

# **Drainage Letter**

## **15905 Sniper Lane**

**Proposed Fountain Springs Addition No. 2**  
**(Colorado Springs Police Department Firing Range)**  
**El Paso County, Colorado**

Prepared for:  
Colorado Springs Police Department  
Pat Rigdon, 1342, Commander  
705 South Nevada Avenue  
Colorado Springs,  
CO 80903  
Ph: 719-444-7439

Prepared by:



1604 South 21st Street  
Colorado Springs, Colorado 80904  
Ph: (719)630-7342

Kiowa Project No. 19007

August 13th, 2019

## TABLE OF CONTENTS

Table of Contents.....	i
Statements and Approvals.....	ii
I. General Location and Description .....	1
II. Major Drainage Basins and Subbasins .....	1
III. Drainage Design Criteria .....	2
IV. Drainage Facility Design.....	2
A. Stormwater Detention and Water Quality Design .....	3
B. Cost of Proposed Public Drainage Facilities.....	3
C. Drainage and Bridge Fees .....	3
V. Conclusions .....	3
VI. References.....	4
Appendix Table of Contents .....	5

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

## STATEMENTS AND APPROVALS

### ENGINEER'S STATEMENT:

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

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

\_\_\_\_\_  
Registered Engineer (PE #25057)  
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: \_\_\_\_\_  
xxx  
Colorado Springs Police Department

\_\_\_\_\_  
Date

Print Name: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

### EL PASO COUNTY:

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

\_\_\_\_\_  
El Paso County Engineer/ECM Administrator

\_\_\_\_\_  
Date

## **I. GENERAL LOCATION AND DESCRIPTION**

The Site is located north of and adjacent to Pikes Peak International Raceway (PPIR). The overall property, owned by North Park 200 LLC, is approximately 199.954 acres in size with the Colorado Springs Police Department (CSPD) shooting range parcel being approximately 17.21 acres of that total. The CSPD parcel was conveyed from North Park 200 LLC to the City of Colorado Springs. The site is located southwest of exit 122 on Interstate 25. A portion of the overall site is located within the city limits of Fountain as is the PPIR site. The portion of the property within the City of Fountain was due to the contiguous annexation of PPIR. The CSPD shooting range property is located within El Paso County and is anticipated to be annexed into the City of Fountain in the future. The site is located within the southern half of Section 5, Township 17 South, Range 65 West of the 6th Principal Meridian, in El Paso County, Colorado. The overall site is bounded to the east by Interstate 25 and its frontage road, to the south by PPIR, to the west and north by Colorado Springs Utilities property. A vicinity map of the site is shown on Figure 1 included in the Appendix.

The existing vegetative cover within the development is in fair to good condition with numerous weeds and grasses throughout the site. The existing ground slopes within the overall property as well as the subject property generally northwest to southeast at slopes from 0.5 to 1.5 percent. Soils within the subject site are classified to be within Hydrologic Soils Group C (Limon Clay #47) as shown in the *El Paso County Soils Survey*.

The site lies within the Crooked Canyon Drainage Basin. Crooked Canyon is an unstudied basin and as such is classified as a miscellaneous drainage basin by El Paso County.

A major drainageway draining the property to the west runs along the southern boundary of the overall property and the northern boundary of PPIR. A small drainageway runs north to south on the western boundary of the overall property as well as the subject property. This drainageway drains to the above-mentioned major drainageway. The major drainageway is directed around the raceway of PPIR to the north and then east of the raceway. The drainageway turns south along the eastern side of the raceway where it is directed under Interstate-25 at Exit 122 and a short way south under the BNSF railroad. The drainageway converges with Fountain Creek just east of the Interstate and railroad.

The site is intended to become a training facility for Colorado Springs' first responders. The project includes four shooting ranges including three 50-yard ranges and a single 100-yard range along with classroom/instructional space.

The site has been previously studied with the proposed Colorado Training Institute for Public Safety (COTIPS) project, which was not constructed. The site layout of the shooting ranges has remained the same from the previous COTIPS project. The approved drainage report is still applicable in general to this project.

## **II. MAJOR DRAINAGE BASINS AND SUBBASINS**

The site lies within the Crooked Canyon Drainage Basin. The subject site currently sheet flows to the major drainageway, which then conveys the runoff to Fountain Creek. No offsite flow enters the subject site area as flows are directed south by the existing channel located along the western boundary of overall property and this site. The overall site is encumbered by a Zone A floodplain which is located just north of the subject site. The major drainageway to the south located generally between the overall property and PPIR is also shown as a Zone A floodplain. The floodplains are shown per FIRM map 08041C1160G (with an effective date of December 7, 2018). The floodplains have been located on the property per the FIRM maps.

There is currently offsite runoff that approaches the site from the west and is deflected by the channel along the western boundary. Offsite Basin OS1 conveys runoff by sheet flow from undeveloped land west of the site to the western property boundary, where it is turned south and directed to the drainageway on the north side of PPIR.

### **III. DRAINAGE DESIGN CRITERIA**

Hydrologic and hydraulic calculations for the site were performed using the methods outlined in the *El Paso County Drainage Criteria Manual*. Recent topography was prepared for the site. The topography was compiled using two-foot contour intervals as presented on The Drainage Plan. Hydrological Calculations were performed to reflect Proposed Conditions. The Drainage Plan presents the drainage patterns for the site, including the sub-basins. The peak flow rates for the sub-basins were estimated using Rational Method. The 5-year (Minor Storm) and 100-year (Major Storm) recurrence intervals were determined. The peak flow data generated using the Rational Method was used to size the pipes to drain each range. The drainage basin area, time of concentration, and rainfall intensity were determined for each of the sub-basins within the project. The onsite soils were assumed to be Hydrologic Soil Group C, based on the *Soil Survey*. The existing and proposed conditions are the effectively the same for the purposes of determining runoff coefficients.

Hydraulic calculations are provided for the proposed drainage facilities. No water quality facility was designed as the imperviousness between existing and proposed conditions remains effectively unchanged.

### **IV. DRAINAGE FACILITY DESIGN**

The drainage of the proposed ranges is to be accomplished by generally sloping the ranges from north to south at approximately one percent. Along the southern berm of each range the floor of the range will be tipped to the west to capture runoff in the southwest corner of each range. Each range is then drained to the existing drainage channel along the western boundary of the project and the overall property. Runoff will then be directed south to the drainageway located north of PPIR.

The proposed drainage patterns for the site are shown on the Proposed Drainage Plan (Sheet DP-1) provided in the map pocket at the end of this report. The hydrologic and hydraulic calculations are provided in the Appendix.

The following is a description of the on-site drainage sub-basins:

Sub-basin A1 is the southern 50-yard range and is approximately 1.55 acres in area. This area has been assumed to be 45% impervious as it is outside of the gravel parking surface for the PPIR overflow parking. Runoff from this basin will sheet flow to the southwest corner of the range. The anticipated runoff amounts are 2.2 cfs and 5.9 cfs for the 5 and 100-year storms respectively.

Sub-basin A2 is the middle 50-yard range and is approximately 1.46 acres in area. This area has been assumed to be 45% impervious as it is outside of the gravel parking surface for the PPIR overflow parking. Runoff from this basin will sheet flow to the southwest corner of the range. The anticipated runoff amounts are 2.1 cfs and 5.5 cfs for the 5 and 100-year storms respectively.

Sub-basin A3 is the northern 50-yard range and is approximately 1.78 acres in area. This area has been assumed to be 45% impervious as it is outside of the gravel parking surface for the PPIR overflow parking. Runoff from this basin will sheet flow to the southwest corner of the range. The anticipated runoff amounts are 2.5 cfs and 6.7 cfs for the 5 and 100-year storms respectively.

Sub-basin A4 is the 100-yard range and is approximately 3.32 acres in area. This area has been assumed to be 45% impervious as it is outside of the gravel parking surface for the PPIR overflow

parking. Runoff from this basin will sheet flow to the southwest corner of the range. The anticipated runoff amounts are 4.6 cfs and 12.2 cfs for the 5 and 100-year storms respectively.

Sub-basin A5 is the outside portion of the northern 100-yard range including the area north of the berm. The remainder of the subbasin includes the eastern portion of the site including the proposed classroom and gravel parking (native) lot. It contains approximately 6.36 acres in area. Runoff from this basin will sheet flow to the southeast in the same pattern as the existing site currently drains. The anticipated runoff amounts are 7.6 cfs and 20.0 cfs for the 5 and 100-year storms respectively.

Sub-basin A6 is the outside berm of all four ranges including the northern, western and southern berms. It contains approximately 2.21 acres in area. Runoff from this basin will sheet flow to the existing drainage channel located west of the ranges. The anticipated runoff amounts are 2.6 cfs and 6.9 cfs for the 5 and 100-year storms respectively.

Sub-basin E1 includes the existing drainage channel along the western boundary and contains approximately 0.54 acres in area. Runoff from this basin will combine with the range runoff and offsite flow and flow south and then east around the proposed ranges in the existing drainage channels. The anticipated runoff amounts are 0.3 cfs and 1.5 cfs for the 5 and 100-year storms respectively.

Sub-basin OS1 includes the offsite area to the west that is tributary to the existing drainage channel running along the western property boundary. It contains approximately 32.64 acres in area. Runoff from this basin will sheet flow to the existing drainage channel located west of the ranges. The anticipated runoff amounts are 12.8 cfs and 66.8 cfs for the 5 and 100-year storms respectively.

#### **A. STORMWATER DETENTION AND WATER QUALITY DESIGN**

Detention and storm water quality measures are not required by the County in Volume 2 of the *City/County Drainage Criteria Manual* as there is no urbanization or increase in imperviousness for the project.

#### **B. COST OF PROPOSED PUBLIC DRAINAGE FACILITIES**

There are no public facilities proposed for the shooting ranges.

#### **C. DRAINAGE AND BRIDGE FEES**

The site lies within the Crooked Canyon Creek Drainage Basin. The current drainage basin fee associated with the Crooked Canyon Creek Drainage Basin is \$5,540 per impervious acre. The current bridge fee associated with the Crooked Canyon Creek Drainage Basin is \$0 per impervious acre. As there is effectively no increase in imperviousness, no drainage fees are required.

### **V. CONCLUSIONS**

This project will contain four shooting ranges and associated supporting facilities covering approximately 17.21 acres. Onsite Drainage will sheet flow within the ranges, generally, to the southwestern corner of each range. The runoff will then be directed in a pipe to the existing drainage channel located along the west side of the project and the western boundary of the overall property. The proposed development will not adversely impact or deteriorate improvements or natural drainageways downstream of the property.

## VI. REFERENCES

- 1) Final Drainage Report, Phase 1 Colorado Training Institute for Public Safety (Proposed Fountain Springs Addition No. 2), prepared by Kiowa Engineering Corporation, dated August 13, 2016.
- 2) City of Colorado Springs and El Paso County Flood Insurance Study, prepared by the Federal Emergency Management Agency, dated March 1997.
- 3) El Paso County Drainage Criteria Manual (Volumes 1 and 2) and Engineering Criteria Manual, current editions.
- 4) Soil Survey of El Paso County Area, Colorado, prepared by United States Department of Agriculture Soil Conservation Service, dated June 1981.

## **APPENDIX TABLE OF CONTENTS**

### **APPENDIX**

Figure 1: Vicinity Map

Figure 2: Soils Map

FEMA Flood Insurance Rate Map (Panels 1160)

### **APPENDIX A**

Hydrologic Calculations

Developed Condition – Runoff Coef, Time of Concentration and Runoff Calcs

### **APPENDIX B**

Hydraulic Calculations

Culvert Sizing Calculations

### **APPENDIX C**

Drainage Plans

Sheet DP2 – Overall Phase 1 Drainage Plan

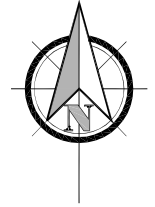


**APPENDIX**

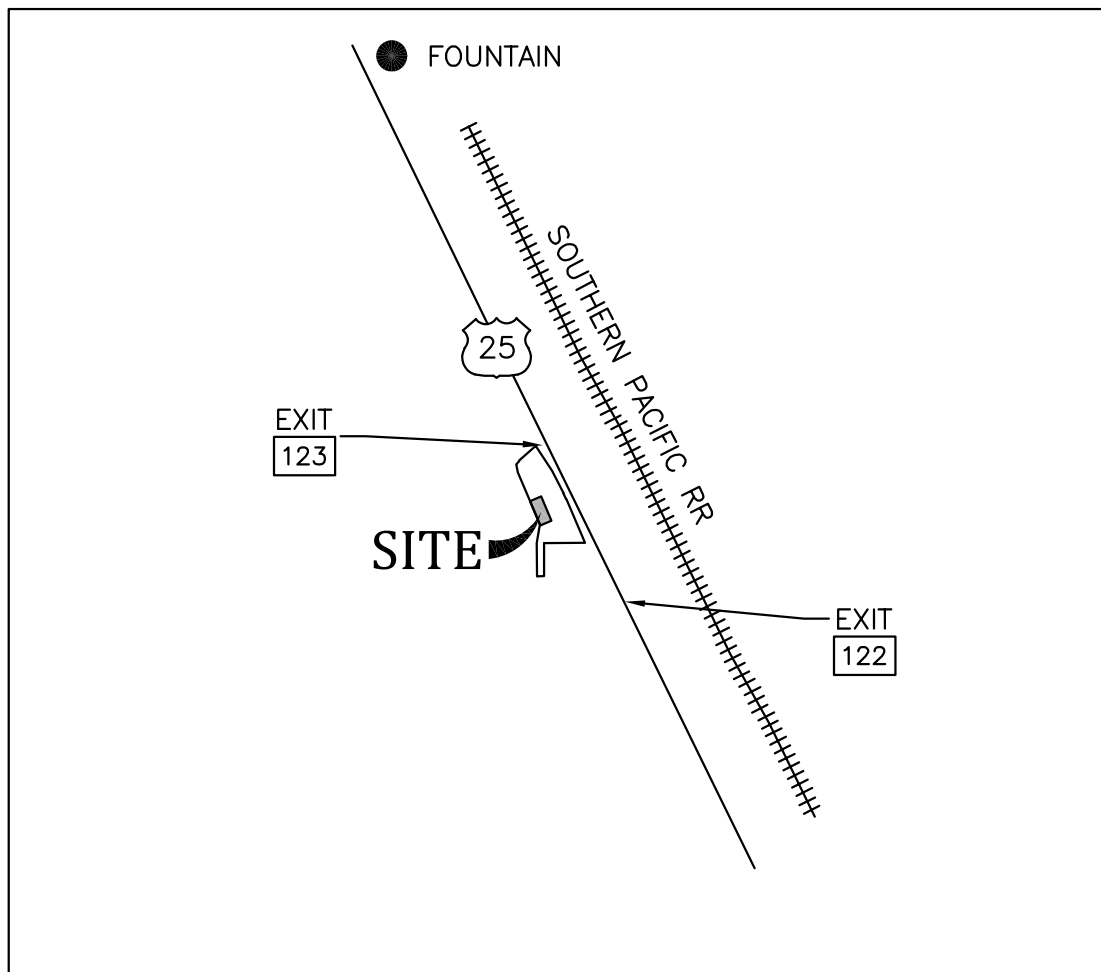
**Figure 1: Vicinity Map**

**Figure 2: Soils Map**

**FEMA Flood Insurance Rate Map (Panels 1160)**



Not to Scale



VICINITY MAP

FIGURE 1

Colorado Springs Police Department  
Final Drainage Report  
Colorado Springs, Colorado

**Kiowa**  
Engineering Corporation

1604 South 21st Street  
Colorado Springs, Colorado 80904  
(719) 630-7342

# Custom Soil Resource Report Soil Map

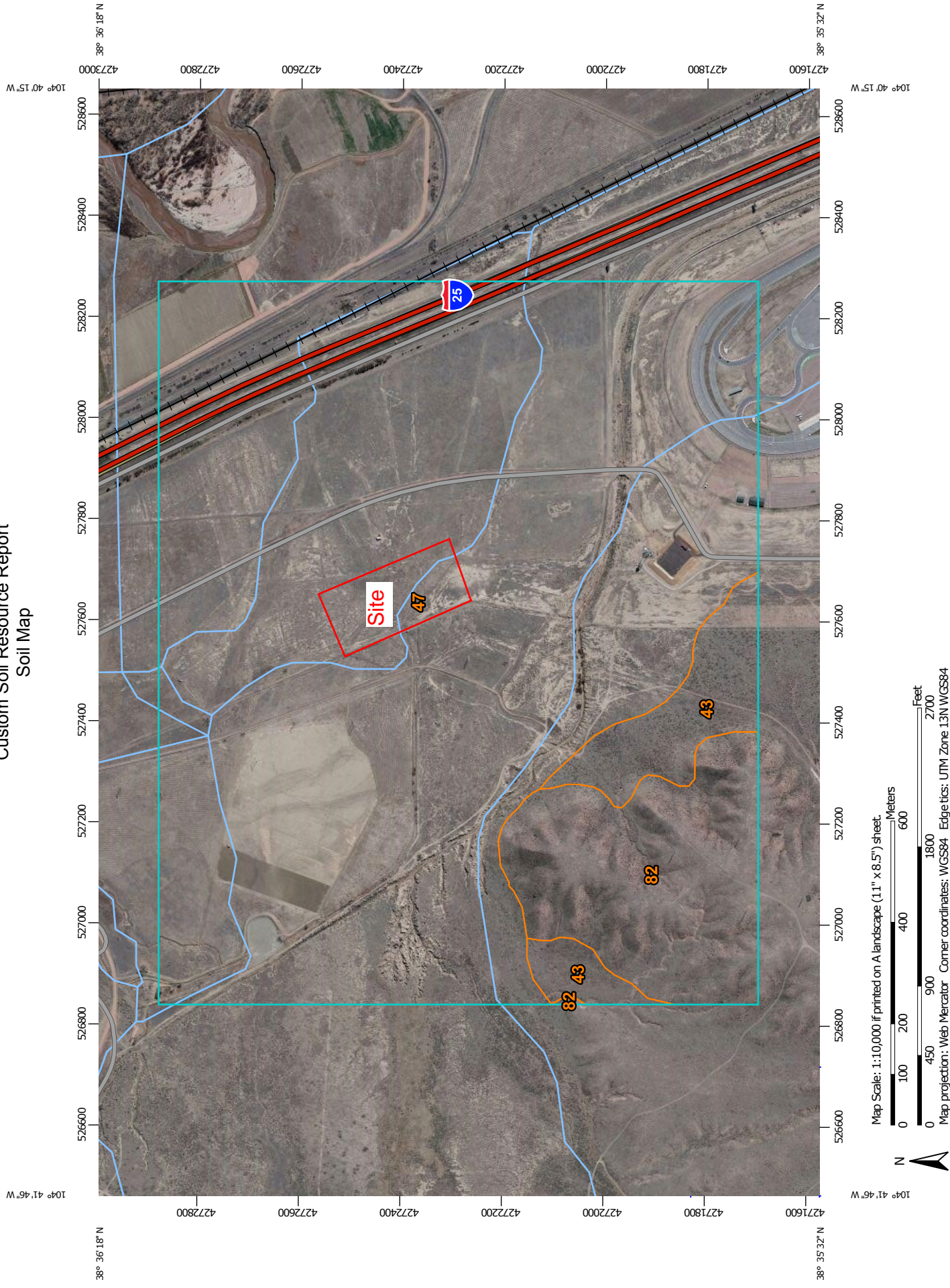


Figure 2





## **APPENDIX A**

### **Hydrologic Calculations**

**Developed Condition – Runoff Coeff, Time of Concentration and Runoff Calcs**

# CSPD Shooting Ranges

## Runoff Coefficient and Percent Impervious Calculation

Basin / DP	Basin or DP Area (DP contributing basins)	Soil Type	OF		HI		RO		CO		DR		Area 5 LandUse		Basin % Imperv	Basin Runoff Coef	
			% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp		C <sub>5</sub>	C <sub>100</sub>
A1	67,537 sf	1.55ac	45%	1.55ac	100%	45%	2%	0%	0%	0%	90%	0%	0%	0%	0%	0.37	0.59
A2	63,696 sf	1.46ac	45%	1.46ac	100%	45%	2%	0%	0%	0%	90%	0%	0%	0%	0%	0.37	0.59
A3	77,526 sf	1.78ac	45%	1.78ac	100%	45%	2%	0%	0%	0%	90%	0%	0%	0%	0%	0.37	0.59
A4	144,530 sf	3.32ac	45%	3.32ac	100%	45%	2%	0%	0%	0%	90%	0%	0%	0%	0%	0.37	0.59
A5	276,967 sf	6.36ac	45%	6.21ac	98%	44%	2%	0%	0%	2%	90%	0.15ac	0%	0%	0%	0.38	0.59
A6	96,306 sf	2.21ac	45%	2.21ac	100%	45%	2%	0%	0%	0%	90%	0%	0%	0%	0%	0.37	0.59
E1	23,307 sf	0.54ac	45%	0.00ac	0%	0%	2%	0.54ac	100%	2%	90%	0%	0%	0%	0%	0.16	0.51
OS1	1,421,756 sf	32.64ac	45%	0.00ac	0%	0%	2%	32.64ac	100%	2%	90%	0%	0%	0%	0%	0.16	0.51
Onsite (H)	749,870 sf	17.21ac	45%	16.67ac	97%	44%	2%	0.54ac	3%	0%	90%	0%	0%	0%	0%	0.37	0.59
Onsite (P)	749,870 sf	17.21ac	45%	16.52ac	96%	43%	2%	0.54ac	3%	1%	90%	0.15ac	0%	0%	0%	0.37	0.59
DP 1	353,289 sf	8.11ac	45%	8.11ac	100%	45%	2%	0.00 ac	0%	0%	90%	0%	0%	0%	0%	0.37	0.59
DP2	2,075,319 sf	47.64ac	45%	15.00ac	31%	14%	2%	32.64 ac	69%	1%	90%	0.00 ac	0%	0%	0%	0.24	0.54

Basin Runoff Coefficient is based on % Imperviousness Calculation

Based on Table 6-6: Runoff Coefficients for Rational Method from City of Colo Springs DCM

Runoff Coefficients and Percents Impervious				
Hydrologic Soil Type:	CD	Runoff Coef Method		
		%	C <sub>5</sub>	C <sub>100</sub>
Land Use	Abb			
Commercial Area	CO	95%	0.82	0.89
Drives and Walks	DR	100%	0.90	0.96
Streets - Gravel (Packed)	GR	80%	0.63	0.74
Historic Flow Analysis	HI	2%	0.16	0.26
Lawns	LA	0%	0.15	0.25
Off-site flow-Undeveloped	OF	45%	0.37	0.44
Park	PA	7%	0.19	0.29
Streets - Paved	PV	100%	0.90	0.92
Roofs	RO	90%	0.75	0.83
User Input 1	US1	40%	0.35	0.42
User Input 2	US2	65%	0.49	0.65

# CSPD Shooting Ranges

## Time of Concentration Calculation

Sub-Basin Data			Time of Concentration Estimate										Min. Tc in Urban		Final t <sub>c</sub>	
Basin / Design Point	Contributing Basins	Area	C <sub>5</sub>	Initial/Overland Time (t <sub>i</sub> )			Travel Time (t <sub>t</sub> )					Comp.	Tc Check (urban)			
				Length	Slope	t <sub>i</sub>	18	Slope	Land Type	Cv	Velocity	t <sub>t</sub>	t <sub>c</sub>	Total Length		t <sub>c</sub> Check
A1	Site outside Ranges (East)	1.55ac	0.37	20lf	66.7%	1.5 min.	405lf	0.6%	SP	7	0.6 ft/sec	12.2 min.	13.7 min.	425lf	12.4 min.	12.4 min.
A2		1.46ac	0.37	20lf	66.7%	1.5 min.	405lf	0.6%	SP	7	0.6 ft/sec	12.2 min.	13.7 min.	425lf	12.4 min.	12.4 min.
A3		1.78ac	0.37	35lf	66.7%	1.9 min.	440lf	0.5%	SP	7	0.5 ft/sec	14.8 min.	16.8 min.	475lf	12.6 min.	12.6 min.
A4		3.32ac	0.37	32lf	66.7%	1.9 min.	580lf	0.5%	SP	7	0.5 ft/sec	19.5 min.	21.4 min.	612lf	13.4 min.	13.4 min.
A5		6.36ac	0.38	32lf	66.7%	1.8 min.	1602lf	0.5%	GW	15	1.1 ft/sec	25.2 min.	27.0 min.	1634lf	19.1 min.	19.1 min.
A6		2.21ac	0.37	32lf	66.7%	1.9 min.	1602lf	0.5%	GW	15	1.1 ft/sec	25.2 min.	27.0 min.	1634lf	19.1 min.	19.1 min.
E1	Site outside Ranges (West)	0.54ac	0.16	32lf	0.5%	12.2 min.	1246lf	0.5%	GW	15	1.1 ft/sec	19.6 min.	31.8 min.	1278lf	17.1 min.	17.1 min.
OS1		32.64ac	0.16	100lf	2.0%	13.6 min.	3780lf	0.9%	SP	7	0.7 ft/sec	94.9 min.	108.5 min.	3880lf	31.6 min.	31.6 min.
Onsite	A1-A4  A1-A5, E1 & OS1	17.21ac	0.37	100lf	2.0%	10.6 min.	3780lf	0.9%	SP	7	0.7 ft/sec	94.9 min.	105.5 min.	3880lf	31.6 min.	31.6 min.
DP1		8.11ac	0.37	100lf	2.0%	10.6 min.	3780lf	0.9%	SP	7	0.7 ft/sec	94.9 min.	105.4 min.	3880lf	31.6 min.	31.6 min.
DP2		47.64ac	0.24	32lf	66.7%	2.2 min.	1602lf	0.5%	GW	15	1.1 ft/sec	25.2 min.	27.4 min.	1634lf	19.1 min.	19.1 min.

Equations:

$$t_i (\text{Overland}) = 0.395(1.1 - C_5)L^{0.5}S^{-0.333}$$

C<sub>5</sub> = Runoff coefficient for 5-year

L = Length of overland flow (ft)

S = Slope of flow path (ft/ft)

t<sub>c</sub> Check = (L/180)+10 (Developed Cond. Only)

L = Overall Length

Table 6-7: Conveyance Coef (City CS DCM, Vol 1)

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

$$\text{Velocity (Travel Time)} = C_v S^{0.5}$$

C<sub>v</sub> = Conveyance Coef (see table)

S = Watercourse slope (ft/ft)

## CSPD Shooting Ranges Runoff Calculation

Basin / Design Point	Contributing Basins	Drainage Area	C <sub>5</sub>	C <sub>10</sub>	C <sub>100</sub>	Time of Concentration	i <sub>5</sub>	i <sub>10</sub>	i <sub>100</sub>	Q <sub>5</sub>	Q <sub>10</sub>	Q <sub>100</sub>	Basin / DP
A1	Site outside ranges (E)	1.55 ac	0.37	0.44	0.59	12.4 min.	3.8 in/hr	4.4 in/hr	6.4 in/hr	2.2 cfs	3.0 cfs	5.9 cfs	A1
A2		1.46 ac	0.37	0.44	0.59	12.4 min.	3.8 in/hr	4.4 in/hr	6.4 in/hr	2.1 cfs	2.8 cfs	5.5 cfs	A2
A3		1.78 ac	0.37	0.44	0.59	12.6 min.	3.8 in/hr	4.4 in/hr	6.3 in/hr	2.5 cfs	3.4 cfs	6.7 cfs	A3
A4		3.32 ac	0.37	0.44	0.59	13.4 min.	3.7 in/hr	4.3 in/hr	6.2 in/hr	4.6 cfs	6.2 cfs	12.2 cfs	A4
A5		6.36 ac	0.38	0.44	0.59	19.1 min.	3.2 in/hr	3.7 in/hr	5.3 in/hr	7.6 cfs	10.3 cfs	20.0 cfs	A5
A6		2.21 ac	0.37	0.44	0.59	19.1 min.	3.2 in/hr	3.7 in/hr	5.3 in/hr	2.6 cfs	3.6 cfs	6.9 cfs	A6
E1	Site outside ranges (W)	0.54 ac	0.16	0.26	0.51	17.1 min.	3.3 in/hr	3.9 in/hr	5.6 in/hr	0.3 cfs	0.5 cfs	1.5 cfs	E1
OS1		32.64 ac	0.16	0.26	0.51	31.6 min.	2.4 in/hr	2.8 in/hr	4.0 in/hr	12.8 cfs	24.0 cfs	66.8 cfs	OS1
Onsite	Phase 1 A2-A5 All	17.21 ac	0.37	0.43	0.59	31.6 min.	2.4 in/hr	2.8 in/hr	4.0 in/hr	15.2 cfs	20.9 cfs	41.0 cfs	Onsite
DP1		8.11 ac	0.37	0.44	0.59	31.6 min.	2.4 in/hr	2.8 in/hr	4.0 in/hr	7.3 cfs	9.9 cfs	19.4 cfs	DP1
DP2		47.64 ac	0.24	0.33	0.54	19.1 min.	3.2 in/hr	3.7 in/hr	5.3 in/hr	36.0 cfs	57.4 cfs	137.5 cfs	DP2

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

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

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

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

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

Q = C i A

Q = Peak Runoff Rate (cubic feet/second)

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

i = average rainfall intensity in inches per hour

A = Drainage area in acres



**APPENDIX B**  
**Hydraulic Calculations**  
**Culvert Sizing Calculations**

## CSPD Shooting Ranges Pipe Diameter Calculations

Pipe #	100yr Flow	Design Flow	Contributing Flows	Manning 'n'	Pipe Slope	Calculated Pipe Diameter	Pipe Diameter	Minimum Slope of Pipe	Full Pipe Flow Velocity	Head above Pipe Flowline	H	Pipe Inlet Control Capacity	Mannings Pipe Capacity	Capacity Check
A1	5.9 cfs	2.2 cfs		0.013	0.5%	11-inch	12-inch	0.38%	3.2 ft/sec		----	----	2.5 cfs	OK
A2	5.5 cfs	2.1 cfs		0.013	0.5%	11-inch	12-inch	0.35%	3.2 ft/sec		----	----	2.5 cfs	OK
A3	6.7 cfs	2.5 cfs		0.013	0.5%	12-inch	12-inch	0.49%	3.2 ft/sec		----	----	2.5 cfs	OK
A4	12.2 cfs	4.6 cfs		0.013	0.5%	15-inch	18-inch	0.19%	4.2 ft/sec		----	----	7.4 cfs	OK

### Equations:

Pipe Dia= $((2.16Qn)/(S^{0.5}))^{0.375}$

Q = Discharge in cubic feet per second

n = Manning's roughness coefficient

RCP=0.013, CMP=0.024, HDPE (smooth)=0.012

S = Slope of the pipe

R<sub>h</sub> = Hydraulic Radius

Flow Velocity =  $(1.49/n)R_h^{2/3} S^{1/2}$

Pipe Capacity =  $(1.49/n)AR_h^{2/3} S^{1/2}$

A = Cross-sectional area of pipe

A= $p(D^2/4)$

D = Inside Diameter of Pipe

R<sub>h</sub> =  $A_w/W_p$

A<sub>w</sub> =  $p(d^2/4)$

A<sub>w</sub> = Water Cross Sectional Area

d = Water (Flow) Depth Within Pipe

W<sub>p</sub> = pd (For Capacity Calculation)

W<sub>p</sub>=Wetted Perimeter of Pipe

### Orifice Equation:

Q =  $CA(2gH)^{0.5}$

C = Orifice coefficient (dimensionless)

C = 0.65

A = Cross-sectional area of opening, in sf

g = Gravitational accel constant, 32.2 ft/sec<sup>2</sup>

H = Head above centerline of pipe, ft

**APPENDIX C**  
**Drainage Plans**  
**Sheet DR-1 – Proposed Drainage Plan**



