GLEN ASPEN RESERVOIR PRIMARY ACCESS

FINAL DRAINAGE REPORT

RSI-3689

PREPARED BY
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RESPEC
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PREPARED FOR
City of Woodland Park
220 West South Avenue
Woodland Park, Colorado 80863

MARCH 2026

Project Number W0309.25020
PCD File No. CDR2512

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RESPEC

Design 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 applicable 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.

COLORADO LICENSED
KEVIN MATTHEW GARCIA
64503
03/13/2026
PROFESSIONAL ENGINEER

_______________________ _______________________.

[Kevin Garcia, P.E. #64503] Date

Owner/Developer's Statement

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

_______________________ 3/13/26.

Kip Wiley, Utilities Director ~~February 13, 2026~~

City of Woodland Park

220 West South Avenue
Woodland Park, CO 80863

El Paso County:

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

Daniel Torres, P.E. Digitally signed by Daniel Torres, P.E.
Reason: Authorized signatory as County Engineer designee
Date: 2026.04.07 10:51:41-06'00'

4/7/2026

_______________________ _______________________.

Joshua J. Palmer, P.E. Date

County Engineer / ECM Administrator

Conditions:

EXECUTIVE SUMMARY

This drainage report supports the design and development of the primary access for the proposed Glen Aspen Dam near Woodland Park, Colorado. The private access will originate from Loy Creek Road and traverse approximately 3.9 acres of steep, mountainous terrain to provide essential access for dam construction and long-term dam maintenance. The site is currently undeveloped, with minimal utility infrastructure and natural vegetation that includes low-lying shrubs, spruce and aspen trees, and native grasses typical of the region.

The project spans portions of El Paso and Teller Counties and includes clearing, grading, and earthwork on slopes ranging from 3 percent to over 100 percent. A geotechnical investigation and Natural Resources Conservation Service (NRCS) Web Soil Survey identified the site's soils as Hydraulic Soil Group (HSG) B, which indicates moderate runoff potential and suitable infiltration characteristics. Hydrologic analysis has confirmed that subcatchment boundaries will remain unchanged. An increase in 1.6 acres of impervious surface which is approximately a 0.36% change because of the addition of the gravel-surfaced primary access. Post-development drainage conditions will maintain the same catchment area of 441.6 acres, with consistent flow paths and slopes to the existing conditions. The overall peak flows changed from 63.2 cfs to 63.5 cfs. Onsite ditches and channels used the Rational Method for a 5-year and 100-year storm event to ensure proper sediment and erosion control. Culvert P-1 was incorporated into the design to maintain continuous water flow through the wetland area at the lower end of the project during storm events. Culvert P-2 was added to support natural drainage patterns and minimize erosion at the intersection of the access crossing and natural drainage channel. Vegetation plays a key role in the site's erosion and sediment control strategy. All ditches will be lined with selected native grasses for their ability to withstand high-velocity flows in conjunction with turf reinforcement mat. Seed mix is described more in the SWMP, generally the mixes include a PBSI Native Mountain Mix. This vegetated mat will slow runoff, promote infiltration, and stabilize slopes.
This project follows El Paso County's Four-Step Process for receiving water protection, which minimizes impervious surfaces, stabilizes drainageways, and uses temporary and permanent BMPs such as seeding, mulching, check dams, silt fences, erosion control blankets (turf mats), vehicle tracking control, staging area stabilization, and inlet/outlet protection. The site is agriculturally zoned with less than 10% imperviousness, exempting it from WQCV per ECM Appendix I.7.1.B.5. Any runoff reduction using receiving pervious areas is informal and not an official permanent control measure. Overall, the drainage design supports environmental protection, effective stormwater management, and the long-term functionality of the primary access, all while preserving natural hydrologic conditions and minimizing impacts to the surrounding landscape and downstream infrastructure.

1.0 PURPOSE

This drainage report supports the design of the primary access associated with the proposed Glen Aspen Dam. The primary access will originate from Loy Creek Road in Woodland Park, Colorado, and lead directly to the future dam site. Currently, the proposed site is untouched, with only a few existing off-road trail systems.

The scope of work includes clearing, grading, and conducting the earthwork necessary to establish the private access through natural terrain. These improvements are intended to support future dam construction and facilitate access to maintain the proposed dam.

2.0 LOCATION AND DESCRIPTION OF PROPERTY

The project site is in the Pike National Forest region near Woodland Park, Colorado, with access via Loy Creek Road in El Paso County and extends partially into Teller County. Rampart Range Road borders the area to the northwest. The project site vicinity is shown in Figure 2-1. The project spans a few sections: Township 12 South, Range 68, 6th principal meridian, El Paso County section 08 SW ¼, section 17 NW ¼, section 18 SW ¼, and Teller County section 18 NE1/4, section 18 NW ¼, and section 18 SE ¼.

The Glen Aspen Ranch, a Scouting America camp, is located southeast of the proposed primary access.

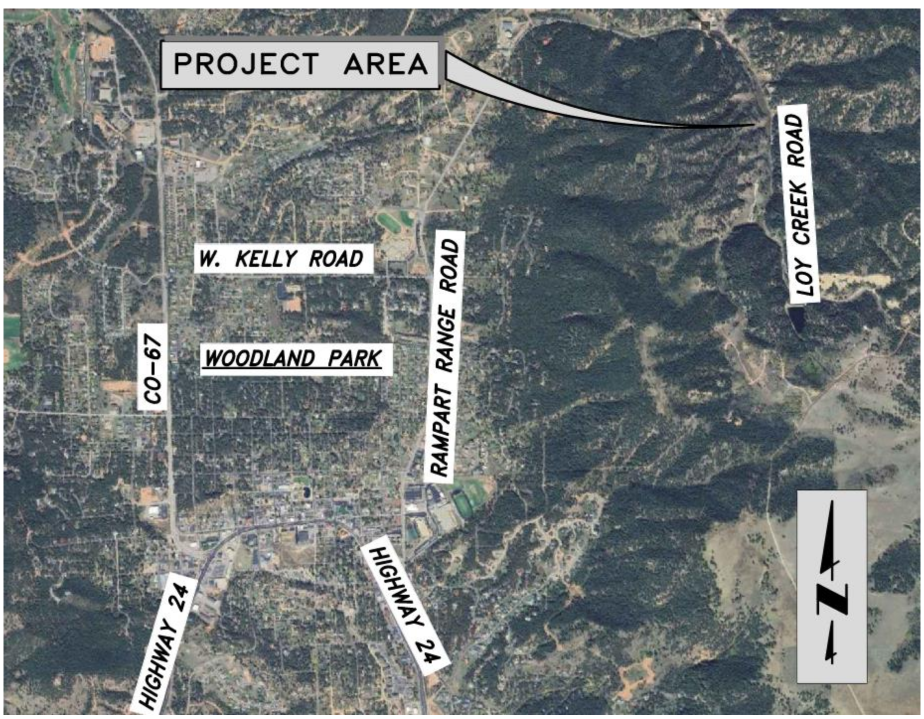


Figure 2-1. Project Location Vicinity Map (Not to Scale).

The project site features a mix of low-lying shrubs, spruce and aspen trees, and shorter grasses typical of mountainous terrain. The topography is notably steep, with slopes ranging from relatively flat areas to grades exceeding 100 percent; in particular, the slopes across the site range between 20 percent and 50 percent. The proposed disturbance footprint is approximately 5.4 acres and because of the natural conditions and remote location, irrigation facilities are not applicable for this project.

Utility infrastructure in the area is minimal as the site is predominantly undeveloped. Near the entrance to the proposed primary access, several existing features were observed, including two filled-in culverts, a manhole, an electrical box, a well, two water valve caps, and utility poles. These utilities are not expected to interfere with the proposed design and have been accounted for in the site layout. Additionally, the existing access road and any existing culverts will not be removed or altered as a result of this project.

2.1 SOIL CONDITIONS

A geotechnical investigation conducted using three boreholes showed the soil conditions to have a 6-inch organic layer, on average, followed by denser sands and gravels, with some clays near the surface of one of the boreholes. Based on geotechnical bore logs and the NRCS Web Soil Survey, HSG B was selected to describe the site soil conditions. This indicates a moderate runoff potential—on average, these soils drain well, with moderate infiltration rates when approximately wet (El Paso County Drainage Criteria Manual Volume 1). The NRCS Web Soil Survey was used to determine the site soil's erodibility. The erodibility for the wetland area has a K factor of 0.32 whereas the remaining areas of the site have a K factor of 0.15. The higher erodibility of the wetlands is not concerning because the terrain is generally flat and highly vegetated. The lower erodibility of the remaining portions of the site suggest that overland flow will not lead to significant sheet and rill erosion. The NRCS Web Soil Survey results are included in Appendix A. El Paso County's DCM Vol 1 update section 4.1 table 6-8 assigns HSG B to areas within Pike National Forest that predominantly comprise the Sphinx soil component (map symbol 43).

3.0 MAJOR AND SUB-BASINS

3.1 FLOODPLAIN STATEMENT

According to Federal Emergency Management Agency (FEMA) floodplain mapping, the project site is in Zone D, indicating that the area has an undetermined flood hazard; no flood hazard analysis has been conducted on the site. Colorado floodplain mapping was also checked, and the results indicate that no analysis has yet been conducted. This region is a mountainous area with high elevation near the Continental Divide of the Americas, which suggests that the area is not prone to flooding. Appendix D illustrates the FEMA flood map results.

3.2 MAJOR AND SUB-BASINS

Loy Creek is a minor tributary within the upper reaches of the South Platte River Basin, near the Continental Divide, and lies within the Trout Creek Drainage Basin, which has no drainage and bridge fees. It is an intermittent stream with highly brushy and vegetated banks. The presence of established vegetation indicates a stable stream with minimal active erosion. Loy Creek flows northward along Loy Creek Road to a culvert at Rampart Range Road. From there, it continues west along Rampart Range Road before diverging and flowing westward past Highway 67, ultimately terminating at Lowell Creek. Existing sub-basins currently have water runoff that sheet flows down the side of the mountain before collecting in gullies and continuing toward Loy Creek. Wetlands were delineated along Loy Creek Road, and the primary access entrance crosses a small portion of the wetland area, as shown in the plans. A 36-inch reinforced concrete pipe (Culvert P-1) has been installed within the wetlands near station 10+81 to maintain the natural flow path during rainfall events.

The sub-basins' off-site drainage flow patterns will be altered only slightly. A 24-inch concrete culvert (Culvert P-2) will be installed where the access crosses a sub-basin to ensure runoff remains on its existing drainage path near station 15+86. Figure 3-1 depicts the general location of Culverts P-1 and P-2 for detailed information regarding the culverts refer to sheets F7 and F8 in the plans. Because this new access follows the top of the ridge, most of the runoff will sheet flow down the fill slopes and down the side of the mountain, which is similar to the existing conditions. Within cut areas and areas where ditching is proposed, the water runoff from the access's surface will follow the ditch until the ditch daylights, which will allow the water to flow down the mountain or at least until it reaches the bottom of the alignment near the wetlands.

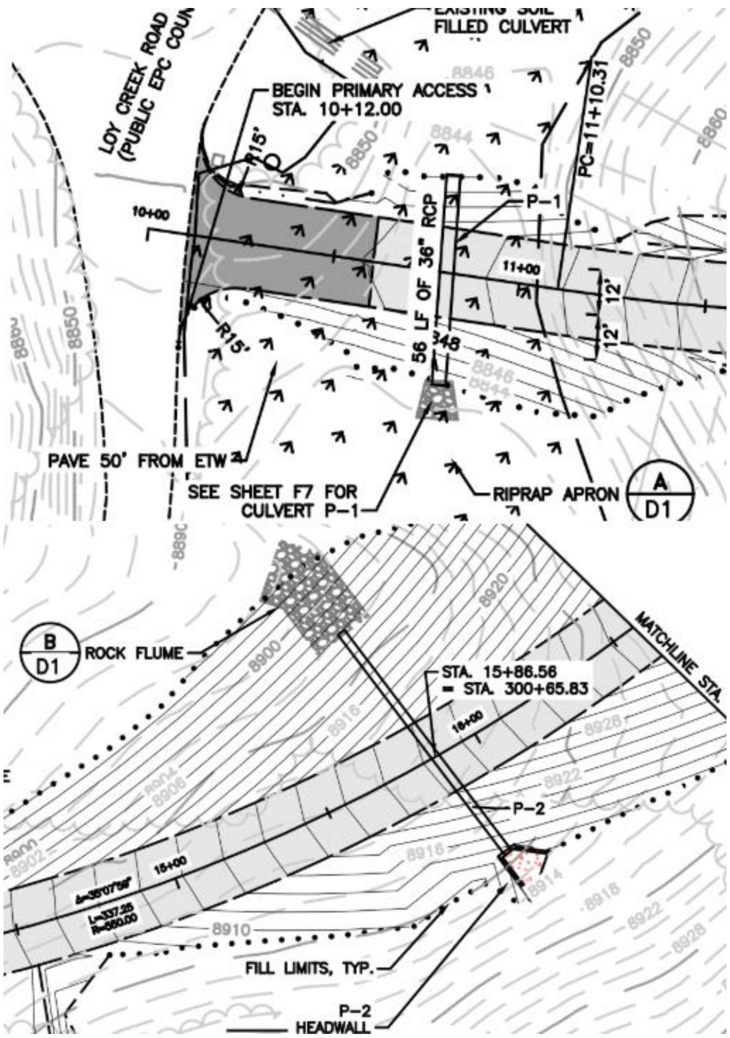


Figure 3-1. General location of Culverts P-1 and P-2.

4.0 DRAINAGE DESIGN CRITERIA

The drainage design for the proposed access was developed in accordance with the El Paso County DCM, Volumes 1 and 2, Engineering Criteria Manual (ECM), Colorado Department of Transportation (CDOT) Drainage Design Manual (DDM), and American Association of State Highway and Transportation Officials (AASHTO) Drainage Manual. Key references include:

- Hydrologic Soil Groups
  - El Paso County DCM Table 6-8: Identifies HSGs for soils in the Pike National Forest. Based on geotechnical bore logs and the NRCS Web Soil Survey, HSG B was selected for the site soil conditions.
- El Paso County DCM 1 9.4.2: Minimum Culvert Size
- El Paso County DCM 1 6.5.2: Channel Velocity Maximum
  - CDOT Section 9.2.2 also mentions "The maximum velocity at the culvert exit must be consistent with the velocity in the natural channel or must be mitigated with channel stabilization and energy dissipation.
- AASHTO Drainage Manual Section 11.4.6: Culvert Slopes
  - Maximum culvert slopes should not exceed 6 percent for reinforced concrete pipes.
- El Paso County DCM 6.2.3 Table 6-1: Allowable use of Roads and Streets
  - Depth of flow shall not exceed 6 inches from access shoulder
- El Paso County DCM 6.4.1 Table 6-4: Allowable Culvert Overtopping
  - Depth of flow shall not exceed 6 inches from access shoulder
- El Paso County DCM Vol1 Update 3.1 Table 6-6
  - Table 6-6 Runoff Coefficients for Rational Method – Forest & Offsite Flow Analysis
- El Paso County DCM 1 634.4: hydraulics for Manning's Roughness Coefficient "n"
  - Reinforced Concrete Pipe (RCP): 0.013
  - Because the project area is less than 130 acres, the Rational Method was selected as an appropriate approach for estimating runoff, in accordance with DCM guidelines for site ditches, channels, and culverts—except for Culvert P-1, which was analyzed using computer modeling based on StreamStats data. To reduce runoff and promote infiltration, several runoff reduction practices were incorporated into the design, including:
- Maintaining natural vegetation buffers
- Minimizing impervious surfaces during alignment layout
- Constructing ditches and slopes that are grass-lined and covered with permanent turf reinforcement mats.
- Establishing erosion and sediment control BMPs (described in their respective sections)
- It should be mentioned that no previous drainage studies were found for this site area.

5.0 FOUR-STEP PROCESS

El Paso County follows a "Four Step Process" for receiving water protection, which emphasizes reducing stormwater volume and implementing long-term source control strategies. This approach is designed to effectively manage more frequent storm events. Below is a summary of how the Four Step Process is applied to this project:

- Step 1: Mitigating runoff from impervious areas and reducing impervious areas that encourage infiltration into in situ soils
  - The access's top surface is gravel rather than asphalt, which allows a slower runoff and better infiltration.
  - This private access is aligned in a more direct path that follows the mountainous ridge to reduce unnecessary impervious surfaces.
  - All slopes and ditches will be seeded so that vegetation can enhance water absorption.
  - Proposed Culvert P-2 will allow the naturally existing channel runoff to resume its existing path under the access top surface and encounter a vegetation buffer approximately 280' in length before reaching the drainage path near Loy Creek Road.
- Step 2: Stabilize drainageways
  - All the proposed ditches, culverts, and slopes will be permanently stabilized using design elements and temporary and permanent BMPs. There are no major on-site streams, and much of the site consists of gullies that are active during rain events. Loy Creek is classified as a minor tributary. The proposed Culvert P-1 will be located along the flow path in the wetlands, as seen in Figure 3-1.
  - No drainage basin planning study has been conducted.
- Step 3: Stormwater Quality Capture Volume
  - According to the El Paso County ECM I.7.1.B.5 agriculturally zoned sites with imperviousness under 10%, the project is excluded from the requirements of Section I.7. This project will not utilize the water quality capture volume standard or full-spectrum detention.
- Step 4: BMPs for pollutants
  - Temporary and permanent BMPs will be implemented before and throughout construction activities to minimize erosion and capture sediment-related pollutants, primarily sands and fines, in accordance with the Grading and Erosion Control Plans. These measures are designed to prevent particulate matter from depositing into nearby waterways and drainage systems. Additional details regarding BMP selection, placement, and maintenance will be provided in the Stormwater Management Plan. BMP quantities are shown and discussed in Section 8.2. The BMPs to be utilized include the following:
    - Permanent seeding
    - Check dams
    - Vegetation buffer
    - Silt fences
    - Inlet and outlet protection
    - Turf Reinforcement Mat
    - Vehicle tracking control
    - Riprap apron
    - Rock flume

6.0 HYDROLOGIC METHOD

The drainage design for the proposed access was prepared in accordance with the El Paso County Drainage Criteria Manual (DCM) and Engineering Criteria Manual (ECM). Design rainfall was based on a 5-year minor storm and a 100-year major storm. Considering the project site drains less than 130 acres, peak runoff was estimated using the Rational Method (Q=CiA). Hydrologic computations for the project site were performed using the Urban Drainage and Flood Control District (UDFCD) Rational Method Spreadsheet v2.00, and the analysis is provided in Appendix C. Loy Creek, which crosses through Culvert P-1 at the bottom of the access road, is excluded from this calculation because its contributing basin exceeds 130 acres and includes areas outside the project limits. The analysis for Culvert P-1 incorporated peak flow estimates obtained using USGS StreamStats and the NRCS curve number loss and dimensionless unit hydrograph method outlined in United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Technical Release 55 (TR-55).

- Q = peak runoff (cfs)
- C = runoff coefficient
- i = rainfall intensity (inches/hour)
- A = drainage area (acres)

Runoff coefficients were selected from El Paso County DCM Volume 1, Update 3.1, Table 6-6 using the 'Offsite Flow Analysis' criteria, specifically applicable to ditch and roadway conditions. The only exception was culvert P-2, for which the 'Forest' coefficient was used, as the majority of the contributing drainage area consists of undeveloped mountainous terrain. Rainfall intensities were calculated within the UDFCD sheet using equation $i = (a \times P_1)/(b + t_c)^c$. Coefficients a, b, and c used Denver Area's coefficients 28.5, 10, and 0.786, respectively. The parameter P_1 corresponds to the 1-hour rainfall depth. One-hour rainfall depth for each storm recurrence interval for the Woodland Park area was obtained from National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Volume 8 Version 2, as shown in Table 6-1. The raw output data is included in Appendix E.

Table 6-1. One-Hour Rainfall Depths

One-Hour Rainfall Depth, P_1 (inches)						
2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	500 yr
0.76	0.98	1.18	1.49	1.75	2.04	2.80

Supporting parameters and criteria were sourced from the DCM and ECM, including:

- El Paso ECM Section 3.2.8.E: 5-year minor and 100-year major design storm requirements
- El Paso ECM Section 3.2.8.F: Design Runoff Methods
- El Paso DCM Table 6-7: NRCS Conveyance Factor (K)
  - Used toward time of concentration

During site visits, field engineers assessed the landscape and vegetation and determined that the NRCS conveyance factor from Table 6-7 is best represented by the classification "short pasture and lawn." Figure 6-1 provides an example of the grassy, pasture-like vegetation observed on site. For the proposed ditches, a similar grass-lined channel was identified and used as a reference. This channel type corresponds to a conveyance factor of 7.

Inputs needed for the TR-55 method used for sub-basin M include sub-basin area, curve number, precipitation values, and flow path information. Sub-basin area was directly determined from the delineated area. A curve number representative of a woods-grass combination for good type B soils was determined to be an adequate representation of the overall project area. Precipitation values were taken from the NOAA Atlas 14 dataset. Flow path information was determined by examining topographic data and aerial imagery of the sub-basin.

Peak flow rates, derived from either the Rational Method, StreamStats, or TR-55, for a 5-year minor and 100-year major storm events are summarized in Table 6-2. These flows served as input for the hydraulic analysis discussed in the hydraulic method section. Catchment locations are shown in Appendix F. These areas were selected to account for sheet flow and shallow channel flow occurring within the project site, primarily along natural drainage paths and ditches.

Figure 6-1. On-Site Vegetation.

Table 6-2. Peak Flow Rates (Q)

Subcatchment Location	Area (AC)	Runoff Coeffient, C (5-year)	Runoff Coeffient, C (100-year)	Rainfall Intensity, I (in/hr) (5-year)	Rainfall Intensity, I (in/hr) (100-year)	Peak Flow, Q (cfs) (5-year)	Peak Flow, Q (cfs) (100-year)
Sub-basin A	0.95	0.32	0.51	2.10	4.38	0.64	2.12
Sub-basin B	1.20	0.32	0.51	2.36	4.91	0.91	3.01
Sub-basin C	0.15	0.32	0.51	3.21	6.69	0.16	0.53
Sub-basin D	0.07	0.32	0.51	3.32	6.92	0.07	0.24
Sub-basin E	0.13	0.32	0.51	3.28	6.83	0.14	0.45
Sub-basin F	0.08	0.32	0.51	3.32	6.92	0.09	0.30
Sub-basin G	0.08	0.32	0.51	3.30	6.88	0.08	0.28
Sub-basin H	0.08	0.32	0.51	3.32	6.92	0.09	0.28
Sub-basin I	0.55	0.32	0.51	2.59	5.39	0.46	1.51
Sub-basin J	0.15	0.32	0.51	3.17	6.60	0.15	0.50
Sub-basin K	25.9	0.08	0.35	1.63	3.40	3.49	31.8
Sub-basin L	1.61	0.32	0.51	2.03	4.23	4.42	36.4
Sub-basin M*	442	0.45	0.45	-	-	14.8	63.2

*Peak 5-year flow for sub-basin M (Culvert P-1) was estimated using USGS StreamStats. Peak 100-year flow for this sub-basin was estimated using NRCS TR-55. Both the 5-year and 100-year flows were analyzed using both the StreamStats and TR-55 methods, with the higher value between the two methods conservatively chosen for each event, because Culvert P-1 is located within the existing Loy Creek minor tributary.

In contrast, the remaining catchments consist primarily of ditches and natural mountainous channels, where localized runoff patterns are better represented using the Rational Method.

7.0 HYDRAULIC METHOD

Hydraulic calculations for culverts and ditches were completed using the Federal Highway Administration's HY-8 program and Hydraulic Toolbox. Appendix C shows the output report file from the programs. This software estimated ditch water flow velocities, ditch water depths during a 5-year minor and 100-year major storm event, overtopping estimation, and outlet and tailwater velocities. Supporting parameters and criteria were sourced from the El Paso DCM, ECM, and CDOT DDM and included the following:

- El Paso ECM Section 3.2.8.E: The 5-year minor and 100-year major design storm requirement
- El Paso ECM Section 3.2.8.F: Design Runoff Methods
- Due to steep longitudinal slopes, the design includes a required Turf Reinforcement Mat (TRM), specifically the VMAX SC250 or approved equal, which provides engineering properties for a roughness coefficient of 0.040 and a permissible flow velocity of 9.5 and 15 fps, for non-vegetated and vegetated conditions, respectively. Conservatively we will use 9.5 fps for our analysis to assume a condition before vegetation growth.
- El Paso DCM Section 10.5.5: Minimum 1-ft freeboard for 5-year minor storm

  El Paso DCM Section III.6.2 Table 6-1, Type A (Local with Roadside Ditch). Major storm flow depth shall not exceed 6 inches above the shoulder.

Manning's roughness coefficient of 0.040 was chosen for ditch channels, which is appropriate for simulating flow through a turf reinforcement mat, using the product VMAX SC250 or approved equal. The proposed culverts are reinforced concrete pipes, which have a Manning's n roughness value of 0.013.

All slopes and ditches will utilize turf reinforcement mats because of their superior erosion protection and ability to withstand higher permissible mean channel velocities. For the 5-year design storm, a minimum of 1 ft of freeboard is required. For the 100-year storm, the design allows water to rise up to 6 in. above the shoulder elevation.

Based on these criteria, a minimum ditch depth of 1.5 ft is needed. This depth accommodates a maximum 5-year flow depth of approximately 0.5 ft while still providing the required 1 ft of freeboard and 2ft for the 100-year event.

In some areas, the transition from fill slopes to natural ground creates shallow swales rather than defined roadside ditches. These natural features influence the access road profile, resulting in localized variations from the typical 1.5-ft ditch depth.

Table 7-1 and 7-2 show the inputs and results for the selected ditch and channel areas using Hydraulic Toolbox, and Table 7-3 and 7-4 shows the inputs and results for the HY-8 analysis.

Table 7-1. Hydraulic Toolbox Inputs and Results 5-year Minor Storm

Location	Side Slopes	Longitudinal Slope (ft/ft)	Manning's Roughness (n)	Enter Flow (cfs)	Estimated Flow Depth (ft)	Average Velocity (fps)
Sub-basin A	2:1 & 2:1	0.235	0.04	0.67	0.27	4.45
Sub-basin B	2:1 & 2:1	0.130	0.04	0.91	0.34	3.85
Sub-basin C	2:1 & 2:1	0.150	0.04	0.16	0.17	2.63
Sub-basin D	2:1 & 2:1	0.161	0.04	0.07	0.13	2.19
Sub-basin E	2:1 & 2:1	0.185	0.04	0.14	0.16	2.75
Sub-basin F	*3:1 & 10:1	0.150	0.04	0.09	0.09	1.78
Sub-basin G	2:1 & 2:1	0.138	0.04	0.08	0.14	2.14
Sub-basin H	*8:1 & 3:1	0.108	0.04	0.09	0.10	1.64
Sub-basin I	2:1 & 1:1	0.093	0.04	0.46	0.32	2.95
Sub-basin J	2:1 & 1:1	0.093	0.04	0.15	0.21	2.23
Sub-basin K	*2:1 & 4:1	0.149	0.04	3.49	0.47	5.26
Sub-basin L	*6:1 & 5:1	0.154	0.04	4.42	0.07	2.47
Sub-basin M	3:1 & 3:1	0.070	0.05	14.9	0.21	2.75

* All sub-basins with side slopes flatter than 3:1 represent the average natural terrain slope where it intersects the access route.

Table 7-2. Hydraulic Toolbox Inputs and Results 100-year Major Storm

Location	Side Slopes	Longitudinal Slope (ft/ft)	Manning's Roughness (n)	Enter Flow (cfs)	Estimated Flow Depth (ft)	Average Velocity (fps)
Sub-basin A	2:1 & 2:1	0.235	0.04	2.23	0.43	6.01
Sub-basin B	2:1 & 2:1	0.130	0.04	3.01	0.58	5.18
Sub-basin C	2:1 & 2:1	0.150	0.04	0.53	0.27	3.55
Sub-basin D	2:1 & 2:1	0.161	0.04	0.24	0.20	2.99
Sub-basin E	2:1 & 2:1	0.185	0.04	0.45	0.25	3.68
Sub-basin F	*3:1 & 10:1	0.150	0.04	0.30	0.14	2.40
Sub-basin G	2:1 & 2:1	0.138	0.04	0.28	0.22	2.93
Sub-basin H	*8:1 & 3:1	0.108	0.04	0.28	0.15	2.17
Sub-basin I	2:1 & 1:1	0.093	0.04	1.51	0.50	3.97
Sub-basin J	2:1 & 1:1	0.093	0.04	0.50	0.33	3.01
Sub-basin K	*2:1 & 4:1	0.149	0.04	31.8	1.08	9.13
Sub-basin L	*6:1 & 5:1	0.154	0.04	36.4	0.25	5.57
Sub-basin M	3:1 & 3:1	0.070	0.05	63.5	0.50	4.76

* All sub-basins with side slopes flatter than 3:1 represent the average natural terrain slope where it intersects the access route.

Table 7-3. Federal Highway Administration's HY-8 Inputs and Results 5-year Minor Storm

Location	Diameter (inches)	Culvert Slope (ft/ft)	Manning's Roughness (n)	Enter Flow (cfs)	Headwater/Depth Ratio (HW/D)	Outlet Velocity (fps)	Tailwater Velocity (fps)
Culvert P-1	36	0.042	0.013	14.9	0.55	11.37	3.02
Culvert P-2	24	0.051	0.013	3.49	0.43	9.12	2.95

Table 7-4. Federal Highway Administration's HY-8 Inputs and Results 100-year Major Storm

Location	Diameter (inches)	Culvert Slope (ft/ft)	Manning's Roughness (n)	Enter Flow (cfs)	Headwater/Depth Ratio (HW/D)	Outlet Velocity (fps)	Tailwater Velocity (fps)
Culvert P-1	36	0.042	0.013	63.5	1.52	15.31	4.65
Culvert P-2	24	0.051	0.013	31.8	2.30	15.62	6.37

7.1 RIPRAP SIZING

2019 CDOT DDM Chapter 9 section 9.2.2, mentions the outlet velocity and natural channel should be consistent. Because the analysis showed a significant difference between outlet and tailwater velocities for Culvert P-1 and Culvert P-2, riprap apron and flume are necessary and will be used as an energy dissipater. Below are riprap sizing calculations using FHWA HEC-14 Section 10.2.
Culvert P-1 and P-2 are supercritical because the outlet depth is less than the critical depth. These values can be found in Appendix C.

$$D_{50} = 0.2D'\left(\frac{Q}{\sqrt{g}D'^{2.5}}\right)^{\frac{4}{3}}\left(\frac{D'}{TW}\right)$$

$$D' = \frac{D + y_n}{2}$$

Table 7-5. Federal Highway Administration's Riprap Sizing (use with 100-year major event)

Location	Diameter (inches)(D)	Super Critical Depth (ft) (y_n)	Adjusted Diameter (ft) (D')	Outlet Flow (cfs)(Q)	Tailwater Depth (TW)	Gravity (g)	Riprap D_{50} (in)
Culvert P-1	36	1.43	2.22	63.5	1.20	32.2	17.3
Culvert P-2	24	1.89	1.95	31.8	0.50	32.2	19.7

7.2 DISCUSSION

The project area was divided into sub-basins to allow for targeted analysis of individual components, ensuring that the site's drainage features perform effectively. In general, all sub-basins are distinct and do not overlap; however, sub-basins K and M (associated with culvert inlets) are exceptions, as discussed in their respective sections. The sub-basins are discussed in detail in this section, and their locations on the site are shown in Appendix F. This discussion section uses the tables above from Hydraulic Toolbox, Hy-8, and riprap sizing analysis. For a comprehensive discussion of existing versus proposed drainage conditions across the site, please refer to Section 8.0 Drainage Facility Design.

7.2.1 SUB-BASIN A

This 0.95-acre sub-basin is located upstream of P-2, where a steep channel is formed by the embankment fill condition and the existing terrain, as shown in Appendix F on the left side of the alignment. The drainage path consists of approximately 300 ft of overland sheet flow received from rainfall on the gravel road surface and the surrounding terrain, followed by approximately 330 ft of concentrated flow within a swale that conveys runoff from both the road and the adjacent terrain. Sub-basin A discharges approximately 0.65 cfs during the 5-year storm and 2.12 cfs during the 100-year storm at design point DP-A into sub-basin L, which is an existing swale that conveys flow toward the wetlands and into sub-basin L. The calculated channel velocity for the 5-year storm event is 4.45 fps and for the 100-year storm event is 6.01 fps. This design is adequate for erosion and sediment control, meeting the permissible channel velocity of 9.5 fps specified for the turf reinforcement mat that will be placed within the channel confines. The exiting velocity is 6.01 fps; however, the flow is immediately intercepted by Culvert P-2's rock flume. For the 5-year minor storm, the maximum estimated depth within the 1.5 ft deep ditch is 0.27 ft and satisfies the minimum 1-ft freeboard requirement, yielding approximately 1.3 ft of freeboard. For the 100-year major storm, the estimated depth of 0.43 ft within the ditch complies with the overtopping criterion of not exceeding 6 inches above the shoulder; the flow depth would need to be 2 ft to exceed this criterion. The flow in the channel created by the fill slope and the existing slope is supercritical flow with a max shear stress of 4 psf and 6.3 psf for 5-year and 100-year flows respectively. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The BMPs installed in the channel will remain until vegetation is established and no erosion concerns are anticipated.

7.2.2 SUB-BASIN B

This 1.2-acre sub-basin is near station 12+00 on the right side of the alignment as shown in Appendix F. Sub-basin B drains northeast, receiving rainfall runoff from the staging area, gravel roadway, and mountain side. The runoff becomes concentrated within the ditch and discharges approximately 0.91 cfs and 3.01 cfs for the 5-year and 100-year storm events, respectively, near the wetlands and the P-1 culvert outlet within sub-basin M, at design point DP-B. The drainage path includes approximately 250 ft of overland sheet flow along the existing mountainous terrain, followed by 395 ft of channelized flow within a 1.5 ft deep ditch. The design provides adequate erosion and sediment control, meeting the permissible channel velocity of 9.5 fps specified for the turf reinforcement mat that will be placed within the channel confines. The calculated channel velocity for the 5-year storm event is 3.85 fps, and for the 100-year storm event is 5.18 fps. The 5.18 fps speed is not a concern as the flow will be released into Loy Creek, which is highly vegetated with existing grasses and brush (shown in Figure 7-1), and has a permissible velocity of 6 fps. Because the discharge velocity is lower than the creek's permissible velocity, and the flow rapidly expands and velocities reduce once the ditch meets Loy Creek, downstream erosion will not increase and therefore is not a hazard of the design. For the 5-year event, the ditch experiences an estimated flow depth of 0.34 ft, providing approximately 1.16 ft of freeboard and satisfying the minimum 1 ft. For the 100-year event, the estimated flow depth is 0.58 ft, which complies with the overtopping threshold. The ditch would only exceed 6 inches above the shoulder if flow depths reached approximately 2 ft. The flow in the channel is supercritical flow with a max shear stress of 2.8 psf and 4.4 psf for 5-year and 100-year flows respectively. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The BMPs installed in the channel will remain until vegetation is established and no erosion concerns are anticipated.

7.2.3 SUB-BASIN C

This 0.15-acre sub-basin consists of the ditch, existing undisturbed land, and the access up to the crown. Sub-basin C begins near station 11+00 and is on the left side of the alignment as shown in Appendix F. The sub-basin receives most water from the gravel roadway lane and some from the existing terrain. Sub-basin C discharges approximately 0.16 cfs and 0.53 cfs for the 5-year and 100-year storm events, respectively, into sub-basin M at design point DP-C. The drainage path includes approximately 66 ft of overland sheet flow directly from the gravel roadway, followed by 271 ft of channelized flow. The design provides adequate erosion and sediment control, meeting the permissible channel velocity of 9.5 fps specified for the turf reinforcement mat that will be placed within the channel confines. The calculated channel velocity for the 5-year storm event is 2.63 fps, and for the 100-year storm event is 3.55 fps. The exiting velocity is 3.55 fps, below the permissible speed for the existing terrain, estimated at 5 to 6 fps because of its grassy and brushy nature, shown in Figure 7-1. During the 5-year event, the estimated flow depth is 0.17 ft, providing approximately 1.33 ft of freeboard and meeting the minimum 1 ft. During the 100-year event, the flow depth increases to 0.27 ft, which remains within the allowable overtopping limit; the ditch would need to reach a depth of approximately 2 ft to exceed 6 inches above the shoulder. The flow in the channel is supercritical flow with a max shear stress of 1.6 psf and 2.6 psf for 5-year and 100-year flows respectively. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The BMPs installed in the channel will remain until vegetation is established and no erosion concerns are anticipated.

7.2.4 SUB-BASIN D

This 0.07-acre sub-basin begins near station 22+00 and is on the right side of the alignment as shown in Appendix F. This sub-basin receives rainfall runoff from both the gravel roadway and the adjacent ditch area, and ultimately discharges 0.07 cfs and 0.24 cfs for the 5-year and 100-year events respectively, into sub-basin K at design point DP-D. The runoff initially travels approximately 81 ft as overland sheet flow from the access before entering the ditch and continuing for approximately 154 ft as channelized flow. The flow direction is generally to the northeast. The ditch design provides adequate erosion and sediment control, meeting the permissible channel velocity of 9.5 fps for the selected turf reinforcement mat that will be placed within the channel confines. The calculated channel velocities are 2.19 fps for the 5-year event and 2.99 fps for the 100-year event. At the design point, the exiting velocity remains under the estimated permissible range of 5 to 6 fps for the existing vegetated terrain, shown in Figure 7-1, indicating no erosion concerns. Therefore, although turf reinforcement mat is required to armor the channel, additional protection at the channel outfall is not warranted. The 5-year minor storm estimated flow depth is 0.13-ft with a 1.37 ft freeboard depth satisfying the minimum requirement of 1-ft freeboard. The 100-year major storm results in an estimated flow depth of 0.20 ft, below the threshold for overtopping. The ditch would need to reach approximately 2 ft of depth to exceed 6 inches above the shoulder. The flow in the channel is supercritical flow with a max shear stress of 1.3 psf and 2.0 psf for 5-year and 100-year flows respectively. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The BMPs installed in the channel will remain until vegetation is established and no erosion concerns are anticipated.

7.2.5 SUB-BASIN E

This 0.13-acre area is near station 22+00 and is on the left side of the alignment as shown in Appendix F. Sub-basin E receives rainfall runoff from both the gravel roadway and the adjacent ditch and discharges approximately 0.14 cfs during the 5-year storm and 0.45 cfs during the 100-year storm into sub-basin M at design point DP-E. The drainage path flows to the northeast, consisting of approximately 76 ft of overland sheet flow from the gravel roadway, followed by approximately 260 ft of channelized flow through the ditch. The design provides adequate erosion and sediment control, meeting the permissible channel velocity of 9.5 fps specified for the turf reinforcement mat that will be placed within the channel confines. The calculated channel velocity for the 5-year storm event is 2.75 fps, and for the 100-year storm event is 3.68 fps. The 3.68 fps exiting velocity is below the estimated existing terrain permissible speed of 5 to 6 fps. Therefore, although turf reinforcement mat is required to armor the channel, additional protection at the channel outfall is not warranted. The estimated flow depth for the 5-year minor storm is 0.16 ft, providing approximately 1.34 ft of freeboard, which exceeds the minimum 1-ft freeboard. During the 100-year major storm, the estimated flow depth increases to 0.25 ft, which remains within acceptable overtopping criteria, as it does not surpass 6 inches above the shoulder. The ditch would need to reach a depth of approximately 2 ft for flow to exceed the 6-inch shoulder threshold. The flow in the channel is supercritical flow with a max shear stress of 1.8 psf and 2.9 psf for 5-year and 100-year flows respectively. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The BMPs installed in the channel will remain until vegetation is established and no erosion concerns are anticipated.

7.2.6 SUB-BASIN F

The 0.08-acre sub-basin is near station 26+00 on the left side of the alignment as shown in Appendix F. It is formed by natural terrain sloping toward the fill embankment, directing flow northeast. The sub-basin receives rainfall runoff from the gravel access surface and the adjacent sloped terrain, which travels approximately 40 ft as overland sheet flow before concentrating into approximately 200 ft of channelized flow within the swale. This runoff discharges into sub-basin M at design point DP-F, contributing approximately 0.09 cfs during the 5-year storm and 0.30 cfs during the 100-year storm. The design provides adequate erosion and sediment control, meeting the permissible channel velocity of 9.5 fps specified for the turf reinforcement mat that will be placed within the channel confines. The calculated channel velocity for the 5-year storm event is 1.78 fps, and for the 100-year storm event is 2.40 fps. The velocity is below the permissible speed of the existing terrain, estimated to be around 5 to 6 fps based on the existing vegetation as shown in Figure 7-1. Therefore, although turf reinforcement mat is required to armor the channel, additional protection at the channel outfall is not warranted. The estimated flow depth for the 5-year minor storm is 0.09 ft, providing approximately 1.41 ft of freeboard and exceeding the minimum 1 ft requirement. The 100-year major storm is estimated to produce a flow depth of 0.14 ft, which meets overtopping criteria, as it remains below the 6-inch threshold above the shoulder. A flow depth of approximately 2 ft would be required to exceed the 6-inch limit. The flow in the channel created by the fill slope and the existing slope is supercritical flow with a max shear stress of 0.8 psf and 1.3 psf for 5-year and 100-year flows respectively. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The shear stress values being below the permissible value for the TRM do not bring up erosion concerns.

7.2.7 SUB-BASIN G

This 0.08 acre sub-basin is near station 30+00 on the left side of the alignment as shown in Appendix F. The sub-basin receives rainfall runoff from the gravel access and adjacent ditch. It goes from a swale into a ditch, as the natural terrain slopes toward the fill embankment in the beginning of the basin. This sub-basin discharges runoff to sub-basin M at design point DP-G at approximately 0.08 cfs for the 5-year storm and 0.28 cfs for the 100-year storm, with flow directed to the northeast. The drainage path flows northeast and includes approximately 84 ft of overland sheet flow from the gravel roadway, followed by 110 ft of channelized flow along the ditch. The design provides adequate erosion and sediment control, meeting the permissible channel velocity of 9.5 fps specified for the turf reinforcement mat that will be placed within the channel confines. The calculated channel velocity for the 5-year storm event is 2.14 fps, and for the 100-year storm event is 2.93 fps. Once the flow discharges onto the natural terrain, the resulting velocities remain below the permissible limits. Therefore, although turf reinforcement mat is required to armor the channel, additional protection at the channel outfall is not warranted. The 5-year minor storm estimated flow is 0.14-ft, which satisfies the minimum requirement of 1-ft freeboard, as there would be 1.36-ft of freeboard. The 100-year major storm meets the overtopping criteria, as it has an estimated flow depth of 0.22-ft, which does not exceed 6 inches above the shoulder. A flow depth of approximately 2 ft would be required to exceed the 6-inch limit. The flow in the channel is supercritical flow with a max shear stress of 1.2 psf and 1.9 psf for 5-year and 100-year flows respectively. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The BMPs installed in the channel will remain until vegetation is established and no erosion concerns are anticipated.

7.2.8 SUB-BASIN H

This 0.08-acre sub-basin is near station 33+00 and is on the right side of the alignment as shown in Appendix F. The natural terrain slopes toward the fill embankment. The sub-basin receives runoff from the gravel roadway and adjacent ditch. The drainage path flows northeast and includes approximately 42 ft of overland sheet flow from the gravel surface, followed by 146 ft of channelized flow within the ditch. This sub-basin discharges into sub-basin K at design point DP-H, contributing approximately 0.09 cfs for the 5-year storm and 0.28 cfs for the 100-year storm. The design provides adequate erosion and sediment control, meeting the permissible channel velocity of 9.5 fps specified for the turf reinforcement mat that will be placed within the channel confines. The calculated channel velocity for the 5-year storm event is 1.64 fps, and for the 100-year storm event is 2.17 fps. The exiting flow velocity of 2.17 fps is below the permissible range of 5 to 6 fps for the existing vegetated terrain. Therefore, although turf reinforcement mat is required to armor the channel, additional protection at the channel outfall is not warranted. The 5-year minor storm has an estimated flow depth of 0.10-ft, with a freeboard of 1.40-ft, which satisfies the minimum requirement of 1-ft freeboard. The 100-year major storm has an estimated flow depth of 0.15, which meets the overtopping criteria, as it does not exceed 6 inches above the shoulder. A flow depth of approximately 2 ft would be required to exceed the 6-inch limit. The flow in the channel created by the fill slope and the existing slope is supercritical flow with a max shear stress of 0.7 psf and 1.0 psf for 5-year and 100-year flows respectively. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The shear stress values being below the permissible value for the TRM do not bring up erosion concerns.

7.2.9 SUB-BASIN I

This 0.55-acre sub-basin is situated before and within the turnaround area near station 35+00 and is on the left side of the alignment as depicted in Appendix F. Near station 35+00 the access has a high point, which allows this sub-basin to drain south as opposed to the other sub-basins. The sub-basin receives rainfall runoff from the gravel surface, ditch area, and the existing terrain sloped toward the access. The drainage path flows southeast and includes approximately 81 ft of overland sheet flow, received from the gravel roadway, followed by 411 ft of channelized flow. This sub-basin discharges into sub-basin M at design point DP-I, contributing approximately 0.46 cfs for the 5-year storm and 1.51 cfs for the 100-year storm. The design provides adequate erosion and sediment control, meeting the permissible channel velocity of 9.5 fps specified for the turf reinforcement mat that will be placed within the channel confines. The calculated channel velocity for the 5-year storm event is 2.95 fps, and for the 100-year storm event is 3.97 fps. The exiting flow velocity is below the existing terrain's permissible speed, estimated around 5 to 6 fps, due to the existing vegetation; as such, increased erosion is not a concern. Therefore, although turf reinforcement mat is required to armor the channel, additional protection at the channel outfall is not warranted. The 5-year minor storm estimated flow is 0.32-ft with a freeboard of approximately 1.18 ft, which satisfies the minimum requirement of 1-ft freeboard. The 100-year major storm estimated flow depth is 0.50-ft, which meets the overtopping criteria, as it does not exceed 6 inches above the shoulder. A flow depth of approximately 2 ft would be required to exceed the 6-inch limit. The flow in the channel is supercritical flow with a max shear stress of 1.9 psf and 2.9 psf for 5-year and 100-year flows respectively. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The BMPs installed in the channel will remain until vegetation is established and no erosion concerns are anticipated.

7.2.10 SUB-BASIN J

This 0.15-acre sub-basin lies near the project terminus on the south side, opposite the access route and across from the turnaround at station 36+00 as depicted in Appendix F. This sub-basin receives runoff from the gravel surface and adjacent ditch area and discharges approximately 0.15 cfs during the 5-year storm and 0.50 cfs during the 100-year storm into sub-basin M at design point DP-J. The drainage path flows southeast and includes approximately 68 ft of overland sheet flow, followed by 228 ft of channelized flow. The design provides adequate erosion and sediment control, meeting the permissible channel velocity of 9.5 fps specified for the turf reinforcement mat that will be placed within the channel confines. The calculated channel velocity for the 5-year storm event is 2.23 fps, and for the 100-year storm event is 3.01 fps. The exiting flow velocity is less than the allowable velocity for the existing vegetated terrain, estimated to be 5 to 6 fps; as such, these flows will not cause erosion issues. Therefore, although turf reinforcement mat is required to armor the channel, additional protection at the channel outfall is not warranted. The 5-year minor storm's estimated flow depth is 0.21-ft with 1.28-ft of freeboard, which satisfies the minimum requirement of 1-ft freeboard. The 100-year major storm estimate flow depth is 0.33-ft, which meets the overtopping criteria, as it does not exceed 6 inches above the shoulder. A flow depth of approximately 2 ft would be required to exceed 6-inches above the shoulder. The flow in the channel is supercritical flow with a max shear stress of 1.9 psf and 2.9 psf for 5-year and 100-year flows respectively. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The BMPs installed in the channel will remain until vegetation is established and no erosion concerns are anticipated.

7.2.11 SUB-BASIN K

This basin is 25.85 acres and is bordered by the crown of the access on the south, the ridge near station 36+00 on the west, the top of the ridge on the north, delineated on the east perpendicular to the slope at the inlet of culvert P-2. The basin is mostly comprised of undisturbed forest land within a small valley. The majority of runoff entering this basin originates from the adjacent mountainside, with additional contributions from the gravel roadway surface to the right of the proposed alignment. Sub-basins D and H contribute runoff to sub-basin K, but lie entirely within sub-basin K. Sub-basin K was analyzed in its entirety. Sub-basins D and H were analyzed separately to ensure the newly formed concentrated flows did not have adverse effects. The drainage path flows northeast and includes approximately 300 ft of overland sheet flow, followed by 1933 ft of channelized flow discharging into the inlet structure for culvert P-2 at design point DP-K. The 5-year and 100-year flow rates are 3.49 cfs and 31.8 cfs respectively. The inlet structure is a reinforced concrete headwall with wingwalls and an apron to direct flow into the culvert and mitigate erosion caused by approach velocities. The approach velocities are 5.25 fps for the 5-year storm and 9.13 fps for the 100-year storm at the channel immediately upstream of the inlet. The wingwall elevation is set at El. 8916′, which is higher than the anticipated headwater elevation of El. 8914.85′, ensuring that all flow is directed into Culvert P-2. Culvert P-2 is a 24-inch diameter reinforced concrete pipe 83 ft long, and placed at the bottom of the valley of sub-basin K to maintain the existing flow path across the access. Details for the culvert, headwall and wingwall design are provided in the plans. The embankment height is approximately 14 ft from the culvert inlet to the top of the gravel surface; therefore, the estimated 100-year flow depth of 1.08 ft and headwater depth of 4.59 ft, do not present a concern for overtopping. The culvert is set at less than 6 percent grade, which represents the maximum slope recommended by the AASHTO Drainage Manual. HY-8 modeling indicates outlet velocities of 9.12 fps for the 5-year storm and 15.6 fps for the 100-year storm, while tailwater velocities are 2.95 fps and 6.37 fps, respectively. Given the culvert's location along the embankment foreslope and the substantial difference between outlet and tailwater velocities, an energy dissipation measure is necessary to prevent erosion. A riprap flume is recommended for this purpose. Based on FHWA riprap sizing analysis shown in Section 7.1, a minimum D_{50} of 19.7 inches is required for the flume design, in this case the riprap was upsized to D_{50}=24″. It's necessary to have a 4-ft thickness of the D_{50}=24″. A second 12-inch thick layer using D_{50}=6″ will be underneath the 24-inch riprap to protect the geotextile from sharp edges of the large riprap. The location for sub-basin K and its components are shown in Appendix F. Most of the flow in the channel is on undisturbed land and not considered in the erosion consideration. The flow in the channel formed by the fill slope and the existing ground is supercritical flow with a max shear stress of 1.7 psf and 5.9 psf for 5-year and 100-year flows respectively. This channel is designed to be a trapezoidal channel with a 4 ft flat bottom to disperse flow as opposed to the other channels that are triangular. The selected TRM has an unvegetated permissible shear stress of 3 psf and a partially vegetated shear stress of 8 psf. The BMPs installed in the channel will remain until vegetation is established and no erosion concerns are anticipated.

7.2.12 SUB-BASIN L

Sub-basin L delineates the drainage area for the swale that outlets culvert P-2 and drains into Loy Creek. This basin also receives all flow leaving sub-basin A. Sub-basin L is 1.6 acres, and the rational method was therefore used for determining runoff values. Overall peak flow values were determined by adding these runoff values to P-2 and sub-basin A outlet flow rates. This basin discharges approximately 4.42 cfs during the 5-year storm event, and 36.4 cfs during the 100-year event into Loy

Creek at design point DP-L. The drainage path flows northeast, beginning with 300 ft of overland flow before transitioning into approximately 520 ft of channelized flow. The 5-year event has a typical flow depth of less than 1 inch and a velocity of 2.47 fps, and the 100-year event's flow depth is approximately 0.25 ft with a velocity of 5.57 fps. These small depths follow freeboard and overtopping requirements. The velocities do not pose an erosion concern because they fall below the permissible velocity for this terrain of 6 fps. Therefore, the swale within sub-basin L provides adequate conveyance to Loy Creek. The flow in the swale is supercritical flow with a max shear stress of 0.7 psf and 2.4 psf for 5-year and 100-year flows respectively. The swale is existing and well vegetated with flows similar to the existing flow regime and no erosion concerns are expected.

7.2.13 SUB-BASIN M

Sub-basin M represents the full project drainage area, totaling 441.6 acres and incorporating sub-basins A through L which contribute to sub-basin M. Runoff is received from Loy Creek, the gravel road surface, roadside ditches associated with the proposed roadway, and the surrounding mountainous slopes. The sub-basin generally drains northward and discharges back into Loy Creek. The design point DP-M for sub-basin M was established at the outlet of the proposed 36-inch diameter, 56 ft long reinforced concrete pipe, culvert P-1. This culvert will maintain the natural flow path of Loy Creek as it crosses the primary site access, as illustrated in Appendix F. Because the total drainage area exceeds the 130-acre applicability limit of the Rational Method, USGS StreamStats and the method outlined in NRCS TR-55 were used to determine the design discharge for sub-basin M. Each method was run for both the 5-year and 100-year flow, and the higher value between the two methods was conservatively chosen. For the 5-year flow, the result from StreamStats was chosen; for the 100-year flow, the result from TR-55 was chosen. Based on this analysis, and the additional impervious area of the site, the design flow through the culvert is 14.9 cfs for the 5-year storm event and 63.5 cfs for the 100-year storm event. See Section 8.2 to see the developed drainage conditions. HY-8 modeling indicates outlet velocities of 11.37 fps and 15.31 fps for the 5-year and 100-year storms, respectively, while tailwater velocities are 3.02 fps and 4.65 fps. According to CDOT DDM (2019), Chapter 9, Section 9.2.2, outlet velocity should be consistent with the natural channel velocity. The substantial difference between outlet and tailwater velocities indicates the need for an energy dissipation measure, such as a riprap apron. Based on FHWA riprap sizing analysis, a minimum D_{50} of 17.3 inches is recommended for the apron design; riprap was upsized to D_{50}=18". After passing over the riprap, tailwater velocity slows to 4.65 fps, significantly lower than the permissible velocity for the downstream channel because of the dense vegetation and stable natural terrain. Therefore, the reduced velocity will not pose an erosion concern.

Culvert P-1 is shown to have adequate inlet velocities for the 5-year, 2.75 fps, and 100-year, 4.77 fps, and does not warrant permanent inlet protection. It's noted that a Mannings roughness of 0.05 was used from El Paso DCM 1 III.10 Table 10-2 which is best described as a channel that is not maintained, weeds and uncut brush. An example field photo can be shown below in Figure 7-1. This basin's channel is Loy Creek with supercritical flow and the calculated shear stress at the P-2 outlet is 0.9 psf and 2.2 psf. Loy Creek is a stable creek with heavy vegetation with no erosion concerns.

7.2.14 LOY CREEK

Loy Creek is an intermittent creek that originates in the eastern portion of the existing basin and flows west near Loy Creek Road and turns north and is on the western side of Loy Creek Road. Loy Creek is adjacent to the road until it enters a culvert and crosses Rampart Range Road where it turns west and is not easily discernable. It follows Rampart Range Road but continues west where the road goes to the southwest. At some point Loy Creek joins Lovell Gulch and ultimately ends up in Trout Creek.

The portion of Loy Creek that is the subject of this report is the section that is adjacent to Loy Creek Road. Loy Creek in this area is heavily vegetated. The creek is dominated by mountain willow (Salix monticola) with less amounts of water sedge (Carex aquatilis), marsh bluegrass (Poa leptocoma), and cow parsnip (Heracleum maximum). The stream is stable and where there is a visible stream flow the channel is approximately 1-1.5 ft wide with 2-3 inches of water, and has a gravel bottom with heavily grassed banks.

The lack of a visible stream channel downstream near Rampart Range Road suggests that much of the flow from the creek goes underground between the proposed access and Rampart Range Road. The proposed development will add 0.3 cfs amount of flow to the existing flow of 63.2 cfs during the 100-year storm which is a negligible increase and no further stabilization is warranted. Loy Creek's condition upstream and downstream suggests that the proposed development will have a negligible impact on the creek's stability.

This report details the development of a primary access across Loy Creek where no existing access exists. As part of the same construction contract, but not included in the scope of this report, is the construction of an access to an adjacent parcel to the South owned by the same entity. This access will be approximately 1,850 ft south of the primary access. This was initially to widen an existing access for the property owner. The existing access was elected to remain in place and be decommissioned for vehicle access because it has a small bridge with historical significance, and the new access will be installed adjacent to the existing.

Figure 7-1. Field Photo of Loy Creek South of Primary Access

8.0 DRAINAGE FACILITY DESIGN

This report evaluates drainage conditions for the project site before and after installation of the proposed primary access. The analysis compares existing undeveloped conditions with post-development conditions to determine changes in impervious surface area and potential impacts on watershed hydrology. Design considerations for maintaining natural drainage patterns are also discussed.

8.1 EXISTING DRAINAGE CONDITIONS

The project site is currently undeveloped, except for the paved Loy Creek Road, which is considered 100% impervious. Surrounding mountainous and forested slopes are classified as 0% impervious, consistent with El Paso County DCM Table 5-1 for Undeveloped Areas – Forest.
StreamStats delineated the contributing watershed for the existing conditions as approximately 441.6 acres, representing the entire outfall drainage basin of the project site. Existing drainage patterns follow natural flow paths toward the outfall location. Figure found in Appendix F.

8.2 DEVELOPED DRAINAGE CONDITIONS

The proposed primary access road will be gravel and is conservatively considered impervious for this analysis. The design preserves existing drainage patterns by aligning closely with natural flow paths. Culverts will be installed where natural channels intersect the access road to maintain uninterrupted flow downstream.
Post-development conditions maintain the same outfall sub-basin area of 441.6 acres for sub-basin M (Appendix F), and StreamStats and TR-55 were again used for peak-flow estimation because the drainage area exceeds the 130-acre applicability limit of the Rational Method. The only change is the addition of approximately 1.6 acres of impervious surface from the access road, increasing the overall imperviousness by 0.36%. Table 8-1 summarizes peak-flow estimates for existing and proposed conditions at the outlet of culvert P-1 and shown in Appendix F as DP-M. The developed site will incorporate many sediment and erosion control measures dictated in the erosion control plan section.

Table 8-1. Existing and Proposed Peak Flows at P-1

Subcatchment	Area (AC)	Additional Imperviousness (%)	Peak Flow, Q (cfs) 5-year	Peak Flow, Q (cfs) 100-year
Existing	441.6	N/A	14.8	63.2
Proposed	441.6	0.36	14.9	63.5

9.0 EROSION CONTROL PLAN

Temporary and permanent erosion control measures are essential for both environmental protection and site stability. All proposed ditches are lined with grass and turf reinforcement mats to reduce runoff velocities, thereby minimizing erosion potential.
During construction but before vegetation establishment, temporary erosion control BMPs will be deployed. These BMPs are detailed on the Grading and Erosion Control Plans and include the following:

- Permanent seeding
- Check dams
- Vegetation buffer
- Silt fences
- Inlet and outlet protection
- Turf Reinforcement Mat
- Vehicle tracking control
- Riprap apron
- Rock flume

These measures are designed to control sediment transport, reduce flow velocities, and protect downstream resources.

Temporary inlet protections will be at all culverts, permanent turf reinforcement mats will be installed along all project site slope limits and ditches, and permanent seeding and mulching to stabilize disturbed areas. Check dams will be installed within the ditch to slow water flow and capture sediment during construction but will be removed once construction has ended. Silt fences will be placed along the outer boundaries of the fill slopes to prevent sediment migration, and pre-fabricated vehicle tracking control pads, will be constructed to reduce debris from entering the existing Loy Creek roadway. Based on the minimal increase in imperviousness associated with the proposed access and the negligible change in off-site discharge, detention sediment basins are not warranted. Table 9-1 outlines the estimated quantities and total costs associated with these BMPs.

Table 9-1. Erosion Control Estimate

Description	Quantity	Units	Unit Cost ($)	Total ($)
Turf Reinforcement Mat	10,020	Square Yards	7	70,140
Permanent Seeding and Mulching	2.4	Acre	2,169	4,888.80
Rock Check Dam	59	Each	908	53,572
Silt Fence	4,550	Linear Ft	3	13,650
Straw Wattle/Rock Sock	540	Linear Ft	11	5,940
Pre-Fab Vehicle Tracking Control	24	Each	3,840	92,160
Geotextile (Separator)(Class 1)	85	Square Yards	17.00	1445
Riprap, d50 size from 6" to 24"	189	Ton	102	21,216

10.0 WATER QUALITY

The site is located on land that is zoned as agricultural in the northwestern corner of El Paso County, but the site also partially extends into Teller County. The project is a private access to facilitate maintenance to a future dam. The project is located within an area zoned as agricultural and is excluded from Section I.7 of the ECM. The exclusion only applies to the Permanent Control Measure (PCM) and Water Quality Control Volume. Any runoff reduction using receiving pervious areas is informal and not an official permanent control measure.

11.0 CONCLUSIONS

This drainage report supports the design and development of the primary access for the proposed Glen Aspen Dam near Woodland Park, Colorado. The private access will provide essential access for future dam construction and ongoing dam maintenance, traversing largely undeveloped terrain with minimal existing infrastructure. The proposed improvements, which include clearing, grading, and earthwork, have been carefully evaluated to ensure minimal impact on the existing drainage patterns. While the sub-basin boundaries remain unchanged, the impervious surface area has only slightly increased from the gravel surface. Pre-and post-drainage conditions are shown in Figure 11-1. All ditches will be lined with turf reinforcement mats, which meets erosion and sediment control standards for the site's conditions. Culvert P-2 has been designed to maintain natural drainage flow across the access and will include a concrete headwall at the inlet and a rock flume at the outlet to mitigate high outlet velocities and prevent erosion. A minimum ditch depth of 1.5 ft has been determined to be sufficient for managing runoff from a 5-year minor storm and 100-year major storm event across the site.

Temporary and permanent best management practices (BMPs) will be implemented before and during construction to further control sediment transport and potential pollutant runoff. Based on the limited increase in impervious area, maintenance of pre-development drainage patterns, and incorporation of erosion control and energy dissipation measures, runoff rates, flow paths, and discharge locations will remain consistent with existing conditions. As a result, downstream and surrounding properties will not be adversely affected by the proposed development.

Overall, the drainage design ensures that stormwater is effectively managed and that pollutants are contained within the site, supporting both environmental protection and long-term infrastructure integrity.

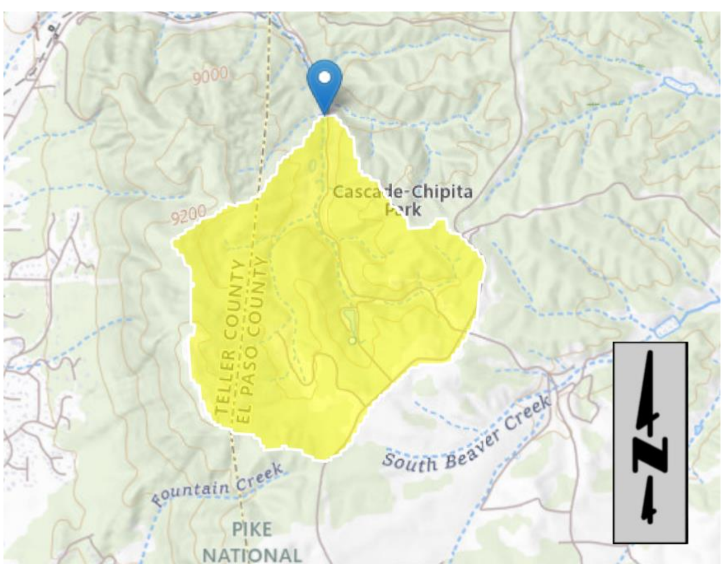


Figure 11-1. Existing & Developed Drainage Condition Catchment Sub-basin.

12.0 REFERENCES

"Drainage Criteria Manual County of El Paso, Colorado," 2018. *Municode Library*, accessed August 13, 2025, from https://library.municode.com/co/el_paso_county/codes/drainage_criteria_manual?nodeId=DRCRMACOELPACO

"El Paso Engineering Criteria Manual," 2023. *Municode Library,* accessed September 5, 2025, from *library.municode.com/co/el_paso_county/codes/engineering_criteria_manual_*

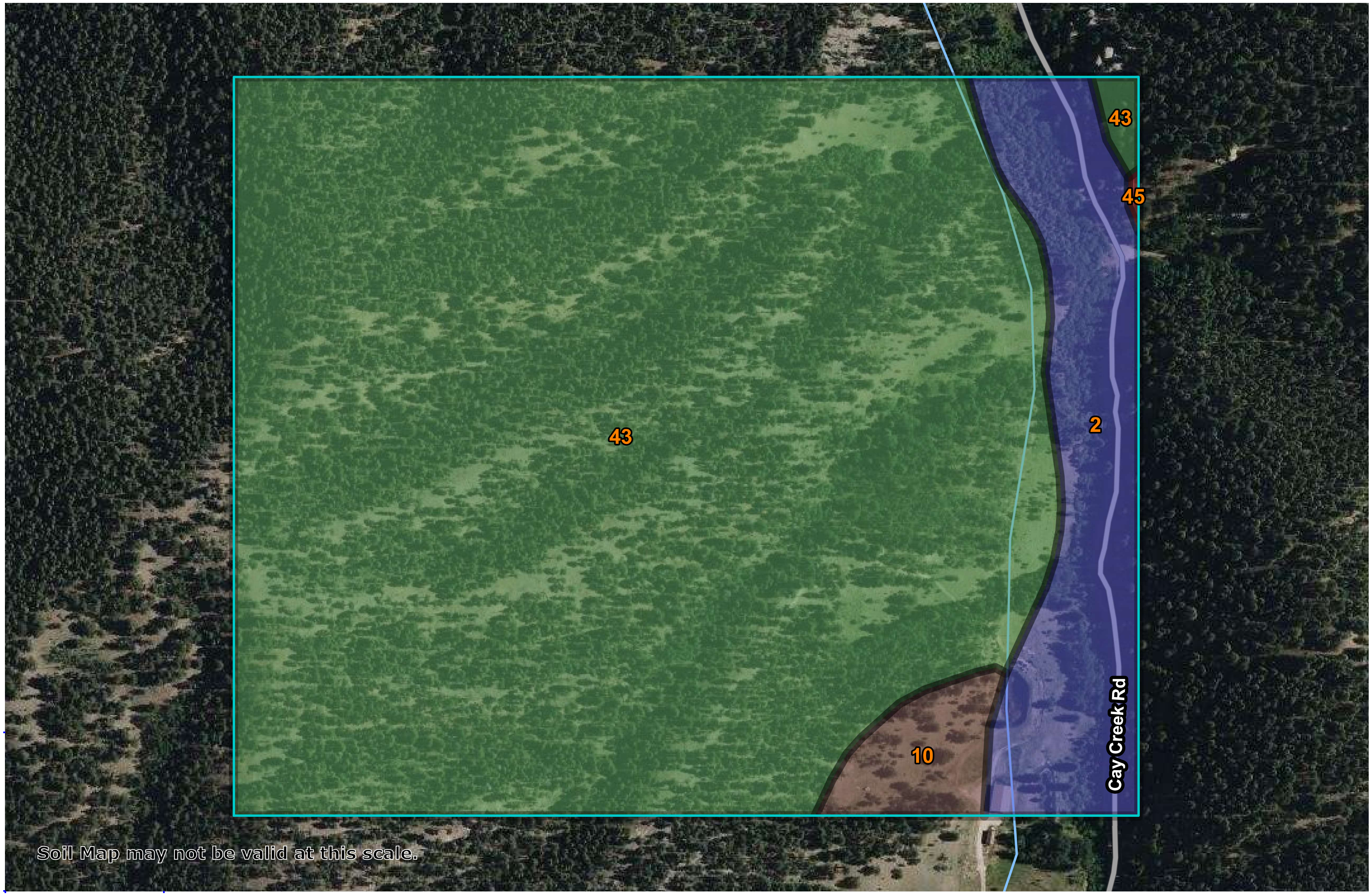
Colorado Department of Transportation, 2019. *2019 Drainage Design Manual.*

American Association of State Highway and Transportation Officials, 2014. *AASHTO Drainage Manual*.

United States Department of Agriculture Natural Resources Conservation Service, 1986. Technical Release 55. *Urban Hydrology for Small Watersheds.*

APPENDIX A
NATIONAL COOPERATIVE SOIL SURVEY MAP

Map Unit Name—Pike National Forest, Eastern Part, Colorado, Parts of Douglas, El Paso, Jefferson, and Teller Counties



Map Scale: 1:4,570 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 200, 400, 800, 1200

N

Map projection: Web Mercator Corner coordinates: WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- Aquolls, 1 to 10 percent slopes
- Condie coarse sandy loam, 2 to 15 percent slopes
- Sphinx gravelly coarse sandy loam, 40 to 70 percent slopes
- Sphinx gravelly coarse sandy loam, warm, 40 to 70 percent slopes
- Not rated or not available

Soil Rating Lines

- Aquolls, 1 to 10 percent slopes
- Condie coarse sandy loam, 2 to 15 percent slopes
- Sphinx gravelly coarse sandy loam, 40 to 70 percent slopes
- Sphinx gravelly coarse sandy loam, warm, 40 to 70 percent slopes
- Not rated or not available

Soil Rating Points

- Aquolls, 1 to 10 percent slopes
- Condie coarse sandy loam, 2 to 15 percent slopes
- Sphinx gravelly coarse sandy loam, 40 to 70 percent slopes
- Sphinx gravelly coarse sandy loam, warm, 40 to 70 percent slopes
- 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: Pike National Forest, Eastern Part, Colorado, Parts of Douglas, El Paso, Jefferson, and Teller Counties
Survey Area Data: Version 12, Aug 29, 2025

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

Date(s) aerial images were photographed: Jul 1, 2020—Jul 2, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Name

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2	Aquolls, 1 to 10 percent slopes	Aquolls, 1 to 10 percent slopes	10.7	12.0%
10	Condie coarse sandy loam, 2 to 15 percent slopes	Condie coarse sandy loam, 2 to 15 percent slopes	2.4	2.7%
43	Sphinx gravelly coarse sandy loam, 40 to 70 percent slopes	Sphinx gravelly coarse sandy loam, 40 to 70 percent slopes	75.8	85.3%
45	Sphinx gravelly coarse sandy loam, warm, 40 to 70 percent slopes	Sphinx gravelly coarse sandy loam, warm, 40 to 70 percent slopes	0.1	0.1%
Totals for Area of Interest			**88.9**	**100.0%**

Description

A soil map unit is a collection of soil areas or nonsoil areas (miscellaneous areas) delineated in a soil survey. Each map unit is given a name that uniquely identifies the unit in a particular soil survey area.

Rating Options

Aggregation Method: No Aggregation Necessary

Tie-break Rule: Lower

K Factor, Whole Soil

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2	Aquolls, 1 to 10 percent slopes	.32	10.7	12.0%
10	Condie coarse sandy loam, 2 to 15 percent slopes	.15	2.4	2.7%
43	Sphinx gravelly coarse sandy loam, 40 to 70 percent slopes	.15	75.8	85.3%
45	Sphinx gravelly coarse sandy loam, warm, 40 to 70 percent slopes	.15	0.1	0.1%
Totals for Area of Interest			**88.9**	**100.0%**

Description

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Factor K does not apply to organic horizons and is not reported for those layers.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): All Layers (Weighted Average)

APPENDIX B

DESIGN TABLES

TABLE 10-1
COMPOSITE ROUGHNESS COEFFICIENTS FOR UNLINED OPEN CHANNELS (Reference: Chow, Ven Te, 1959;Open-Channel Hydraulics)

$N = (n_o + N_1 + n_2 + n_3 + n_4)m$ (10-2)

	Channel Conditions	Value
Material Type	Earth	0.020
n_o	Fine Gravel	0.024
	Coarse Gravel	0.028
Degree of Irregularity	Smooth	0.000
	Minor	0.005
n_1	Moderate	0.010
	Severe	0.020
Variation of Channel	Gradual	0.000
Cross Section	Alternating	
n_2	Occasionally	0.005
	Alternating	
	Frequently	0.010 - 0.015
Relative Effect	Negligible	0.000
of Obstructions	Minor	0.010 - 0.015
n_3	Appreciable	0.020 - 0.030
	Severe	0.040 - 0.060
Vegetation	Low	0.005 - 0.010
	Medium	0.010 - 0.025
n_4	High	0.025 - 0.050
	Very High	0.050 - 0.100
Degree of Meandering	Minor	1.000 - 1.200
	Appreciable	1.200 - 1.500
m	Severe	1.500

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20
* For buried riprap, select C_v value based on type of vegetative cover.	

TABLE 10-2
TYPICAL ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS
(Reference: Chow, Ven Te, 1959;Open-Channel Hydraulics)

Type of Channel and Description	Minimum	Normal	Maximum
EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c.Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120

2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
NATURAL STREAMS			
Minor streams (top width at flood stage 100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
LINED OR BUILT-UP CHANNELS			
a. Corrugated Metal	0.021	0.025	0.030
b. Concrete			
1. Trowel finish	0.011	0.013	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	
8. On irregular excavated rock	0.022	0.027	
c. Concrete bottom float finished with sides of			

1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
d. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
e. Asphalt			
1. Smooth		0.013	
2. Rough		0.016	
f. Grassed	0.030	0.040	0.050

TABLE 10-3
MAXIMUM PERMISSIBLE DESIGN OPEN CHANNEL FLOW VELOCITIES IN EARTH*

Soil Types	**Permissible Mean Channel Velocity (ft/sec)**
Fine Sand (noncolloidal)	2.0
Coarse Sand (noncolloidal)	4.0
Sandy Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Silty Clay	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (colloidal)	5.5
Alluvial Silts (noncolloidal)	3.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5
Hard Shales and Hard Pans	6.0
Soft Shales	3.5
Soft Sandstone	8.0
Sound rock (usu. igneous or hard metamorphic)	20.0
*These velocities shall be used in conjunction with scour calculations and as approved by City/County.	

TABLE 10-4
MAXIMUM PERMISSIBLE VELOCITIES FOR EARTH CHANNELS WITH VARIED GRASS LININGS AND SLOPES

Channel Slope	Lining	Permissible Mean Channel Velocity* (ft/sec)
0 - 5%	Sodded grass	7
	Bermudagrass	6
	Reed canarygrass	5
	Tall fescue	5
	Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue	2.5
	Redtop	2.5
	Sericea lespedeza	2.5
	Annual lespedeza	2.5
	Small grains (temporary)	2.5
5 - 10%	Sodded grass	6
	Bermudagrass	5
	Reed canarygrass	4
	Tall fescue	4
	Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Sodded grass	5
	Bermudagrass	4
	Reed canarygrass	3
	Tall fescue	3
	Kentucky bluegrass	3
*For highly erodible soils, decrease permissible velocities by 25%.		
*Grass lined channels are dependent upon assurances of continuous growth and maintenance of grass.		

1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
d. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
e. Asphalt			
1. Smooth		0.013	
2. Rough		0.016	
f. Grassed	0.030	0.040	0.050

634.4. Hydraulics

A. Pipe capacity and design shall be in accordance with the City/County Drainage Criteria Manual.

B. Acceptable Manning's Roughness Coefficient "n" for pipe materials are:

Reinforced Concrete Pipe (RCP)	0.013
Corrugated Steel Pipe-Galvanized (CSP)	see Figure C
Aluminized Corrugated Steel Pipe (ACSP)	see Figure C
Ribbed Polyvinyl Chloride (RPVC)	0.012
Smooth Polyvinyl Chloride (SPVC)	0.010
Profile Wall Polyethylene (PWPE)	0.012
Corrugated Polyethylene Pipe, Type S (CPE)	0.012

Table 6-8. HSG for Soils in the Pike National Forest

Map Symbol	Major Soil Component	Assigned HSG
42, 43, 44, 45, 46, 47	Sphinx	B
5, 6, 7	Catamount	B
21	Ivywild	B
33, 34, 35, 36	Rock outcrop	D
24, 25, 26	Legault	B
48, 49	Tecolote	B
9	Cirque land	D
2	Aquolls	D
10	Condie	B
29, 31	Pendant	D
Note: Minor soil map units not listed above shall retain the published HSG.		

Turf Reinforcement Mat (VMAX SC250) Product Properties

Roughness Coefficients – Unveg.	
Flow Depth	Manning's n
≤ 0.50 ft (0.15 m)	0.040
0.50 – 2.0 ft	0.040-0.012
≥ 2.0 ft (0.60 m)	0.011

Design Permissible Shear Stress		
	Short Duration	**Long Duration**
Phase 1: Unvegetated	3.0 psf (144 Pa)	2.5 psf (120 Pa)
Phase 2: Partially Veg.	8.0 psf (383 Pa)	8.0 psf (383 Pa)
Phase 3: Fully Veg.	10.0 psf (480 Pa)	8.0 psf (383 Pa)
Unvegetated Velocity	9.5 fps (2.9 m/s)	
Vegetated Velocity	15 fps (4.6 m/s)	

Table 6-6. Runoff Coefficients for Rational Method (Source: UDFCD 2001)

Land Use or Surface Characteristics	Percent Impervious	Runoff Coefficients											
		2-year		5-year		10-year		25-year		50-year		100-year	
		HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D
Forest	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50

Table 6-8. HSG for Soils in the Pike National Forest

EXPAND

Map Symbol	Major Soil Component	Assigned HSG
42, 43, 44, 45, 46, 47	Sphinx	B
5, 6, 7	Catamount	B

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

APPENDIX C

CALCULATIONS

Calculation of Peak Runoff using Rational Method

Designer: Kevin Garcia
Company: RESPEC
Date: 3/10/2026
Project: Glen Aspen Dam - Primary Access Road
Location: Woodland Park, CO

Version 2.00 released May 2017

Cells of this color are for required user-input
Cells of this color are for optional override values
Cells of this color are for calculated results based on overrides

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_i^{0.33}}$$

$$t_t = \frac{L_t}{60K\sqrt{S_t}} = \frac{L_t}{60V_t}$$

$$\text{Computed } t_c = t_i + t_t$$

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

$t_{minimum}$ = 5 (urban)
$t_{minimum}$ = 10 (non-urban)

$$\text{Selected } t_c = \max\{t_{minimum}, \min(\text{Computed } t_c, \text{Regional } t_c)\}$$

Select UDFCD location for NOAA Atlas 14 Rainfall Depths from the pulldown list OR enter your own depths obtained from the NOAA website (click this link)

	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1-hour rainfall depth, P1 (in) =	0.76	0.98	1.18	1.49	1.75	2.04	2.80

	a	b	c
Rainfall Intensity Equation Coefficients =	28.50	10.00	0.786

$$I(in/hr) = \frac{a * P_1}{(b + t_c)^c}$$

$$Q(cfs) = CIA$$

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness	Runoff Coefficient, C: 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Sub-basin A	0.95	B	14.4	0.09	0.10	0.17	0.34	0.41	0.49	0.59
				0.26	0.32	0.38	0.44	0.48	0.51	
Sub-basin B	1.20	B	9.3	0.05	0.07	0.13	0.31	0.38	0.47	0.57
				0.26	0.32	0.38	0.44	0.48	0.51	
Sub-basin C	0.15	B	49.8	0.37	0.40	0.46	0.56	0.61	0.66	0.72
				0.26	0.32	0.38	0.44	0.48	0.51	
Sub-basin D	0.07	B	63.4	0.49	0.52	0.57	0.65	0.68	0.72	0.77
				0.26	0.32	0.38	0.44	0.48	0.51	
Sub-basin E	0.13	B	57.3	0.44	0.47	0.52	0.61	0.65	0.69	0.75
				0.26	0.32	0.38	0.44	0.48	0.51	
Sub-basin F	0.08	B	55.5	0.42	0.45	0.50	0.60	0.64	0.68	0.74
				0.26	0.32	0.38	0.44	0.48	0.51	
Sub-basin G	0.08	B	59.8	0.46	0.49	0.54	0.62	0.66	0.70	0.75
				0.26	0.32	0.38	0.44	0.48	0.51	
Sub-basin H	0.08	B	48.7	0.36	0.39	0.45	0.55	0.60	0.65	0.71
				0.26	0.32	0.38	0.44	0.48	0.51	
Sub-basin I	0.55	B	25.8	0.17	0.20	0.27	0.41	0.47	0.55	0.63
				0.26	0.32	0.38	0.44	0.48	0.51	
Sub-basin J	0.15	B	48.9	0.36	0.39	0.45	0.56	0.60	0.65	0.72
				0.26	0.32	0.38	0.44	0.48	0.51	
Sub-basin K	25.85	B	1.9	0.01	0.01	0.07	0.26	0.34	0.43	0.54
				0.02	0.08	0.15	0.25	0.30	0.35	0.50
Sub-basin L	1.61	B	0.0	0.00	0.00	0.06	0.25	0.33	0.43	0.54
				0.26	0.08	0.15	0.25	0.30	0.35	

Subcatchment Name	Overland (Initial) Flow Time: Overland Flow Length L_i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)	Channelized (Travel) Flow Time: Channelized Flow Length L_t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)
Sub-basin A	300.00			0.125	13.55	330.60			0.235	7	3.39	1.62
					10.61							
Sub-basin B	250.20			0.225	10.58	395.60			0.130	7	2.52	2.62
					7.97							
Sub-basin C	66.00			0.176	3.98	271.00			0.150	7	2.71	1.67
					4.44							
Sub-basin D	81.15			0.195	3.53	153.66			0.161	7	2.81	0.91
					4.76							
Sub-basin E	76.40			0.184	3.82	260.00			0.185	7	3.01	1.44
					4.71							
Sub-basin F	40.00			0.147	3.05	200.00			0.150	7	2.71	1.23
					3.67							
Sub-basin G	83.75			0.124	4.39	110.00			0.138	7	2.60	0.71
					5.62							
Sub-basin H	41.70			0.119	3.65	145.60			0.108	7	2.30	1.05
					4.02							
Sub-basin I	81.00			0.080	7.40	411.00			0.093	7	2.13	3.21
					6.38							
Sub-basin J	68.25			0.167	4.16	227.60			0.093	7	2.13	1.78
					4.59							
Sub-basin K	300.00			0.163	13.55	1933.40			0.149	7	2.70	11.93
					12.70							
Sub-basin L	300.00			0.117	15.28	520.74			0.200	7	3.13	2.77
					14.17							

Subcatchment Name	Time of Concentration: Computed t_c (min)	Regional t_c (min)	Selected t_c (min)	Rainfall Intensity, I (in/hr): 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Sub-basin A	15.17	24.58	15.17	1.73	2.21	2.66	3.36	3.95	4.61	6.32
	12.24									
Sub-basin B	13.20	26.19	13.20	1.84	2.36	2.84	3.59	4.21	4.91	6.74
	10.59									
Sub-basin C	5.64	18.27	5.64	2.51	3.21	3.87	4.89	5.74	6.69	9.19
	6.11									
Sub-basin D	4.44	15.57	5.00	2.59	3.32	4.00	5.05	5.94	6.92	9.50
	5.67									
Sub-basin E	5.26	16.85	5.26	2.56	3.28	3.95	4.99	5.86	6.83	9.37
	6.15									
Sub-basin F	4.28	17.08	5.00	2.59	3.32	4.00	5.05	5.94	6.92	9.50
	4.90									
Sub-basin G	5.10	16.11	5.10	2.58	3.30	3.98	5.03	5.91	6.88	9.45
	6.32									
Sub-basin H	4.71	18.19	5.00	2.59	3.32	4.00	5.05	5.94	6.92	9.50
	5.08									
Sub-basin I	10.60	23.40	10.60	2.02	2.59	3.12	3.94	4.63	5.39	7.40
	9.59									
Sub-basin J	5.94	18.47	5.94	2.47	3.17	3.82	4.82	5.66	6.60	9.06
	6.37									
Sub-basin K	25.48	34.68	25.48	1.32	1.69	2.03	2.57	3.02	3.52	4.83
	24.62									
Sub-basin L	18.05	28.16	18.05	1.58	2.03	2.45	3.09	3.63	4.23	5.81
	16.94									

Subcatchment Name	Peak Flow, Q (cfs): 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Sub-basin A	0.14	0.22	0.44	1.09	1.53	2.16	3.54
	0.43	0.67	0.96	1.41	1.80	2.23	
Sub-basin B	0.12	0.18	0.45	1.32	1.92	2.77	4.61
	0.57	0.91	1.30	1.89	2.43	3.01	
Sub-basin C	0.14	0.20	0.27	0.42	0.54	0.68	1.02
	0.10	0.16	0.23	0.33	0.42	0.53	
Sub-basin D	0.09	0.12	0.15	0.22	0.28	0.34	0.50
	0.05	0.07	0.10	0.15	0.19	0.24	
Sub-basin E	0.14	0.20	0.27	0.39	0.49	0.61	0.91
	0.09	0.14	0.20	0.29	0.37	0.45	
Sub-basin F	0.09	0.13	0.17	0.25	0.32	0.40	0.59
	0.06	0.09	0.13	0.19	0.24	0.30	
Sub-basin G	0.09	0.13	0.17	0.25	0.31	0.39	0.57
	0.05	0.08	0.12	0.18	0.23	0.28	
Sub-basin H	0.07	0.10	0.14	0.22	0.28	0.36	0.54
	0.05	0.09	0.12	0.18	0.23	0.28	
Sub-basin I	0.19	0.28	0.45	0.89	1.20	1.62	2.57
	0.29	0.46	0.65	0.95	1.22	1.51	
Sub-basin J	0.13	0.19	0.26	0.40	0.51	0.65	0.97
	0.10	0.15	0.22	0.32	0.41	0.50	
Sub-basin K	0.28	0.51	3.81	17.34	26.42	39.54	67.77
	0.68	3.49	7.89	16.60	23.40	31.82	62.40
Sub-basin L	0.00	0.00	0.22	1.24	1.92	2.90	5.01
	0.66	0.26	0.59	1.24	1.75	2.38	

Channel Analysis: Subbasin A Channel LT South Before P-2, 2:1, 100 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.2350 ft/ft

Manning's n: 0.0400

Flow: 2.2300 cfs

Result Parameters

Depth: 0.4308 ft

Area of Flow: 0.3712 ft^2

Wetted Perimeter: 1.9267 ft

Hydraulic Radius: 0.1927 ft

Average Velocity: 6.0075 ft/s

Top Width: 1.7233 ft

Froude Number: 2.2811

Critical Depth: 0.5992 ft

Critical Velocity: 3.1059 ft/s

Critical Slope: 0.0405 ft/ft

Critical Top Width: 2.40 ft

Calculated Max Shear Stress: 6.3175 lb/ft^2

Calculated Avg Shear Stress: 2.8253 lb/ft^2

Channel Analysis: Subbasin A Channel LT South Before P-2, 2:1, 5 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.2350 ft/ft

Manning's n: 0.0400

Flow: 0.6700 cfs

Result Parameters

Depth: 0.2744 ft

Area of Flow: 0.1506 ft^2

Wetted Perimeter: 1.2273 ft

Hydraulic Radius: 0.1227 ft

Average Velocity: 4.4477 ft/s

Top Width: 1.0978 ft

Froude Number: 2.1159

Critical Depth: 0.3704 ft

Critical Velocity: 2.4420 ft/s

Critical Slope: 0.0475 ft/ft

Critical Top Width: 1.48 ft

Calculated Max Shear Stress: 4.0244 lb/ft^2

Calculated Avg Shear Stress: 1.7998 lb/ft^2

Hydraulic Analysis Report

Project Data

Project Title: Glen Aspen Dam

Designer: Dominic Russo

Project Date: Thursday, February 12, 2026

Project Units: U.S. Customary Units

Notes:

Channel Analysis: Subbasin B, 12+00 RT Ditch 100 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.1300 ft/ft

Manning's n: 0.0400

Flow: 3.0100 cfs

Result Parameters

Depth: 0.5387 ft

Area of Flow: 0.5804 ft^2

Wetted Perimeter: 2.4091 ft

Hydraulic Radius: 0.2409 ft

Average Velocity: 5.1861 ft/s

Top Width: 2.1548 ft

Froude Number: 1.7610

Critical Depth: 0.6755 ft

Critical Velocity: 3.2979 ft/s

Critical Slope: 0.0389 ft/ft

Critical Top Width: 2.70 ft

Calculated Max Shear Stress: 4.3699 lb/ft^2

Calculated Avg Shear Stress: 1.9543 lb/ft^2

Channel Analysis: Subbasin B, 12+00 RT Ditch 5 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.1300 ft/ft

Manning's n: 0.0400

Flow: 0.9100 cfs

Result Parameters

Depth: 0.3440 ft

Area of Flow: 0.2366 ft^2

Wetted Perimeter: 1.5383 ft

Hydraulic Radius: 0.1538 ft

Average Velocity: 3.8455 ft/s

Top Width: 1.3759 ft

Froude Number: 1.6341

Critical Depth: 0.4186 ft

Critical Velocity: 2.5962 ft/s

Critical Slope: 0.0456 ft/ft

Critical Top Width: 1.67 ft

Calculated Max Shear Stress: 2.7903 lb/ft^2

Calculated Avg Shear Stress: 1.2479 lb/ft^2

Channel Analysis: Subbasin C, 11+00 LT Ditch 100 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.1500 ft/ft

Manning's n: 0.0400

Flow: 0.5300 cfs

Result Parameters

Depth: 0.2734 ft

Area of Flow: 0.1495 ft^2

Wetted Perimeter: 1.2228 ft

Hydraulic Radius: 0.1223 ft

Average Velocity: 3.5446 ft/s

Top Width: 1.0937 ft

Froude Number: 1.6894

Critical Depth: 0.3372 ft

Critical Velocity: 2.3301 ft/s

Critical Slope: 0.0490 ft/ft

Critical Top Width: 1.35 ft

Calculated Max Shear Stress: 2.5592 lb/ft^2

Calculated Avg Shear Stress: 1.1445 lb/ft^2

Channel Analysis: Subbasin C, 11+00 LT Ditch 5 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.1500 ft/ft

Manning's n: 0.0400

Flow: 0.1600 cfs

Result Parameters

Depth: 0.1745 ft

Area of Flow: 0.0609 ft^2

Wetted Perimeter: 0.7804 ft

Hydraulic Radius: 0.0780 ft

Average Velocity: 2.6274 ft/s

Top Width: 0.6980 ft

Froude Number: 1.5676

Critical Depth: 0.2089 ft

Critical Velocity: 1.8338 ft/s

Critical Slope: 0.0575 ft/ft

Critical Top Width: 0.84 ft

Calculated Max Shear Stress: 1.6333 lb/ft^2

Calculated Avg Shear Stress: 0.7304 lb/ft^2

Channel Analysis: Subbasin D, 22+00 RT Ditch 100 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.1610 ft/ft

Manning's n: 0.0400

Flow: 0.2400 cfs

Result Parameters

Depth: 0.2005 ft

Area of Flow: 0.0804 ft^2

Wetted Perimeter: 0.8965 ft

Hydraulic Radius: 0.0897 ft

Average Velocity: 2.9859 ft/s

Top Width: 0.8019 ft

Froude Number: 1.6620

Critical Depth: 0.2456 ft

Critical Velocity: 1.9887 ft/s

Critical Slope: 0.0545 ft/ft

Critical Top Width: 0.98 ft

Calculated Max Shear Stress: 2.0140 lb/ft^2

Calculated Avg Shear Stress: 0.9007 lb/ft^2

Channel Analysis: Subbasin D, 22+00 RT Ditch 5 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.1610 ft/ft

Manning's n: 0.0400

Flow: 0.0700 cfs

Result Parameters

Depth: 0.1263 ft

Area of Flow: 0.0319 ft^2

Wetted Perimeter: 0.5648 ft

Hydraulic Radius: 0.0565 ft

Average Velocity: 2.1943 ft/s

Top Width: 0.5052 ft

Froude Number: 1.5389

Critical Depth: 0.1501 ft

Critical Velocity: 1.5543 ft/s

Critical Slope: 0.0642 ft/ft

Critical Top Width: 0.60 ft

Calculated Max Shear Stress: 1.2688 lb/ft^2

Calculated Avg Shear Stress: 0.5674 lb/ft^2

Channel Analysis: Subbasin E, 22+00 LT Ditch 100 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.1850 ft/ft

Manning's n: 0.0400

Flow: 0.4500 cfs

Result Parameters

Depth: 0.2472 ft

Area of Flow: 0.1223 ft^2

Wetted Perimeter: 1.1057 ft

Hydraulic Radius: 0.1106 ft

Average Velocity: 3.6810 ft/s

Top Width: 0.9889 ft

Froude Number: 1.8450

Critical Depth: 0.3159 ft

Critical Velocity: 2.2551 ft/s

Critical Slope: 0.0501 ft/ft

Critical Top Width: 1.26 ft

Calculated Max Shear Stress: 2.8541 lb/ft^2

Calculated Avg Shear Stress: 1.2764 lb/ft^2

Channel Analysis: Subbasin E, 22+00 LT Ditch 5 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.1850 ft/ft

Manning's n: 0.0400

Flow: 0.1400 cfs

Result Parameters

Depth: 0.1596 ft

Area of Flow: 0.0509 ft^2

Wetted Perimeter: 0.7136 ft

Hydraulic Radius: 0.0714 ft

Average Velocity: 2.7491 ft/s

Top Width: 0.6383 ft

Froude Number: 1.7151

Critical Depth: 0.1980 ft

Critical Velocity: 1.7855 ft/s

Critical Slope: 0.0585 ft/ft

Critical Top Width: 0.79 ft

Calculated Max Shear Stress: 1.8421 lb/ft^2

Calculated Avg Shear Stress: 0.8238 lb/ft^2

Channel Analysis: Subbasin F, 26+00 LT Ditch 100 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 3.0000 ft/ft

Side Slope 2 (Z2): 10.0000 ft/ft

Longitudinal Slope: 0.1500 ft/ft

Manning's n: 0.0400

Flow: 0.3000 cfs

Result Parameters

Depth: 0.1386 ft

Area of Flow: 0.1249 ft^2

Wetted Perimeter: 1.8315 ft

Hydraulic Radius: 0.0682 ft

Average Velocity: 2.4017 ft/s

Top Width: 1.8021 ft

Froude Number: 1.6077

Critical Depth: 0.1795 ft

Critical Velocity: 1.4325 ft/s

Critical Slope: 0.0378 ft/ft

Critical Top Width: 3.29 ft

Calculated Max Shear Stress: 1.2975 lb/ft^2

Calculated Avg Shear Stress: 0.6383 lb/ft^2

Channel Analysis: Subbasin F, 26+00 LT Ditch 5 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 3.0000 ft/ft

Side Slope 2 (Z2): 10.0000 ft/ft

Longitudinal Slope: 0.1500 ft/ft

Manning's n: 0.0400

Flow: 0.0900 cfs

Result Parameters

Depth: 0.0883 ft

Area of Flow: 0.0506 ft^2

Wetted Perimeter: 1.1661 ft

Hydraulic Radius: 0.0434 ft

Average Velocity: 1.7775 ft/s

Top Width: 1.1474 ft

Froude Number: 1.4911

Critical Depth: 0.1109 ft

Critical Velocity: 1.1259 ft/s

Critical Slope: 0.0444 ft/ft

Critical Top Width: 2.03 ft

Calculated Max Shear Stress: 0.8261 lb/ft^2

Calculated Avg Shear Stress: 0.4064 lb/ft^2

Channel Analysis: Subbasin G, 30+00 LT Ditch 100 Year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.1380 ft/ft

Manning's n: 0.0400

Flow: 0.2800 cfs

Result Parameters

Depth: 0.2186 ft

Area of Flow: 0.0956 ft^2

Wetted Perimeter: 0.9777 ft

Hydraulic Radius: 0.0978 ft

Average Velocity: 2.9290 ft/s

Top Width: 0.8745 ft

Froude Number: 1.5612

Critical Depth: 0.2613 ft

Critical Velocity: 2.0510 ft/s

Critical Slope: 0.0534 ft/ft

Critical Top Width: 1.05 ft

Calculated Max Shear Stress: 1.8827 lb/ft^2

Calculated Avg Shear Stress: 0.8419 lb/ft^2

Channel Analysis: Subbasin G, 30+00 LT Ditch 5 Year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.1380 ft/ft

Manning's n: 0.0400

Flow: 0.0800 cfs

Result Parameters

Depth: 0.1367 ft

Area of Flow: 0.0374 ft^2

Wetted Perimeter: 0.6112 ft

Hydraulic Radius: 0.0611 ft

Average Velocity: 2.1414 ft/s

Top Width: 0.5467 ft

Froude Number: 1.4436

Critical Depth: 0.1583 ft

Critical Velocity: 1.5964 ft/s

Critical Slope: 0.0631 ft/ft

Critical Top Width: 0.63 ft

Calculated Max Shear Stress: 1.1769 lb/ft^2

Calculated Avg Shear Stress: 0.5263 lb/ft^2

Channel Analysis: Subbasin H, 33+00 RT Ditch 100 Year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 8.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.1080 ft/ft

Manning's n: 0.0400

Flow: 0.2800 cfs

Result Parameters

Depth: 0.1531 ft

Area of Flow: 0.1289 ft^2

Wetted Perimeter: 1.7186 ft

Hydraulic Radius: 0.0750 ft

Average Velocity: 2.1717 ft/s

Top Width: 1.6842 ft

Froude Number: 1.3832

Critical Depth: 0.1826 ft

Critical Velocity: 1.5272 ft/s

Critical Slope: 0.0422 ft/ft

Critical Top Width: 2.53 ft

Calculated Max Shear Stress: 1.0318 lb/ft^2

Calculated Avg Shear Stress: 0.5056 lb/ft^2

Channel Analysis: Subbasin H, 33+00 RT Ditch 5 Year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 8.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.1080 ft/ft

Manning's n: 0.0400

Flow: 0.0900 cfs

Result Parameters

Depth: 0.1000 ft

Area of Flow: 0.0550 ft^2

Wetted Perimeter: 1.1229 ft

Hydraulic Radius: 0.0490 ft

Average Velocity: 1.6352 ft/s

Top Width: 1.1004 ft

Froude Number: 1.2885

Critical Depth: 0.1160 ft

Critical Velocity: 1.2170 ft/s

Critical Slope: 0.0491 ft/ft

Critical Top Width: 1.61 ft

Calculated Max Shear Stress: 0.6742 lb/ft^2

Calculated Avg Shear Stress: 0.3303 lb/ft^2

Channel Analysis: Subbasin I, LT Ditch Near Turnaround 100 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 1.0000 ft/ft

Longitudinal Slope: 0.0930 ft/ft

Manning's n: 0.0400

Flow: 1.5100 cfs

Result Parameters

Depth: 0.5039 ft

Area of Flow: 0.3808 ft^2

Wetted Perimeter: 1.8393 ft

Hydraulic Radius: 0.2071 ft

Average Velocity: 3.9651 ft/s

Top Width: 1.5116 ft

Froude Number: 1.3921

Critical Depth: 0.5889 ft

Critical Velocity: 2.9030 ft/s

Critical Slope: 0.0405 ft/ft

Critical Top Width: 1.99 ft

Calculated Max Shear Stress: 2.9240 lb/ft^2

Calculated Avg Shear Stress: 1.2016 lb/ft^2

Channel Analysis: Subbasin I, LT Ditch Near Turnaround 5 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 1.0000 ft/ft

Longitudinal Slope: 0.0930 ft/ft

Manning's n: 0.0400

Flow: 0.4600 cfs

Result Parameters

Depth: 0.3227 ft

Area of Flow: 0.1562 ft^2

Wetted Perimeter: 1.1778 ft

Hydraulic Radius: 0.1326 ft

Average Velocity: 2.9458 ft/s

Top Width: 0.9680 ft

Froude Number: 1.2925

Critical Depth: 0.3660 ft

Critical Velocity: 2.2888 ft/s

Critical Slope: 0.0474 ft/ft

Critical Top Width: 1.24 ft

Calculated Max Shear Stress: 1.8724 lb/ft^2

Calculated Avg Shear Stress: 0.7694 lb/ft^2

Channel Analysis: Subbasin J, EOP RT South Ditch 100 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 1.0000 ft/ft

Longitudinal Slope: 0.0930 ft/ft

Manning's n: 0.0400

Flow: 0.5000 cfs

Result Parameters

Depth: 0.3329 ft

Area of Flow: 0.1662 ft^2

Wetted Perimeter: 1.2152 ft

Hydraulic Radius: 0.1368 ft

Average Velocity: 3.0078 ft/s

Top Width: 0.9987 ft

Froude Number: 1.2992

Critical Depth: 0.3785 ft

Critical Velocity: 2.3273 ft/s

Critical Slope: 0.0469 ft/ft

Critical Top Width: 1.28 ft

Calculated Max Shear Stress: 1.9319 lb/ft^2

Calculated Avg Shear Stress: 0.7939 lb/ft^2

Channel Analysis: Subbasin J, EOP RT South Ditch 5 year

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 1.0000 ft/ft

Longitudinal Slope: 0.0930 ft/ft

Manning's n: 0.0400

Flow: 0.1500 cfs

Result Parameters

Depth: 0.2120 ft

Area of Flow: 0.0674 ft^2

Wetted Perimeter: 0.7737 ft

Hydraulic Radius: 0.0871 ft

Average Velocity: 2.2260 ft/s

Top Width: 0.6359 ft

Froude Number: 1.2050

Critical Depth: 0.2338 ft

Critical Velocity: 1.8292 ft/s

Critical Slope: 0.0551 ft/ft

Critical Top Width: 0.79 ft

Calculated Max Shear Stress: 1.2300 lb/ft^2

Calculated Avg Shear Stress: 0.5054 lb/ft^2

Hydraulic Analysis Report

Project Data

Project Title: Glen Aspen Dam

Designer: Dominic Russo

Project Date: Tuesday, December 9, 2025

Project Units: U.S. Customary Units

Notes:

Channel Analysis: Subbasin K, RT P-2 Inlet 100 year

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.1490 ft/ft

Manning's n: 0.0400

Flow: 31.8000 cfs

Result Parameters

Depth: 0.6295 ft

Area of Flow: 3.7067 ft^2

Wetted Perimeter: 8.0030 ft

Hydraulic Radius: 0.4632 ft

Average Velocity: 8.5791 ft/s

Top Width: 7.7769 ft

Froude Number: 2.1899

Critical Depth: 0.9762 ft

Critical Velocity: 4.7016 ft/s

Critical Slope: 0.0277 ft/ft

Critical Top Width: 9.86 ft

Calculated Max Shear Stress: 5.8527 lb/ft^2

Calculated Avg Shear Stress: 4.3063 lb/ft^2

Channel Analysis: Subbasin K, RT P-2 Inlet 5 year

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.1490 ft/ft

Manning's n: 0.0400

Flow: 3.4900 cfs

Result Parameters

Depth: 0.1815 ft

Area of Flow: 0.8250 ft^2

Wetted Perimeter: 5.1544 ft

Hydraulic Radius: 0.1601 ft

Average Velocity: 4.2304 ft/s

Top Width: 5.0892 ft

Froude Number: 1.8517

Critical Depth: 0.2676 ft

Critical Velocity: 2.7160 ft/s

Critical Slope: 0.0390 ft/ft

Critical Top Width: 5.61 ft

Calculated Max Shear Stress: 1.6878 lb/ft^2

Calculated Avg Shear Stress: 1.4881 lb/ft^2

Channel Analysis: Subbasin L, 5 Year

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 6.0000 ft/ft

Side Slope 2 (Z2): 5.0000 ft/ft

Channel Width 24.80 ft

Longitudinal Slope: 0.1540 ft/ft

Manning's n: 0.0400

Flow 4.4200 cfs

Result Parameters

Depth 0.0710 ft

Area of Flow 1.7874 ft^2

Wetted Perimeter 25.5934 ft

Hydraulic Radius 0.0698 ft

Average Velocity 2.4729 ft/s

Top Width 25.5805 ft

Froude Number: 1.6486

Critical Depth 0.0988 ft

Critical Velocity 1.7649 ft/s

Critical Slope: 0.0509 ft/ft

Critical Top Width 25.89 ft

Calculated Max Shear Stress 0.6819 lb/ft^2

Calculated Avg Shear Stress 0.6711 lb/ft^2

Channel Analysis: Subbasin L, 100 Year

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 6.0000 ft/ft

Side Slope 2 (Z2): 5.0000 ft/ft

Channel Width 24.80 ft

Longitudinal Slope: 0.1540 ft/ft

Manning's n: 0.0400

Flow 36.4000 cfs

Result Parameters

Depth 0.2494 ft

Area of Flow 6.5277 ft^2

Wetted Perimeter 27.5889 ft

Hydraulic Radius 0.2366 ft

Average Velocity 5.5763 ft/s

Top Width 27.5436 ft

Froude Number: 2.0186

Critical Depth 0.3939 ft

Critical Velocity 3.4266 ft/s

Critical Slope: 0.0328 ft/ft

Critical Top Width 29.13 ft

Calculated Max Shear Stress 2.3968 lb/ft^2

Calculated Avg Shear Stress 2.2737 lb/ft^2

Channel Analysis: Subbasin M, P-1 Inlet 5 year

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 3.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Channel Width 25.00 ft

Longitudinal Slope: 0.0700 ft/ft

Manning's n: 0.0500

Flow 14.9000 cfs

Result Parameters

Depth 0.2118 ft

Area of Flow 5.4286 ft^2

Wetted Perimeter 26.3393 ft

Hydraulic Radius 0.2061 ft

Average Velocity 2.7447 ft/s

Top Width 26.2706 ft

Froude Number: 1.0640

Critical Depth 0.2206 ft

Critical Velocity 2.6317 ft/s

Critical Slope: 0.0611 ft/ft

Critical Top Width 26.32 ft

Calculated Max Shear Stress 0.9250 lb/ft^2

Calculated Avg Shear Stress 0.9003 lb/ft^2

Channel Analysis: Subbasin M, P-1 Inlet 100 year

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 3.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Channel Width 25.00 ft

Longitudinal Slope: 0.0700 ft/ft

Manning's n: 0.0500

Flow 63.5000 cfs

Result Parameters

Depth 0.5022 ft

Area of Flow 13.3130 ft^2

Wetted Perimeter 28.1765 ft

Hydraulic Radius 0.4725 ft

Average Velocity 4.7698 ft/s

Top Width 28.0135 ft

Froude Number: 1.2193

Critical Depth 0.5716 ft

Critical Velocity 4.1586 ft/s

Critical Slope: 0.0452 ft/ft

Critical Top Width 28.43 ft

Calculated Max Shear Stress 2.1938 lb/ft^2

Calculated Avg Shear Stress 2.0638 lb/ft^2

HY-8 Culvert Analysis Report

Table 1 - Project Headwater Table

Crossing Name	Culvert Name	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	HW / D (ft)	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Outlet Velocity (ft/s)
Subbasin M, Primary Access Crossing 5-year	Subbasin M, Primary Access Culvert 5-year	14.90	14.90	8845.52	1.66	0.0*	0.55	0.67	1.23	0.72	11.37
Subbasin M, Primary Access Crossing 100-year	Subbasin M, Primary Access Culvert 100-year	63.50	63.50	8848.41	4.55	2.563	1.52	1.43	2.56	1.70	15.31
Subbasin K, Culvert P-2 5-year	Subbasin K, Primary Access Culvert 5-year	3.49	3.49	8911.12	0.86	0.0*	0.43	0.36	0.65	0.36	9.12
Subbasin K, Culvert P-2 100-year	Subbasin K, Primary Access Culvert 100-year	31.80	31.80	8914.85	4.59	1.344	2.30	1.16	1.89	1.23	15.62

* Full Flow Headwater elevation is below inlet invert.

Crossing Input: Subbasin M, Primary Access Crossing 5-year

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	1.000	cfs
Design Flow	14.900	cfs
Maximum Flow	14.900	cfs
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	10.000	ft
Side Slope (H:V)	8.000	_:1
Channel Slope	0.0500	ft/ft
Manning's n (channel)	0.050	
Channel Invert Elevation	8841.669	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	100.000	ft
Crest Elevation	8850.191	ft
Roadway Surface	Gravel	
Top Width	24.000	ft

Culvert Input: Subbasin M, Primary Access Crossing 5-year

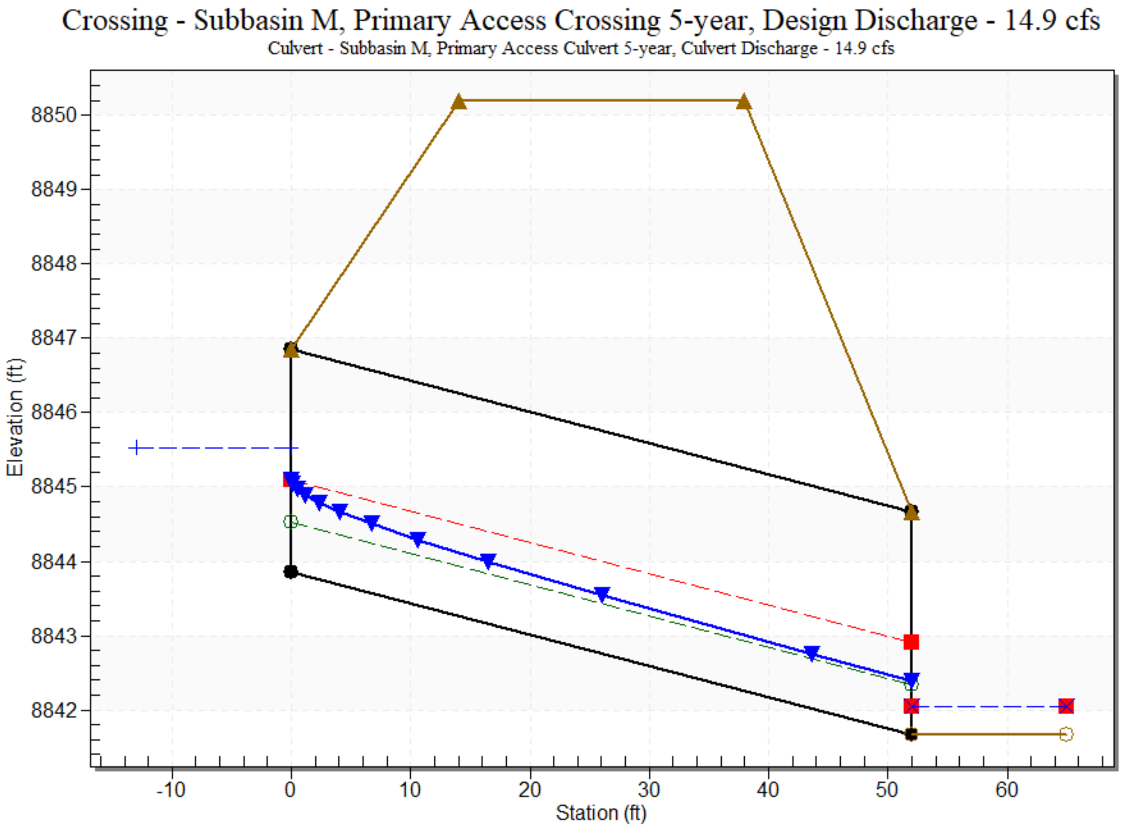
Parameter	Value	Units
CULVERT DATA		
Name	Subbasin M, Primary Access Culvert 5-year	
Shape	Circular	
Material	Concrete	
Diameter	3.000	ft
Embedment Depth	0.000	in
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Grooved End Projecting (Ke=0.2)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	8843.859	ft
Outlet Station	52.000	ft
Outlet Elevation	8841.669	ft
Number of Barrels	1	
Computed Culvert Slope	0.042115	ft/ft

Table 2 - Culvert Summary Table: Subbasin M, Primary Access Culvert 5-year

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	HW / D (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1.00	1.00	8844.26	0.40	0.0*	0.13	1-S2n	0.18	0.31	0.18	0.08	5.77	1.18
2.39	2.39	8844.49	0.63	0.0*	0.21	1-S2n	0.27	0.48	0.27	0.13	7.44	1.63
3.78	3.78	8844.65	0.79	0.0*	0.26	1-S2n	0.34	0.61	0.34	0.17	8.51	1.91
5.17	5.17	8844.79	0.93	0.0*	0.31	1-S2n	0.40	0.71	0.41	0.21	9.04	2.13
6.56	6.56	8844.92	1.06	0.0*	0.35	1-S2n	0.45	0.80	0.46	0.24	9.52	2.31
7.95	7.95	8845.03	1.17	0.0*	0.39	1-S2n	0.49	0.89	0.51	0.27	10.00	2.46
9.34	9.34	8845.13	1.27	0.0*	0.42	1-S2n	0.53	0.97	0.56	0.29	10.16	2.60
10.73	10.73	8845.23	1.37	0.0*	0.46	1-S2n	0.57	1.04	0.60	0.32	10.62	2.72
12.12	12.12	8845.32	1.47	0.0*	0.49	1-S2n	0.60	1.11	0.65	0.34	10.83	2.83
13.51	13.51	8845.42	1.56	0.0*	0.52	1-S2n	0.64	1.17	0.68	0.36	11.19	2.93
14.90	14.90	8845.52	1.66	0.0*	0.55	1-S2n	0.67	1.23	0.72	0.38	11.37	3.02
83.98	82.75	8850.22	6.36	4.058	2.12	5-S2n	1.68	2.79	2.01	0.95	16.45	5.03

* Full Flow Headwater elevation is below inlet invert.

Water Surface Profile Plot for Culvert: Subbasin M, Primary Access Culvert 5-year



Crossing Input: Subbasin M, Primary Access Crossing 100-year

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	1.000	cfs
Design Flow	63.500	cfs
Maximum Flow	100.000	cfs
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	10.000	ft
Side Slope (H:V)	8.000	_:1
Channel Slope	0.0500	ft/ft
Manning's n (channel)	0.050	
Channel Invert Elevation	8841.669	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	100.000	ft
Crest Elevation	8850.191	ft
Roadway Surface	Gravel	
Top Width	24.000	ft

Culvert Input: Subbasin M, Primary Access Crossing 100-year

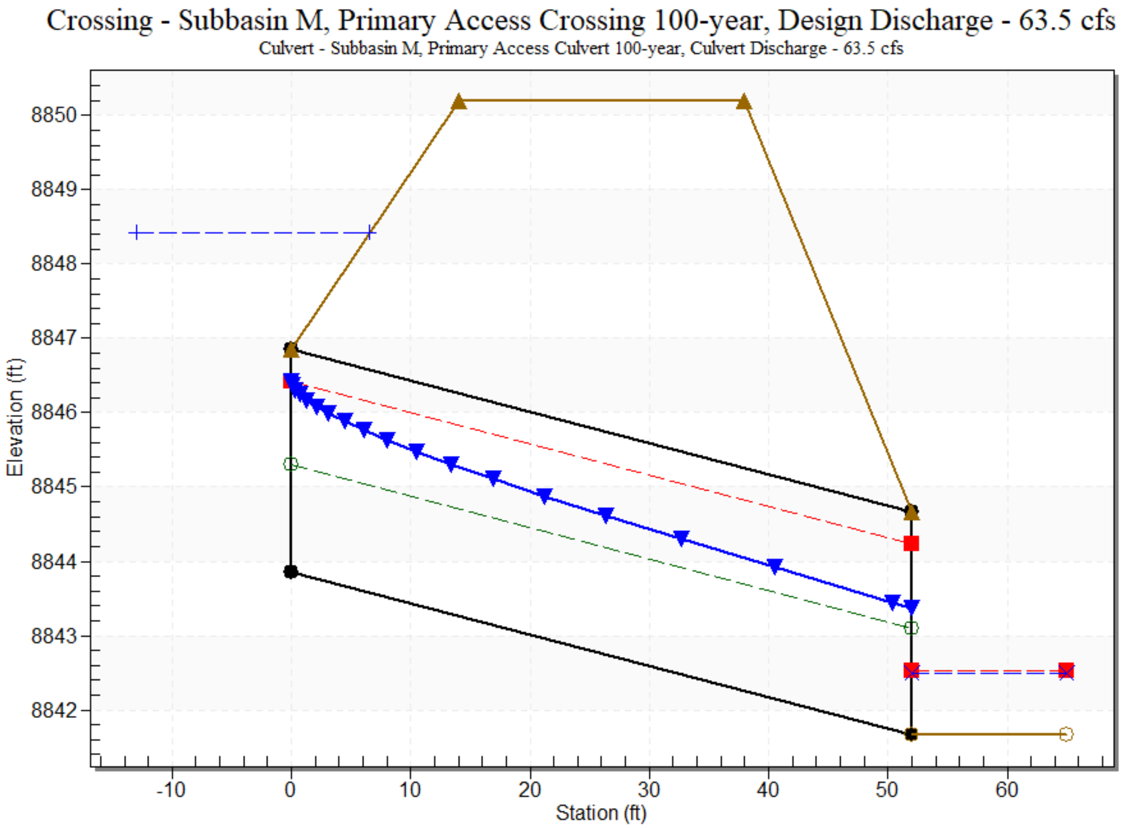
Parameter	Value	Units
CULVERT DATA		
Name	Subbasin M, Primary Access Culvert 100-year	
Shape	Circular	
Material	Concrete	
Diameter	3.000	ft
Embedment Depth	0.000	in
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Grooved End Projecting (Ke=0.2)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	8843.859	ft
Outlet Station	52.000	ft
Outlet Elevation	8841.669	ft
Number of Barrels	1	
Computed Culvert Slope	0.042115	ft/ft

Table 3 - Culvert Summary Table: Subbasin M, Primary Access Culvert 100-year

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	HW / D (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1.00	1.00	8844.26	0.40	0.0*	0.13	1-S2n	0.18	0.31	0.18	0.08	5.77	1.18
10.90	10.90	8845.24	1.38	0.0*	0.46	1-S2n	0.57	1.05	0.60	0.32	10.71	2.73
20.80	20.80	8845.89	2.03	0.0*	0.68	1-S2n	0.79	1.46	0.87	0.46	12.26	3.35
30.70	30.70	8846.41	2.55	0.067	0.85	1-S2n	0.96	1.80	1.09	0.56	13.20	3.77
40.60	40.60	8846.92	3.06	0.691	1.02	5-S2n	1.12	2.07	1.29	0.65	13.91	4.09
50.50	50.50	8847.49	3.63	1.714	1.21	5-S2n	1.26	2.31	1.48	0.73	14.54	4.36
63.50	63.50	8848.41	4.55	2.563	1.52	5-S2n	1.43	2.56	1.70	0.82	15.31	4.65
70.30	70.30	8848.99	5.13	3.059	1.71	5-S2n	1.52	2.66	1.82	0.87	15.71	4.79
80.20	80.20	8849.95	6.09	3.843	2.03	5-S2n	1.65	2.77	1.97	0.93	16.30	4.97
90.10	83.32	8850.28	6.42	4.106	2.14	5-S2n	1.69	2.80	2.02	0.98	16.48	5.13
100.00	83.95	8850.35	6.49	4.160	2.16	5-S2n	1.70	2.80	2.03	1.04	16.52	5.28
100.00	83.95	8850.35	6.49	4.160	2.16	5-S2n	1.70	2.80	2.03	1.04	16.52	5.28

* Full Flow Headwater elevation is below inlet invert.

Water Surface Profile Plot for Culvert: Subbasin M, Primary Access Culvert 100-year



Crossing Input: Subbasin K, Culvert P-2 5-year

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	0.000	cfs
Design Flow	3.490	cfs
Maximum Flow	3.490	cfs
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	8.000	ft
Side Slope (H:V)	4.000	_:1
Channel Slope	0.1500	ft/ft
Manning's n (channel)	0.050	
Channel Invert Elevation	8906.017	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	1.000	ft
Crest Length	119.000	ft
Crest Elevation	8924.618	ft
Roadway Surface	Gravel	
Top Width	24.000	ft

Culvert Input: Subbasin K, Culvert P-2 5-year

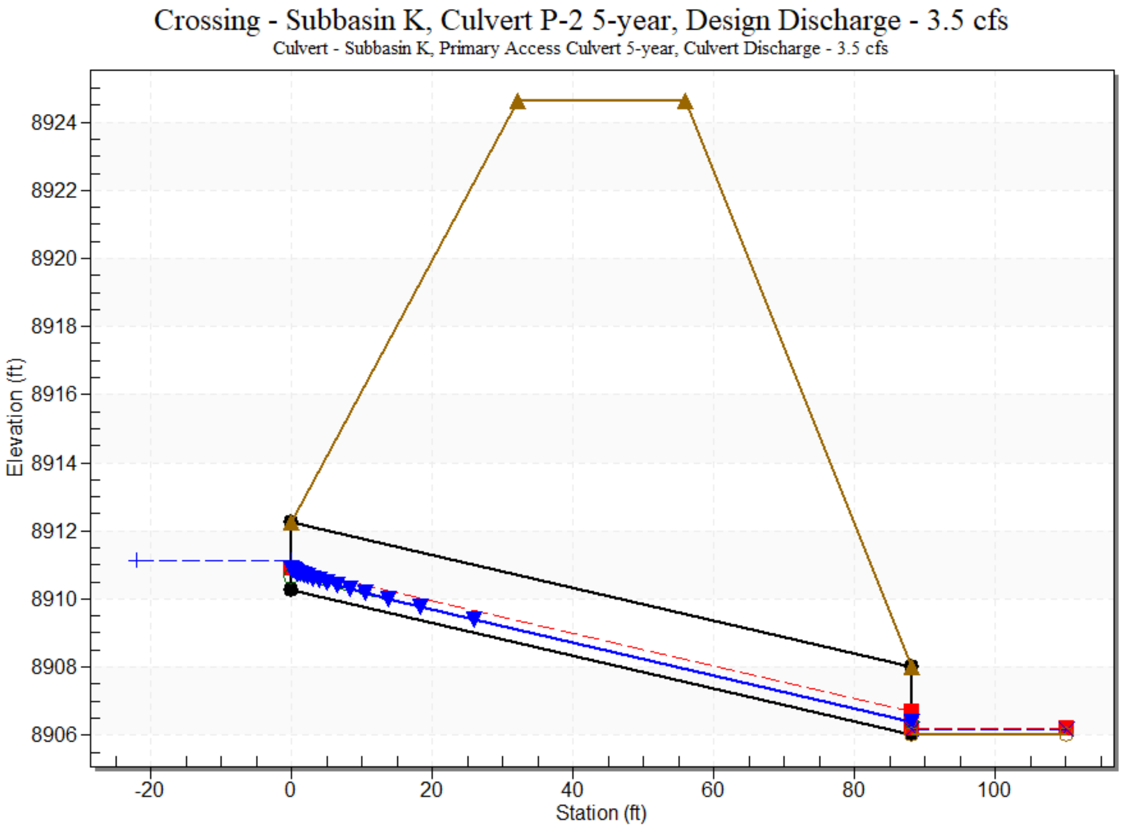
Parameter	Value	Units
CULVERT DATA		
Name	Subbasin K, Primary Access Culvert 5-year	
Shape	Circular	
Material	Concrete	
Diameter	2.000	ft
Embedment Depth	0.000	in
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Grooved End Projecting (Ke=0.2)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	8910.260	ft
Outlet Station	88.163	ft
Outlet Elevation	8906.017	ft
Number of Barrels	1	
Computed Culvert Slope	0.048127	ft/ft

Table 4 - Culvert Summary Table: Subbasin K, Primary Access Culvert 5-year

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	HW / D (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	8910.26	0.00	0.000	0.00	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
0.35	0.35	8910.52	0.26	0.0*	0.13	1-S2n	0.12	0.20	0.12	0.04	4.65	1.22
0.70	0.70	8910.63	0.37	0.0*	0.19	1-S2n	0.16	0.29	0.16	0.05	5.67	1.60
1.05	1.05	8910.72	0.46	0.0*	0.23	1-S2n	0.20	0.35	0.20	0.07	6.38	1.87
1.40	1.40	8910.79	0.53	0.0*	0.27	1-S2n	0.23	0.41	0.23	0.08	6.98	2.09
1.75	1.75	8910.86	0.60	0.0*	0.30	1-S2n	0.26	0.46	0.26	0.09	7.42	2.27
2.09	2.09	8910.92	0.66	0.0*	0.33	1-S2n	0.28	0.50	0.28	0.10	7.87	2.43
2.44	2.44	8910.97	0.71	0.0*	0.36	1-S2n	0.30	0.54	0.30	0.11	8.22	2.58
2.79	2.79	8911.02	0.76	0.0*	0.38	1-S2n	0.32	0.58	0.32	0.12	8.56	2.71
3.14	3.14	8911.07	0.81	0.0*	0.41	1-S2n	0.34	0.62	0.34	0.13	8.86	2.83
3.49	3.49	8911.12	0.86	0.0*	0.43	1-S2n	0.36	0.65	0.36	0.14	9.12	2.95
62.50	62.15	8924.63	14.37	11.673	7.18	6-FFc	2.00	2.00	2.00	0.73	19.78	7.88

* Full Flow Headwater elevation is below inlet invert.

Water Surface Profile Plot for Culvert: Subbasin K, Primary Access Culvert 5-year



Crossing Input: Subbasin K, Culvert P-2 100-year

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	0.000	cfs
Design Flow	31.800	cfs
Maximum Flow	31.800	cfs
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	8.000	ft
Side Slope (H:V)	4.000	_:1
Channel Slope	0.1500	ft/ft
Manning's n (channel)	0.050	
Channel Invert Elevation	8906.017	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	1.000	ft
Crest Length	119.000	ft
Crest Elevation	8924.618	ft
Roadway Surface	Gravel	
Top Width	24.000	ft

Culvert Input: Subbasin K, Culvert P-2 100-year

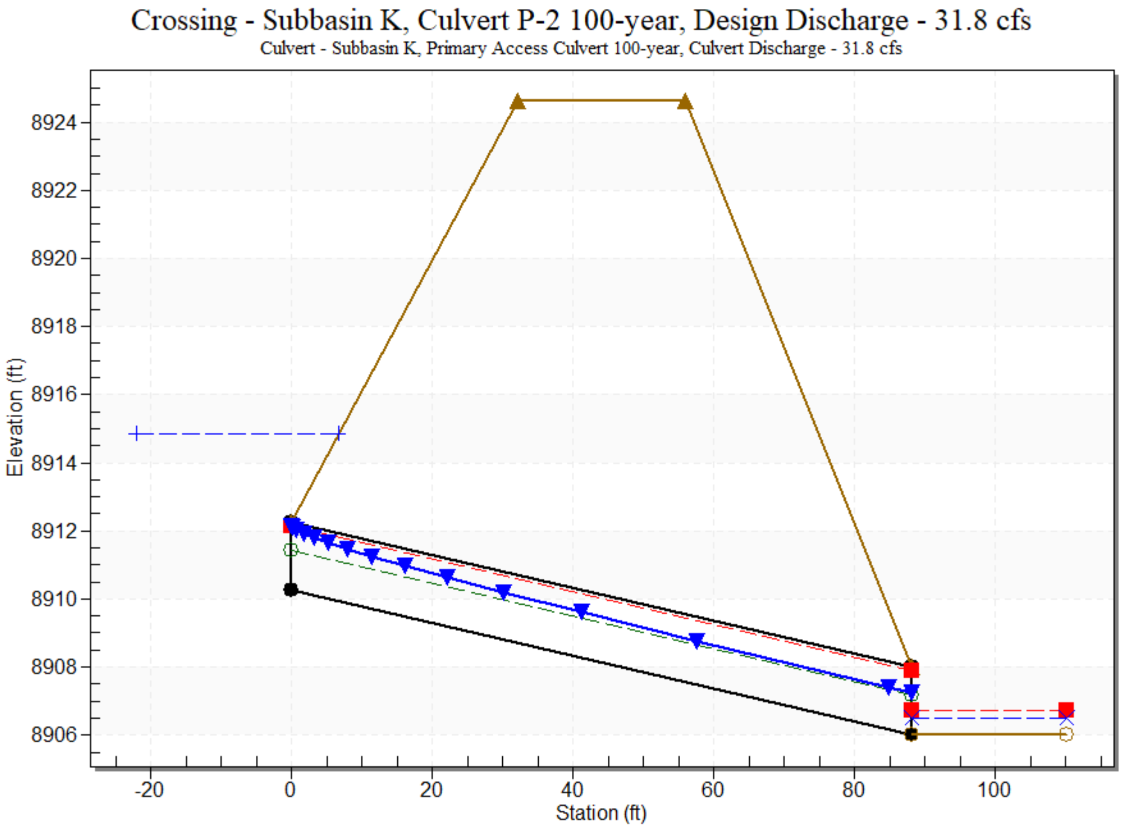
Parameter	Value	Units
CULVERT DATA		
Name	Subbasin K, Primary Access Culvert 100-year	
Shape	Circular	
Material	Concrete	
Diameter	2.000	ft
Embedment Depth	0.000	in
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Grooved End Projecting (Ke=0.2)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	8910.260	ft
Outlet Station	88.163	ft
Outlet Elevation	8906.017	ft
Number of Barrels	1	
Computed Culvert Slope	0.048127	ft/ft

Table 5 - Culvert Summary Table: Subbasin K, Primary Access Culvert 100-year

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	HW / D (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	8910.26	0.00	0.000	0.00	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
3.18	3.18	8911.08	0.82	0.0*	0.41	1-S2n	0.34	0.62	0.34	0.13	8.89	2.85
6.36	6.36	8911.48	1.22	0.0*	0.61	1-S2n	0.48	0.89	0.48	0.20	10.88	3.67
9.54	9.54	8911.81	1.55	0.0*	0.77	1-S2n	0.59	1.10	0.59	0.25	12.22	4.24
12.72	12.72	8912.10	1.84	0.0*	0.92	1-S2n	0.69	1.28	0.72	0.30	12.52	4.69
15.90	15.90	8912.41	2.15	0.0*	1.07	5-S2n	0.78	1.44	0.81	0.34	13.32	5.06
19.08	19.08	8912.76	2.50	0.0*	1.25	5-S2n	0.86	1.57	0.90	0.37	13.87	5.38
22.26	22.26	8913.18	2.92	0.0*	1.46	5-S2n	0.94	1.68	0.98	0.41	14.49	5.67
25.44	25.44	8913.66	3.40	0.0*	1.70	5-S2n	1.01	1.77	1.07	0.44	14.88	5.92
28.62	28.62	8914.22	3.96	0.628	1.98	5-S2n	1.09	1.84	1.15	0.47	15.24	6.16
31.80	31.80	8914.85	4.59	1.344	2.30	5-S2n	1.16	1.89	1.23	0.50	15.62	6.37
63.60	62.19	8924.65	14.39	11.691	7.19	6-FFc	2.00	2.00	2.00	0.73	19.79	7.92

* Full Flow Headwater elevation is below inlet invert.

Water Surface Profile Plot for Culvert: Subbasin K, Primary Access Culvert 100-year



Culvert P-1 Riprap Sizing		
Design Discharge	Q	63.5 cfs
Culvert Diameter	D	3
Adjusted Culvert Size	D'	2.215
Normal (supercritical) depth in the culvert	y	1.43
Tailwater Depth	TW	1.2
Acceleration (gravity)	g	32.2

(Fletcher and Grace, 1972) is recommended for circular culverts:

$$D_{50} = 0.2\,D\left(\frac{Q}{\sqrt{g}D^{2.5}}\right)^{4/3}\left(\frac{D}{TW}\right) \quad (10.4)$$

D50 =	1.444813 ft
	17.33775 inches

where,

- D_{50} = riprap size, m (ft)
- Q = design discharge, m^3/s (ft^3/s)
- D = culvert diameter (circular), m (ft)
- TW = tailwater depth, m (ft)
- g = acceleration due to gravity, 9.81 m/s^2 (32.2 ft/s^2)

$$D_{50} = 0.2D'\left(\frac{Q}{\sqrt{g}D'^{2.5}}\right)^{\frac{4}{3}}\left(\frac{D'}{TW}\right)$$

$$D' = \frac{D + y_n}{2}$$

Tailwater depth for Equation 10.4 should be limited to between 0.4D and 1.0D. If tailwater is unknown, use 0.4D.

Whenever the flow is supercritical in the culvert, the culvert diameter is adjusted as follows:

$$D' = \frac{D + y_n}{2} \quad (10.5)$$

where,

- D' = adjusted culvert rise, m (ft)
- y_n = normal (supercritical) depth in the culvert, m (ft)

Equation 10.4 assumes that the rock specific gravity is 2.65.

Culvert P-2 Riprap Sizing		
Design Discharge	Q	31.8 cfs
Culvert Diameter	D	2
Adjusted Culvert Size	D'	1.945
Normal (supercritical) depth in the culvert	y	1.89
Tailwater Depth	TW	0.5
Acceleration (gravity)	g	32.2

(Fletcher and Grace, 1972) is recommended for circular culverts:

$$D_{50} = 0.2\,D\left(\frac{Q}{\sqrt{g}D^{2.5}}\right)^{4/3}\left(\frac{D}{TW}\right) \qquad (10.4)$$

D50	1.639958 ft
	19.6795 inches

where,

- D_{50} = riprap size, m (ft)
- Q = design discharge, m^3/s (ft^3/s)
- D = culvert diameter (circular), m (ft)
- TW = tailwater depth, m (ft)
- g = acceleration due to gravity, 9.81 m/s^2 (32.2 ft/s^2)

$$D_{50} = 0.2D'\left(\frac{Q}{\sqrt{g}D'^{2.5}}\right)^{\frac{4}{3}}\left(\frac{D'}{TW}\right)$$

$$D' = \frac{D + y_n}{2}$$

Tailwater depth for Equation 10.4 should be limited to between 0.4D and 1.0D. If tailwater is unknown, use 0.4D.

Whenever the flow is supercritical in the culvert, the culvert diameter is adjusted as follows:

$$D' = \frac{D + y_n}{2} \qquad (10.5)$$

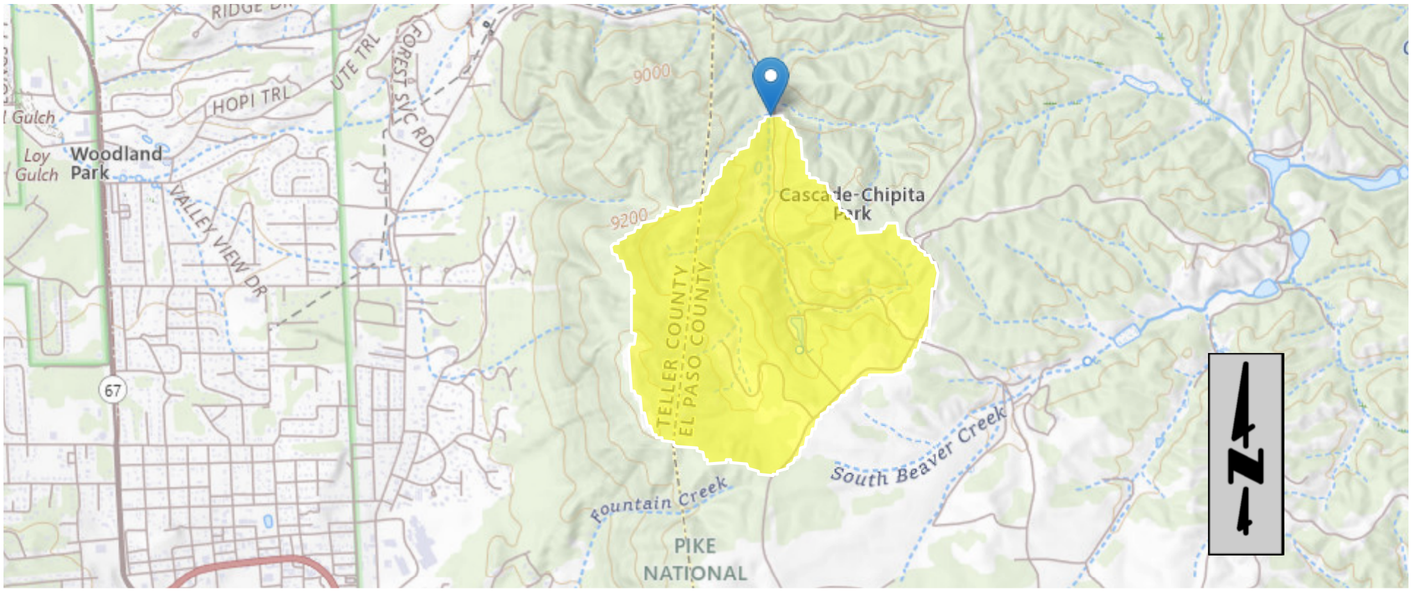
where,

- D' = adjusted culvert rise, m (ft)
- y_n = normal (supercritical) depth in the culvert, m (ft)

Equation 10.4 assumes that the rock specific gravity is 2.65.

Culvert P-1 StreamStats Report

Region ID: CO
Workspace ID: CO20250905230046251000
Clicked Point (Latitude, Longitude): 39.01469, -105.02423
Time: 2025-09-05 15:01:07 -0800



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BSLDEM10M	Mean basin slope computed from 10 m DEM	26	percent
DRNAREA	Area that drains to a point on a stream	0.69	square miles
PRECIP	Mean Annual Precipitation	24.7	inches

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Mountain Region Peak Flow]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
BSLDEM10M	Mean Basin Slope from 10m DEM	26	percent	7.6	60.2
DRNAREA	Drainage Area	0.69	square miles	1	1060
PRECIP	Mean Annual Precipitation	24.7	inches	18	47

Peak-Flow Statistics Disclaimers [Mountain Region Peak Flow]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Peak-Flow Statistics Flow Report [Mountain Region Peak Flow]

Statistic	Value	Unit
50-percent AEP flood	9.76	ft^3/s
20-percent AEP flood	14.8	ft^3/s
10-percent AEP flood	18	ft^3/s
4-percent AEP flood	23.1	ft^3/s
2-percent AEP flood	27.9	ft^3/s
1-percent AEP flood	31.4	ft^3/s
0.5-percent AEP flood	34.5	ft^3/s
0.2-percent AEP flood	41.8	ft^3/s

Peak-Flow Statistics Citations

Capesius, J.P., and Stephens, V. C.,2009, Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado: U. S. Geological Survey Scientific Investigations Report 2009-5136, 32 p. (http://pubs.usgs.gov/sir/2009/5136/)

Application Version: 4.29.2
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

APPENDIX D

FEMA FLOODMAP

105°1'50.21"W 39°1'42.05"N

104°59'56.86"W 38°59'36.38"N

FLOOD HAZARD INFORMATION

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

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE) *Zone A, V, A99* With BFE or Depth *Zone AE, AO, AH, VE, AR*
	Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
	Future Conditions 1% Annual Chance Flood Hazard *Zone X*
	Area with Reduced Flood Risk due to Levee See Notes *Zone X*
	Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN Area of Minimal Flood Hazard *Zone X*
	Effective LOMRs
	Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES	Channel, Culvert, or Storm Sewer
	Levee, Dike, or Floodwall
OTHER FEATURES	(B) 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
	(8) Coastal Transect
	Coastal Transect Baseline
	Profile Baseline
	Hydrographic Feature
	513 Base Flood Elevation Line (BFE)
	Limit of Study
	Jurisdiction Boundary

LINK> </CLR>for official maps and additional

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Basemap information shown on this FIRM was provided in digital format by USDA, Farm Service Agency (FSA). This information was derived from NAIP, dated April 11, 2018.

This map was exported from FEMA's National Flood Hazard Layer (NFHL) on **9/11/2025 11:21 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. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet at https://www.fema.gov/media-library/assets/documents/118418

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. 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.

SCALE

Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: No elevation features on this FIRM

For information about the specific vertical datum for elevation features, datum conversions, or vertical monuments used to create this map, please see the Flood Insurance Study (FIS) Report for your community at https://msc.fema.gov

N

1 inch = 500 feet 1:6,000

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

0 50 100 200 300 400 Meters

FEMA

National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

PANEL **250** OF **1275**

Panel Contains:

COMMUNITY	NUMBER	PANEL
TELLER COUNTY	080173	0250
PIKE NATIONAL FOREST	08FED	0250
EL PASO COUNTY	080059	0250

MAP NUMBER
08041C0250G
EFFECTIVE DATE
December 07, 2018

105°4'34.74"W 39°3'58.21"N

105°0'48.03"W 38°59'46.85"N

FLOOD HAZARD INFORMATION

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

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE) *Zone A, V, A99* With BFE or Depth *Zone AE, AO, AH, VE, AR*
	Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
	Future Conditions 1% Annual Chance Flood Hazard *Zone X*
	Area with Reduced Flood Risk due to Levee See Notes *Zone X*
	Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN Area of Minimal Flood Hazard *Zone X*
	Effective LOMRs
	Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES	Channel, Culvert, or Storm Sewer
	Levee, Dike, or Floodwall
OTHER FEATURES	(B) 20.2 Cross Sections with 1% Annual Chance
	17.5 Water Surface Elevation
	(8) Coastal Transect
	Coastal Transect Baseline
	Profile Baseline
	Hydrographic Feature
	513 Base Flood Elevation Line (BFE)
	Limit of Study
	Jurisdiction Boundary

LINK> </CLR>for official maps and additional

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Basemap information shown on this FIRM was provided in digital format by USDA, Farm Service Agency (FSA). This information was derived from NAIP, dated April 11, 2018.

This map was exported from FEMA's National Flood Hazard Layer (NFHL) on **9/11/2025 11:22 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. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet at https://www.fema.gov/media-library/assets/documents/118418

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. 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.

SCALE

Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: No elevation features on this FIRM
For information about the specific vertical datum for elevation features, datum conversions, or vertical monuments used to create this map, please see the Flood Insurance Study (FIS) Report for your community at https://msc.fema.gov

N

1 inch = 1,000 feet **1:12,000**

0 500 1,000 2,000 3,000 4,000 Feet

Meters 0 105 210 420 630 840

FEMA

National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

PANEL **145** OF **415**

Panel Contains:

COMMUNITY	NUMBER	PANEL
TELLER COUNTY	080173	0145
PIKE NATIONAL FOREST	08FED	0145
EL PASO COUNTY	080059	0145

MAP NUMBER
08119C0145D
EFFECTIVE DATE
September 25, 2009

APPENDIX E

NOAA ATLAS 14

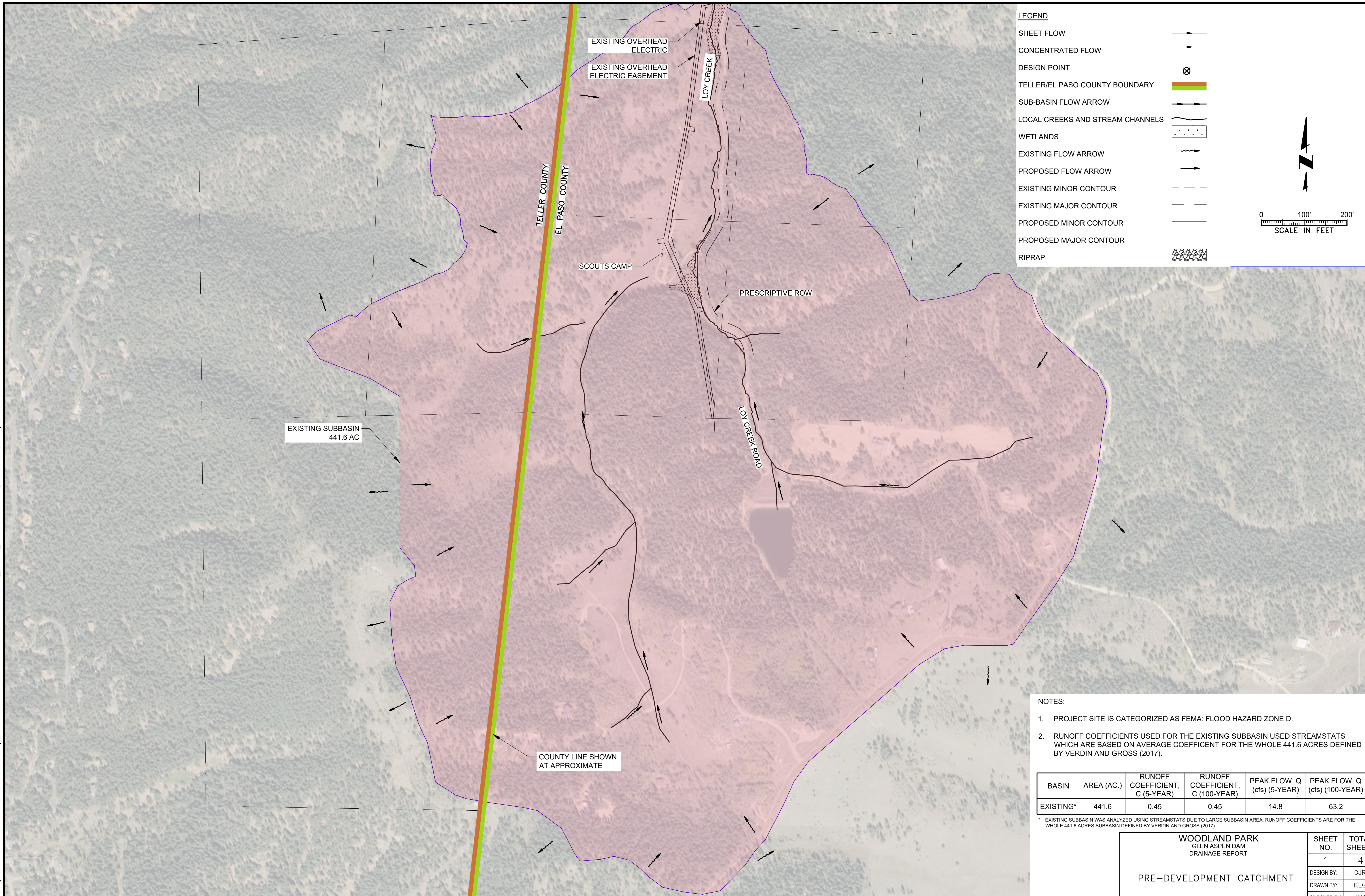
Point precipitation frequency estimates (inches)
NOAA Atlas 14 Volume 8 Version 2
Data type: Precipitation depth
Time series type: Partial duration
Project area: Midwestern States
Location na Colorado USA
Station Name: -
Latitude: 38.9946 Degree
Longitude: -105.0517 Degree
Elevation (USGS): 8455 ft

PRECIPITATION FREQUENCY ESTIMATES										
by duration	1	2	5	10	25	50	100	200	500	1000
5-min:	0.232	0.279	0.361	0.437	0.55	0.645	0.746	0.856	1.01	1.14
10-min:	0.34	0.408	0.529	0.639	0.805	0.944	1.09	1.25	1.48	1.66
15-min:	0.415	0.498	0.645	0.78	0.982	1.15	1.33	1.53	1.81	2.03
30-min:	0.526	0.632	0.82	0.99	1.25	1.46	1.69	1.94	2.29	2.57
60-min:	0.647	0.764	0.979	1.18	1.49	1.75	2.04	2.35	2.8	3.17
2-hr:	0.768	0.896	1.14	1.37	1.73	2.04	2.39	2.77	3.32	3.78
3-hr:	0.865	0.995	1.25	1.5	1.9	2.25	2.64	3.07	3.71	4.24
6-hr:	1.09	1.23	1.53	1.82	2.3	2.73	3.21	3.75	4.55	5.22
12-hr:	1.39	1.57	1.94	2.31	2.9	3.43	4.02	4.68	5.65	6.46
24-hr:	1.7	1.94	2.42	2.88	3.62	4.27	4.98	5.78	6.93	7.89
2-day:	1.97	2.28	2.87	3.43	4.31	5.07	5.91	6.84	8.2	9.31
3-day:	2.16	2.48	3.09	3.68	4.61	5.43	6.32	7.31	8.76	9.95
4-day:	2.33	2.66	3.28	3.88	4.84	5.68	6.6	7.62	9.11	10.3
7-day:	2.78	3.15	3.83	4.48	5.49	6.37	7.33	8.39	9.92	11.2
10-day:	3.2	3.62	4.38	5.08	6.15	7.07	8.05	9.13	10.7	11.9
20-day:	4.39	4.99	6	6.88	8.14	9.15	10.2	11.3	12.8	14
30-day:	5.32	6.05	7.25	8.25	9.64	10.7	11.8	12.9	14.4	15.5
45-day:	6.43	7.3	8.69	9.81	11.3	12.4	13.5	14.6	15.9	16.9
60-day:	7.33	8.29	9.81	11	12.6	13.7	14.8	15.8	17	17.9

Date/time (GMT): Mon Dec 15 18:08:02 2025
pyRunTime: 0.033385276794433594

APPENDIX F

PRE-DEVELOPMENT AND POST-DEVELOPMENT SUB-BASIN MAPS



LEGEND

- SHEET FLOW
- CONCENTRATED FLOW
- DESIGN POINT
- TELLER/EL PASO COUNTY BOUNDARY
- SUB-BASIN FLOW ARROW
- LOCAL CREEKS AND STREAM CHANNELS
- WETLANDS
- EXISTING FLOW ARROW
- PROPOSED FLOW ARROW
- EXISTING MINOR CONTOUR
- EXISTING MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- PROPOSED MAJOR CONTOUR
- RIPRAP

NOTES:

1. PROJECT SITE IS CATEGORIZED AS FEMA: FLOOD HAZARD ZONE D.
2. RUNOFF COEFFICIENTS USED FOR THE EXISTING SUBBASIN USED STREAMSTATS WHICH ARE BASED ON AVERAGE COEFFICENT FOR THE WHOLE 441.6 ACRES DEFINED BY VERDIN AND GROSS (2017).

BASIN	AREA (AC.)	RUNOFF COEFFICIENT, C (5-YEAR)	RUNOFF COEFFICIENT, C (100-YEAR)	PEAK FLOW, Q (cfs) (5-YEAR)	PEAK FLOW, Q (cfs) (100-YEAR)
EXISTING*	441.6	0.45	0.45	14.8	63.2

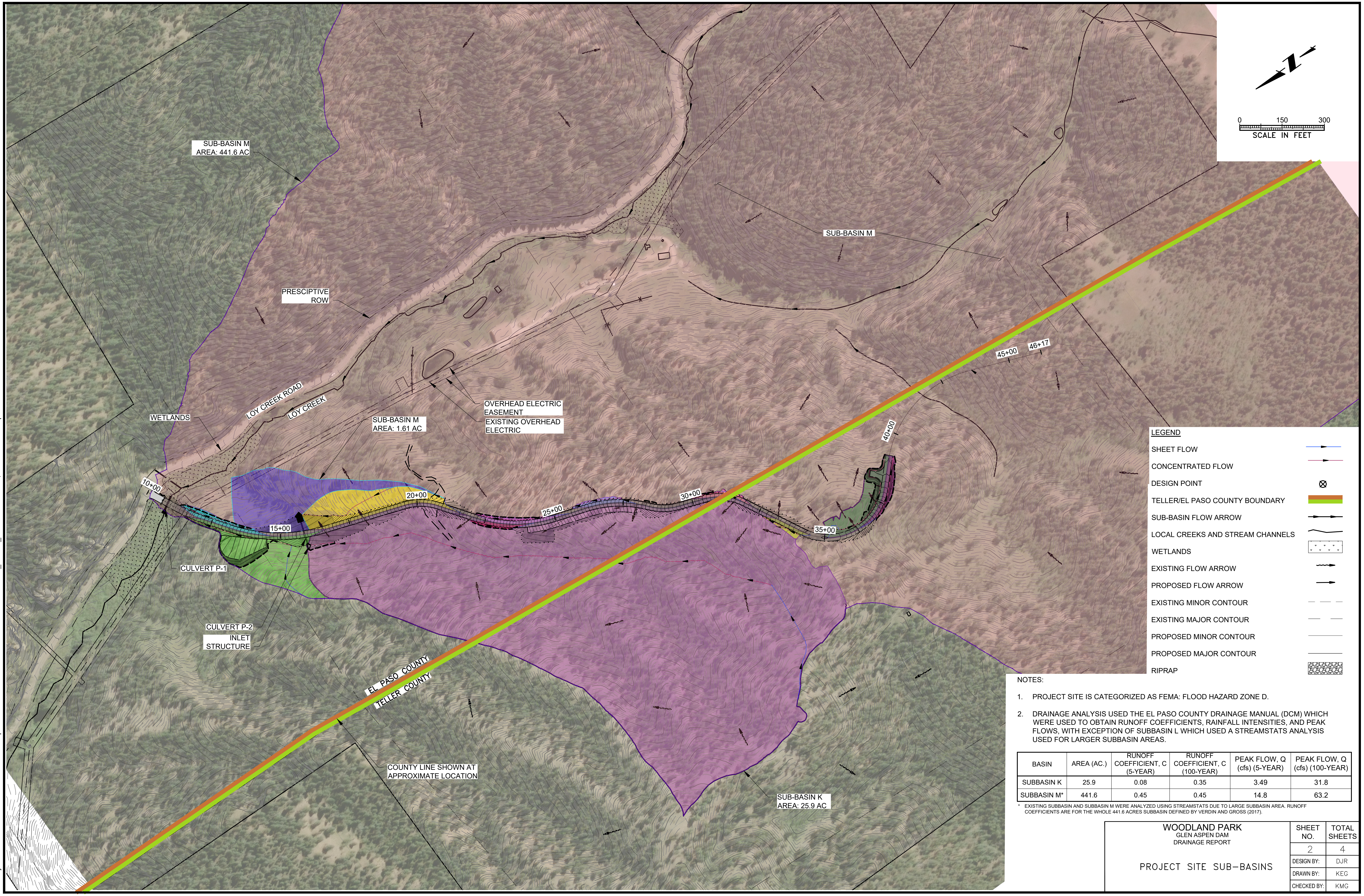
* EXISTING SUBBASIN WAS ANALYZED USING STREAMSTATS DUE TO LARGE SUBBASIN AREA. RUNOFF COEFFICIENTS ARE FOR THE WHOLE 441.6 ACRES SUBBASIN DEFINED BY VERDIN AND GROSS (2017).

WOODLAND PARK
GLEN ASPEN DAM
DRAINAGE REPORT

PRE–DEVELOPMENT CATCHMENT

SHEET NO.	TOTAL SHEETS
1	4
DESIGN BY:	DJR
DRAWN BY:	KEG
CHECKED BY:	KMG

PLANS DEVELOPED BY: RESPEC COMPANY, LLC, CERT. OF AUTHORIZATION NO.: AECC163270, 2700 GAMBELL STREET, SUITE 500, ANCHORAGE, AK 99503, (907)743-3200
N:\Projects\109 Woodland Park\109.18 Glen Aspen Reservoir\06 CAD\Model\CMODL-DRAINAGE_109.18_SG-Pre-Dev 1 Fri, Mar/13/26 02:58pm



NOTES:

1. PROJECT SITE IS CATEGORIZED AS FEMA: FLOOD HAZARD ZONE D.

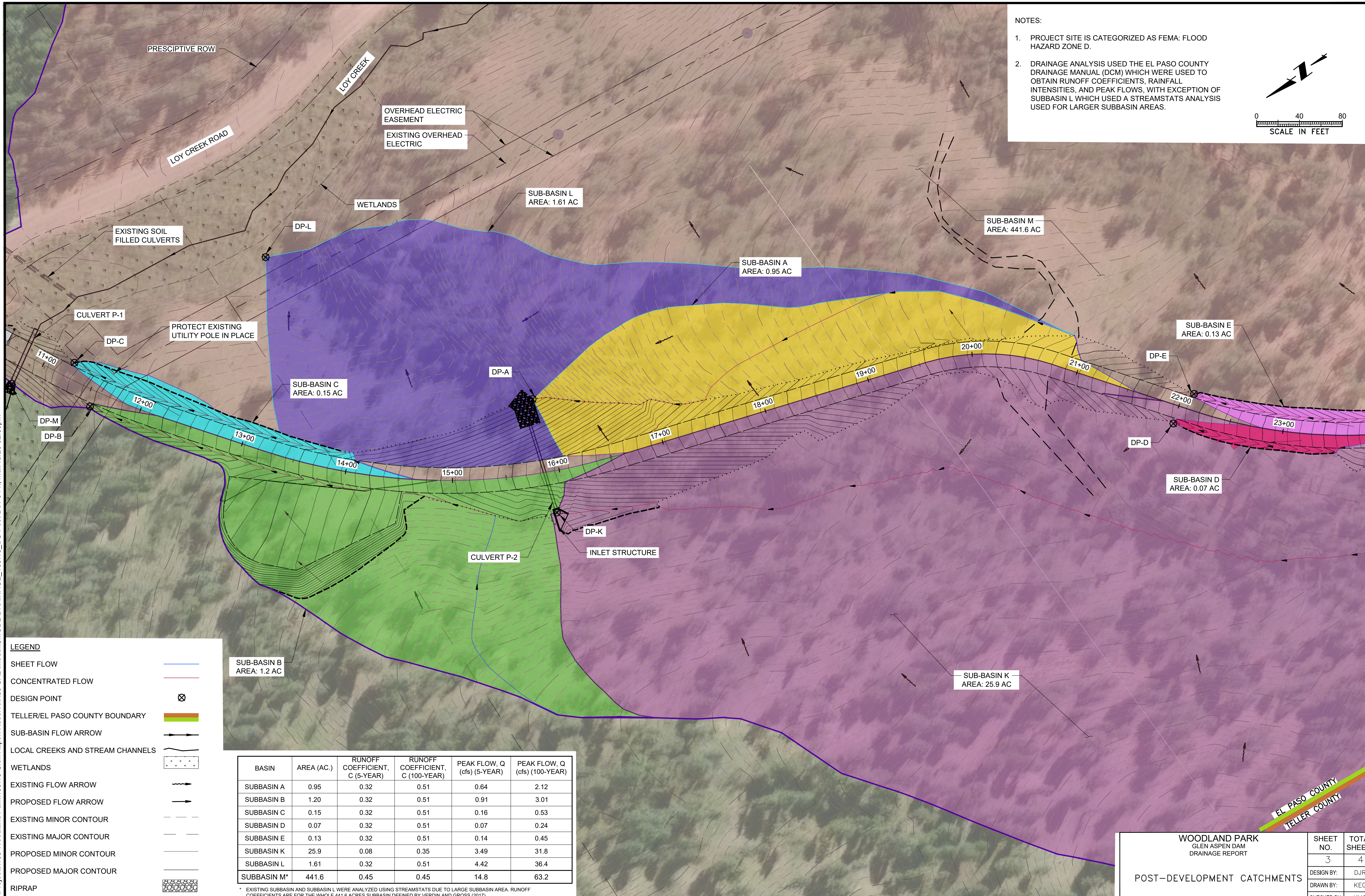
2. DRAINAGE ANALYSIS USED THE EL PASO COUNTY DRAINAGE MANUAL (DCM) WHICH WERE USED TO OBTAIN RUNOFF COEFFICIENTS, RAINFALL INTENSITIES, AND PEAK FLOWS, WITH EXCEPTION OF SUBBASIN L WHICH USED A STREAMSTATS ANALYSIS USED FOR LARGER SUBBASIN AREAS.

BASIN	AREA (AC.)	RUNOFF COEFFICIENT, C (5-YEAR)	RUNOFF COEFFICIENT, C (100-YEAR)	PEAK FLOW, Q (cfs) (5-YEAR)	PEAK FLOW, Q (cfs) (100-YEAR)
SUBBASIN K	25.9	0.08	0.35	3.49	31.8
SUBBASIN M*	441.6	0.45	0.45	14.8	63.2

* EXISTING SUBBASIN AND SUBBASIN M WERE ANALYZED USING STREAMSTATS DUE TO LARGE SUBBASIN AREA. RUNOFF COEFFICIENTS ARE FOR THE WHOLE 441.6 ACRES SUBBASIN DEFINED BY VERDIN AND GROSS (2017).

WOODLAND PARK GLEN ASPEN DAM DRAINAGE REPORT PROJECT SITE SUB-BASINS	SHEET NO.	TOTAL SHEETS
	2	4
	DESIGN BY:	DJR
	DRAWN BY:	KEG
	CHECKED BY:	KMG

PLANS DEVELOPED BY: RESPEC COMPANY, LLC, CERT. OF AUTHORIZATION NO.: AECC163270, 2700 GAMBELL STREET, SUITE 500, ANCHORAGE, AK 99503, (907)743-3200
N:\Projects\109 Woodland Park\109.18 Glen Aspen Reservoir\06 CAD\Model\CMODL-DRAINAGE_109.18_SG-Post-Dev 2 Fri, Mar/13/26 02:58pm



NOTES:

1. PROJECT SITE IS CATEGORIZED AS FEMA: FLOOD HAZARD ZONE D.
2. DRAINAGE ANALYSIS USED THE EL PASO COUNTY DRAINAGE MANUAL (DCM) WHICH WERE USED TO OBTAIN RUNOFF COEFFICIENTS, RAINFALL INTENSITIES, AND PEAK FLOWS, WITH EXCEPTION OF SUBBASIN L WHICH USED A STREAMSTATS ANALYSIS USED FOR LARGER SUBBASIN AREAS.

LEGEND

SHEET FLOW
CONCENTRATED FLOW
DESIGN POINT
TELLER/EL PASO COUNTY BOUNDARY
SUB-BASIN FLOW ARROW
LOCAL CREEKS AND STREAM CHANNELS
WETLANDS
EXISTING FLOW ARROW
PROPOSED FLOW ARROW
EXISTING MINOR CONTOUR
EXISTING MAJOR CONTOUR
PROPOSED MINOR CONTOUR
PROPOSED MAJOR CONTOUR
RIPRAP

BASIN	AREA (AC.)	RUNOFF COEFFICIENT, C (5-YEAR)	RUNOFF COEFFICIENT, C (100-YEAR)	PEAK FLOW, Q (cfs) (5-YEAR)	PEAK FLOW, Q (cfs) (100-YEAR)
SUBBASIN A	0.95	0.32	0.51	0.64	2.12
SUBBASIN B	1.20	0.32	0.51	0.91	3.01
SUBBASIN C	0.15	0.32	0.51	0.16	0.53
SUBBASIN D	0.07	0.32	0.51	0.07	0.24
SUBBASIN E	0.13	0.32	0.51	0.14	0.45
SUBBASIN K	25.9	0.08	0.35	3.49	31.8
SUBBASIN L	1.61	0.32	0.51	4.42	36.4
SUBBASIN M*	441.6	0.45	0.45	14.8	63.2

* EXISTING SUBBASIN AND SUBBASIN L WERE ANALYZED USING STREAMSTATS DUE TO LARGE SUBBASIN AREA. RUNOFF COEFFICIENTS ARE FOR THE WHOLE 441.6 ACRES SUBBASIN DEFINED BY VERDIN AND GROSS (2017).

WOODLAND PARK
GLEN ASPEN DAM
DRAINAGE REPORT

POST-DEVELOPMENT CATCHMENTS

SHEET NO.	TOTAL SHEETS
3	4
DESIGN BY:	DJR
DRAWN BY:	KEG
CHECKED BY:	KMG

PLANS DEVELOPED BY: RESPEC COMPANY, LLC. CERT. OF AUTHORIZATION NO.: AECC163270, 2700 GAMBELL STREET, SUITE 500, ANCHORAGE, AK 99503, (907)743-3200
N:\Projects\109 Woodland Park\109.18 Glen Aspen Reservoir\06 CAD\Model\CMODL-DRAINAGE_109.18_SG-Post-Dev 3 Fri, Mar/13/26 02:59pm

LEGEND

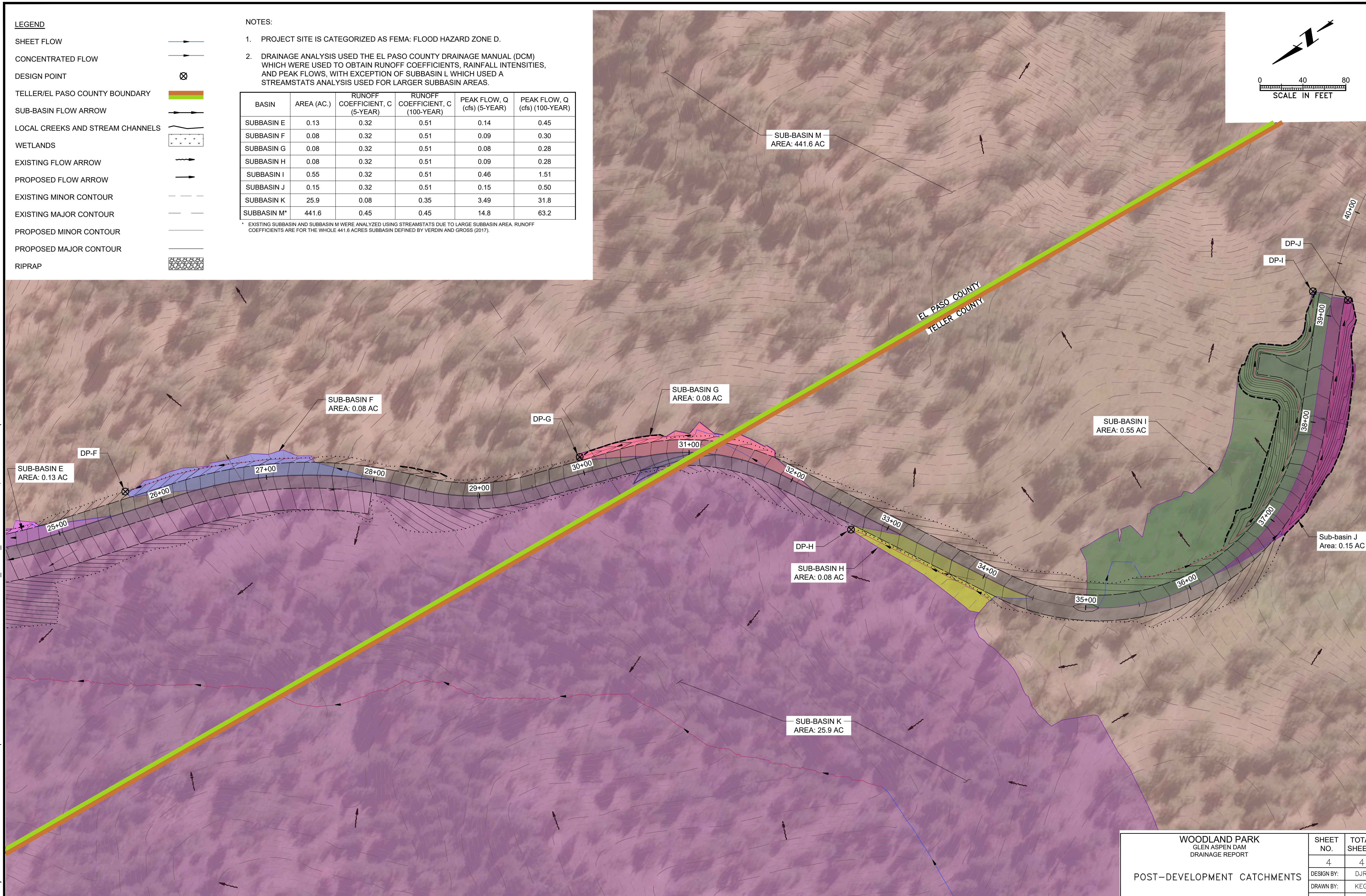
- SHEET FLOW
- CONCENTRATED FLOW
- DESIGN POINT
- TELLER/EL PASO COUNTY BOUNDARY
- SUB-BASIN FLOW ARROW
- LOCAL CREEKS AND STREAM CHANNELS
- WETLANDS
- EXISTING FLOW ARROW
- PROPOSED FLOW ARROW
- EXISTING MINOR CONTOUR
- EXISTING MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- PROPOSED MAJOR CONTOUR
- RIPRAP

NOTES:

1. PROJECT SITE IS CATEGORIZED AS FEMA: FLOOD HAZARD ZONE D.
2. DRAINAGE ANALYSIS USED THE EL PASO COUNTY DRAINAGE MANUAL (DCM) WHICH WERE USED TO OBTAIN RUNOFF COEFFICIENTS, RAINFALL INTENSITIES, AND PEAK FLOWS, WITH EXCEPTION OF SUBBASIN L WHICH USED A STREAMSTATS ANALYSIS USED FOR LARGER SUBBASIN AREAS.

BASIN	AREA (AC.)	RUNOFF COEFFICIENT, C (5-YEAR)	RUNOFF COEFFICIENT, C (100-YEAR)	PEAK FLOW, Q (cfs) (5-YEAR)	PEAK FLOW, Q (cfs) (100-YEAR)
SUBBASIN E	0.13	0.32	0.51	0.14	0.45
SUBBASIN F	0.08	0.32	0.51	0.09	0.30
SUBBASIN G	0.08	0.32	0.51	0.08	0.28
SUBBASIN H	0.08	0.32	0.51	0.09	0.28
SUBBASIN I	0.55	0.32	0.51	0.46	1.51
SUBBASIN J	0.15	0.32	0.51	0.15	0.50
SUBBASIN K	25.9	0.08	0.35	3.49	31.8
SUBBASIN M*	441.6	0.45	0.45	14.8	63.2

* EXISTING SUBBASIN AND SUBBASIN M WERE ANALYZED USING STREAMSTATS DUE TO LARGE SUBBASIN AREA. RUNOFF COEFFICIENTS ARE FOR THE WHOLE 441.6 ACRES SUBBASIN DEFINED BY VERDIN AND GROSS (2017).



PLANS DEVELOPED BY: RESPEC COMPANY, LLC, CERT. OF AUTHORIZATION NO.: AECC163270, 2700 GAMBELL STREET, SUITE 500, ANCHORAGE, AK 99503, (907)743-3200
N:\Projects\109 Woodland Park\109.18 Glen Aspen Reservoir\06 CAD\Model\CMODL-DRAINAGE_109.18_SG-Post-Dev 4 Fri, Mar/13/26 02:59pm

WOODLAND PARK
GLEN ASPEN DAM
DRAINAGE REPORT

POST-DEVELOPMENT CATCHMENTS

SHEET NO.	TOTAL SHEETS
4	4
DESIGN BY:	DJR
DRAWN BY:	KEG
CHECKED BY:	KMG