

FINAL DRAINAGE REPORT

**Lot 3A Northcrest Center Filing No 1A
(My Garage @ Northcrest Center)**

2510 CANADA DRIVE COLORADO SPRINGS, COLORADO 80922

PCD File #PPR2412

Prepared for:
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Kiowa Project No. 23049

August 02, 2024

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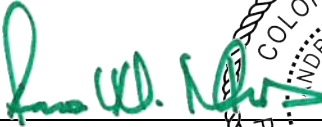
List of Figures and Tables (Refer to the Appendix Table of Contents)

STATEMENTS AND APPROVALS


ENGINEER'S STATEMENT:

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.

Kiowa Engineering Corporation, 1604 South 21st Street, Colorado Springs, Colorado 80904



Andrew W. McCord (PE #25057)
For and on Behalf of Kiowa Engineering Corporation

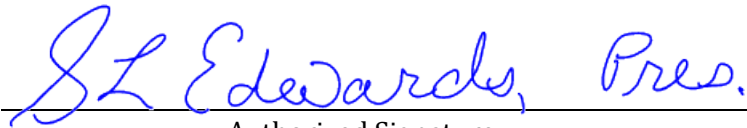


9/9/2024
Date

DEVELOPER'S STATEMENT:

I, the Owner/Developer, have read and will comply with all of the requirements specified in this drainage report and plan.

K&S Development, LLC
Name of Developer



Authorized Signature

9/9/2024
Date

Printed Name: Sean L. Edwards

Title: Managing Member

Address: 3442 Tampa Rd., Suite B, Palm Harbor, FL 34684

El Paso County:
Filed in accordance with the requirements of the Drainage Criteria Manual, Volumes 1 & 2, El Paso County Engineering Criteria Manual, and Land Development Code, as amended.

Joshua Palmer, P.E.
El Paso County Engineer/ECM Administrator

Date

I. PURPOSE

This report is a Final Drainage Report for Lot 3A Northcrest Center Filing No 1A, at 2510 & 2522 Canada Drive Colorado Springs, Colorado 80922, for the development of a multi-unit commercial storage center, *My Garage @ Northcrest Center*.

The purpose of this report is to identify on-site and off-site drainage patterns, assess stormwater conditions per delineated basin and sub-basins, demonstrate adequate design standards for storm water flow and release into the existing storm water system or right-of-way, and provide a narrative for any other drainage considerations related to the development of this parcel.

II. GENERAL LOCATION AND DESCRIPTION

A. LOCATION

This proposed development of 70 commercial storage units is located at the address of Northcrest Center in the City of Colorado Springs, Colorado in El Paso County within the Lot 3A Northcrest Center Filing No 1A Subdivision. The parcel schedule number is 53323-09-008 and the legal descriptions is Lot 3A Northcrest Center Filing No 1A. It is comprised of an earlier Vacation & Replat of Tract B Northcrest Fil No 2 Phase 1, Lot 5 Northcrest Center, A Vacation & Replat Of Tract B Northcrest Fil No 2 Phase 1, and Lot 4 Northcrest Center, and A Vacation & Replat Of Tract B Northcrest Fil No 2 Phase 1. The parcel is located to the north of Constitution Avenue, west of Canada Drive, east of Peterson Road, and south of Bismark Road.

The surrounding parcels are as follows:

2508 Weyburn Way, Schedule No. 5332308031, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 15 Constitution Hills Fil No 8

2507 Weyburn Way, Schedule No. 5332308032, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 14 Constitution Hills Fil No 8

2630 Tibburn Way, Schedule No. 5332308040, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 6 Constitution Hills Fil No 8

2610 Tibburn Way, Schedule No. 5332308041, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 5 Constitution Hills Fil No 8

2605 Tibburn Way, Schedule No. 5332308042, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 4 Constitution Hills Fil No 8

2535 Canada Drive, Schedule No. 5332310002, Zoning RS-6000 CAD-O, Plat No. 8956, Lot 1 Living Waters Sub

2525 Canada Drive, Schedule No. 5332310003, Zoning PUD CAD-O, Plat No. 8956, Lot 2 Living Waters Sub

2455 Canada Drive, Schedule No. 5405207050, Zoning RM-30 CAD-O, Plat No. 7588, Lot 2 Northcrest Fil No 4

6855 Constitution Avenue, Schedule No. 5405218002, Zoning CC CAD-O, Plat No. 9808, Lot 1 Eight Line Sub

6805 Bismark Road, Schedule No. 5332309007, Zoning CC CAD-O, Plat No. 7776, Lots 1 & 2 Northcrest Center, A Vacation & Replat of Tract B Northcrest Fil No 2 Phase 1

2624 Tibburn Way, Schedule No. 5332308043, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 3 Constitution Hills Fil No 8

B. DESCRIPTION OF PROPERTY – EXISTING CONDITIONS

Lot 3A Northcrest Center Filing No 1A Subdivision is approximately 141,390 square feet (3.246 acres) and is located on the north side of Constitution Avenue, east side of Peterson Road, West of Canada Drive, and south of Bismark Road. The parcels fall within the SW 1/4 of Section 32, Township 13 South, Range 65 West of the 6th P.M. of Colorado Springs, El Paso County, Colorado.

The property currently consists of undeveloped natural vegetation. There is existing curb and gutter along Bismark Drive, Canada Drive, and Constitution Avenue.

The existing percent imperviousness is approximately 1.5 percent.

The existing topography consists of grades between 2 and 25 percent. Drainage patterns sheet flow across the parcel southeasterly to the corner of Canada Drive and Constitution Avenue.

C. EXISTING SOILS

The soils indicative to the site are classified as Truckton sandy loam by the USDA Soil Conservation Service and are listed as NRCS (National Resources Conservation Service) Hydrologic Soil Group A. A USDA Soil Map is provided in the Appendix.

A subsurface soils investigation was conducted for the site within a letter entitled *Geotechnical Report* by RMG – Rocky Mountain Group dated February 23, 2021 (Ref. Appendix B). The investigation “revealed similar substance subsurface soil conditions across the site, being primarily silty sand extending from the ground surface to the extent of the test borings. Neither expansive clay soil nor bedrock was encountered in the borings.”

“Test Borings for structures and storage yards were advanced with a power-driven, continuous-flight auger drill rig to depths of 15 and 20-feet below the existing ground surface. Pavement Borings were advanced to 5 and 10-foot depths.”

The study found that, “groundwater was not encountered in the test borings during field exploration.”

These soils are classified within Hydrologic Soil Group A. Erosion Potential is moderate to low depending on the granularity of the subsurface soil matrix and must be actively contained during construction activities.

D. EXISTING DRAINAGE

The existing topography consists of grades between 2 and 25 percent within the entire parcel that ultimately flows southeast. The existing imperviousness of the lot is approximately 1.5 percent. The existing vegetation consists of native grasses and has been identified via site visits and aerial photography as well as survey data and pictures.

The existing drainage pattern from storm runoff is generally characterized as overland flow to the southeast of the parcel across pervious landscaped yard. The runoff from this parcel and the surrounding neighborhood flows via curb and gutter in the public right of way of Bismark Road, Constitution Avenue, and Canada Drive. The runoff flows south on Canada Drive into the existing Public 15' CDOT Type R Curb Inlet located at the northwest corner of the intersection of Canada Drive and Constitution Avenue. This Public Storm Inlet is a branch of the Public 24" RCP Storm Main that flows west to east along the north side of Constitution Avenue and ultimately outfalls into the East Fork of Sand Creek Creek approximately one mile to the east.

Lot 3A Northcrest Center Filing No 1A does not lie within a designated floodplain according to information published in the Federal Emergency Management Agency Floodplain Map No. 08041C0752G, dated December 7, 2018. The FEMA Floodplain map is provided in Appendix A showing it lies within Zone X, a minimal flood hazard area.

There are no known non-stormwater discharges that contribute to the storm water systems on site and downstream, both private and public.

The Site was previously platted (Ref. ECP EDARP File V222 "NORTHCREST CENTER NO. 1A A VACATION AND REPLAT OF LOTS 3,4 AND 5, "NORTHCREST CENTER", BEING A PORTION OF THE SOUTHWEST QUARTER OF SECTION 32, TOWNSHIP 13 SOUTH, RANGE 65 WEST OF THE 6TH P.M., COUNTY OF EL PASO, STATE OF COLORADO") and approved for drainage (Ref: EPC PPR2136 as LOTS 3, 4, AND 5 NORTHCREST CENTER FILING NO 2 PHASE 1 SUBDIVISION") on February 21, 2023. The plat and drainage report have both been reviewed and considered in preparation of this report.

E. DESCRIPTION OF PROPERTY – PROPOSED CONDITIONS

The proposed development consists of 70 commercial units containing approximately 63,240 square feet along with concrete and asphalt pavement for drive accesses, sidewalks, and curb and gutter. Other on-site features include approximately 25,420 square feet of landscaping, 600 linear feet of retaining wall, and 5,000 square feet for a full spectrum detention pond (EDB Pond 'A').

There is no existing access point to the property. Two new curb cuts are proposed along Canada Drive. Easement vacations and replatting will be required to accommodate the planned development.

The Site has been redeveloped for similar use, but with a higher density of storage units and with a more compacted detention storage area that will incorporate full a concrete perimeter wall and a three stage outlet structure instead of a two-stage structure with an overtopping area inlet. The revised design will have a concrete access ramp and a smaller wetted perimeter. Perimeter swales will actively harvest and direct runoff from roof areas, and direct flows to Pond A. The revised design will employ less storm piping and fewer inlets. The outfall location from Pond A remains the same, which is the rear side of an existing inlet at Canada Drive.

The westerly edge of the revised project will rely on a substantial retaining wall to create a flatter site that will allow for more ADA accessibility.

Planned Access Points to the site are unchanged at Canada Drive, but no site access is planned for the west margin of the property with the planned redevelopment as it was with the previous plan.

III. DRAINAGE BASINS AND SUBBASINS

A. EXISTING BASINS AND SUB-BASINS

The parcel is delineated into sub-basins according to the existing and proposed grading for existing and developed conditions.

Basin H-1 is the entirety of the parcel representing existing conditions and consists of one on-site sub-basin. There are some off-site flows that enter the property along its westerly margin which will be discussed in Sub-Basin O-1.

Sub-basin H-1 (3.25 ac.; $Q_{10} = 1.7$ cfs, $Q_{100} = 10.4$ cfs) is the entirety of Lot 3a which contains natural vegetation that flows to the right of ways of Bismark Road, Canada Drive, and Constitution Ave. Those right of ways have curb and gutter directly adjacent to the lot that flow to a Public 15' CDOT Type R Curb Inlet located in Canada Drive. This public stormwater system is connected to a Public

30" CMP Storm Main that runs west to east along the south side of the lot within Constitution Avenue. The Public 15' & 5' CDOT Type R Curb Inlets located at the northwest and northeast corners, respectively, of the intersection of Canada Drive and Constitutions Avenue are branches that connect to the public stormwater main within Canada Drive. The public stormwater system ultimately flows north within Canada Drive to the East Fork of Sand Creek. Design Point 1 is the existing conditions design point representing the on-site area. The emergency flow route of this public storm inlet is due east along the north side of Constitution Avenue.

Basin O-1 contains 0.23 acres lying adjacent to and west of the site. Flows from this sub-basin enter the westerly edge of the site in a sheet flow manner from paved areas, and travel overland across the unimproved site ($Q_5=0.8\text{cfs}/Q_{100}=1.6\text{cfs}$). Runoff descends along the existing alleyway to a point lying along the westerly edge of the site.

Basin O-2 contains 0.07 acres consisting of a narrow strip of unimproved land lying between the site's north property line, and the public curb and gutter section of Bismark Road ($Q_5=0.0\text{cfs}/Q_{100}=0.2\text{cfs}$). Runoff descends to the public curb and gutter section in a sheet flow manner.

Basin O-3 contains 0.06 acres consisting of a narrow strip of unimproved land lying between the site's east property line, and the public curb and gutter section of Canada Drive ($Q_5=0.0\text{cfs}/Q_{100}=0.2\text{cfs}$). Runoff descends to the public curb and gutter section in a sheet flow manner.

Basin O-4 contains 0.07 acres consisting of a narrow strip of unimproved land lying between the site's south property line, and the public curb and gutter section of Constitution Avenue ($Q_5=0.0\text{cfs}/Q_{100}=0.2\text{cfs}$). Runoff descends to the public curb and gutter section in a sheet flow manner. Developed Drainage Basins and Sub-Basins

B. ON-SITE BASINS – DEVELOPED CONDITION

Basin D-1 contains 0.55 acres of roof and lawn area ($Q_5=1.4\text{cfs}/Q_{100}=3.0\text{cfs}$). Flows either sheet flow or accumulate in downspouts and are directed to a new private grassed swale (GS 'North') for water quality treatment ahead of being released to a new private Type 'C' area inlet at Design Point 1. There are no offsite flows entering this sub-basin. Concentrated and treated runoff is collected within new private inlet and storm pipe and directed to the new private EDB. Combined flows are allowed to infiltrate within the informal grassed swale 'GS North' which is not a PCM, but which does provide some additional water quality treatment ahead of discharging to Pond A via a recessed, private Type C area inlet at DP-1. Water Quality Treatment is provided within Pond A.

Basin D-2 contains 0.40 acres of roof and drive aisle ($Q_5=3.2\text{cfs}/Q_{100}=5.9\text{cfs}$). Flows either sheet flow or accumulate in downspouts and are directed to a 4' valley pan ahead of being released to a new private Type 'C' area inlet at Design Point 2. There are no offsite flows entering this sub-basin. Concentrated runoff is collected within new storm pipe and directed to the new private EDB. Water Quality Treatment is provided within Pond A.

Basin D-3 contains 0.08 acres of driveway and parking area ($Q_5=0.3\text{cfs}/Q_{100}=0.6\text{cfs}$). Flows initially sheet flow across paved surfaces and are discharged through slotted curb at the low side of the basin nearest to Canada Drive. New landscape area is planned to receive surface runoff via two-inch curb slots located every ten feet. The slotted curb incorporates a hard ledge six inches below the invert of the curb assembly for informal (no PCM) WQ Treatment ahead of being released to public roadway at Design Point 3. There are no offsite flows entering this sub-basin.

Basin D-4 contains 0.98 acres of roof and drive aisle area in the center of the site ($Q_5=4.0\text{cfs}/Q_{100}=7.3\text{cfs}$). Runoff flows sheet flow and accumulate in downspouts and are directed to

a new four-foot valley pan located in the center of the drive aisle and ahead of being released to a new private Type 'C' area inlet at Design Point 4, although it is preferable that these flows find their way along the west margin of the site to Sub-Basin D-4. Regardless, combined and concentrated runoff is collected within new private inlets and storm pipes and directed to the new private EDB at Forebay One or Two via depressed Type C area inlets at either DP 4 or DP 5. Water Quality Treatment is provided within Pond A.

Basin D-5 contains 0.15 acres of roof and lawn area ($Q_5=1.3\text{cfs}/Q_{100}=2.7\text{cfs}$). Flows either sheet flow or accumulate in downspouts and are directed to a new private, informal grassed swale (GS 'South') for water quality treatment ahead of being released to a new private Type 'C' area inlet at Design Point 5. Off-site Runoff descends along the existing alleyway to the west within Sub-Basin O-1 and combines with on-site flows at a point lying along the westerly edge of the site where it concentrates and enters a new informal, private, grassed swale designated to harvest this flow along with roof flows within on-site Sub-Basin D-5. These combined flows are allowed to infiltrate within the informal grassed swale, which is not a PCM, but which does provide some additional water quality treatment ahead of discharging to Pond A via a recessed, private Type C area inlet at DP-5 (See Forebay One). Supplemental Water Quality Treatment in excess of MS 4 Permit requirements at the grassed swale is evaluated for reference and information purposes within Appendix C.

Basin D-6 contains 0.12 acres of ramp, channel and grassed area ($Q_5=1.4\text{cfs}/Q_{100}=3.0\text{cfs}$). Flows either sheet flow or are released under controlled conditions from one of two new private forebays (One and at Two) at Design Point 6. There are no offsite flows entering this sub-basin. Concentrated runoff is directed via trickle channels to a new private outlet structure ahead of release to public storm systems. Calculations for the three-stage release structure are provided in Appendix B. Water Quality is provided within the pond itself (Pond A).

Basin D-7 contains 0.15 acres of drive aisle, sidewalk, entrances and lawn areas which are generally below the pond's elevation, and are constrained by topography such that they cannot be directed to the EDB ($Q_5=0.2\text{cfs}/Q_{100}=0.6\text{cfs}$). Flows sheet flow to lawn areas and public roadway. Some water quality treatment benefit is achieved within the receiving pervious lawn area ahead of being released to a existing roadway curb and gutter. There are no offsite flows entering this sub-basin. Concentrated and partially treated runoff is collected within existing curb and gutter and are received at the existing public 15' Type 'R'; curb inlet located along the west side of Canada Drive. Water Quality Treatment for this basin is not required to meet the specific levels required by the App I / MS 4 Permit. However, informal (non PCM) WQ Treatment is provided in excess of the permitting requirement and is included in calculation for informal purposes only. Those supplemental calculations are provided within Appendix C for reference only.

Basin D-8 contains 0.16 acres of lawn and sidewalk area at the extreme south and southeast corner of the site. Flows generally sheet flow to new receiving public sidewalks which they cross ahead of entering Public curb & gutter sections along Constitution Avenue. Combined and concentrated flows continue to the Public Type 'R' Inlet located just north of Constitution Avenue along the west side of Canada Drive ($Q_5=0.4\text{cfs}/Q_{100}=0.9\text{cfs}$) at Design Point 8. There are no upstream offsite flows entering this sub-basin. Runoff is ultimately collected within public inlets and pipes and directed to downstream portions of the storm sewer system. Water Quality Treatment for this basin is not required to meet the specific levels required by the App I / MS 4 Permit. However, informal (non PCM) WQ Treatment is provided in excess of the permitting requirement and is included in calculation for informal purposes only. Those supplemental calculations are provided within Appendix C for reference only.

C. OFF-SITE BASINS - DEVELOPED CONDITION

Basin O-1 contains 0.23 acres lying adjacent to and west of the site. Flows from this sub-basin enter the westerly edge of the site in a sheet flow manner from paved areas, and travel overland across the unimproved site ($Q_5=0.8\text{cfs}/Q_{100}=1.6\text{cfs}$). Under developed conditions, the easterly edge of the existing off-site alleyway to the west *may* discharge some runoff over the planned retaining wall to hardened surface areas of Basin D-4. However, the preferred route under developed conditions is to capture these flows along the west side of Building A, and direct them to a new private, informal grassed swale (GS South). The swale is sized to accommodate these flows and to allow them to combine with roof flows from Sub-basin D-5 ahead of routing them to Pond A for storage and water quality treatment. In either case, Water Quality Treatment is achieved within Pond A.

Basin O-2 contains 0.07 acres consisting of a narrow strip of unimproved land lying between the site's north property line, and the public curb and gutter section of Bismark Road ($Q_5=0.0\text{cfs}/Q_{100}=0.2\text{cfs}$). Runoff descends to the public curb and gutter section in a sheet flow manner. Under developed conditions, new five-foot public attached sidewalk is added to the roadway (Bismark Road). The basin consists primarily of new public sidewalk and offers little-to-no opportunities for infiltration or water quality treatment. Basin O-2 is excluded from formal WQ Treatment by ECM Application Section I.7.1.C.1.

Basin O-3 contains 0.06 acres consisting of a narrow strip of unimproved land lying between the site's east property line, and the public curb and gutter section of Canada Drive ($Q_5=0.0\text{cfs}/Q_{100}=0.2\text{cfs}$). Runoff descends to the public curb and gutter section in a sheet flow manner. Under developed conditions, new five-foot public attached sidewalk is added to the roadway (Canada Drive). The basin consists primarily of new public sidewalk and offers little-to-no opportunities for infiltration or water quality treatment. Basin O-3 is excluded from formal WQ Treatment by ECM Application Section I.7.1.C.1.

Basin O-4 contains 0.06 acres consisting of a narrow strip of unimproved land lying between the site's east property line, and the public curb and gutter section of Canada Drive ($Q_5=0.0\text{cfs}/Q_{100}=0.2\text{cfs}$). Runoff descends to the public curb and gutter section in a sheet flow manner. Under developed conditions, new five-foot public attached sidewalk is added to the roadway (Constitution Avenue). The basin consists primarily of new public sidewalk and offers little-to-no opportunities for infiltration or water quality treatment. Basin O-4 is excluded from formal WQ Treatment by ECM Application Section I.7.1.C.1.

There is also an existing Water Quality Capture Volume BMP/control measure constructed for the neighboring lot (Northcrest Center Fil No 2 Lots 1 & 2). This feature will not see additional runoff due to the proposed development and was not evaluated for its current conditions.

A Full Spectrum Extended Detention Basin (EDB) is proposed for the site to provide water quality and detention prior to attenuated storm water release to the public storm system. The vertical concrete walls on all four sides of the Extended Detention Basin are due to site constraints including an existing electric vault and existing easement where the pond is being constructed. The Full Spectrum Extended Detention Basin includes a 10' wide concrete maintenance access ramp that slopes to the pond's bottom.

Some incidental water quality treatment via infiltration is anticipated in addition to and in excess of that which is required by the MS 4 Permit via the meandering grass swales at the north and south margins of the project. The EDB provided 100% of the WQ Treatment, per the MS 4 Permit. Supplementary Runoff Reduction, and Grassed Swale Calculations are provided within Appendix C to quantify the additional runoff reduction achieved by the marginal grass areas of the site as well as the grassed swales (GS North & GS South) for reference and information purposes only.

IV. DRAINAGE DESIGN CRITERIA

A. REGULATIONS

The hydrological and hydraulic calculations and design of the site conform to the City of Colorado Springs Drainage Criteria Manuals I and II (latest revision, May 2014) as well as the Mile High Flood District Drainage Criteria manuals revised August 2018.

PCMs must be provided to achieve Water Quality Treatment. Extended Detention of Runoff must be provided for this development as it is over 1 acre in size.

B. DEVELOPMENT CRITERIA REFERENCE AND CONSTRAINTS

The parcel falls within the Sand Creek major drainage basin (East Fork Sand Creek) designated by the City of Colorado Springs Water Resources Engineering Department with the ultimate receiving waters of Arkansas River.

Relevant criteria for the calculations shown further include equations and design criteria for the rational method, volumes and runoff of various storm events.

Under developed conditions, the drainage on this parcel will have no effect on downstream infrastructure or facilities, streets, utilities, transit, or further development of adjacent lots.

C. HYDROLOGICAL CRITERIA

The rational method was used to calculate the peak runoff of the delineated sub-basins using the manuals referenced prior with the C, I, and P1 values from the Design Criteria Manual Volume I, Chapter 6 as well as the Colorado Springs designated IDF curve values. Specific calculations and tables are provided further with inputs including design rainfall, sub-basin acreage and percent imperviousness, runoff coefficients, one-hour rainfall depths, rainfall intensities, time of concentration, and peak discharge of various storm events.

The default rainfall intensities and volumes use runoff coefficients based on soil types. Weighted runoff coefficients were calculated for each basin and sub-basin due to the mix of impervious surfaces, shown in the Appendix B exhibits.

PBMPs in the form of an EDB are planned to achieve Water Quality Treatment and in order to match Historic Release Rates for the developed site. Additional Water Quality Treatment above that which is required by MS Permitting is also provided in Appendix C for reference and informational purposes.

D. FOUR-STEP PROCESS

The selection of appropriate control measures is based on the characteristics of the site and potential pollutants. The Four-Step Process provides a method of going through the selection process. The following applies the four-step process to the Development Plan for My Garage @ Northcrest Center.

Step 1: Employ Runoff Reduction Practices

The Development Plan including the Landscape Plan utilizes landscaping areas for plantings and grass or mulch wherever possible without obstructing utilities or drainageways. Given the proposed land use, the majority of the site consists of roof or paved surface. Where possible, roof runoff is directed to perimeter grassed swales ahead of entering private storm systems. All other areas are marginal edges which cannot be captured by grading.

Step 2: Provide Water Quality Capture Volume

The Development Plan and Final Drainage Report indicate the use of a PBMP storm water detention Pond A (PBMP Pond A) as a control measure for capturing storm water runoff and properly treating the storm water prior to release either via percolation into the soil or attenuated to the public storm system. The PBMP Pond A is to be installed and the configuration is sized for capture of the WQCV as well as the EURV and full-spectrum detention, and 100-year detention. In addition to PBMP Pond A, additional informal, (non PCM) Water Quality Treatment is planned the perimeter of the property where roof flows find their way to grassed swale which allow some sediments and pollutants to settle out of the concentrated runoff prior to entering pipe systems, and being conveyed to the PBMP Pond A. The site provides two locations for additional water quality treatment via three-hundred-foot grassed swales. Treatment benefit for these swales is informal (non PCM) and supplementary treatment above and beyond that which is otherwise required by the MS 4 Permit. Runoff Reduction for the whole site is summarized in the table below:

Water Quality Treatment Summary Table							
Bains ID	Total Area (ac)	Total Proposed Disturbed Area (ac)	Area Trib to Pond A (ac)	Informal (non PCM) Disturbed Area Treated via Runoff Reduction (ac)	Disturbed Area Excluded from WQ per ECM App I.7.1.C.1 (ac)	Disturbed Area Excluded from WQ per ECM App I.7.1.B.# (ac)	Applicable WQ Exclusions (App I.7.1.B.#)
O1	0.23	0.03	0.23				
O2	0.07	0.07	-		0.07		
O3	0.06	0.06	-		0.06		
O4	0.07	0.07	-		0.07		
D1	0.56	0.56	0.56				
D2	0.75	0.75	0.75				
D3	0.08	0.08	0.08				
D4	0.98	0.98	0.98				
D5	0.46	0.46	0.46				
D6	0.12	0.12	0.12				ECM App I.7.1.B.5
D7	0.15	0.15	0.00	0.07	0.08		ECM App I.7.1.B.7
D8	0.16	0.00	-	0.16			
Total	3.69	3.33	3.18	0.23	0.28	0.00	
		Total Proposed Disturbed Area (ac)	Total Proposed Treated Area (ac)		Total Proposed Disturbed Area Excluded		Minimum Area to be Treated (ac)

			from WQ (ac)	
3.33	3.41		0.28	3.04

Step 3: Stabilize Drainageways

The drainage within the site is stabilized by way of pavement with features such as grassed swales, valley pans, area inlets, curb and gutter, and sloped pavement to direct storm water to the private storm system. There are no unstabilized drainageways on this site.

Step 4: Implement Site Specific and Other Source Control BMPs

In addition to Full Spectrum Extended Detention, two 300-foot grassed swales are proposed at the north and south margins of the site to provide some opportunities for infiltration and sediment removal. Concentrated and partially treated flows within these grassed swales are subsequently captured within separate area inlets at the bottom of the swales and directed to the extended detention basin (EDB) within private collection systems. A Slotted Curb with a dropped ledge is planned along the easterly margin where topographic constraints prevent capture within the on-site private storm collection system. A small portion of the site in the extreme southeast corner lies below the pond and is allowed to sheet flow across landscaped surface to maximize opportunities for infiltration.

V. DRAINAGE INFRASTRUCTURE COSTS AND FEES

A. DRAINAGE AND BRIDGE FEES

The development falls within the Sand Creek drainage basin (FOFO4000) which has a drainage basin fee of \$20,387 per impervious acre and a bridge fee of \$8,339 per impervious acre according to the 2021 El Paso County Drainage Basin Fees document. The development has a total impervious acreage of 2.33 acres (3.25 acres * 71.7% imperviousness).

Drainage Basin Fee: \$20,387/impervious acre * 2.33 impervious acres = \$47,507
 Bridge Fee: \$8,339/impervious acre * 2.33 impervious acres = \$19,429.87

Since the site is already platted, drainage fees are assumed to have already been paid. Since this development is increasing imperviousness, the County shall review their records and make a decision on fee requirements.

The property has been platted. There are no outstanding fees to be paid associated with platting.

B. STORM DRAIN SYSTEM QUANTITIES AND COST ESTIMATE

Table 1 - Northcrest Center - Private Storm Improvements

Description	Quan.	Unit	Cost	Total
Slotted Curb w/ Dropped Ledge	110	LF	\$55	\$6,050
Type 'C' Area Inlet (3'x3')	4	EA	\$9,800	\$39,200
4-ft Dia Manhole (conc)	2	EA	\$8,322	\$16,644
12" HDPE Dbl Smooth Pipe	50	LF	\$41	\$2,050
18" HDPE Dbl Smooth Pipe	152	LF	\$56	\$8,512
19"x30" HERCP Pipe	31	LF	\$112	\$3,472
			Sub- Total	\$75,928
Inlet/Outlet Structure	1	EA	\$15,000	\$15,000
Forebay One	1	EA	\$5,800	\$5,800
Forebay Two	1	EA	\$9,100	\$9,100
Concrete Access Ramp	14	CY	\$714	\$9,996
Spillway	54	LF	\$125	\$6,750
Soil Rap	3.7	CY	\$535	\$1,980
Trickle Pan	125	LF	\$96	\$12,000
Safety Railing	192	LF	\$55	\$10,560
Detention Basin Retaining Wall	44	CY	\$714	\$31,416
			Sub- Total	\$102,602
				\$178,530

VI. CONCLUSIONS

The criteria used to design the storm water runoff volumes are formulas and figures within the City of Colorado Springs Drainage Manuals as well as the Mile High Flood District Drainage Criteria manual. Grading practices for optimal drainage shall comply with the geotechnical investigative report and City standards. The development of Lots 3a is within compliance and standards and meets the requirements for the Northcrest Center. The difference between Basin H-1 and Basins D-1 through D-8 results in an overall increase of the 100-year storm Water volume of 4.3 cfs overall due to increased impervious surfaces.

3.09 acres (71.7% imperviousness) of on-site flows, and 0.23 acres of off-site flows drain to the Full Spectrum Detention Basin, with a total runoff of 15.4 cfs (100-yr storm) being captured.

The proposed grading and drainage is within substantial conformance for the master drainage plan for the Subdivision and Drainage Basin. There is no impact on major drainageway planning studies within the larger drainage basin. This development will not adversely affect downstream development.

VII. REFERENCES

El Paso County & Colorado Springs Drainage Manual Volumes I & II (May 2014)

El Paso County Engineering Criteria Manual, El Paso County, Colorado, (Rev. 12/16/2013)

Colorado Urban Drainage and Flood Control District Drainage Criteria Manual, Volume I (August 2018)

Colorado Urban Drainage and Flood Control District Drainage Criteria Manual, Volume III (April 2018)

Urban Storm Drainage Criteria Manual, Volume III (November, 2015)

West Fork Jimmy Camp Creek Drainage Basin Planning Study, prepared by Kiowa Engineering Corporation, dated October 17, 2003.

City of Colorado Springs and El Paso County Flood Insurance Study, prepared by the Federal Emergency Management Agency, dated March 1997.

Soil Survey of El Paso County Area, Colorado, prepared by United States Department of Agriculture Soil Conservation Service, dated June 1981.

FEMA Flood Online Map Service Center

United States Department of Agriculture National Resources Conservation Service

Subsurface Soil Investigation prepared by RMG-Rocky Mountain Group Engineers dated February 23, 2021

APPENDIX TABLE OF CONTENTS

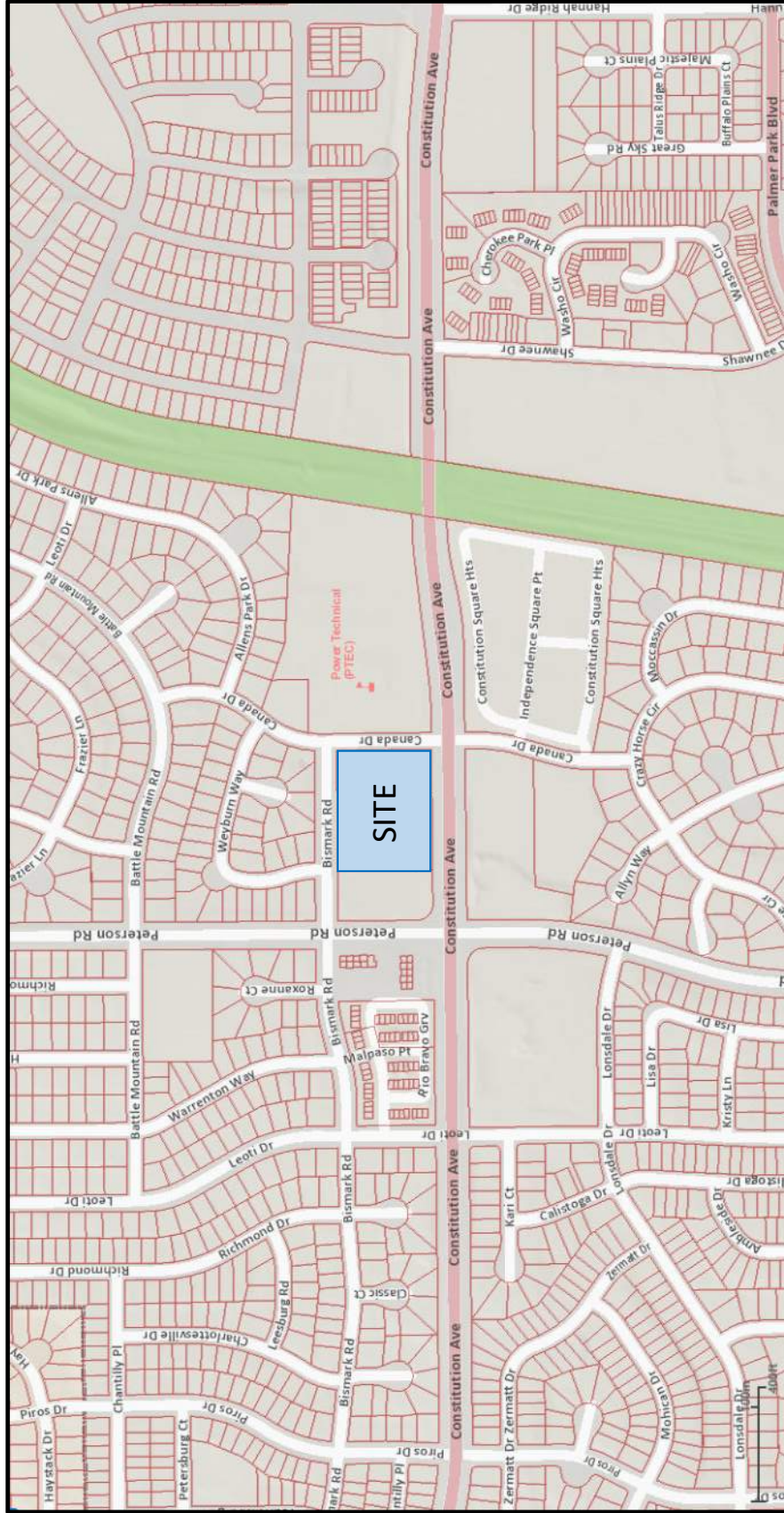
APPENDIX A

Figure 1: Vicinity Map

Figure 2: Soils Map

FEMA Flood Insurance Rate Map

VICINITY MAP
NORTHCREST CENTER
TBD BISMARK ROAD
COLORADO SPRINGS, COLORADO 80922
EL PASO COUNTY





LWKRWV %DVHDPRGOHVWLRQ %
 #CHS 9 \$
 LWK%RUHBMK #R1\$ 8 9 9 \$
 \$HODVURU)ORRGA

\$0000 &00H)ORRG-EDUG \$JHV
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XVXUH 800L WLRV) \$0000
 &00H)ORRG-EDUG #RH;
 \$JHZWK68H)ORRG \$WGHWR
 HHH 6H)RWHV #RH;
 \$JHZWK0ORRG \$WGHWRH)H #RH;

\$JDR D0LBD)ORRG-EDUG #RH;
 (H)WLVH
 \$JDR 88H)WUEQ)ORRG-EDUG #RH;
 &0000 &0YHUW RU 8VURR0U
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\$JRV 8VRLR)ZWK\$0000 &00H
 DVHU 6U)RHO)H)WLRQ
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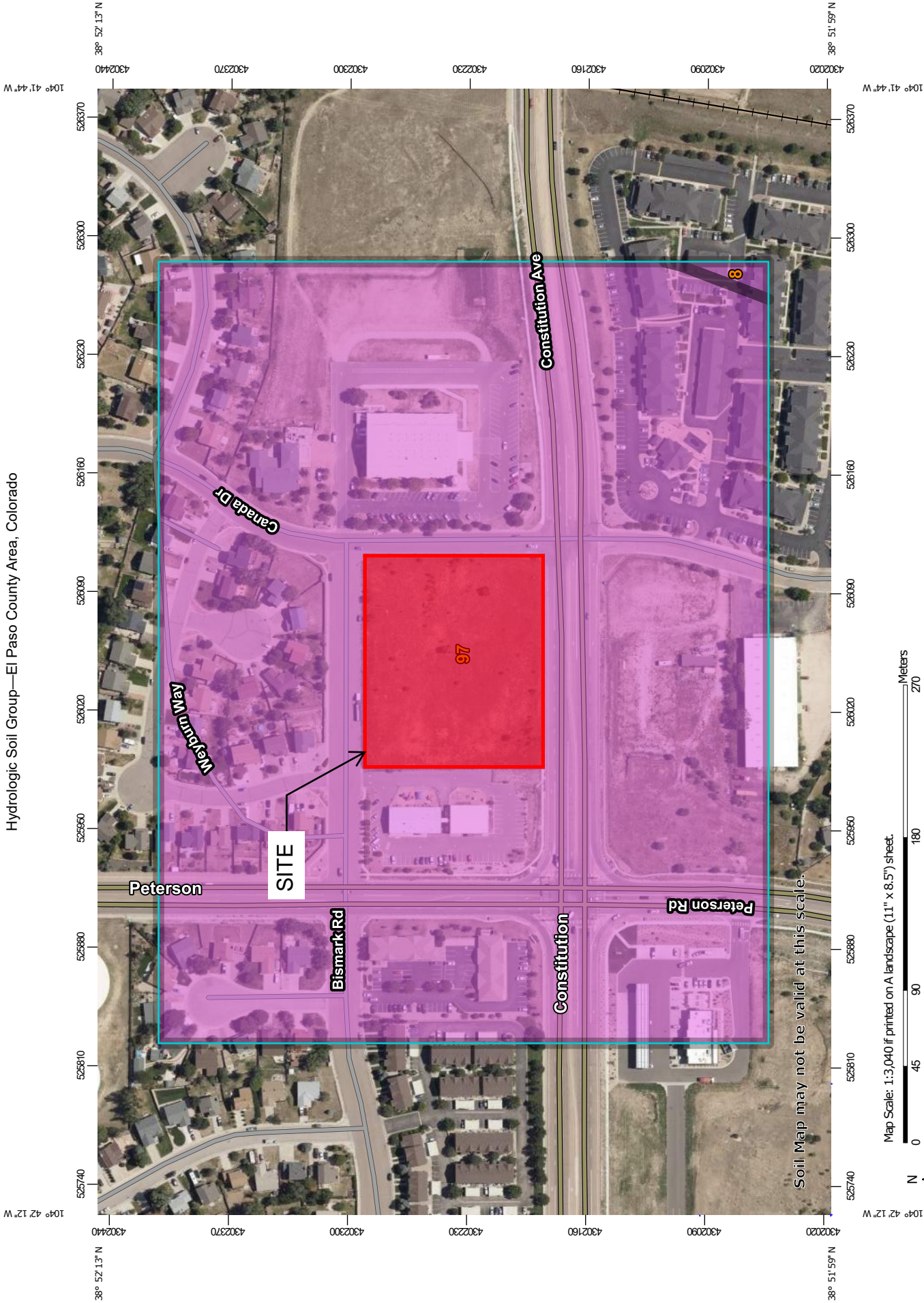
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




Soil Map may not be valid at this scale.

Map Scale: 1:3,040 if printed on A landscape (11" x 8.5") sheet.



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

MAP LEGEND

Area of Interest (AOI)	 C
Soils	 C/D
Area of Interest (AOI)	 D
Soil Rating Polygons	 Not rated or not available
Soil Rating Lines	 Streams and Canals
Soil Rating Polygons	 Rails
Soil Rating Lines	 Interstate Highways
Soil Rating Polygons	US Routes
Soil Rating Lines	Major Roads
Soil Rating Polygons	Local Roads
Soil Rating Lines	Aerial Photography
Soil Rating Polygons	Background

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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: El Paso County Area, Colorado
 Survey Area Data: Version 18, 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: Aug 19, 2018—Sep 23, 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.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
8	Blakeland loamy sand, 1 to 9 percent slopes	A	0.2	0.4%
97	Truckton sandy loam, 3 to 9 percent slopes	A	40.9	99.6%
Totals for Area of Interest			41.1	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

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

APPENDIX B

Hydrologic Calculations

Existing Condition – Runoff Co-eff, Time of Concentration and Runoff Calcs
Developed Condition – Runoff Co-eff, Time of Concentration and Runoff Calcs
Full Spectrum Detention Basin/Extended Detention Basin
Detention Volume and Emergency Spillway
Outlet Structure Calculations
Trickle Channel Capacity and Outlet Structure Sizing
Forebay Sizing Calculations
MHFD Inlet Summaries & Calculations

**Existing Time of Concentration Calculation
Existing Condition**

EXISTING TIME OF CONCENTRATION SUMMARY

Sub-Basin Data			Time of Concentration Estimate										Final t_c		
Basin / Design Point	Contributing Basins	Area	C_s	Up Elev	Down Elev	Initial/Overland Time (t_i)		Travel Time (t_t)			Comp. t_c				
						Length	Slope	t_i	Length	Slope	Land Type	Cv	Velocity	t_t	
Cheyenne Creek to Fountain Creek Tributary															
O-1	Off-Site:	0.23ac	0.73	6534.00	6528.70	100lf	5.3%	3.9 min.	182lf	4.5%	SP	7	1.5 ft/sec	2.0 min.	6.0 min.
O-2	Off-Site:	0.07ac	0.09	6530.00	6529.00	9lf	11.1%	2.5 min.	1lf	10.0%	SP	7	2.2 ft/sec	0.0 min.	5.0 min.
O-3	Off-Site:	0.06ac	0.09	6511.00	6510.00	9lf	11.1%	2.5 min.	1lf	10.0%	SP	7	2.2 ft/sec	0.0 min.	5.0 min.
O-4	Off-Site:	0.07ac	0.09	6515.00	6514.00	9lf	11.1%	2.5 min.	1lf	10.0%	SP	7	2.2 ft/sec	0.0 min.	5.0 min.
H-1	On-Site:	3.25ac	0.10	6532.00	6528.00	100lf	4.0%	11.5 min.	457lf	4.4%	SP	7	1.5 ft/sec	5.2 min.	16.7 min.
Summary															

Equations:

t_i (Overland) = $0.395(1.1 - C_s)L^{0.5} S^{-0.333}$
(DCM Equation 6-8) Where:

C_s = Runoff coefficient for 5-year

L = Length of overland flow (ft)

S = Average basin slope (ft/ft)

t_t (1st DP) = $(18-15i) + L_t / (60(24+12)S^0.5)$ Where:

t_t (1st DP) = First DP Time of Concentration in urban catchments

L_t = Length of Flow Path

i = imperviousness (expressed as a decimal)

$t_t = L_t / 60KS^{0.5}$ Where:

t_t = Channelized flow time (travel time)(min.)

L_t = Waterway length (ft)

K = Conveyance Factor (see DCM Table 6-7)

S = Watercourse slope (ft/ft)

City of Colorado Springs DCM Table 6-7

Type of Land Surface	Land Type	K
Grassed Waterway	GW	15
Heavy Meadow	HM	2.5
Nearly Bare Ground	NBG	10
Paved Area/Swales	PV	20
Riprap (Not Buried)	RR	6.5
Short Pasture/Lawns	SP	7
Tillage/Fields	TF	5

Runoff Calculation Developed Condition

Basin / Design Point	Contributing Basins	Drainage Area	C ₅	C ₁₀₀	Time of Concentration	Rainfall Intensity i ₅	Rainfall Intensity i ₁₀₀	Q ₅	Q ₁₀₀	Basin / DP
Off-Site										
O-1	0-1	0.23 ac	0.73	0.83	6.0 min.	4.9 in/hr	8.2 in/hr	0.8 cfs	1.6 cfs	
O-2	0-2	0.07 ac	0.09	0.36	5.0 min.	5.2 in/hr	8.7 in/hr	0.0 cfs	0.2 cfs	
O-3	0-3	0.06 ac	0.09	0.36	5.0 min.	5.2 in/hr	8.7 in/hr	0.0 cfs	0.2 cfs	
O-4	0-4	0.07 ac	0.09	0.36	5.0 min.	5.2 in/hr	8.7 in/hr	0.0 cfs	0.2 cfs	
		0.43 ac						0.9 cfs	2.2 cfs	
On-Site										
H-1	0-4	3.25 ac	0.10	0.37	5.0 min.	5.2 in/hr	8.7 in/hr	1.7 cfs	10.4 cfs	H-1
						SUM:		1.7 cfs	10.4 cfs	

Design Point Summary		Weighted	Lagged	Rainfall Intensity	Q ₅	Q ₁₀₀
DP-1	0-1 & H-1	0.14	0.35	4.9 in/hr 8.2 in/hr	2.5 cfs	9.9 cfs
				Summ:	2.7 cfs	12.6 cfs

Equations (taken from Fig 6-5, City of Colorado Springs DCM):

$$i_2 = -1.19 \ln(T_c) + 6.035$$

$$i_5 = -1.50 \ln(T_c) + 7.583$$

$$i_{10} = -1.75 \ln(T_c) + 8.847$$

$$i_{25} = -2.00 \ln(T_c) + 10.111$$

$$Q = CIA$$

Q = Peak Runoff Rate (cubic feet/second)

C = Runoff coef representing a ratio of peak runoff rate to ave rainfall intensity for a duration equal to the runoff time of concentration.

P1	Inches
WQCV	0.60 in
2 yr	1.19 in
5 yr	1.50 in
10 yr	1.75 in

Runoff Coefficient and Percent Impervious Calculation
Developed Condition

DEVELOPED RUNOFF COEFFICIENT SUMMARY

Basin / DP	Basin or DP Area (DP contributing basins)	Soil Type	Area 1 Land Use		Area 2 Land Use		Area 3 Land Use		Area 4 Land Use		Area 5 Land Use		Basin Runoff Coefficient						
			Imperv %	Comp Land Use %	Imperv %	Comp Land Use %	Imperv %	Comp Land Use %	Imperv %	Comp Land Use %	Imperv %	Comp Land Use %	C2	C5	C10	C100			
Non-Tributary to Detention Basin (Exempt - Not capturable by grade - primarily New Public Sidewalk)																			
O-2	3,111 sf	A	100%	0.04ac	62%	2%	0.03ac	38%	1%	80%	0.00ac	0%	0%	0.00ac	0%	0%	0.56	0.63	0.73
O-3	2,437 sf	A	100%	0.01ac	23%	2%	0.03ac	51%	1%	80%	0.00ac	0%	0%	0.00ac	0%	0%	0.45	0.49	0.66
O-4	3,119 sf	A	100%	0.05ac	73%	2%	0.02ac	27%	1%	80%	0.00ac	0%	0%	0.00ac	0%	0%	0.66	0.69	0.80
Tributary to Detention Basin (Full Spectrum EDP Treatment)																			
O-1	10,178 sf	A	100%	0.16ac	71%	2%	0.04ac	15%	0%	80%	0.03ac	14%	11%	0.00ac	0%	0%	0.71	0.73	0.83
D-1	24,299 sf	A	100%	0.00ac	0%	2%	0.17ac	30%	1%	80%	0.00ac	0%	0%	0.00ac	0%	0%	0.51	0.54	0.68
D-2	32,548 sf	A	100%	0.39ac	52%	2%	0.02ac	3%	0%	90%	0.34ac	45%	41%	0.00ac	3%	3%	0.81	0.83	0.90
D-3	3,384 sf	A	100%	0.07ac	85%	2%	0.01ac	15%	0%	80%	0.00ac	0%	0%	0.00ac	0%	0%	0.76	0.78	0.81
D-4	42,621 sf	A	100%	0.54ac	55%	2%	0.05ac	5%	0%	80%	0.00ac	0%	0%	0.00ac	0%	0%	0.77	0.78	0.80
D-5	19,996 sf	A	100%	0.00ac	0%	2%	0.12ac	26%	1%	80%	0.00ac	0%	0%	0.00ac	1%	1%	0.53	0.56	0.60
D-6	5,129 sf	A	100%	0.02ac	17%	2%	0.10ac	83%	2%	80%	0.00ac	0%	0%	0.00ac	3%	3%	0.20	0.25	0.32
D-7	6,421 sf	A	100%	0.07ac	50%	2%	0.05ac	35%	1%	80%	0.00ac	0%	0%	0.00ac	2%	2%	0.47	0.50	0.62
D-8	7,000 sf	A	100%	0.00ac	0%	2%	0.15ac	92%	2%	80%	0.00ac	0%	0%	0.00ac	0%	0%	0.10	0.15	0.23
On-Site Summary	122,840 sf	A	100 %	0.99ac	31 %	2 %	0.36ac	11 %	0 %	80 %	0.00ac	0 %	0 %	1.43ac	44 %	##	0.60	0.62	0.70
Tributary to Detention Basin:																			
Basin Runoff Coefficient is a weighted average																			
Runoff Coefficients and Percents Impervious (DCM Table 6-6)																			
Land Use	Hydrologic Soil Type	%	C2	C5	C10	C25	C50	C100	Runoff Coef Calc Method: Weighted										
Business: Downtown	Bbb	95%	0.79	0.81	0.83	0.85	0.87	0.88	Area 1	Area 2	Area 3	Area 4	Area 5	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv
Business: Suburban	BS	70%	0.45	0.49	0.53	0.58	0.60	0.62	Area 1	Area 2	Area 3	Area 4	Area 5	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv
Drives and Walks	DR	100%	0.89	0.90	0.92	0.94	0.95	0.96	Area 1	Area 2	Area 3	Area 4	Area 5	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv
Streets - Gravel (Packed)	GR	80%	0.57	0.59	0.63	0.66	0.68	0.70	Area 1	Area 2	Area 3	Area 4	Area 5	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv
Historic Flow Analysis	HI	2%	0.03	0.09	0.17	0.26	0.31	0.36	Area 1	Area 2	Area 3	Area 4	Area 5	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv
Lawns (match Historic Flow)	LA	2%	0.03	0.09	0.17	0.26	0.31	0.36	Area 1	Area 2	Area 3	Area 4	Area 5	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv
Off-site (low-Undeveloped)	OF	45%	0.26	0.32	0.38	0.44	0.48	0.56	Area 1	Area 2	Area 3	Area 4	Area 5	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv
Park	PA	7%	0.05	0.12	0.20	0.30	0.34	0.39	Area 1	Area 2	Area 3	Area 4	Area 5	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv
Streets - Paved	PV	100%	0.89	0.90	0.92	0.94	0.95	0.96	Area 1	Area 2	Area 3	Area 4	Area 5	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv
Roofs	RO	90%	0.71	0.73	0.75	0.78	0.80	0.81	Area 1	Area 2	Area 3	Area 4	Area 5	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv	Basin % Imperv

Equation:
 $Cc = (C1A1 + C2A2 + C3A3 + \dots + CnAn) / At$
 (City of Colorado Springs DCM Equation 6-6) Where:
 Cc = composite runoff coefficient for total area
 Ci = runoff coefficient for subarea (surface type or land use)
 Ai = area of subarea corresponding to Ci
 At = total area of all sub areas
 i = number of surface types in the drainage area

**Time of Concentration Calculation
Developed Condition**

EXISTING TIME OF CONCENTRATION SUMMARY

Basin / Design Point	Contributing Basins	Area	C _s	Time of Concentration Estimate										Final t _c			
				Sub-Basin Data		Initial/Overland Time (t _i)		Travel Time (t _t)				Comp.					
				Down Elev	Up Elev	Length	Slope	t _i	Elev	Elev	Length	Slope	Land Type		Cv	Velocity	t _t
Non-Tributary to Detention																	
O-2	Off-Site:	0.07ac	0.59	6530.50	6530.00	101f	5.0%	1.7 min.	6530.00	6511.00	3901f	4.9%	PV	20	4.4 ft/sec	1.5 min.	5.0 min.
O-3	Off-Site:	0.06ac	0.49	6510.50	6510.00	101f	5.0%	2.1 min.	6510.00	6507.50	2901f	0.9%	PV	20	1.9 ft/sec	2.6 min.	5.0 min.
O-4	Off-Site:	0.07ac	0.69	6517.00	6516.50	101f	5.0%	1.4 min.	6516.50	6508.00	3901f	2.2%	PV	20	3.0 ft/sec	2.2 min.	5.0 min.
Tributary to Detention																	
O-1	Off-Site:	0.23ac	0.73	6534.00	6528.70	1001f	5.3%	3.9 min.	6528.70	6520.50	1821f	4.5%	SP	7	1.5 ft/sec	2.0 min.	5.9 min.
D-1	On-Site:	0.56ac	0.54	6531.75	6525.25	1001f	6.5%	5.5 min.	6525.25	6512.50	3021f	4.2%	GW	15	3.1 ft/sec	1.6 min.	7.1 min.
D-2	On-Site:	0.75ac	0.83	6531.75	6527.50	651f	6.5%	2.1 min.	6527.50	6512.25	3651f	4.2%	PV	20	4.1 ft/sec	1.5 min.	5.0 min.
D-3	On-Site:	0.08ac	0.78	6513.75	6512.75	361f	2.8%	2.5 min.	6512.75	6509.25	201f	17.5%	SP	7	2.9 ft/sec	0.1 min.	5.0 min.
D-4	On-Site:	0.98ac	0.78	6528.00	6522.00	341f	17.6%	1.3 min.	6522.00	6512.50	4301f	2.2%	PV	20	3.0 ft/sec	2.4 min.	5.0 min.
D-5	On-Site:	0.46ac	0.56	6522.00	6520.00	241f	8.3%	2.4 min.	6520.00	6513.75	3501f	1.8%	GW	15	2.0 ft/sec	2.9 min.	5.3 min.
D-6	On-Site:	0.12ac	0.25	6513.75	6509.00	421f	11.3%	4.5 min.	6509.00	6507.50	1021f	1.5%	GW	15	1.8 ft/sec	0.9 min.	5.4 min.
D-7	On-Site:	0.15ac	0.50	6512.75	6509.50	641f	5.1%	5.1 min.	6509.50	6507.75	1651f	1.1%	PV	20	2.1 ft/sec	1.3 min.	6.5 min.
D-8	On-Site:	0.16ac	0.15	6513.50	6509.75	301f	12.5%	4.1 min.	6509.75	6508.25	401f	3.8%	SP	7	1.4 ft/sec	0.5 min.	5.0 min.
Summary		3.25ac									Dev TC						

Equations:

t_i (Overland) = 0.395(1.1-C_s)L_i^{0.5} S^{-0.333}

(DCM Equation 6-8) Where:

C_s = Runoff coefficient for 5-year

L_i = Length of overland flow (ft)

S = Average basin slope (ft/ft)

t_t (1st DP) = (18-15i) + L_i / (60 (24+12i)^{0.5}) Where:

t_t (1st DP) = First DP Time of Concentration in urban catchments

L_i = Length of Flow Path

i = imperviousness (expressed as a decimal)

t_t = L_i / 60KS^{0.5} Where:

t_t = Channelized flow time (travel time)(min.)

L_i = Waterway length (ft)

K = Conveyance Factor (see DCM Table 6-7)

S = Watercourse slope (ft/ft)

City of Colorado Springs DCM Table 6-7

Type of Land Surface	Land Type	K
Grassed Waterway	GW	15
Heavy Meadow	HM	2.5
Nearly Bare Ground	NBG	10
Paved Area/Swales	PV	20
Riprap (Not Buried)	RR	6.5
Short Pasture/Lawns	SP	7
Tillage/Fields	TF	5

**Runoff Calculation
Developed Condition**

Basin / Design Point	Contributing Basins	Drainage Area	C ₂	C ₅	C ₁₀₀	Time of Concentration	Rainfall Intensity		Runoff Q _{WQCV}	Q ₂	Q ₅	Q ₁₀₀	Basin / DP
							i ₅	i ₁₀₀					
Northcrest Center													
Non-Tributary Offsite Flow													
0-2	0-2	0.07 ac	0.56	0.59	0.73	5.0 min.	5.2 in/hr	8.7 in/hr	0.1 cfs	0.2 cfs	0.5 cfs	0-2	
0-3	0-3	0.06 ac	0.45	0.49	0.66	10.0 min.	4.1 in/hr	6.9 in/hr	0.0 cfs	0.1 cfs	0.3 cfs	0-3	
0-4	0-4	0.07 ac	0.66	0.69	0.80	5.0 min.	5.2 in/hr	8.7 in/hr	0.1 cfs	0.2 cfs	0.5 cfs	0-4	
Tributary Flows (Offsite and On-Site)													
Offsite Flow													
DP-1	D-1	0.23 ac	0.71	0.73	0.83	5.9 min.	4.9 in/hr	8.3 in/hr	0.3 cfs	0.7 cfs	1.6 cfs	0-1	
DP-2	D-2	0.56 ac	0.51	0.54	0.68	7.1 min.	4.6 in/hr	7.8 in/hr	0.5 cfs	1.1 cfs	3.0 cfs	DP-1	
DP-3	D-3	0.75 ac	0.81	0.83	0.90	5.0 min.	5.2 in/hr	8.7 in/hr	1.2 cfs	2.5 cfs	5.9 cfs	DP-2	
DP-4	D-4	0.08 ac	0.76	0.78	0.87	5.0 min.	5.2 in/hr	8.7 in/hr	0.1 cfs	0.2 cfs	0.6 cfs	DP-3	
DP-5	D-5	0.98 ac	0.77	0.78	0.86	5.0 min.	5.2 in/hr	8.7 in/hr	1.5 cfs	3.1 cfs	7.3 cfs	DP-4	
DP-6	D-6	0.46 ac	0.53	0.56	0.69	5.3 min.	5.1 in/hr	8.5 in/hr	0.5 cfs	1.0 cfs	2.7 cfs	DP-5	
DP-7	D-7	0.12 ac	0.20	0.25	0.49	5.4 min.	5.0 in/hr	8.5 in/hr	0.0 cfs	0.1 cfs	0.5 cfs	DP-5	
DP-8	D-8	0.15 ac	0.47	0.25	0.49	6.5 min.	4.8 in/hr	8.0 in/hr	0.1 cfs	0.3 cfs	0.6 cfs	DP-7	
		0.16 ac	0.10	0.50	0.62	5.0 min.	5.2 in/hr	8.7 in/hr	0.0 cfs	0.1 cfs	0.4 cfs	DP-8	
		Tributary Summary:	0.60	0.62	0.70	13.0 min.	Detention Basin:		4.2 cfs	8.4 cfs	10.9 cfs	20.9 cfs	Detained Only

Design Point Summary	Weighted	Lagged	Rainfall Intensity	QWQCV	Q2	Q5	Q100
DP-1	0.54	7.1 min.	4.6 in/hr			1.4 cfs	3.0 cfs
DP-2	0.71	7.1 min.	4.6 in/hr			4.3 cfs	8.2 cfs
DP-3	0.78	7.1 min.	4.6 in/hr			0.3 cfs	0.5 cfs
DP-4	0.74	13.0 min.	3.7 in/hr			6.9 cfs	13.1 cfs
DP-5	0.56	5.3 min.	5.1 in/hr			1.3 cfs	2.7 cfs
DP-6	0.69	13.0 min.	3.7 in/hr			8.0 cfs	15.4 cfs
DP-7	0.25	6.5 min.	4.8 in/hr			0.2 cfs	0.6 cfs
DP-8	0.50	5.0 min.	5.2 in/hr			0.4 cfs	0.9 cfs
ALL	0.62	13.0 min.		Disturbed Area Summary:		8.6 cfs	16.9 cfs

Equations (taken from Fig 6-5, City of Colorado Springs DCM):

$$i_2 = -1.19 \ln(T_c) + 6.035$$

$$i_5 = -1.50 \ln(T_c) + 7.583$$

$$i_{10} = -1.75 \ln(T_c) + 8.847$$

$$i_{25} = -2.00 \ln(T_c) + 10.111$$

$$i_{50} = -2.25 \ln(T_c) + 11.375$$

$$i_{100} = -2.52 \ln(T_c) + 12.735$$

$$Q = CIA$$

Q = Peak Runoff Rate (cubic feet/second)

C = Runoff coef representing a ratio of peak runoff rate to ave rainfall intensity for a duration equal to the runoff time of concentration.

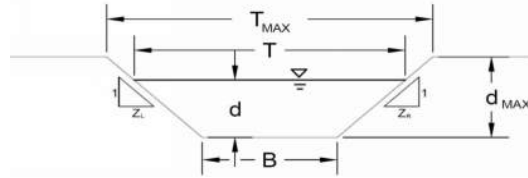
i = average rainfall intensity in inches per hour

A = Drainage area in acres

P1	Inches
WQCV	0.60 in
2 yr	1.19 in
5 yr	1.50 in
10 yr	1.75 in
25 yr	2.00 in
50 yr	2.25 in
100 yr	2.52 in

AREA INLET IN A SWALE

DP1



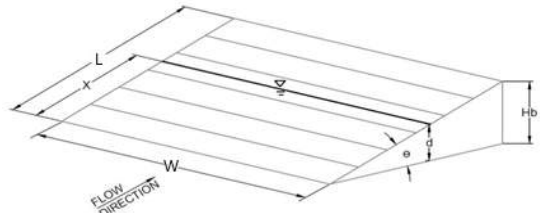
This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)		
NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E = <input type="text" value="D"/>	
Manning's n (Leave cell D16 blank to manually enter an n value)	n = <input type="text" value="see details below"/> ft/ft	
Channel Invert Slope	S ₀ = <input type="text" value="0.0500"/> ft/ft	
Bottom Width	B = <input type="text" value="5.00"/> ft	
Left Side Slope	Z1 = <input type="text" value="4.00"/> ft/ft	
Right Side Slope	Z2 = <input type="text" value="4.00"/> ft/ft	
Check one of the following soil types:		
Soil Type:	Max. Velocity (V _{MAX})	Max Froude No. (F _{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A
Choose One:		
<input checked="" type="checkbox"/> Non-Cohesive <input type="checkbox"/> Cohesive <input type="checkbox"/> Paved		
Maximum Allowable Top Width of Channel for Minor & Major Storm	Minor Storm	Major Storm
T _{MAX} =	<input type="text" value="7.50"/>	<input type="text" value="8.00"/>
Maximum Allowable Water Depth in Channel for Minor & Major Storm	Minor Storm	Major Storm
d _{MAX} =	<input type="text" value="0.33"/>	<input type="text" value="0.50"/>
ft		
Allowable Channel Capacity Based On Channel Geometry		
MINOR STORM Allowable Capacity is based on Top Width Criterion		
MAJOR STORM Allowable Capacity is based on Top Width Criterion		
Choose One:		
<input checked="" type="checkbox"/> Non-Cohesive <input type="checkbox"/> Cohesive <input type="checkbox"/> Paved		
Water Depth in Channel Based On Design Peak Flow	Minor Storm	Major Storm
Design Peak Flow	<input type="text" value="2.9"/>	<input type="text" value="5.2"/>
Water Depth	Minor Storm	Major Storm
Q _o =	<input type="text" value="0.31"/>	<input type="text" value="0.38"/>
d =	<input type="text" value="1.4"/>	<input type="text" value="3.0"/>
	<input type="text" value="0.25"/>	<input type="text" value="0.32"/>
ft		
cfs		
<p style="color: red; font-weight: bold;">Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'</p> <p style="color: red; font-weight: bold;">Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'</p>		

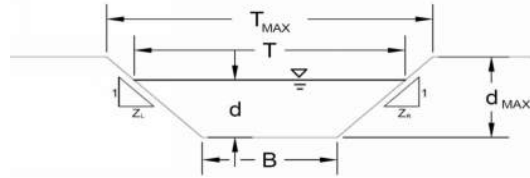
AREA INLET IN A SWALE

DP1

Inlet Design Information (Input)																					
Type of Inlet User-Defined	Inlet Type = User-Defined																				
Angle of Inclined Grate (must be <= 30 degrees)	$\theta = 0.00$ degrees																				
Width of Grate	$W = 3.00$ ft																				
Length of Grate	$L = 3.00$ ft																				
Open Area Ratio	$A_{RATIO} = 0.70$																				
Height of Inclined Grate	$H_b = 0.00$ ft																				
Clogging Factor	$C_f = 0.50$																				
Grate Discharge Coefficient	$C_d = N/A$																				
Orifice Coefficient	$C_o = 0.64$																				
Weir Coefficient	$C_w = 2.05$																				
																					
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th></th> <th>MINOR</th> <th>MAJOR</th> <th></th> </tr> </thead> <tbody> <tr> <td>$d =$</td> <td>0.25</td> <td>0.32</td> <td></td> </tr> <tr> <td>$Q_a =$</td> <td>2.4</td> <td>3.3</td> <td>cfs</td> </tr> <tr> <td>$Q_b =$</td> <td>0.0</td> <td>0.0</td> <td>cfs</td> </tr> <tr> <td>$C\% =$</td> <td>100</td> <td>100</td> <td>%</td> </tr> </tbody> </table>		MINOR	MAJOR		$d =$	0.25	0.32		$Q_a =$	2.4	3.3	cfs	$Q_b =$	0.0	0.0	cfs	$C\% =$	100	100	%
	MINOR	MAJOR																			
$d =$	0.25	0.32																			
$Q_a =$	2.4	3.3	cfs																		
$Q_b =$	0.0	0.0	cfs																		
$C\% =$	100	100	%																		
Total Inlet Interception Capacity (assumes clogged condition)																					
Bypassed Flow																					
Capture Percentage = Q_a/Q_o																					

AREA INLET IN A SWALE

DP2



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)		
NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =	
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	0.012
Channel Invert Slope	S ₀ =	0.0400 ft/ft
Bottom Width	B =	0.00 ft
Left Side Slope	Z1 =	25.00 ft/ft
Right Side Slope	Z2 =	25.00 ft/ft
Check one of the following soil types:		
Soil Type:	Max. Velocity (V _{MAX})	Max Froude No. (F _{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A
Choose One:		
<input type="checkbox"/> Non-Cohesive		
<input type="checkbox"/> Cohesive		
<input checked="" type="checkbox"/> Paved		
Maximum Allowable Top Width of Channel for Minor & Major Storm	Minor Storm	Major Storm
T _{MAX} =	9.00	12.00 ft
Maximum Allowable Water Depth in Channel for Minor & Major Storm	Minor Storm	Major Storm
d _{MAX} =	0.25	0.33 ft
Allowable Channel Capacity Based On Channel Geometry		
MINOR STORM Allowable Capacity is based on Top Width Criterion		
MAJOR STORM Allowable Capacity is based on Top Width Criterion		
Water Depth in Channel Based On Design Peak Flow		
Design Peak Flow	Minor Storm	Major Storm
Q _o =	3.2	5.9 cfs
Water Depth	Minor Storm	Major Storm
d =	0.16	0.21 ft
Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'		
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'		

AREA INLET IN A SWALE

DP2

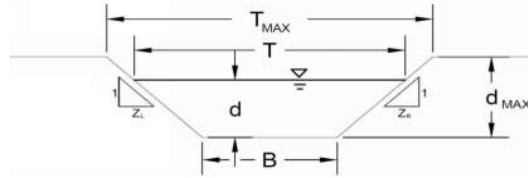
Inlet Design Information (Input)	
Type of Inlet CDOT Type C (Depressed) ▼	Inlet Type = CDOT Type C (Depressed)
Angle of Inclined Grate (must be <= 30 degrees)	$\theta = 0.00$ degrees
Width of Grate	$W = 3.00$ ft
Length of Grate	$L = 3.00$ ft
Open Area Ratio	$A_{RATIO} = 0.70$
Height of Inclined Grate	$H_b = 0.00$ ft
Clogging Factor	$C_f = 0.50$
Grate Discharge Coefficient	$C_d = 0.84$
Orifice Coefficient	$C_o = 0.56$
Weir Coefficient	$C_w = 1.81$

	MINOR	MAJOR	
$d =$	1.16	1.21	
$Q_a =$	15.4	15.6	cfs
$Q_b =$	0.0	0.0	cfs
$C\% =$	100	100	%

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	
Total Inlet Interception Capacity (assumes clogged condition)	
Bypassed Flow	
Capture Percentage = Q_a/Q_o	

AREA INLET IN A SWALE

DP4



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)		
NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =	
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	0.012
Channel Invert Slope	S ₀ =	0.0214 ft/ft
Bottom Width	B =	0.00 ft
Left Side Slope	Z1 =	25.00 ft/ft
Right Side Slope	Z2 =	25.00 ft/ft
Check one of the following soil types:		
Soil Type:	Max. Velocity (V _{MAX})	Max Froude No. (F _{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A
Choose One:		
<input type="checkbox"/> Non-Cohesive		
<input type="checkbox"/> Cohesive		
<input checked="" type="checkbox"/> Paved		
Maximum Allowable Top Width of Channel for Minor & Major Storm	Minor Storm	Major Storm
T _{MAX} =	12.00	15.00 ft
Maximum Allowable Water Depth in Channel for Minor & Major Storm	Minor Storm	Major Storm
d _{MAX} =	0.25	0.33 ft
Allowable Channel Capacity Based On Channel Geometry		
MINOR STORM Allowable Capacity is based on Top Width Criterion		
MAJOR STORM Allowable Capacity is based on Top Width Criterion		
Water Depth in Channel Based On Design Peak Flow		
Design Peak Flow	Minor Storm	Major Storm
Q _o =	4.0	7.3 cfs
Water Depth	Minor Storm	Major Storm
d =	0.20	0.25 ft
Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'		
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'		

AREA INLET IN A SWALE

DP4

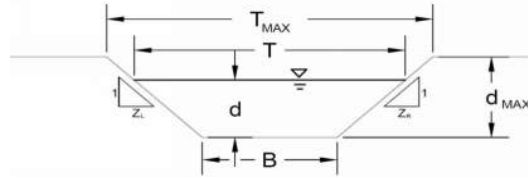
Inlet Design Information (Input)	
Type of Inlet CDOT Type C (Depressed) ▼	Inlet Type = CDOT Type C (Depressed)
Angle of Inclined Grate (must be <= 30 degrees)	$\theta = 0.00$ degrees
Width of Grate	$W = 3.00$ ft
Length of Grate	$L = 3.00$ ft
Open Area Ratio	$A_{RATIO} = 0.70$
Height of Inclined Grate	$H_B = 0.00$ ft
Clogging Factor	$C_f = 0.50$
Grate Discharge Coefficient	$C_d = 0.84$
Orifice Coefficient	$C_o = 0.56$
Weir Coefficient	$C_w = 1.81$

	MINOR	MAJOR	
$d =$	1.20	1.25	
$Q_a =$	15.6	15.9	cfs
$Q_b =$	0.0	0.0	cfs
$C\% =$	100	100	%

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	
Total Inlet Interception Capacity (assumes clogged condition)	
Bypassed Flow	
Capture Percentage = Q_a/Q_o	

AREA INLET IN A SWALE

D5



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)		
NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =	
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	0.013
Channel Invert Slope	S ₀ =	75.0000 ft/ft
Bottom Width	B =	6.00 ft
Left Side Slope	Z1 =	25.00 ft/ft
Right Side Slope	Z2 =	25.00 ft/ft
Check one of the following soil types:		
Soil Type:	Max. Velocity (V _{MAX})	Max Froude No. (F _{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A
Choose One:		
<input type="checkbox"/> Non-Cohesive		
<input type="checkbox"/> Cohesive		
<input checked="" type="checkbox"/> Paved		
Maximum Allowable Top Width of Channel for Minor & Major Storm	Minor Storm	Major Storm
T _{MAX} =	7.00	8.00
Maximum Allowable Water Depth in Channel for Minor & Major Storm	Minor Storm	Major Storm
d _{MAX} =	0.17	0.33
Allowable Channel Capacity Based On Channel Geometry		
MINOR STORM Allowable Capacity is based on Top Width Criterion		
MAJOR STORM Allowable Capacity is based on Top Width Criterion		
Water Depth in Channel Based On Design Peak Flow		
Design Peak Flow	Minor Storm	Major Storm
Q _o =	1.3	2.7
Water Depth	Minor Storm	Major Storm
d =	0.01	0.01
Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'		
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'		

AREA INLET IN A SWALE

D5

Inlet Design Information (Input)	
Type of Inlet	<input type="text" value="CDOT Type C (Depressed)"/>
Inlet Type =	<input type="text" value="CDOT Type C (Depressed)"/>
Angle of Inclined Grate (must be <= 30 degrees)	$\theta = 0.00$ degrees
Width of Grate	$W = 3.00$ ft
Length of Grate	$L = 3.00$ ft
Open Area Ratio	$A_{RATIO} = 0.70$
Height of Inclined Grate	$H_B = 0.00$ ft
Clogging Factor	$C_f = 0.50$
Grate Discharge Coefficient	$C_d = 0.84$
Orifice Coefficient	$C_o = 0.56$
Weir Coefficient	$C_w = 1.81$

	MINOR	MAJOR	
$d =$	1.01	1.01	
$Q_a =$	14.3	14.3	cfs
$Q_b =$	0.0	0.0	cfs
$C\% =$	100	100	%

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	
Total Inlet Interception Capacity (assumes clogged condition)	
Bypassed Flow	
Capture Percentage = Q_a/Q_o	

INLET MANAGEMENT

Worksheet Protected

INLET NAME	DP1	DP2	DP4	D5
Site Type (Urban or Rural)	URBAN	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	AREA	AREA	AREA	AREA
Hydraulic Condition	Swale	Swale	Swale	Swale
Inlet Type	User-Defined	CDOT Type C (Depressed)	CDOT Type C (Depressed)	CDOT Type C (Depressed)

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{known} (cfs)	1.4	3.2	4.0	1.3
Major Q_{known} (cfs)	3.0	5.9	7.3	2.7

Bypass (Carry-Over) Flow from Upstream Inlets must be organized from upstream (left) to downstream (right) in order for bypass flows to be linked.

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)	0.56	0.75	0.98	0.46
Percent Impervious	64.2	95.8	89.9	67
NRCS Soil Type	A	A	A	A

Watershed Profile

Overland Slope (ft/ft)	0.050	0.021	0.021	0.015
Overland Length (ft)	300	300	300	300
Channel Slope (ft/ft)	0.050	0.021	0.021	0.015
Channel Length (ft)	300	300	300	300

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)				
One-Hour Precipitation, P_1 (inches)				

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)				
One-Hour Precipitation, P_1 (inches)				

CALCULATED OUTPUT

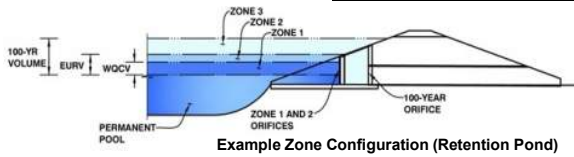
Minor Total Design Peak Flow, Q (cfs)	1.4	3.2	4.0	1.3
Major Total Design Peak Flow, Q (cfs)	3.0	5.9	7.3	2.7
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0	0.0

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: My Garage @ Northcrest Center

Basin ID: EDB - NW Corner Constitution Blvd & Canada Drive - Pond A



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.64	0.075	Orifice Plate
Zone 2 (EURV)	3.73	0.215	Circular Orifice
Σ (100+1/2WQCV)	5.25	0.170	Weir&Pipe (Restrict)
Total (all zones)		0.460	

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

Underdrain Orifice Invert Depth =	<input type="text"/>	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	<input type="text"/>	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	<input type="text"/>	ft ²
Underdrain Orifice Centroid =	<input type="text"/>	feet

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)

Calculated Parameters for Plate

Centroid of Lowest Orifice =	<input type="text" value="0.00"/>	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	<input type="text" value="N/A"/>	ft ²
Depth at top of Zone using Orifice Plate =	<input type="text" value="3.73"/>	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	<input type="text" value="N/A"/>	feet
Orifice Plate: Orifice Vertical Spacing =	<input type="text" value="N/A"/>	inches	Elliptical Slot Centroid =	<input type="text" value="N/A"/>	feet
Orifice Plate: Orifice Area per Row =	<input type="text" value="N/A"/>	sq. inches	Elliptical Slot Area =	<input type="text" value="N/A"/>	ft ²

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	0.60	1.20	1.80	2.40			
Orifice Area (sq. inches)	0.37	0.37	0.65	0.65	0.84			

	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)

Calculated Parameters for Vertical Orifice

	Zone 2 Circular	Not Selected		Zone 2 Circular	Not Selected
Invert of Vertical Orifice =	<input type="text" value="3.10"/>	<input type="text" value="N/A"/>	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	<input type="text" value="0.03"/>
Depth at top of Zone using Vertical Orifice =	<input type="text" value="3.73"/>	<input type="text" value="N/A"/>	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	<input type="text" value="0.10"/>
Vertical Orifice Diameter =	<input type="text" value="2.45"/>	<input type="text" value="N/A"/>	inches		<input type="text" value="N/A"/>

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

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected		Zone 3 Weir	Not Selected
Overflow Weir Front Edge Height, Ho =	<input type="text" value="4.48"/>	<input type="text" value="N/A"/>	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H _t =	<input type="text" value="5.68"/>
Overflow Weir Front Edge Length =	<input type="text" value="4.00"/>	<input type="text" value="N/A"/>	feet	Overflow Weir Slope Length =	<input type="text" value="6.12"/>
Overflow Weir Grate Slope =	<input type="text" value="5:00"/>	<input type="text" value="N/A"/>	H:V	Grate Open Area / 100-yr Orifice Area =	<input type="text" value="73.99"/>
Horiz. Length of Weir Sides =	<input type="text" value="6.00"/>	<input type="text" value="N/A"/>	feet	Overflow Grate Open Area w/o Debris =	<input type="text" value="19.36"/>
Overflow Grate Type =	<input type="text" value="Close Mesh Grate"/>	<input type="text" value="N/A"/>		Overflow Grate Open Area w/ Debris =	<input type="text" value="9.68"/>
Debris Clogging % =	<input type="text" value="50%"/>	<input type="text" value="N/A"/>	%		<input type="text" value="N/A"/>

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

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected		Zone 3 Restrictor	Not Selected
Depth to Invert of Outlet Pipe =	<input type="text" value="0.33"/>	<input type="text" value="N/A"/>	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	<input type="text" value="0.26"/>
Outlet Pipe Diameter =	<input type="text" value="18.00"/>	<input type="text" value="N/A"/>	inches	Outlet Orifice Centroid =	<input type="text" value="0.18"/>
Restrictor Plate Height Above Pipe Invert =	<input type="text" value="3.70"/>	<input type="text" value="N/A"/>	inches	Half-Central Angle of Restrictor Plate on Pipe =	<input type="text" value="0.94"/>

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Calculated Parameters for Spillway

Spillway Invert Stage =	<input type="text" value="4.83"/>	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth =	<input type="text" value="0.17"/>	feet
Spillway Crest Length =	<input type="text" value="50.00"/>	feet	Stage at Top of Freeboard =	<input type="text" value="6.00"/>	feet
Spillway End Slopes =	<input type="text" value="4:00"/>	H:V	Basin Area at Top of Freeboard =	<input type="text" value="0.12"/>	acres
Freeboard above Max Water Surface =	<input type="text" value="1.00"/>	feet	Basin Volume at Top of Freeboard =	<input type="text" value="0.55"/>	acre-ft

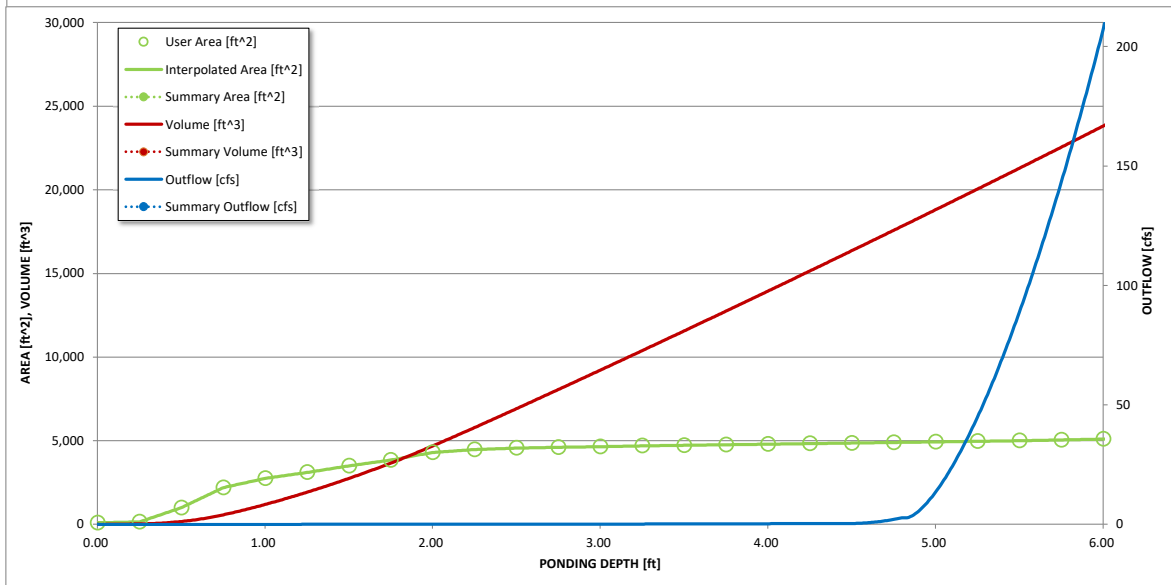
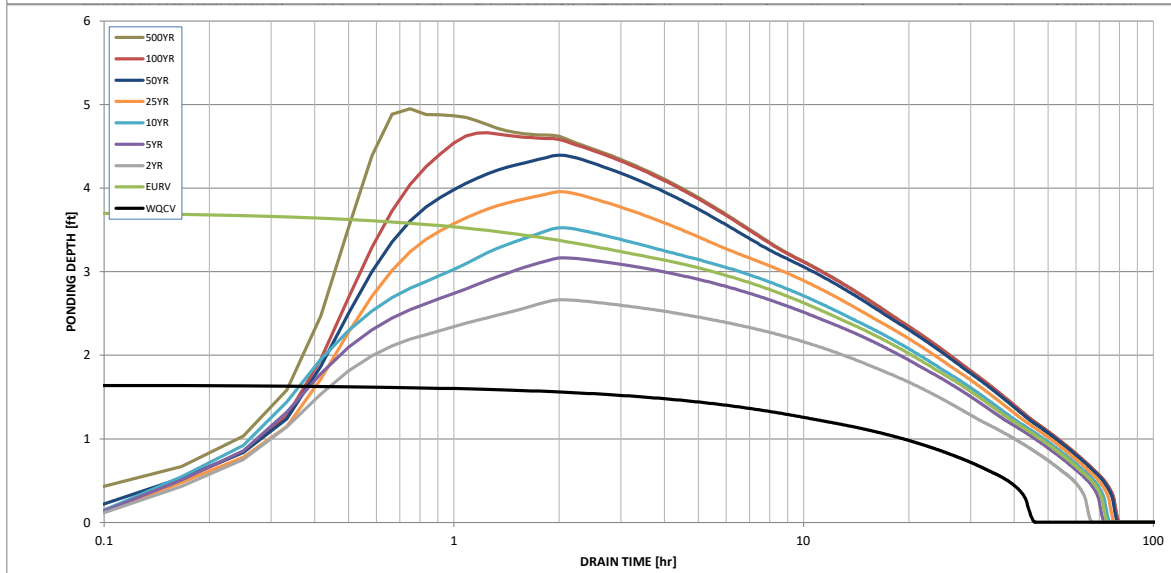
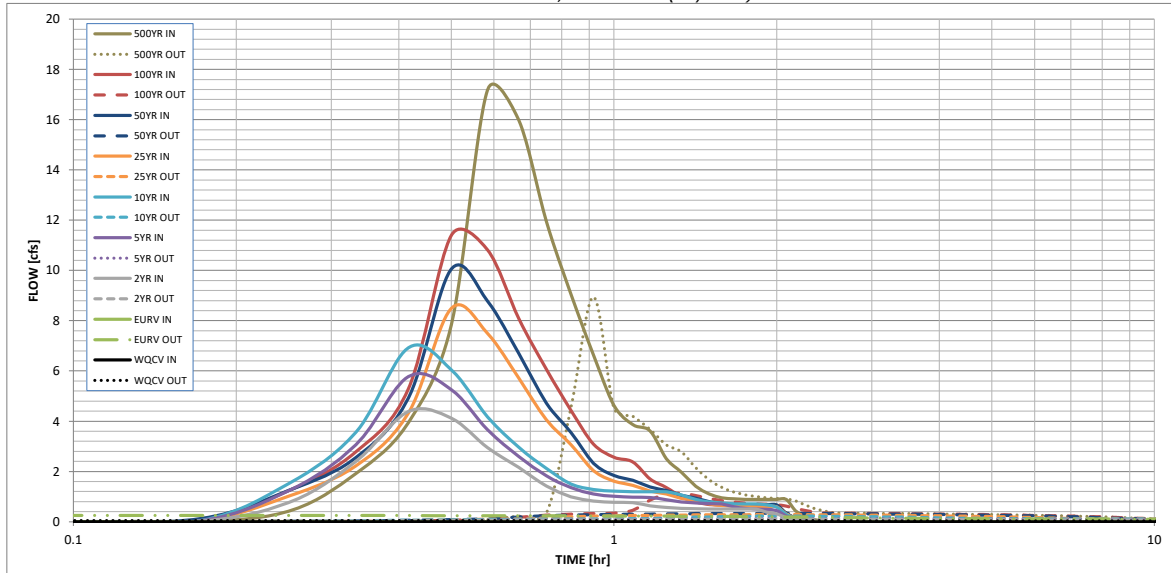
Routed Hydrograph Results

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

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period									
One-Hour Rainfall Depth (in)	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.48
CUHP Runoff Volume (acre-ft)	0.075	0.290	0.188	0.245	0.291	0.347	0.403	0.469	0.696
Inflow Hydrograph Volume (acre-ft)	N/A	N/A	0.188	0.245	0.291	0.347	0.403	0.469	0.696
CUHP Predevelopment Peak Q (cfs)	N/A	N/A	0.0	0.1	0.1	1.0	1.8	3.0	6.7
OPTIONAL Override Predevelopment Peak Q (cfs)	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre)	N/A	N/A	0.01	0.02	0.03	0.30	0.58	0.94	2.10
Peak Inflow Q (cfs)	N/A	N/A	4.4	5.8	6.9	8.5	10.1	11.4	17.2
Peak Outflow Q (cfs)	0.0	0.3	0.1	0.1	0.2	0.3	0.3	1.0	9.2
Ratio Peak Outflow to Predevelopment Q	N/A	N/A	N/A	1.7	2.1	0.3	0.2	0.3	1.4
Structure Controlling Flow	Plate	Vertical Orifice 1	Plate	Vertical Orifice 1	Vertical Orifice 1	Vertical Orifice 1	Vertical Orifice 1	Overflow Weir 1	Spillway
Max Velocity through Grate 1 (fps)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0	0.1
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	61	57	61	62	63	63	62	58
Time to Drain 99% of Inflow Volume (hours)	43	68	62	67	69	71	72	71	69
Maximum Ponding Depth (ft)	1.65	3.73	2.66	3.16	3.52	3.96	4.39	4.69	4.95
Area at Maximum Ponding Depth (acres)	0.09	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Maximum Volume Stored (acre-ft)	0.076	0.291	0.176	0.229	0.268	0.315	0.363	0.396	0.426

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)



Presedementation / Forebay Sizing

Design Point	Forebay	100 Yr Flow	Detention WQCV	Total Req'd Forebay Vol		Tributary Area	% Total Trib Area	Required Forebay Volume	Forebay Design			Discharge Design Flow	Calc'd Open Width (1" min)	Design Width
				3.0% WQCV	1.0% 100yr				Area	Depth	Volume			
DP5	One	2.7cfs	517cf	16cf	0.46ac	14.8%	2cf	32sf	1.00-ft	32 cf	1.0% 100yr	2.5-inch	2.5-inch	
DP6	Two	13.1cfs	2,968cf	89cf	2.63ac	85.2%	76cf	135sf	1.00-ft	135 cf	0.13 cfs	3.0-inch	3.0-inch	
	Totals	15.8	3,485cf	105cf	3.09ac	14.8%								

Opening Width Equation for Rectangular Opening

$$L = Q / (CH^{1.5}) \times 12 + 0.2xHx12 \text{ (UD-BMP Spreadsheet -- EDB tab)}$$

Forebay	Design Point
C = 2.5	DP5
C = 3.0	DP6

Forebay Overflow Calculation

Design Point	Forebay	Water Surf Elev	Crest Elev	Crest Length	Flow Depth	Calc'd Flow
DP5	One	6,511.00	6,510.0	2.0 ft	1.00 ft	6.0 cfs
DP6	Two	6,509.00	6,508.0	10.0 ft	1.00 ft	30.0 cfs

Weir Equation:

$$Q = CLH^{1.5}$$

C = Weir coefficient (dimensionless), C = 3.0 (most cases)

L = Length of weir at Crest, in ft. Not including sideslopes.

C = 3.0

Trickle Channel Calculation

Design Point	Location	100yr Flow	Req'd Flow		Bottom Width	Flow Depth	Side Slope	Slope	Manning 'n'	Top Width	Flow Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	Capacity
			1.0% 100yr	0.03											
DP5	One	2.7cfs	0.03	1.0 ft	1.0 ft	0.50 ft	0.7%	0.7%	0.013	1.0 ft	0.50 sf	2.0 ft	0.25 ft	3.8 ft/sec	1.9 cfs
DP6	Two	13.1cfs	0.13	1.0 ft	1.0 ft	0.50 ft	0.7%	0.7%	0.013	1.0 ft	0.50 sf	2.0 ft	0.25 ft	3.8 ft/sec	1.9 cfs

Equations:

$$\text{Area (A)} = b(d) + zd^2$$

b = width

d = depth

$$\text{Perimeter (P)} = b + 2d \sqrt{1 + z^2}^{0.5}$$

z = side slope

$$\text{Hydraulic Radius} = A/P$$

$$\text{Velocity} = (1.49/n)R_n^{2/3} S^{1/2}$$

S = Slope of the channel

n = Manning's number

R_n = Hydraulic Radius (Reynold's Number)

$$\text{Flow} = (1.49/n)AR_n^{2/3} S^{1/2}$$

Northcrest Center Subdivision

Emergency Spillway Calculation:

Detention Area	100-yr Flow	120% 100yr Flow	Water Surf Elev	Crest Elev	Crest Length	Z	C	Flow Depth (H)	Calc'd Flow	Check
EDB	15.4 cfs	19 cfs	6,512.42	6,512.25	50.00 ft	4:1	3.0	0.25 ft	19.1	OK

Broad Crested Weir Equation (USDCM Eqn 12-20 and 12-21):

$$Q = CLH^{1.5} + 2x((2/5)CZH^{5/2})$$

C = Weir coefficient, C = 3.0 (most cases)

L = Length of weir at Crest, in ft. Not including sideslopes.

H = Head above weir crest, in ft

Z = Side slope (horizontal:vertical)

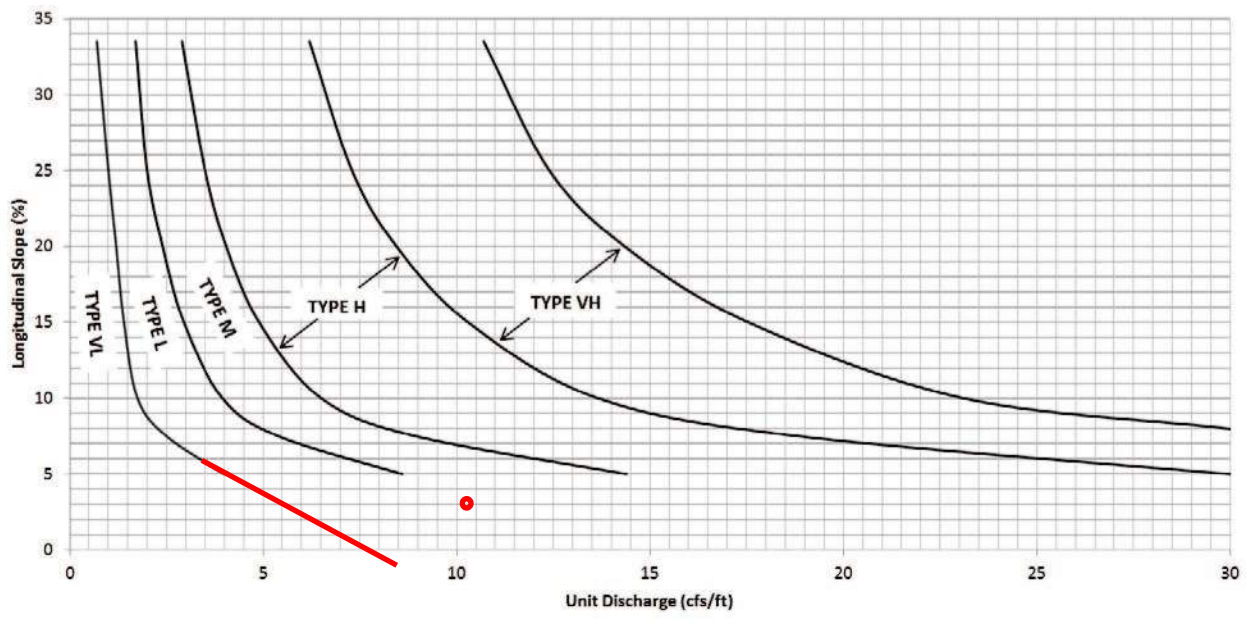
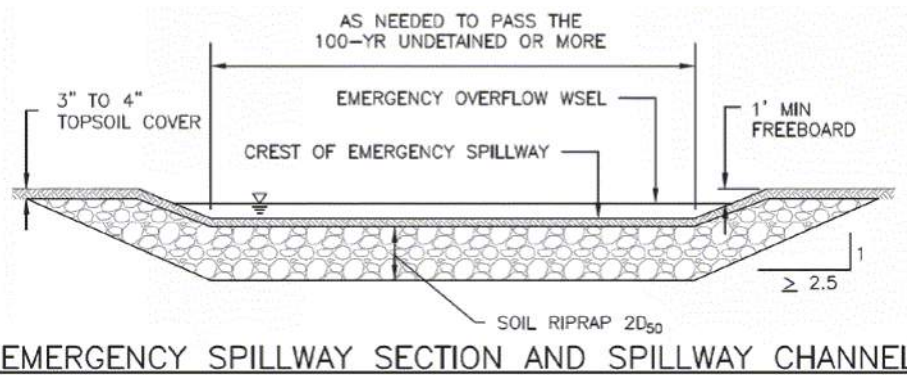
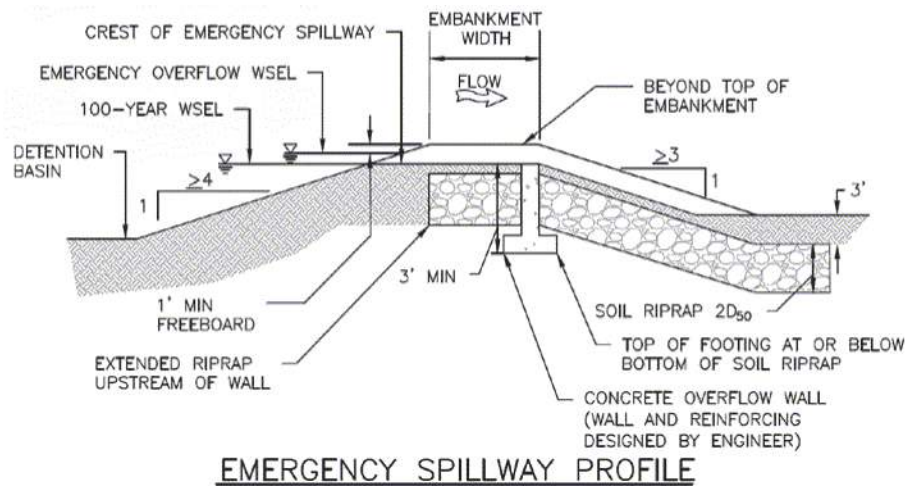


Figure 12-21. Embankment protection details and rock sizing chart (adapted from Arapahoe County)

Forebay 2 ~ 15.4 CFS (Type L) ~ Slope = 3-5%

Presedimentation / Forebay Sizing

Design Point	Forebay	100 Yr Flow	Detention WQCV	Total Req'd Forebay Vol	Tributary Area	% Total Trib Area	Required Forebay Volume		Forebay Design		Discharge Design Flow (1" min)	Calc'd Open Width	Design Width
							Volume	Area	Depth	Volume			
DP5	One	2.7cfs	791cf	24cf	0.69ac	22.7%	5cf	18sf	1.00-ft	18cf	0.03 cfs	2.5-inch	2.5-inch
DP6	Two	13.1cfs	2.694cf	81cf	2.36ac	77.3%	62cf	135sf	1.00-ft	135cf	0.13 cfs	3.0-inch	3.0-inch
	Totals	15.8	3.485cf	105cf	3.05ac	22.7%							

Opening Width Equation for Rectangular Opening
 $L = Q / (CH^{1.5}) \times 12 + 0.2xHx12$ (UD-BMP Spreadsheet -- EDB tab)

Forebay	Design Point
One	DP5
Two	DP6

Forebay Overflow Calculation

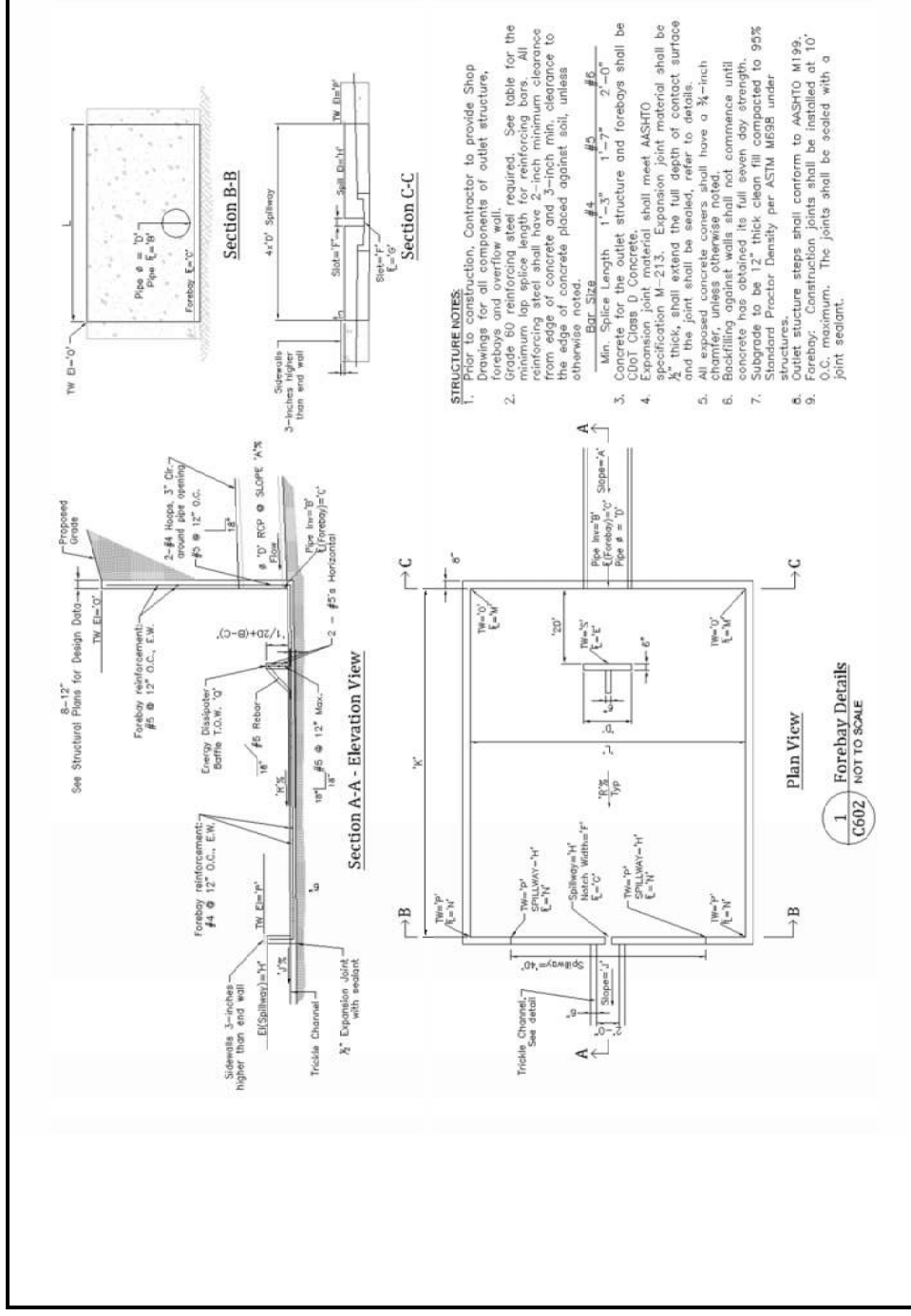
Design Point	Forebay	Water Surf Elev	Crest Elev	Crest Length	Flow Depth	Calc'd Flow
DP5	One	6.511.00	6.510.0	2.0 ft	1.00 ft	6.0 cfs
DP6	Two	6.509.00	6.508.0	10.0 ft	1.00 ft	30.0 cfs

Weir Equation:
 $Q = CLH^{1.5}$
 C = Weir coefficient (dimensionless), C = 3.0 (most cases)
 L = Length of weir at Crest, in ft. Not including sideslopes.

Trickle Channel Calculation

Design Point	Location	100yr Flow	Req'd Flow	Bottom Width	Flow Depth	Side Slope	Slope	Manning 'n'	Top Width	Flow Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	Capacity
DP5	One	2.7cfs	0.03	1.0 ft	0.50 ft	0:0.1	0.7%	0.013	1.0 ft	0.50 sf	2.0 ft	0.25 ft	3.8 ft/sec	1.9 cfs
DP6	Two	13.1cfs	0.13	1.0 ft	0.50 ft	0:0.1	0.7%	0.013	1.0 ft	0.50 sf	2.0 ft	0.25 ft	3.8 ft/sec	1.9 cfs

Equations:
 Area (A) = b(d) + zd² Perimeter (P) = b + 2d(1 + z²)^{0.5}
 b = width z = side slope
 d = depth Hydraulic Radius = A/P
 Velocity = (1.49/n)R^{2/3}S^{1/2}
 S = Slope of the channel
 n = Manning's number
 R_n = Hydraulic Radius (Reynold's Number)

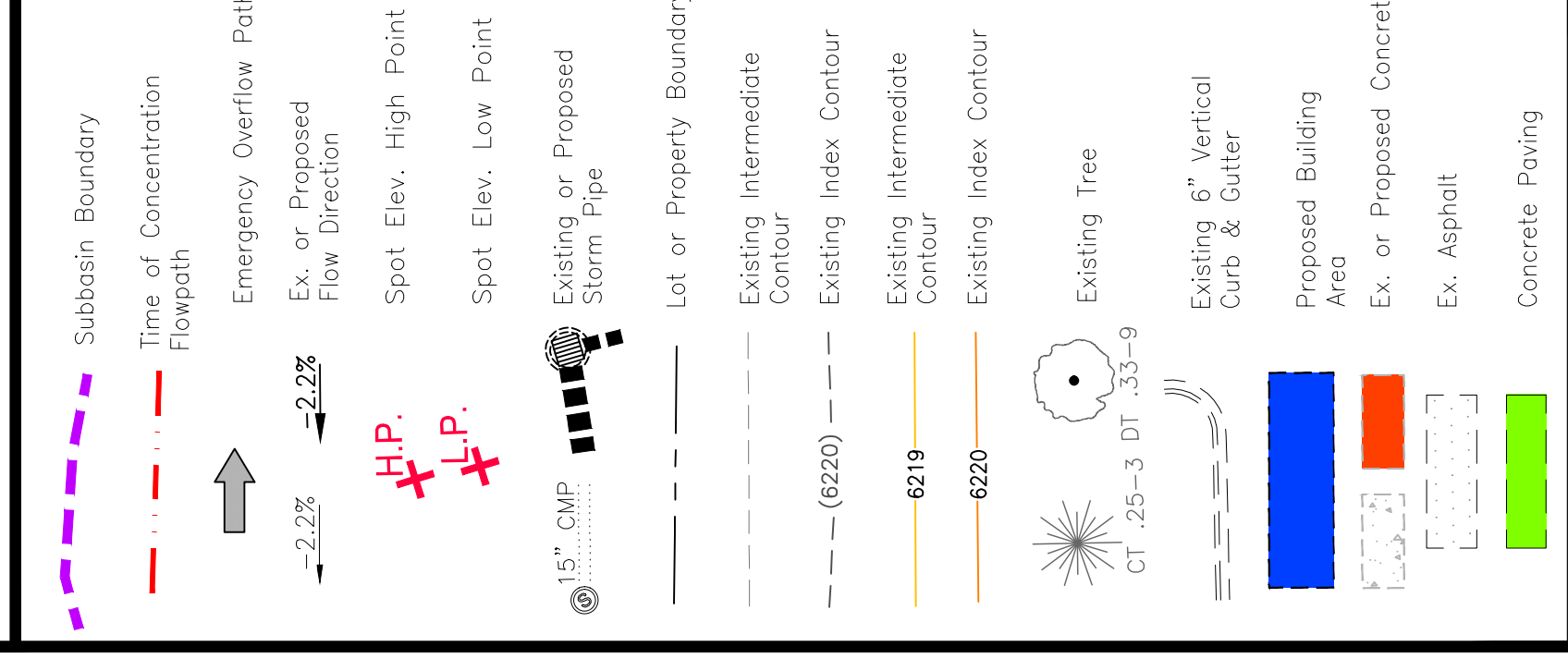


- STRUCTURE NOTES:**
- Prior to construction, Contractor to provide Shop Drawings for all components of outlet structure, forebays and overflow wall.
 - Grade 60 reinforcing steel required. See table for the minimum lap splice length for reinforcing bars. All reinforcing steel shall have a 3/8 inch minimum clearance from concrete and 3/4 inch minimum clearance from the edge of concrete placed against soil, unless otherwise noted.
 - Min. Splice Length: #4: 1'-3", #5: 1'-7", #6: 2'-0"
 - Concrete for the outlet structure and forebays shall be Class D Concrete. All concrete shall meet AASHTO specification M-213. Expansion joint material shall be 3/4" thick, shall extend the full depth of contact surface and the joint shall be sealed, refer to details.
 - All exposed concrete corners shall have a 3/4"-inch chamfer, unless otherwise noted.
 - Backfilling against walls shall not commence until concrete has cured. Expansion joints shall be connected to 95% Standard Proctor Density per ASTM M688 under structures.
 - Outlet structure steps shall conform to AASHTO M199.
 - Forebay: Construction joints shall be installed at 10' O.C. maximum. The joints shall be sealed with a joint sealant.

Variable	Presedimentation		Inflow
	One (DS)	Two (D6)	
A	Forebay	Forebay	Two
B	Pipe Slope%	Pipe Slope%	0.60
C	Pipe Inv In	Pipe Inv In	6510.00
D	Forebay Inv In	Forebay Inv In	6509.50
E	Pipe Size (ft)	Baffle Face Inv	0.67
F	Baffle Face Inv	Slot Width	2.50
G	Forebay Inv Out	Forebay Inv Out	6509.46
H	Spillway Inv	Spillway Inv	6510.21
I	Spillway Top	Spillway Top	6510.46
J	Trickle Pan Slope	Trickle Pan Slope	2.00
K	Forebay Length	Forebay Length	4.00
L	Forebay Width	Forebay Width	4.50
M	Toe of Wall	Toe of Wall	6509.50
N	Toe of Wall	Toe of Wall	6509.46
O	Top of Wall	Top of Wall	6513.75
P	Top of Wall	Top of Wall	6510.46
Q	Baffle Wall Top	Baffle Wall Top	6513.50
R	Forebay Slope %	Forebay Slope %	1.00

APPENDIX C
Water Quality Calculations and Exhibit

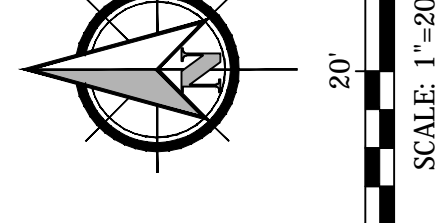
DRAINAGE LEGEND



Color Legend for IRF Calculation



Note: Water Quality Treatment for the site is achieved within the EDB. However Additional Informal Treatment is provided via Runoff Reduction.



IRF INVESTIGATION SUMMARY

Basin / DP	Soil Type	UA Square Feet	RA Square Feet	SA Square Feet	DCA Square Feet	WQCV Event CREDIT
0 - Site IRF Disturbed Area Only						
Family Life Services						
D-1	B	518 sf	2,189 sf	0 sf	265 sf	100.0%
D-2	B	25,548 sf	2,914 sf	0 sf	0 sf	0.0%
D-3	B	42,623 sf	0 sf	0 sf	0 sf	100.0%
D-4	B	42,623 sf	0 sf	0 sf	0 sf	100.0%
D-5	B	7,637 sf	5,070 sf	0 sf	12 sf	100.0%
D-6	B	6 sf	0 sf	0 sf	0 sf	0.0%
D-7	B	976 sf	935 sf	0 sf	2,282 sf	100.0%
D-8	B	550 sf	6,450 sf	0 sf	3 sf	100.0%
Summary		87,783 sf	24,870 sf	502 sf	7,882 sf	14.0%

Constition Avenue

Bismark Road (80' Public R.O.W.)

Canada Drive (60' Public R.O.W.)

Commercial Center
70 Unit Storage Facility
63,240 s.f. Total

Ex. Water Quality Feature Outlet Structure

**Northeast Center Sub
IRF Reduction Summary
Existing Condition**

IRF INVESTIGATION SUMMARY

Basin / DP	Soil Type	UIA Square Feet ²	RPA Square Feet ³	SPA Square Feet ⁵	DCIA Square Feet ⁴	On-Site IRF Disturbed Area Only	WQCV Event CREDIT
Family Life Services							
D-1	B	518 sf	7,189 sf	0 sf	265 sf	Roof Flows to North Margin Grassed Swale PCM 'North' (also detained)	100.0%
D-2	B	32,548 sf	0 sf	0 sf	0 sf	Roof and Drive Aisle Only (to Detention Basin)	0.0%
D-3	B	2,930 sf	2,225 sf	502 sf	0 sf	Wash Area and Turnout - Slotted Curb at Low Side (not detained)	100.0%
D-4	B	42,621 sf	0 sf	0 sf	1 sf	Roof and Drive Aisle Only (to Detention Basin)	0.0%
D-5	B	7,637 sf	5,070 sf	0 sf	12 sf	Roof Flows to South Margin Meandering Grassed Swale PCM 'South' (detained)	100.0%
D-6	B	0 sf	0 sf	0 sf	5,278 sf	Detention Basin Only (grass bottom)	0.0%
D-7	B	976 sf	935 sf	0 sf	2,282 sf	Site Exit Drive below captured grade (not detained)	100.0%
D-8	B	550 sf	6,450 sf	0 sf	3 sf	Extreme Southeast Corner. New UIA/RPA Transfer at Sidewalk (not detained)	100.0%
Summary		87,781 sf	21,870 sf	502 sf	7,842 sf	WQCV Reduction¹:	14.0%
Percentage of Total:		74.4%	18.5%	0.4%	6.6%		

Notes:

- Water Quality Treatment for the site is achieved within the EDB. However Additional Treatment is provided via Runoff Reduction.
- UIA acres - are equated with rooftops, concreted, drives, walks and asphaltic pavements
- RPA acres - are equated with vegetative hillsides which receive flows initially part of UIA
- DCIA acres - flows which are low in the sub-basin, and which do not enter or reenter an RPA.
- SPA acres - are equated with raw undeveloped portions of the overall property. N/A

Design Procedure Form: Grass Swale (GS)

UD-BMP (Version 3.07, March 2018)

Sheet 1 of 1

Designer: M Kahnke
Company: Kiowa Engineering
Date: September 9, 2024
Project: Northcrest Center (My Garage) 'North Swale' Informal (non PCM) WQ Treatment
Location: Bismark Road & Canada Dr

1. Design Discharge for 2-Year Return Period	$Q_2 = $ <input style="width: 50px;" type="text" value="1.10"/> cfs
2. Hydraulic Residence Time A) : Length of Grass Swale B) Calculated Residence Time (based on design velocity below)	$L_S = $ <input style="width: 50px;" type="text" value="300.0"/> ft $T_{HR} = $ <input style="width: 50px;" type="text" value="6.5"/> minutes
3. Longitudinal Slope (vertical distance per unit horizontal) A) Available Slope (based on site constraints) B) Design Slope	$S_{avail} = $ <input style="width: 50px;" type="text" value="0.050"/> ft / ft $S_D = $ <input style="width: 50px;" type="text" value="0.050"/> ft / ft
4. Swale Geometry A) Channel Side Slopes (Z = 4 min., horiz. distance per unit vertical) B) Bottom Width of Swale (enter 0 for triangular section)	$Z = $ <input style="width: 50px;" type="text" value="4.00"/> ft / ft $W_B = $ <input style="width: 50px;" type="text" value="5.00"/> ft
5. Vegetation A) Type of Planting (seed vs. sod, affects vegetal retardance factor)	Choose One <input style="width: 100px;" type="text"/> <input type="radio"/> Grass From Seed <input checked="" type="radio"/> Grass From Sod
6. Design Velocity (1 ft / s maximum)	$V_2 = $ <input style="width: 50px;" type="text" value="0.77"/> ft / s
7. Design Flow Depth (1 foot maximum) A) Flow Area B) Top Width of Swale C) Froude Number (0.50 maximum) D) Hydraulic Radius E) Velocity-Hydraulic Radius Product for Vegetal Retardance F) Manning's n (based on SCS vegetal retardance curve D for sodded grass) G) Cumulative Height of Grade Control Structures Required	$D_2 = $ <input style="width: 50px;" type="text" value="0.24"/> ft $A_2 = $ <input style="width: 50px;" type="text" value="1.4"/> sq ft $W_T = $ <input style="width: 50px;" type="text" value="6.9"/> ft $F = $ <input style="width: 50px;" type="text" value="0.30"/> $R_H = $ <input style="width: 50px;" type="text" value="0.20"/> $VR = $ <input style="width: 50px;" type="text" value="0.16"/> $n = $ <input style="width: 50px;" type="text" value="0.151"/> $H_D = $ <input style="width: 50px;" type="text" value="0.00"/> ft
8. Underdrain (Is an underdrain necessary?)	Choose One <input style="width: 100px;" type="text"/> <input type="radio"/> YES <input checked="" type="radio"/> NO
9. Soil Preparation (Describe soil amendment)	_____ _____ _____
10. Irrigation	Choose One <input style="width: 100px;" type="text"/> <input checked="" type="radio"/> Temporary <input type="radio"/> Permanent

Notes: Predicted Infiltration benefit for informal private grassed swale at North Margin of site.
(For Informational and Reference Purposes Only) Supplemental Calculations in Excess of MS 4 Permit Requirements

Design Procedure Form: Grass Swale (GS)

UD-BMP (Version 3.07, March 2018)

Sheet 1 of 1

Designer: M Kahnke
Company: Kiowa Engineering
Date: September 9, 2024
Project: Northcrest Center (My Garage) 'South Swale' Informal (non PCM) WQ Treatment
Location: Constitution Avenue & Canada Dr

1. Design Discharge for 2-Year Return Period	$Q_2 = $ <input style="width: 50px;" type="text" value="1.00"/> cfs
2. Hydraulic Residence Time A) : Length of Grass Swale B) Calculated Residence Time (based on design velocity below)	$L_S = $ <input style="width: 50px;" type="text" value="300.0"/> ft $T_{HR} = $ <input style="width: 50px;" type="text" value="7.7"/> minutes
3. Longitudinal Slope (vertical distance per unit horizontal) A) Available Slope (based on site constraints) B) Design Slope	$S_{avail} = $ <input style="width: 50px;" type="text" value="0.020"/> ft / ft $S_D = $ <input style="width: 50px;" type="text" value="0.020"/> ft / ft
4. Swale Geometry A) Channel Side Slopes (Z = 4 min., horiz. distance per unit vertical) B) Bottom Width of Swale (enter 0 for triangular section)	$Z = $ <input style="width: 50px;" type="text" value="4.00"/> ft / ft $W_B = $ <input style="width: 50px;" type="text" value="2.00"/> ft
5. Vegetation A) Type of Planting (seed vs. sod, affects vegetal retardance factor)	Choose One <input style="width: 100px;" type="text"/> <input type="radio"/> Grass From Seed <input checked="" type="radio"/> Grass From Sod
6. Design Velocity (1 ft / s maximum)	$V_2 = $ <input style="width: 50px;" type="text" value="0.65"/> ft / s
7. Design Flow Depth (1 foot maximum) A) Flow Area B) Top Width of Swale C) Froude Number (0.50 maximum) D) Hydraulic Radius E) Velocity-Hydraulic Radius Product for Vegetal Retardance F) Manning's n (based on SCS vegetal retardance curve D for sodded grass) G) Cumulative Height of Grade Control Structures Required	$D_2 = $ <input style="width: 50px;" type="text" value="0.42"/> ft $A_2 = $ <input style="width: 50px;" type="text" value="1.5"/> sq ft $W_T = $ <input style="width: 50px;" type="text" value="5.4"/> ft $F = $ <input style="width: 50px;" type="text" value="0.21"/> $R_H = $ <input style="width: 50px;" type="text" value="0.28"/> $VR = $ <input style="width: 50px;" type="text" value="0.18"/> $n = $ <input style="width: 50px;" type="text" value="0.139"/> $H_D = $ <input style="width: 50px;" type="text" value="0.00"/> ft
8. Underdrain (Is an underdrain necessary?)	Choose One <input style="width: 100px;" type="text"/> <input type="radio"/> YES <input checked="" type="radio"/> NO
9. Soil Preparation (Describe soil amendment)	_____ _____ _____
10. Irrigation	Choose One <input style="width: 100px;" type="text"/> <input checked="" type="radio"/> Temporary <input type="radio"/> Permanent

Notes: Predicted Infiltration benefit for informal private grassed swale at South Margin of site.
 (For Informational and Reference Purposes Only) Supplemental Calculations in Excess of MS 4 Permit Requirements

Design Procedure Form: Runoff Reduction

UD-BMP (Version 3.07, March 2018)

Sheet 1 of 1

Designer: AWMc
Company: Kiowa Engineering Corporation
Date: September 9, 2024
Project: Northcrest Storage Center (My Garage) Informal (non PCM) WQ Treatment above the level required by MS 4 Permit
Location: El Paso County, CO (Full Site)

SITE INFORMATION (User Input in Blue Cells)

WQCV Rainfall Depth = 0.60 inches
 Depth of Average Runoff Producing Storm, d_6 = 0.43 inches (for Watersheds Outside of the Denver Region, Figure 3-1 in USDCM Vol. 3)

Area Type			UIA:RPA				UIA:RPA	UIA:RPA			
Area ID			D-3				D-7	D-8			
Downstream Design Point ID			D-3				D-7	D-8			
Downstream BMP Type			None				None	None			
DCIA (ft ²)	--		--		--		--	--			
UIA (ft ²)	--		2,930	--			976	550			
RPA (ft ²)	--		2,225	--			935	6,392			
SPA (ft ²)	--		--	--	--		--	--			
HSG A (%)	--		100%	--			100%	100%			
HSG B (%)	0%	--	0%	--	0%		0%	0%			
HSG C/D (%)	0%	--	0%	--	0%		0%	0%			
Average Slope of RPA (ft/ft)	--		0.100	--			0.100	0.100			
UIA:RPA Interface Width (ft)	--		32.00	--			20.00	25.00			

CALCULATED RUNOFF RESULTS

Area ID			D-3				D-7	D-8			
UIA:RPA Area (ft ²)			5,155				1,911	6,942			
L / W Ratio			5.03				4.78	11.11			
UIA / Area			0.5684				0.5107	0.0792			
Runoff (in)			0.00				0.00	0.00			
Runoff (ft ³)			0				0	0			
Runoff Reduction (ft ³)			122				41	23			

CALCULATED WQCV RESULTS

Area ID			D-3				D-7	D-8			
WQCV (ft ³)			122				41	23			
WQCV Reduction (ft ³)			122				41	23			
WQCV Reduction (%)			100%				100%	100%			
Untreated WQCV (ft ³)			0				0	0			

CALCULATED DESIGN POINT RESULTS (sums results from all columns with the same Downstream Design Point ID)

Downstream Design Point ID	D-3	D-7	D-8								
DCIA (ft ²)	0	0	0								
UIA (ft ²)	2,930	976	550								
RPA (ft ²)	2,225	935	6,392								
SPA (ft ²)	0	0	0								
Total Area (ft ²)	5,155	1,911	6,942								
Total Impervious Area (ft ²)	2,930	976	550								
WQCV (ft ³)	122	41	23								
WQCV Reduction (ft ³)	122	41	23								
WQCV Reduction (%)	100%	100%	100%								
Untreated WQCV (ft ³)	0	0	0								

CALCULATED SITE RESULTS (sums results from all columns in worksheet)

Total Area (ft ²)	14,008
Total Impervious Area (ft ²)	4,456
WQCV (ft ³)	186
WQCV Reduction (ft ³)	186
WQCV Reduction (%)	100%
Untreated WQCV (ft ³)	0

APPENDIX D

Existing and Proposed Drainage Plans

Sheet 1 – Historic Conditions H-1

Sheet 2 - Developed Conditions D-1

DRAINAGE LEGEND

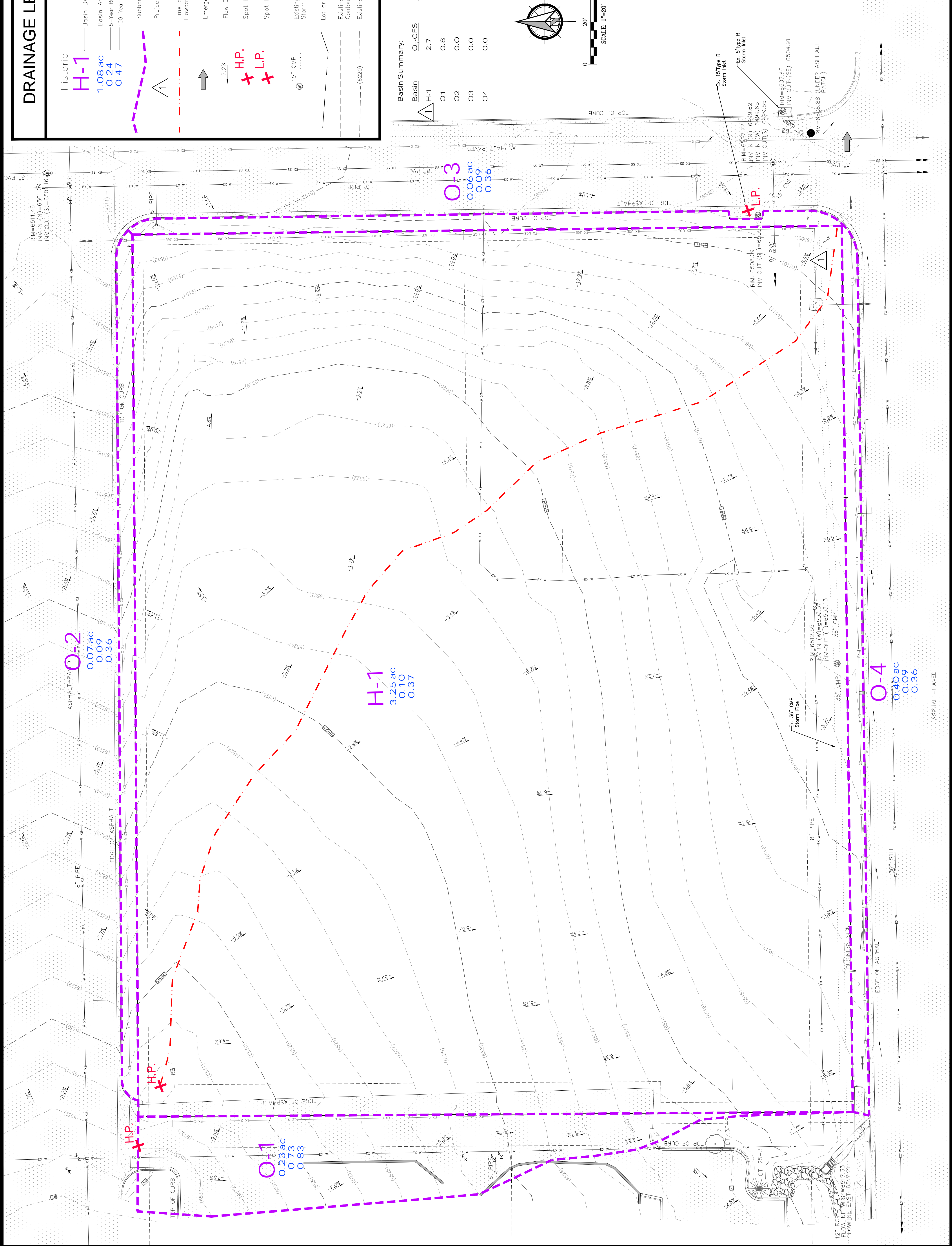
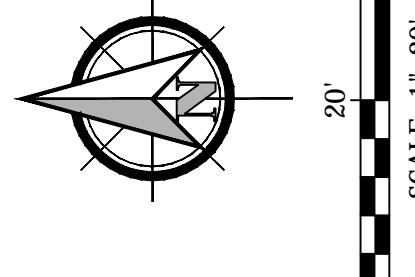
Historic
H-1

- Basin Designation
- Basin Area
- 5-Year Runoff Coeff.
- 100-Year Runoff Coeff.

Subbasin Boundary
Project Design Point
Time of Concentration Flowpath
Emergency Overflow Path
Flow Direction
Spot Elev. High Point
Spot Elev. Low Point
Existing Conduit or Storm Pipe
Lot or Property Boundary
Existing Intermediate Contour
Existing Index Contour

Basin Summary:

Basin	Q ₅ -CFS	Q ₁₀₀ -CFS	Acres
1 H-1	2.7	12.6	3.25
01	0.8	01.6	0.23
02	0.0	00.2	0.07
03	0.0	00.2	0.06
04	0.0	00.2	0.07



12" RCP
WEST=6517.33
FLOWLINE EAST=6517.21

DRAINAGE LEGEND

Developed

- Basin Designation
- 1.08 ac Basin Area
- 0.24 5-Year Runoff Coeff.
- 0.47 100-Year Runoff Coeff.
- Subbasin Boundary
- Project Design Point
- Time of Concentration Flowpath
- Emergency Overflow Path
- Ex. or Proposed Flow Direction
- Spot Elev. High Point
- Spot Elev. Low Point
- Existing or Proposed Storm Pipe
- 15" CMP
- Lot or Property Boundary
- Existing Intermediate Contour
- Existing Index Contour
- Existing Intermediate Contour
- Existing Index Contour
- Existing Tree
- Existing 6" Vertical Curb & Gutter
- Proposed Building Area
- Ex. or Proposed Concrete
- Ex. Asphalt
- Concrete Paving
- Proposed Water Elements
- Proposed Sanitary Elements

Basin / Design Point	Acres	Qs	Q100
0-2	0.07 ac	0.2 cfs	0.5 cfs
0-3	0.06 ac	0.1 cfs	0.3 cfs
0-4	0.07 ac	0.3 cfs	0.5 cfs
0-1	0.23 ac	0.8 cfs	1.6 cfs
DP-1	0.56 ac	1.4 cfs	3.0 cfs
DP-2	0.75 ac	3.2 cfs	5.9 cfs
DP-3	0.08 ac	0.3 cfs	0.6 cfs
DP-4	0.98 ac	4.0 cfs	7.3 cfs
DP-5	0.46 ac	1.3 cfs	2.7 cfs
DP-6	0.12 ac	0.1 cfs	0.5 cfs
DP-7	0.15 ac	0.4 cfs	0.6 cfs
DP-8	0.16 ac	0.4 cfs	0.9 cfs
Raw Summary	3.68 ac	12.4 cfs	24.2 cfs

Detained Flows (Weighted & Lagged)

System	Historic	2.7 cfs
Developed	9.6 cfs	18.8 cfs
% Increase	-261.43%	48.83%

Design Point Summary	Weighted Lagged	Rainfall Intensity	QWQCV	Q2	Q5	Q100
DP-1	0.54 ac	0.68	4.6 in/hr	7.8 in/hr	1.4 cfs	3.0 cfs
DP-2	0.71 ac	0.81	4.6 in/hr	7.8 in/hr	4.3 cfs	8.2 cfs
DP-3	0.78 ac	0.87	4.6 in/hr	7.8 in/hr	0.3 cfs	0.5 cfs
DP-4	0.74 ac	0.83	3.2 in/hr	6.3 in/hr	6.9 cfs	13.1 cfs
DP-5	0.36 ac	0.69	3.2 in/hr	6.3 in/hr	1.3 cfs	2.7 cfs
DP-6	0.11 ac	0.54	4.8 in/hr	8.0 in/hr	0.2 cfs	0.4 cfs
DP-7	0.15 ac	0.62	5.0 in/hr	8.7 in/hr	0.4 cfs	0.6 cfs
DP-8	0.16 ac	0.70	13.0 in/hr	13.0 in/hr	0.4 cfs	0.9 cfs
ALL	3.40 ac	0.62	0.70	13.0 in/hr	8.6 cfs	16.9 cfs

