CONCEPTUAL DRAINAGE REPORT
FOR
GRAZING YAK SOLAR PROJECT
EL PASO COUNTY, CO
(WSE-O)

PREPARED FOR:

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CORE PROJECT NUMBER: 18-082

OCTOBER 23, 2018
REVISED JANUARY 16, 2019

PCD FILE NUMBER
WSEO-18-002

APPROVAL BLOCKS

I. 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.

sign after edit- tis item is anticipated to goto PC hearing

_____ _____

David Bacci, P.E. #42104 Date

II. OWNER/DEVELOPER'S STATEMENT:

I, the developer, have read and will comply with all the requirements specified in this Drainage Report and Plan.

_____

Development Manager

III. EL PASO COUNTY STATEMENT:

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

_____ _____

Jennifer Irvine, PE Date

County Engineer / ECM Administrator

1950 W LITTLETON BLVD | SUITE 109 | LITTLETON CO 80120 | 303.703.4444

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I. GENERAL LOCATION AND DESCRIPTION

A. SITE LOCATION

This Conceptual Drainage Report has been prepared on behalf of Grazing Yak Solar, LLC for the development of the proposed Grazing Yak Solar Project, referred to as "The Project". The Project would consist of a 35 megawatt (MW) utility scale photovoltaic solar facility and underground collection line that would encompass approximately 317 acres in El Paso County (EPC), Colorado. The solar array site, referred to as "The Site", is located to the east of the intersection of McQueen Road and Washington Road, approximately 4 miles southeast of the Town of Calhan on private, agricultural land. Rural residences and agricultural land surround the Site, as well as the Golden West Wind Energy Center located to the north, west, and south. The Site is located on 272-acres in Section 29, Township 12 South, Range 61 West of the 6th Principal Meridian, El Paso County, Colorado. A vicinity map for the site can be found in Appendix A.

B. DESCRIPTION OF PROPERTY

The Site is flat to gently rolling, at elevations ranging from approximately 6,830 to 6,735 feet. The site has naturally occurring slopes ranging from 2 to 10 percent and is currently agricultural land. Surface runoff is to the north, south and east. Runoff from the northern portion of the site flows north overland through multiple conveyances. These flows continue north under Washington through a culvert and eventually into Horse Creek. Flows from the central portion of the site flow toward the drainage that bisects the site. Runoff travels east of the project through an unnamed drainage and eventually into Horse Creek. Flows from the southeast portion of the site flow southeast into an unnamed drainage and eventually into Horse Creek. The proposed improvements to the site consist of a 35 megawatt (MW) photovoltaic solar array, inverters, dirt and gravel access paths, and other necessary ancillary features. The soils vary throughout the site and include mainly Truckton sandy loam, (Hydrologic soil group A), Truckton-Bresser complex (Hydrologic soil group A), Bresser sandy loam (Hydrologic soil group B) and Ascalon sandy loam (Hydrologic soil group B). A soils map has been provided and can be found in Appendix A.

II. DRAINAGE BASINS AND SUB-BASINS

A. MAJOR DRAINAGE BASINS

The existing drainage patterns for the major basin will follow the historic patterns. Grazing Yak will drain north, east and south through drainageways and culverts and eventually discharging into Horse Creek. Horse Creek flows to the east and is part of the Arkansas River basin

~~The site falls within Zone X, as shown on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) panels 08041C0650 F and 0841C0625 F. A copy of the FIRM maps can be found in Appendix A.~~

Update (G-series as of Dec. 2018)

B. MINOR DRAINAGE BASINS

Minor Drainage Basins for Grazing Yak Solar Project have been delineated per the preliminary layout of the solar arrays. Layout of the arrays and dirt and gravel access paths may change during the preliminary development of the site. The developed minor basins will include pole mounted solar arrays with native ground beneath and dirt and gravel access roads constructed of 12" re-compacted soil and Class 5 Gravel respectively. An Extended Detention Basin for the site will be designed to mitigate the increase in runoff. The EDB will be privately owned and maintained. Overall, the proposed drainage patterns for the sub-basins will follow the historic patterns prior to development. For sub-basins within the site, runoff will drain to the north, south and east.

Basin (A1) consists of dirt access paths, a portion of the solar array and offsite undeveloped land. Runoff generated in this basin will flow northeast toward the western property line of the project site. The runoff flows northeast, into the unnamed drainage bisecting the site. This runoff is conveyed through the site and eventually into Horse Creek.

Basin (A2) consists of dirt access paths, a portion of the solar array and offsite undeveloped land. Runoff generated in this basin will flow northeast toward the southern property line of the project site. The runoff flows east and northeast, into the unnamed drainage bisecting the site. This runoff is conveyed through the site and eventually into Horse Creek.

Basin (A3) consists of dirt access paths, a portion of the solar array and offsite undeveloped land. Runoff generated in this basin will flow north and east toward and existing stock pond located in the unnamed drainage within the project site. The runoff exits the stock pond into the unnamed drainage bisecting the site and travels northeast. This runoff leaves the site at the eastern boundary and eventually into Horse Creek.

Basin (A4) consists of gravel access paths, dirt access paths, and a portion of the solar array. Runoff generated in this basin will flow north and south into the unnamed drainage and an extended detention basin (EDB) respectively within the project site. The EDB will be sized to provide a 10% reduction in predevelopment flows generate by the increase in imperviousness for the total site. Runoff is discharged from the EDB into the unnamed drainage and conveyed to the eastern property line. This runoff leaves the site at the eastern boundary and eventually into Horse Creek.

Basin (B1) consists of dirt access paths and a portion of the solar array. Runoff generated in this basin will flow to the south east and eventually into Horse Creek. Flowrates or flow patterns within this basin will not be affected by this development.
Basin (B2) consists of dirt access paths and a portion of the solar array. Runoff generated in this basin will flow to the south east and eventually into Horse Creek. Flowrates or flow patterns within this basin will not be affected by this development.

Basin (C1) consists of dirt access paths and a portion of the solar array. Runoff generated in this basin flows will travel north through multiple conveyances towards the northern property line, under Washington road through a culvert and eventually into Horse Creek. Flowrates or flow patterns within this basin will not be affected by this development.

Basin (D1) consists of gravel access paths, a portion of the solar array and undeveloped land. The increase in imperviousness is being mitigated in the EDB located in basing A4. Runoff generated in this basin flows will travel north along the proposed site access road towards Washington Rd. Flows are conveyed under Washington road through a culvert and eventually into Horse Creek. Flowrates or flow patterns within this basin will not be affected by this development.

III. DRAINAGE DESIGN CRITERIA

A. REGULATIONS

This Conceptual Drainage Report is in accordance with El Paso County Drainage Criteria Manual and the *Urban Drainage and Flood Control District (UDFCD) Storm Drainage Criteria Manual*. These manuals were used as a basis of design for the site. All applicable tables, figures, and charts from the referenced reports and criteria manuals used in the drainage design of the site can be found in Appendix B. The report will analyze the minor (5-year) and major (100-year) storm events.

B. DRAINAGE STUDIES, MASTER PLANS, AND SITE CONSTRAINTS

There are no previous drainage studies, master plans or site constraints for this development.

C. HYDROLOGY

All the basins within the site were less than 160 acres thus the Rational Method was used to determine the flow rates for various basins within the site. The sub-basins were delineated based on the existing topography for the project. Flow rates for each basin can be found in Appendix A. The impervious panels are going to be pole mounted with the ground underneath them to remain vegetated. The main

access from Washington Road to just south of the unnamed drainage will be constructed with Class 5 Gravel. The remaining site access paths will be constructed as recompacted dirt to promote infiltration back into the ground.

The intensity-frequency curves used in the Rational Method calculations were taken from the El Paso County Drainage Criteria Manual. All drainage facilities were analyzed and designed for both the minor (5-year) and major (100-year) storm events. Time of concentration calculations were used to determine the rainfall intensity. These calculations also can be found in Appendix A.

D. HYDRAULICS

Hydraulic calculations for the EDB sizing were based on UDFCD design spreadsheets. Street and inlet capacity will not be necessary for this development.

E. WATER QUALITY ENHANCEMENT

The Project will require gravel access paths to a small portion of the site for access year-round. The remaining access paths will be constructed of recompacted dirt. The Project will employ runoff reduction practices such as allowing sheet flow across grass buffers and minimizing the increased imperviousness to 2% total for the site post construction. The site consists of Type A & B soils, allowing for optimal infiltration throughout the site. The proposed water quality facility for the site was designed as an EDB which incorporates a structure that release flows for the water quality capture volume (WQCV), Excess Urban Runoff Volume (EURV), and the 100-year storm event. The preliminary design of this structure can be found in the Appendix. The EDB is located in an area with a NRCS Type A soil designation. The EDB is located to receive the sheet flow runoff from the basin with the increased imperviousness. The total area of increased imperviousness (approximately 2 acres of 270 acres) will create a minimal impact to the natural drainageway that stabilization beyond protection at the EDB outlet will not be necessary. The natural drainageway will be protected from sediment discharge, introduction of contaminants and other site operations during construction activities in conformance with El Paso County GEC requirements and MS4 permit.

IV. STORMWATER MANAGEMENT FACILITY DESIGN

A. STORMWATER CONVEYANCE FACILITIES

The general concept for the drainage design is to maintain the historic drainage patterns and release rates. This approach reduces the impacts to existing channels and ultimately Horse Creek. No public infrastructure is proposed within this site.

B. STORMWATER STORAGE FACILITIES

Preliminary basin A4 EDB pond sizing calculations can be found in the Appendix. The EDB mitigates the increase of runoff generated by the gravel access road. Runoff

generated by the access roads will sheet flows into the EDB. The EDB will have an approximate volume of 1.4 acre-feet and release below historic runoff rates.

C. Water Quality Enhancement Best Management Practices

Water quality measures have been included in the design of the proposed EDBs. The basin will be designed to incorporate a structure that release flows for the water quality capture volume (WQCV) and the 100-year storm event.

D. Floodplain Modification

There will be no modification to the floodplain.

E. Additional Permitting Requirements

No additional permitting will be required for this site.

F. General

All applicable tables, figures, and charts from the referenced reports and criteria manuals used in the drainage design of the site can be found in the Appendix. The site is not going to be platted at this time therefore no drainage fees are due.

REFERENCES

A. El Paso County Drainage Criteria Manual, Volumes 1 and 2.

B. Drainage Criteria Manual, Volumes 1, 2, & 3, Urban Drainage and Flood Control District, June 2001, Revised June 2004.

APPENDIX
HYDROLOGIC CALCULATIONS

VICINITY MAP

FIRM MAP

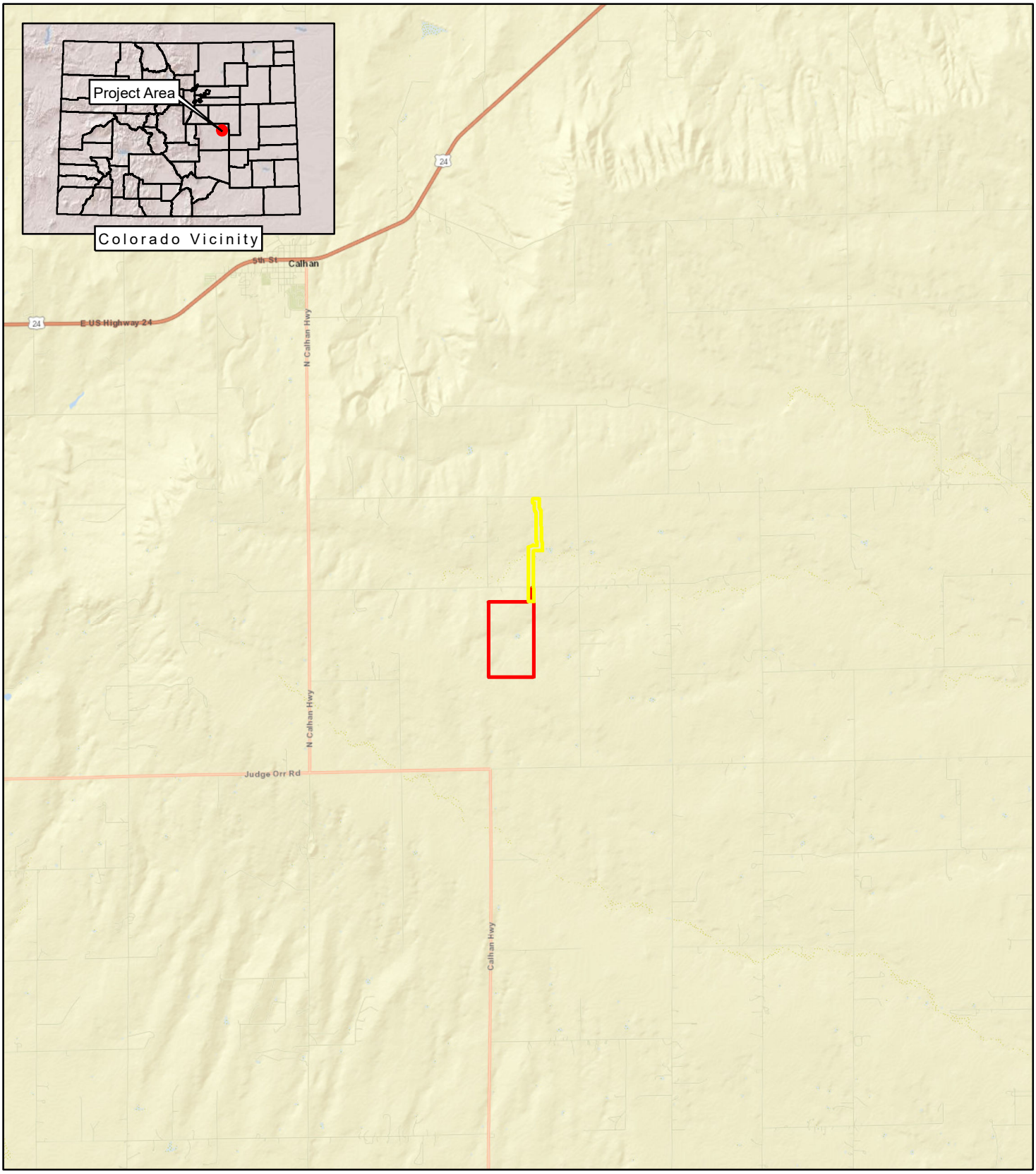
SOILS MAP

CIA CALCULATIONS

REFERENCE MATERIAL

PRELIMINARY DETENTION POND SIZING

DRAINAGE PLAN



Grazing Yak Solar Project

Vicinity Map

El Paso County, Colorado

Proposed Solar Array

Proposed Underground Collection Line Corridor

0 1 2

Miles

Date: 1/14/2019

CORE Project #: 18-082

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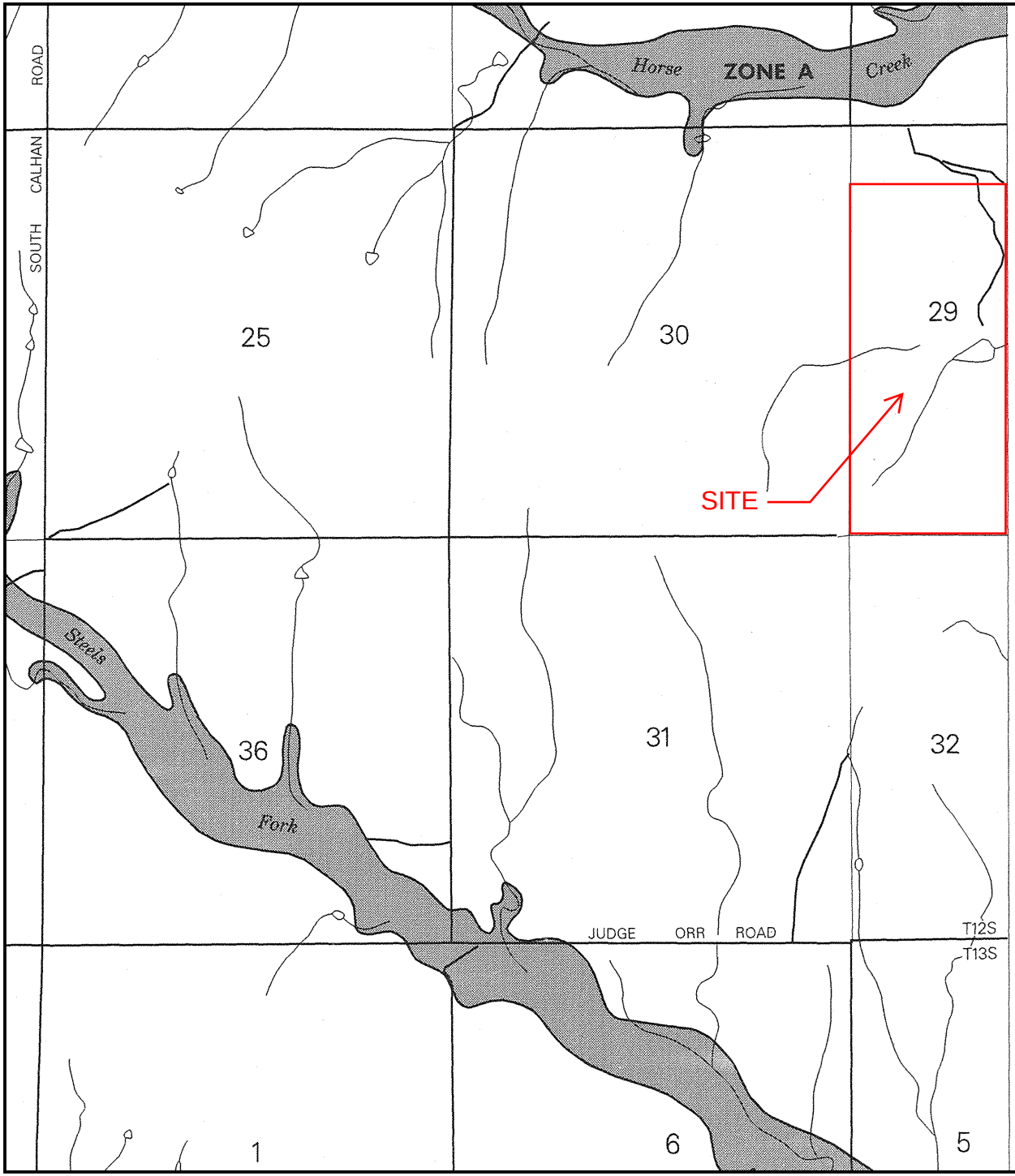


APPROXIMATE SCALE IN FEET

2000 0 2000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

EL PASO COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 625 OF 1300

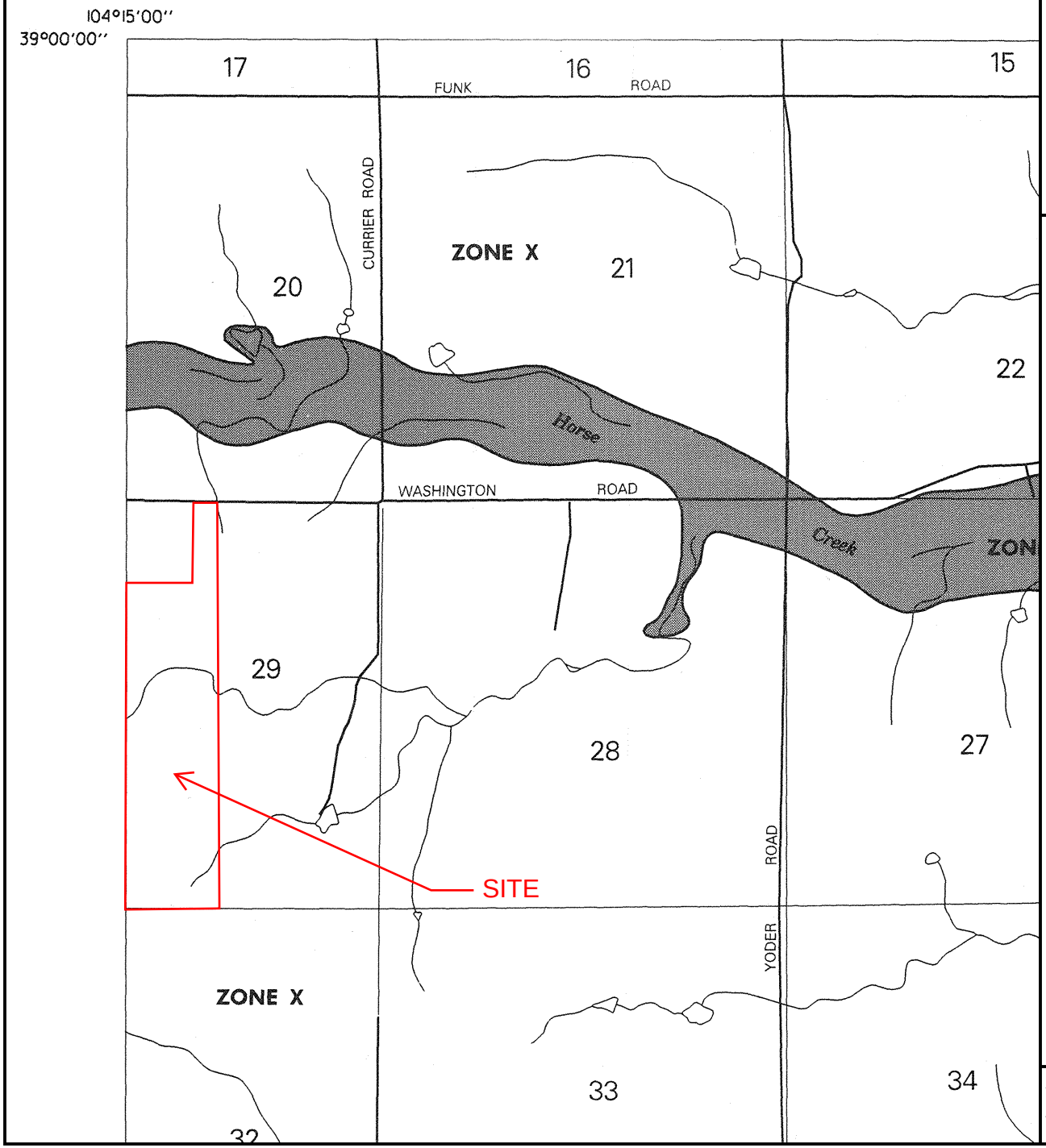
(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS: COMMUNITY	NUMBER	PANEL	SUFFIX
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0625	F

MAP NUMBER
08041C0625 F

EFFECTIVE DATE:
MARCH 17, 1997

Federal Emergency Management Agency



APPROXIMATE SCALE IN FEET

2000 0 2000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

EL PASO COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 650 OF 1300

(SEE MAP INDEX FOR PANELS NOT PRINTED)

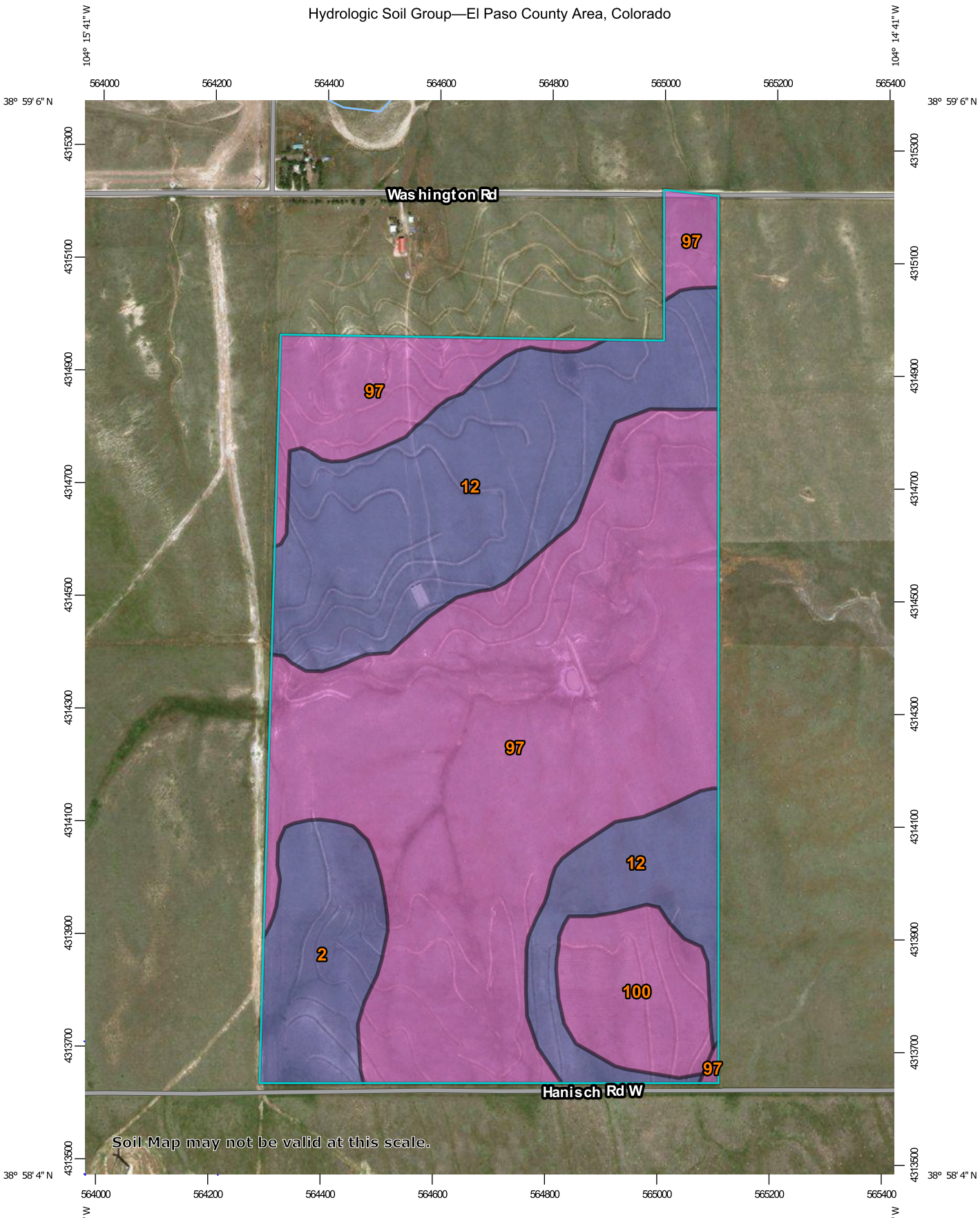
CONTAINS: COMMUNITY	NUMBER	PANEL	SUFFIX
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0650	F

MAP NUMBER
08041C0650 F

EFFECTIVE DATE:
MARCH 17, 1997

Federal Emergency Management Agency

Hydrologic Soil Group—El Paso County Area, Colorado



Map Scale: 1:9,290 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 450 900 1800 2700

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

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

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

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 15, Oct 10, 2017

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

Date(s) aerial images were photographed: May 22, 2016—Mar 9, 2017

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2	Ascalon sandy loam, 1 to 3 percent slopes	B	21.3	7.9%
12	Bresser sandy loam, cool, 3 to 5 percent slopes	B	79.4	29.6%
97	Truckton sandy loam, 3 to 9 percent slopes	A	150.7	56.2%
100	Truckton-Bresser complex, eroded	A	16.9	6.3%
Totals for Area of Interest			**268.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Grazing Yak Solar

CORE Project #: 18-082

Prepared By: DJB

COMPOSITE BASIN - WEIGHTED "C" CALCULATIONS

-REFERENCE UDFCD Vol.1 RUNOFF Table 6-3

	Residential							Lawns				
	Single Family			Multi-Unit				Clay Soil				
	0.25 acres	2.5 acres or larger	5 DU's/Ac 3,000 sf 2 story	(attached)	Roof	Streets: Paved	Gravel	2-7% Slope	>7% Slope	Historic		
% Imperv.	45.00%	12.00%	63.00%	75.00%	90.00%	100.00%	80.00%	2.00%	2.00%	2.00%		
											Total	Percent
BASIN	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Impervious**
A1										86.97	86.97	2.0%
A2										120.45	120.45	2.0%
A3										86.87	86.87	2.0%
A4							0.62			79.50	80.33	2.6%
Total A							**0.62**			**373.79**	**374.62**	**2.13%**
B1										3.82	3.82	2.0%
B2										5.60	5.60	2.0%
Total B										**9.42**	**9.42**	**2.0%**
C1										46.03	46.03	2.0%
Total C										**46.03**	**46.03**	**2.0%**
D1							0.53			5.07	5.56	9.4%
Total D							**0.53**			**5.07**	**5.56**	**9.45%**

Grazing Yak Solar

CORE Project #: 18-082
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COMPOSITE DEVELOPED BASIN -WEIGHTED "C" CALCULATIONS

-REFERENCE UDFCD Vol.1 RUNOFF Table 6-4

i = % imperviousness/100 expressed as a decimal
C_A = Runoff coefficient for NRCS HSG A soils
C_B = Runoff coefficient for NRCS HSG B soils
C_{CD} = Runoff coefficient for NRCS HSG C and D soils.
Natural Resource Conservation Service (NRCS)

Table 6-4. Runoff coefficient equations based on NRCS soil group and storm return period

NRCS Soil Group	Storm Return Period						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
A	$C_A = 0.84i^{1.302}$	$C_A = 0.86i^{1.276}$	$C_A = 0.87i^{1.232}$	$C_A = 0.84i^{1.124}$	$C_A = 0.85i+0.025$	$C_A = 0.78i+0.110$	$C_A = 0.65i+0.254$
B	$C_B = 0.84i^{1.169}$	$C_B = 0.86i^{1.088}$	$C_B = 0.81i+0.057$	$C_B = 0.63i+0.249$	$C_B = 0.56i+0.328$	$C_B = 0.47i+0.426$	$C_B = 0.37i+0.536$
C/D	$C_{C/D} = 0.83i^{1.122}$	$C_{C/D} = 0.82i+0.035$	$C_{C/D} = 0.74i+0.132$	$C_{C/D} = 0.56i+0.319$	$C_{C/D} = 0.49i+0.393$	$C_{C/D} = 0.41i+0.484$	$C_{C/D} = 0.32i+0.588$

Basin ID	% Imperv.	*i*	Soil Type	Runoff Coefficients, C				Basin Area	Total Area	Weighted Runoff Coefficients, C			
				2-Year	5-Year	10-Year	100-Year			2-Year	5-Year	10-Year	100-Year
A1	2.0%	0.02	A	0.01	0.01	0.01	0.13	50.70	86.97	0.01	0.01	0.03	0.25
			B	0.01	0.01	0.07	0.44	36.27					
			C or D	0.01	0.05	0.15	0.49	0.00					
A2	2.0%	0.02	A	0.01	0.01	0.01	0.13	72.11	120.45	0.01	0.01	0.03	0.25
			B	0.01	0.01	0.07	0.44	48.34					
			C or D	0.01	0.05	0.15	0.49	0.00					
A3	2.0%	0.02	A	0.01	0.01	0.01	0.13	53.99	86.87	0.01	0.01	0.03	0.24
			B	0.01	0.01	0.07	0.44	32.88					
			C or D	0.01	0.05	0.15	0.49	0.00					
A4	2.6%	0.03	A	0.01	0.01	0.01	0.13	52.23	80.33	0.01	0.01	0.03	0.24
			B	0.01	0.02	0.08	0.44	28.10					
			C or D	0.01	0.06	0.15	0.49	0.00					
B1	2.0%	0.02	A	0.01	0.01	0.01	0.13	2.04	3.82	0.01	0.01	0.04	0.27
			B	0.01	0.01	0.07	0.44	1.78					
			C or D	0.01	0.05	0.15	0.49	0.00					
B2	2.0%	0.02	A	0.01	0.01	0.01	0.13	4.66	5.60	0.01	0.01	0.02	0.18
			B	0.01	0.01	0.07	0.44	0.94					
			C or D	0.01	0.05	0.15	0.49	0.00					
C1	2.0%	0.02	A	0.01	0.01	0.01	0.13	25.62	46.03	0.01	0.01	0.04	0.26
			B	0.01	0.01	0.07	0.44	20.41					
			C or D	0.01	0.05	0.15	0.49	0.00					
D1	9.4%	0.09	A	0.04	0.04	0.05	0.18	1.24	5.56	0.05	0.06	0.11	0.41
			B	0.05	0.07	0.13	0.47	4.32					
			C or D	0.06	0.11	0.20	0.52	0.00					

Grazing Yak Solar

CORE Project #: 18-082

Prepared By: DJB

TIME OF CONCENTRATION CALCULATIONS

-REFERENCE UDFCD Vol.1 Section 2.4

NRCS Conveyance factors, K -REFERENCE UDFCD Vol.1 RUNOFF Table 6-2

SF-2

Heavy Meadow	2.50	Short Grass Pasture & Lawns	7.00	Grassed Waterway	15.00
Tillage/field	5.00	Nearly Bare Ground	10.00	Paved Area & Shallow Gutter	20.00

SUB-BASIN DATA			INITIAL / OVERLAND TIME			TRAVEL TIME T(t)						T(c) CHECK (URBANIZED BASINS)		FINAL T(c)
DRAIN BASIN	AREA ac.	C(5)	Length ft.	Slope %	T(i) min	Length ft.	Slope %	Coeff.	Velocity fps	T(t) min.	COMP. T(c)	% IMPER-VIOUS	USDCM Eq . 6-5	min.
A1	86.97	0.01	148	1.3	21.7	2623	2.4	5.00	0.8	54.7	76.4	2.0%		76.4
A2	120.45	0.01	300	1.7	28.8	3149	1.7	5.00	0.7	75.0	103.8	2.0%		103.8
A3	86.87	0.01	300	3.3	22.9	3203	2.4	5.00	0.8	66.7	89.6	2.0%		89.6
A4	80.33	0.01	300	3.7	22.2	3023	2.0	5.00	0.7	72.0	94.2	2.6%		94.2
B1	3.82	0.01	240	1.0	30.1	357	2.0	5.00	0.7	8.5	38.6	2.0%		38.6
B2	5.60	0.01	300	1.5	29.9	466	3.0	5.00	0.9	8.6	38.5	2.0%		38.5
C1	46.03	0.01	300	5.2	19.8	1517	1.6	5.00	0.6	42.1	61.9	2.0%		61.9
D1	5.56	0.06	529	0.9	45.5	1189	2.5	5.00	0.8	24.8	70.3	9.4%		70.3

Grazing Yak Solar

CORE Project #: 18-082
Prepared By: DJB

RATIONAL METHOD PEAK RUNOFF

5-YR STORM

SF-3 *Rainfall Depth-Duration-Frequency (1-hr) =* **1.5**

-REFERENCE UDFCD Vol.1 EQ 5-1 & EQ 6-1

BASIN INFORMATON				DIRECT RUNOFF				TOTAL RUNOFF				
DESIGN POINT	DRAIN BASIN	AREA ac.	5yr RUNOFF COEFF	T(c) min	C x A	I in/hr	Q cfs	T(c) min	SUM C x A	I in/hr	Q cfs	REMARKS
1	A1	86.97	0.01	76.4	0.74	1.28	0.9					
2	A2	120.45	0.01	103.8	1.01	1.03	1.0					
3	A3	86.87	0.01	89.6	0.72	1.15	0.8					
4	A4	80.33	0.01	94.2	0.88	1.11	1.0					
5	B1	3.82	0.01	38.6	0.03	2.02	0.1					
6	B2	5.60	0.01	38.5	0.04	2.02	0.1					
7	C1	46.03	0.01	61.9	0.40	1.48	0.6					
8	D1	5.56	0.06	70.3	0.34	1.36	0.5					

Grazing Yak Solar

CORE Project #: 18-082

Prepared By: DJB

RATIONAL METHOD PEAK RUNOFF

100-YR STORM

SF-3 *Rainfall Depth-Duration-Frequency (1-hr) =* **2.52**

-REFERENCE UDFCD Vol.1 EQ 5-1 & EQ 6-1

BASIN INFORMATON				DIRECT RUNOFF				TOTAL RUNOFF				
DESIGN POINT	DRAIN BASIN	AREA ac.	100yr RUNOFF COEFF	T(c) min	C x A	I in/hr	Q cfs	T(c) min	SUM C x A	I in/hr	Q cfs	REMARKS
1	A1	86.97	0.25	76.4	22.16	2.16	47.8					
2	A2	120.45	0.25	103.8	30.10	1.74	52.3					
3	A3	86.87	0.24	89.6	21.10	1.93	40.7					
4	A4	80.33	0.24	94.2	19.12	1.86	35.6					
5	B1	3.82	0.27	38.6	1.03	3.39	3.5					
6	B2	5.60	0.18	38.5	0.99	3.40	3.4					
7	C1	46.03	0.26	61.9	12.10	2.49	30.2					
8	D1	5.56	0.41	70.3	2.26	2.29	5.2					

For Colorado Springs and much of the Fountain Creek watershed, the 1-hour depths are fairly uniform and are summarized in Table 6-2. Depending on the location of the project, rainfall depths may be calculated using the described method and the NOAA Atlas maps shown in Figures 6-6 through 6-17.

Table 6-2. Rainfall Depths for Colorado Springs

Return Period	1-Hour Depth	6-Hour Depth	24-Hour Depth
2	1.19	1.70	2.10
5	1.50	2.10	2.70
10	1.75	2.40	3.20
25	2.00	2.90	3.60
50	2.25	3.20	4.20
100	2.52	3.50	4.60

Where Z= 6,840 ft/100

These depths can be applied to the design storms or converted to intensities (inches/hour) for the Rational Method as described below. However, as the basin area increases, it is unlikely that the reported point rainfalls will occur uniformly over the entire basin. To account for this characteristic of rain storms an adjustment factor, the Depth Area Reduction Factor (DARF) is applied. This adjustment to rainfall depth and its effect on design storms is also described below. The UDFCD UD-Rain spreadsheet, available on UDFCD's website, also provides tools to calculate point rainfall depths and Intensity-Duration-Frequency curves[2] and should produce similar depth calculation results.

2.2 Design Storms

Design storms are used as input into rainfall/runoff models and provide a representation of the typical temporal distribution of rainfall events when the creation or routing of runoff hydrographs is required. It has long been observed that rainstorms in the Front Range of Colorado tend to occur as either short-duration, high-intensity, localized, convective thunderstorms (cloud bursts) or longer-duration, lower-intensity, broader, frontal (general) storms. The significance of these two types of events is primarily determined by the size of the drainage basin being studied. Thunderstorms can create high rates of runoff within a relatively small area, quickly, but their influence may not be significant very far downstream. Frontal storms may not create high rates of runoff within smaller drainage basins due to their lower intensity, but tend to produce larger flood flows that can be hazardous over a broader area and extend further downstream.

- **Thunderstorms**: Based on the extensive evaluation of rain storms completed in the Carlton study (Carlton 2011), it was determined that typical thunderstorms have a duration of about 2 hours. The study evaluated over 300,000 storm cells using gage-adjusted NEXRAD data, collected over a 14-year period (1994 to 2008). Storms lasting longer than 3 hours were rarely found. Therefore, the results of the Carlton study have been used to define the shorter duration design storms.

  To determine the temporal distribution of thunderstorms, 22 gage-adjusted NEXRAD storm cells were studied in detail. Through a process described in a technical memorandum prepared by the City of Colorado Springs (City of Colorado Springs 2012), the results of this analysis were interpreted and normalized to the 1-hour rainfall depth to create the distribution shown in Table 6-3 with a 5 minute time interval for drainage basins up to 1 square mile in size. This distribution represents the rainfall

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	0.58	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	7	0.05	0.09	0.12	0.19	0.20	0.29	0.30	0.40	0.34	0.46	0.39	0.52
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	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
Roofs	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
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.

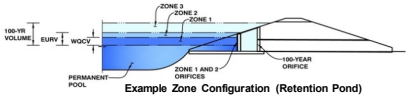
For urban areas, the time of concentration (t_c) consists of an initial time or overland flow time (t_i) plus the travel time (t_t) in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time (t_i) plus 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.

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: Grazing Yak

Basin ID: Detention Pond



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB	
Watershed Area =	85.89	acres
Watershed Length =	3,300	ft
Watershed Slope =	0.024	ft/ft
Watershed Imperviousness =	3.04%	percent
Percentage Hydrologic Soil Group A =	64.8%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	35.2%	percent
Desired WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	User Input	
Water Quality Capture Volume (WQCV) =	0.162	acre-feet
Excess Urban Runoff Volume (EURV) =	0.159	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.112	acre-feet
5-yr Runoff Volume (P1 = 1.5 in.) =	0.328	acre-feet
10-yr Runoff Volume (P1 = 1.75 in.) =	0.862	acre-feet
25-yr Runoff Volume (P1 = 2 in.) =	2.102	acre-feet
50-yr Runoff Volume (P1 = 2.25 in.) =	3.254	acre-feet
100-yr Runoff Volume (P1 = 2.52 in.) =	5.404	acre-feet
500-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet
Approximate 2-yr Detention Volume =	0.103	acre-feet
Approximate 5-yr Detention Volume =	0.313	acre-feet
Approximate 10-yr Detention Volume =	0.486	acre-feet
Approximate 25-yr Detention Volume =	0.583	acre-feet
Approximate 50-yr Detention Volume =	0.719	acre-feet
Approximate 100-yr Detention Volume =	1.368	acre-feet

Optional User Override 1-hr Precipitation	
1.19	inches
1.50	inches
1.75	inches
2.00	inches
2.25	inches
2.52	inches
	inches

Stage-Storage Calculation

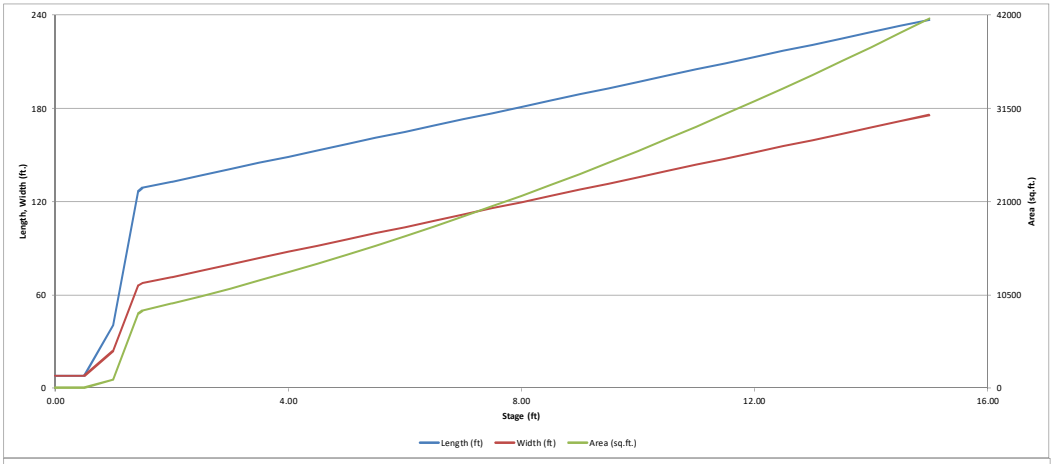
Zone 1 Volume (WQCV) =	0.162	acre-feet
Zone 2 Volume (100-year - Zone 1) =	1.206	acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =	1.368	acre-feet
Initial Surcharge Volume (ISV) =	21	ft^3
Initial Surcharge Depth (ISD) =	0.33	ft
Total Available Detention Depth (H_{total}) =	6.00	ft
Depth of Trickle Channel (H_{TC}) =	0.50	ft
Slope of Trickle Channel (S_{TC}) =	0.005	ft/ft
Slopes of Main Basin Sides (S_{main}) =	4	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	2	
Initial Surcharge Area (A_{ISV}) =	64	ft^2
Surcharge Volume Length (L_{ISV}) =	8.0	ft
Surcharge Volume Width (W_{ISV}) =	8.0	ft
Depth of Basin Floor (H_{FLOOR}) =	0.59	ft
Length of Basin Floor (L_{FLOOR}) =	128.3	ft
Width of Basin Floor (W_{FLOOR}) =	67.0	ft
Area of Basin Floor (A_{FLOOR}) =	8,589	ft^2
Volume of Basin Floor (V_{FLOOR}) =	1,846	ft^3
Depth of Main Basin (H_{MAIN}) =	4.58	ft
Length of Main Basin (L_{MAIN}) =	164.9	ft
Width of Main Basin (W_{MAIN}) =	103.6	ft
Area of Main Basin (A_{MAIN}) =	17,086	ft^2
Volume of Main Basin (V_{MAIN}) =	57,697	ft^3
Calculated Total Basin Volume (V_{total}) =	**1.368**	acre-feet

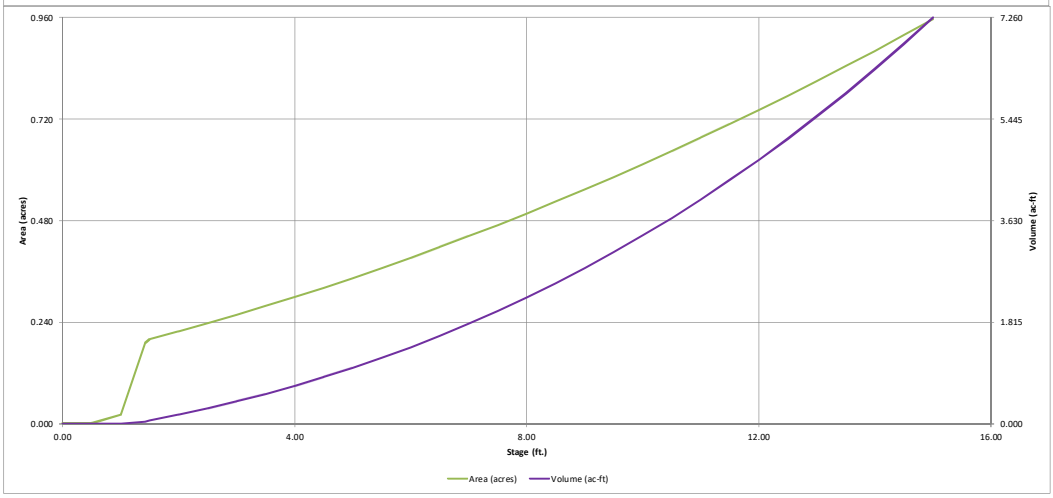
Depth Increment = 0.5 ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	0.00		8.0	8.0	64		0.001		
ISV	0.33		8.0	8.0	64		0.001	21	0.000
	0.50		8.0	8.0	64		0.001	31	0.001
	1.00		40.7	24.0	976		0.022	123	0.003
Floor	1.42		126.3	66.0	8,339		0.191	1,827	0.042
	1.50		128.8	67.5	8,699		0.200	2,517	0.058
Zone 1 (WQCV)	1.99		132.8	71.5	9,501		0.218	7,065	0.162
	2.00		132.8	71.5	9,501		0.218	7,065	0.162
	2.50		136.9	75.6	10,351		0.238	12,126	0.278
	3.00		140.9	79.6	11,217		0.258	17,517	0.402
	3.50		144.9	83.6	12,115		0.278	23,349	0.536
	4.00		148.9	87.6	13,045		0.299	29,637	0.680
	4.50		152.9	91.6	14,007		0.322	36,399	0.836
	5.00		156.9	95.6	15,001		0.344	43,650	1.002
	5.50		160.9	99.6	16,028		0.368	51,406	1.180
Zone 2 (100-year)	6.00		164.9	103.6	17,086		0.392	59,683	1.370
	6.50		168.9	107.6	18,176		0.417	68,497	1.572
	7.00		172.9	111.6	19,298		0.443	77,864	1.788
	7.50		176.9	115.6	20,452		0.470	87,800	2.016
	8.00		180.9	119.6	21,638		0.497	98,321	2.257
	8.50		184.9	123.6	22,856		0.525	109,443	2.512
	9.00		188.9	127.6	24,106		0.553	121,182	2.782
	9.50		192.9	131.6	25,388		0.583	133,555	3.066
	10.00		196.9	135.6	26,702		0.613	146,576	3.365
	10.50		200.9	139.6	28,048		0.644	160,262	3.679
	11.00		204.9	143.6	29,426		0.676	174,629	4.009
	11.50		208.9	147.6	30,836		0.708	189,694	4.355
	12.00		212.9	151.6	32,278		0.741	205,471	4.717
	12.50		216.9	155.6	33,752		0.775	221,977	5.096
	13.00		220.9	159.6	35,259		0.809	239,229	5.492
	13.50		224.9	163.6	36,797		0.845	257,241	5.905
	14.00		228.9	167.6	38,367		0.881	276,031	6.337
	14.50		232.9	171.6	39,969		0.918	295,613	6.786
	15.00		236.9	175.6	41,603		0.955	316,005	7.254

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)





LEGEND

- BASIN DESIGNATION (XX)
- BASIN AREA (XX.X) / 5 YEAR COEFFICIENTS (.XXX) / 100 YEAR COEFFICIENTS (.XXX)
- BASIN BOUNDARY
- DIRECTIONAL FLOW ARROW
- DESIGN POINT (1)

	RUNOFF				
	BASIN	DESIGN POINT	AREA (AC)	5-YEAR RUNOFF (CFS)	100-YEAR RUNOFF (CFS)
A	A1	1	86.97	0.9	47.8
	A2	2	120.45	1.0	52.3
	A3	3	86.87	0.8	40.7
	A4	4	80.33	1.0	35.6
B	B1	5	3.82	0.1	3.5
	B2	6	5.60	0.1	3.4
C	C1	7	46.03	0.6	30.2
D	D1	8	5.56	0.5	5.2

0 200' 400'

1 inch = 200 ft.

A1 86.97 0.01 0.25

A2 120.45 0.01 0.25

A3 86.87 0.01 0.24

A4 80.33 0.01 0.24

B1 3.82 0.01 0.27

B2 5.60 0.01 0.18

C1 46.03 0.01 0.26

D1 5.56 0.06 0.41

DIRT ACCESS PATHS (TYP.)

DETENTION POND 1.4 AC-FT

GRAVEL ACCESS

WASHINGTON ROAD (60' PUBLIC R.O.W.)

DSD FILE NO. EA17223

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#	REVISION DESCRIPTION	DATE	BY
1	1ST SUBMITTAL	10/1/18	DB

GRAZING YAK SOLAR

EL PASO COUNTY, COLORADO

WIND/SOLAR ENERGY OVERLAY PLAN
DRAINAGE PLAN

DESIGNED BY: DB
DRAWN BY: DB
CHECKED BY: DB

JOB NO. 18-082

SHEET 1 OF 1

10/25/2018 11:35 AM - N:\CORE_2012-EL PSO\PROJECTS\18-082 GRAZING YAK SOLAR\ENGINEERING\CAD\CIVIL\WSE-JOB SITE DETAILS.DWG

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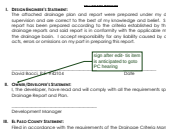

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