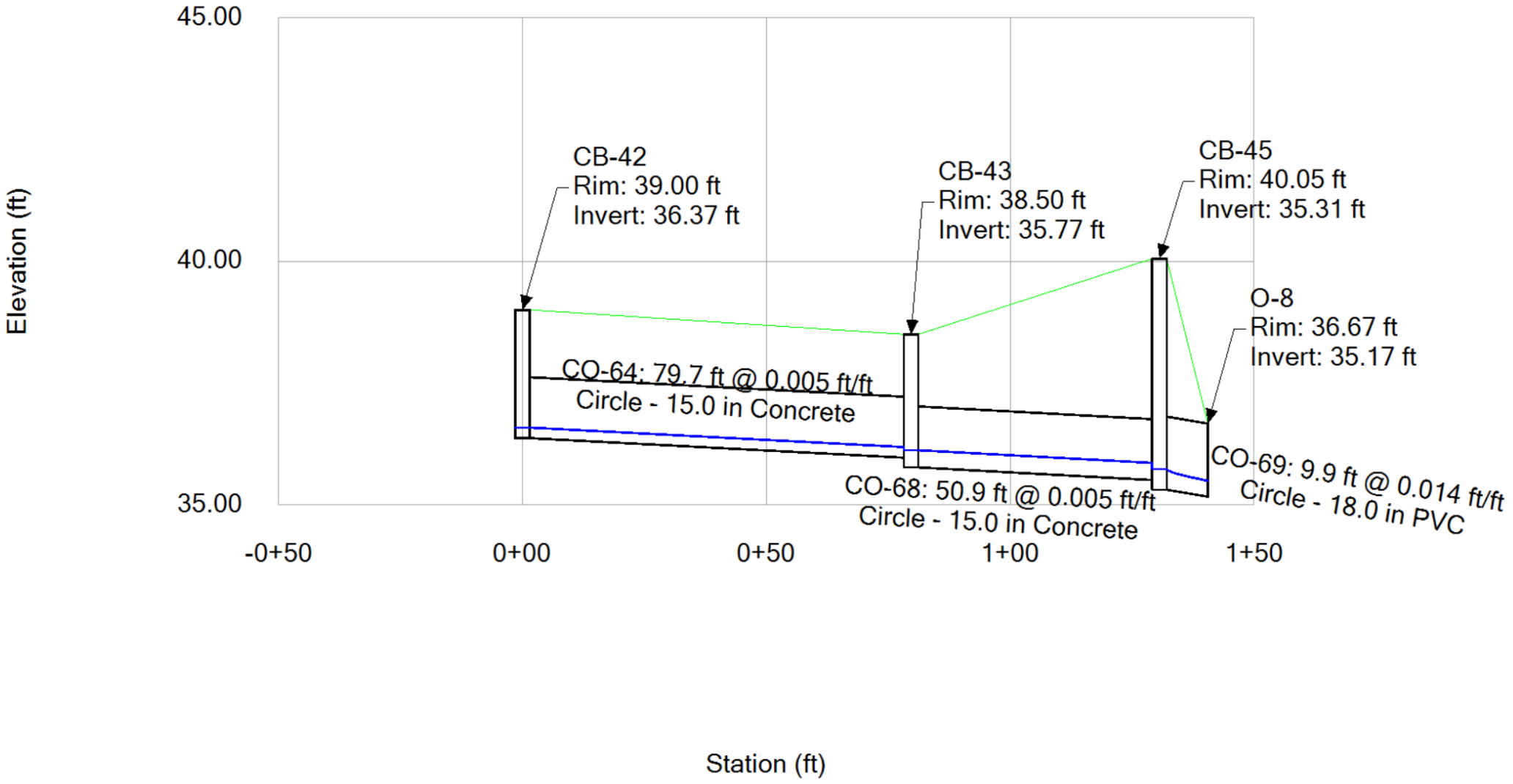
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	0.52	0.52	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	N/A	N/A	ft
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	0.94	0.94	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	N/A	N/A	
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**2.6**	**2.6**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)	$Q_{PEAK\ REQUIRED}$ =	0.5	1.1	cfs

Scenario: Base



HGL Calculations

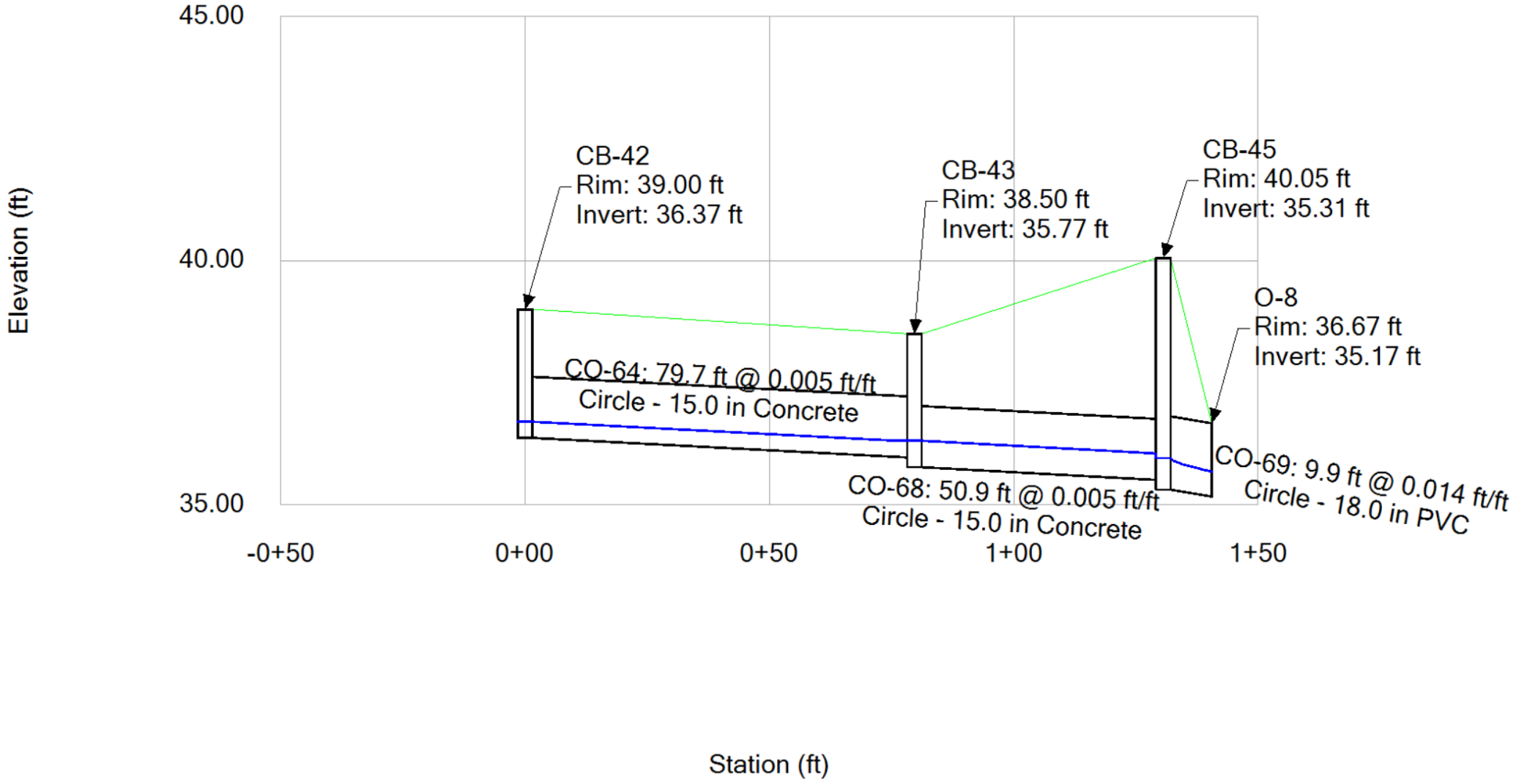

45.00
40.00
35.00
Elevation (ft)
CB-42
Rim: 39.00 ft
Invert: 36.37 ft
CB-43
Rim: 38.50 ft
Invert: 35.77 ft
CB-45
Rim: 40.05 ft
Invert: 35.31 ft
O-8
Rim: 36.67 ft
Invert: 35.17 ft
CO-64: 79.7 ft @ 0.005 ft/ft
Circle - 15.0 in Concrete
CO-68: 50.9 ft @ 0.005 ft/ft
Circle - 15.0 in Concrete
CO-69: 9.9 ft @ 0.014 ft/ft
Circle - 18.0 in PVC
-0+50
0+00
0+50
1+00
1+50
Station (ft)

5-year HGLs

Network Elements FlexTable: HGL table

Label	Flow (cfs)	Diameter (in)	Length (Unified) (ft)	Slope (Calculated) (ft/ft)	Velocity (ft/s)	Time (Pipe Flow) (hours)	Hydraulic Grade Line (In) (ft)	Elevation Ground (Start) (ft)	Hydraulic Grade Line (Out) (ft)	Elevation Ground (Stop) (ft)	Energy Grade Line (In) (ft)	Energy Grade Line (Out) (ft)
CB-42							36.59		36.59		36.66	36.66
CB-43							36.12		36.12		36.20	36.25
CB-45							35.74		35.74		35.86	35.89
O-8												
CO-64	0.30	15.0	79.7	0.005	2.11	0.011	36.59	39.00	36.18	38.50	36.66	36.26
CO-68	0.80	15.0	50.9	0.005	2.82	0.005	36.12	38.50	35.86	40.05	36.25	35.99
CO-69	1.30	18.0	9.9	0.014	5.50	0.001	35.74	40.05	35.49	36.67	35.89	35.83

5-year HGLs



100-year HGLs

Network Elements FlexTable: HGL table

Label	Flow (cfs)	Diameter (in)	Length (Unified) (ft)	Slope (Calculated) (ft/ft)	Velocity (ft/s)	Time (Pipe Flow) (hours)	Hydraulic Grade Line (In) (ft)	Elevation Ground (Start) (ft)	Hydraulic Grade Line (Out) (ft)	Elevation Ground (Stop) (ft)	Energy Grade Line (In) (ft)	Energy Grade Line (Out) (ft)
CB-42							36.70		36.70		36.81	36.81
CB-43							36.31		36.31		36.41	36.51
CB-45							35.96		35.96		36.16	36.20
O-8												
CO-64	0.70	15.0	79.7	0.005	2.70	0.008	36.70	39.00	36.31	38.50	36.81	36.41
CO-68	1.80	15.0	50.9	0.005	3.53	0.004	36.31	38.50	36.04	40.05	36.51	36.25
CO-69	2.90	18.0	9.9	0.014	6.94	0.000	35.96	40.05	35.68	36.67	36.20	36.15

APPENDIX C
Water Quality Enhancement
Best Management Practices

See Appendix D for information on the existing detention and water quality facility which serves this property.

APPENDIX D
Referenced Information

Pages from previous drainage study:

PHASE III DRAINAGE REPORT
FOR
LAGAE FAMILY TRUST
DOUGLAS COUNTY, COLORADO

Job Number: D-2038

Prepared for:
LS Partners
9801 East Easter Avenue
Centennial, Colorado 80112
(303) 346-7006

Prepared by:
RICK ENGINEERING COMPANY
9801 East Easter Avenue
Centennial, Colorado 80112
(303) 537-8020

December 16, 2019
Revised: February 13, 2020
Revised: April 13, 2020
Revised: May 13, 2020

Basin 1F is approximately 1.3 acres and includes a commercial building and associated parking lot. This basin is tributary to a proposed CDOT Type C inlet that will discharge directly to EDB-1.

Basin 1G is approximately 0.8 acres and includes a parking lot. Runoff from the basin will be routed to Extended Detention Basin - 1 (EDB-1) by a proposed Type R curb inlet.

Basin 1H and Basin 1I are approximately 0.8 acres and 0.2 acres respectively. Runoff from the property will be routed to roadside swales and routed by a Type C Inlet to the existing storm drain system.

Basin 2A is approximately 0.8 acres and will drain in a similar pattern as pre-project conditions. The existing Castle Pines Parkway pavement will maintain pre-project drainage patters. Peak flows are reduced at Design Point 2B from pre-project conditions due to a small reduction in area. Runoff from the property will be routed to roadside swales and will be directed to the existing storm drain system on Lagae Road.

Basin 2B is approximately 0.9 acres and is located on the eastern portion of the property and includes portions of Lagae Road and the east driveway of the development. This basin is tributary to the existing 5-foot curb inlet on Lagae Road.

Basin 2C is approximately 0.6 acres and is located at the northeast corner of the property. This basin is tributary to Extended Detention Basin – 2 (EDB-2) and will discharge to the existing 5’ curb inlet on Lagae Road.

Basin 2D is approximately 0.3 acres and includes EDB-2. This basin is directly tributary to the detention basin.

Basin 2E is approximately 0.3 acres and includes pervious open space. This basin is directly tributary to a Type C inlet that will direct runoff to the existing public storm drain system.

Basin 2F is approximately 0.1 acres and includes a roadside swale. Runoff from this basin will be routed to a curb cut and a cross gutter before eventually discharging to Lagae Road.

Basin 3A is approximately 0.3 acres and maintains pre-project drainage patterns. The peak flows remain the same as pre-project conditions for the 5-year event, however; there is a 0.1 cfs increase for the 100-year event due to a slight variation in basin delineation.

B. Stormwater Storage Facilities:

The project proposes two (2) detention basins, EDB-1 and EDB- 2. The detention basins are designed at 3:1 side slope and a micropool is provided at the bottom. Per Douglas County Drainage Criteria Manual, freeboard of 1 foot is provided. The emergency spillway for the proposed detention basins have been designed to convey the post-project un-detained 100-year runoff while maintaining the minimum freeboard.

In accordance with the Detention Criteria for Douglas County, the detention basins will provide detention of the Water Quality Capture Volume (WQCV), Excess Urban Runoff Volume (EURV), and the 100-Year storm event. The post-project flow rates for the 100-year storm event will be detained back to the predevelopment peak flow rates.

Detention basins were designed utilizing the UDFCD Detention Basin Design Workbook spreadsheet (MHDF-Detention Version 4.02) for all return periods to mitigate for the additional impervious area in the proposed condition. The design maximum allowable release rate for these detention basins will match the overall pre-project development flow rate for the 100-year storm, as stipulated by Douglas County Drainage Criteria Manual. Please refer to Appendix B for supporting detention calculations.

The detention basins were designed to provide detention for all of their respective tributary areas. The tributary areas for EDB-1 and 2 are 7.6 acres and 1.1 acres respectively. EDB-2 was sized to reduce peak flows prior to connecting into the existing curb inlet on Lagae Street. This basin's tributary area includes portions of Lagae Road in order to ensure peak flow reductions.

The following table presents a summary of the peak flow rates:

Detention Basin ID	Post-Project 100-Year Un-Detained Peak Flow (cfs)	Post-Project 100-Year Detained Peak Flow (cfs)	Pre-Project 100-Year Peak Flow (cfs)
1	24.6	7.2	11.3
2	2.4	1.1	1.3

Emergency overflow structure has been sized for EDB-1 and EDB-2 to convey the un-detained Q100 safely through the proposed outfall pipes without flooding or impacting the adjacent roads or pads. The un-detained Q100 will be conveyed through a conventional emergency spillway for both basins. Riprap for pipe outlets into the extended detention basin has been designed per Chapter 8 and Chapter 9 of the UDFCD's Urban Storm Drainage Criteria Manual (USDCM). Emergency overflow spillway riprap has been designed per Chapter 12 of the USDCM. Maintenance of these detention basins will be required as defined by the Standard Operating Procedure (SOP) for Extended Detention Basin (EDB) Inspection and Maintenance – Douglas County, Colorado, September 2014. This will be facilitated via the future homeowner's association and/or maintenance district that may be established.

C. Water Quality Enhancement BMPs:

Non-Structural Best Management Practices (BMPs) focus on preserving open space, protecting natural systems and incorporating existing landscape into the site plan to manage stormwater at its source. Non-structural BMPs are incorporated into the site plan by the including grassed islands within the parking facilities and parkways fronting the roadways surrounding the property. Grassy trapezoidal swales are proposed along the perimeter of the site to provide treatment for the proposed driveways. The site is also constrained by an existing electric easement that transects the property, which will remain in mostly pervious conditions. The development minimizes impervious areas where applicable and incorporates preventative maintenance measures during construction to minimize storm water contamination.

Structural BMPs are incorporated to improve water quality and runoff leaving the site. Structural BMPs include ditches and EDB with low flow channels, micropools, forebays and outlet control systems to control sediment in the stormwater and attenuate the peak flows. Two (2) EDB are proposed as part of the project.

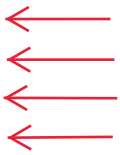
5-YR POST-PROJECT RUNOFF

$P_{5\ Year} = 1.43$ inch

DESIGNED BY: LC JOB NO. 2038

CHECKED BY: DATE: 5/13/2020

Design Point	Basin	Area	C_5	t_c	I	Q_5
		acres		min	in/hr	cfs
1A	1A	1.0	0.74	6.00	4.61	3.3
1B	1B	0.5	0.05	8.25	4.16	0.11
1C	1C	0.9	0.05	7.25	4.35	0.2
1D	1D	4.2	0.62	12.08	3.58	9.2
1E	1E	0.1	0.86	5.00	4.85	0.4
1F	1F	1.1	0.45	8.56	4.10	1.9
1G	1G	0.8	0.68	5.00	4.85	2.7
1H	1H	0.8	0.05	14.30	3.32	0.1
1I	1I	0.2	0.05	5.00	4.85	0.04
2A	2A	0.6	0.81	5.00	4.85	2.4
2B	2B	0.8	0.68	6.50	4.50	2.3
2C	2C	0.8	0.44	6.35	4.53	1.5
2D	2D	0.4	0.05	5.00	4.85	0.1
2E	2E	0.4	0.05	6.69	4.46	0.1
2F	2F	0.1	0.05	5.00	4.85	0.03
3A	3A	0.3	0.12	9.69	3.92	0.1



100-YR POST-PROJECT RUNOFF

$P_{100\ Year}$ = 2.60 inch

DESIGNED BY: LC JOB NO. 2038

CHECKED BY: DATE: 5/13/2020

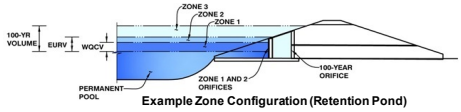
Design Point	Basin	Area	C_{100}	t_c	I	Q_{100}	
		acres		min	in/hr	cfs	
1A	1A	1.0	0.84	6.00	8.38	6.7	
1B	1B	0.5	0.49	8.25	7.56	1.8	
1C	1C	0.9	0.49	7.25	7.90	3.7	
1D	1D	4.2	0.78	12.08	6.51	21.0	
1E	1E	0.1	0.89	5.00	8.82	0.7	
1F	1F	1.1	0.69	8.56	7.46	5.5	
1G	1G	0.8	0.81	5.00	8.82	5.8	
1H	1H	0.8	0.49	14.30	6.04	2.4	
1I	1I	0.2	0.49	5.00	8.82	0.8	
2A	2A	0.6	0.87	5.00	8.82	4.7	
2B	2B	0.8	0.81	6.50	8.18	5.0	
2C	2C	0.8	0.69	6.35	8.24	4.3	
2D	2D	0.4	0.49	5.00	8.82	1.5	
2E	2E	0.4	0.49	6.69	8.11	1.4	
2F	2F	0.1	0.49	5.00	8.82	0.5	
3A	3A	0.3	0.53	9.69	7.12	1.1	

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.02 (February 2020)

Project: Lagae Family Trust

Basin ID: EDB-2



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	**EDB**	
Watershed Area =	1.10	acres
Watershed Length =	290	ft
Watershed Length to Centroid =	195	ft
Watershed Slope =	0.020	ft/ft
Watershed Imperviousness =	45.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	100.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Castle Pines - City Office	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides
Water Quality Capture Volume (WQCV) =	0.018	acre-feet	acre-feet
Excess Urban Runoff Volume (EURV) =	0.046	acre-feet	acre-feet
2-yr Runoff Volume (P1 = 0.84 in.) =	0.030	acre-feet	inches
5-yr Runoff Volume (P1 = 1.12 in.) =	0.047	acre-feet	inches
10-yr Runoff Volume (P1 = 1.36 in.) =	0.065	acre-feet	inches
25-yr Runoff Volume (P1 = 1.72 in.) =	0.101	acre-feet	inches
50-yr Runoff Volume (P1 = 2.01 in.) =	0.127	acre-feet	inches
100-yr Runoff Volume (P1 = 2.31 in.) =	0.158	acre-feet	inches
500-yr Runoff Volume (P1 = 3.07 in.) =	0.228	acre-feet	inches
Approximate 2-yr Detention Volume =	0.029	acre-feet	
Approximate 5-yr Detention Volume =	0.046	acre-feet	
Approximate 10-yr Detention Volume =	0.055	acre-feet	
Approximate 25-yr Detention Volume =	0.066	acre-feet	
Approximate 50-yr Detention Volume =	0.072	acre-feet	
Approximate 100-yr Detention Volume =	0.085	acre-feet	

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.018	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.029	acre-feet
Zone 3 Volume (User Defined - Zones 1 & 2) =	0.047	acre-feet
Total Detention Basin Volume =	0.093	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	

Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

Depth Increment = ft

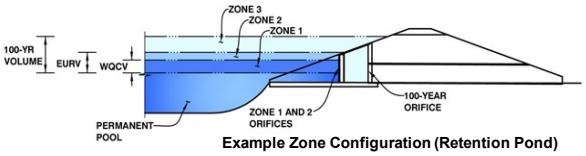
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	2,163	0.050		
	--	0.50	--	--	--	2,660	0.061	1,206	0.028
	--	1.00	--	--	--	3,173	0.073	2,664	0.061
	--	1.50	--	--	--	3,697	0.085	4,381	0.101
	--	2.00	--	--	--	4,233	0.097	6,364	0.146
	--	2.50	--	--	--	4,786	0.110	8,619	0.198
	--	3.00	--	--	--	5,343	0.123	11,151	0.256
	--	3.50	--	--	--	5,924	0.136	13,968	0.321
	--	4.00	--	--	--	6,503	0.149	17,074	0.392

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.02 (February 2020)

Project: Lagae Family Trust

Basin ID: EDB-2



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.34	0.018	Orifice Plate
Zone 2 (EURV)	0.80	0.029	Orifice Plate
Zone 3 (User)	1.42	0.047	Weir&Pipe (Circular)
Total (all zones)		0.093	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft²
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	N/A	ft²
Depth at top of Zone using Orifice Plate =	0.80	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	N/A	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	N/A	inches	Elliptical Slot Area =	N/A	ft²

Calculated Parameters for Plate

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	0.25	0.50					
Orifice Area (sq. inches)	0.42	0.50	0.50					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft²
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir (and No Outlet Pipe))

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	1.25	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	2.51	N/A	feet
Overflow Weir Front Edge Length =	4.00	N/A	feet	Overflow Weir Slope Length =	4.00	N/A	feet
Overflow Weir Grate Slope =	3.00	N/A	H:V	Grate Open Area / 100-yr Orifice Area =	6.33	N/A	
Horiz. Length of Weir Sides =	3.79	N/A	feet	Overflow Grate Open Area w/o Debris =	11.19	N/A	ft²
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area	Overflow Grate Open Area w/ Debris =	5.59	N/A	ft²
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Circular	Not Selected			Zone 3 Circular	Not Selected	
Depth to Invert of Outlet Pipe =	2.50	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	1.77	N/A	ft²
Circular Orifice Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.75	N/A	feet
				Half-Central Angle of Restrictor Plate on Pipe =	N/A	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	3.00	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.27	feet
Spillway Crest Length =	5.00	feet	Stage at Top of Freeboard =	4.27	feet
Spillway End Slopes =	3.00	H:V	Basin Area at Top of Freeboard =	0.15	acres
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	0.39	acre-ft

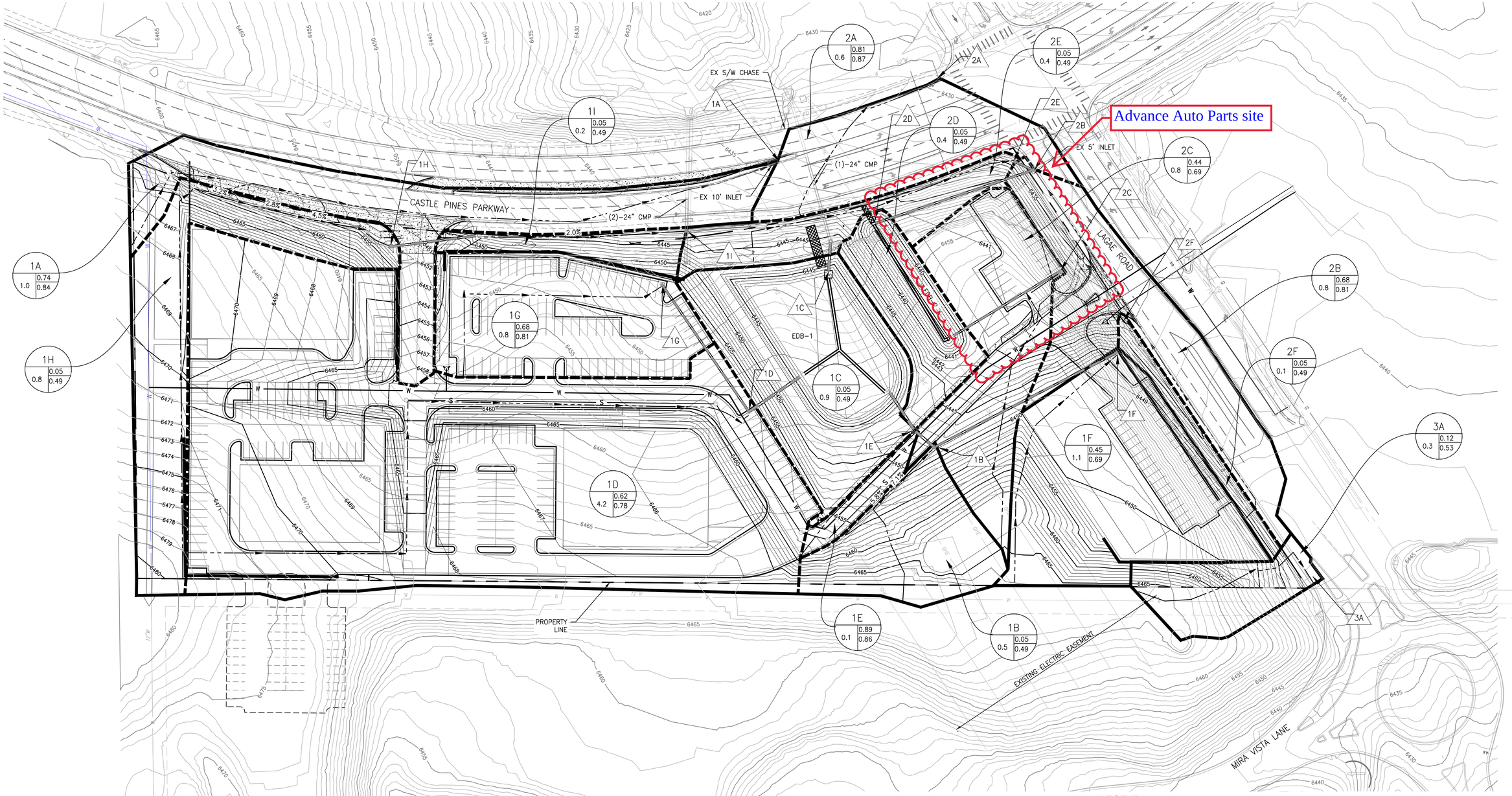
Calculated Parameters for Spillway

Routed Hydrograph Results

The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	0.84	1.12	1.36	1.72	2.01	2.31	3.07
CUHP Runoff Volume (acre-ft) =	0.018	0.046	0.030	0.047	0.065	0.101	0.127	0.158	0.228
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.030	0.047	0.065	0.101	0.127	0.158	0.228
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.0	0.1	0.3	0.7	1.0	1.3	2.0
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.01	0.11	0.28	0.67	0.91	1.20	1.83
Peak Inflow Q (cfs) =	N/A	N/A	0.4	0.7	1.0	1.6	2.0	2.4	3.5
Peak Outflow Q (cfs) =	0.0	0.0	0.0	0.0	0.0	0.2	0.6	1.1	2.2
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.3	0.1	0.3	0.6	0.8	1.1
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	0.0	0.1	0.1	0.2
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	41	51	48	52	56	58	55	53	47
Time to Drain 99% of Inflow Volume (hours) =	**46**	57	53	59	63	67	65	64	61
Maximum Ponding Depth (ft) =	0.34	0.79	0.49	0.73	0.98	1.33	1.43	1.52	1.65
Area at Maximum Ponding Depth (acres) =	0.06	0.07	0.06	0.07	0.07	0.08	0.08	0.09	0.09
Maximum Volume Stored (acre-ft) =	0.018	0.046	0.027	0.042	0.059	0.087	0.094	0.101	0.114

Rick Engineering Study Drainage Plan



LEGEND

- MAJOR BASIN BOUNDARY
- MINOR BASIN BOUNDARY
- SURFACE FLOW PATH
- PROPERTY LINE

BASIN DESIGNATION
5-YEAR RUNOFF COEFFICIENT
100-YEAR RUNOFF COEFFICIENT
BASIN AREA IN ACRES
DESIGN POINT DESIGNATION

50 25 0 50 100 150
GRAPHIC SCALE: 1"=50'

DRAINAGE STUDY MAP
LAGAE FAMILY TRUST

POST-PROJECT

DATE: 4/9/2020
REVISED: –

J– 2038 SHEET 1 OF 1

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rickengineering.com
Tucson - San Diego - Sacramento - Riverside - Orange - San Luis Obispo - Phoenix

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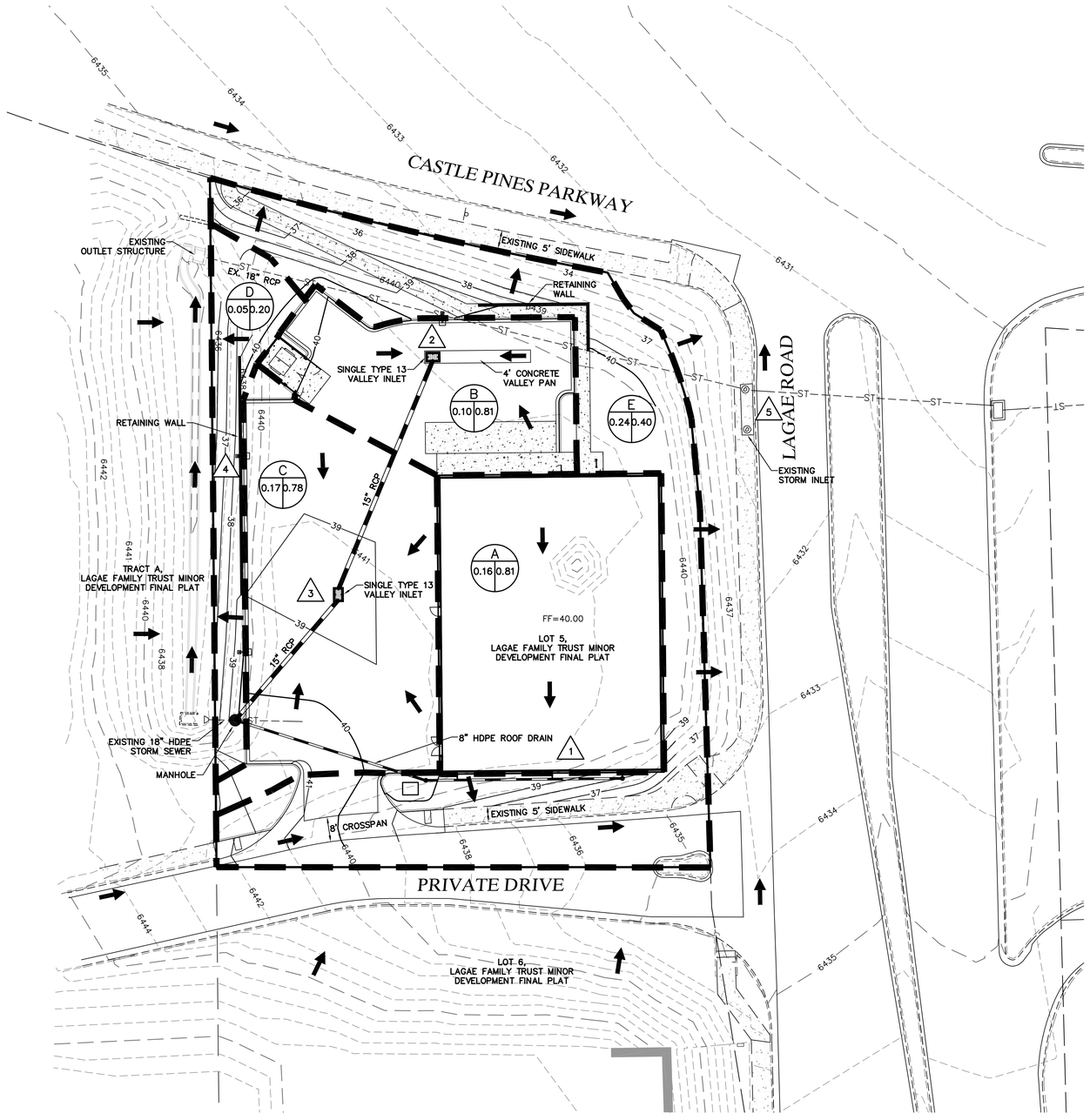
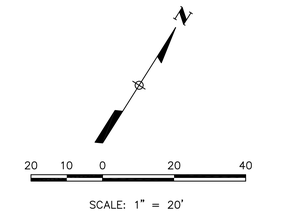
NOT FOR CONSTRUCTION – EXHIBIT FOR DRAINAGE STUDY REPORT ONLY

PHASE III DRAINAGE PLAN
LAGAE FAMILY TRUST MINOR DEVELOPMENT , LOT 5
LOCATED IN THE SW 1/4, SEC. 3, T7S, R67W, 6TH P.M.
CITY OF CASTLE PINES, COUNTY OF DOUGLAS, STATE OF COLORADO
0.71 ACRES





LEGEND

- PROPERTY LINE
- EXISTING CONTOUR (1' INTERVAL)
- PROPOSED CONTOUR
- DRAINAGE FLOW DIRECTION
- EXISTING CURB & GUTTER
- PROPOSED 1' SPILL CURB AND GUTTER
- LIMITS OF RIGHT-OF-WAY
- EXISTING EASEMENT
- SUB-BASIN BOUNDARY
- DESIGN POINT (n)
- A = BASIN DESIGNATION, B = AREA IN ACRES, C = 5 YEAR RUNOFF COEFFICIENT (A / B C)

BENCHMARK

WEST ¼ CORNER SECTION 3, FOUND 3.25" ALUMINUM CAP PLS 10734 MATCHING MONUMENT RECORD FILED 7/31/17.

RUNOFF TABLE

DRAINAGE BASIN	DESIGN POINT	CUMULATIVE CONTRIBUTING BASIN (ACRES)	Q_5 cfs	Q_{100} cfs
A	1	0.16	0.5	1.1
B	2	0.10	0.3	0.7
C	3	0.17	0.5	1.1
D	4	0.05	0.0	0.2
E	5	0.24	0.4	1.2

PHASE III DRAINAGE PLAN
ADVANCE AUTO PARTS
JOB NO. 25013
DATE: AUGUST 5, 2026
SHEET 1 OF 1

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