

CASTLE ROCK – CITY HOTEL

PHASE II DRAINAGE REPORT

MARCH 2024
REVISION 1: JULY 2024
SDP24-0014

For:
WHITE DEVELOPMENT, LLC
P.O. BOX 178
DENVER, CO 80201

Prepared By: :
Personalized Engineering Solutions, LLC
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Castle Rock – City Hotel

Phase II Drainage Report

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ENGINEER'S STATEMENT:

I hereby certify that this report and plan for the Phase II drainage design of the Castle Rock City Hotel development was prepared by me (or under my direct supervision) in accordance with the provisions of the Town of Castle Rock and Douglas County Storm Drainage and Technical Criteria Manuals for the owners thereof.

Stephen M. Douglas, P.E.

State of Colorado No. 41176

For and on behalf of Personalized Engineering Solutions, LLC

DEVELOPER'S STATEMENT:

White Development, LLC hereby certifies that the drainage facilities for the Castle Rock City Hotel development shall be constructed according to the design presented in this report. I understand that the Town of Castle Rock does not and will not assume liability for the drainage facilities designed and/or certified by my engineer and that the Town of Castle Rock reviews drainage plans pursuant to the Town of Castle Rock and Douglas County Storm Drainage and Technical Criteria Manuals; but cannot guarantee that the final drainage design review will absolve White Development, LLC and/or their successors and/or assigns of future liability for improper design. I further understand that approval of the Site Development Plan and/or the Construction Documents does not imply approval of my engineer's drainage design.

White Development, LLC

Authorized Signature

Date

For and on behalf of White Development, LLC

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Castle Rock – City Hotel

Phase II Drainage Report

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SCOPE

This report discusses the historic and proposed design for the Castle Rock City Hotel drainage improvements. The intent of this report is to present the initial design details for the drainage facilities to be proposed with this development and discuss project conformance with the Town of Castle Rock Storm Drainage Design and Technical Criteria Manual (SDDTCM).

This report covers the detailed development of the 0.35-acre hotel development known as the Castle Rock City Hotel. The report accounts for the existing conditions of the site and has been analysed with this development.

The Castle Rock City Hotel drainage design describes the proposed permanent drainage features including permeable pavers and gravel surface allowing for infiltration to a perforated PVC pipe collection system that will discharge to the existing Type 16 inlets within N. Perry St. at or less than the historic flow from the project site. Permanent stormwater control features were designed in accordance with the Mile High Flood District (MHFD) Design Manuals along with the Town of Castle Rock and Douglas County Storm Drainage and Technical Criteria Manuals.

To the maximum extent feasible, the developed impervious drainage areas have been routed via roof drain laterals to the gravel and permeable paver courtyard where the water will infiltrate and flow subsurface to the perforated PVC collection system, providing a significant measure of water quality treatment. All impervious areas not tributary to the courtyard will drain off-site either on the alley side of the building and to the alley v-pan, or to the N. Perry St. side of the building and into the existing storm sewer system via the existing and proposed curb & gutter at a rate less than or equal to the historic runoff from the site.

This study includes hydrologic analysis and inlet capacity calculations to ensure downstream capacities of the storm infrastructure have not been exceeded. This report also includes hydrologic and hydraulic calculations, tables, graphs, exhibits showing both proposed and existing drainage basins, stormwater routing and proposed storm improvements.

I. GENERAL LOCATION AND DESCRIPTION

A. Location

- The proposed Castle Rock City Hotel development is located 415 N. Perry St., Castle Rock, Douglas County, Colorado. The site is the location of the historic City Hotel, originally constructed on or around 1872. The original structure will be maintained and repurposed into the overall concept for the new hotel on the site.
- See the Vicinity Map located in Appendix A.

B. Description of Property

- The property is approximately 0.35 acres in size.
- The site includes the historic City Hotel structure, a concrete patio, and concrete parking area.
- The project site historically drains west-northwest, with the historic flows leaving the site at the northwest property corner into the alley v-pan.

- General site topography slopes from the southeast to the northwest across the site, with grades between ranging 1% and 3%.
- Site Soil Mapping Units include: Bo (100%) (Blakeland-Orsa) across the entire site.
- The type Bo soil group is assigned the Hydrologic Soil Group A.
- The development is located within Zone X, as shown on Flood Insurance Rate Map panel 08035C0188G. No mapped 100-year floodplains exist within or immediately adjacent to the site.
- Proposed uses for this site include a new construction hotel structure incorporating the existing historic hotel structure, and public use spaces including courtyard and parking areas.
- See Appendix A for Soil and FEMA FIRM maps.

II. DRAINAGE BASINS

A. Basin Description

The overall drainage concept is to route the as much of the developed impervious areas as is feasible to the three Type 16 curb inlets in N. Perry St. via roof drain laterals to the gravel and permeable paver courtyard where the water will infiltrate and flow subsurface to the perforated PVC collection system, providing a significant measure of water quality treatment. All impervious areas not tributary to the courtyard will drain off-site either on the alley side of the building and to the alley v-pan, or to the N. Perry St. side of the building and into the existing storm sewer system via the existing and proposed curb & gutter at a rate less than or equal to the historic runoff from the site.

The permeable pavers are an Oldcastle product and the installation and maintenance information for this product is included in the report appendices. A single off-site developed basin will discharge off-site at the northwest corner of the property and into the existing alley v-pan at runoff rates significantly less than the historic site discharge. The total existing site imperviousness value was found to be 98.7%. The total developed site imperviousness value will be reduced to 83.8%.

Historically, the pre-construction 0.35-ac site has an overall impervious value of 98.67% and discharges 1.42 CFS during the 5-yr storm and 2.68 CFS during the 100-yr storm. Historic discharge generally leaves the site at the northwest corner where it enters the existing alley v-pan. Post-development, the flows at the same location primarily from the 6 parking spaces and the trash enclosure on the alley side of the building will be reduced to 0.16 CFS during the 5-year storm and 0.31 CFS during the 100-yr storm.

Post development, the composite site impervious value will be reduced to 83.8% and the majority of the site runoff will be routed via roof drain laterals to the courtyard or the N. Perry St. side of the building. Runoff tributary to the courtyard will be allowed to infiltrate through the gravel material and the permeable pavers, allowing for a

measure of water quality treatment via the filtering process. Once infiltrated, the sloped subsurface will direct the treated runoff to the subsurface perforated PVC pipe system where it will be conveyed underground to the three existing Type 16 curb inlets near the northeast corner of the site, within N. Perry St. Runoff that is collected by roof drains but is not tributary to the courtyard will be directed to the N. Perry St. curb & gutter system where it will flow north directly to the three Type 16 curb inlets.

See Appendix A for the existing and proposed conditions drainage maps.

III. DRAINAGE DESIGN CRITERIA

A. Development Criteria Reference and Constraints

Criteria used in the development of this Phase II Drainage Report include:

- The Town of Castle Rock and Douglas County Storm Drainage and Technical Criteria Manuals.
- The Mile High Flood District's *Urban Storm Drainage Criteria Manual* (USDCM).

B. Hydrologic Criteria

- Peak storm runoff was determined by using the Rational Formula: $Q=CIA$.
- Runoff coefficients, C, were taken from the USDCM Table 6-5 and the rainfall intensities, I, were taken from the Douglas County Storm Drainage Design and Technical Criteria Manual, Chapter 6, Figures 6-1 and 6-2.
- The 5-year storm was analyzed as the minor event, with a 1-hour point rainfall value of 1.45 in/hr. The 100-year storm was analyzed as the major event, with a 1-hour point rainfall value of 2.62 in/hr.

IV. DRAINAGE FACILITY DESIGN

A. General Concept

- The proposed drainage patterns will follow existing drainage patterns as closely as possible and the developed project runoff will discharge either to the alley on the west side of the site, or to the storm sewer system in N. Perry St. on the east side of the site.
- Developed condition flows from within the on-site basin PR1 will be routed via roof gutters and downspout laterals to the courtyard and the N. Perry St. curb & gutter system. As much as feasible, the runoff from PR1 will be routed to the courtyard where the water will be allowed to infiltrate through the gravel and permeable paver media, providing a significant measure of water quality treatment prior to being discharged off-site within the N. Perry St. storm sewer system. Flows developed from basin OS1 will be routed off-site undetained at the northwest corner of the site via the existing alley v-pan.
- Untreated Runoff: Due to site constraints and grading feasibility, basin OS1 will not be able to be routed to the courtyard. The total area of this untreated basin is

0.04-ac with a 100% impervious value. The untreated discharge from basin OS1 during the 5-year storm will be 0.16 CFS post-construction (vs. 1.42 CFS pre-construction), and 0.31 CFS post-construction (vs. 2.68 CFS pre-construction) during the 100-year storm. Please see appendix B for Rational exhibits of off-site flows/volumes.

B. Specific Details

- **Basin OS1** lies on the west/northwest side of the site adjacent to the existing alley. The basin is comprised of 6 surface parking spaces, an electrical and generator enclosure, and a two separate trash enclosures. Basin OS1 has an area of 0.04 acres with a 100% impervious value. Flows from this basin will not be routed to the courtyard for treatment and will follow the existing condition drainage patterns to the existing alley v-pan. Off-site flows from basin OS1 are significantly reduced from the pre-construction conditions and are considered to be negligible.
- **Basin PR1** consists of the majority of the site and includes the hotel structure, courtyard area, and the concrete flatwork along the entire frontage of N. Perry St. Basin PR1 has an area of 0.35 acres with a 81.98% impervious value. A majority of the flows from this basin will be routed via roof drain laterals to the gravel and permeable paver courtyard area and allowed to infiltrate through the filter media prior to being collected by the subsurface perforated PVC pipe system and routed to the curb inlets within N. Perry St. A small portion of flows from basin PR1 that are not able to be routed to the courtyard will discharge directly to the N. Perry St. curb & gutter system and transported north to the curb inlets within N. Perry St. Please see Appendix B for the permeable paver specifications, and installation details.

V. CONCLUSIONS

A. Compliance with Standards

- This report is in general accordance with the Town of Castle Rock Storm Drainage Design and Technical Criteria Manual (SDDTCM).
- This report is in general accordance, where applicable and not superseded by other criteria, to the USDCM.
- This report is in general accordance with FEMA, there is no known existing floodplain within the site boundary.

B. Drainage Concept

- Runoff from the proposed basin PR1 will be routed via roof gutters and downspout laterals to the courtyard and the N. Perry St. curb & gutter system.
- Runoff from basin OS1 will be conveyed via general sheet flow undetained and off-site into the existing alley v-pan.

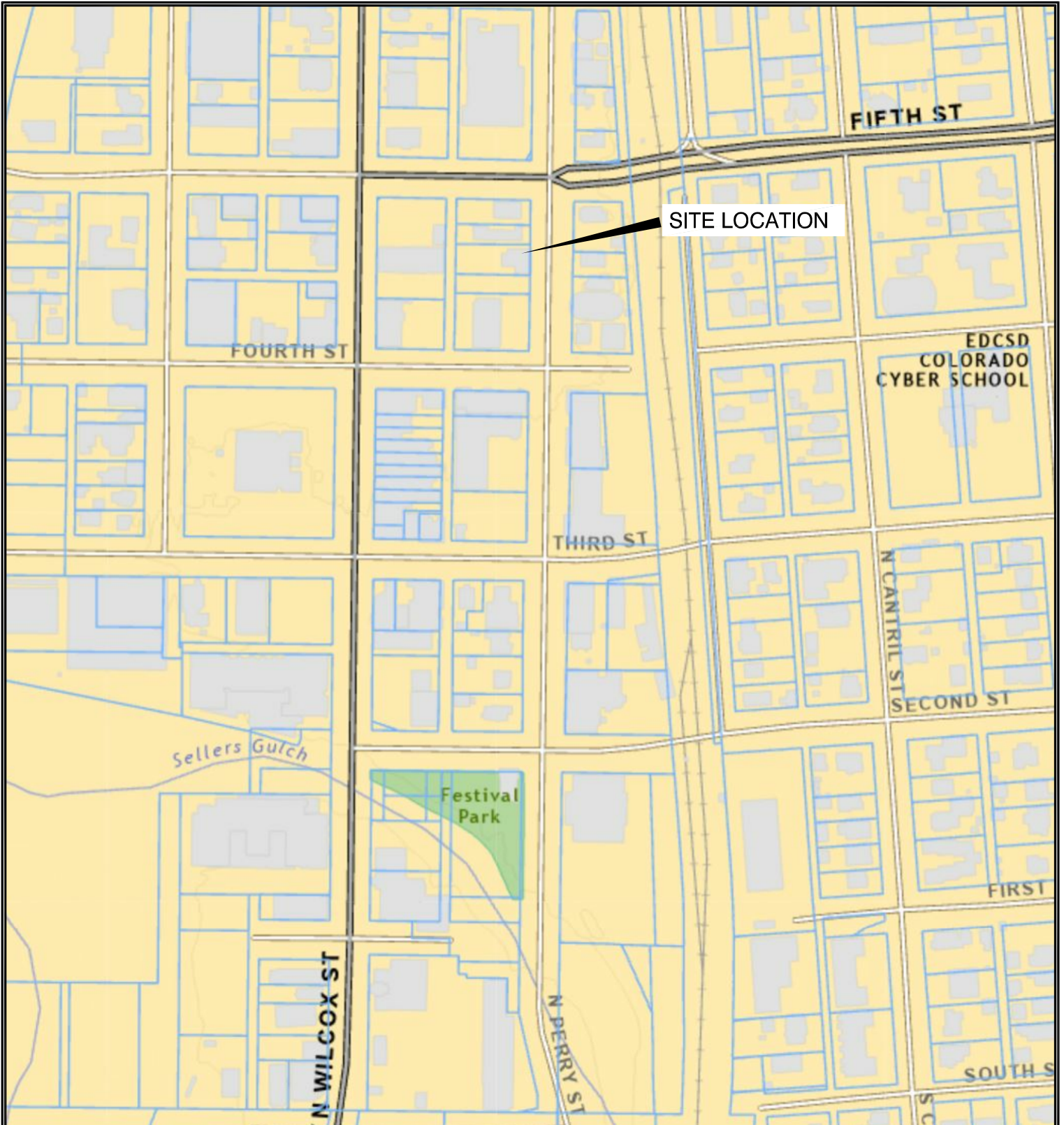
- Untreated off-site flows will be significantly less than the historic discharge from the site and are considered to be negligible.
- There are no anticipated negative impacts to downstream flows, channel depths, velocities, and erosion rates.

VI. LIST OF REFERENCES

1. *Town of Castle Rock Storm Drainage Design and Technical Criteria Manual (SDDTCM), Amended June, 2019.*
2. *Urban Storm Drainage Criteria Manual (Now Mile High Flood District), Volumes 1, 2 & 3, Urban Drainage Flood Control District, Revised 2008.*

APPENDIX A

MAPS AND EXHIBITS



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 Const. Management Civil Engineering Land Planning

CASTLE ROCK CITY HOTEL VICINITY MAP

Sheet

01

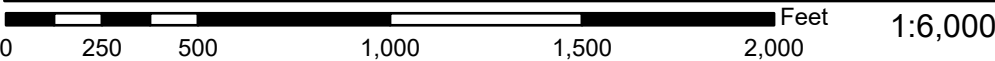
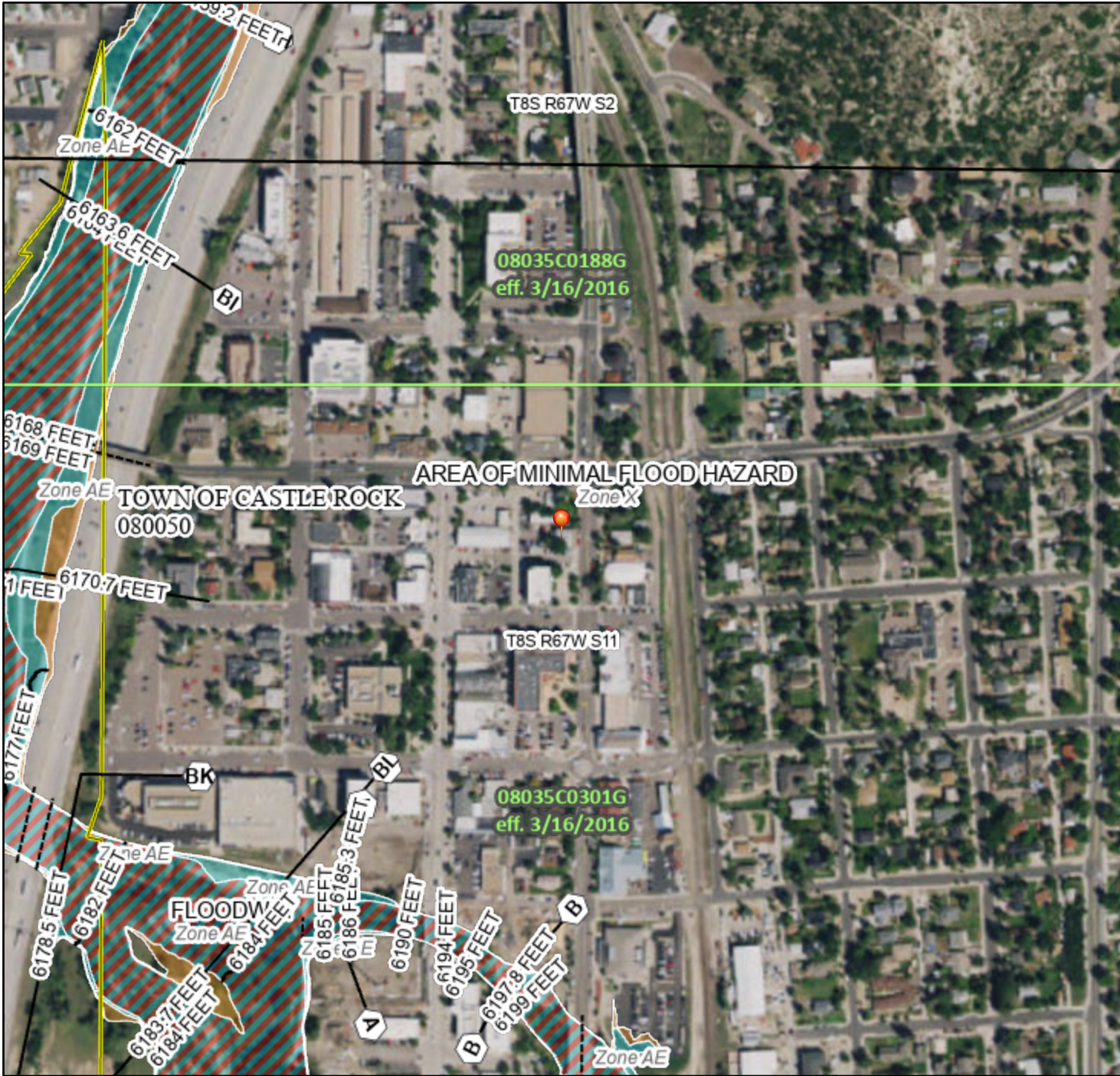
Scale N.T.S.

Date MARCH 2024

National Flood Hazard Layer FIRMMette



104°51'51"W 39°22'40"N



104°51'13"W 39°22'12"N

Basemap Imagery Source: USGS National Map 2023

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
GENERAL STRUCTURES		Area of Undetermined Flood Hazard Zone D
		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
MAP PANELS		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
		Digital Data Available
		No Digital Data Available
		Unmapped



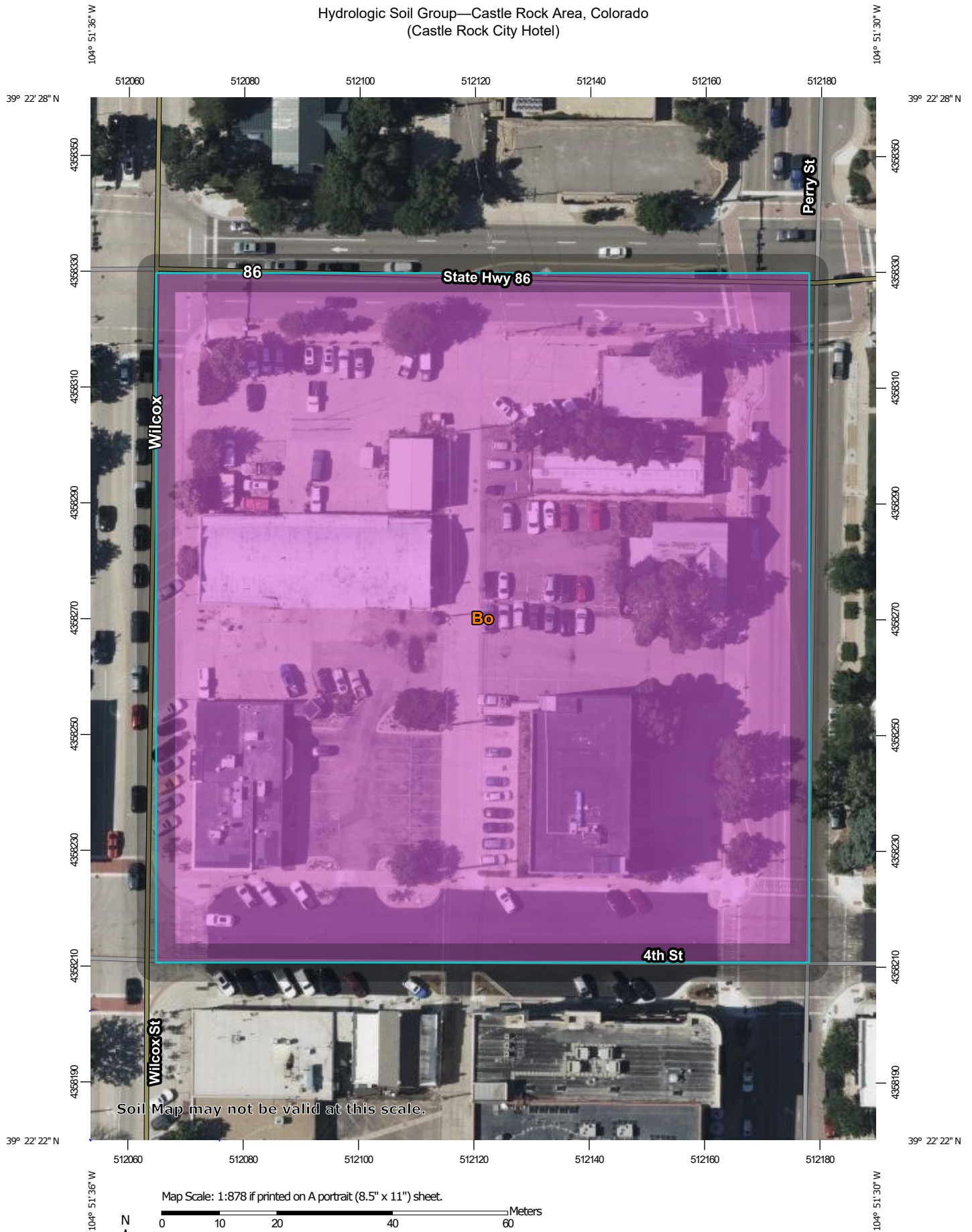
The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

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 3/14/2024 at 1:18 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.

Hydrologic Soil Group—Castle Rock Area, Colorado (Castle Rock City Hotel)



Hydrologic Soil Group—Castle Rock Area, Colorado (Castle Rock City Hotel)

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: Castle Rock Area, Colorado
 Survey Area Data: Version 16, Aug 24, 2023

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

Date(s) aerial images were photographed: Mar 1, 2023—Sep 1, 2023

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.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Bo	Blakeland-Orsa association, 1 to 4 percent slopes	A	3.3	100.0%
Totals for Area of Interest			3.3	100.0%

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

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

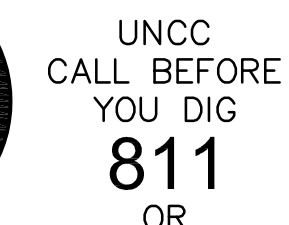
The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Component Percent Cutoff: None Specified

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.



Utility Notification
Center of Colorado



1. WHERE CONSTRUCTION DETAILS AND SPECIFICATIONS ARE NOTED ON THESE PLANS USE TOWN OF CASTLE ROCK STANDARD SPECIFICATIONS FOR DESIGN AND CONSTRUCTION.
2. ALL DIMENSIONS ARE TO FLOWLINE, EXCEPT PROFILES, WHICH ARE CENTERLINE DIMENSIONS, OR UNLESS OTHERWISE NOTED.
3. SEE SURVEY DOCUMENTS FOR BENCHMARK AND BASIS OF BEARINGS.
4. IT IS THE CONTRACTORS RESPONSIBILITY TO LOCATE AND ILLUSTRATE TOPSOIL, STOCKPILES, STAGING AREAS, EQUIPMENT STORAGE, REFUELING/MAINTENANCE AREAS, AND DISPOSAL.
5. CONTRACTOR SHALL CLEAN ALL INLETS AND STORM PIPES ON AND ADJACENT TO THE SITE AT FINAL CLEAN-UP AS NEEDED.

- - - - - 9030 - - - - - EXISTING MAJOR CONTOUR
 - - - - - 9029 - - - - - EXISTING MINOR CONTOUR
 = = = = = 5300 = = = = = PROPOSED MAJOR CONTOUR
 - - - - - 5300 - - - - - PROPOSED MINOR CONTOUR

DESIGN POINT

PROPOSED BASIN LABEL

AREA (AC.) 0.35

PR1	
.67	BASIN DESIGNATION
.75	5-YR RUNOFF COEF.
	100-YR RUNOFF COEF.



Sheet	2
DR2	of
	2
Date	MARCH 2024

APPENDIX B

HYDROLOGIC CALCULATIONS

EXISTING RATIONAL CALCULATIONS

PROPOSED RATIONAL CALCULATIONS

COMPOSITE 'C' FACTORS																																	
LOCATION: CR-CITY HOTEL						CITY OF: Town of Castle Rock / Douglas County																				DATE :				4/3/2023			
BASIN	AREAS (ACRES)					SOIL TYPE	ROOFS					PAVED					LAWNS					GRAVEL					COMP. C FACTOR						
DESIGNATION	ROOFS	PAVED	LAWNS	GRAVEL	TOTAL		%I	2YR	5 YR	10 YR	100 YR	%I	2YR	5 YR	10 YR	100 YR	%I	2YR	5 YR	10 YR	100 YR	%I	2YR	5 YR	10 YR	100 YR	%I	2YR	5 YR	10 YR	100 YR		
EXISTING																																	
EX1	0.05	0.30	0.00	0.00	0.35	A	90	0.73	0.75	0.77	0.81	100	0.84	0.86	0.87	0.89	2	0.01	0.01	0.01	0.13	40	0.25	0.27	0.28	0.42	98.67	0.83	0.85	0.86	0.88		
DEVELOPED																																	
PR1	0.243	0.041	0.000	0.064	0.35	A	90	0.73	0.75	0.77	0.81	100	0.84	0.86	0.87	0.89	2	0.01	0.01	0.01	0.13	40	0.25	0.27	0.28	0.42	81.98	0.65	0.67	0.69	0.75		
OS1	0.000	0.039	0.000	0.000	0.04	A	90	0.73	0.75	0.77	0.81	100	0.84	0.86	0.87	0.89	2	0.01	0.01	0.01	0.13	40	0.25	0.27	0.28	0.42	100.00	0.84	0.86	0.87	0.89		
																						PROPOSED CONDITIONS COMPOSITE % IMPERVIOUS:					83.8%						
																						EXISTING CONDITIONS COMPOSITE % IMPERVIOUS:					98.7%						

DESCRIPTION
ULTIMATE OR INITIAL
DESIGNER
CITY OR COUNTY
Checked By

CR-CITY HOTEL
Initial vs. Ultimate
SMD
Town of Castle Rock / Douglas County

1 HOUR DESIGN POINT RAINFALL VALUES

2 YR	1.06
5 YR	1.43
10YR	1.66
50 YR	2.26
100 YR	2.60

Reference: Town of Castle Rock Table 6-1
1-Hour Point Rainfall Values

TIME OF CONCENTRATION															REMARKS	
LOCATION: CR-CITY HOTEL					Initial vs. Ultimate					BY: SN					DATE: 4/3/2023	
BASIN DATA			INIT./OVERLAND TIME (Ti)			TRAVEL TIME (Tt)					TOTAL	Tc Check			FINAL Tc	FORMULAS: * $Ti = 0.395 (1.1-C5)L^{0.5}/S^{1/3}$ ** $V=Cv(Sw^{1/2})$ where Cv=15 for grassed waterways and 20 for paved areas
DESIGNATION	C5	AREA (AC)	LENGTH (FT)	SLOPE %	Ti (Min.)*	GRASS/PAVED	LENGTH (FT)	SLOPE %	VEL. (FPS)**	Tt(Min.)	Ti+Tt(Min.)	LENGTH (FT)	Urbanized Basins $Tc = (L/180) + 10$		(minutes)	
EXISTING																
EX1	0.84	0.35	100	2.0	3.8	PAVED	150	2.0	2.8	0.9	4.7	250.00	11.4		5	
DEVELOPED																
PR1	0.70	0.35	100	1.0	7.3	PAVED	300	2.0	2.8	1.8	9.0	400.00	12.2		10	
OS1	0.85	0.04	18	1.0	1.9	PAVED	0	2.0	2.8	0.0	1.9	17.50	10.1		5	

STORM DRAINAGE SYSTEM DESIGN**(RATIONAL METHOD PROCEDURE)****DESIGN STORM: 5-YEAR DEVELOPED**Calc. by: **SN**Chk'd by: **SMD**LOCATION: **CR-CITY HOTEL**

Date:

		DIRECT RUNOFF							TRAVEL TIME				
STRUCTURE	DESIGN POINT	BASIN	AREA (AC)	COEFF. (C)	Tc (Min.)	C*A	I (in./ hr.)	Q (cfs)	LENGTH (FT)	VEL. (FPS)	TRAVEL TIME Tt	SUM CxA	I (in./ hr.)
		EXISTING											
-	1	EX1	0.35	0.85	5	0.29	4.85	1.42	-	-	-	-	-
		DEVELOPED											
-	1	PR1	0.35	0.67	10	0.23	3.87	0.91	-	-	-	-	-
	2	OS1	0.04	0.84	5	0.03	4.85	0.16	-	-	-	-	-

STORM DRAINAGE SYSTEM DESIGN**(RATIONAL METHOD PROCEDURE)****DESIGN STORM: 100-YEAR DEVELOPED**Calc. by: **SN**Chk'd by: **SMD**LOCATION: **CR-CITY HOTEL**

Date:

		DIRECT RUNOFF							TRAVEL TIME				
STRUCTURE	DESIGN POINT	BASIN	AREA (AC)	COEFF. (C)	Tc (Min.)	C*A	I (in./ hr.)	Q (cfs)	LENGTH (FT)	VEL. (FPS)	TRAVEL TIME Tt	SUM CxA	I (in./ hr.)
		EXISTING											
-	1	EX1	0.35	0.88	5	0.30	8.82	2.68	-	-	-	-	-
		DEVELOPED											
-	1	PR1	0.35	0.74	10	0.26	7.03	1.83	-	-	-	-	-
	2	OS1	0.04	0.87	5	0.03	8.82	0.31	-	-	-	-	-

APPENDIX C

HYDRAULIC CALCULATIONS

PERMEABLE PAVER INFORMATION

AQUALINE™

PERMEABLE PAVER

LOW MAINTENANCE AND PROVEN DURABILITY
IN A CONTEMPORARY 3-PIECE SYSTEM



AQUALINE™

PERMEABLE PAVER

LOW MAINTENANCE AND PROVEN
DURABILITY IN A CONTEMPORARY
3-PIECE SYSTEM

✓ FEATURES & BENEFITS

- Interlocking spacer bars for increased structural performance
- Smooth surface with a micro-chamfer to minimize vibration and enhance wheelchair comfort
- Can be utilized to construct an ADA-compliant pavement
- True installed dimensions for design optimization
- Optimal joint openings for infiltration and maintenance
- Can eliminate stormwater runoff and improve water quality
- Meets the requirements of ASTM C936
- Chamfer Width: 3 mm
- Spacer Bar Width: 10 mm
- Surface Infiltration Rate: > 500 inches per hour (varies based on joint infill gradation)
- Surface Open Area: 12%
- Can be installed mechanically

🔹 AVAILABLE COLORS



TOSCANA



VICTORIAN

🧱 SHAPES & SIZES

80MM



4½ x 9 x 3⅜

*NOTE: Sold in herringbone machine lay pattern.
Multiple half pieces on every layer.*

BELGARD® | PAVES
THE WAY

For more info, visit Belgard.com

AMCOR
333 S. Redwood Road
North Salt Lake, UT 84054
Ph: 1-800-800-4004

1820 E / CO-402,
Loveland, CO 80537
Ph: 970-669-0535



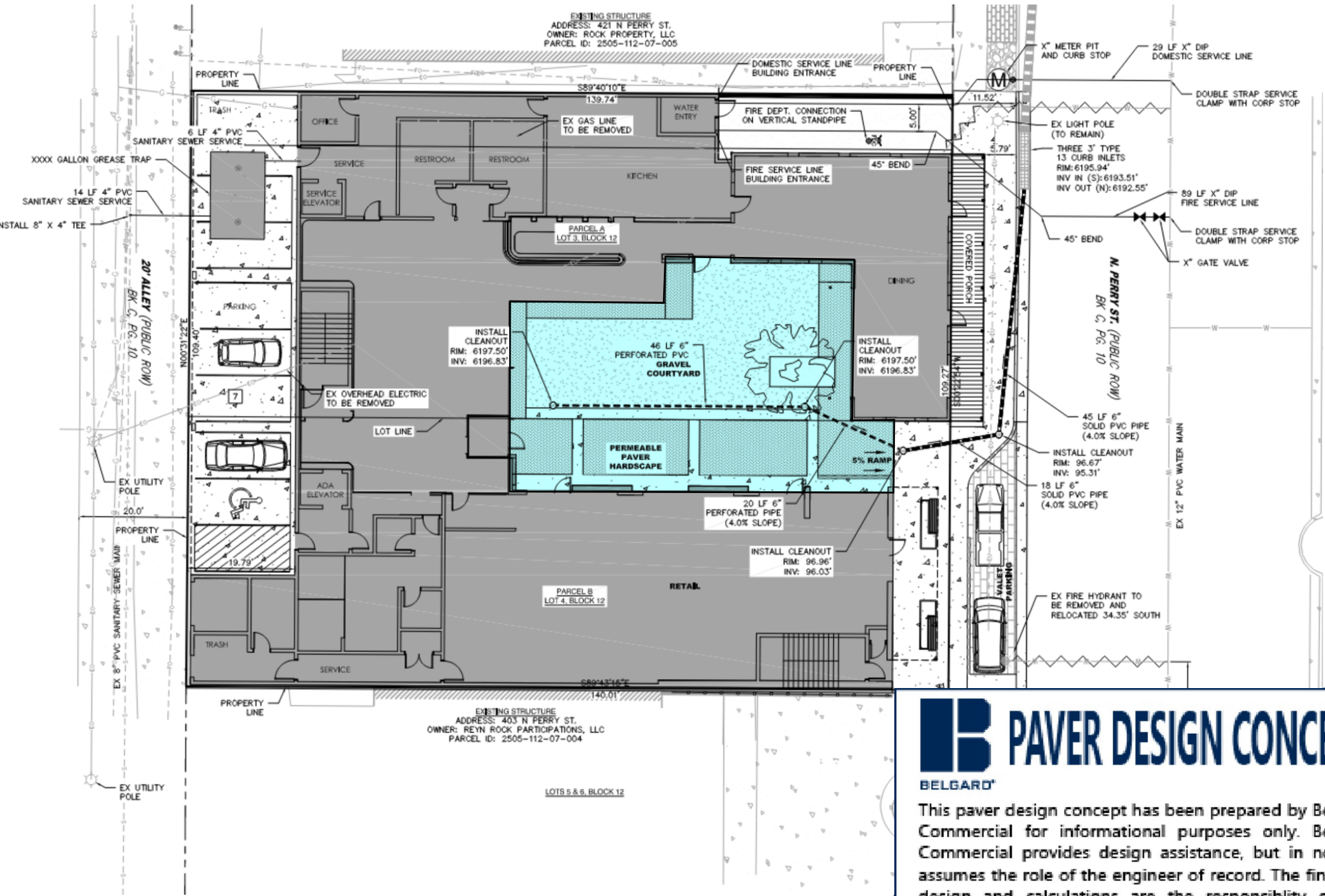
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Revised: 01/04/23 BEL22-412_Amcor

BELGARD PAVER DESIGN SERVICES

Castle Rock City Hotel Courtyard

Belgard Stormwater Concept

March 7, 2024



Belgard Product:

Aqualine™
4.5" x 9" x 3 1/8"
(80 mm)

SHEET INDEX

C0.0	COVER
C0.1-0.2	GENERAL NOTES
C1.0	PICP SITE PLAN
C1.1	PICP SECTION
C2.0	PICP DETAILS
C3.0-3.1	PICP O & M NOTES



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Engineer of Record: Personalized Engineering Solutions

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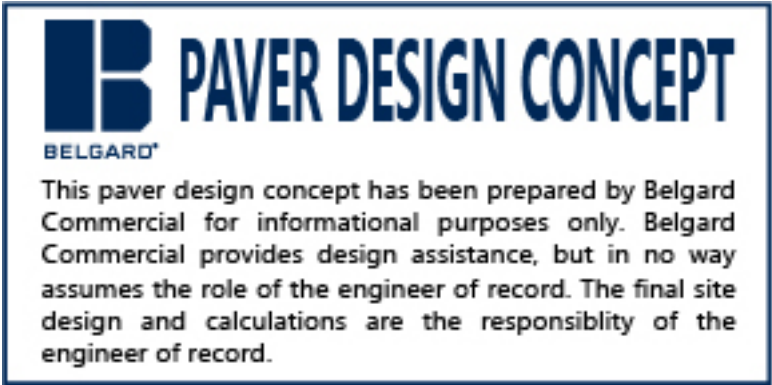


QUALITY ASSURANCE

- A. Contractor Qualifications:
- Contractor shall submit a list of five (5) previously constructed projects of similar size and magnitude prior to the bid date to be qualified. Contact names, telephone numbers, and date of completion shall be listed for each project.
 - The Contractor's site foreman shall hold a PICP Specialist Designation from the Interlocking Concrete Pavement Institute (ICPI). The site foreman shall be onsite for the entire installation.
 - Contractor shall conform to all local, state/provincial licensing and bonding requirements.
- B. Mockups: Build mockups to verify selections made under submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
- Install a 10 ft x 10 ft paver area following the installation practices described in Article 3.2 to 3.4. This area shall be used to verify joint sizes; lines; laying pattern(s); stitching details (for mechanical installation); color(s); and, texture of the job.
 - To provide a proper representation of color blend, blending during installation of sample mock-up will be pulled from a minimum of 3 cubes.
 - This area shall be the standard from which the work will be judged.
 - Subject to approval by the Owner, the mock-up may be retained as part of the finished work. If mock-up is not retained, remove and dispose of mock-up at the completion of the project.

PRODUCTS

- A. Permeable Interlocking Concrete Pavers Basis-of-Design:
- Paver Name: Aqualine™ 4.5" x 9"
 - Thickness: 3-1/8 inches (80 mm)
 - Color: TBD
 - Finish: Standard (Smooth)
 - Supplier: Oldcastle APG - Amcor
 - Contact Person: David Martin 720.591.9236
 - Substitutions: No substitutions permitted.
- B. Pavers shall meet the minimum material and physical properties set forth in ASTM C 936, Standard Specification for Interlocking Concrete Paving Units.
- Measured length or width of test specimens shall not differ by more than +/- 0.063 in, while measured thickness shall not differ by more than +/- 0.125 in.
 - Average compressive strength of 8,000 psi (55 MPa) with no individual unit under 7,200 psi (50 MPa) when tested in accordance with ASTM C140.
 - Average absorption of 5% or less with no unit greater than 7% when tested in accordance with ASTM C140.
 - Freeze-thaw durable as tested in accordance with ASTM C1645. The average mass loss of all specimens tested shall not be greater than (A) 225 g/m2 when subject to 28 freeze-thaw cycles, or (b) 500 g/m2 when subject to 49 freeze-thaw cycles. Testing shall be conducted using a 3% saline solution.
 - Efflorescence shall not be a cause for rejection.
 - Pigment in Concrete Pavers shall conform to ASTM C979.



PREPARATION

- A. Prior to commencement of any work, the Contractor shall conduct a pre-construction meeting with the Owner, Designer, and affected sub-trades. The pre-construction meeting should establish contractor responsibilities and at a minimum verify:
- The location of the mock-up, and whether it will be part of the final construction or need to be removed.
 - The site layout is in general conformance to the construction documents. In particular, the location and elevation of discharge points (if any) of the pipe underdrains.
 - The subgrade lines and elevations are in general conformance with the construction documents. The subgrade elevations shall be within +/- 0.1 ft of the specified grades.
 - The minimum slope of subgrade shall be at least 0.5% or as specified in the design.
 - Subgrade soil conditions and grades meet the requirements in the construction documents.

- The details of the site's erosion and sediment control plan.

- B. Proof-roll prepared subgrade according to requirements in Section 31 20 00 Earth Moving to identify soft pockets and areas of excess yielding. Proceed with subbase installation only after deficient subgrades have been corrected. Scarify subgrade surface following any stabilization efforts before installing subbase course.
- C. If compaction is required in the construction documents, Contractor shall verify compaction of the subgrade is in general conformance with the construction documents prior to placing subbase materials.
- D. Once the Contractor has confirmed the subgrade conditions are in general conformance with the requirements in the construction documents, the Contractor shall begin installing the subbase material. By initiating installation of the subbase material, the Contractor acknowledges acceptance of the subgrade.

AGGREGATE MATERIALS

- A. General Requirements:
- Clean, non-plastic aggregate, free from deleterious or foreign matter, manufactured from crushed rock. Recycled aggregates shall not be used.
 - Percent of angular and sub-angular particles greater than 90%. Rounded river gravel shall not be used.
 - LA Abrasion of the aggregate used shall be less than 40 as per ASTM C131.
 - All aggregates shall be washed and have less than 2% passing the No. 200 (0.075 mm) sieve.
 - All aggregate material gradations shall be tested in accordance with ASTM C136.
- B. Bedding course/joint fill material - open-graded aggregate conforming to ASTM C33 No. 8, 89, or 9.
- C. Base course material - open-graded aggregate conforming to ASTM C33 No. 57.
- D. Subbase material - open-graded aggregate conforming to ASTM C33 No. 2, 3, or 34.

INSTALLATION OF SUBBASE AND BASE COURSES

- A. Keep the area where the pavement is to be constructed free from sediment during the entire job. Any materials contaminated with sediment shall be removed and replaced with clean material.
- B. Install the subbase course and base course at the thicknesses, compaction rates, surface tolerances, and elevations outlined below.
- Place and spread the first layer of subbase without displacing or damaging the geosynthetics (if used). To prevent damage, tracked vehicles shall not be allowed directly on the geotextiles or geomembranes during the initial spreading process of the subbase layer.
 - The aggregate should be spread and compacted in uniform layers not exceeding 6-inch loose thickness. Compaction is performed using either a 10 T (10 ton) vibratory roller or a minimum 13,500 lb-f centrifugal force reversible vibratory plate compactor. For each lift, make at least two passes in the vibratory mode and at least two passes in the static mode and continue compaction until there is no visible movement in the materials.
 - At the specified elevation(s), install the pipe underdrains in accordance with the manufacturer's recommendations. Ensure the pipes are sloped to provide proper drainage to the outlets. Pipes shall be surrounded by a minimum of 4 inches of base course material to prevent damage during compaction. Care must be taken not to damage pipe underdrains during subsequent aggregate installation.
 - Final subbase surface tolerance shall be plus or minus 0.1 ft over a 10-foot straight edge laid in any direction.
 - Final base surface tolerance shall be plus or minus 3/4 inch over a 10-foot straight edge laid in any direction.
 - Provide proper compaction near curbs, grade beams, concrete collars around utility structures, lights standards, tree wells, building edges and other protrusions as applicable to the project.

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INSTALLATION OF BEDDING COURSE, PAVERS, & JOINT MATERIAL

- A. Spread the bedding course evenly over the base course and screed to a nominal 2 in. thickness utilizing an approved mechanical spreader or by screed rails and boards. Do not use the bedding material to fill depressions in the base course surface. Surface tolerances shall be +/- 3/8 inch over a 10-foot straight edge.
- B. Ensure that concrete pavers are free of foreign material before installation. Concrete pavers shall be inspected for color distribution and all chipped, damaged, or discolored concrete pavers shall be replaced. Initiation of concrete paver placement shall be deemed to represent acceptance of the pavers.
- C. Lay the concrete pavers in the pattern(s) shown on the drawings. Maintain straight pattern lines. For mechanical installations, follow the stitching details as submitted and verified during the mock-up.
- D. Paving units shall be installed simultaneously from a minimum of 3 bundles for hand installations, and 6 bundles for mechanical installations to provide proper color blending.
- E. Joints between the individual concrete pavers shall be uniformly maintained and installed in accordance with the in-place dimensions
- F. Fill gaps at the edges of the paved area with cut pavers or edge units. Do not install cut pavers smaller than one-third of a whole paver along edges subject to vehicular traffic - trim two pavers to fit.
- G. Cut pavers using a masonry saw or splitting device. Upon completion of cutting, the area must be swept clean of all debris.
- H. Using a low amplitude plate compactor capable of at least 5,000 lbs. (22 kN) compaction at a frequency of 75 Hz -100 Hz, compact and seat the concrete pavers into the bedding course.
- I. The pavers shall be compacted to achieve consolidation of the bedding course and brought to level and profile by not less than three passes. Initial compaction should proceed as closely as possible following the installation of the paving units and prior to the acceptance of any traffic.
- J. Any units that are structurally damaged during compaction shall be immediately removed and replaced.
- K. Apply the joint material to the surface and sweep into the joints and voids. Fill joints and voids then sweep off excess material before vibrating the material down into the joints using a plate compactor. This will typically require two to three passes with the plate compactor.
- L. Do not compact within 6 feet of unrestrained edges of the paving units.
- M. All work to within 6 feet (1 m) of the laying face must be left fully compacted at the end of each day.
- N. Sweep off excess aggregate when the job is complete.

AS-BUILT CONSTRUCTION TOLERANCES

- A. Final inspection shall be conducted to verify conformance to the drawings after removal of excess aggregate. All pavements shall be finished to lines and levels to ensure positive drainage at all drainage outlets and channels.
- B. The final surface elevations shall not deviate more than +/- 3/8 inch under a 10 ft long straight edge.
- C. Lippage shall be no greater than 1/8-inch difference in height between adjacent pavers.
- D. Surface elevation of pavers shall be 1/8-inch to 1/4-inch above adjacent rigid surfaces, including drainage inlets, concrete collars or gutters, sidewalks, etc.
- E. Bond lines for the pavers shall be +/- 1/2-inch over a 50-foot string ling.
- F. Verify the in-situ surface infiltration rate of the permeable pavement is a minimum of 100 in/hour using ASTM C1781.

MAINTENANCE & PROTECTION

- A. At the completion of the work, the Contractor shall provide the Owner with the manufacturer's PICP System Operation and Maintenance Guidelines.
- B. Once the work is complete, the Owner shall be responsible for protecting the work from sediment deposition and damage due to subsequent construction activity on the site.
- C. The Contractor shall return to the site after 6 months from the completion of the work and conduct an inspection of the PICP System with the Owner, Designer, and Contractor in accordance with the PICP System Operation and Maintenance Guidelines, and refill joint material, if required.



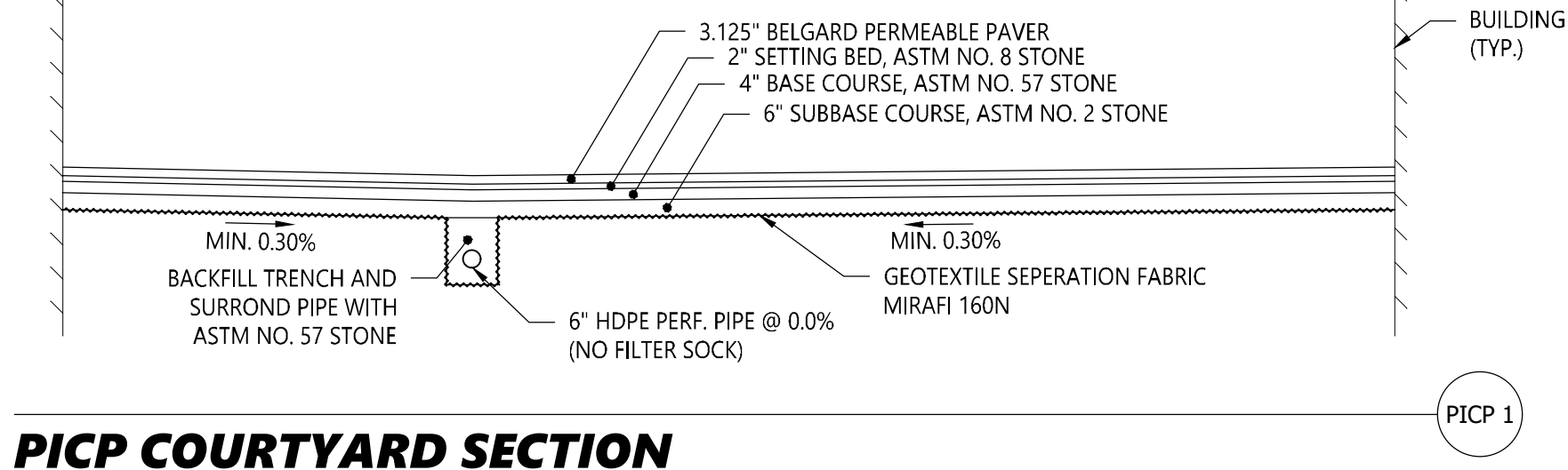
PAVER DESIGN CONCEPT

BELGARD®

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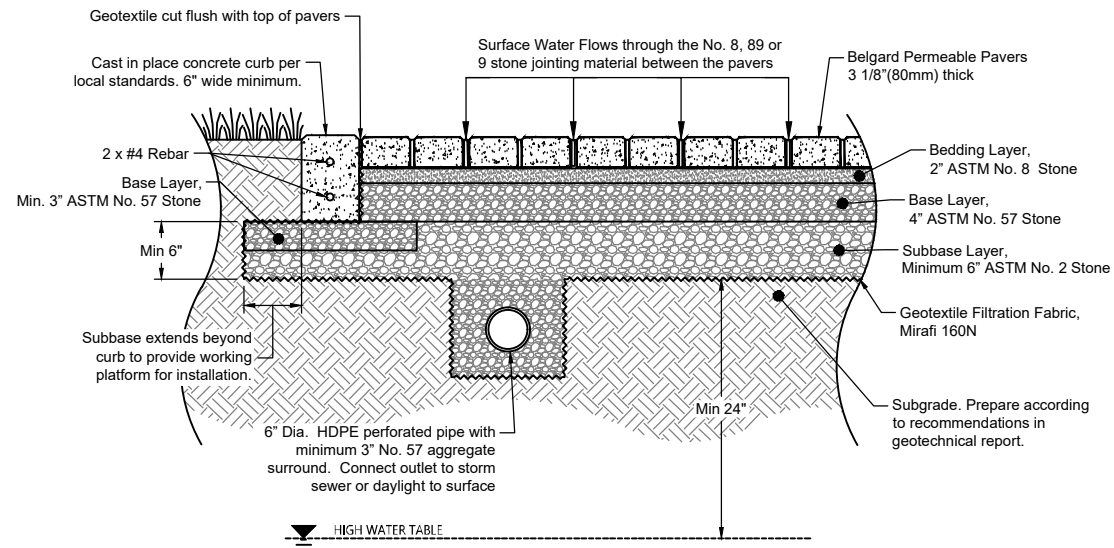
PICP COURTYARD SECTION

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PICP PAVEMENT SECTION W/ UNDERDRAIN

Design Notes:

1. Depth of subbase subject to site specific hydraulic and structural requirements. Contact Belgard Commercial for design assistance.
2. Paver dimensions subject to aspect and plan ratio requirements based on traffic loading.
3. Geotechnical engineer needs to balance structural stability and soil infiltration when recommending subgrade conditions.
4. Where the filtration geotextile is used, verify with the manufacturer that the material is not subject to clogging and meets requirements of AASHTO M-288.
5. ASTM No. 2 stone may be substituted with No. 3 or No. 4 stone.
6. Strictly pedestrian applications may substitute base/subbase layers with one 6" base layer of ASTM No. 57 stone.



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CONSTRUCTION PROTECTION FOR PICP

Protecting PICP from excessive sediment buildup during construction is important to long-term performance and effective future maintenance efforts. Most sites build PICP systems first to protect the open-graded aggregates from debris, dirt, etc., and then the PICP is used for site access during construction. During the pre-construction meeting, various trades should review material flow that will impact the PICP system by contamination or staining. Concrete trucks, masonry equipment, and delivery vehicles may utilize the PICP, but consideration on how washout and debris from these trades will impact the paver surface must be addressed. Excessive mud tracked on the pavers may cause clogging in some areas, but can be removed with a vacuum street sweeper at the conclusion of construction activities and prior to turning the project over to the owner. In addition, the PICP system can serve as an integral part of the project's Stormwater Pollution Prevention Plan if designated before construction with a plan to maintain and restore the PICP to full surface infiltration capacity. Oldcastle recommends that the PICP be used by construction traffic if the joint material is removed and replaced upon substantial completion of the project. Surface infiltration testing should be performed with infiltration results of at least 100-inches/hour or as agreed upon by the owner.

An alternative solution to protect the PICP system would be to make an initial cut to within 12-inches of final sub-grade and cover with a sacrificial layer of ASTM No. 2 aggregate subbase to use as a construction traffic and sediment trap. When final PICP construction can proceed, the sacrificial 12-inches of soil and aggregate layer can be excavated, and the PICP system is built in its entirety as designed. Once final road construction begins, prohibit construction traffic access over the open-graded aggregate subbase and base materials.

Another alternative solution would employ the use of a sacrificial layer of asphalt over the base (ASTM No. 57 aggregate). This approach would require the eventual removal of the asphalt layer and re-grading of the base layer before proceeding with setting the bed layer and paver installation.

Each of these options would allow immediate traffic flow after the permeable pavers have been installed, compacted and joint fill added. Protection of the pavers may or may not be required based on the stage at which they were installed, the projected use by the trades, and needs of the property owner. Plywood, fabric with chips, tarps and numerous other methods have been used in attempts to provide a protective layer over the paver surface, however, most have been costly and ineffective.

UTILITY REPAIRS

One advantage of PICP is that the pavers can be easily removed and reinstated for access to underground utilities. This important advantage allows the pavement surface to be utilized immediately after repairs are made.

Should utility repairs be required below the PICP surface, the pavers can be removed by hand without the use of saw cutting equipment or pneumatic jack hammers. Specialty equipment like a paver extractor can be used. Once the first paver is removed, it is relatively easy to remove the remaining pavers to beyond the extent of excavation. Set the pavers aside for future reinstallation. Undisturbed pavers can be secured with a wood or metal frame as shown in the Figure.

The bedding material (ASTM No. 8 Stone) encountered should be removed and disposed of, then replaced with new aggregate. The ASTM No. 57 base and ASTM No. 2 subbase can be carefully removed and stored separately for reinstallation. Care must be taken to prevent intermixing of the base and subbase materials, and store these materials in a place where the aggregates will remain clean. Any aggregates that become dirty or contaminated should be discarded and replaced. Where repairs require excavation into the underlying subgrade soil, Oldcastle recommends using flowable concrete fill (200 to 500 psi) to support the repaired utility. The open graded base cannot adequately fill under pipes or boxes, nor can it be compacted in these places. When pouring the flowable fill, use a plastic sheet or geotextile to prevent the flowable fill from seeping into the ASTM No.2 Stone. A minimum 4-inch layer of flowable concrete fill should be used to cover a pipe or box structure.

When reinstalling the aggregates, place and level the ASTM No.2 stone in no more than 4-inch lifts and use a plate compactor to compact each lift; the thinner lift thickness is to accommodate the smaller sized compactor that will likely be used due to access limitations in the excavation. The ASTM No. 57 stone can be placed, leveled and compacted in one 4-inch thick lift. The setting bed of ASTM No. 8 stone shall then be placed and screeded in one 2-inch lift without compaction. When reinstalling the pavers, place the pavers level with the adjacent pavers, or slightly higher to account for settlement of the underlying materials (based on the depth of excavation). In either scenario, the bedding layer should be 1/8-inch higher so that once the pavers are reinstalled and compacted, they should be the same elevation as the adjacent units. Once the desired grades are accomplished, sweep jointing material into the joints and vibrate into place; repeat until the joints are full. Belgard can provide an authorized paver contractor to reinstate pavers if required.

Replacement of a single broken or stained paver may be required. However, replacement is not recommended for isolated individual pavers with hairline cracks or other cracks than are not adversely affecting the structural performance of the pavement system. If the paver is otherwise intact and locked in place with little evidence

POST-CONSTRUCTION (PUNCHLIST) INSPECTION CHECKLIST

- ☐The pavers utilized are the type, thickness, and dimensions specified in the construction documents.
- ☐The pavers utilized are the type, thickness, and dimensions specified in the construction documents.
- ☐Paver joint openings are filled with the specified aggregate to the bottom of the chamfer of the paver.
- ☐The area around the permeable paver perimeter is stabilized and covered with required vegetation or specified surface material.
- ☐Final paver surface elevations do not deviate by ± 3/8 in. over a 10ft. long straightedge.
- ☐The surface elevation of the pavers is 1/8 in. to 1/4 in. above adjacent utility structures, concrete collars, channels, curbing, or edge restraints within designated ADA routes. Note: Vehicular areas may be 3/8 in. above adjacent structures outside of ADA routes.
- ☐Lippage is not greater than 1/8 in. between adjacent pavers.
- ☐Cracked paver units (if applicable) have been removed and replaced.
- ☐The installed surface slope is in general conformance with the construction documents.
- ☐Drains and outfalls (if applicable) related to the PICP system are constructed and functioning in general conformance with the construction documents.
- ☐Observation wells (if applicable) related to the permeable pavement system have been installed in accordance with the construction drawings and have been accessed to confirm the reservoir is draining as designed (based on rain event size).
- ☐Surface infiltration testing in accordance with ASTM C1781, Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems, has been conducted within 60 days post-installation, and results exceed 100 inches/hour unless otherwise specified by the construction documents.

Oldcastle recommends that the contractor return to the site along with the owner and/or their representative 6-months after substantial completion to observe the permeable paver system and refill joints where joint infill is 1/2" or more below the chamfer of the pavers. Designers should include this requirement in the project specificatoins to ensure that it is included in the contractor's bid.



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ROUTINE MAINTENANCE

The initial Routine Maintenance cycle of a permeable pavement should commence 6 months from the substantial completion date of the project and be repeated every 12 months, or more frequently as needed. The objective is to remove debris and sediment from the surface with standard sweeping equipment such as power or manual brooms, blowers, mechanical sweepers or regenerative air vacuums.

It is not recommended to use power washing (i.e. pressure washers) to remove sediment within the joints or paver openings. The water will lubricate the sediment particles and force them further into the joint aggregates. In addition, excessive water will also create a slurry containing contaminants that may require special off-site disposal. Lawn maintenance personnel should be instructed to blow grass clippings away from permeable pavement and blow off any grass clippings, plant debris, or leaves that are deposited on the permeable pavement during lawn maintenance and landscaping operations.

A dry mechanical or regenerative air type sweeper may be used during dry periods to remove encrusted sediment, leaves, grass clippings, etc. Vacuum or sweeper settings may require adjustments to prevent uptake of aggregate from the paver voids or joints. Leaf blowers or other standard onsite manual methods that are used for standard pavement maintenance may be employed to remove this surface debris.

RESTORATIVE MAINTENANCE

In rare cases, excessive sediment loading can occur in PICP surfaces. These conditions are typically in isolated areas within the pavement (often along edges) and are usually due to contributory run-on. Fortunately PICP, unlike other types of porous pavements, provides vertical filter columns (joints with specific aggregate infill) that allow for the capture and extraction of sediment build-up within the paver openings. Remedial maintenance should be done utilizing a vacuum sweeper, such as the Elgin Whirlwind as shown below, or an equivalent. A regenerative air vacuum is more appropriately suited for Routine maintenance, as it only will remove the near-surface sediment. A true vacuum machine will remove the entire 3-inch column of joint aggregates.

Sediment collects within the joint or paver openings (voids). As particles attach to the interior infill aggregates, the fine particles bind together below the surface as shown. The majority of the particulate or sediment travel is limited to the near surface and typically does not advance more than 1-2-inches below the paver surface and typically does not reach the bedding layer. The ability for PICP to collect sediment near the surface is a key advantage to this type of infiltration system. Maintenance can be easily performed on the near-surface joint filters within a PICP system.

Municipal vacuum trucks and other equipment, even a shop vac, may be used for restorative maintenance in smaller areas. Restorative maintenance should be attempted in dry conditions and if removal is not achieved, flooding the area with water will help release the sediment under pressure from the vacuum source (water may be effective for Restorative maintenance).

Replace openings with joint fill (ASTM No. 8, 89, or 9) specified in the construction documents by sweeping joints full to within 1/2-inch from the top of the paver surface. Remove excess chip materials from surface, and pavement is ready for use.

Restorative maintenance is sometimes required on older installations not routinely maintained. An indication that restorative maintenance is needed is when rainwater ponds on permeable paver surfaces. In addition, on some land development or phased construction projects, permeable pavers are installed early in the project and often are subjected to significant sediment loading prior to overall project completion or owner acceptance. Project developers, HOAs, and municipal inspectors may require that the PICP system is restored to full surface infiltration capacity or to a minimum industry standard of 100 inches/hour to achieve final acceptance and approval. On these projects subject to sediment loading, Belgard Commercial recommends a restorative maintenance program be implemented to restore the PICP infiltration rate and jointing material.

ANNUAL INSPECTION & ROUTINE MAINTENANCE PROGRAM

The following items are minimum requirements for any annual PICP maintenance program:

An annual inspection is recommended in the spring after snow events have subsided for the year. The purpose of the annual inspection is to assess the functional condition of the permeable pavers as a structural pavement and stormwater control measure. Once the annual inspection is completed, routine maintenance activities should be performed to correct any deficiencies.

- ☐ Replenish paver joints with additional aggregate if the level is more than ½ in. below the bottom of the chamfer at the paver surface.
- ☐ Inspect vegetation around PICP perimeter for cover & soil stability, repair/replant as needed.
- ☐ Inspect and repair all paver surface deformations (depressions/settlement) exceeding 1/2 in.
- ☐ Repair paver heights offset by more than 1/4 in. above or below adjacent units, or offset by more than 1/8 in. lippage from paver-to-paver.
- ☐ Replace cracked paver units of medium and high severity impairing surface structural integrity.
- ☐ Check drains and outfalls (if existing) for the free flow of water. Remove any obstructions.
- ☐ Check observation wells (if existing) to confirm reservoir is draining (based on last measurable rain event).
- ☐ Conduct Routine Maintenance and increase frequency based on sediment loading.
- ☐ If evidence of surface excessive sedimentation exists, test surface infiltration rate using ASTM C1781. If pavement infiltration rate is < 100 in/hr. increase Routine Maintenance from annually to quarterly. If surface infiltration rates fall to 10 in/hr., employ a Restorative Maintenance program utilizing a high pressure air or vacuum methods to extract affected joint material and replace joint material with ASTM No. 8, 89 or 9 washed chip aggregates (based on original design requirements). In most cases, restorative cleaning will only be necessary in isolated locations. Retest surface infiltration rate to confirm reinstated areas exceed 100 in/hr. Repeat the restorative process as needed to exceed the 100 in/hr. criteria.

The initial routine maintenance cycle of a permeable pavement should commence 6 months from the PICP installation date, and be repeated every 12 months or more frequently as needed. The objective is to remove debris and sediment from the surface with standard sweeping equipment such as power or manual brooms, blowers, mechanical sweepers or regenerative air vacuums. Contact you Belgard Sales Representative for more maintenance information.



PAVER DESIGN CONCEPT

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APPENDIX D

REFERENCES, FIGURES, TABLES AND GRAPHS

TOWN OF CASTLE ROCK & DOUGLAS COUNTY

STORM DRAIN CRITERIA REFERENCES

Table 6-5. Runoff coefficients, *c*

Total or Effective % Impervious	NRCS Hydrologic Soil Group A						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.01	0.01	0.01	0.04	0.13	0.27
5%	0.02	0.02	0.02	0.03	0.07	0.15	0.29
10%	0.04	0.05	0.05	0.07	0.11	0.19	0.32
15%	0.07	0.08	0.08	0.1	0.15	0.23	0.35
20%	0.1	0.11	0.12	0.14	0.2	0.27	0.38
25%	0.14	0.15	0.16	0.19	0.24	0.3	0.42
30%	0.18	0.19	0.2	0.23	0.28	0.34	0.45
35%	0.21	0.23	0.24	0.27	0.32	0.38	0.48
40%	0.25	0.27	0.28	0.32	0.37	0.42	0.51
45%	0.3	0.31	0.33	0.36	0.41	0.46	0.54
50%	0.34	0.36	0.37	0.41	0.45	0.5	0.58
55%	0.39	0.4	0.42	0.45	0.49	0.54	0.61
60%	0.43	0.45	0.47	0.5	0.54	0.58	0.64
65%	0.48	0.5	0.51	0.54	0.58	0.62	0.67
70%	0.53	0.55	0.56	0.59	0.62	0.65	0.71
75%	0.58	0.6	0.61	0.64	0.66	0.69	0.74
80%	0.63	0.65	0.66	0.69	0.71	0.73	0.77
85%	0.68	0.7	0.71	0.74	0.75	0.77	0.8
90%	0.73	0.75	0.77	0.79	0.79	0.81	0.84
95%	0.79	0.81	0.82	0.83	0.84	0.85	0.87
100%	0.84	0.86	0.87	0.88	0.88	0.89	0.9
Total or Effective % Impervious	NRCS Hydrologic Soil Group B						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.01	0.07	0.26	0.34	0.44	0.54
5%	0.03	0.03	0.1	0.28	0.36	0.45	0.55
10%	0.06	0.07	0.14	0.31	0.38	0.47	0.57
15%	0.09	0.11	0.18	0.34	0.41	0.5	0.59
20%	0.13	0.15	0.22	0.38	0.44	0.52	0.61
25%	0.17	0.19	0.26	0.41	0.47	0.54	0.63
30%	0.2	0.23	0.3	0.44	0.49	0.57	0.65
35%	0.24	0.27	0.34	0.47	0.52	0.59	0.66
40%	0.29	0.32	0.38	0.5	0.55	0.61	0.68
45%	0.33	0.36	0.42	0.53	0.58	0.64	0.7
50%	0.37	0.4	0.46	0.56	0.61	0.66	0.72
55%	0.42	0.45	0.5	0.6	0.63	0.68	0.74
60%	0.46	0.49	0.54	0.63	0.66	0.71	0.76
65%	0.5	0.54	0.58	0.66	0.69	0.73	0.77
70%	0.55	0.58	0.62	0.69	0.72	0.75	0.79
75%	0.6	0.63	0.66	0.72	0.75	0.78	0.81
80%	0.64	0.67	0.7	0.75	0.77	0.8	0.83
85%	0.69	0.72	0.74	0.78	0.8	0.82	0.85
90%	0.74	0.76	0.78	0.81	0.83	0.84	0.87
95%	0.79	0.81	0.82	0.85	0.86	0.87	0.88
100%	0.84	0.86	0.86	0.88	0.89	0.89	0.9

Table 6-5. Runoff coefficients, *c* (continued)

Total or Effective % Impervious	NRCS Hydrologic Soil Group C						
	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	0.5	0.6
10%	0.06	0.12	0.21	0.37	0.44	0.52	0.62
15%	0.1	0.16	0.24	0.4	0.47	0.55	0.64
20%	0.14	0.2	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	0.51	0.57	0.63	0.7
40%	0.3	0.36	0.43	0.54	0.59	0.65	0.71
45%	0.34	0.4	0.46	0.57	0.62	0.67	0.73
50%	0.38	0.44	0.5	0.6	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	0.65	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%	0.6	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%	0.7	0.73	0.76	0.79	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%	0.83	0.85	0.87	0.88	0.89	0.89	0.9

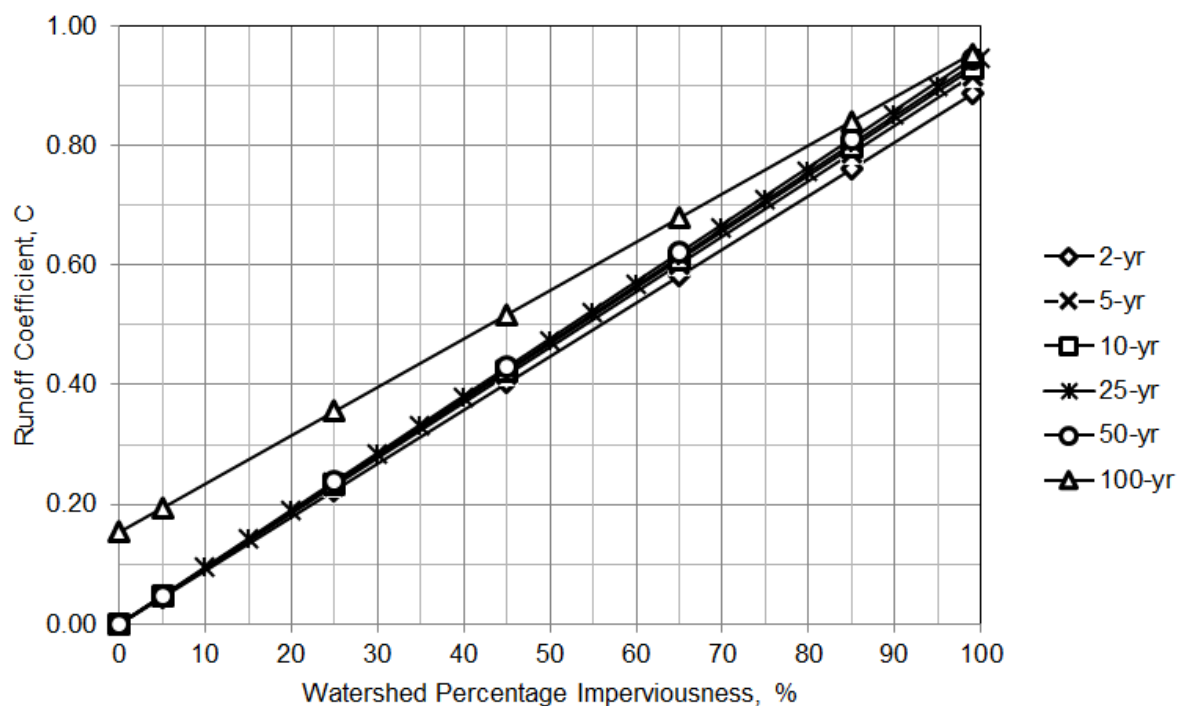


Figure 6-1. Runoff coefficient vs. watershed imperviousness NRCS HSG A

Table 6-3. Recommended percentage imperviousness values

Land Use or Surface Characteristics	Percentage Imperviousness (%)
Business:	
Downtown Areas	95
Suburban Areas	75
Residential lots (lot area only):	
Single-family	
2.5 acres or larger	12
0.75 – 2.5 acres	20
0.25 – 0.75 acres	30
0.25 acres or less	45
Apartments	75
Industrial:	
Light areas	80
Heavy areas	90
Parks, cemeteries	10
Playgrounds	25
Schools	55
Railroad yard areas	50
Undeveloped Areas:	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
Streets:	
Paved	100
Gravel (packed)	40
Drive and walks	90
Roofs	90
Lawns, sandy soil	2
Lawns, clayey soil	2

**FIGURE 6-1
DOUGLAS COUNTY RAINFALL ZONES**

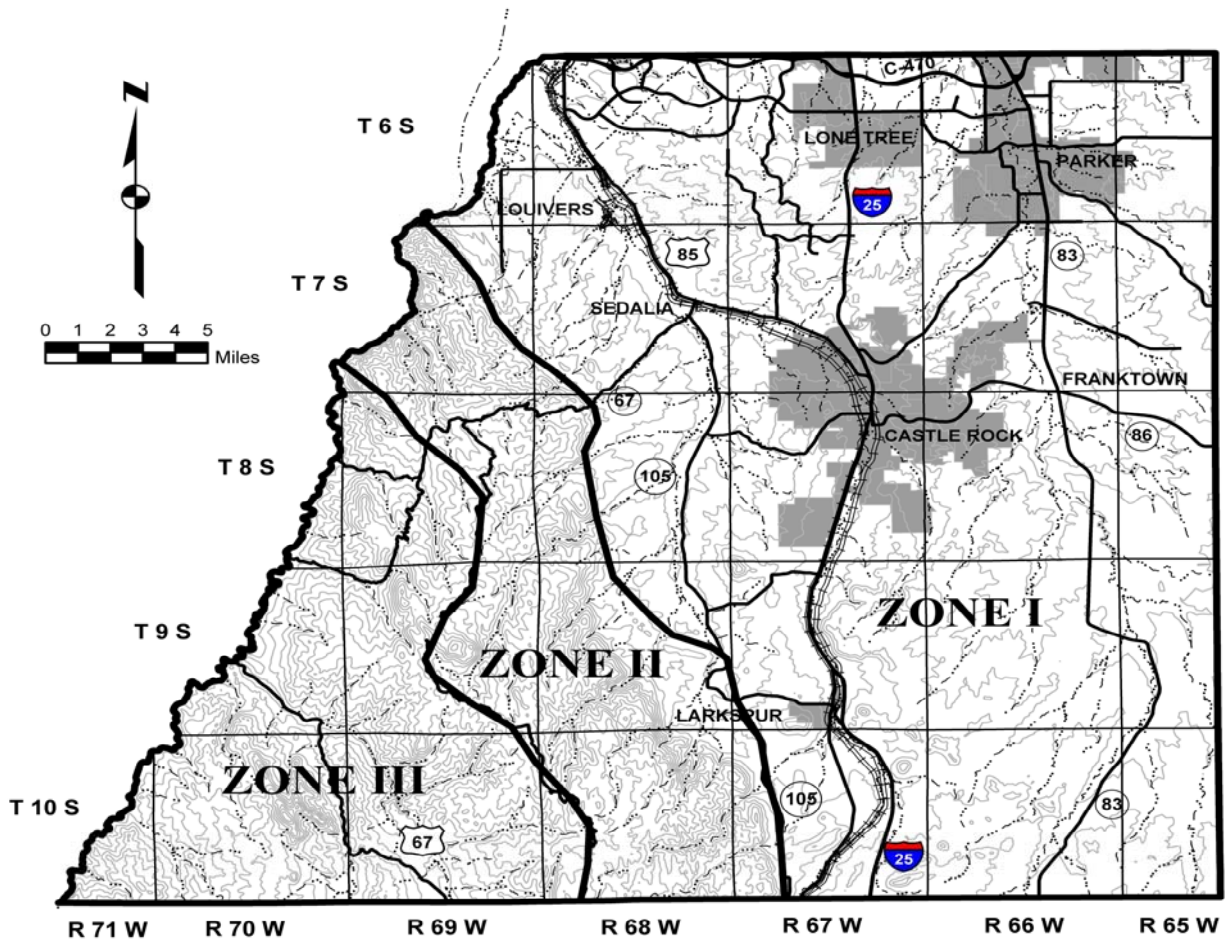
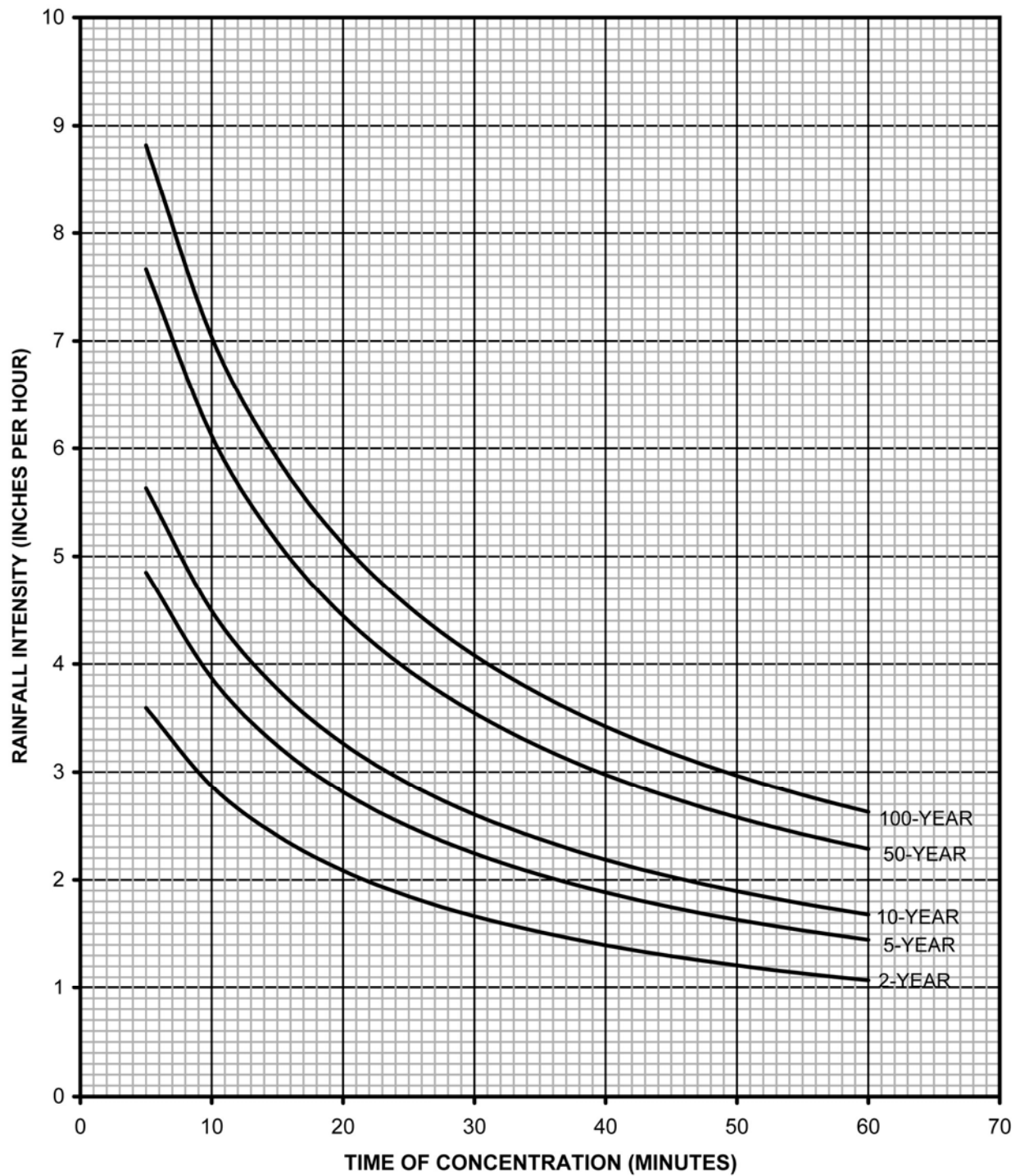


FIGURE 6-2
RAINFALL INTENSITY-DURATION CURVE
DOUGLAS COUNTY ZONE I





Summary of Water Quality Conformance to MS4 Permit

The purpose of this worksheet is to document conformance with the Town of Castle Rock's MS4 permit with regard to permanent water quality on land disturbance projects.

Project Name City Hotel

Project Owner Devin Visciano, White Development

Project Location 415 Perry St., Castle Rock, CO 80104

ToCR Project Number PREAPP22-0098-City Hotel

Total Site Area 0.351 acres

Total Size of Common Plan of Development 0.351 acres

Check all that apply:

☐ **Project within Plum Creek Basin**

☐ **Project within Cherry Creek Basin**

Estimated construction completion date Fall 2025

1. The water quality control measure(s) for applicable development sites shall meet one of the following base design standards as per the SDDTCM Section 14.4. Please select all design standards that were applied to meet conformance with the MS4 on this site.

- ☐ WQCV standard
- ☐ Pollutant removal standard
- ☐ Runoff reduction standard
- ☐ Applicable site draining to regional WQVC control measure (accepts drainage prior to discharging to WOTS)
- ☐ Applicable site draining to regional WQVC control facility (with receiving pervious area control measure upstream of WOTS)
- ☐ Constrained redevelopment sites standard
 - Imperviousness of existing site _____/_____ (Imp. Ac/Site Ac) = ____%
 - Variance required TCV No. _____
- ☐ Existing control measure with WQCV per previous criteria standards
 - Reference Construction Permit No. _____
- ☐ Cherry Creek Basin only, choose one: ☐ Tier 1 ☐ Tier 2 ☐ Tier 3
- ☒ No control measures provided (See Permanent WQ Worksheet for applicability)

Summary of Water Quality Conformance to MS4 Permit

2. Was an exclusion to water quality applied as per SDDTCM Section 13.1.5? ☐ Yes ☐ No

i. If yes, please select all that apply, provide total excluded impervious area(s) and submit variance, as applicable: TCV No. _____

- ☐ Pavement management site
Excluded impervious area: _____ acres
- ☐ Excluded roadway redevelopment
Excluded impervious area: _____ acres
- ☐ Excluded existing roadway areas
Excluded impervious area: _____ acres
- ☐ Above ground and below ground utilities
- ☐ Large lot single family home
- ☐ Non-residential and non-commercial infiltration
Excluded impervious area: _____ acres
- ☐ Land disturbance for land to remain undeveloped
Excluded impervious area: _____ acres
- ☐ Stream Stabilization Sites
Excluded impervious area: _____ acres
- ☐ Trails
Excluded impervious area: _____ acres
- ☐ Oil and Gas Exploration

3. For Development and Redevelopment sites, following any exclusions claimed above, was any portion of the site excluded up to 20% of the site and not to exceed one acre? ☐ Yes ☒ No

If yes, complete the following:

Excluded area: _____ acres
Total Site area: _____ acres, _____ % site excluded

4. For Constrained sites, was any portion of the site excluded up to 50% of the site and not to exceed 50% of the impervious area? ☐ Yes ☐ No

If yes, complete the following:

Excluded area: _____ acres
Excluded impervious area: _____ acres
Total Site area: _____ acres, _____ % site excluded
Total Impervious area: _____ acres, _____ % impervious excluded

Permanent Water Quality Determination Worksheet (Taken from 2019 SDDTCM Sections 13.1.4 and 13.1.5)

Project:		Project#		Applicant:
Section	Questions	Response	Check those that apply	Instructions
1	Non-applicable Sites			
1.1	Will the project result in a temporary disturbance of greater than one acre?	No Yes	☒ ☐	Proceed to section 1.2. Proceed to section 2.
1.2	Is the project part of a larger common plan of development or sale where multiple separate and distinct construction activities may be taking place at different times on different schedules, but remain related and are within 1/4 mile of each other? (A common plan of development will generally be documented on a site development plan, master plan, or equivalent, for the property/project)	No Yes	☒ ☐	Proceed to section 1.3. Proceed to section 2.
1.3	Is the project within the Cherry Creek Watershed?	Yes No	☐ ☒	Permanent water quality control measures may be required. Refer to Water Quality Control Regulation 72.7 for details and allowable exclusions. Permanent water quality control measures are not required.
2	Applicable Site Types and Exclusions by Variance			
2.1	Does the project have more than 35% impervious area on the existing site?	No Yes	☐ ☐	Project is an applicable Development Site. Proceed to section 3. Proceed to 2.2.
2.2	Does the project have greater than 75% impervious area on the existing site?	No Yes	☐ ☐	Project is an applicable Redevelopment Site. Proceed to section 3. Project is an applicable Constrained Redevelopment Site. Proceed to 2.3.
2.3	Will 100% of the runoff from the existing and proposed site be captured and treated using one or more of the allowable design standards for permanent water quality?	Yes No	☐ ☐	No further action required. Proceed to 2.4.
2.4	Do any other water quality exclusions apply to the site?	No Yes	☐ ☐	Portions of the project are excluded. Proceed with design in accordance with Constrained Redevelopment standards and apply for variance for <u>Constrained Redevelopment Sites</u> . Proceed to section 3. Following approval of other exclusions, design remaining site in accordance with Constrained Redevelopment standards and apply for variance for <u>Constrained Redevelopment Sites</u> .
3	Applicable Sites with Other Exclusions by Variance			
3.1	Category 1: Roadways, bridges and trails only			
3.1.1	Is the project a bike or pedestrian trail?	Yes No	☐ ☐	Proceed to next line. Proceed to 3.1.2.
	Is the trail for a roadway?	Yes No	☐ ☐	Proceed to 3.1.2. Project is excluded. Submit variance for <u>Trails Excluded from Permanent Water Quality Requirements</u> .
3.1.2	Is the project primarily used for parking or access to parking?	Yes No	☐ ☐	This exclusion does not apply. Permanent water quality is required. Proceed to 3.1.3.
3.1.3	Does the project add impervious area?	No Yes	☐ ☐	Project is excluded. Submit variance for <u>Pavement Management Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.1.4.

Section	Questions	Response	Check those that apply	Instructions
3.1.4	Does the project add more than 8.25 feet of paved width at any location to the existing roadway?	No Yes	☐ ☐	Project is excluded. Submit variance for <u>Roadway Redevelopment Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
	Does the project add more than one acre of paved area per mile to an existing roadway?	No Yes	☐ ☐	Project is excluded. Submit variance for <u>Roadway Redevelopment Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
	Does the project increase the width by two times or more, on average, of the original roadway area?	No Yes	☐ ☐	Existing areas of site are excluded only. Submit variance for <u>Existing Roadway Surfaces Only Excluded from Permanent Water Quality Requirements</u> . This exclusion does not apply. Permanent water quality is required.
3.2	Category 2: Non-residential and non-commercial projects only			
3.2.1	Is the project associated with oil and gas exploration, production, processing, or treatment operations or transmission facilities, including activities necessary to prepare a site for drilling and the movement and placement of drilling equipment?	Yes No	☐ ☐	Project is excluded. Submit variance for <u>Oil and Gas Exploration Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.2.
3.2.2	Is the project for stream stabilization?	Yes No	☐ ☐	Project is excluded. Submit variance for <u>Stream Stabilization Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.3.
3.2.3	Is the project for installation or maintenance of aboveground or underground utilities or infrastructure that does not permanently alter the terrain, ground cover, or drainage patterns from those present prior to the construction activity including activities to install, replace or maintain utilities under roadways or other paved areas that return the surface to the same condition?	Yes No	☐ ☐	Project is excluded. Submit variance for <u>Aboveground and Underground Utilities Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.4.
3.2.4	Is the project on undeveloped land (land with no human-made structures such as buildings or pavement) that will remain undeveloped after the project?	Yes No	☐ ☐	Project is excluded. Submit variance for <u>Sites with Land Disturbances to Undeveloped Land that will Remain Undeveloped Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.5.
3.2.5	Will the post-project condition result in surface water discharge during the 80th percentile storm runoff event?	No Yes	☐ ☐	Project is excluded. Submit study along with variance for <u>Non-residential and Non-commercial Infiltration Conditions Excluded from Permanent Water Quality Requirements</u> . This exclusion does not apply. Permanent water quality is required.
3.3	Category 3: Residential, Agricultural and Commercial projects			
3.3.1	Is the project a single-family residential lot, or agricultural zoned lands, greater than or equal to 2.5 acres in size per dwelling unit?	Yes No	☐ ☐	Proceed to next line. Proceed to 3.3.2.
	Is the project site greater than 10% impervious?	No Yes	☐ ☐	Project is excluded. Submit variance for <u>Large Lot Single Family Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
	Is the project site greater than 20% impervious?	Yes No	☐ ☐	This exclusion does not apply. Permanent water quality is required. Proceed to next line.
	Will the post-project condition result in surface water discharge during the 80th percentile storm runoff event?	No Yes	☐ ☐	Project is excluded. Submit study along with variance for <u>Large Lot Single Family Sites Excluded from Permanent Water Quality Requirements</u> . This exclusion does not apply. Permanent water quality is required.

Section	Questions	Response	Check those that apply	Instructions
3.3.2	Will 100% of the runoff from the residential or commercial site be captured?	Yes No	☐ ☐	This exclusion does not apply. Permanent water quality is required. Proceed to next line.
	Is all or a portion of the site undeveloped or will it remain undeveloped after construction?	Yes No	☐ ☐	This portion of the project is excluded. Submit variance for <u>Sites with Land Disturbance to Undeveloped Land that will Remain Undeveloped Excluded from Permanent Water Quality Requirements</u> . Proceed to next line. Proceed to next line.
	Is the remaining untreated impervious area greater than 20% of the site?	Yes No	☐ ☐	This exclusion does not apply. Permanent water quality is required. Proceed to next line.
	Is the remaining untreated impervious area greater than one acre?	Yes No	☐ ☐	This exclusion does not apply. Permanent water quality is required. Proceed to next line.
	Is it practicable to capture runoff from portions of the site that will not drain to a control measure?	No Yes	☐ ☐	Document justification demonstrating that it is not practicable to capture runoff from this portion of the site in the drainage report . No further action is needed. This exclusion does not apply. Permanent water quality is required.