

**Final Drainage Report
Rocky Top Resources
Tract 7 Valley Garden Subdivision
1755 East Las Vegas
El Paso County, Colorado**

PCD File No. PPR 1913

Prepared for:
Rocky Top Resources
1755 East Las Vegas
Colorado Springs, Colorado 80903
719-579-9103

Prepared by:
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Kiowa Project No. 17066
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Appendix A – Hydrologic Calculations

Appendix B – Hydraulic Calculations

Map Pocket – Exhibit 1 Existing Drainage Plan

Exhibit 2 Proposed Drainage Plan

Engineer's Statement:

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

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

Richard N. Wray
Registered Engineer #19310
For and on Behalf of Kiowa Engineering Corporation

Date

Developer's Statement:

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

BY: _____

Date

Printed

ADDRESS: Rocky Top Resources Inc.
1755 East Las Vegas
Colorado Springs, Colorado 80903

El Paso County:

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

Jennifer Irvine, P.E.
County Engineer/ECM Administrator

Date

I. General Location and Description of Project

The Rocky Top Resources project is a site development involving a portion of Tract 7 of the Garden Subdivision located in El Paso County, Colorado. The property subject to site development covers approximately 22 acres of the total 44.81 acres. Site development activities as proposed will not require that a re-plat be prepared however a rezone of the property is required.

The proposed site improvements will include grading, stormwater detention basin, office building, parking lot(s), onsite individual wastewater system (septic and leach field), landscaping and access driveways. The site presently operates as a waste wood, lawn waste and concrete recycling center. Recycled materials are used to make mulch, fine soil mulch and concrete base course. Approximately 22 acres of the parcel are not used for the active recycling and sales operations.

The site is a 44.8 -acre commercial recycling center site located at 1755 East Las Vegas in El Paso County, Colorado. The site is located within a portion of Sections 28 and 29, Township 14 South, Range 66 West of the 6th Principal Meridian, in Colorado Springs, Colorado. The El Paso County Assessor parcel number is 64291-01-029, 030 and 031. The parcel is legally described as Tract 7 in the Valley Gardens Subdivision. The location of the site is shown on the Vicinity Map (Figure 1). The site is bordered by East Las Vegas Street on the northeast, US Highway 24 Bypass right-of-way on the northwest, Spring Creek on the southeast and Fountain Creek on the southwest.

There are no public streets that will be constructed as part of the development of the site. Access off Las Vegas Avenue has already been designed as part of the City's Spring Creek/Royer Road/Las Vegas Street Roadway Design. The access is shown on the site development plan. A private full spectrum detention (FSD), basin will be constructed and will be operated and maintained by the property owner and subject to a private detention basin maintenance agreement. An operations and maintenance manual will be prepared for the FSD.

II. Previous Reports and References

The following reports and plans were reviewed in the process of preparing this drainage report:

- 1) *Spring Creek Road/Las Vegas Street Roadway Design Plan*, prepared by Felsburg Holt and Ullevig, March 2018.
- 2) *City of Colorado Springs and El Paso County Flood Insurance Study* prepared by the Federal Emergency Management Agency, dated December 2018.
- 3) *City of Colorado Springs and El Paso County Drainage Criteria Manual*, most current versions, Volumes 1 and 2.
- 4) *Soil Survey of El Paso County Area, Colorado*, prepared by United States Department of Agriculture Soil Conservation Service, dated June 1981.

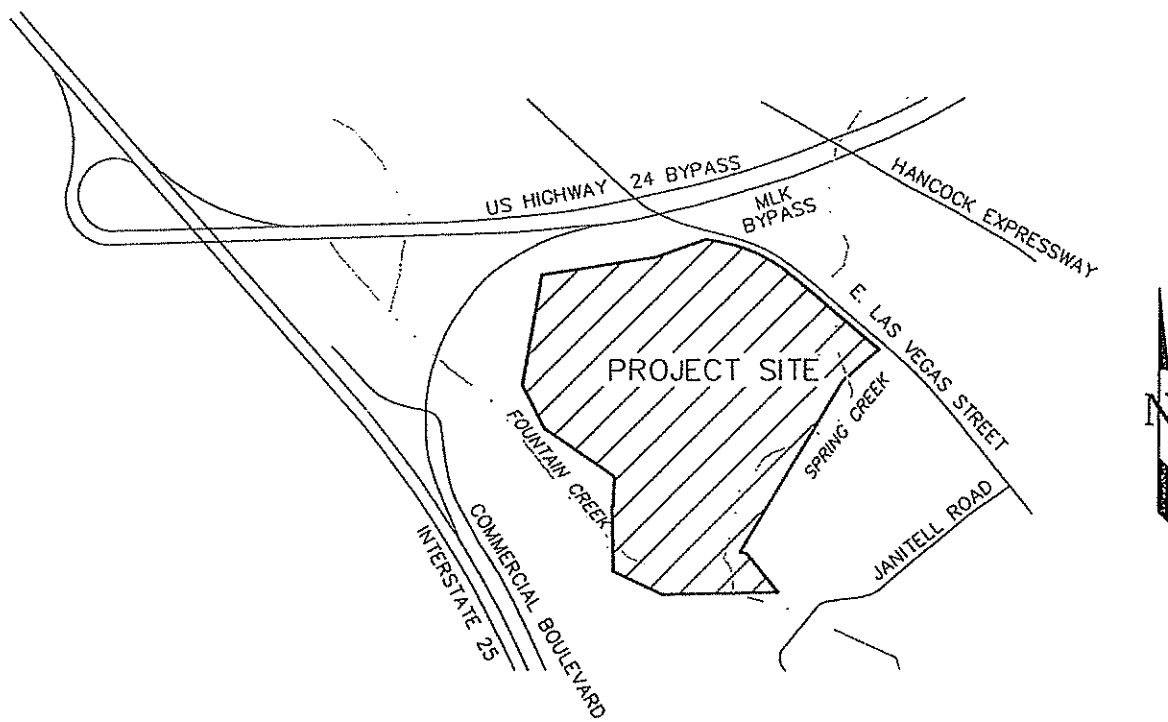


FIGURE 1
VICINITY MAP
NO SCALE

Reference 1 was reviewed to assess whether any facilities shown on the design plans would impact the site development. The access off Las Vegas will be constructed as part of the City's roadway improvement project.

Reference 2 was reviewed in order to assess whether the regulatory floodplains for Spring Creek and Fountain Creek impact any of the proposed buildings or the recycling operation itself. As a result of this review, there will be no habitable structures that will be constructed within the 100-year floodplain, and all grading associated with the FSD and site improvements will occur within the 500-year or the 100-year flood fringe. There will be no encroachment of fill into the floodway of either Spring or Fountain Creek.

III. Hydrology

Existing Basin Description: Existing sub-basins have been delineated on Exhibit 1. Four existing condition sub-basins occur within the Rocky Top property. Approximately one-third of the property now drains to the Spring Creek floodplain and the remaining portion of the property drains to the Fountain Creek floodplain. There is only one area of offsite drainage that enters the property at the north boundary which is the slope to the US 24 Bypass on ramp.

Soils within portion of the property subject to the recycling operations are classified to be within Hydrologic Soils Groups (HSG) A and B as shown in the El Paso County Soils Survey. The predominant soil covering 85 percent of the recycling operation are identified as Ustic Torrifluvents (HSG B), that is a loamy soil that is well drained. Soil covering the remainder of the recycling operation is identified as Ellicott (HSG A), loamy coarse sand that is somewhat excessively drained. These soils have a moderate to high infiltration rate when thoroughly wet. These soils have a low to moderate hazard of erosion. The existing vegetation is mostly native grasses within the portion of the property that is not used for the recycling operation. Along the Springs Creek and Fountain Creek drainageways cottonwoods, native shrubs and invasive species such as Russian olive and Dutch elm. There will be no disturbance to these areas as part of the site improvements. Within the active areas of the recycling operations the vegetative cover is sparse and there are numerous haul roads and gravel access drives. Vegetative cover outside of the active area of the recycling operation is 85 percent. Within the operations areas vegetative cover is less than 10 percent. Ground slopes are less than 2 percent in the active operations areas.

Existing Basin Descriptions: Total drainage area estimated to discharge to Fountain Creek and Spring Creek 44.8 acres. Developed runoff from the active area of the recycling operations is now being controlled by a temporary storage bas located near the southwest corner of the property. There is no discharge of runoff from the active portion of the site. The descriptions below are for present development condition and the discharges are for the pre-development condition.

Sub-basin A: This sub-basin is located at east corner of the property. This sub-basin is a direct flow area to Spring Creek. The colorant and colored mulch storage area operations is within this sub-basin. This sub-basin lies within portion of the 100- and 500-year floodplain of Spring Creek however the active portion associated with the colorant storage and processing lies outside of the 500-year floodplain. The colorant storage material is stored on an existing concrete

slab. The sub-basin covers 5.32 acres and has slopes of 1 to 2 percent. The estimated 5- and 100-year discharges are 0.9 and 6.1 cubic feet per second, respectively.

Sub-basin B: This sub-basin is located at south corner of the property and is a direct flow basin to Spring Creek. This sub-basin lies within portion of the 100- and 500-year floodplain of Spring Creek. There are no active operations associated with the recycling within this sub-basin. This sub-basin covers 7.51 acres and has slopes of 2 to 4 percent. The estimated 5- and 100-year discharges are 1.6 and 10.9 cubic feet per second, respectively for the pre-development condition.

Sub-basin C: This sub-basin is located at south corner of the property and is a direct flow basin to Fountain Creek. This sub-basin lies within portion of the 100- and 500-year floodplain of Spring Creek. There are no active operations associated with the recycling within this sub-basin. This sub-basin covers 3.59 acres and has slopes of 1 to 2 percent. The estimated 5- and 100-year discharges are 0.9 and 5.7 cubic feet per second, respectively for the pre-development condition.

Sub-basin D: This sub-basin covers the active areas of the recycling operations and discharges to the existing temporary storage basin located in sub-basin B. The retail office, waste concrete storage, waste concrete processing waste wood storage and yard waste storage and processing now existing in this sub-basin. This sub-basin lies within portion of the 500-year floodplain of Fountain Creek. The sub-basin covers 29.42 acres and has slopes of 1 to 2 percent. The estimated 5- and 100-year discharges are 4.4 and 28.6 cubic feet per second, respectively for the pre-development condition.

Proposed Basin Descriptions: Developed runoff from the active area of the recycling operations will be controlled by a proposed full spectrum detention basin. There will be no direct discharge to Spring or Fountain Creek other than from this sub-basin that lies outside of the active area of operations. The descriptions below are for the proposed development condition. The proposed condition sub-basins are shown on Exhibit 2.

Sub-basin 1: This sub-basin covers the active areas of the recycling operations and will discharge to a proposed extended detention basin. The new retail office, parking area and access driveways, waste concrete storage, waste concrete processing waste wood storage and yard waste storage and processing now existing in this sub-basin. This sub-basin lies within portion of the 500-year floodplain of Fountain Creek. The sub-basin covers 30.45 acres and will have slopes of 1 to 2 percent. The estimated 5- and 100-year discharges are 28.9 and 79.5 cubic feet per second, respectively.

Sub-basin 2: This sub-basin is located at east corner of the property and is a direct flow basin to Spring Creek. This sub-basin lies within portion of the 100- and 500-year floodplain of Spring Creek. There will be no active operations associated with the recycling within this sub-basin. This sub-basin covers 1.4 acres and has slopes of 2 to 4 percent. The estimated 5- and 100-year discharges are .5 and 3.4 cubic feet per second, respectively.

Sub-basin 3: This sub-basin is located at southwest corner of the property and is a direct flow basin to Fountain Creek. This sub-basin lies within portion of the 100- and 500-year floodplain of Fountain Creek. There will be no active operations associated with the recycling within this sub-basin. This sub-basin covers 2.5 acres and has slopes of 2 to 4 percent. The estimated 5- and 100-year discharges are .5 and 3.2 cubic feet per second, respectively.

Sub-basin 4: This sub-basin is located at south corner of the property and is a direct flow basin to Fountain Creek. The Fountain Creek Greenway Trail passes through this sub-basin. This sub-basin lies within portion of the 100- and 500-year floodplain of Fountain Creek. There will be no active operations associated with the recycling within this sub-basin. This sub-basin covers 11.49 acres and has slopes of 2 to 5 percent. The estimated 5- and 100-year discharges are 2.0 and 13.2 cubic feet per second, respectively.

IV. Hydrology Calculations

Storm runoff for the site was estimated using the methods outlined in the *City of Colorado Springs and El Paso County, Drainage Criteria Manual*. Chapters 6 and 13 of DCM Volume 1 was used to assess the hydrologic characteristics of the site and for the design of the FSD. The topography for the site is presented with a one-foot contour interval at a horizontal scale of 1-inch to 100-feet. Exhibit 1 presents the existing drainage patterns for the area and Exhibit 2 presents the developed drainage patterns for the area, including the sub-basins and the corresponding flow rates. The flow rates for the sub-basins were estimated by using the Rational Method. The 5-year and 100-year recurrence intervals were determined. The calculations can be found within Appendix A of this report.

V. Hydraulic Calculations

The sizing of the onsite hydraulic structures was determined using the methods outlined in the *City of Colorado Springs and El Paso County, Drainage Criteria Manual*. The site will be drained primarily via sheet flow that is collected in onsite swales. All runoff will outfall to the proposed extended detention basin. Discharge from the FSD will be directly to Springs Creek via a 30-inch RCP.

The capacities for proposed inlets and culverts were determined assuming inlet control, a 100-year storm and a maximum headwater to depth ratio of 1.2. The hydraulic capacities of the culverts were determined using the Urban Drainage and Flood Control District (UDFCD), UD-Culvert. The FSD outlet pipe is proposed to be reinforced concrete with flared-end section. The outlets of all culverts will be protected with riprap which will be sized to meet the outlet velocity condition at each culvert. The riprap at the outlet of all the culverts has been sized to withstand the forces attributable to the 100-year design discharge. Inlets were sized using the UDFCD's UD-INLET spreadsheets. Hydraulic calculations are contained within Appendix B.

The size of the proposed FSD was determined using UDFCD's UD-Detention spreadsheets. The required water quality capture volume (WQCV), excess urban runoff volume (EURV) and the 100-year storage volume were estimated for the proposed. Per El Paso County requirements, one-half of the WQCV was added to the 100-year storage volume. The FSD'S

will be designed in accordance with the City of Colorado Springs DCM Volume 1, in combination with the UDFCD DCM Volumes 2 and 3. The FSD's will have a forebay(s), a low flow trickle channel and an outlet structure that will control the discharge of the WCQV, EURV and 100-year detention volume. Discharge from the FSD's during a 100-year inflow event will be limited to the rates of runoff for Hydrologic Soil Groups A and B. The FSD will have a forebay(s) with the required discharge rate and storage volume per Table T5 of Volume III of the UDFCD DCM. The FSD will concrete trickle channel(s) to carry the discharge from the forebay(s) to the principal outlet structure. The principal outlet structures will have perforated plates that will be designed to control the discharge of the WQCV and the EURV (stages 1 and 2). The 100-year discharge (stage 3), will be controlled to pre-development conditions using a 30-inch RCP with a restrictive orifice plate. An emergency spillway will be provided over the crest of the FSD's embankment sized to convey the maximum 100-year un-detained inflow from sub-basin 1 estimated at 79.5 cubic feet per second. Calculations supporting the design of the FSD's are contained in Appendix B.

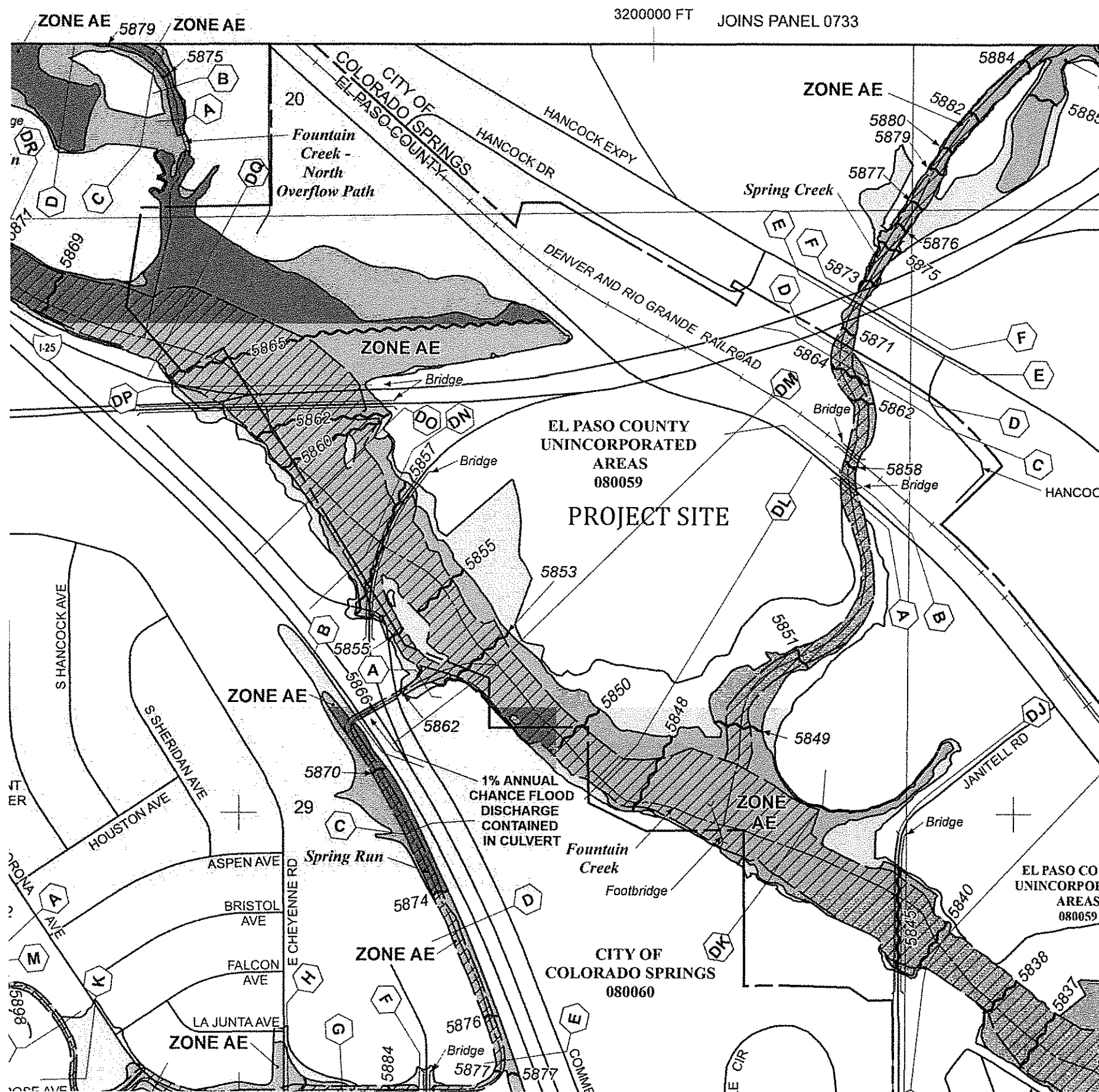
Earthwork at the site of the FSD basins will be completed initially to provide for sediment storage during the period of construction and the outlet works blocked accordingly.

VI. Floodplain Statement

The Floodplain Insurance Rate Map (FIRM) for El Paso County Flood Insurance Study (FIS) panel 0741G dated December 7, 2018 was reviewed to determine any potential regulatory floodplains within the property. The property is impacted by the 100-year and 500-year floodplains of Fountain and Spring creeks. Only a small portion of the active recycling operations lies within the 500-year floodplain. Grading will occur within the 100- and 500-year floodplain of Fountain and Spring creeks. The FSD will lie outside of the 100- year floodplain but a small portion will lie within the 500-year floodplain. FIRM panel 0741G is shown on Figure 2. No grading will occur within the floodway of Spring or Fountain creek.

VII. Grading and Erosion Control

The primary earth disturbing activity within the Rocky Top site will result from the construction of the FSD, new office building, driveways and parking areas. Outside of the areas of new construction no grading proposed to occur. It is the property owner's responsibility to monitor the condition of the temporary erosion control features. Should any of the erosion control facilities come into disrepair prior to the establishment of the native or natural erosion control measures, the developer is responsible for the maintenance and any associated costs. The developer is also responsible for the clean-up of offsite areas affected by any excessive erosion that may leave the site. Control of erosion from areas disturbed by utility construction or home building will be the responsibility of the respective contractor. All erosion control measures shall be installed and maintained in accordance with Volume 2 of the *City/County Drainage Criteria Manual*. Final grading and erosion control plans will be provided within the design plans to be prepared for this project.



The primary erosion control measure to be utilized in this project will include seeding and mulching of all the disturbed areas with the native seed mix. All areas disturbed by construction shall be seeded and mulched within sixty days after the rough grading has occurred. Cut and fill slopes will be reseeded and the slopes equal to or greater than three-to-one will be protected with erosion control fabric. Silt fence barriers will be placed along the site at the bottom of the re-vegetated and rough graded slopes. Inlet protection will be used around each of the proposed culverts and inlets.

VIII. Drainage and Bridge Fees

Tract 7 of the Valley Garden Subdivision lies within the Fountain Creek and Spring Creek drainage basins. Drainage fees will not be due for this site development application.

IX. Economic Analysis

Summarized on Table 1 is the cost estimate for the private drainage improvements associated with Rocky Top Resources project. No publicly maintained drainage facilities are required or proposed.

X. Best Management Plan Selection

The site will be developed to minimize wherever possible the rate of developed runoff that will leave the site and to provide water quality management for the runoff produced by the site as proposed on the development plan. The following steps were accounted for when the storm water collection and storage facilities were designed.

Step 1: Runoff reduction

Recycled asphalt (RCA) has been used as an alternative to concrete and asphalt within the proposed driveway areas within the active areas of the site. Runoff is reduced by approximately 15 percent as compared to a concrete surface. Some portions of the operations, such as the colorant additive and storage area, are protected by earthen berms that prevent direct discharge to the site or into the receiving drainageways. These berms act to slow the rate of runoff by increasing the time of concentration and provides for a lower effective impervious factor compared to areas that directly discharge.

Step 2: Stabilized drainageways

No major drainageways cross through the site. The banks of Fountain Creek and Spring Creek where they are adjacent to the site are presently stable. Discharge from the FSD will control runoff to pre-development conditions and therefore not expected to adversely affect the receiving drainageways.

Step 3: Water Quality Capture Volume

Runoff from the site will outfall to a FSD basin that will be sized to store and release at prescribed rates and time periods, the water quality capture volume (WQCV), the excess urban

**TABLE 1: TRACT 7 VALLEY GARDEN SUBDIVISION
PRIVATE DRAINAGE IMPROVEMENT COST ESTIMATE
KIOWA PROJECT NUMBER 17066**

| ITEM | UNIT COST | UNIT | QUANTITY | TOTAL |
|------------------------------------|-----------|------|----------|--------------------|
| PRIVATE DRAINAGE FACILITIES | | | | |
| EDB DETENTION (1) | \$35,000 | AF | 2.6 | \$91,000 |
| 30-INCH RCP | \$97 | LF | 166 | \$16,102 |
| CDOT TYPE D INLET | \$5,731 | EA | 2 | \$11,462 |
| <hr/> | | | | |
| SUBTOTAL | | | | \$118,564.00 |
| CONTINGENCY (5 %) | | | | \$5,928.20 |
| ENGINEERING (10 %) | | | | \$11,856.40 |
| TOTAL | | | | <hr/> \$136,348.60 |

(1) PER ACRE FOOT UNIT COST INCLUDES, GRADING, OUTLET STRUCTURE AND OUTLET STORM SEWER, FOREBAY, CONCRETE TRICKLE CHNNEL AND EMERGENCY SPILLWAY

runoff volume (EURV) and the 100-year runoff volume. The FSD is design to operate as an extended detention basin (EDB). The discharge of the WQCV, EURV and the 100-year will be managed by means of a water quality outlet structure. The FSD will have a concrete trickle channel and forebay(s). The FSD has been designed to be on conformance with El Paso County engineering and drainage criteria.

Step 4: Industrial and Commercial BMP's

All chemical and fuels used in the recycling operations that are routinely stored on the site will have spill containment measure provided. A separate spill prevention and containment plan will be prepared by the operators of the facility. Access to the retail mulch, aggregate and soil drop-off and pickup are restricted to designated RAP driveways. Access to areas not part of the recycling operation is limited by the property owner by fencing and signage.

Appendix A
Hydrologic Calculations
Runoff Coefficient Calculations
Time of Concentration Calculations
Runoff Calculations

KIOWA ENGINEERING CORPORATION

JOB Full top Reserve ①
 SHEET NO. _____ OF 3/10/19
 CALCULATED BY RW DATE 17066
 CHECKED BY _____ DATE _____
 SCALE Hydrology

Hydrology - Existing Conditions (Pre-development)

| SB # | Cs | C100 | Area (ac) | Tc (min) |
|------|------|------|-----------|----------|
| A | 0.09 | 1.36 | 5.32 | 45.5 |
| B | ↓ | ↓ | 7.51 | 29.4 |
| C | | | 3.59 | 25.3 |
| D | | | 28.42 | 55.5 |

Tc: See color sheets 2-4

Rainfall Intensity (Figure 6-5)

| SB # | I5 | I100 (in/hr) |
|------|------|--------------|
| A | 1.9 | 3.2 |
| B | 2.35 | 4.05 |
| C | 2.65 | 4.4 |
| D | 1.65 | 2.7 |

Time of Concentration Ex. Conditions

Use longest flow path.

SB#D: Per Exhibit 1:

* Flow path 1 = 1430'

* Flow path 2 = 1510' ←

SB#D initial travel time: $L = 300'$ (overland)

$$t_b = \frac{.395 (1.1 - C_s) \sqrt{L}}{S^{.33}}$$

$$L = 300'$$

$$C_s = .09$$

$$S = 67 - 60 / 300 = .02\%$$

$$t_b = \frac{.395 (1.1 - .09) \sqrt{300}}{(.02)^{.33}} = \frac{6.91}{.275} = \underline{25.1 \text{ min}}$$

SB#A:

$$L_o = 1100' \quad S = 61 - 59 / 1100 = .018\%$$

$$L_{TOT} = 730'$$

Flow path
④

$$t_b = \frac{.395 (1.09) \sqrt{1100}}{((.018)^{.33})} = \frac{4.51}{.27} = 16.7$$

SB#B:

$$L_{TOT} = 1020'$$

Flow path

⑤

$$\text{Overland } L = 210' \quad S = \frac{54.5 - 41}{210} = .064\%$$

$$t_b = \frac{.395 (1.01) \sqrt{210}}{(.064)^{.33}} = \frac{5.78}{.403} = 14.3 \text{ min}$$

* See Exhibit 1

Time of Concentration Exist. Conditions cont'd

SB C: $L_{TOT} = 820'$

*Flowpath (6) Overland $L = 150'$ $S = \frac{53 - 42}{300} = .037\%$

$$t_c = \frac{.395(1.01)\sqrt{150}}{(.033)^{.33}} = \frac{4.84}{.32} = \underline{14.8}$$

Travel Time $V = C_u(S_u)^5$

SB A: slope S_u $\frac{66 - 55}{(1410 - 300)} = \frac{6}{1210} = .005\%$

$C_u = (\text{Table 9-7}) = 10$

$V = 10(.005)^5 = .70 \text{ fps}$

$t_c = 1210 / .70 = 1729 \text{ sec} = \underline{28.8}$

SB B: $S = .005$ (Spring creek) $L = 1020 - 210 = 810$

$C_u = 15$ $V = 15(.005)^5 = 1.06$

$t_c = 810 / 1.06 = 760 \text{ sec} = 12.7 \text{ min}$

SB C: $S = .005$ (Fountain Creek) $L = 820 - 150 = 670$

$V = 15(.005)^5 = 1.06$

$t_c = 670 / 1.06 = 632 \text{ s} = \underline{10.5 \text{ min}}$

SB D: $L = 1560 - 300 = 1260$ $S = 6 / 1260 = .0048\%$

$V = 10(.0048)^5 = .69$

$t_c = 1260 / .69 = 1826 \text{ s} = \underline{30.4 \text{ min}}$

CLIENT Rocky Top Resources
PROJECT Hydrology
DETAIL Hydrology

JOB NO. 17066

DATE CHECKED _____

CHECKED BY _____

PAGE 4
DATE 6/10/19
COMPUTED BY FW

Time of Concentration Ex. Cont'd

$$T_c = t_i + t_e$$

SBA: $T_c = 16.7 + 28.8 = 45.5 \text{ min}$

SBB: $T_c = 16.7 + 12.7 = 29.4 \text{ min}$

SBC: $T_c = 14.8 + 10.5 = 25.3 \text{ min}$

SBD: $T_c = 25.1 + 30.4 = 55.5 \text{ min}$

Rainfall Intensity Per Figure 6-5

SBA: $I_5 = 1.09 \text{ "/hr}$ $I_{100} = 3.2 \text{ "/hr}$

SBB: $I_5 = 2.35 \text{ "/hr}$ $I_{100} = 4.05 \text{ "/hr}$

SBC: $I_5 = 2.65 \text{ "/hr}$ $I_{100} = 4.4 \text{ "/hr}$

SBD: $I_5 = 1.65 \text{ "/hr}$ $I_{100} = 2.7 \text{ "/hr}$

SUB-WATERSHED RUNOFF CALCULATIONS PRE-DEVELOPMENT CONDITIONS

PROJECT: Rocky Top Resources

PROJECT NO: 17066

RATIONAL METHOD FORMULA: $Q=CIA$

| SUB-BASIN NO. | AREA (AC) | RUNOFF COEFFICIENTS | | RAINFALL INTENSITY | | RUNOFF (CFS) | |
|------------------|--------------|---------------------|------|--------------------|------|--------------|------|
| | | C5 | C100 | I5 | I100 | Q5 | Q100 |
| (INCHES/HR) | | | | | | | |
| A | 5.32 | 0.09 | 0.36 | 1.90 | 3.20 | 0.9 | 6.1 |
| B | 7.51 | 0.09 | 0.36 | 2.35 | 4.05 | 1.6 | 10.9 |
| C | 3.59 | 0.09 | 0.36 | 2.65 | 4.40 | 0.9 | 5.7 |
| D | 29.42 | 0.09 | 0.36 | 1.65 | 2.70 | 4.4 | 28.6 |

JOB Rocky Top Resource 1
 SHEET NO. _____ OF 17065
 CALCULATED BY _____ DATE 3/10/19
 CHECKED BY Raw DATE _____
 SCALE Hydrology - Proposed
At

| SR | Area (sq) | C ₅ | C ₁₀₀ | T _u (min) | I ₅ | I ₁₀₀ |
|----|-----------|----------------|------------------|----------------------|----------------|------------------|
| 1 | 30.45 | .045 | .60 | 25.5 | 2.1 | 4.35 |
| 2 | 1.40 | .09 | .34 | 10 | 4.0 | 6.8 |
| 3 | 2.50 | .09 | .34 | 36.3 | 2.15 | 3.6 |
| 4 | 11.49 | .09 | .34 | 42.9 | 1.95 | 3.25 |

Runoff coefficients: SB 1

50% of site: Light Industrial $C_5 = .59$ $C_{00} = .70$

50% of Site: poor to Fair grasses. $C_5 = .30$ $C_{100} = .50$

SG#1 Wtd Rndff Coeff.

5-yr $C_5 = .5(.59) + .3(.50) = .45$

$$C_{100} = .5(.70) + .50(.50) = .60$$

T_c SB 1: $L = 1450'$ $T_c = 1450 / 180 + 10 = 18.1$

SB 4: $L = 950$ $T_L = 950 / (180 + 10) = 15.3$

SB 3: $L = 1450$ $T_c = 1450 / (180 + 10) = 18.1$

Initial Travel Time

$$t_i = \frac{.395(1-C_s)\sqrt{L}}{S^{.33}}$$

SB # 1 :

$$L_o = 100' \quad S = .04 \quad C_s = .45$$

$$t_i = \frac{.395(1-.45)\sqrt{100}}{(.04)^{.33}} = \frac{2.57}{.35} = \underline{7.4 \text{ min}}$$

SB # 2: $L_o = 0' \therefore t_i = 0$

$$\text{SB # 3 : } L_o = 100' \quad S = .01 \quad C_s = .09$$

$$t_i = \frac{.395(1-.09)\sqrt{100}}{.01^{.33}} = \frac{3.99}{.219} = \underline{18.2 \text{ min}}$$

SB # 4 : $L = 300'$ (this SB remains undveloped)

$$S = .015 \quad C = .09$$

$$t_i = \frac{.395(1-.09)\sqrt{300}}{.015^{.33}} = \frac{6.91}{.25} = \underline{27.6 \text{ min}}$$

$$T_c: \text{SB \# 1 : } 7.4 + 18.1 = 25.5$$

$$\text{SB \# 2 : } 10 \text{ min}$$

$$\text{SB \# 3 : } 18.2 + 18.1 = 36.3$$

$$\text{SB \# 4 : } 27.6 + 15.3 = 42.9$$

SUB-WATERSHED RUNOFF CALCULATIONS PROPOSED DEVELOPMENT CONDITIONS

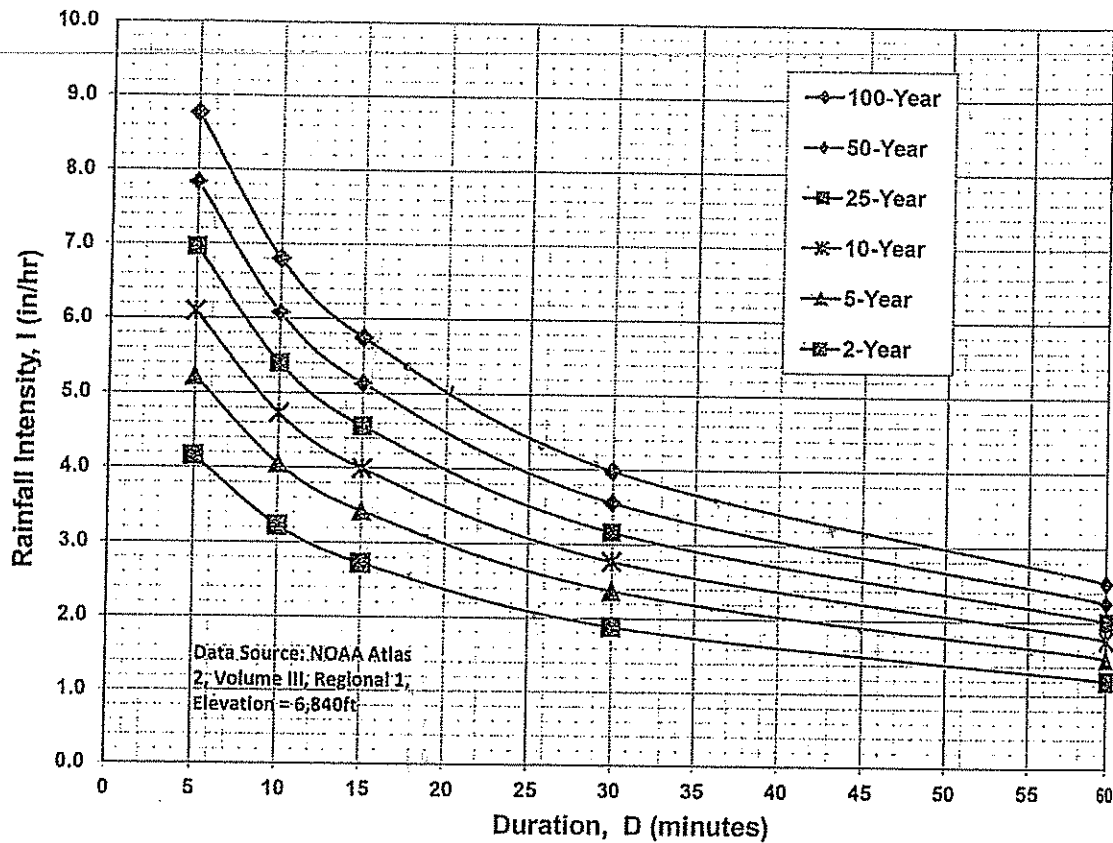
PROJECT: Rocky Top Resources

PROJECT NO: 17066

RATIONAL METHOD FORMULA: $Q=CIA$

| SUB-BASIN NO. | AREA (AC) | RUNOFF COEFFICIENTS | | RAINFALL INTENSITY | | RUNOFF (CFS) | |
|------------------|--------------|---------------------|------|--------------------|------|--------------|------|
| | | C5 | C100 | I5 | I100 | Q5 | Q100 |
| (INCHES/HR) | | | | | | | |
| 1 | 30.45 | 0.45 | 0.6 | 2.1 | 4.4 | 28.8 | 79.5 |
| 2 | 1.4 | 0.09 | 0.36 | 4.0 | 6.8 | 0.5 | 3.4 |
| 3 | 2.5 | 0.09 | 0.36 | 2.2 | 3.6 | 0.5 | 3.2 |
| 4 | 11.49 | 0.09 | 0.36 | 1.95 | 3.2 | 2.0 | 13.2 |

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

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

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

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

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

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

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

Note: Values calculated by equations may not precisely duplicate values read from figure.

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 |
| Business | | | | | | | | | | | | | |
| Commercial Areas | 95 | 0.79 | 0.80 | 0.81 | 0.82 | 0.83 | 0.84 | 0.85 | 0.87 | 0.87 | 0.88 | 0.88 | 0.89 |
| Neighborhood Areas | 70 | 0.45 | 0.49 | 0.49 | 0.53 | 0.53 | 0.57 | 0.62 | 0.62 | 0.60 | 0.65 | 0.62 | 0.68 |
| Residential | | | | | | | | | | | | | |
| 1/8 Acre or less | 65 | 0.41 | 0.45 | 0.45 | 0.49 | 0.49 | 0.54 | 0.54 | 0.59 | 0.57 | 0.62 | 0.59 | 0.65 |
| 1/4 Acre | 40 | 0.23 | 0.28 | 0.30 | 0.35 | 0.36 | 0.42 | 0.42 | 0.50 | 0.46 | 0.54 | 0.50 | 0.58 |
| 1/3 Acre | 30 | 0.18 | 0.22 | 0.25 | 0.30 | 0.32 | 0.38 | 0.39 | 0.47 | 0.43 | 0.52 | 0.47 | 0.57 |
| 1/2 Acre | 25 | 0.15 | 0.20 | 0.22 | 0.28 | 0.30 | 0.36 | 0.37 | 0.46 | 0.41 | 0.51 | 0.46 | 0.56 |
| 1 Acre | 20 | 0.12 | 0.17 | 0.20 | 0.26 | 0.27 | 0.34 | 0.35 | 0.44 | 0.40 | 0.50 | 0.44 | 0.55 |
| Industrial | | | | | | | | | | | | | |
| Light Areas | 80 | 0.57 | 0.60 | 0.59 | 0.63 | 0.63 | 0.66 | 0.66 | 0.70 | 0.68 | 0.72 | 0.70 | 0.74 |
| Heavy Areas | 90 | 0.71 | 0.73 | 0.73 | 0.75 | 0.75 | 0.77 | 0.78 | 0.80 | 0.80 | 0.82 | 0.81 | 0.83 |
| Parks and Cemeteries | | | | | | | | | | | | | |
| Playgrounds | 13 | 0.07 | 0.13 | 0.16 | 0.23 | 0.24 | 0.31 | 0.32 | 0.42 | 0.37 | 0.48 | 0.41 | 0.54 |
| Railroad Yard Areas | 40 | 0.23 | 0.28 | 0.30 | 0.35 | 0.36 | 0.42 | 0.42 | 0.50 | 0.46 | 0.54 | 0.50 | 0.58 |
| Undeveloped Areas | | | | | | | | | | | | | |
| Historic Flow Analysis-- Greenbelts, Agriculture | 2 | 0.03 | 0.05 | 0.09 | 0.16 | 0.17 | 0.26 | 0.26 | 0.38 | 0.31 | 0.45 | 0.36 | 0.51 |
| Pasture/Meadow | 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 |
| 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 |
| Exposed Rock | 100 | 0.89 | 0.89 | 0.90 | 0.90 | 0.92 | 0.92 | 0.94 | 0.94 | 0.95 | 0.95 | 0.96 | 0.96 |
| Offsite Flow Analysis (when landuse is undefined) | 45 | 0.26 | 0.31 | 0.32 | 0.37 | 0.38 | 0.44 | 0.44 | 0.51 | 0.48 | 0.55 | 0.51 | 0.59 |
| Streets | | | | | | | | | | | | | |
| Paved | 100 | 0.89 | 0.89 | 0.90 | 0.90 | 0.92 | 0.92 | 0.94 | 0.94 | 0.95 | 0.95 | 0.96 | 0.96 |
| Gravel | 80 | 0.57 | 0.60 | 0.59 | 0.63 | 0.63 | 0.66 | 0.66 | 0.70 | 0.68 | 0.72 | 0.70 | 0.74 |
| Drive and Walks | | | | | | | | | | | | | |
| Roofs | 90 | 0.89 | 0.89 | 0.90 | 0.90 | 0.92 | 0.92 | 0.94 | 0.94 | 0.95 | 0.95 | 0.96 | 0.96 |
| Lawns | 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 |

3.2 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration can be an empirical value that results in reasonable and acceptable peak flow calculations.

For urban areas, the time of concentration (t_c) consists of an initial time or overland flow time (t_i) plus the travel time (t_t) in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time (t_i) plus the time of travel in a concentrated form, such as a swale or drainageway. The travel portion (t_t) of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Initial time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. The time of concentration is represented by Equation 6-7 for both urban and non-urban areas.

Table 3. Summary of Discharges (Cont'd)

| Flooding Source and Location | Drainage Area (Square Miles) | Peak Discharges (Cubic Feet Per Second) | | | |
|---|---------------------------------|---|-----------------|----------------|----------------|
| | | 10-Year | 50-Year | 100-Year | 500-Year |
| Sand Creek East Fork Subtributary At confluence with Sand Creek East Fork | 5.92 | 610 | 1,480 | 1,970 | 3,800 |
| Sand Creek West Fork At confluence with Sand Creek ¹ Above Platte Avenue | 5.17 -- ² | 3,459 3,510 | 4,727 5,490 | 5,162 6,810 | 5,542 9,600 |
| Security Creek Upstream of confluence with Windmill Gulch | 3.7 | 2,700 | 4,300 | 5,400 | 10,100 |
| South Shooks Run At confluence with Fountain Creek | 7.82 | 2,640 | 4,230 | 5,570 | 8,000 |
| South Valley Dry Creek Above confluence with Dry Creek | 0.15 | -- ² | -- ² | 162 | 229 |
| Spring Creek At confluence with Fountain Creek | 6.7 | 960 | 1,790 | 2,340 | 4,340 |
| Spring Run At Interstate 25 | 3.63 | 890 | 1,350 | 1,660 | 2,340 |
| Sutherland Creek At confluence with Fountain Creek | 5.09 | 1,810 | 3,400 | 4,700 | 7,500 |
| Templeton Gap Floodway At Academy Boulevard Approximately 2,300 feet above Academy Boulevard | 2.49 2.14 | 2,820 2,440 | 4,180 3,610 | 5,040 4,340 | 6,800 5,850 |

¹Discharges are reduced because of losses at Platte Avenue²Data not available

Appendix B
Hydraulic Calculations

FOUNTAIN CREEK

HEC-RAS Plan: FC_Mar 2013 (Continued)

| Reach | River Sta | Profile | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crt W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # Chl |
|------------|-----------|---------|------------------|-------------------|-------------------|------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|--------------|
| NOF to SOF | 17515 | 10 YR | 7900.00 | 5851.04 | 5858.87 | 5856.39 | 5859.29 | 0.001224 | 5.45 | 2056.30 | 746.04 | 0.40 |
| NOF to SOF | 17515 | 50 YR | 14300.00 | 5851.04 | 5860.41 | 5858.45 | 5861.05 | 0.001583 | 7.08 | 3105.49 | 784.62 | 0.46 |
| NOF to SOF | 17515 | 100 YR | 18000.00 | 5851.04 | 5861.09 | 5859.11 | 5861.86 | 0.001760 | 7.86 | 3572.82 | 799.56 | 0.49 |
| NOF to SOF | 17515 | 500 YR | 29079.86 | 5851.04 | 5862.76 | 5860.70 | 5863.89 | 0.002178 | 9.78 | 4716.88 | 821.45 | 0.55 |
| NOF to SOF | 17430 | Bridge | | | | | | | | | | |
| NOF to SOF | 17374 | 10 YR | 7900.00 | 5851.07 | 5858.11 | 5856.01 | 5858.43 | 0.001865 | 5.17 | 1915.74 | 658.32 | 0.40 |
| NOF to SOF | 17374 | 50 YR | 14300.00 | 5851.07 | 5859.71 | 5857.84 | 5860.16 | 0.001866 | 6.18 | 2827.19 | 671.72 | 0.42 |
| NOF to SOF | 17374 | 100 YR | 18000.00 | 5851.07 | 5860.42 | 5858.23 | 5860.96 | 0.001934 | 6.72 | 3237.50 | 677.86 | 0.43 |
| NOF to SOF | 17374 | 500 YR | 29079.86 | 5851.07 | 5862.19 | 5859.43 | 5862.97 | 0.002097 | 8.05 | 4342.69 | 809.28 | 0.46 |
| NOF to SOF | 17342 | 10 YR | 7900.00 | 5851.00 | 5857.63 | 5856.99 | 5858.28 | 0.003165 | 7.47 | 1641.44 | 576.51 | 0.55 |
| NOF to SOF | 17342 | 50 YR | 14300.00 | 5851.00 | 5859.28 | 5858.15 | 5860.02 | 0.002925 | 8.49 | 2630.63 | 602.51 | 0.55 |
| NOF to SOF | 17342 | 100 YR | 18000.00 | 5851.00 | 5860.00 | 5858.66 | 5860.82 | 0.003005 | 9.14 | 3057.05 | 606.84 | 0.58 |
| NOF to SOF | 17342 | 500 YR | 29079.86 | 5851.00 | 5861.71 | 5859.98 | 5862.82 | 0.003265 | 10.81 | 4117.32 | 650.83 | 0.61 |
| NOF to SOF | 17284 | 10 YR | 7900.00 | 5849.90 | 5856.74 | 5856.74 | 5857.99 | 0.005437 | 10.07 | 1199.10 | 506.45 | 0.74 |
| NOF to SOF | 17284 | 50 YR | 14300.00 | 5849.90 | 5858.09 | 5858.09 | 5859.72 | 0.006205 | 12.31 | 1897.40 | 541.28 | 0.82 |
| NOF to SOF | 17284 | 100 YR | 18000.00 | 5849.90 | 5858.72 | 5858.72 | 5860.51 | 0.006367 | 13.21 | 2243.93 | 558.95 | 0.84 |
| NOF to SOF | 17284 | 500 YR | 29079.86 | 5849.90 | 5860.20 | 5860.20 | 5862.47 | 0.006942 | 15.51 | 3103.63 | 604.52 | 0.90 |
| NOF to SOF | 17250 | 10 YR | 7900.00 | 5846.00 | 5853.97 | 5852.49 | 5855.77 | 0.005717 | 10.77 | 733.68 | 201.62 | 0.72 |
| NOF to SOF | 17250 | 50 YR | 14300.00 | 5846.00 | 5856.59 | 5855.32 | 5858.54 | 0.005658 | 12.03 | 1622.20 | 492.72 | 0.71 |
| NOF to SOF | 17250 | 100 YR | 18000.00 | 5846.00 | 5857.71 | 5857.40 | 5859.52 | 0.005049 | 12.09 | 2182.25 | 507.58 | 0.67 |
| NOF to SOF | 17250 | 500 YR | 29079.86 | 5846.00 | 5859.95 | 5859.16 | 5861.86 | 0.004676 | 13.25 | 3379.58 | 577.67 | 0.67 |
| NOF to SOF | 16973 | 10 YR | 7900.00 | 5846.00 | 5851.63 | 5851.31 | 5853.27 | 0.015396 | 10.30 | 767.02 | 189.94 | 0.90 |
| NOF to SOF | 16973 | 50 YR | 14300.00 | 5846.00 | 5853.28 | 5853.23 | 5855.93 | 0.017802 | 13.03 | 1097.60 | 204.59 | 0.99 |
| NOF to SOF | 16973 | 100 YR | 18000.00 | 5846.00 | 5854.49 | 5854.49 | 5857.21 | 0.015127 | 13.27 | 1408.15 | 333.23 | 0.93 |
| NOF to SOF | 16973 | 500 YR | 29079.86 | 5846.00 | 5856.95 | 5856.95 | 5859.86 | 0.011496 | 14.23 | 2407.92 | 461.67 | 0.85 |
| NOF to SOF | 16672 | 10 YR | 7900.00 | 5845.00 | 5850.82 | 5848.92 | 5851.33 | 0.002679 | 5.71 | 1382.79 | 314.84 | 0.48 |
| NOF to SOF | 16672 | 50 YR | 14300.00 | 5845.00 | 5852.93 | 5850.39 | 5853.86 | 0.002734 | 6.85 | 2101.63 | 377.85 | 0.49 |
| NOF to SOF | 16672 | 100 YR | 18000.00 | 5845.00 | 5853.81 | 5851.09 | 5854.67 | 0.002849 | 7.49 | 2476.43 | 459.04 | 0.50 |
| NOF to SOF | 16672 | 500 YR | 29079.86 | 5845.00 | 5856.15 | 5852.95 | 5857.31 | 0.002847 | 8.76 | 3597.06 | 491.92 | 0.51 |
| NOF to SOF | 16643 | 10 YR | 7900.00 | 5845.00 | 5850.78 | 5848.99 | 5851.23 | 0.001953 | 5.51 | 1624.07 | 458.18 | 0.46 |
| NOF to SOF | 16643 | 50 YR | 14300.00 | 5845.00 | 5852.95 | 5850.41 | 5853.50 | 0.001710 | 6.28 | 2739.78 | 581.51 | 0.43 |
| NOF to SOF | 16643 | 100 YR | 18000.00 | 5845.00 | 5853.87 | 5851.06 | 5854.48 | 0.001700 | 6.72 | 3271.63 | 602.04 | 0.43 |
| NOF to SOF | 16643 | 500 YR | 29079.86 | 5845.00 | 5856.29 | 5852.76 | 5857.04 | 0.001597 | 7.62 | 4721.54 | 627.38 | 0.42 |
| NOF to SOF | 16625 | Bridge | | | | | | | | | | |
| NOF to SOF | 16607 | 10 YR | 7900.00 | 5845.00 | 5850.64 | 5848.88 | 5851.01 | 0.004136 | 5.08 | 1618.90 | 476.35 | 0.45 |
| NOF to SOF | 16607 | 50 YR | 14300.00 | 5845.00 | 5852.83 | 5850.24 | 5853.24 | 0.002943 | 5.28 | 2795.29 | 569.97 | 0.39 |
| NOF to SOF | 16607 | 100 YR | 18000.00 | 5845.00 | 5853.73 | 5850.82 | 5854.20 | 0.002701 | 5.58 | 3314.58 | 581.52 | 0.38 |
| NOF to SOF | 16607 | 500 YR | 29079.86 | 5845.00 | 5856.13 | 5852.26 | 5856.73 | 0.002267 | 6.29 | 4732.52 | 612.32 | 0.37 |
| NOF to SOF | 16560 | 10 YR | 7900.00 | 5845.00 | 5848.89 | 5848.89 | 5850.40 | 0.008999 | 10.17 | 846.12 | 281.59 | 0.94 |
| NOF to SOF | 16560 | 50 YR | 14300.00 | 5845.00 | 5850.45 | 5850.45 | 5852.52 | 0.008618 | 12.15 | 1341.66 | 357.77 | 0.95 |
| NOF to SOF | 16560 | 100 YR | 18000.00 | 5845.00 | 5851.50 | 5851.35 | 5853.54 | 0.007024 | 12.23 | 1776.52 | 496.09 | 0.87 |
| NOF to SOF | 16560 | 500 YR | 29079.86 | 5845.00 | 5855.14 | 5853.25 | 5856.42 | 0.002672 | 10.30 | 3826.99 | 591.11 | 0.58 |
| NOF to SOF | 16544 | 10 YR | 7900.00 | 5843.00 | 5847.68 | 5847.68 | 5849.59 | 0.016934 | 11.09 | 712.37 | 236.42 | 1.02 |
| NOF to SOF | 16544 | 50 YR | 14300.00 | 5843.00 | 5850.23 | 5849.59 | 5851.94 | 0.009038 | 10.78 | 1408.89 | 298.89 | 0.78 |
| NOF to SOF | 16544 | 100 YR | 18000.00 | 5843.00 | 5851.74 | 5850.42 | 5853.28 | 0.006373 | 10.36 | 1946.21 | 451.88 | 0.67 |
| NOF to SOF | 16544 | 500 YR | 29079.86 | 5843.00 | 5855.12 | 5852.77 | 5856.36 | 0.003454 | 9.82 | 3692.94 | 577.39 | 0.53 |
| NOF to SOF | 16431 | 10 YR | 7900.00 | 5838.70 | 5847.05 | 5843.88 | 5847.80 | 0.002578 | 6.96 | 1135.11 | 175.60 | 0.46 |
| NOF to SOF | 16431 | 50 YR | 14300.00 | 5838.70 | 5850.20 | 5846.25 | 5851.27 | 0.002542 | 8.39 | 1833.51 | 285.74 | 0.47 |
| NOF to SOF | 16431 | 100 YR | 18000.00 | 5838.70 | 5851.55 | 5847.34 | 5852.76 | 0.002490 | 9.05 | 2254.68 | 358.75 | 0.48 |
| NOF to SOF | 16431 | 500 YR | 29079.86 | 5838.70 | 5854.67 | 5850.62 | 5856.04 | 0.002259 | 10.15 | 3850.74 | 613.49 | 0.47 |
| NOF to SOF | 16191 | 10 YR | 7900.00 | 5837.00 | 5846.06 | 5843.00 | 5847.07 | 0.003338 | 8.08 | 978.23 | 130.30 | 0.52 |
| NOF to SOF | 16191 | 50 YR | 14300.00 | 5837.00 | 5848.75 | 5845.73 | 5850.43 | 0.004247 | 10.48 | 1461.61 | 254.72 | 0.59 |
| NOF to SOF | 16191 | 100 YR | 18000.00 | 5837.00 | 5850.04 | 5847.08 | 5851.93 | 0.004164 | 11.28 | 1843.06 | 347.71 | 0.60 |
| NOF to SOF | 16191 | 500 YR | 29079.86 | 5837.00 | 5853.45 | 5851.22 | 5855.34 | 0.003317 | 12.04 | 3334.51 | 664.89 | 0.56 |
| Main DS | 15913 | 10 YR | 7900.00 | 5835.00 | 5844.97 | 5842.35 | 5846.03 | 0.004141 | 8.53 | 1069.94 | 208.30 | 0.55 |
| Main DS | 15913 | 50 YR | 14300.00 | 5835.00 | 5847.72 | 5845.41 | 5849.21 | 0.004125 | 10.40 | 1681.86 | 248.32 | 0.57 |
| Main DS | 15913 | 100 YR | 18000.00 | 5835.00 | 5849.07 | 5846.48 | 5850.73 | 0.004031 | 11.15 | 2032.61 | 270.62 | 0.58 |
| Main DS | 15913 | 500 YR | 29400.00 | 5835.00 | 5851.87 | 5849.32 | 5854.22 | 0.004519 | 13.64 | 2827.58 | 292.77 | 0.63 |
| Main DS | 15241 | 10 YR | 7900.00 | 5831.00 | 5841.41 | 5839.00 | 5842.41 | 0.007213 | 8.05 | 890.11 | 169.57 | 0.57 |
| Main DS | 15241 | 50 YR | 14300.00 | 5831.00 | 5844.12 | 5841.57 | 5845.64 | 0.007064 | 9.97 | 1503.65 | 223.98 | 0.59 |
| Main DS | 15241 | 100 YR | 18000.00 | 5831.00 | 5845.13 | 5842.84 | 5847.03 | 0.007817 | 11.19 | 1749.88 | 304.27 | 0.63 |
| Main DS | 15241 | 500 YR | 29400.00 | 5831.00 | 5848.04 | 5846.29 | 5850.33 | 0.007578 | 12.79 | 2821.89 | 596.70 | 0.64 |
| Main DS | 14715 | 10 YR | 7900.00 | 5828.82 | 5840.15 | 5835.08 | 5840.60 | 0.001749 | 5.50 | 1623.53 | 339.83 | 0.33 |
| Main DS | 14715 | 50 YR | 14300.00 | 5828.82 | 5843.37 | 5837.75 | 5843.84 | 0.001554 | 6.02 | 3079.94 | 513.41 | 0.32 |

PROJECT
DATA

Table EDB-4. EDB component criteria



| | On-Site EDBs for Watersheds up to 1 Impervious Acre ¹ | EDBs with Watersheds between 1 and 2 Impervious Acres ¹ | EDBs with Watersheds up to 5 Impervious Acres | EDBs with Watersheds over 5 Impervious Acres | EDBs with Watersheds over 20 Impervious Acres |
|---|--|---|---|---|--|
| Forebay Release and Configuration | EDBs should not be used for watersheds with less than 1 impervious acre. | Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration | Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration | Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration | Release 2% of the undetained 100-year peak discharge by way of a wall/notch or berm/pipe ² configuration |
| Minimum Forebay Volume | | 1% of the WQCV | 2% of the WQCV | 3% of the WQCV | 3% of the WQCV |
| Maximum Forebay Depth | | 12 inches | 18 inches | 18 inches | 30 inches |
| Trickle Channel Capacity | | ≥ the maximum possible forebay outlet capacity | ≥ the maximum possible forebay outlet capacity | ≥ the maximum possible forebay outlet capacity | ≥ the maximum possible forebay outlet capacity |
| Micropool | | Area ≥ 10 ft ² | Area ≥ 10 ft ² | Area ≥ 10 ft ² | Area ≥ 10 ft ² |
| Initial Surcharge Volume | | Depth ≥ 4 inches | Depth ≥ 4 inches | Depth ≥ 4 in. Volume ≥ 0.3% WQCV | Depth ≥ 4 in. Volume ≥ 0.3% WQCV |

¹ EDBs are not recommended for sites with less than 2 impervious acres. Consider a sand filter or rain garden.

² Round up to the first standard pipe size (minimum 8 inches).

KIOWA ENGINEERING CORPORATION

JOB Ready-Top Reservoir
SHEET NO. _____ OF 17066
CALCULATED BY _____ DATE 3/10/19
CHECKED BY _____ DATE RW
SCALE Water Quality Calc

Per Table EDB-4, UDFCD Vol 3.

Watershed with over 5 imp. Acres (Includes R&P)

Forebay Release \geq 2% of Undetained Inflow
 $Q_{\text{undetained}} = 98.7 \therefore \text{Release} = .02(98.7) = 2.0 \text{ cfs}$

Forebay Volume \geq
 $.036(WQCV) = .065 \text{ ft} = 632 \text{ cfs}$

Maximum Forebay depth = 18"

Trickle Channel Cap:
 \geq Forebay Release 2.0 cfs

Micropool Area $\geq 10 \text{ sf}$

Initial Surge $\geq 4"$, use 12"

$$\text{Volume} = .39(WQCV) = .00145 \\ = 63.2 \text{ ft}^3$$

Surge Volume provided:

$$(8' \times 8' \times 1') = \underline{64 \text{ cfs}}$$

Micro-pool area provide = $8' \times 8' = 64 \text{ sf}$

KIOWA ENGINEERING CORPORATION

JOB Rocky Top Reservoir
 SHEET NO. _____ OF 17006
 CALCULATED BY _____ DATE 3/10/19
 CHECKED BY _____ DATE 3/10/19
 SCALE WD Calculations

Total Acreage 44.8 ac

Area of Active Recycling operations = 30.5 ac

Superiorious Acreage

- | | | % Imp. |
|---------------------------------|--------------------|--------|
| - Concrete pads: Existing | 3.38 ac ✓ | 95 |
| - Area of Bldgs | | 90 |
| new bldg 5400 sf | | |
| - Bldgs to remain: 1500 | | |
| | 6900 sf = .16 ac ✓ | |
| - Concrete Drives: | | 95% |
| - Las Vegas Access 5750 sf | | |
| - Manipulating + driveway 10400 | | |
| | 16150 = .37 ac ✓ | |
| - Recycled Asphalt: | 3.44 ac | 80% |

Total Paved / Bldgs: 7.35 ac

Balance - piles, native grasses poor to fair = 23.1 ac 30%
 23.5 ac

$$Wt \& \% \text{ Imp} = \frac{(3.38 + .37) \cdot 95 + .16(90) + 3.44(.80) + 23.5(.30)}{30.5 \text{ ac}}$$

$$= 13.5 / 30.5 = .44 \text{ use } 44\%$$

$$\text{Imp ac} = 3.38 + .16 + .37 = 3.91 \text{ ac} \quad \text{For WD Detention}$$

UD-Detention, Version 3.07 (February 2017)

Basin ID: FSD Design Drainage area 30.45



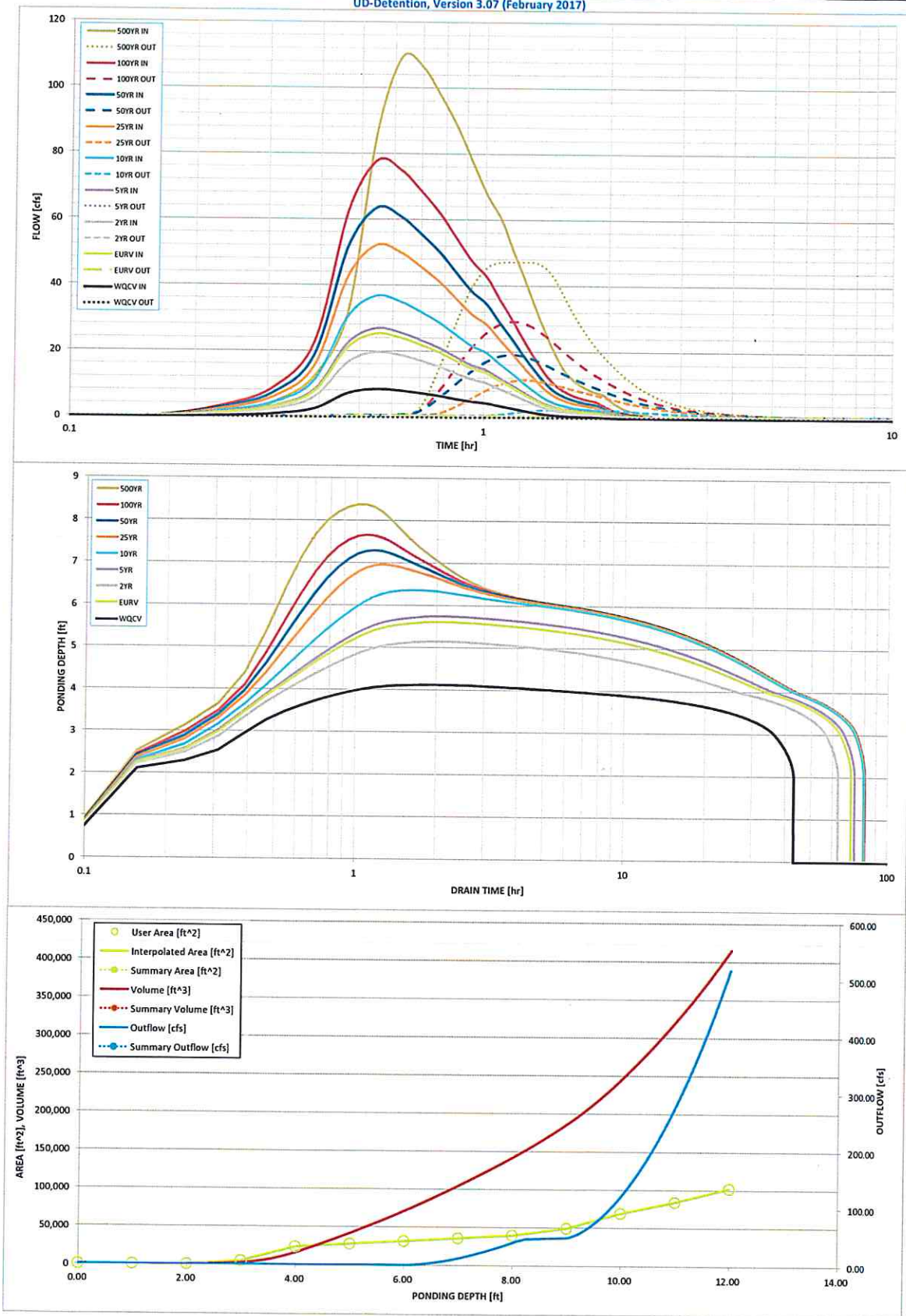
| | |
|------|--------|
| 3.20 | inches |
|------|--------|

Please provide the stage-storage calculation that is part of this calculation sheet as done in the previous submittal.

10/1/2019, 12:19 PM

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)



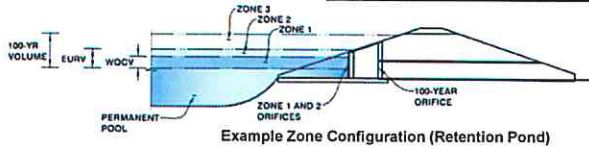
| S-A-V-D Chart Axis Override | X-axis | Left Y-Axis | Right Y-Axis |
|-----------------------------|--------|-------------|--------------|
| minimum bound | | | |
| maximum bound | | | |

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: Rocky Top Resources

Basin ID: FSD design drainage area 30.45 acres



| | Stage (ft) | Zone Volume (ac-ft) | Outlet Type |
|---------------|------------|---------------------|----------------------|
| Zone 1 (WQCV) | 4.21 | 0.483 | Orifice Plate |
| Zone 2 (EURV) | 5.72 | 0.946 | Orifice Plate |
| (100+1/2WQCV) | 7.51 | 1.392 | Weir&Pipe (Restrict) |
| | | 2.820 | Total |

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

Underdrain Orifice Invert Depth = ft (distance below the filtration media surface)
Underdrain Orifice Diameter = inches

Calculated Parameters for Underdrain

Underdrain Orifice Area = ft²
Underdrain Orifice Centroid = feet

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

Invert of Lowest Orifice = ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate = ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing = inches
Orifice Plate: Orifice Area per Row = inches

Calculated Parameters for Plate

WQ Orifice Area per Row = ft²
Elliptical Half-Width = feet
Elliptical Slot Centroid = feet
Elliptical Slot Area = ft²

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

| | Row 1 (required) | Row 2 (optional) | Row 3 (optional) | Row 4 (optional) | Row 5 (optional) | Row 6 (optional) | Row 7 (optional) | Row 8 (optional) |
|--------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Stage of Orifice Centroid (ft) | 0.00 | 1.98 | 3.96 | | | | | |
| Orifice Area (sq. inches) | 1.00 | 1.50 | 8.00 | | | | | |

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

User Input: Vertical Orifice (Circular or Rectangular)

Invert of Vertical Orifice = ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice = ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter = inches

Calculated Parameters for Vertical Orifice

Vertical Orifice Area = ft²
Vertical Orifice Centroid = feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

Overflow Weir Front Edge Height, H_o = ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length = feet
Overflow Weir Slope = H:V (enter zero for flat grate)
Horiz. Length of Weir Sides = feet
Overflow Grate Open Area % = % grate open area/total area
Debris Clogging % = %

Calculated Parameters for Overflow Weir

Height of Grate Upper Edge, H_i = feet
Over Flow Weir Slope Length = feet
Grate Open Area / 100-yr Orifice Area = should be ≥ 4
Overflow Grate Open Area w/o Debris = ft²
Overflow Grate Open Area w/ Debris = ft²

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

Depth to Invert of Outlet Pipe = ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter = inches
Restrictor Plate Height Above Pipe Invert = inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

Outlet Orifice Area = ft²
Outlet Orifice Centroid = feet
Half-Central Angle of Restrictor Plate on Pipe = radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

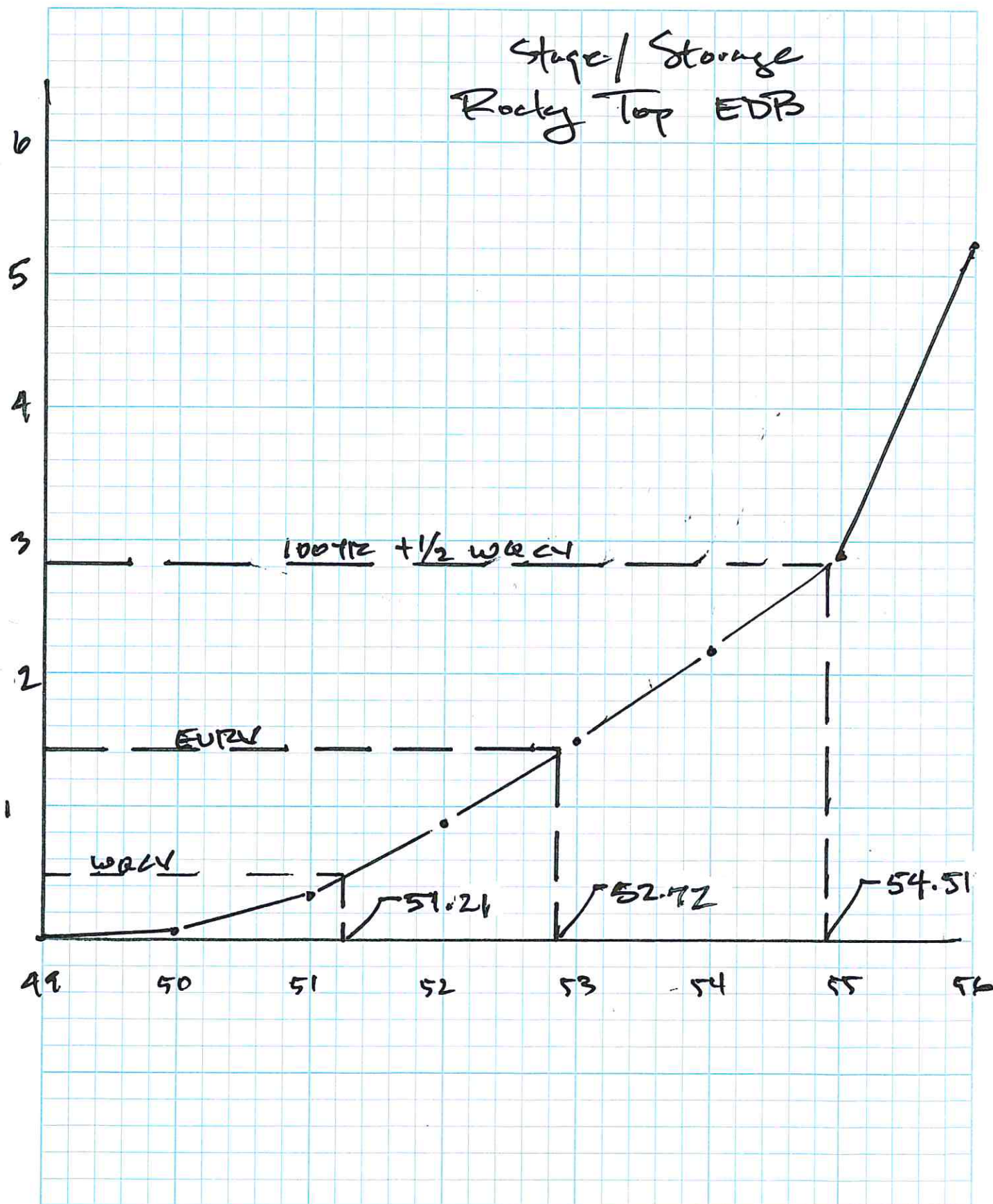
Spillway Invert Stage = ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length = feet
Spillway End Slopes = H:V
Freeboard above Max Water Surface = feet

Calculated Parameters for Spillway

Spillway Design Flow Depth = feet
Stage at Top of Freeboard = feet
Basin Area at Top of Freeboard = acres

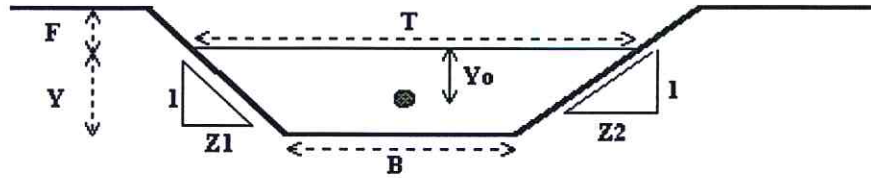
Routed Hydrograph Results

| | WQCV | EURV | 2 Year | 5 Year | 10 Year | 25 Year | 50 Year | 100 Year | 500 Year |
|---|-------|-------|--------|--------|------------------|------------------|------------------|------------------|----------------|
| Design Storm Return Period = | | | | | | | | | |
| One-Hour Rainfall Depth (in) = | 0.53 | 1.07 | 1.19 | 1.50 | 1.75 | 2.00 | 2.25 | 2.52 | 3.20 |
| Calculated Runoff Volume (acre-ft) = | 0.483 | 1.429 | 1.111 | 1.524 | 2.089 | 2.991 | 3.648 | 4.499 | 6.381 |
| OPTIONAL Override Runoff Volume (acre-ft) = | | | | | | | | | |
| Inflow Hydrograph Volume (acre-ft) = | 0.482 | 1.427 | 1.110 | 1.523 | 2.087 | 2.989 | 3.645 | 4.496 | 6.369 |
| Predevelopment Unit Peak Flow, q (cfs/acre) = | 0.00 | 0.00 | 0.01 | 0.02 | 0.19 | 0.62 | 0.88 | 1.22 | 1.89 |
| Predevelopment Peak Q (cfs) = | 0.0 | 0.0 | 0.3 | 0.6 | 5.8 | 18.8 | 26.8 | 37.1 | 57.6 |
| Peak Inflow Q (cfs) = | 8.6 | 25.1 | 19.6 | 26.8 | 36.6 | 52.1 | 63.4 | 77.9 | 109.4 |
| Peak Outflow Q (cfs) = | 0.3 | 0.5 | 0.5 | 0.5 | 2.6 | 11.4 | 19.0 | 29.1 | 47.2 |
| Ratio Peak Outflow to Predevelopment Q = | N/A | N/A | N/A | 0.9 | 0.4 | 0.6 | 0.7 | 0.8 | 0.8 |
| Structure Controlling Flow = | Plate | Plate | Plate | Plate | Overflow Grate 1 | Overflow Grate 1 | Overflow Grate 1 | Overflow Grate 1 | Outlet Plate 1 |
| Max Velocity through Grate 1 (fps) = | N/A | N/A | N/A | N/A | 0.1 | 0.4 | 0.7 | 1.1 | 1.8 |
| Max Velocity through Grate 2 (fps) = | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Time to Drain 97% of Inflow Volume (hours) = | 41 | 65 | 59 | 67 | 72 | 70 | 68 | 65 | 60 |
| Time to Drain 99% of Inflow Volume (hours) = | 42 | 69 | 61 | 71 | 77 | 76 | 76 | 75 | 73 |
| Maximum Ponding Depth (ft) = | 4.14 | 5.61 | 5.15 | 5.74 | 6.35 | 6.96 | 7.29 | 7.66 | 8.37 |
| Area at Maximum Ponding Depth (acres) = | 0.55 | 0.69 | 0.64 | 0.70 | 0.75 | 0.81 | 0.84 | 0.87 | 0.99 |
| Maximum Volume Stored (acre-ft) = | 0.448 | 1.350 | 1.045 | 1.447 | 1.890 | 2.359 | 2.639 | 2.948 | 3.611 |



Critical Flow Analysis - Trapezoidal Channel

Project: 17066 Rocky Top Resources
 Channel ID: Spillway design Q over spillway =100 cfs



Design Information (Input)

| | |
|------------------|-----------------|
| Bottom Width | B = 20.00 ft |
| Left Side Slope | Z1 = 4.00 ft/ft |
| Right Side Slope | Z2 = 4.00 ft/ft |
| Design Discharge | Q = 80.00 cfs |

Critical Flow Condition (Calculated)

| | |
|------------------------------------|-----------------|
| Critical Flow Depth | Y = 0.75 ft |
| Critical Flow Area | A = 17.25 sq ft |
| Critical Top Width | T = 26.00 ft |
| Critical Hydraulic Depth | D = 0.66 ft |
| Critical Flow Velocity | V = 4.64 fps |
| Froude Number | Fr = 1.00 |
| Critical Wetted Perimeter | P = 26.18 ft |
| Critical Hydraulic Radius | R = 0.66 ft |
| Critical (min) Specific Energy | Esc = 1.08 ft |
| Centroid on the Critical Flow Area | Yoc = 0.34 ft |
| Critical (min) Specific Force | Fsc = 1.09 kip |

$$Q/b = 80/20 = 4.0$$

Figure 13-12c. Emergency Spillway Protection

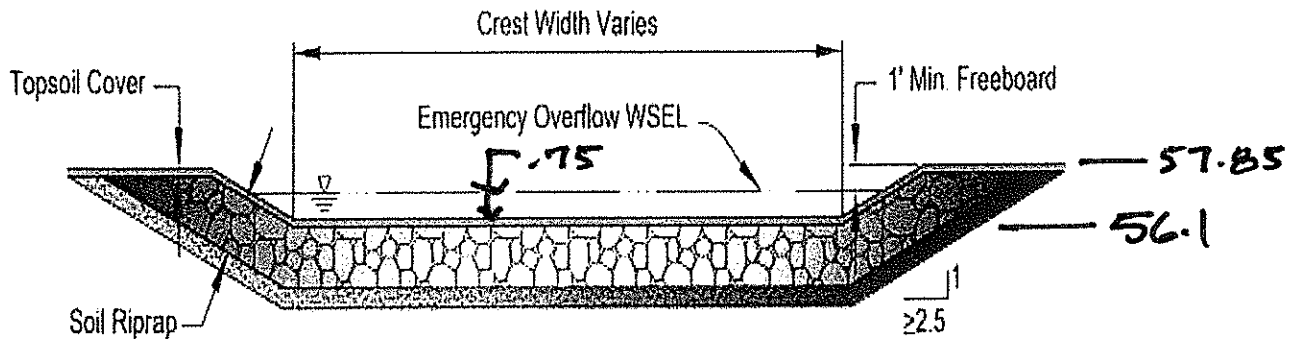
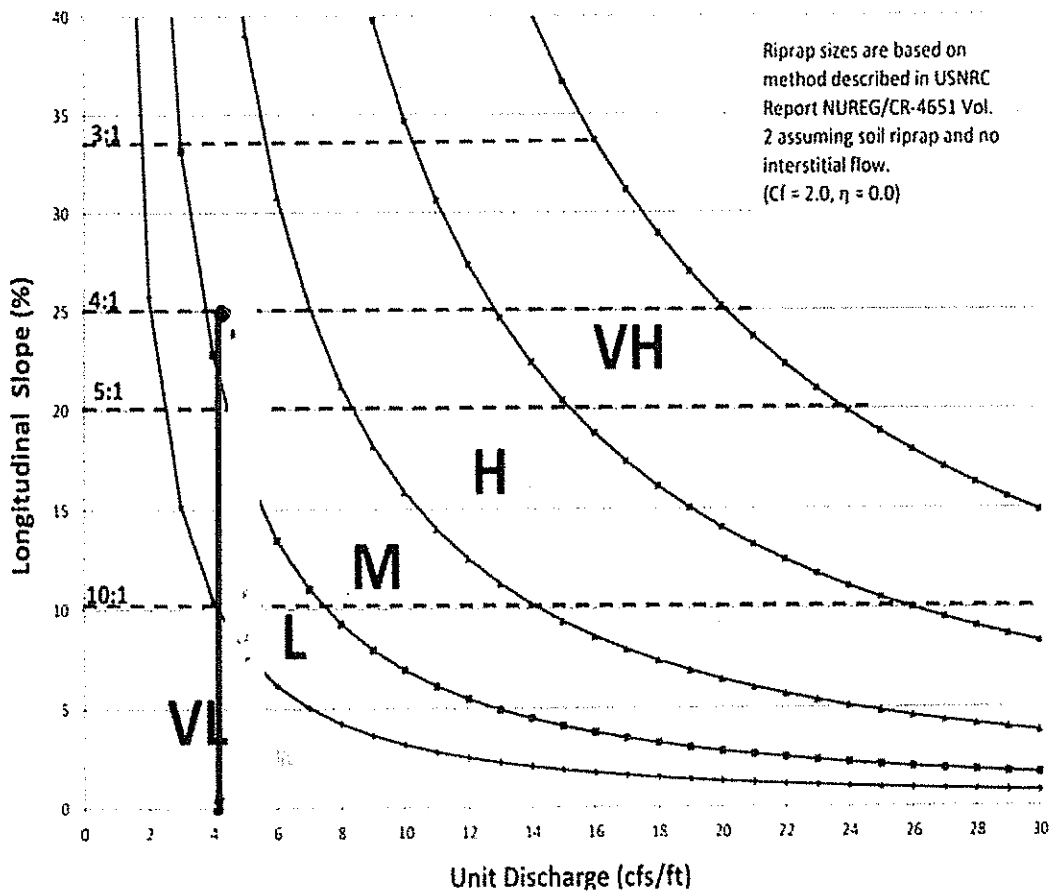


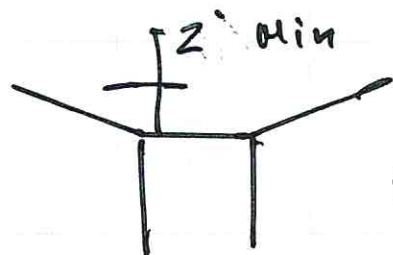
Figure 13-12d. Riprap Types for Emergency Spillway Protection



* TYPE M SOIL/RIPRAP

Type 'C' inlet & cutries to EDB

Assume 40 cfs (1/2 Q_{100} to each inlet) $Q_{100} = 79.5 \text{ cfs}$



35" x 35" opening; std grate

$$A = 5.83 \text{ sf}$$

$$Q = C C_B A \sqrt{2gH} \quad C = .6; C_B = .75$$

$$Q = .6(.75) \sqrt{2g(2)} (5.83) = 29.7 \text{ cfs} \quad \underline{\text{low}}$$

Bay Type D inlet

$$35" \times 80" = 19.4 \text{ sf.}$$

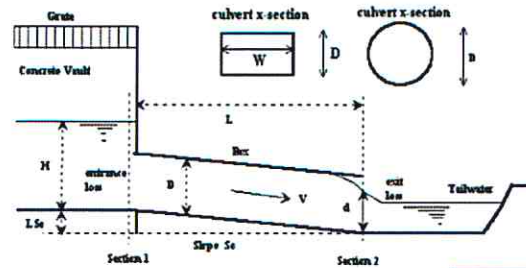
Level grate: $H = 1.5$

$$Q = .6(.75)(19.4) \sqrt{2g(1.5)} = 86 \text{ cfs} \quad \underline{\text{ok}}$$

use 30" RCP out: @ 56 elev. $Q = 48 \text{ cfs}$

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: **Rocky Top Resources**
 Basin ID: **30-inch RCP**
 Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches
 Inlet Edge Type (choose from pull-down list)

OR:

Box Culvert: Barrel Height (Rise) in Feet
 Barrel Width (Span) in Feet
 Inlet Edge Type (choose from pull-down list)

$D =$ inches
 Square End with Headwall

Height (Rise) = ft.
 Width (Span) = ft.

1.5 : 1 Bevel w/ 45 Deg. Flared Wingwall

Number of Barrels
 Inlet Elevation at Culvert Invert
 Outlet Elevation at Culvert Invert OR Slope of Culvert (ft v./ft h.)
 Culvert Length in Feet
 Manning's Roughness
 Bend Loss Coefficient
 Exit Loss Coefficient

No =
 Inlet Elev = ft. elev.
 Outlet Elev = ft. elev.
 L = ft.
 n =
 $K_b =$
 $K_x =$

Design Information (calculated):

Entrance Loss Coefficient
 Friction Loss Coefficient
 Sum of All Loss Coefficients
 Orifice Inlet Condition Coefficient
 Minimum Energy Condition Coefficient

$K_e =$
 $K_f =$
 $K_{\Sigma} =$
 $C_d =$
 $KE_{low} =$

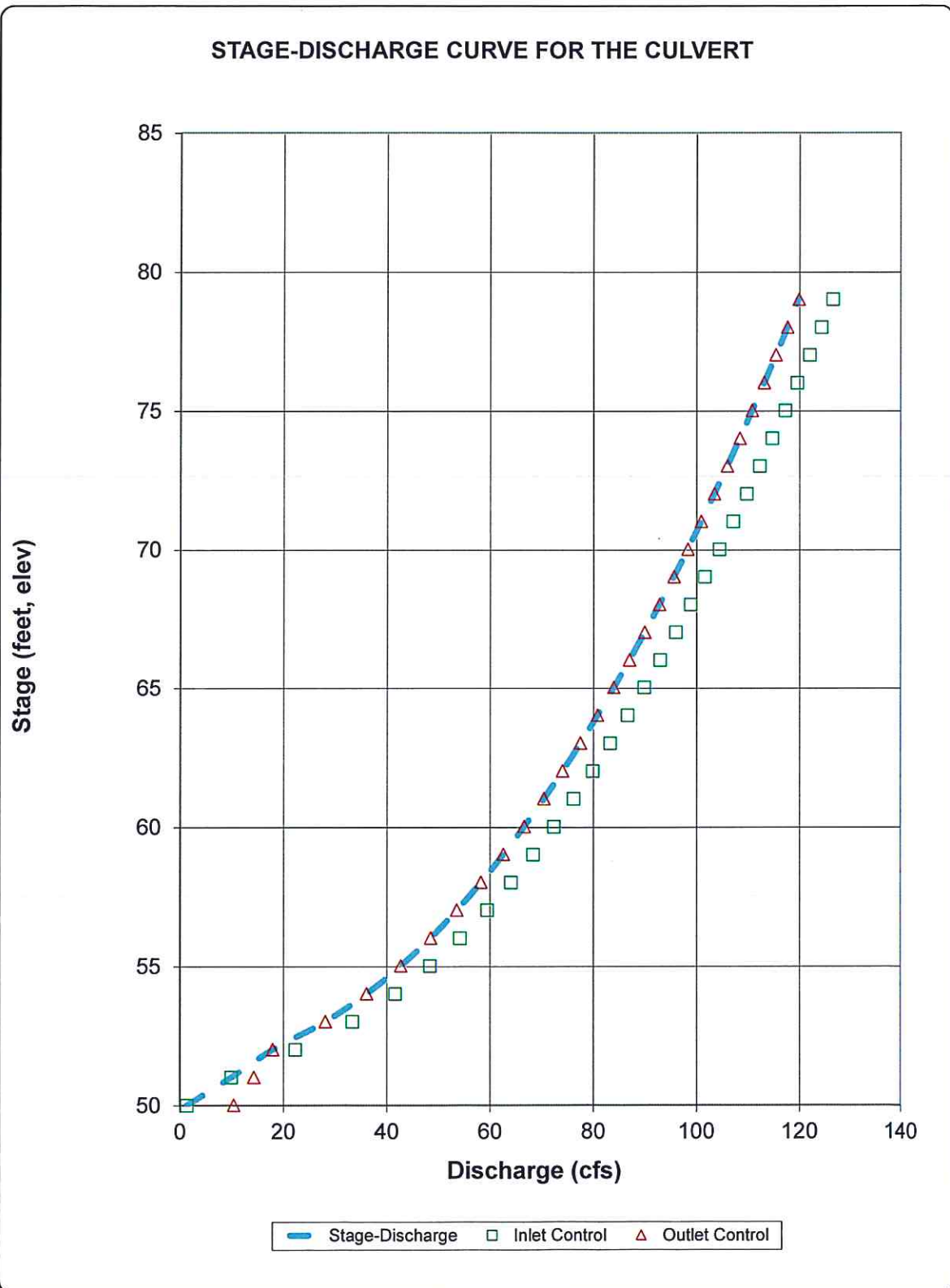
Calculations of Culvert Capacity (output):

| Water Surface Elevation (ft., linked) | Tailwater Surface Elevation ft | Culvert Inlet-Control Flowrate cfs | Culvert Outlet-Control Flowrate cfs | Controlling Culvert Flowrate cfs (output) | Inlet Equation Used: | Flow Control Used |
|--|-----------------------------------|---------------------------------------|--|--|----------------------|-------------------|
| 50.00 | 49.00 | 1.40 | 10.45 | 1.40 | Min. Energy Eqn. | INLET |
| 51.00 | 49.00 | 10.00 | 14.34 | 10.00 | Regression Eqn. | INLET |
| 52.00 | 49.00 | 22.40 | 17.99 | 17.99 | Regression Eqn. | OUTLET |
| 53.00 | 49.00 | 33.40 | 28.17 | 28.17 | Regression Eqn. | OUTLET |
| 54.00 | 49.00 | 41.70 | 36.16 | 36.16 | Regression Eqn. | OUTLET |
| 55.00 | 49.00 | 48.40 | 42.77 | 42.77 | Regression Eqn. | OUTLET |
| 56.00 | 49.00 | 54.20 | 48.51 | 48.51 | Regression Eqn. | OUTLET |
| 57.00 | 49.00 | 59.50 | 53.63 | 53.63 | Regression Eqn. | OUTLET |
| 58.00 | 49.00 | 64.10 | 58.29 | 58.29 | Orifice Eqn. | OUTLET |
| 59.00 | 49.00 | 68.40 | 62.63 | 62.63 | Orifice Eqn. | OUTLET |
| 60.00 | 49.00 | 72.40 | 66.67 | 66.67 | Orifice Eqn. | OUTLET |
| 61.00 | 49.00 | 76.20 | 70.48 | 70.48 | Orifice Eqn. | OUTLET |
| 62.00 | 49.00 | 79.90 | 74.09 | 74.09 | Orifice Eqn. | OUTLET |
| 63.00 | 49.00 | 83.30 | 77.54 | 77.54 | Orifice Eqn. | OUTLET |
| 64.00 | | 86.70 | 80.84 | 80.84 | Orifice Eqn. | OUTLET |
| 65.00 | | 89.90 | 84.01 | 84.01 | Orifice Eqn. | OUTLET |
| 66.00 | | 93.00 | 87.07 | 87.07 | Orifice Eqn. | OUTLET |
| 67.00 | | 96.00 | 90.01 | 90.01 | Orifice Eqn. | OUTLET |
| 68.00 | | 98.90 | 92.87 | 92.87 | Orifice Eqn. | OUTLET |
| 69.00 | | 101.70 | 95.65 | 95.65 | Orifice Eqn. | OUTLET |
| 70.00 | | 104.50 | 98.35 | 98.35 | Orifice Eqn. | OUTLET |
| 71.00 | | 107.20 | 100.96 | 100.96 | Orifice Eqn. | OUTLET |
| 72.00 | | 109.80 | 103.52 | 103.52 | Orifice Eqn. | OUTLET |
| 73.00 | | 112.30 | 106.01 | 106.01 | Orifice Eqn. | OUTLET |
| 74.00 | | 114.80 | 108.45 | 108.45 | Orifice Eqn. | OUTLET |
| 75.00 | | 117.30 | 110.84 | 110.84 | Orifice Eqn. | OUTLET |
| 76.00 | | 119.60 | 113.17 | 113.17 | Orifice Eqn. | OUTLET |
| 77.00 | | 122.00 | 115.46 | 115.46 | Orifice Eqn. | OUTLET |
| 78.00 | | 124.30 | 117.70 | 117.70 | Orifice Eqn. | OUTLET |
| 79.00 | | 126.50 | 119.91 | 119.91 | Orifice Eqn. | OUTLET |

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CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: Rocky Top Resources
Basin ID: 30-inch RCP



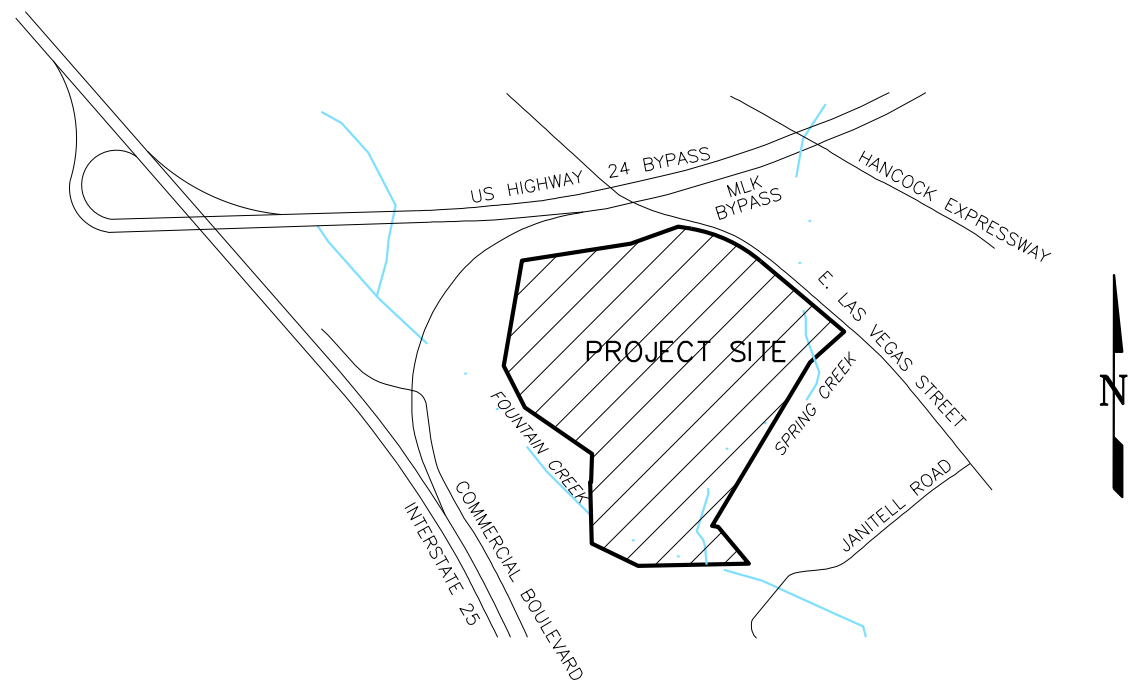
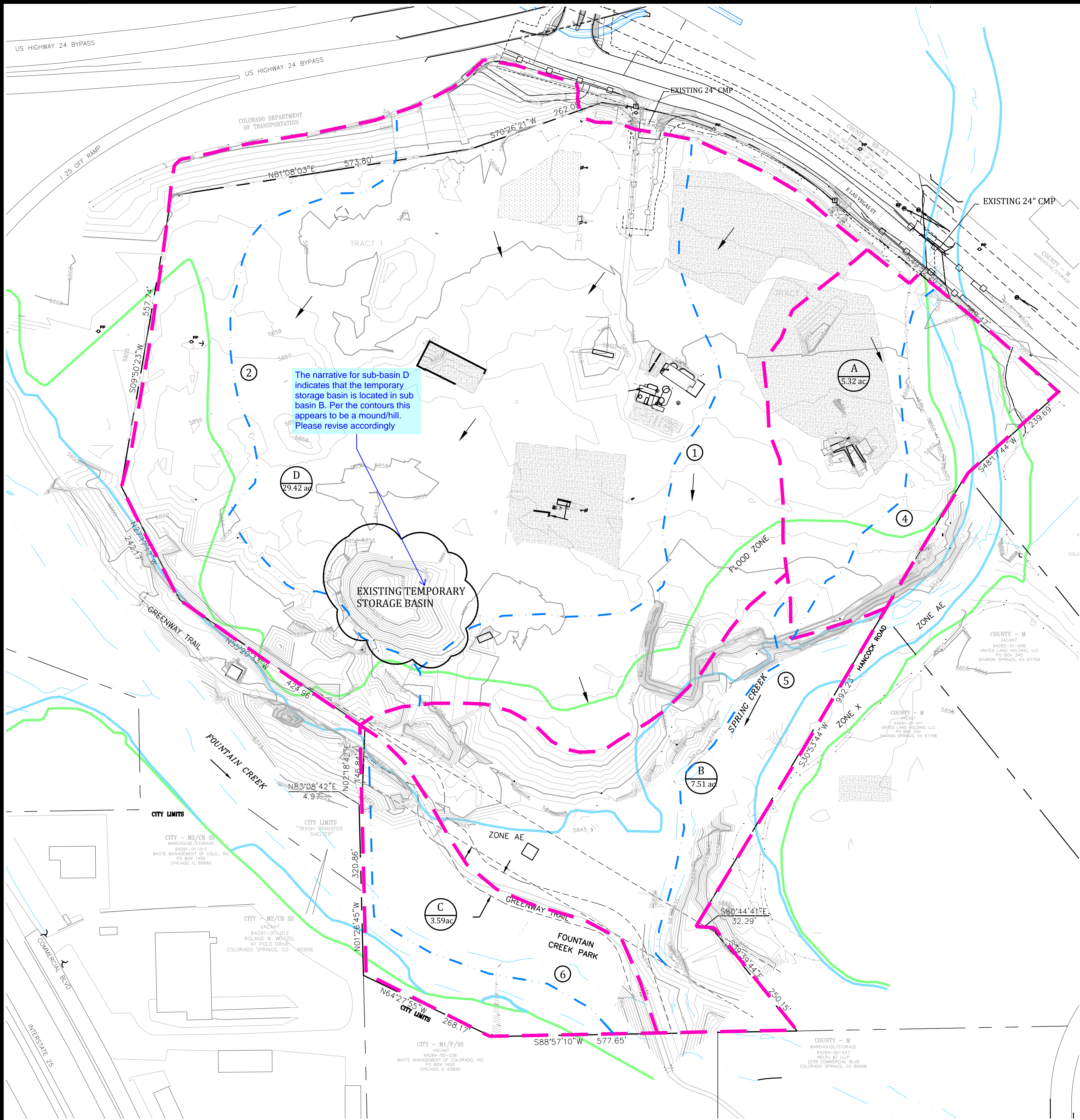


FIGURE 1
VICINITY MAP
NO SCALE

SPRING CREEK HYDROLOGY

$Q_{10} = 960$ cfs
 $Q_{50} = 1,790$ cfs
 $Q_{100} = 2,340$ cfs
 $Q_{500} = 4,340$ cfs

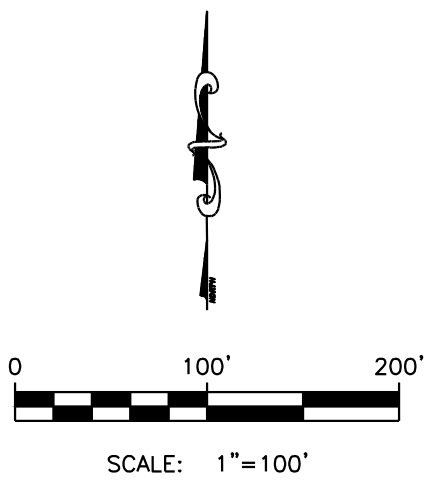
FOUNTAIN CREEK HYDROLOGY

$Q_{10} = 7,900$ cfs
 $Q_{50} = 14,300$ cfs
 $Q_{100} = 18,000$ cfs
 $Q_{500} = 29,080$ cfs

| SUMMARY OF DISCHARGES-PREDEVELOPMENT | | | |
|--------------------------------------|-------|-----|------|
| SUB-BASIN | AREA | Q5 | Q100 |
| | ac | cfs | cfs |
| A | 5.32 | 0.9 | 6.1 |
| B | 7.51 | 1.6 | 10.9 |
| C | 3.59 | 0.9 | 5.7 |
| D | 29.42 | 4.4 | 28.6 |

LEGEND

- BASIN BOUNDARY
- BASIN #
AREA IN ACRES
- DESIGN POINT
- FLOW DIRECTION
- 100 YEAR FLOODPLAIN
- 500 YEAR FLOODPLAIN
- FLOWPATH
- FLOWPATH NUMBER
- EXISTING CONCRETE PAVEMENT



ROCKY TOP RESOURCES
EXISTING DRAINAGE PLAN
TRACT 7 GARDEN VALLEY SUBDIVISION
1755 EAST LAS VEGAS STREET
COLORADO SPRINGS, COLORADO

| | |
|--------------|--------------|
| Project No.: | 17066 |
| Date: | OCTOBER 2019 |
| Design: | RNW |
| Drawn: | EAK |
| Check: | RNW |
| Revisions: | |

EXH. 1

