



Preliminary Drainage Report

Villas at Aspen Trails El Paso County, Colorado

PCD File No.: PUDSP208
SF-21-025

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Prepared: November 3, 2022

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CERTIFICATION

ENGINEERS 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 City/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.

SIGNATURE (Affix Seal): _____
Colorado P.E. No. 60470 Date

DEVELOPER'S STATEMENT

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

Business Name

By:

Title:

Address:

EL PASO COUNTY STATEMENT

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

County Engineer/ECM Administrator Date

Conditions:

GENERAL LOCATION AND DESCRIPTION

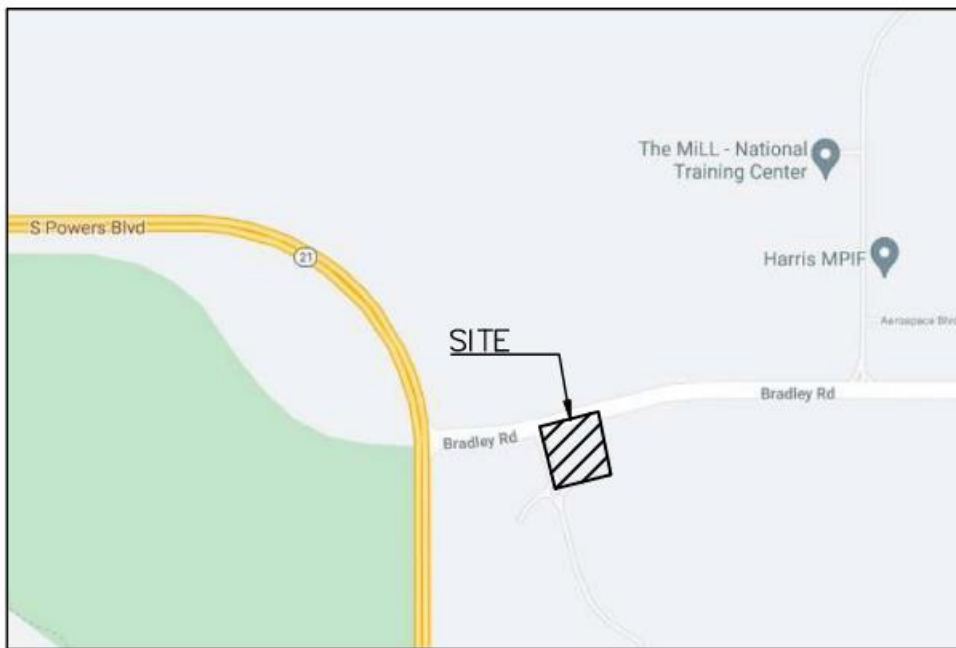
PURPOSE AND SCOPE OF STUDY

The purpose of this Final Drainage Report (FDR) is to provide the hydrologic and hydraulic calculations and to document and finalize the drainage design methodology in support of the proposed Villas at Aspen Trails residential development (the “Project”). The Project is located within the jurisdictional limits of El Paso County (the “County”). Thus, the guidelines for the hydrologic and hydraulic design were based on the criteria outlined by the County’s Engineering Criteria Manual.

LOCATION

The Project is located south of the Colorado Springs Airport and at the southeast corner of Bradley Road and Legacy Hill Drive. More specifically, the Project is within portions of Section 8 & 9, Township 15 South, Range 65 West of the 6th Principal Meridian, County of El Paso, State of Colorado (parcel number 5509200003). A vicinity map is provided below.

VICINITY MAP



LOCATION MAP
NTS

DESCRIPTION OF PROPERTY

The Project is located on approximately 4.25 acres of undeveloped land with limited vegetation and grass cover. The site is currently vacant and does not provide stormwater quality or detention and there are no known major drainage ways or irrigation facilities on the site. The proposed services in the development include the following: water, sewer, electric service,

natural gas service, telephone service, and fire protection. The site generally drains from the north to south with slopes ranging from 1.75% to 3.60%. The Project is not adjacent to any major drainageways and does not outfall directly to any major drainageways.

NRCS soil data is available for the Site (See Appendix) and the onsite soils are USCS Hydrologic Soil Group B. Group B soils have a moderate infiltration rate when thoroughly wet and mainly consist of well drained soils that have moderately fine texture to moderately coarse texture. This site specifically is predominately comprised of fine sandy loams, with a mix of stoneham sandy loam. A Soil, Geology, and Geologic Hazard report was prepared for the site by Entech Engineering, Inc. dated February 21, 2018 and is provided in the Appendix of this report for reference.

PROJECT CHARACTERISTICS

The Project is a proposed single family attached development that will include single-family lots attached with private road access. The site will be configured in seven attached (townhome) 3-plex units across 21 lots and five attached (townhome) 4-plex units across 20 lots. The project will include the construction of tracts for buffering, landscaping, open spaces, pedestrian corridors, private roads, and a full spectrum extended detention pond to serve the Project. Water quality and detention is required for the site improvements and will be accomplished with the construction of a full spectrum extended detention pond located on the southwest corner of the site. As part of the utility infrastructure improvements, a proposed storm sewer system will be constructed to collect runoff. Stormwater will be conveyed via overland flow across the lots, within the curb and gutter of the proposed streets before being captured in proposed storm inlets. The storm sewer system will then convey runoff into the full spectrum extended detention pond before being discharged offsite.

DRAINAGE BASINS AND SUB-BASINS

MAJOR BASIN DESCRIPTIONS

The site is located within the Jimmy Camp Creek Basin. It is within the service area of the Widefield Water and Sanitation District (WWSD).

The Site is also located outside the 100-year floodplain and within Zone X (an area of minimal flood hazard) as noted on the FEMA FIRM Map No. 08041C0752G revised on December 7, 2018 (See Appendix).

There are no identified nearby irrigation facilities or other obstructions which could influence the local drainage.

SUB-BASIN DESCRIPTION

Historic Drainage Patterns

The existing drainage is divided into two sub-basins, Basin EX-1 and EX-2. Sub-Basin EX-1 is approximately 3.27 acres and consists of most of the on-site area within the property line. Runoff generated from this Sub-Basin drains overland from north to south. The weighted imperviousness for Sub-Basin EX-1 with existing conditions is 2% and the runoff for the 5-year and 100-year storm events are 1.33 cfs and 9.77 cfs respectively. Sub-Basin EX-2 is approximately 0.98 acres and consists of the northeast portion of this site. Runoff generated

from this Sub-Basin drains overland from west to east. The weighted imperviousness of Sub-Basin EX-2 is 2% and the runoff for the 5-year and 100-year storm events are 0.40 cfs and 2.97 cfs respectively.

Off-Site Drainage Flow Patterns

The site experiences offsite runoff from the north but is accounted for in proposed Sub-Basin A1. This offsite flow will be captured by the proposed storm sewer infrastructure and routed to the detention pond for water quality treatment and detention.

DRAINAGE DESIGN CRITERIA

DEVELOPMENT CRITERIA REFERENCE

The proposed storm facilities follow the El Paso County Drainage Criteria Manual (the “CRITERIA”), El Paso Engineering Criteria Manual (the “ECM”), and the Mile High Flood Control District Urban Storm Drainage Criteria Manual (the “MANUAL”). Site drainage is not significantly impacted by such constraints as utilities or existing development. Further detail regarding onsite drainage patterns is provided in the Proposed Drainage Conditions Section.

HYDROLOGIC CRITERIA

The 5-year and 100-year design storm events were used in determining rainfall and runoff for the proposed drainage system per chapter 6 of the CRITERIA. Table 6-2 of the CRITERIA is the source for rainfall data for the 5-year and 100-year design storm events. Design runoff was calculated using the Rational Method for developed conditions as established in the CRITERIA and MANUAL. Runoff coefficients for the proposed development were determined using Table 6-6 of the CRITERIA by calculating weighted impervious values for each specific site basin. The detention storage requirement was calculated using Full Spectrum Detention methods as specified in the CRITERIA and MANUAL. The Full Spectrum Extended Detention Basin’s outlet structure will be designed to release the Water Quality Capture Volume (WQCV) in at least 40 hours and the EURV will be released with a 72 hour drain time. Outlet structure calculations will be provided in the Final Drainage Report. Based upon this approach, we feel that the drainage design provided for the Site is conservative and in keeping with the historic drainage patterns for the Site.

The proposed drainage facilities are designed in accordance with the CRITERIA and MANUAL. Floodplain identification was determined using FIRM panels by FEMA. Hydraulic calculations will be computed using StormCAD for the proposed storm sewer system and provided in the Final Drainage Report.

DRAINAGE FACILITY DESIGN

GENERAL CONCEPT

PROPOSED DRAINAGE PATTERNS

The developed runoff from the Project will generally be collected by means of a curb and gutter and storm sewer system with inlets located on the west street within each delineated sub-basin area. Additionally, there will be a proposed 6’ wide concrete v-gutter that captures flows and

routes them to a 8' curb cut to discharge directly into the detention pond. A proposed 6' v-shaped vegetated swale will be located on the south portion of the project to direct the runoff to the detention pond. The runoff collected from each Sub-Basin A1 and A2 will be captured by storm inlets and conveyed through storm pipes to a Full Spectrum Extended Detention Basin located in the southwest corner of the site.

SPECIFIC DETAILS

The property has been divided into seven sub-basins, A1 through A5 and OS-1 - OS-2. Sub-basins A1 through A5 make up the Project on-site area and Sub-Basins OS-1 - OS-2 are the offsite basins consisting of the runoff that sheet flows offsite.

The weighted imperviousness of the Site area (Sub-basins A1 through A5) is 49.4%. The weighted imperviousness of the offsite area (Sub-basin OS1-OS2) with Sub-Basins A1 through A5 is 45.68%. Cumulative runoff for the 5-year and 100-year storm events are 8.02 cfs and 18.75 cfs, respectively.

Sub-Basin A1

Sub-basin A1 consists of approximately 0.84 acres and is the area along the north and central portions of the site, consisting of rooftops, landscaping, pavement, Road D and a portion of Road C. A Proposed 4' COS D-10-R storm inlet (Design point A1) on Road C captures this runoff and routes it to the detention pond. Developed runoff during the 5-year and 100-year events are 1.39 cfs and 3.32 cfs respectively.

Sub-Basin A2

Sub-basin A2 consists of approximately 0.45 acres and is made up of a portion of the west buildings along Road C, a portion of Road C, and a section of landscaping in the central portion of the site. A proposed 4' COS D-10-R storm inlet on Road C (Design Point A2) will capture the runoff from the roofs, landscaping, and pavement and route this runoff to the detention pond. Developed runoff during the 5-year and 100-year events are 0.69 cfs and 1.71 cfs respectively.

Sub-Basin A3

Sub-basin A3 consists of approximately 1.96 acres and is the south and eastern portions of the site, consisting of pavement, landscaping, roofing, Road A, Road B, and a portion of Road C. The runoff from this area is conveyed via curb and gutter before being collected by an 8-foot curb cut (Design point A3) that is discharged directly into the detention pond. Developed runoff during the 5-year and 100-year events are 5.17 cfs and 10.53 cfs respectively.

Sub-Basin A4

Sub-basin A4 consists of approximately 0.40 acres and consists of runoff within the private detention basin. The runoff from this area is directly into the pond (Design Point A4). Developed runoff during the 5-year and 100-year events are 0.15 cfs and 1.10 cfs respectively.

Sub-Basin A5

Sub-basin A5 consists of approximately 0.15 acres and consists of landscaping and an associated drainage swale directed from east to west into the proposed detention pond. Developed runoff during the 5-year and 100-year events are 0.08 cfs and 0.40 cfs respectively.

Sub-Basin OS-1

Sub-basin OS-1 consists of approximately 0.55 acres and consists of an eastern portion of the site which is vegetated hillside. Runoff will sheet flow to the portion of land that is east of the project (Design Point OS1), following historic drainage patterns. Developed runoff during the 5-year and 100-year events are 0.47 cfs and 1.58 cfs respectively.

Sub-Basin OS-2

Sub-basin OS-2 consists of approximately 0.01 acres and consists of the western section of Road B that runs outside of the proposed property boundary. Runoff from this Sub-Basin is conveyed offsite to the intersection of Legacy Hill Drive and Road B (Design Point OS2), following historic drainage patterns. Developed runoff during the 5-year and 100-year events are 0.06 cfs and 0.11 cfs respectively.

EMERGENCY OVERFLOW ROUTING

Emergency overflow routing consists of flows following historic drainage patterns from north to south and discharging into Frontside Drive.

DETENTION AND WATER QUALITY

The WQCV and 100-year detention is required for this Project. This is accomplished through the proposed private Full Spectrum Extended Detention Basin on the southwest corner of the Site. The Extended Detention Basin was sized to provide water quality and detention for the entire Site (Sub-Basins A1-A5 and OS-1 and OS-2) per UDFCD criteria. The water quality and detention calculations are provided in the Appendix of this report. The proposed Extended Detention Basin will be maintained by the homeowner's association.

Four-Step Process

The four-step process per the MANUAL provides guidance and requirements for the selection of siting of structural Construction Control Measures (CCMs) for new development and significant redevelopment.

Step 1: Employ Runoff Reduction Practices

Currently the site is vacant undeveloped land. Development of the site will increase current runoff conditions due to increased imperviousness values. However, implementation of landscaping throughout the site, the proposed storm sewer infrastructure, and the proposed Extended Detention Basin will help slow runoff and encourage infiltration.

Step 2: Provide Water Quality Capture Volume (WQCV)

The water quality capture volume will be detained using a full spectrum extended detention basin on the southwest corner of the Site. The water quality outlet structure will control the release of stormwater to at or less than historic rates.

Step 3: Stabilize Drainageways

There are no current drainageways conveyed through this property. No improvements to stabilize drainageways are a part of this Project.

Step 4: Consider need for Industrial and Commercial BMPs

Erosion control features for the final stages of the Project will be designed to reduce contamination. Source control BMPs will include the use of, inlet protection, silt fences,

concrete washout areas, stockpile management, and stabilized staging areas. The Grading and Erosion Control Plans will be submitted as a separate construction document set.

Detention and Water Quality Design

The proposed private Full Spectrum Extended Detention Basin will be designed with an outlet structure that is fitted with an orifice plate and restrictor plate to release the WQCV in at least a 40-hour drain time period and the EURV in a 72 hour drain time period per the MANUAL.

Calculations included in the Appendix provide details regarding the private water quality and detention basins design. The calculations include determination of the storage volumes required for full spectrum detention for the WQCV and 100 year detention and allowable release rates. The Final Drainage Report will provide calculations for the proposed outlet structure.

Overall, 0.352 acre-feet of WQCV is required. The total area contributing to the Extended Detention Basin consists of 3.80 acres (49.4% imperviousness).

Outlet Requirements

The water quality standards established by the CRITERIA are met by the proposed Full Spectrum Extended Detention Basin. The water quality outlet structures will be designed per the specifications in the CRITERIA. The outlet structure for the extended detention basin will meet the micro-pool requirement that it be integrated into the design of the structure with an additional initial surcharge volume. The orifice plates of the structures will be designed based on the CRITERIA. The orifice plates will allow the WQCV to be drained from the structure in at least 40 hours and the EURV in 72 hours. The calculations for the design of the outlet structures will be provided in the Final Drainage Report.

Emergency Spillway Path

The emergency overflow from the Extended Detention Basin will be located on the south side of the pond and will discharge into Frontside Drive. The Final Drainage Report will provide calculations on the emergency overflow spillway for the pond which will be located on the south side of the detention pond.

COST OF PROPOSED DRAINAGE FACILITIES

An Estimated Opinion of Probable Construction Cost (EOPCC) is provided in the Appendix of the report. There are no public drainage facilities. All improvements with this Project will be private.

DRAINAGE AND BRIDGE FEES

The Site is located in the Jimmy Camp Creek Drainage Basin. The total impervious acreage of the parcel (5509200003) is 2.08 acres. The total drainage and bridge fees due for the Site is \$36,449.92.

| | 2022 Fees (\$ / Impervious acre) | Impervious Area (Acre) | Amount Due (\$) |
|--------------------------|-------------------------------------|---------------------------|--------------------|
| Drainage Fee | \$9,185 | 2.08 | \$19,104.80 |
| Pond Facility Fee | \$8,339 | 2.08 | \$17,345.12 |
| Total amount due: | | | \$36,449.92 |

GRADING AND EROSION CONTROL

The GEC plans will be submitted to El Paso County Planning and Community Development Department for review and approval prior to construction.

MAINTENANCE AND OPERATIONS

Maintenance of the extended detention basin is provided by the homeowner's association.

OTHER GOVERNMENT AGENCY REQUIREMENTS

Approval from other agencies such as the FEMA, the Army Corps of Engineers, Colorado State Engineer, Colorado Water Conservation Board, and others are not needed with this Project.

SUMMARY

The Project will provide water quality and detention for the Site per a full spectrum detention pond located in the southwest corner of the Site. The proposed cumulative 5-year runoff is 8.02 cfs and the cumulative 100-year runoff is 18.75 cfs. The overall imperviousness tributary to the pond is 49.4%, with a total site imperviousness of 45.7%.

COMPLIANCE WITH STANDARDS

The drainage design presented within this report for Villas at Aspen Trails, conforms to the El Paso County Drainage Criteria Manual and the Mile High Flood District Urban Storm Drainage Criteria Manual. Additionally, the Site runoff and storm drain facilities will not adversely affect the downstream and surrounding developments. The proposed flows entering the extended detention basin will be released at or less than historic rates via an outlet structure which will be designed with the Final Drainage Report.

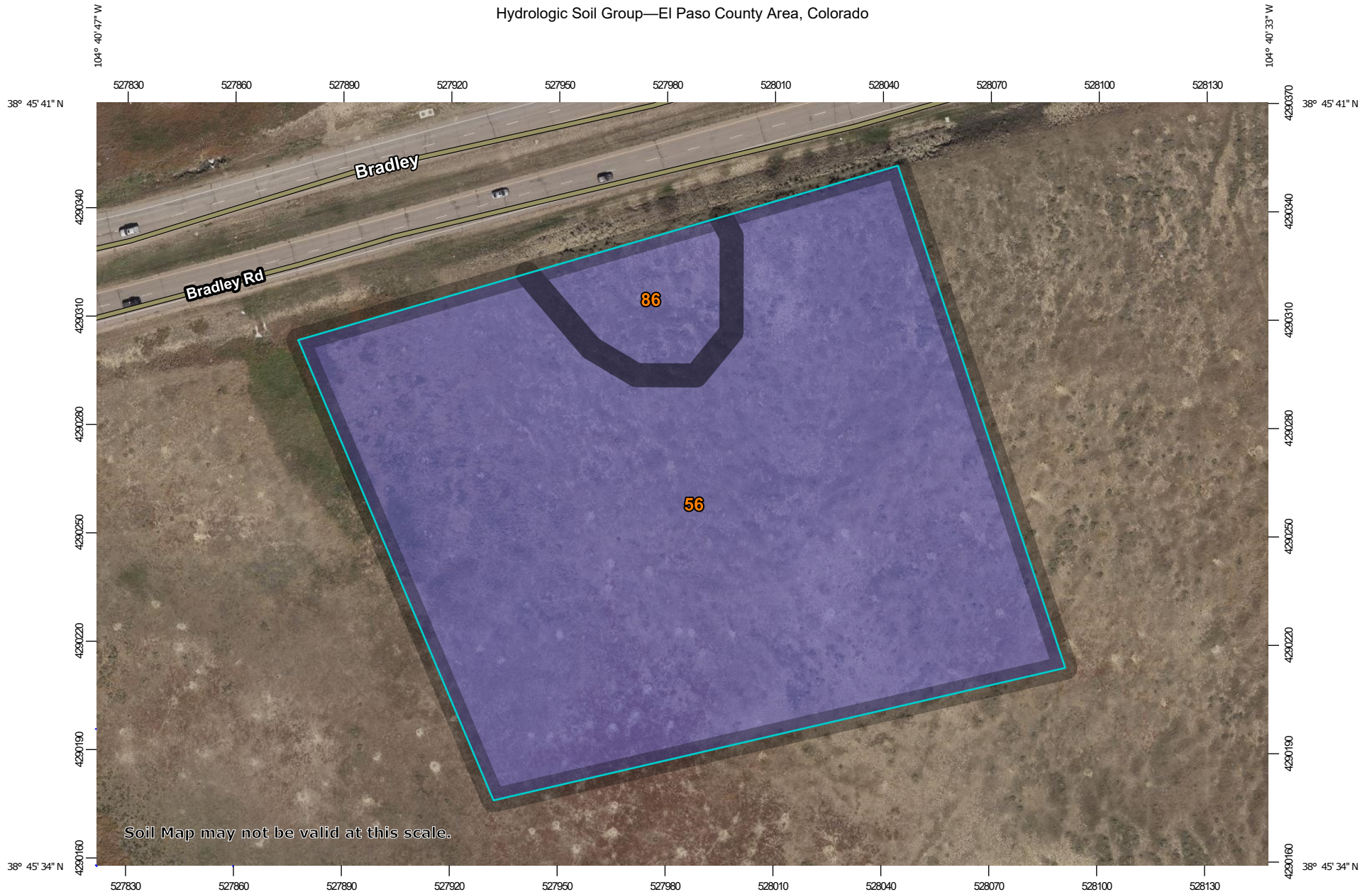
REFERENCES

1. City of Colorado Springs Drainage Criteria Manual, May 2014, Revised January 2021.
2. El Paso County Drainage Criteria Manual, Vol. 1 and 2, October 1994.
3. Mile High Flood District Drainage Criteria Manual (MHFDCM), Vol. 1, prepared by Wright-McLaughlin Engineers, June 2001, with latest revisions.
4. Flood Insurance Rate Map, El Paso County, Colorado and Incorporated Areas, Map Number 08041C0459G, Effective Date December 7, 2018, prepared by the Federal Emergency Management Agency (FEMA).

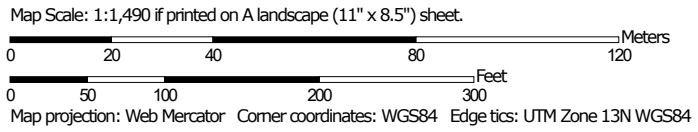
APPENDIX

APPENDIX A – FEMA FIRM MAP AND USGS SOILS MAP

Hydrologic Soil Group—El Paso County Area, Colorado




Soil Map may not be valid at this scale.



MAP LEGEND

Area of Interest (AOI)









 Area of Interest (AOI)

Soils

Soil Rating Polygons





-  A
-  A/D
-  B
-  B/D
-  C
-  C/D
-  D
-  Not rated or not available

Soil Rating Lines

-  A
-  A/D
-  B
-  B/D
-  C
-  C/D
-  D
-  Not rated or not available

Soil Rating Points



-  A
-  A/D
-  B
-  B/D

-  C
-  C/D
-  D
-  Not rated or not available


Water Features

 Streams and Canals

Transportation

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

Background

 Aerial Photography

MAP INFORMATION

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

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 19, Aug 31, 2021

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 |
|------------------------------------|--|--------|--------------|----------------|
| 56 | Nelson-Tassel fine sandy loams, 3 to 18 percent slopes | B | 5.5 | 93.1% |
| 86 | Stoneham sandy loam, 3 to 8 percent slopes | B | 0.4 | 6.9% |
| Totals for Area of Interest | | | 5.9 | 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

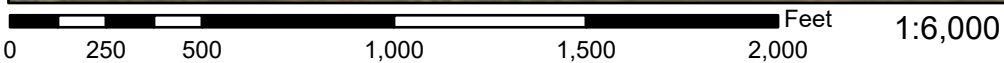
Component Percent Cutoff: None Specified

Tie-break Rule: Higher

National Flood Hazard Layer FIRMette



104°40'58"W 38°45'52"N



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

Legend

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

- | | | |
|------------------------------------|--|--|
| SPECIAL FLOOD HAZARD AREAS | | Without Base Flood Elevation (BFE) <i>Zone A, V, A99</i> |
| | | With BFE or Depth <i>Zone AE, AO, AH, VE, AR</i> |
| | | Regulatory Floodway |
| OTHER AREAS OF FLOOD HAZARD | | 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile <i>Zone X</i> |
| | | Future Conditions 1% Annual Chance Flood Hazard <i>Zone X</i> |
| | | Area with Reduced Flood Risk due to Levee. See Notes. <i>Zone X</i> |
| | | Area with Flood Risk due to Levee <i>Zone D</i> |
| OTHER AREAS | | NO SCREEN Area of Minimal Flood Hazard <i>Zone X</i> |
| | | Effective LOMRs |
| GENERAL STRUCTURES | | Area of Undetermined Flood Hazard <i>Zone D</i> |
| | | Channel, Culvert, or Storm Sewer |
| | | Levee, Dike, or Floodwall |
| OTHER FEATURES | | 20.2 Cross Sections with 1% Annual Chance |
| | | 17.5 Water Surface Elevation |
| | | Coastal Transect |
| | | Base Flood Elevation Line (BFE) |
| | | Limit of Study |
| | | Jurisdiction Boundary |
| MAP PANELS | | Digital Data Available |
| | | No Digital Data Available |
| | | Unmapped |
| | | The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location. |



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

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on **2/21/2022 at 7:00 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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

APPENDIX B – SITE DRAINAGE CALCULATIONS (PROPOSED)

IDF Equations:

$$I_{100} = -2.52\ln(D) + 12.735$$

$$I_{50} = -2.25\ln(D) + 11.375$$

$$I_{25} = -2.00\ln(D) + 10.111$$

$$I_{10} = -1.75\ln(D) + 8.847$$

$$I_5 = -1.50\ln(D) + 7.583$$

$$I_2 = -1.19\ln(D) + 6.035$$

Where:

I = Rainfall Intensity (in/hr)

D = Duration (minutes)

| | | | | |
|---------|---------------------|--------------------|----------------------|-----------------------|
| $P_1 =$ | <u>2-yr</u> 1.19 | <u>5-yr</u> 1.5 | <u>10-yr</u> 1.75 | <u>100-yr</u> 2.52 |
|---------|---------------------|--------------------|----------------------|-----------------------|

Time Intensity Frequency Tabulation

| Time | 2 YR | 5 YR | 10 YR | 25 YR | 50 YR | 100 YR |
|------|------|------|-------|-------|-------|--------|
| 5 | 4.12 | 5.17 | 6.03 | 6.89 | 7.75 | 8.68 |
| 10 | 3.29 | 4.13 | 4.82 | 5.51 | 6.19 | 6.93 |
| 15 | 2.81 | 3.52 | 4.11 | 4.69 | 5.28 | 5.91 |
| 30 | 1.99 | 2.48 | 2.89 | 3.31 | 3.72 | 4.16 |
| 60 | 1.16 | 1.44 | 1.68 | 1.92 | 2.16 | 2.42 |
| 120 | 0.34 | 0.40 | 0.47 | 0.54 | 0.60 | 0.67 |

*The Design Point Rainfall Values and Time Intensity Frequency Tabulation are found in Table 6-2 and Figure 6-5 respectively, of the Colorado Springs Drainage Criteria Manual, Volume 1

Weighted Imperviousness Calculations

| SUB-BASIN | AREA (SF) | AREA (Acres) | ROOF AREA | ROOF IMPERVIOUSNESS | ROOF | | | | LANDSCAPE AREA | LANDSCAPE IMPERVIOUSNESS | LANDSCAPE | | | | PAVEMENT AREA | PAVEMENT IMPERVIOUSNESS | PAVEMENT | | | | WEIGHTED IMPERVIOUSNESS | WEIGHTED COEFFICIENTS | | | |
|-----------|-----------|--------------|-----------|---------------------|------|------|------|------|----------------|--------------------------|-----------|------|------|------|---------------|-------------------------|----------|------|------|------|-------------------------|-----------------------|------|------|------|
| | | | | | C2 | C5 | C10 | C100 | | | C2 | C5 | C10 | C100 | | | C2 | C5 | C10 | C100 | | C2 | C5 | C10 | C100 |
| A1 | 36,687 | 0.84 | 8,090 | 90% | 0.71 | 0.73 | 0.75 | 0.81 | 19,797 | 0% | 0.02 | 0.08 | 0.15 | 0.35 | 8,800 | 100% | 0.89 | 0.90 | 0.92 | 0.96 | 43.8% | 0.38 | 0.42 | 0.47 | 0.60 |
| A2 | 19,652 | 0.45 | 3,564 | 90% | 0.71 | 0.73 | 0.75 | 0.81 | 11,350 | 0% | 0.02 | 0.08 | 0.15 | 0.35 | 4,738 | 100% | 0.89 | 0.90 | 0.92 | 0.96 | 40.4% | 0.35 | 0.40 | 0.44 | 0.58 |
| A3 | 85,176 | 1.96 | 24,866 | 90% | 0.71 | 0.73 | 0.75 | 0.81 | 25,379 | 0% | 0.02 | 0.08 | 0.15 | 0.35 | 34,931 | 100% | 0.89 | 0.90 | 0.92 | 0.96 | 67.3% | 0.58 | 0.61 | 0.64 | 0.73 |
| A4 | 17,452 | 0.40 | 0 | 90% | 0.71 | 0.73 | 0.75 | 0.81 | 17,452 | 0% | 0.02 | 0.08 | 0.15 | 0.35 | 0 | 100% | 0.89 | 0.90 | 0.92 | 0.96 | 0.0% | 0.02 | 0.08 | 0.15 | 0.35 |
| A5 | 6,520 | 0.15 | 0 | 90% | 0.71 | 0.73 | 0.75 | 0.81 | 6,100 | 0% | 0.02 | 0.08 | 0.15 | 0.35 | 420 | 100% | 0.89 | 0.90 | 0.92 | 0.96 | 6.4% | 0.08 | 0.13 | 0.20 | 0.39 |
| OS1 | 24,090 | 0.55 | 0 | 90% | 0.71 | 0.73 | 0.75 | 0.81 | 19,546 | 0% | 0.02 | 0.08 | 0.15 | 0.35 | 4,544 | 100% | 0.89 | 0.90 | 0.92 | 0.96 | 18.9% | 0.18 | 0.23 | 0.30 | 0.47 |
| OS2 | 602 | 0.01 | 0 | 90% | 0.71 | 0.73 | 0.75 | 0.81 | 35 | 0% | 0.02 | 0.08 | 0.15 | 0.35 | 567 | 100% | 0.89 | 0.90 | 0.92 | 0.96 | 94.2% | 0.84 | 0.85 | 0.88 | 0.92 |
| (A1-A5) | 165,487 | 3.80 | 36,520 | 90% | 0.71 | 0.73 | 0.75 | 0.81 | 80,078 | 0% | 0.02 | 0.08 | 0.15 | 0.35 | 48,889 | 100% | 0.89 | 0.90 | 0.92 | 0.96 | 49.4% | 0.43 | 0.47 | 0.51 | 0.63 |

**Villas at Aspen Trails
Drainage Report
El Paso County, CO**

| Villas at Aspen Trails - Drainage Report | | | | | | | | | | | | | | | | |
|---|----------------|--------------|----------|-----------------------|-------------------------|-----------------------------|----------|------------------|---------|--------|--------------|-----------------------------|-------------------------------|--------------|----------|-----------------|
| Proposed Runoff Calculations | | | | | | | | | | | | | | | | |
| Time of Concentration | | | | | | | | | | | | | | | | |
| Watercourse Coefficient | | | | | | | | | | | | | | | | |
| | | | | Forest & Meadow | 2.50 | Short Grass Pasture & Lawns | 7.00 | | | | | Grassed Waterway | 15.00 | | | |
| | | | | Fallow or Cultivation | 5.00 | Nearly Bare Ground | 10.00 | | | | | Paved Area & Shallow Gutter | 20.00 | | | |
| DESIGN POINT | SUB-BASIN DATA | | | | INITIAL / OVERLAND TIME | | | TRAVEL TIME T(t) | | | | | T(c) CHECK (URBANIZED BASINS) | | | FINAL T(c) min. |
| | DRAIN BASIN | AREA sq. ft. | AREA ac. | C(5) | Length ft. | Slope % | T(i) min | Length ft. | Slope % | Coeff. | Velocity fps | T(t) min. | COMP. T(c) | TOTAL LENGTH | L/180+10 | |
| A1 | A1 | 36,687 | 0.84 | 0.42 | 100 | 0.4% | 16.9 | 148 | 3.2% | 20.00 | 3.6 | 0.7 | 17.6 | 248 | 11.4 | 11.4 |
| A2 | A2 | 19,652 | 0.45 | 0.40 | 20 | 1.3% | 5.3 | 304 | 0.7% | 7.00 | 0.6 | 8.7 | 14.0 | 324 | 11.8 | 11.8 |
| A3 | A3 | 85,176 | 1.96 | 0.61 | 70 | 2.4% | 5.7 | 494 | 2.1% | 20.00 | 2.9 | 2.8 | 8.5 | 564 | 13.1 | 8.5 |
| A4 | A4 | 17,452 | 0.40 | 0.08 | 67 | 13.8% | 6.4 | 111 | 20.0% | 7.00 | 3.1 | 0.6 | 7.0 | 178 | 11.0 | 7.0 |
| A5 | A5 | 6,520 | 0.15 | 0.13 | 18 | 6.0% | 4.1 | 245 | 1.0% | 7.00 | 0.7 | 5.8 | 9.9 | 263 | 11.5 | 9.9 |
| OS1 | OS1 | 24,090 | 0.55 | 0.23 | 100 | 2.5% | 11.7 | 563 | 1.9% | 7.00 | 1.0 | 9.7 | 21.4 | 663 | 13.7 | 13.7 |
| OS2 | OS2 | 602 | 0.01 | 0.85 | 33 | 3.6% | 1.7 | 0 | 0.0% | 20.00 | 0.0 | 0.0 | 5.0 | 33 | 10.2 | 5.0 |

Villas at Aspen Trails
Drainage Report
El Paso County, CO

| Villas at Aspen Trails - Drainage Report Proposed Runoff Calculations Design Storm 5 Year (Rational Method Procedure) | | | | | | | | | | | | |
|---|-------------|----------|--------------|---------------|-------|---------|-------|-------------------|-------|---------|-------|-------|
| BASIN INFORMATION | | | | DIRECT RUNOFF | | | | CUMULATIVE RUNOFF | | | | NOTES |
| DESIGN POINT | DRAIN BASIN | AREA ac. | RUNOFF COEFF | T(c) min | C x A | I in/hr | Q cfs | T(c) min | C x A | I in/hr | Q cfs | |
| A1 | A1 | 0.84 | 0.42 | 11.4 | 0.35 | 3.93 | 1.39 | | | | | |
| A2 | A2 | 0.45 | 0.40 | 11.8 | 0.18 | 3.88 | 0.69 | | | | | |
| A3 | A3 | 1.96 | 0.61 | 8.5 | 1.19 | 4.37 | 5.17 | | | | | |
| A4 | A4 | 0.40 | 0.08 | 7.0 | 0.03 | 4.67 | 0.15 | | | | | |
| A5 | A5 | 0.15 | 0.13 | 9.9 | 0.02 | 4.14 | 0.08 | | | | | |
| OS1 | OS1 | 0.55 | 0.23 | 13.7 | 0.13 | 3.66 | 0.47 | | | | | |
| OS2 | OS2 | 0.01 | 0.85 | 5.0 | 0.01 | 5.17 | 0.06 | | | | | |

8.02

Villas at Aspen Trails
Drainage Report
El Paso County, CO

| Villas at Aspen Trails - Drainage Report Proposed Runoff Calculations | | | | | | | | | | | | |
|--|-------------|----------|--------------|---------------|-------|---------|-------|-------------------|-------|---------|-------|-------|
| <i>Design Storm 100 Year</i> | | | | | | | | | | | | |
| <i>(Rational Method Procedure)</i> | | | | | | | | | | | | |
| BASIN INFORMATION | | | | DIRECT RUNOFF | | | | CUMULATIVE RUNOFF | | | | NOTES |
| DESIGN POINT | DRAIN BASIN | AREA ac. | RUNOFF COEFF | T(c) min | C x A | I in/hr | Q cfs | T(c) min | C x A | I in/hr | Q cfs | |
| A1 | A1 | 0.84 | 0.60 | 11.4 | 0.50 | 6.60 | 3.32 | | | | | |
| A2 | A2 | 0.45 | 0.58 | 11.8 | 0.26 | 6.52 | 1.71 | | | | | |
| A3 | A3 | 1.96 | 0.73 | 8.5 | 1.44 | 7.33 | 10.53 | | | | | |
| A4 | A4 | 0.40 | 0.35 | 7.0 | 0.14 | 7.83 | 1.10 | | | | | |
| A5 | A5 | 0.15 | 0.39 | 9.9 | 0.06 | 6.95 | 0.40 | | | | | |
| OS1 | OS1 | 0.55 | 0.47 | 13.7 | 0.26 | 6.14 | 1.58 | | | | | |
| OS2 | OS2 | 0.01 | 0.92 | 5.0 | 0.01 | 8.68 | 0.11 | | | | | |

18.75

**Villas at Aspen Trails
Drainage Report
El Paso County, CO**

| SUMMARY - PROPOSED RUNOFF TABLE | | | | | | |
|--|--------------------------|---------------------------|---------------------------------|-----------------------------------|-----------------------|----------------------------|
| DESIGN POINT | BASIN DESIGNATION | BASIN AREA (ACRES) | DIRECT 5-YR RUNOFF (CFS) | DIRECT 100-YR RUNOFF (CFS) | BASIN IMP. (%) | 100-YR RUNOFF COEF. |
| A1 | A1 | 0.84 | 1.39 | 3.32 | 43.8% | 0.60 |
| A2 | A2 | 0.45 | 0.69 | 1.71 | 40.4% | 0.58 |
| A3 | A3 | 1.96 | 5.17 | 10.53 | 67.3% | 0.73 |
| A4 | A4 | 0.40 | 0.15 | 1.10 | 0.0% | 0.35 |
| A5 | A5 | 0.15 | 0.08 | 0.40 | 6.4% | 0.39 |
| OS1 | OS1 | 0.55 | 0.47 | 1.58 | 0.0% | 0.47 |
| OS2 | OS2 | 0.01 | 0.06 | 0.11 | 94.2% | 0.92 |
| | | | | | | |
| TOTAL | | 4.37 | 8.02 | 18.75 | | |

APPENDIX C – SITE DRAINAGE CALCULATIONS (EXISTING)

IDF Equations:

$$I_{100} = -2.52\ln(D) + 12.735$$

$$I_{50} = -2.25\ln(D) + 11.375$$

$$I_{25} = -2.00\ln(D) + 10.111$$

$$I_{10} = -1.75\ln(D) + 8.847$$

$$I_5 = -1.50\ln(D) + 7.583$$

$$I_2 = -1.19\ln(D) + 6.035$$

Where:

I = Rainfall Intensity (in/hr)

D = Duration (minutes)

| | | | | |
|---------|---------------------|--------------------|----------------------|-----------------------|
| $P_1 =$ | <u>2-yr</u> 1.19 | <u>5-yr</u> 1.5 | <u>10-yr</u> 1.75 | <u>100-yr</u> 2.52 |
|---------|---------------------|--------------------|----------------------|-----------------------|

Time Intensity Frequency Tabulation

| Time | 2 YR | 5 YR | 10 YR | 25 YR | 50 YR | 100 YR |
|------|------|------|-------|-------|-------|--------|
| 5 | 4.12 | 5.17 | 6.03 | 6.89 | 7.75 | 8.68 |
| 10 | 3.29 | 4.13 | 4.82 | 5.51 | 6.19 | 6.93 |
| 15 | 2.81 | 3.52 | 4.11 | 4.69 | 5.28 | 5.91 |
| 30 | 1.99 | 2.48 | 2.89 | 3.31 | 3.72 | 4.16 |
| 60 | 1.16 | 1.44 | 1.68 | 1.92 | 2.16 | 2.42 |
| 120 | 0.34 | 0.40 | 0.47 | 0.54 | 0.60 | 0.67 |

*The Design Point Rainfall Values and Time Intensity Frequency Tabulation are found in Table 6-2 and Figure 6-5 respectively, of the Colorado Springs Drainage Criteria Manual, Volume 1

Weighted Imperviousness Calculations

| SUB-BASIN | AREA (SF) | AREA (Acres) | ROOF AREA | ROOF IMPERVIOUSNESS | ROOF | | | | LANDSCAPE AREA | LANDSCAPE IMPERVIOUSNESS | LANDSCAPE | | | | PAVEMENT AREA | PAVEMENT IMPERVIOUSNESS | PAVEMENT | | | | WEIGHTED IMPERVIOUSNESS | WEIGHTED COEFFICIENTS | | | |
|-----------|-----------|--------------|-----------|---------------------|------|------|------|------|----------------|--------------------------|-----------|------|------|------|---------------|-------------------------|----------|------|------|------|-------------------------|-----------------------|------|------|------|
| | | | | | C2 | C5 | C10 | C100 | | | C2 | C5 | C10 | C100 | | | C2 | C5 | C10 | C100 | | C2 | C5 | C10 | C100 |
| E1 | 142,523 | 3.27 | 0 | 90% | 0.71 | 0.73 | 0.75 | 0.81 | 140,089 | 2% | 0.02 | 0.08 | 0.15 | 0.35 | 0 | 100% | 0.89 | 0.90 | 0.92 | 0.96 | 2.0% | 0.02 | 0.08 | 0.15 | 0.34 |
| E2 | 42,715 | 0.98 | 0 | 90% | 0.71 | 0.73 | 0.75 | 0.81 | 42,634 | 2% | 0.02 | 0.08 | 0.15 | 0.35 | 0 | 100% | 0.89 | 0.90 | 0.92 | 0.96 | 2.0% | 0.02 | 0.08 | 0.15 | 0.35 |

**Ray O 5.2 Single Family Attached
Drainage Report
El Paso County, CO**

| Ray O 5.2 Single Family Attached - Drainage Report Proposed Runoff Calculations | | | | | | | | | | | | | | | Watercourse Coefficient Forest & Meadow 2.50 Short Grass Pasture & Lawns 7.00 Fallow or Cultivation 5.00 Nearly Bare Ground 10.00 Grassed Waterway 15.00 Paved Area & Shallow Gutter 20.00 | |
|--|----------------|--------------|----------|------|-------------------------|---------|----------|-------------|---------|--------|--------------|-----------|-------------------------------|--------------|--|-----------------|
| Time of Concentration | | | | | | | | | | | | | | | | |
| DESIGN POINT | SUB-BASIN DATA | | | | INITIAL / OVERLAND TIME | | | TRAVEL TIME | | | | | T(c) CHECK (URBANIZED BASINS) | | | FINAL T(c) min. |
| | DRAIN BASIN | AREA sq. ft. | AREA ac. | C(5) | Length ft. | Slope % | T(i) min | Length ft. | Slope % | Coeff. | Velocity fps | T(t) min. | COMP. T(c) | TOTAL LENGTH | L/180+10 | |
| 1 | E1 | 142,523 | 3.27 | 0.08 | 0 | 17.0% | 0.0 | 431 | 2.5% | 20.00 | 3.2 | 2.3 | 5.0 | 431 | 12.4 | 5.0 |
| 2 | E2 | 42,715 | 0.98 | 0.08 | 0 | 12.0% | 0.0 | 141 | 2.4% | 20.00 | 3.1 | 0.8 | 5.0 | 141 | 10.8 | 5.0 |

Ray O 5.2 Single Family Attached
Drainage Report
El Paso County, CO

| Ray O 5.2 Single Family Attached - Drainage Report Proposed Runoff Calculations <i>Design Storm 5 Year</i> (Rational Method Procedure) | | | | | | | | | | | | |
|---|-------------|----------|--------------|---------------|-------|---------|-------|-------------------|-------|---------|-------|-------|
| BASIN INFORMATION | | | | DIRECT RUNOFF | | | | CUMULATIVE RUNOFF | | | | NOTES |
| DESIGN POINT | DRAIN BASIN | AREA ac. | RUNOFF COEFF | T(c) min | C x A | I in/hr | Q cfs | T(c) min | C x A | I in/hr | Q cfs | |
| 1 | E1 | 3.27 | 0.08 | 5.0 | 0.26 | 5.17 | 1.33 | | | | | |
| 2 | E2 | 0.98 | 0.08 | 5.0 | 0.08 | 5.17 | 0.40 | | | | | |

1.73

Ray O 5.2 Single Family Attached
Drainage Report
El Paso County, CO

| Ray O 5.2 Single Family Attached - Drainage Report Proposed Runoff Calculations <i>Design Storm 100 Year</i> (Rational Method Procedure) | | | | | | | | | | | | |
|---|-------------|----------|--------------|---------------|-------|---------|-------|-------------------|-------|---------|-------|-------|
| BASIN INFORMATION | | | | DIRECT RUNOFF | | | | CUMULATIVE RUNOFF | | | | NOTES |
| DESIGN POINT | DRAIN BASIN | AREA ac. | RUNOFF COEFF | T(c) min | C x A | I in/hr | Q cfs | T(c) min | C x A | I in/hr | Q cfs | |
| 1 | E1 | 3.27 | 0.34 | 5.0 | 1.13 | 8.68 | 9.77 | | | | | |
| 2 | E2 | 0.98 | 0.35 | 5.0 | 0.34 | 8.68 | 2.97 | | | | | |

12.74

**Ray O 5.2 Single Family Attached
Drainage Report
El Paso County, CO**

| SUMMARY - PROPOSED RUNOFF TABLE | | | | | | |
|--|--------------------------|---------------------------|---------------------------------|-----------------------------------|-----------------------|----------------------------|
| DESIGN POINT | BASIN DESIGNATION | BASIN AREA (ACRES) | DIRECT 5-YR RUNOFF (CFS) | DIRECT 100-YR RUNOFF (CFS) | BASIN IMP. (%) | 100-YR RUNOFF COEF. |
| 1 | E1 | 3.27 | 1.33 | 9.77 | 0.02 | 0.34 |
| 2 | E2 | 0.98 | 0.40 | 2.97 | 0.02 | 0.35 |
| TOTAL | | 4.25 | 1.73 | 12.74 | | |

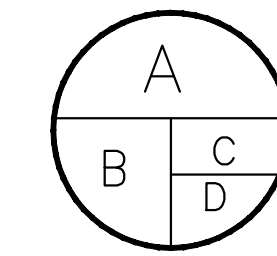
APPENDIX D – SITE DRAINAGE MAP (PROPOSED AND EXISTING)

RAY O 5.2 SINGLE FAMILY ATTACHED

EXISTING DRAINAGE EXHIBIT

SITUATED IN A PORTION OF SECTION 9, TOWNSHIP 15 SOUTH, RANGE 65 WEST OF THE 6TH P.M. CITY OF COLORADO
SPRINGS, COUNTY OF EL PASO, STATE OF COLORADO

LEGEND



A = BASIN DESIGNATION
B = AREA (ACRES)
C = 100-YR DESIGN STORM RUNOFF (CFS)
D = PERCENT IMPERVIOUSNESS



= DESIGN POINT

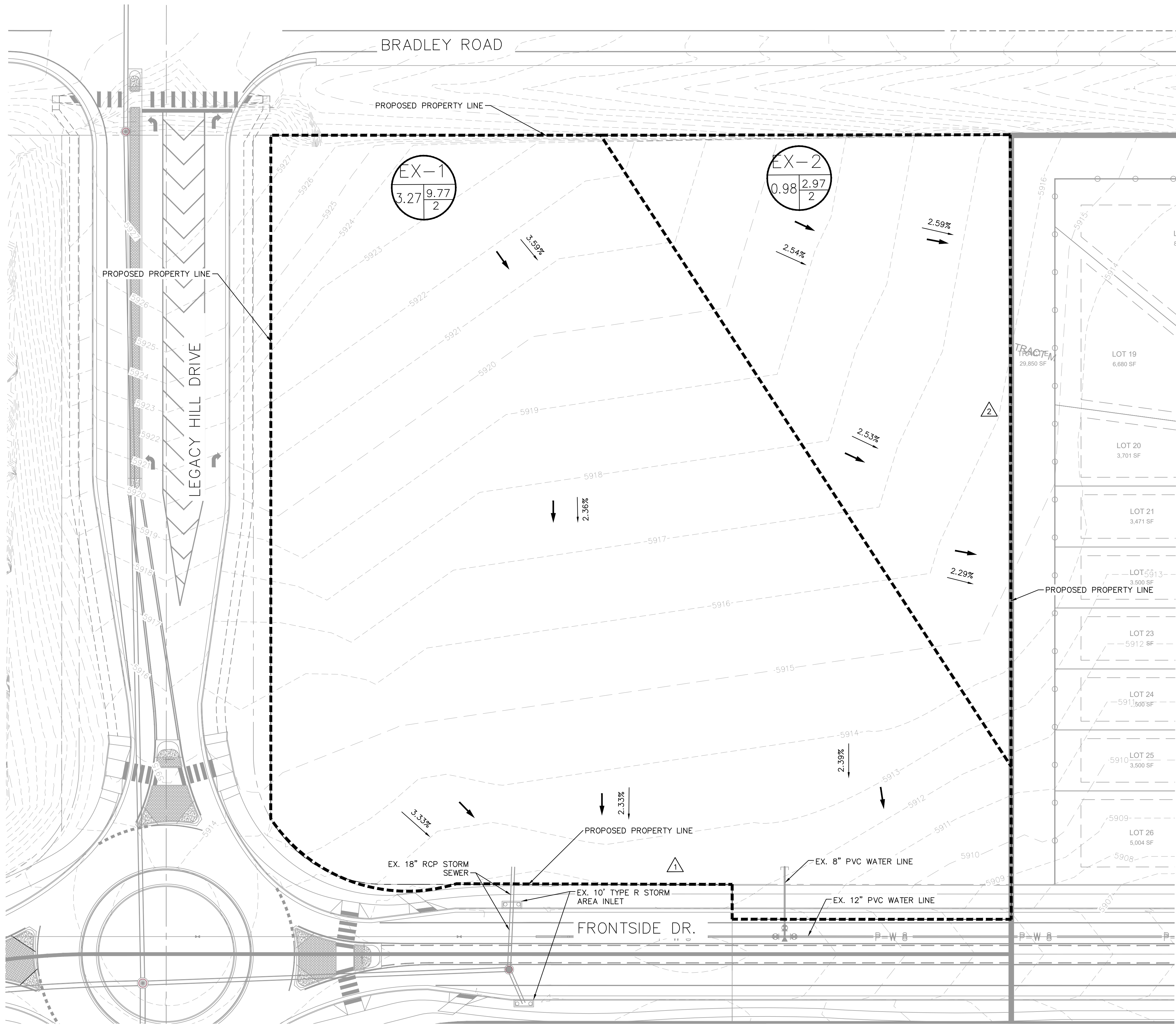
→ FLOW DIRECTION

--- DRAINAGE SUB-BASIN BOUNDARY

- - - - - EXISTING MAJOR CONTOUR

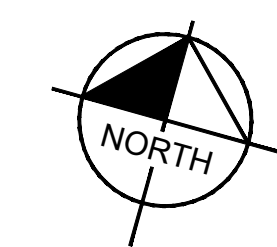
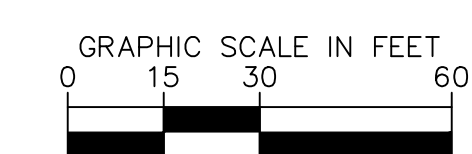
- - - - - EXISTING MINOR CONTOUR

--- PROPERTY LINE



SUMMARY - PROPOSED RUNOFF TABLE

| DESIGN POINT | BASIN DESIGNATION | BASIN AREA (ACRES) | DIRECT 5-YR RUNOFF (CFS) | DIRECT 100-YR RUNOFF (CFS) | BASIN IMP. (%) | 100-YR RUNOFF COEF. |
|--------------|-------------------|--------------------|--------------------------|----------------------------|----------------|---------------------|
| 1 | E1 | 3.27 | 1.33 | 9.77 | 0.02 | 0.34 |
| 2 | E2 | 0.98 | 0.40 | 2.97 | 0.02 | 0.35 |



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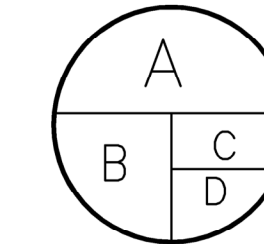
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COLORADO SPRINGS, COLORADO 80903 (719) 453-0180

VILLAS AT ASPEN TRAILS

PROPOSED DRAINAGE EXHIBIT

SITUATED IN A PORTION OF SECTION 9, TOWNSHIP 15 SOUTH, RANGE 65 WEST OF THE 6TH P.M. CITY OF COLORADO SPRINGS,
COUNTY OF EL PASO, STATE OF COLORADO

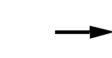
LEGEND



A = BASIN DESIGNATION
B = AREA (ACRES)
C = 100-YR DESIGN STORM
RUNOFF (CFS)
D = PERCENT IMPERVIOUSNESS



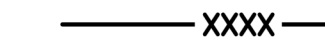
= DESIGN POINT



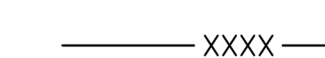
→ FLOW DIRECTION



--- DRAINAGE SUB-BASIN BOUNDARY



XXXX PROPOSED MAJOR CONTOUR



XXXX PROPOSED MINOR CONTOUR



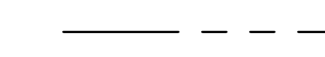
XXXX EXISTING MAJOR CONTOUR



XXXX EXISTING MINOR CONTOUR



--- PROPERTY LINE

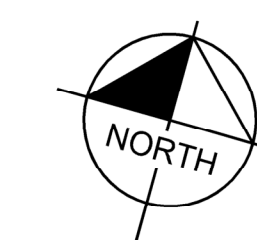
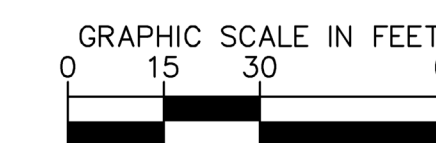
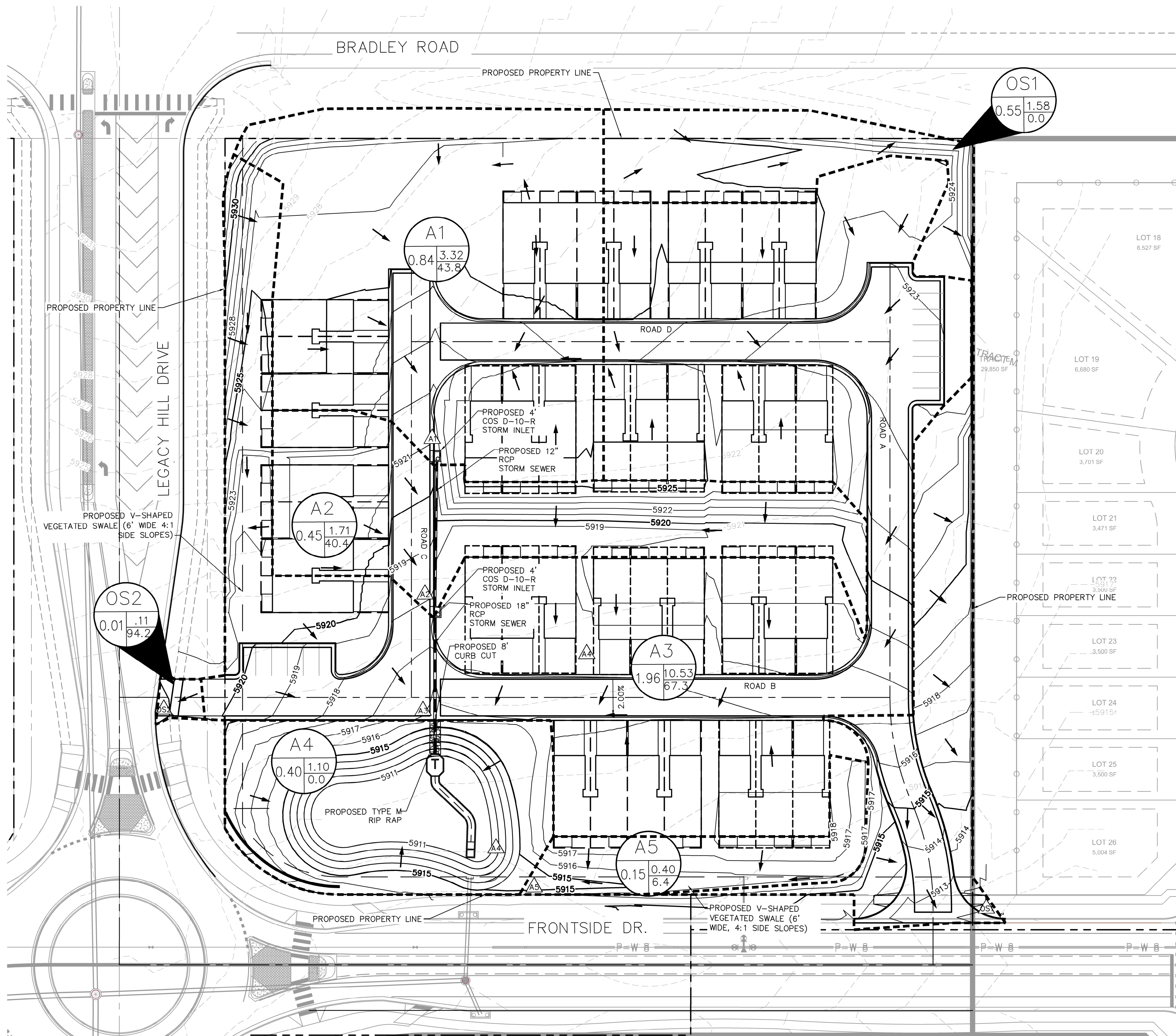


--- PROPOSED STORM SEWER



□ PROPOSED STORM INLET

| SUMMARY - PROPOSED RUNOFF TABLE | | | | | | |
|---------------------------------|-------------------|--------------------|--------------------------|----------------------------|----------------|---------------------|
| DESIGN POINT | BASIN DESIGNATION | BASIN AREA (ACRES) | DIRECT 5-YR RUNOFF (CFS) | DIRECT 100-YR RUNOFF (CFS) | BASIN IMP. (%) | 100-YR RUNOFF COEF. |
| A1 | A1 | 0.84 | 1.39 | 3.32 | 43.8% | 0.60 |
| A2 | A2 | 0.45 | 0.69 | 1.71 | 40.4% | 0.58 |
| A3 | A3 | 1.96 | 5.17 | 10.53 | 67.3% | 0.73 |
| A4 | A4 | 0.40 | 0.15 | 1.10 | 0.0% | 0.35 |
| A5 | A5 | 0.15 | 0.08 | 0.40 | 6.4% | 0.39 |
| OS1 | OS1 | 0.55 | 0.47 | 1.58 | 0.0% | 0.47 |
| OS2 | OS2 | 0.01 | 0.06 | 0.11 | 94.2% | 0.92 |
| TOTAL | | 4.37 | 8.02 | 18.75 | | |



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APPENDIX E – HYDRAULIC COMPUTATIONS

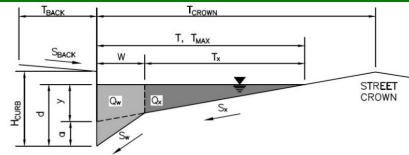
Worksheet for Storm Line A1-2

| Project Description | |
|-----------------------------|---------------------|
| Friction Method | Manning Formula |
| Solve For | Normal Depth |
| Input Data | |
| Roughness Coefficient | 0.013 |
| Channel Slope | 0.020 ft/ft |
| Diameter | 12.0 in |
| Discharge | 2.10 cfs |
| Results | |
| Normal Depth | 5.4 in |
| Flow Area | 0.3 ft ² |
| Wetted Perimeter | 1.5 ft |
| Hydraulic Radius | 2.8 in |
| Top Width | 1.00 ft |
| Critical Depth | 7.4 in |
| Percent Full | 45.0 % |
| Critical Slope | 0.007 ft/ft |
| Velocity | 6.12 ft/s |
| Velocity Head | 0.58 ft |
| Specific Energy | 1.03 ft |
| Froude Number | 1.837 |
| Maximum Discharge | 5.42 cfs |
| Discharge Full | 5.04 cfs |
| Slope Full | 0.003 ft/ft |
| Flow Type | Supercritical |
| GVF Input Data | |
| Downstream Depth | 0.0 in |
| Length | 0.0 ft |
| Number Of Steps | 0 |
| GVF Output Data | |
| Upstream Depth | 0.0 in |
| Profile Description | N/A |
| Profile Headloss | 0.00 ft |
| Average End Depth Over Rise | 0.0 % |
| Normal Depth Over Rise | 45.0 % |
| Downstream Velocity | Infinity ft/s |
| Upstream Velocity | Infinity ft/s |
| Normal Depth | 5.4 in |
| Critical Depth | 7.4 in |
| Channel Slope | 0.020 ft/ft |
| Critical Slope | 0.007 ft/ft |

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

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

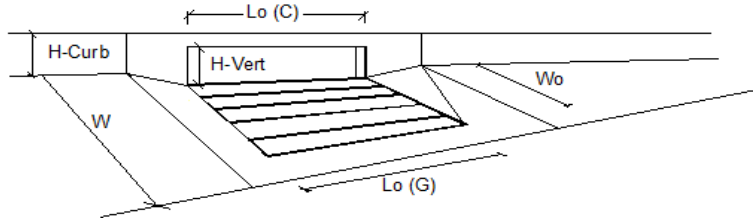
Project: Villas at Aspen Trails
Inlet ID: Sub Basin A2



| Gutter Geometry: | | | | | | | | | |
|--|--|--------------------------|--------------------------|--------------------------|--------|------|------|------|--|
| Maximum Allowable Width for Spread Behind Curb | $T_{BACK} = $ <input style="width: 50px;" type="text" value="17.0"/> ft | | | | | | | | |
| Side Slope Behind Curb (leave blank for no conveyance credit behind curb) | $S_{BACK} = $ <input style="width: 50px;" type="text" value="0.009"/> ft/ft | | | | | | | | |
| Manning's Roughness Behind Curb (typically between 0.012 and 0.020) | $n_{BACK} = $ <input style="width: 50px;" type="text" value="0.020"/> | | | | | | | | |
| Height of Curb at Gutter Flow Line | $H_{CURB} = $ <input style="width: 50px;" type="text" value="6.00"/> inches | | | | | | | | |
| Distance from Curb Face to Street Crown | $T_{CROWN} = $ <input style="width: 50px;" type="text" value="24.0"/> ft | | | | | | | | |
| Gutter Width | $W = $ <input style="width: 50px;" type="text" value="2.00"/> ft | | | | | | | | |
| Street Transverse Slope | $S_X = $ <input style="width: 50px;" type="text" value="0.021"/> ft/ft | | | | | | | | |
| Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft) | $S_W = $ <input style="width: 50px;" type="text" value="0.083"/> ft/ft | | | | | | | | |
| Street Longitudinal Slope - Enter 0 for sump condition | $S_O = $ <input style="width: 50px;" type="text" value="0.018"/> ft/ft | | | | | | | | |
| Manning's Roughness for Street Section (typically between 0.012 and 0.020) | $n_{STREET} = $ <input style="width: 50px;" type="text" value="0.016"/> | | | | | | | | |
| Max. Allowable Spread for Minor & Major Storm | <table style="width: 100%; border: none;"> <tr> <td style="text-align: center; border: none;">$T_{MAX} =$</td> <td style="text-align: center; border: none;">Minor Storm</td> <td style="text-align: center; border: none;">Major Storm</td> <td style="border: none;">ft</td> </tr> <tr> <td style="border: none;"></td> <td style="border: 1px solid black; text-align: center;">24.0</td> <td style="border: 1px solid black; text-align: center;">24.0</td> <td style="border: none;"></td> </tr> </table> | $T_{MAX} = $ | Minor Storm | Major Storm | ft | | 24.0 | 24.0 | |
| $T_{MAX} = $ | Minor Storm | Major Storm | ft | | | | | | |
| | 24.0 | 24.0 | | | | | | | |
| Max. Allowable Depth at Gutter Flowline for Minor & Major Storm | <table style="width: 100%; border: none;"> <tr> <td style="border: none;">$d_{MAX} =$</td> <td style="border: 1px solid black; text-align: center;">6.0</td> <td style="border: 1px solid black; text-align: center;">6.0</td> <td style="border: none;">inches</td> </tr> </table> | $d_{MAX} = $ | 6.0 | 6.0 | inches | | | | |
| $d_{MAX} = $ | 6.0 | 6.0 | inches | | | | | | |
| Allow Flow Depth at Street Crown (check box for yes, leave blank for no) | <table style="width: 100%; border: none;"> <tr> <td style="border: none;"></td> <td style="text-align: center; border: none;"><input type="checkbox"/></td> <td style="text-align: center; border: none;"><input type="checkbox"/></td> <td style="border: none;"></td> </tr> </table> | | <input type="checkbox"/> | <input type="checkbox"/> | | | | | |
| | <input type="checkbox"/> | <input type="checkbox"/> | | | | | | | |
| MINOR STORM Allowable Capacity is based on Depth Criterion | | | | | | | | | |
| MAJOR STORM Allowable Capacity is based on Depth Criterion | | | | | | | | | |
| 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' | | | | | | | | | |
| $Q_{allow} = $ | <table style="width: 100%; border: none;"> <tr> <td style="text-align: center; border: none;">Minor Storm</td> <td style="text-align: center; border: none;">Major Storm</td> <td style="border: none;">cfs</td> </tr> <tr> <td style="border: 1px solid black; text-align: center;">17.9</td> <td style="border: 1px solid black; text-align: center;">17.9</td> <td style="border: none;"></td> </tr> </table> | Minor Storm | Major Storm | cfs | 17.9 | 17.9 | | | |
| Minor Storm | Major Storm | cfs | | | | | | | |
| 17.9 | 17.9 | | | | | | | | |

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 5.01 (April 2021)



| Design Information (Input) | MINOR | MAJOR | |
|---|-------------------------|----------------------|--------|
| Type of Inlet | Colorado Springs D-10-R | | |
| Local Depression (additional to continuous gutter depression 'a') | 4.0 | 4.0 | inches |
| Total Number of Units in the Inlet (Grate or Curb Opening) | 1 | 1 | |
| Length of a Single Unit Inlet (Grate or Curb Opening) | 4.00 | 4.00 | ft |
| Width of a Unit Grate (cannot be greater than W, Gutter Width) | N/A | N/A | ft |
| Clogging Factor for a Single Unit Grate (typical min. value = 0.5) | N/A | N/A | |
| Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1) | 0.10 | 0.10 | |
| Street Hydraulics: OK - Q < Allowable Street Capacity | | | |
| Total Inlet Interception Capacity | Q = 0.8 | Q = 1.9 | cfs |
| Total Inlet Carry-Over Flow (flow bypassing inlet) | Q _s = 0.0 | Q _s = 1.0 | cfs |
| Capture Percentage = Q _i /Q _s = | C% = 100 | C% = 65 | % |

Worksheet for Design Point A3 Curb Cut

| Project Description | |
|-----------------------|---------------------|
| Friction Method | Manning Formula |
| Solve For | Normal Depth |
| Input Data | |
| Roughness Coefficient | 0.013 |
| Channel Slope | 0.005 ft/ft |
| Bottom Width | 8.00 ft |
| Discharge | 15.53 cfs |
| Results | |
| Normal Depth | 5.3 in |
| Flow Area | 3.5 ft ² |
| Wetted Perimeter | 8.9 ft |
| Hydraulic Radius | 4.8 in |
| Top Width | 8.00 ft |
| Critical Depth | 5.9 in |
| Critical Slope | 0.004 ft/ft |
| Velocity | 4.38 ft/s |
| Velocity Head | 0.30 ft |
| Specific Energy | 0.74 ft |
| Froude Number | 1.161 |
| Flow Type | Supercritical |
| GVF Input Data | |
| Downstream Depth | 0.0 in |
| Length | 0.0 ft |
| Number Of Steps | 0 |
| GVF Output Data | |
| Upstream Depth | 0.0 in |
| Profile Description | N/A |
| Profile Headloss | 0.00 ft |
| Downstream Velocity | Infinity ft/s |
| Upstream Velocity | Infinity ft/s |
| Normal Depth | 5.3 in |
| Critical Depth | 5.9 in |
| Channel Slope | 0.005 ft/ft |
| Critical Slope | 0.004 ft/ft |

Worksheet for Storm Line A1-2

| Project Description | |
|-----------------------------|---------------------|
| Friction Method | Manning Formula |
| Solve For | Normal Depth |
| Input Data | |
| Roughness Coefficient | 0.013 |
| Channel Slope | 0.020 ft/ft |
| Diameter | 12.0 in |
| Discharge | 2.10 cfs |
| Results | |
| Normal Depth | 5.4 in |
| Flow Area | 0.3 ft ² |
| Wetted Perimeter | 1.5 ft |
| Hydraulic Radius | 2.8 in |
| Top Width | 1.00 ft |
| Critical Depth | 7.4 in |
| Percent Full | 45.0 % |
| Critical Slope | 0.007 ft/ft |
| Velocity | 6.12 ft/s |
| Velocity Head | 0.58 ft |
| Specific Energy | 1.03 ft |
| Froude Number | 1.837 |
| Maximum Discharge | 5.42 cfs |
| Discharge Full | 5.04 cfs |
| Slope Full | 0.003 ft/ft |
| Flow Type | Supercritical |
| GVF Input Data | |
| Downstream Depth | 0.0 in |
| Length | 0.0 ft |
| Number Of Steps | 0 |
| GVF Output Data | |
| Upstream Depth | 0.0 in |
| Profile Description | N/A |
| Profile Headloss | 0.00 ft |
| Average End Depth Over Rise | 0.0 % |
| Normal Depth Over Rise | 45.0 % |
| Downstream Velocity | Infinity ft/s |
| Upstream Velocity | Infinity ft/s |
| Normal Depth | 5.4 in |
| Critical Depth | 7.4 in |
| Channel Slope | 0.020 ft/ft |
| Critical Slope | 0.007 ft/ft |

Worksheet for Storm Line A2-3

| Project Description | |
|-----------------------------|---------------------|
| Friction Method | Manning Formula |
| Solve For | Normal Depth |
| Input Data | |
| Roughness Coefficient | 0.013 |
| Channel Slope | 0.020 ft/ft |
| Diameter | 18.0 in |
| Discharge | 4.00 cfs |
| Results | |
| Normal Depth | 6.4 in |
| Flow Area | 0.6 ft ² |
| Wetted Perimeter | 1.9 ft |
| Hydraulic Radius | 3.5 in |
| Top Width | 1.44 ft |
| Critical Depth | 9.2 in |
| Percent Full | 35.4 % |
| Critical Slope | 0.005 ft/ft |
| Velocity | 7.13 ft/s |
| Velocity Head | 0.79 ft |
| Specific Energy | 1.32 ft |
| Froude Number | 2.012 |
| Maximum Discharge | 15.98 cfs |
| Discharge Full | 14.85 cfs |
| Slope Full | 0.001 ft/ft |
| Flow Type | Supercritical |
| GVF Input Data | |
| Downstream Depth | 0.0 in |
| Length | 0.0 ft |
| Number Of Steps | 0 |
| GVF Output Data | |
| Upstream Depth | 0.0 in |
| Profile Description | N/A |
| Profile Headloss | 0.00 ft |
| Average End Depth Over Rise | 0.0 % |
| Normal Depth Over Rise | 35.4 % |
| Downstream Velocity | Infinity ft/s |
| Upstream Velocity | Infinity ft/s |
| Normal Depth | 6.4 in |
| Critical Depth | 9.2 in |
| Channel Slope | 0.020 ft/ft |
| Critical Slope | 0.005 ft/ft |

Worksheet for Swale A1

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

| Input Data | |
|-----------------------|-------------|
| Roughness Coefficient | 0.013 |
| Channel Slope | 0.080 ft/ft |
| Normal Depth | 6.0 in |
| Left Side Slope | 50.000 H:V |
| Right Side Slope | 3.000 H:V |

| Results | |
|------------------|---------------------|
| Discharge | 84.81 cfs |
| Flow Area | 6.6 ft ² |
| Wetted Perimeter | 26.6 ft |
| Hydraulic Radius | 3.0 in |
| Top Width | 26.50 ft |
| Critical Depth | 11.0 in |
| Critical Slope | 0.003 ft/ft |
| Velocity | 12.80 ft/s |
| Velocity Head | 2.55 ft |
| Specific Energy | 3.05 ft |
| Froude Number | 4.514 |
| Flow Type | Supercritical |

| GVF Input Data | |
|------------------|--------|
| Downstream Depth | 0.0 in |
| Length | 0.0 ft |
| Number Of Steps | 0 |

| GVF Output Data | |
|---------------------|---------------|
| Upstream Depth | 0.0 in |
| Profile Description | N/A |
| Profile Headloss | 0.00 ft |
| Downstream Velocity | Infinity ft/s |
| Upstream Velocity | Infinity ft/s |
| Normal Depth | 6.0 in |
| Critical Depth | 11.0 in |
| Channel Slope | 0.080 ft/ft |
| Critical Slope | 0.003 ft/ft |

Worksheet for Swale A2

| Project Description | |
|-----------------------|----------------------|
| Friction Method | Manning |
| Solve For | Formula Discharge |
| Input Data | |
| Roughness Coefficient | 0.030 |
| Channel Slope | 0.020 ft/ft |
| Normal Depth | 9.0 in |
| Left Side Slope | 3.000 H:V |
| Right Side Slope | 10.000 H:V |
| Results | |
| Discharge | 13.18 cfs |
| Flow Area | 3.7 ft ² |
| Wetted Perimeter | 9.9 ft |
| Hydraulic Radius | 4.4 in |
| Top Width | 9.75 ft |
| Critical Depth | 9.1 in |
| Critical Slope | 0.018 ft/ft |
| Velocity | 3.60 ft/s |
| Velocity Head | 0.20 ft |
| Specific Energy | 0.95 ft |
| Froude Number | 1.037 |
| Flow Type | Supercritical |
| GVF Input Data | |
| Downstream Depth | 0.0 in |
| Length | 0.0 ft |
| Number Of Steps | 0 |
| GVF Output Data | |
| Upstream Depth | 0.0 in |
| Profile Description | N/A |
| Profile Headloss | 0.00 ft |
| Downstream Velocity | Infinity ft/s |
| Upstream Velocity | Infinity ft/s |
| Normal Depth | 9.0 in |
| Critical Depth | 9.1 in |
| Channel Slope | 0.020 ft/ft |
| Critical Slope | 0.018 ft/ft |

Worksheet for Swale A3

| Project Description | |
|-----------------------|---------------------|
| Friction Method | Manning Formula |
| Solve For | Discharge |
| Input Data | |
| Roughness Coefficient | 0.030 |
| Channel Slope | 0.007 ft/ft |
| Normal Depth | 7.0 in |
| Left Side Slope | 5.000 H:V |
| Right Side Slope | 50.000 H:V |
| Results | |
| Discharge | 17.03 cfs |
| Flow Area | 9.4 ft ² |
| Wetted Perimeter | 32.1 ft |
| Hydraulic Radius | 3.5 in |
| Top Width | 32.08 ft |
| Critical Depth | 5.7 in |
| Critical Slope | 0.021 ft/ft |
| Velocity | 1.82 ft/s |
| Velocity Head | 0.05 ft |
| Specific Energy | 0.63 ft |
| Froude Number | 0.594 |
| Flow Type | Subcritical |
| GVF Input Data | |
| Downstream Depth | 0.0 in |
| Length | 0.0 ft |
| Number Of Steps | 0 |
| GVF Output Data | |
| Upstream Depth | 0.0 in |
| Profile Description | N/A |
| Profile Headloss | 0.00 ft |
| Downstream Velocity | Infinity ft/s |
| Upstream Velocity | Infinity ft/s |
| Normal Depth | 7.0 in |
| Critical Depth | 5.7 in |
| Channel Slope | 0.007 ft/ft |
| Critical Slope | 0.021 ft/ft |

Worksheet for Swale A5

| Project Description | |
|-----------------------|---------------------|
| Friction Method | Manning Formula |
| Solve For | Discharge |
| Input Data | |
| Roughness Coefficient | 0.030 |
| Channel Slope | 0.020 ft/ft |
| Normal Depth | 12.0 in |
| Left Side Slope | 8.000 H:V |
| Right Side Slope | 3.000 H:V |
| Results | |
| Discharge | 23.94 cfs |
| Flow Area | 5.5 ft ² |
| Wetted Perimeter | 11.2 ft |
| Hydraulic Radius | 5.9 in |
| Top Width | 11.00 ft |
| Critical Depth | 12.4 in |
| Critical Slope | 0.017 ft/ft |
| Velocity | 4.35 ft/s |
| Velocity Head | 0.29 ft |
| Specific Energy | 1.29 ft |
| Froude Number | 1.085 |
| Flow Type | Supercritical |
| GVF Input Data | |
| Downstream Depth | 0.0 in |
| Length | 0.0 ft |
| Number Of Steps | 0 |
| GVF Output Data | |
| Upstream Depth | 0.0 in |
| Profile Description | N/A |
| Profile Headloss | 0.00 ft |
| Downstream Velocity | Infinity ft/s |
| Upstream Velocity | Infinity ft/s |
| Normal Depth | 12.0 in |
| Critical Depth | 12.4 in |
| Channel Slope | 0.020 ft/ft |
| Critical Slope | 0.017 ft/ft |

Extended Detention Basin (EDB) Calculations

Date 11/3/2022
 Prepared By JAR
 Checked By JAR

Manual Input
 Multipliers

| | |
|-----------------|------|
| Release Factor: | 0.02 |
|-----------------|------|

Forebay Release and Configuration: Release 2% of the undetained 100-year peak discharge by way of a wall/notch or berm/pipe configuration

| Forebay | Incoming Pipe Diameter (in) | Release Rate (cfs) |
|---------|-----------------------------|--------------------|
| A | 18 | 0.31 |

| Maximum Forebay Depth | | | | |
|-----------------------|-----------------------------------|----------------------------|---------------------------|---------------------------|
| Forebay | Impervious Area in Watershed (ac) | Maximum Forebay Depth (in) | Design Forebay Depth (in) | Design Forebay Depth (ft) |
| A | 1.96 | 12 | 12 | 1 |

Note: a forebay depth of 30" requires handrails by most City Standards

| Baffle Block Design | | | | |
|---------------------|-----------------------------|-----------------|------------------|-------------|
| Forebay | Incoming Pipe Diameter (in) | 1/4 of Diameter | Side length (in) | Height (in) |
| A | 18 | 4.5 | 8.00 | 9 |

| Minimum Forebay Volume Required: 3% WQCV | | | | | | | | | |
|--|--------------|-------------------------|----------------------|-------------------|------------------|----------------------|--------------------|--------------------|--------------------|
| Forebay | WQCV (ac-ft) | Required Volume (ac-ft) | Required Volume (cf) | Total Length (ft) | Total Width (ft) | Corner Calculations | | | Design Volume (cf) |
| | | | | | | Triangle Height (ft) | Triangle Base (ft) | Triangle Area (sf) | |
| A | 0.065 | 0.002 | 85 | 12 | 9 | 2.5 | 2.5 | 3.125 | 95.5 |

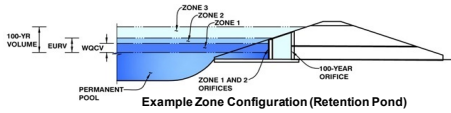
Volume Factor: 0.03

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.04 (February 2021)

Project: **Villas at Aspen Trails**

Basin ID: **South Pond**



Watershed Information

| | | |
|---|------------|---------|
| Selected BMP Type = | EDB | |
| Watershed Area = | 3.80 | acres |
| Watershed Length = | 500 | ft |
| Watershed Length to Centroid = | 250 | ft |
| Watershed Slope = | 0.035 | ft/ft |
| Watershed Imperviousness = | 49.40% | percent |
| Percentage Hydrologic Soil Group A = | 0.0% | percent |
| Percentage Hydrologic Soil Group B = | 100.0% | percent |
| Percentage Hydrologic Soil Groups C/D = | 0.0% | percent |
| Target WQCV Drain Time = | 40.0 | hours |
| Location for 1-hr Rainfall Depths = | User Input | |

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

| | | |
|--|-------|-----------|
| Water Quality Capture Volume (WQCV) = | 0.065 | acre-feet |
| Excess Urban Runoff Volume (EURV) = | 0.200 | acre-feet |
| 2-yr Runoff Volume (P1 = 1.19 in.) = | 0.180 | acre-feet |
| 5-yr Runoff Volume (P1 = 1.5 in.) = | 0.257 | acre-feet |
| 10-yr Runoff Volume (P1 = 1.75 in.) = | 0.326 | acre-feet |
| 25-yr Runoff Volume (P1 = 1.69 in.) = | 0.327 | acre-feet |
| 50-yr Runoff Volume (P1 = 1.99 in.) = | 0.415 | acre-feet |
| 100-yr Runoff Volume (P1 = 2.52 in.) = | 0.587 | acre-feet |
| 500-yr Runoff Volume (P1 = 3.14 in.) = | 0.780 | acre-feet |
| Approximate 2-yr Detention Volume = | 0.151 | acre-feet |
| Approximate 5-yr Detention Volume = | 0.207 | acre-feet |
| Approximate 10-yr Detention Volume = | 0.275 | acre-feet |
| Approximate 25-yr Detention Volume = | 0.255 | acre-feet |
| Approximate 50-yr Detention Volume = | 0.279 | acre-feet |
| Approximate 100-yr Detention Volume = | 0.352 | acre-feet |

Optional User Overrides

| | | |
|--|------|-----------|
| | | acre-feet |
| | | acre-feet |
| | 1.19 | inches |
| | 1.50 | inches |
| | 1.75 | inches |
| | | inches |
| | | inches |
| | 2.52 | inches |
| | | inches |

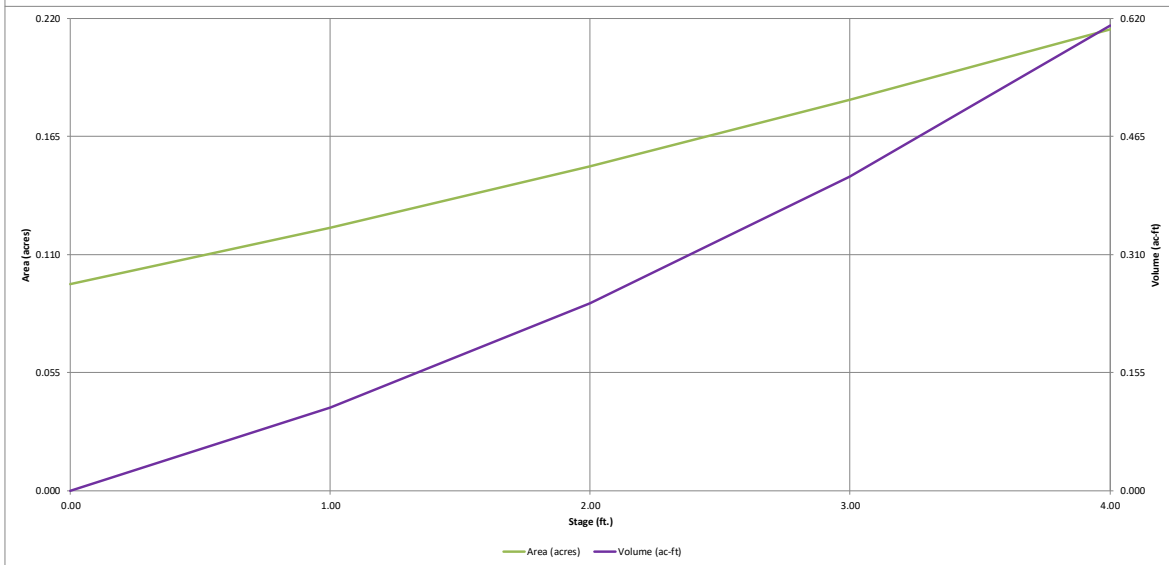
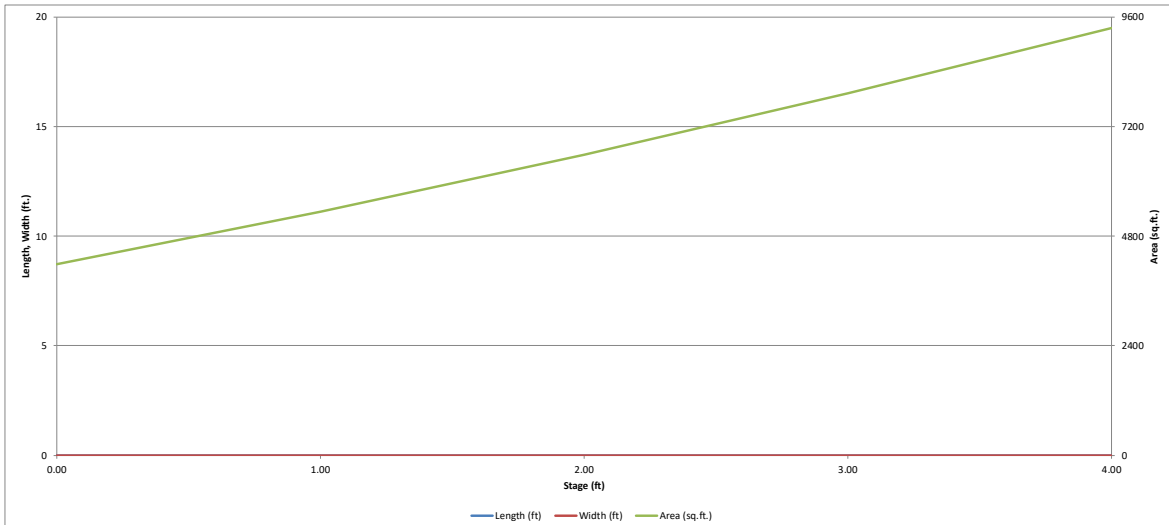
Define Zones and Basin Geometry

| | | |
|---|-------|-----------------|
| Zone 1 Volume (WQCV) = | 0.065 | acre-feet |
| Zone 2 Volume (EURV - Zone 1) = | 0.136 | acre-feet |
| Zone 3 Volume (100-year - Zones 1 & 2) = | 0.152 | acre-feet |
| Total Detention Basin Volume = | 0.352 | acre-feet |
| Initial Surcharge Volume (ISV) = | user | ft ³ |
| Initial Surcharge Depth (ISD) = | user | ft |
| Total Available Detention Depth (H _{total}) = | user | ft |
| Depth of Trickle Channel (H _{TC}) = | user | ft |
| Slope of Trickle Channel (S _{TC}) = | user | ft/ft |
| Slopes of Main Basin Sides (S _{main}) = | user | H:V |
| Basin Length-to-Width Ratio (R _{L/W}) = | user | |
| Initial Surcharge Area (A _{ISV}) = | user | ft ² |
| Surcharge Volume Length (L _{SV}) = | user | ft |
| Surcharge Volume Width (W _{SV}) = | user | ft |
| Depth of Basin Floor (H _{FLOOR}) = | user | ft |
| Length of Basin Floor (L _{FLOOR}) = | user | ft |
| Width of Basin Floor (W _{FLOOR}) = | user | ft |
| Area of Basin Floor (A _{FLOOR}) = | user | ft ² |
| Volume of Basin Floor (V _{FLOOR}) = | user | ft ³ |
| Depth of Main Basin (H _{MAN}) = | user | ft |
| Length of Main Basin (L _{MAN}) = | user | ft |
| Width of Main Basin (W _{MAN}) = | user | ft |
| Area of Main Basin (A _{MAN}) = | user | ft ² |
| Volume of Main Basin (V _{MAN}) = | user | ft ³ |
| Calculated Total Basin Volume (V _{total}) = | user | acre-feet |

| Stage - Storage Description | Stage (ft) | Optional Override Stage (ft) | Length (ft) | Width (ft) | Area (ft ²) | Optional Override Area (ft ²) | Area (acre) | Volume (ft ³) | Volume (ac-ft) |
|-----------------------------|------------|------------------------------|-------------|------------|-------------------------|---|-------------|---------------------------|----------------|
| Top of Micropool | -- | 0.00 | -- | -- | -- | 4,193 | 0.096 | | |
| | -- | 1.00 | -- | -- | -- | 5,337 | 0.123 | 4,765 | 0.109 |
| | -- | 2.00 | -- | -- | -- | 6,581 | 0.151 | 10,724 | 0.246 |
| | -- | 3.00 | -- | -- | -- | 7,925 | 0.182 | 17,977 | 0.413 |
| | -- | 4.00 | -- | -- | -- | 9,371 | 0.215 | 26,625 | 0.611 |

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

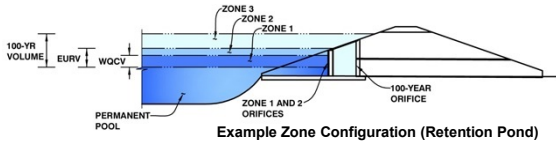
MHFD-Detention, Version 4.04 (February 2021)



DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.04 (February 2021)

Project: Villas at Aspen Trails
Basin ID: South Pond



Example Zone Configuration (Retention Pond)

| | Estimated Stage (ft) | Estimated Volume (ac-ft) | Outlet Type |
|--------------------------|----------------------|--------------------------|----------------------|
| Zone 1 (WQCV) | 0.63 | 0.065 | Orifice Plate |
| Zone 2 (EURV) | 1.69 | 0.136 | Circular Orifice |
| Zone 3 (100-year) | 2.66 | 0.152 | Weir&Pipe (Restrict) |
| Total (all zones) | | 0.352 | |

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

| | | |
|-----------------------------------|-----|--|
| Underdrain Orifice Invert Depth = | N/A | ft (distance below the filtration media surface) |
| Underdrain Orifice Diameter = | N/A | inches |

| | | |
|--------------------------------------|-----|-----------------|
| Calculated Parameters for Underdrain | | |
| Underdrain Orifice Area = | N/A | ft ² |
| Underdrain Orifice Centroid = | N/A | 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)

| | | |
|--|------|---|
| Invert of Lowest Orifice = | 0.00 | ft (relative to basin bottom at Stage = 0 ft) |
| Depth at top of Zone using Orifice Plate = | 0.63 | ft (relative to basin bottom at Stage = 0 ft) |
| Orifice Plate: Orifice Vertical Spacing = | 2.50 | inches |
| Orifice Plate: Orifice Area per Row = | N/A | inches |

| | | |
|---------------------------------|-----|-----------------|
| Calculated Parameters for Plate | | |
| WQ Orifice Area per Row = | N/A | ft ² |
| Elliptical Half-Width = | N/A | feet |
| Elliptical Slot Centroid = | N/A | feet |
| Elliptical Slot Area = | 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 | 0.21 | 0.42 | | | | | |
| Orifice Area (sq. inches) | 0.79 | 0.79 | 0.79 | | | | | |

| | 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)

| | Zone 2 Circular | Not Selected | |
|---|-----------------|--------------|---|
| Invert of Vertical Orifice = | 0.63 | N/A | ft (relative to basin bottom at Stage = 0 ft) |
| Depth at top of Zone using Vertical Orifice = | 1.69 | N/A | ft (relative to basin bottom at Stage = 0 ft) |
| Vertical Orifice Diameter = | 0.47 | N/A | inches |

| | | |
|--|------|-----|
| Calculated Parameters for Vertical Orifice | | |
| Vertical Orifice Area = | 0.00 | N/A |
| Vertical Orifice Centroid = | 0.02 | N/A |

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

| | Zone 3 Weir | Not Selected | |
|---------------------------------------|--------------|--------------|---|
| Overflow Weir Front Edge Height, Ho = | 1.69 | N/A | ft (relative to basin bottom at Stage = 0 ft) |
| Overflow Weir Front Edge Length = | 4.00 | N/A | feet |
| Overflow Weir Grate Slope = | 0.00 | N/A | H:V |
| Horiz. Length of Weir Sides = | 2.92 | N/A | feet |
| Overflow Grate Type = | Type C Grate | N/A | |
| Debris Clogging % = | 50% | N/A | % |

| | | |
|--|-------|-----|
| Calculated Parameters for Overflow Weir | | |
| Height of Grate Upper Edge, H ₁ = | 1.69 | N/A |
| Overflow Weir Slope Length = | 2.92 | N/A |
| Grate Open Area / 100-yr Orifice Area = | 20.70 | N/A |
| Overflow Grate Open Area w/o Debris = | 8.13 | N/A |
| Overflow Grate Open Area w/ Debris = | 4.06 | N/A |

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

| | Zone 3 Restrictor | Not Selected | |
|---|-------------------|--------------|--|
| Depth to Invert of Outlet Pipe = | 0.00 | N/A | ft (distance below basin bottom at Stage = 0 ft) |
| Outlet Pipe Diameter = | 12.00 | N/A | inches |
| Restrictor Plate Height Above Pipe Invert = | 6.00 | N/A | inches |

| | | |
|---|------|-----|
| Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate | | |
| Outlet Orifice Area = | 0.39 | N/A |
| Outlet Orifice Centroid = | 0.29 | N/A |
| Half-Central Angle of Restrictor Plate on Pipe = | 1.57 | N/A |

User Input: Emergency Spillway (Rectangular or Trapezoidal)

| | | |
|-------------------------------------|------|---|
| Spillway Invert Stage = | 2.80 | ft (relative to basin bottom at Stage = 0 ft) |
| Spillway Crest Length = | 4.00 | feet |
| Spillway End Slopes = | 4.00 | H:V |
| Freeboard above Max Water Surface = | 1.00 | feet |

| | | |
|------------------------------------|------|---------|
| Calculated Parameters for Spillway | | |
| Spillway Design Flow Depth = | 0.71 | feet |
| Stage at Top of Freeboard = | 4.51 | feet |
| Basin Area at Top of Freeboard = | 0.22 | acres |
| Basin Volume at Top of Freeboard = | 0.61 | acre-ft |

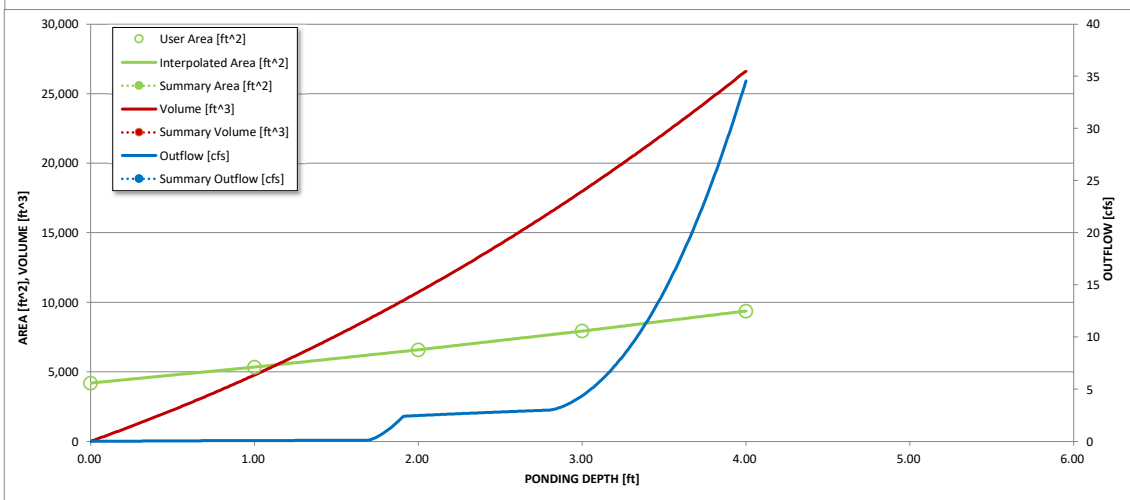
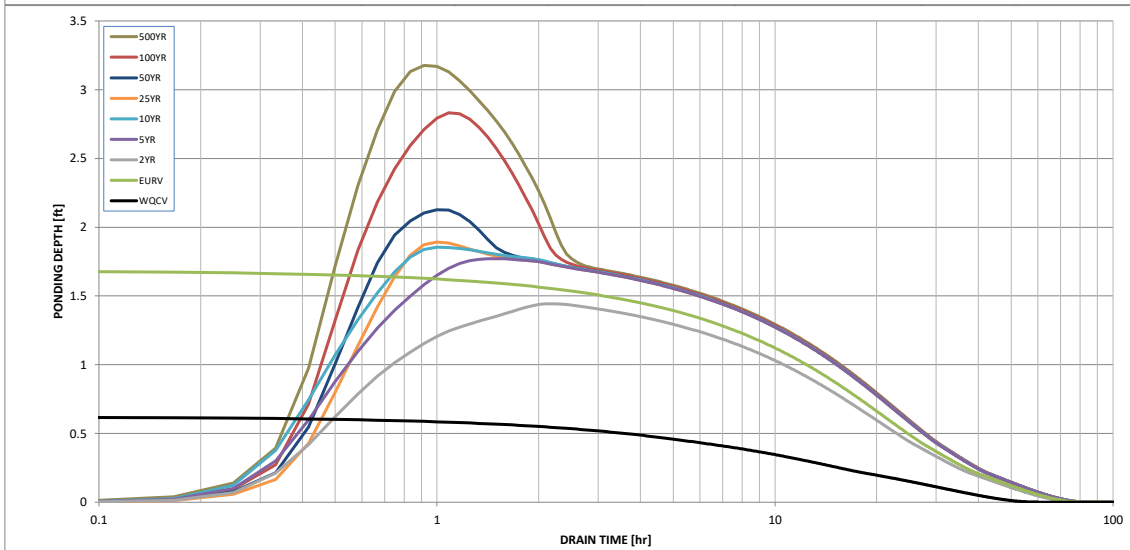
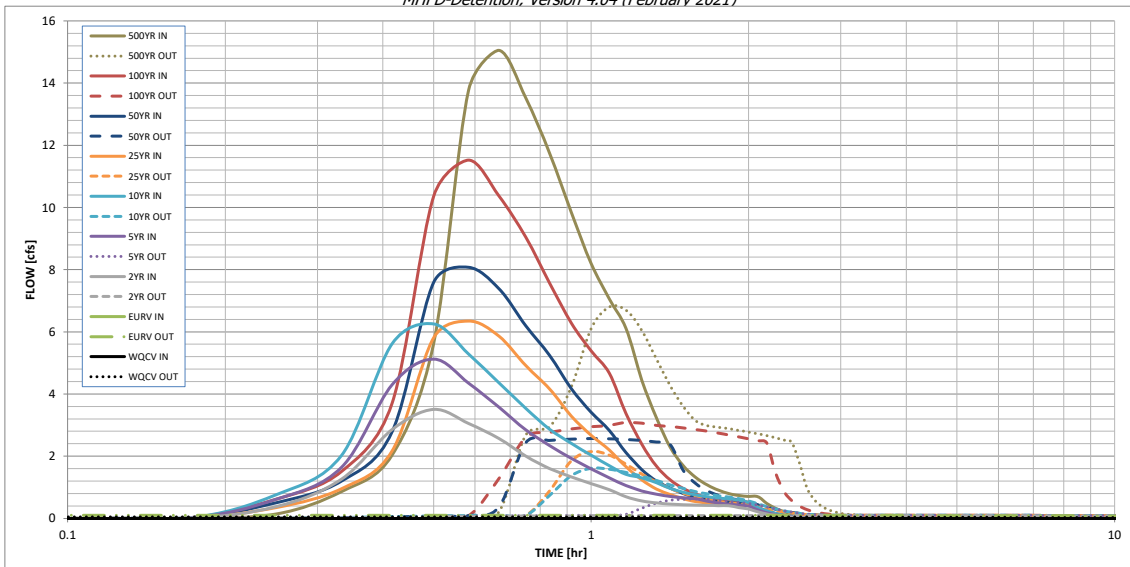
Routed Hydrograph Results

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 | N/A | N/A | 1.19 | 1.50 | 1.75 | 1.69 | 1.99 | 2.52 | 3.14 |
| One-Hour Rainfall Depth (in) | N/A | N/A | 0.180 | 0.257 | 0.326 | 0.327 | 0.415 | 0.587 | 0.780 |
| CUHP Runoff Volume (acre-ft) | 0.065 | 0.200 | 0.180 | 0.257 | 0.326 | 0.327 | 0.415 | 0.587 | 0.780 |
| Inflow Hydrograph Volume (acre-ft) | N/A | N/A | 0.180 | 0.257 | 0.326 | 0.327 | 0.415 | 0.587 | 0.780 |
| CUHP Predevelopment Peak Q (cfs) | N/A | N/A | 0.5 | 1.5 | 2.2 | 2.7 | 3.8 | 6.0 | 8.4 |
| OPTIONAL Override Predevelopment Peak Q (cfs) | N/A | N/A | | | | | | | |
| Predevelopment Unit Peak Flow, q (cfs/acre) | N/A | N/A | 0.14 | 0.39 | 0.58 | 0.70 | 1.01 | 1.59 | 2.21 |
| Peak Inflow Q (cfs) | N/A | N/A | 3.5 | 5.1 | 6.3 | 6.3 | 8.1 | 11.5 | 15.1 |
| Peak Outflow Q (cfs) | 0.0 | 0.1 | 0.1 | 0.6 | 1.6 | 2.1 | 2.6 | 3.1 | 6.8 |
| Ratio Peak Outflow to Predevelopment Q | N/A | N/A | N/A | 0.4 | 0.7 | 0.8 | 0.7 | 0.5 | 0.8 |
| Structure Controlling Flow | Plate | Overflow Weir 1 | Vertical Orifice 1 | Overflow Weir 1 | Overflow Weir 1 | Overflow Weir 1 | Outlet Plate 1 | Spillway | Spillway |
| Max Velocity through Grate 1 (fps) | N/A | N/A | N/A | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 |
| 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) | 47 | 59 | 58 | 59 | 56 | 56 | 52 | 46 | 41 |
| Time to Drain 99% of Inflow Volume (hours) | 53 | 68 | 67 | 69 | 68 | 68 | 66 | 62 | 59 |
| Maximum Ponding Depth (ft) | 0.63 | 1.69 | 1.44 | 1.77 | 1.86 | 1.89 | 2.13 | 2.83 | 3.18 |
| Area at Maximum Ponding Depth (acres) | 0.11 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | 0.15 | 0.18 | 0.19 |
| Maximum Volume Stored (acre-ft) | 0.066 | 0.201 | 0.166 | 0.212 | 0.224 | 0.230 | 0.265 | 0.382 | 0.444 |

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.04 (February 2021)



| S-A-V-D Chart Axis Override | X-axis | Left Y-Axis | Right Y-Axis |
|-----------------------------|--------|-------------|--------------|
| minimum bound | | | |
| maximum bound | | | |

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename: _____

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

| Time Interval | SOURCE | CUHP | CUHP | CUHP | CUHP | CUHP | CUHP | CUHP | CUHP | CUHP |
|---------------|---------|------------|------------|--------------|--------------|---------------|---------------|---------------|----------------|----------------|
| | TIME | WQCV [cfs] | EURV [cfs] | 2 Year [cfs] | 5 Year [cfs] | 10 Year [cfs] | 25 Year [cfs] | 50 Year [cfs] | 100 Year [cfs] | 500 Year [cfs] |
| 5.00 min | 0:00:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0:05:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0:10:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 |
| | 0:15:00 | 0.00 | 0.00 | 0.37 | 0.61 | 0.75 | 0.35 | 0.50 | 0.62 | 0.86 |
| | 0:20:00 | 0.00 | 0.00 | 1.26 | 1.64 | 2.03 | 0.96 | 1.20 | 1.51 | 2.03 |
| | 0:25:00 | 0.00 | 0.00 | 2.85 | 4.30 | 5.61 | 2.17 | 2.78 | 3.70 | 5.62 |
| | 0:30:00 | 0.00 | 0.00 | 3.50 | 5.12 | 6.26 | 5.81 | 7.59 | 10.36 | 13.76 |
| | 0:35:00 | 0.00 | 0.00 | 3.05 | 4.35 | 5.28 | 6.35 | 8.07 | 11.52 | 15.05 |
| | 0:40:00 | 0.00 | 0.00 | 2.57 | 3.57 | 4.36 | 5.86 | 7.39 | 10.37 | 13.52 |
| | 0:45:00 | 0.00 | 0.00 | 2.00 | 2.84 | 3.54 | 4.91 | 6.20 | 9.04 | 11.75 |
| | 0:50:00 | 0.00 | 0.00 | 1.60 | 2.34 | 2.86 | 4.16 | 5.24 | 7.57 | 9.84 |
| | 0:55:00 | 0.00 | 0.00 | 1.34 | 1.93 | 2.41 | 3.29 | 4.17 | 6.28 | 8.20 |
| | 1:00:00 | 0.00 | 0.00 | 1.12 | 1.59 | 2.03 | 2.67 | 3.42 | 5.39 | 7.05 |
| | 1:05:00 | 0.00 | 0.00 | 0.92 | 1.30 | 1.69 | 2.20 | 2.83 | 4.66 | 6.11 |
| | 1:10:00 | 0.00 | 0.00 | 0.70 | 1.06 | 1.42 | 1.66 | 2.12 | 3.37 | 4.45 |
| | 1:15:00 | 0.00 | 0.00 | 0.56 | 0.89 | 1.30 | 1.24 | 1.57 | 2.39 | 3.24 |
| | 1:20:00 | 0.00 | 0.00 | 0.49 | 0.77 | 1.15 | 0.95 | 1.20 | 1.68 | 2.29 |
| | 1:25:00 | 0.00 | 0.00 | 0.46 | 0.70 | 0.96 | 0.77 | 0.98 | 1.24 | 1.69 |
| | 1:30:00 | 0.00 | 0.00 | 0.44 | 0.66 | 0.84 | 0.63 | 0.79 | 0.96 | 1.32 |
| | 1:35:00 | 0.00 | 0.00 | 0.43 | 0.63 | 0.75 | 0.54 | 0.67 | 0.78 | 1.07 |
| | 1:40:00 | 0.00 | 0.00 | 0.42 | 0.55 | 0.70 | 0.49 | 0.60 | 0.66 | 0.91 |
| | 1:45:00 | 0.00 | 0.00 | 0.41 | 0.49 | 0.65 | 0.45 | 0.54 | 0.58 | 0.80 |
| | 1:50:00 | 0.00 | 0.00 | 0.41 | 0.46 | 0.62 | 0.43 | 0.51 | 0.54 | 0.73 |
| | 1:55:00 | 0.00 | 0.00 | 0.35 | 0.43 | 0.58 | 0.42 | 0.49 | 0.52 | 0.71 |
| | 2:00:00 | 0.00 | 0.00 | 0.30 | 0.40 | 0.51 | 0.41 | 0.48 | 0.52 | 0.70 |
| | 2:05:00 | 0.00 | 0.00 | 0.21 | 0.27 | 0.35 | 0.28 | 0.33 | 0.36 | 0.48 |
| | 2:10:00 | 0.00 | 0.00 | 0.14 | 0.18 | 0.24 | 0.19 | 0.22 | 0.24 | 0.33 |
| | 2:15:00 | 0.00 | 0.00 | 0.09 | 0.12 | 0.16 | 0.13 | 0.15 | 0.16 | 0.22 |
| | 2:20:00 | 0.00 | 0.00 | 0.06 | 0.08 | 0.10 | 0.08 | 0.10 | 0.11 | 0.14 |
| | 2:25:00 | 0.00 | 0.00 | 0.04 | 0.05 | 0.06 | 0.05 | 0.06 | 0.07 | 0.09 |
| | 2:30:00 | 0.00 | 0.00 | 0.02 | 0.03 | 0.04 | 0.03 | 0.04 | 0.04 | 0.05 |
| | 2:35:00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 |
| | 2:40:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | 2:45:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 2:50:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 2:55:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:00:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:05:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:10:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:15:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:20:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:25:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:30:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:35:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:40:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:45:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:50:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3:55:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:00:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:05:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:10:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:15:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:20:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:25:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:30:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:35:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:40:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:45:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:50:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4:55:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:00:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:05:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:10:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:15:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:20:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:25:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:30:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:35:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:40:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:45:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:50:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5:55:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 6:00:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

APPENDIX F – OPINION OF PROBABLE CONSTRUCTION COST



Kimley-Horn & Associates, Inc.

Opinion of Probable Construction Cost

| | |
|--|-------------------------|
| Client: ROS Equity Holdings - Independence, LLC | Date: 11/4/2022 |
| Project: Villas at Aspen Trails | Prepared By: JAR |
| KHA No.: 096668022 | Checked By: JAR |

| | |
|------------|----------------------|
| No: | Sheet: 1 of 1 |
|------------|----------------------|

Kimley-Horn & Associates, Inc. has not prepared fully engineered construction drawings for this site; therefore, the final quantities are subject to change. Additionally, the final land plan could change significantly through the development process. This OPC is not intended for basing financial decisions, or securing funding. Review all notes and assumptions. Since Kimley-Horn & Associates, Inc. has no control over the cost of labor, materials, equipment, or services furnished by others, or over methods of determining price, or over competitive bidding or market conditions, any and all opinions as to the cost herein, including but not limited to opinions as to the costs of construction materials, shall be made on the basis of experience and best available data. Kimley-Horn & Associates, Inc. cannot and does not guarantee that proposals, bids, or actual costs will not vary from the opinions on costs shown herein. The total costs and other numbers in this Opinion of Probable Cost have been rounded.

| Item No. | Item Description | Quantity | Unit | Unit Price | Item Cost |
|--|---------------------------|----------|------|------------|----------------|
| Storm Sewer Costs for Ray O 5.2 Multi-Family (Non-reimbursable) | | | | | |
| 1 | 12" RCP Storm Sewer | 83 | LF | \$20.00 | \$1,660 |
| 2 | 18" RCP Storm Sewer | 78 | LF | \$25.00 | \$1,950 |
| 3 | Type M Rip Rap | 1 | CY | \$50.00 | \$50 |
| 4 | 4' COS D-10-R Storm Inlet | 2 | EA | \$2,500.00 | \$5,000 |
| Subtotal: | | | | | \$8,660 |
| Contingency (%,+/-) | | | | 10% | \$866 |
| Project Total: | | | | | \$9,526 |

Basis for Cost Projection:

- No Design Completed
- Preliminary Design
- Final Design

Design Engineer:

Jared A. Roberts
Registered Professional Engineer, State of Colorado No. 60470