FINAL
DRAINAGE PLAN AND REPORT

POENITSCH SUBDIVISION

S1/2, SE1/4, SE1/4, Section 8, Township 12 South, Range 65 West of the 6th P.M.

EL PASO COUNTY

January 16, 2019

Revised
June 18, 2019

Revised
November 26, 2019

Prepared for
Tom Poenitsch and Christy Mullins
P.O. Box 8202
Colorado Springs, CO 80933
(719) 200-5216

Oliver E. Watts, Consulting Engineer, Inc.
Colorado Springs, Colorado

PSD File No. MS193

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Celebrating over 40 years in business

November 27, 2019

El Paso County D.O.T.
2880 International Circle
Colorado Springs, CO 80910

ATTN: *Gilbert LaForce*

SUBJECT: Final Drainage Plan and Report
Poenitsch Subdivision

Gentlemen

Transmitted herewith for your review and approval is the drainage plan and report for The Poenitsch Subdivision in El Paso County. This report has been revised in accordance with your March 28, 2019 and October 23, 2019 review comments. This report will accompany the subdivision plat submittal.

Please contact me if I may provide any further information.

Oliver E. Watts, Consulting Engineer, Inc.

BY: ______________________________
Oliver E. Watts, President

Encl:

Drainage Report 5 pages
Computations, 12 pages
FEMA Panel No. 08041C0320 G
SCS Soils Map and 4 Interpretation Sheets
Backup Information, 6 sheets
Drainage Plan, Dwg 18-5184-08
Offsite Drainage Map, Dwg 18-5184-09

1. 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.

Oliver E. Watts, Consulting Engineer, Inc.

OLIVER E. WATTS REGISTERED 9853 P.E. & L.S. STATE OF COLORADO

1-17-20

Oliver E. Watts Colo. PE-LS No. 9853

2. OWNERS / DEVELOPER'S STATEMENT:

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

By: 1/17/20
Tom Poenitsch
P.O. Box 8202
Colorado Springs, CO 80933
(719) 200-5216

3. EL PASO COUNTY:

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

Jennifer Irvine date
County Engineer / ECM Administrator

Conditions:

4. LOCATION AND DESCRIPTION:

The Poenitsch Subdivision is an 18.858 acre subdivision located in the South half of the Southeast quarter of the Southeast quarter of Section 8, Township 12 South, Range 65 West of the 6th P.M., in El Paso County Colorado. It is zoned RR-5 and will be subdivided into three residential lots as shown on the enclosed drainage plan. The property is on the Northwest corner of Shoup Road and Herring Road.

5. FLOOD PLAIN STATEMENT:

This subdivision is not within the limits of a flood plain or flood hazard area, according to FEMA map panel number 08041C0320 G, dated December 7, 2018, a copy of which is enclosed for reference.

6. METHOD AND CRITERIA:

The method used for all computations is that specified in the City-County Drainage Criteria Manual, using the rational method for areas of the size of the development. All computations are enclosed for reference and review.

The soils in the subdivision have been mapped by the local USDA/SCS office, and a soils map and interpretation sheets are enclosed for reference. All soils in this area are of hydrologic group "B".

7. DESCRIPTION OF RUNOFF:

A. Drainage Inflows. As shown on the enclosed offset drainage plan, three drainage basins will outfall into the subdivision. All basins consist of heavily forested areas typical of the Black Forest region of El Paso County that are now in a recovery state following the fire of five years ago. The runoff from each basin is contained by natural channels. Basin O-1 is 4400 feet in length and drops 150 feet in elevation, occupying 97.4 acres. It has a runoff of 11.7 cfs / 85.2 cfs (5-year / 100-year runoffs) into a 47 foot long 48" RCP culvert across Herring Road. It will contain the 100-year runoff with 0.73' of headwater as shown on the enclosed computations. Basin O-2 is 51.5 acres in size, 4500 feet long and outfalls into the northeast portion of the subdivision in a natural channel. Basin O-3 is 82.4 acres in size, 4100 feet long and outfalls into the north central portion of the subdivision in a natural channel.

B. Internal Routing. All of the natural channels within the subdivision are stable in configuration and more that adequate to contain the design runoff. Progressing downstream basin O-1 will combine with basin A and basin O-2 to create a total runoff of 18.8 cfs / 137 cfs at the channel junction shown on the drainage plan. This will combine with basin O-3 and basin B to create a total runoff of 29.3 cfs / 214 cfs at the next junction. This will combine with basin C for a total outfall from the subdivision of 30 cfs / 219 cfs on the west boundary near the northwest corner. Just downstream is a private roadway crossing with a 34' long 24" RCP culvert, which will overtop under the 100-year runoff, but will contain the 5-year runoff at a headwater depth of 1.46 feet. Backwater due to the overtopping does not affect the subdivision. The drainageway is within a public drainage easement, to be maintained by the individual property owners.

C: Proposed Structures. The County has determined that all access to the lots must be from Herring Road, due to the classification of Shoup Road. Lot 3 can use the existing driveway on east boundary; however lots 2 and 1 will access the property via the access easement along the north boundary as shown on the drainage plan. An 18" CMP will be provided at this location. A design of the grading and drainage for this access is shown. Two culverts will be required as s minimum, a 24" and a 48" HDPE, with the design details shown on the plan. Riprap will be provided at the outlet, along with the culverts on Herring road, as shown on the drainage plan and the enclosed computations. The roadway and culverts will be private and maintained by the homeowners.

8. FOUR-STEP PROCESS

Step 1: Employ Runoff Reduction Practices

This is a 3-lot residential subdivision. Each lot will have less that 1-acre of impervious surface. Each home owner will be encouraged to discharge stormwater across vegetated (grassed) areas before reaching the drainageway. In this way, stormwater runoff will be slowed down and encouraged to infiltrate.

Step 2: Stabilize Drainageways

The drainageways through the site are covered in native vegetation and show no signs of erosion, even after the fire. There will be two driveway crossings of the drainageway. Each crossing will have a culvert sized to handle runoff and rip rap to stabilize the slopes. The crossings will serve as a grade control structure of sorts. The culverts will release the stormwater in a controlled way helping to maintain the existing mild slope along the channel and arresting any stream degradation.

Step 3: Provide Water Quality Capture Volume (WQCV)

This is a 3-lot residential subdivision. Each lot will have less that 1-acre of impervious surface. As such there will be no need for any detention.

Step 4: Consider Need for Industrial and Commercial BMPs

This is a 3-lot residential subdivision. Each lot will have less that 1-acre of impervious surface. As such there will be no need for any industrial or commercial BMPs for the site.

9. COST ESTIMATE:

All facilities are private.

Item No.	Description	Quantity	Unit Cost	Cost
1	18" HDPE Culvert	26 LF	$ 30.00	$ 780.00
2	24" HDPE	34 LF	40.00	1360.00
3	48" HDPE Culvert	88 LF	70.00	6160.00
4	Riprap	6.7 CY	100.00	670.00
	Subtotal Construction Cost			$ 8970.00
	Engineering		10%	897.00
	Total Estimated Cost			$ 9067.00

10. FEES:

The owner has obtained a permit for the joint driveway shown on the drainage plan in order to begin the clearing of burnt trees. We have added potential building sites in order to compute the total impervious acreage, computed from the drainage plan as follows:

2019 Fees: Kettle Creek Drainage Basin
Drainage Fees: 0.95 Ac. @ $9909.00 = $ 9413.55; 25% reduction = $ 2353.39 Net = $ 7060.16
Bridge Fees: None

MAJOR BASIN	SUB BASIN	AREA		BASIN		Tc MIN	I		SOIL GRP	DEV. TYPE	C		FLOW		RETURN PERIOD YR	
		PLANIM READ	ACRES	LENGTH FT	HEIGHT FT								Qp CFS	Qp CFS		
BURGESS	O1	COGO	97.4	300	16	18			B	FOREST	0.08	0.35			5	100
CREEK			V=1.26	+4100	134	+54										
(KETTLE)						72	1.5	2.5					11.7	85.5	5	100
	O2	COGO	51.5	300	26	16										
			V=1.27	+4200	140	+54										
						70	1.5	2.5					6.2	45.1	5	100
	A	COGO	8.08	+810	28	+1.3										
	TOTAL		V=1.30			71.3	1.5	2.5					18.8	137	5	100
	03	COGO	82.4	300	28	15										
			V=1.40	+3800	153	+45										
						60	1.5	2.5					9.9	72.1	5	100
	B	COGO	5.05	+290	10	+3.7										
	TOTAL		244.4	V=1.3		64	1.5	2.5					29.3	214	5	100
	C	COGO	5.72	+380	7	+7										
	TOTAL		250.1	V=0.95		71	1.5	2.5					30.0	219		

HYDROLOGICAL COMPUTATION – BASIC DATA
PROJ: POENITCH SUB. BY: O.E. WATTS
RATIONAL METHOD DATE: 11-22-18, 11-26-19

OLIVER E. WATTS, CONSULTING ENGINEER, INC.
614 ELKTON DRIVE COLORADO SPRINGS, CO 80907

STREET AND STORM SEWER CALCULATIONS

STREET	LOCATION	DISTANCE	ELEVATION & SLOPE	TOTAL RUNOFF	STREET FLOW / CAPACITY	PIPE FLOW	TYPE PIPE, CATCH BASIN & SLOPE %
HERRING RD	01	47’	2.68%	11.7/85.2		85.2	48” RCP CAP = 235, hi=0.16V2=0.73’
							RIPRAP 6” L=12’
PRIVATE	OUTFALL	34’	3.34%	30.0/219		219	24” RCP CAP = 41.3 O’TOPS
						30	OK, hi=1.46’
PRIVATE	LOT 1	88’	2.21%^	18.8/137		137	48”HDPE CAP=151 hi=1.90’
							RIPRAP 6” L-12’
PRIVATE	LOT 3	874’	3.3%	6.2/45.1		45.12	24” HDPE CAP=53.4 hi=3.29’
							RIPRAP 6” L=6’

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Worksheet for Irregular Section - A - A

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.04710	ft/ft
Discharge:	85.20	ft³/s

Options		
Current Roughness Weighted Methc	ImprovedLotters	
Open Channel Weighted Roughnes:	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.035	
Water Surface Elevation:	74.76	ft
Elevation Range:	74.00 to 80.00 ft	
Flow Area:	12.70	ft²
Wetted Perimeter:	20.44	ft
Top Width:	20.26	ft
Normal Depth:	0.76	ft
Critical Depth:	0.97	ft
Critical Slope:	0.01975	ft/ft
Velocity:	6.71	ft/s
Velocity Head:	0.70	ft
Specific Energy:	1.46	ft
Froude Number:	1.49	
Flow Type:	Supercritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(-0+32, 80.00)	(0+40, 80.00)	0.035

Section Geometry

Station	Elevation
-0+32	80.00
-0+21	78.00

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Worksheet for Irregular Section - A - A

Station	Elevation
-0+14	76.00
-0+08	74.00
0+05	74.00
0+18	76.00
0+29	78.00
0+40	80.00

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Worksheet for Irregular Section - 8.B

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.04710	ft/ft
Discharge:	45.10	ft³/s

Options		
Current Roughness Weighted Meth(	ImprovedLotters	
Open Channel Weighted Roughnes:	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.035	
Water Surface Elevation:	66.32	ft
Elevation Range:	66.00 to 70.00 ft	
Flow Area:	11.04	ft²
Wetted Perimeter:	37.35	ft
Top Width:	37.30	ft
Normal Depth:	0.32	ft
Critical Depth:	0.39	ft
Critical Slope:	0.02540	ft/ft
Velocity:	4.08	ft/s
Velocity Head:	0.26	ft
Specific Energy:	0.58	ft
Froude Number:	1.32	
Flow Type:	Supercritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(-0+35, 70.00)	(0+60, 70.00)	0.035

Section Geometry

Station	Elevation
-0+35	70.00
-0+25	68.00

Worksheet for Irregular Section - B-B

Station	Elevation
-0+16	66.00
0+15	66.00
0+45	68.00
0+60	70.00

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Worksheet for Irregular Section - ℄ - C

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.03390	ft/ft
Discharge:	137.00	ft^3/s

Options		
Current Roughness Weighted Methc	ImprovedLotters	
Open Channel Weighted Roughnes:	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.035	
Water Surface Elevation:	52.19	ft
Elevation Range:	51.00 to 54.00 ft	
Flow Area:	24.05	ft^2
Wetted Perimeter:	38.66	ft
Top Width:	38.57	ft
Normal Depth:	1.19	ft
Critical Depth:	1.32	ft
Critical Slope:	0.02019	ft/ft
Velocity:	5.70	ft/s
Velocity Head:	0.50	ft
Specific Energy:	1.70	ft
Froude Number:	1.27	
Flow Type:	Supercritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(-0+60, 54.00)	(0+21, 54.00)	0.035

Section Geometry

Station	Elevation
-0+60	54.00
-0+22	52.00

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Worksheet for Irregular Section - ℄ - C

Station	Elevation
0+00	51.00
0+12	52.00
0+21	54.00

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Worksheet for Irregular Section - D - D

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.02470	ft/ft
Discharge:	72.10	ft³/s

Options		
Current Roughness Weighted Methc	ImprovedLotters	
Open Channel Weighted Roughnes:	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.035	
Water Surface Elevation:	48.74	ft
Elevation Range:	47.50 to 52.00 ft	
Flow Area:	12.78	ft²
Wetted Perimeter:	16.42	ft
Top Width:	16.17	ft
Normal Depth:	1.24	ft
Critical Depth:	1.31	ft
Critical Slope:	0.01937	ft/ft
Velocity:	5.64	ft/s
Velocity Head:	0.49	ft
Specific Energy:	1.73	ft
Froude Number:	1.12	
Flow Type:	Supercritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(-0+28, 52.00)	(0+20, 52.00)	0.035

Section Geometry

Station	Elevation
-0+28	52.00
-0+13	50.00

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Worksheet for Irregular Section - D-D

Station	Elevation
-0+05	48.00
0+00	47.50
0+06	48.00
0+12	50.00
0+20	52.00

Worksheet for Irregular Section - E-E

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.00000	ft/ft
Discharge:	219.00	ft³/s

Options	
Current Roughness Weighted Meth(	ImprovedLotters
Open Channel Weighted Roughnes:	ImprovedLotters
Closed Channel Weighted Roughne	Hortons

Results		
Roughness Coefficient:	0.035	
Water Surface Elevation:	40.55	ft
Elevation Range:	38.60 to 44.00 ft	
Flow Area:	31.09	ft²
Wetted Perimeter:	28.66	ft
Top Width:	28.37	ft
Normal Depth:	1.95	ft
Critical Depth:	2.09	ft
Critical Slope:	0.01707	ft/ft
Velocity:	7.04	ft/s
Velocity Head:	0.77	ft
Specific Energy:	2.72	ft
Froude Number:	1.19	
Flow Type:	Supercritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(-0+34, 44.00)	(0+30, 44.00)	0.035

Section Geometry

Station	Elevation
-0+34	44.00
-0+20	42.00

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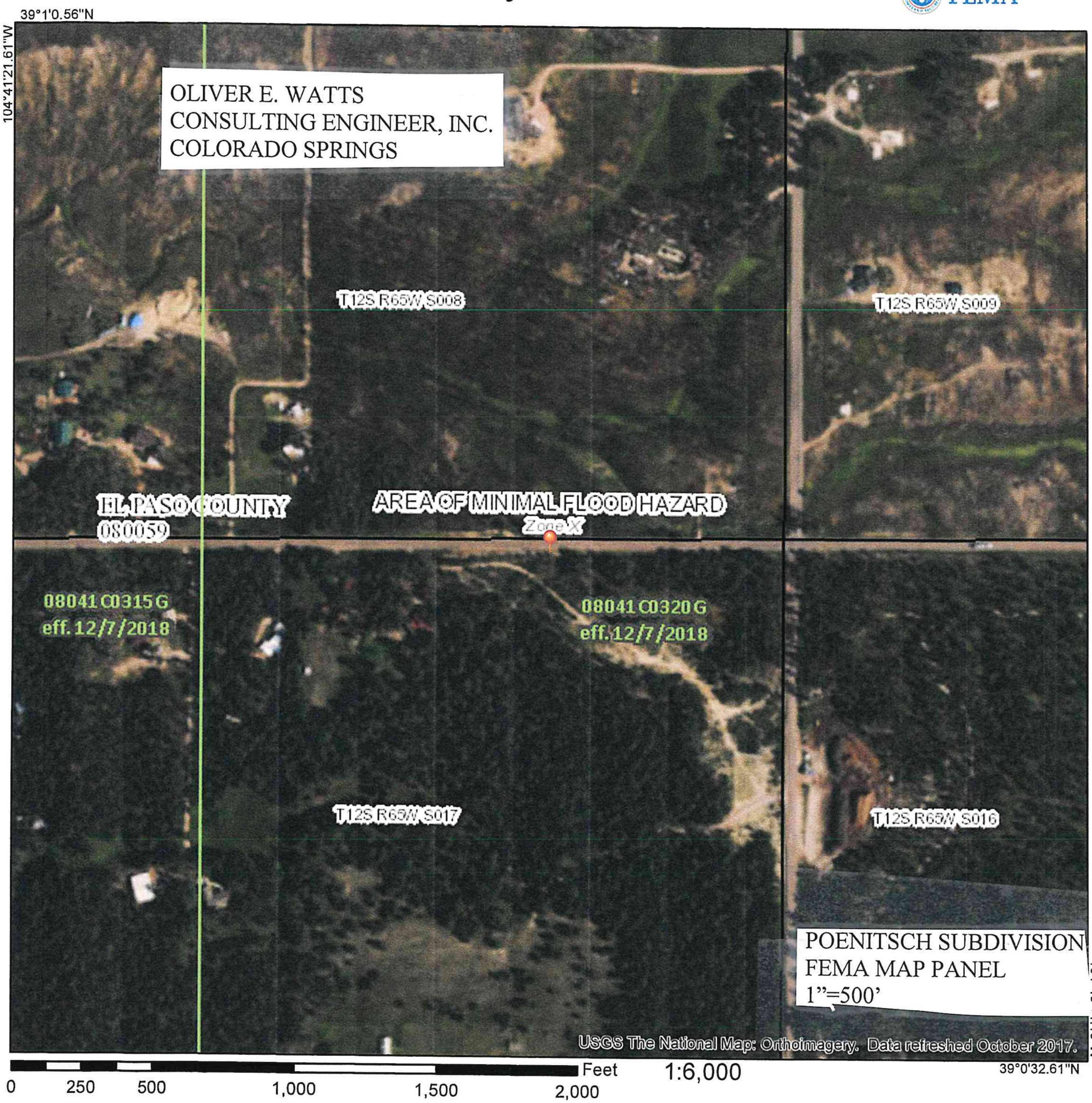
Worksheet for Irregular Section - E-E

Station	Elevation
-0+12	40.00
0+00	38.60
0+12	40.00
0+20	42.00
0+30	44.00

National Flood Hazard Layer FIRMette

FEMA



Legend

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

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

N

The pin displayed on the map is an approximate point selected by the user and does not represen an authoritative property location.

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

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 12/12/2018 at 10:49:53 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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

EL PASO COUNTY AREA, COLORADO NO. 2

TABLE 16.--SOIL AND WATER FEATURES

[Absence of an entry indicates the feature is not a concern. See "flooding" in Glossary for definition of terms as "rare," "brief," and "very brief." The symbol > means greater than]

Soil name and map symbol	Hydro-logic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	Bedrock: Depth	Bedrock: Hardness	Potential frost action
					In		
Alamosa: 1	C	Frequent	Brief	May-Jun	>60	---	High.
Ascalon: 2, 3	B	None	---	---	>60	---	Moderate.
Badland: 4	D	---	---	---	---	---	---
Bijou: 5, 6, 7	B	None	---	---	>60	---	Low.
Blakeland: 8	A	None	---	---	>60	---	Low.
[1]9: Blakeland part	A	None	---	---	>60	---	Low.
Fluvaquentic Haplaquolls part	D	Common	Very brief	Mar-Aug	>60	---	High.
Blendon: 10	B	None	---	---	>60	---	Moderate.
Bresser: 11, 12, 13	B	None	---	---	>60	---	Low.
Brussett: 14, 15	B	None	---	---	>60	---	Moderate.
Chaseville: 16, 17	A	None	---	---	>60	---	Low.
[1]18: Chaseville part	A	None	---	---	>60	---	Low.
Midway part	D	None	---	---	10-20	Rippable	Moderate.
Columbine: 19	A	None to rare	---	---	>60	---	Low.
Connerton: [1]20: Connerton part	B	None	---	---	>60	---	High.
Rock outcrop part	D	---	---	---	---	---	---
Cruckton: 21	B	None	---	---	>60	---	Moderate.
Cushman: 22, 23	C	None	---	---	20-40	Rippable	Moderate.
[1]24: Cushman part	C	None	---	---	20-40	Rippable	Moderate.
Kutch part	C	None	---	---	20-40	Rippable	Moderate.
Elbeth: 25, 26	B	None	---	---	>60	---	Moderate.
[1]27: Elbeth part	B	None	---	---	>60	---	Moderate.

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Hardness	
					In		
Elbeth: Pring part	B	None	---	---	>60	---	Moderate.
Ellicott: 28	A	Frequent	Brief	Mar-Jun	>60	---	Low.
Fluvaquentic Haplaquolls: 29	B/D	Frequent	Brief	Mar-Jul	>60	---	High.
Fort Collins: 30, 31	B	None to rare	---	---	>60	---	Moderate.
Fortwingate: [1]32: Fortwingate part	C	None	---	---	20-40	Hard	Low.
Rock outcrop part	D	---	---	---	---	---	---
Heldt: 33	C	None	---	---	>60	---	Moderate.
Holderness: 34, 35, 36	C	None	---	---	>60	---	Moderate.
Jarre: 37	B	None	---	---	>60	---	Moderate.
[1]38: Jarre part	B	None	---	---	>60	---	Moderate.
Tecolote part	B	None	---	---	>60	---	Moderate.
Keith: 39	B	None	---	---	>60	---	High.
Kettle: 40, 41	B	None	---	---	>60	---	Moderate.
[1]42: Kettle part	B	None	---	---	>60	---	Moderate.
Rock outcrop part	D	---	---	---	---	---	---
Kim: 43	B	None	---	---	>60	---	Moderate.
Kutch: 44, 45	C	None	---	---	20-40	Rippable	Moderate.
Kutler: [1]46: Kutler part	C	None	---	---	20-40	Rippable	Low.
Broadmoor part	C	None	---	---	20-40	Rippable	Low.
Rock outcrop part	D	---	---	---	---	---	---
Limon: 47	C	Occasional	Brief	May-Sep	>60	---	Moderate.
Louviers: 48	D	None	---	---	10-20	Rippable	Moderate.
49	D	None	---	---	10-20	Rippable	Low.

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro- logic group	Flooding			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Hardness	
					In		
Manvel:							
50	C	None	---	---	>60	---	High.
Manzanola:							
51, 52, 53	C	None to rare	---	---	>60	---	Moderate.
Midway:							
54	D	None	---	---	10-20	Rippable	Moderate.
Nederland:							
55	B	None	---	---	>60	---	Moderate.
Nelson:							
[1]56:							
Nelson part	B	None	---	---	20-40	Rippable	Low.
Tassel part	D	None	---	---	10-20	Rippable	Low.
Neville:							
57	B	None	---	---	>60	---	High.
[1]58:							
Neville part	B	None	---	---	>60	---	High.
Rednun part	C	None	---	---	>60	---	Moderate.
Nunn:							
59	C	None	---	---	>60	---	Moderate.
Olney:							
60, 61	B	None	---	---	>60	---	Moderate.
[1]62:							
Olney part	B	None	---	---	>60	---	Moderate.
Vona part	B	None	---	---	>60	---	Moderate.
Paunsaugunt:							
[1]63:							
Paunsaugunt part	D	None	---	---	10-20	Hard	Moderate.
Rock outcrop part	D	---	---	---	---	---	---
Penrose:							
[1]64:							
Penrose part	D	None	---	---	10-20	Rippable	Low.
Manvel part	C	None	---	---	>60	---	High.
Perrypark:							
65	B	None	---	---	>60	---	Moderate.
Peyton:							
66, 67	B	None	---	---	>60	---	Moderate.
[1]68, [1]69:							
Peyton part	B	None	---	---	>60	---	Moderate.
Pring part	B	None	---	---	>60	---	Moderate.
Pits, gravel:							
70	A	---	---	---	---	---	---
Pring:							
71, 72	B	None	---	---	>60	---	Moderate.
Razor:							
73, 74	C	None	---	---	20-40	Rippable	Moderate.

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Hardness	
					In		
Tomah:							
[1]92, [1]93:							
Tomah part-----	B	None----------	---	---	>60	---	Moderate.
Crowfoot part--	B	None----------	---	---	>60	---	Moderate.
Travessilla:							
[1]94:							
Travessilla part----------	D	None----------	---	---	6-20	Hard	Low.
Rock outcrop part----------	D	---	---	---	---	---	---
Truckton:							
95, 96, 97-------	B	None----------	---	---	>60	---	Moderate.
[1]98:							
Truckton part--	B	None----------	---	---	>60	---	Moderate.
Blakeland part-	A	None----------	---	---	>60	---	Low.
[1]99, [1]100:							
Truckton part--	B	None----------	---	---	>60	---	Moderate.
Bresser part---	B	None----------	---	---	>60	---	Low.
Ustic Torrifluvents:							
101--------------	B	Occasional----	Very brief----	Mar-Aug	>60	---	Moderate.
Valent:							
102, 103---------	A	None----------	---	---	>60	---	Low.
Vona:							
104, 105---------	B	None----------	---	---	>60	---	Moderate.
Wigton:							
106--------------	A	None----------	---	---	>60	---	Low.
Wiley:							
107, 108---------	B	None----------	---	---	>60	---	Low.
Yoder:							
109, 110---------	B	None----------	---	---	>60	---	Low.

[1]This map unit is made up of two or more dominant kinds of soil. See map unit description for the composition and behavior characteristics of the map unit.

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.

$$t_c = t_i + t_t \qquad \text{(Eq. 6-7)}$$

Where:

t_c = time of concentration (min)

t_i = overland (initial) flow time (min)

t_t = travel time in the ditch, channel, gutter, storm sewer, etc. (min)

3.2.1 Overland (Initial) Flow Time

The overland flow time, t_i, may be calculated using Equation 6-8.

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \qquad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \qquad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)

C_v = conveyance coefficient (from Table 6-7)

S_w = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*For buried riprap, select C_v value based on type of vegetative cover.

The travel time is calculated by dividing the flow distance (in feet) by the velocity calculated using Equation 6-9 and converting units to minutes.

The time of concentration (t_c) is then the sum of the overland flow time (t_i) and the travel time (t_t) per Equation 6-7.

3.2.3 First Design Point Time of Concentration in Urban Catchments

Using this procedure, the time of concentration at the first design point (typically the first inlet in the system) in an urbanized catchment should not exceed the time of concentration calculated using Equation 6-10. The first design point is defined as the point where runoff first enters the storm sewer system.

$$t_c = \frac{L}{180} + 10 \qquad \text{(Eq. 6-10)}$$

Where:

t_c = maximum time of concentration at the first design point in an urban watershed (min)

L = waterway length (ft)

Equation 6-10 was developed using the rainfall-runoff data collected in the Denver region and, in essence, represents regional "calibration" of the Rational Method. Normally, Equation 6-10 will result in a lesser time of concentration at the first design point and will govern in an urbanized watershed. For subsequent design points, the time of concentration is calculated by accumulating the travel times in downstream drainageway reaches.

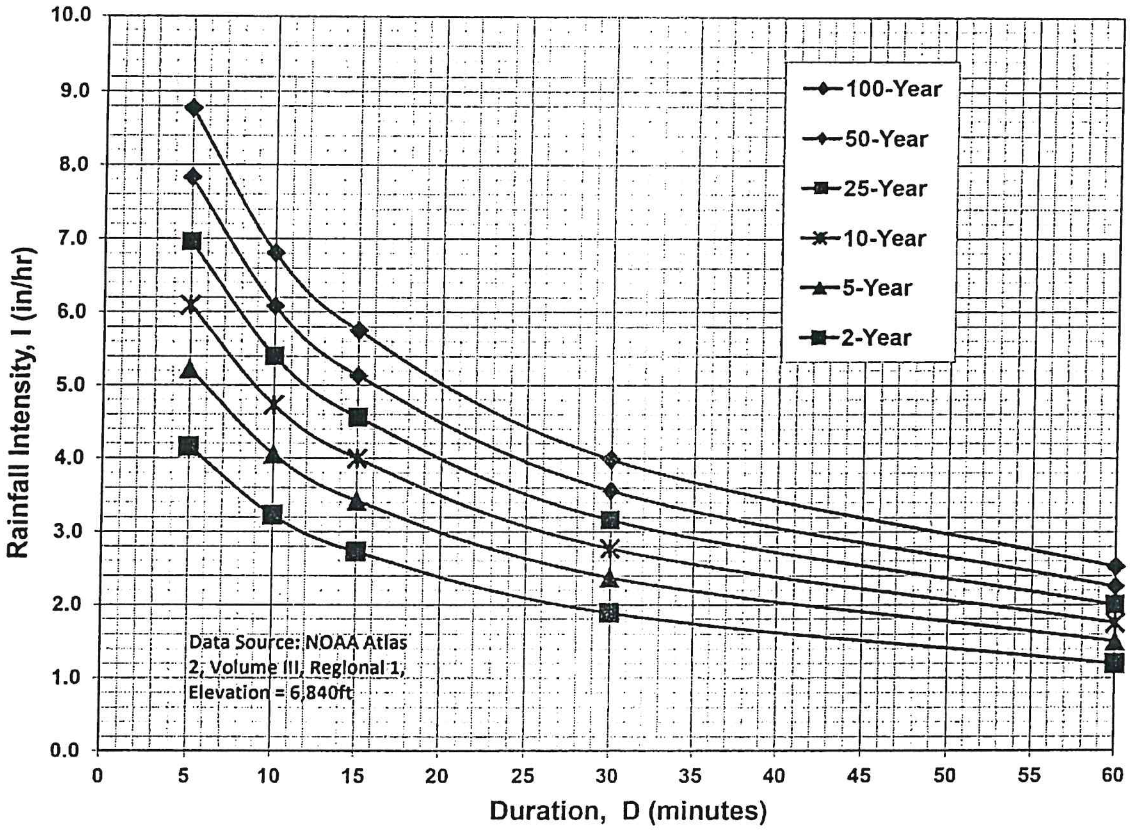
3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

3.2.5 Post-Development Time of Concentration

As Equation 6-8 indicates, the time of concentration is a function of the 5-year runoff coefficient for a drainage basin. Typically, higher levels of imperviousness (higher 5-year runoff coefficients) correspond to shorter times of concentration, and lower levels of imperviousness correspond to longer times of

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.

$Q=\frac{0.463}{n} D^{8/3} S^{1/2}$

$Q=KS^{1/2}$

AMETER -IN.-	AREA -FT2-	D 8/3 -FT-	K			
			N=0.010	N=0.013	N=0.024	N=0.026
2	0.02182	0.008413	0.3895	---	---	---
4	0.08727	0.053420	2.4733	---	---	---
6	0.19630	0.157500	7.2922	5.609	---	---
8	0.34910	0.339200	15.7050	12.081	---	---
10	0.54540	0.615000	28.4745	21.903	---	---
12	0.78540	1.000000	46.3000	35.615	---	---
15	1.22720	1.813100	83.9465	64.574	---	---
18	1.76710	2.948300	136.5100	105.000	56.88	52.50
21	2.40530	4.447400	205.9100	158.400	85.80	79.20
24	3.14160	6.349600	293.9900	226.140	122.49	113.07
27	3.97610	8.692700	402.4700	309.590	167.70	154.79
30	4.90870	11.512600	533.0300	410.030	222.10	205.02
33	5.93960	14.844100	---	528.680	---	---
36	7.06860	18.720800	866.7700	666.700	361.20	333.30
39	8.29580	23.175100	---	825.400	---	---
42	9.62110	28.238900	---	1005.000	544.80	502.50
48	12.56640	40.317500	---	1436.000	777.80	718.00
54	15.90430	55.195000	---	1966.000	1065.00	983.00
60	19.63500	73.100400	---	2604.000	1410.00	1302.00
66	23.75830	94.254200	---	3357.000	1818.00	1678.00
72	28.27430	118.869400	---	4234.000	2293.00	2117.00
78	33.18310	147.152900	---	5241.000	2839.00	2620.00
84	38.48450	179.306000	---	6386.000	3459.00	3193.00
90	44.17860	215.524500	---	7676.000	4158.00	3838.00
96	50.26550	256.000000	---	9118.000	4939.00	4559.00
108	63.61730	350.466600	---	12480.000	6761.00	6140.00
120	78.53980	464.158900	---	16530.000	8954.00	8265.00

Oliver E. Watts
Consulting Engineer
Colorado Springs

3.2.3 Rock Sizing for Riprap Apron and Low Tailwater Basin

Scour resulting from highly turbulent, rapidly decelerating flow is a common problem at conduit outlets. The following section summarizes the method for sizing riprap protection for both riprap aprons (Section 3.2.1) and low tailwater basins (Section 3.2.2).

The required rock size may be selected from Figure 9-36 for circular conduits and from Figure 9-37 for rectangular conduits. Figure 9-36 is valid for $Q/D_c^{2.5}$ of 6.0 or less and Figure 9-37 is valid for $Q/WH^{1.5}$ of 8.0 or less. The parameters in these two figures are:

1. $Q/D^{1.5}$ or $Q/WH^{0.5}$ in which Q is the design discharge in cfs, D_c is the diameter of a circular conduit in feet, and W and H are the width and height of a rectangular conduit in feet.
2. Y_t/D_c or Y_t/H in which Y_t is the tailwater depth in feet, D_c is the diameter of a circular conduit in feet, and H is the height of a rectangular conduit in feet. In cases where Y_t is unknown or a hydraulic jump is suspected downstream of the outlet, use $Y_t/D_t = Y_t/H = 0.40$ when using Figures 9-38 and 9-39.
3. The riprap size requirements in Figures 9-38 and 9-39 are based on the non-dimensional parametric Equations 9-16 and 9-17 (Steven, Simons, and Watts 1971 and Smith 1975).

Circular culvert:

$$d_{50} = \frac{0.023Q}{Y_t^{1.2} D_c^{0.3}}$$ Equation 9-16

Rectangular culvert:

$$d_{50} = \frac{0.014H^{0.5}Q}{Y_t W}$$ Equation 9-17

These rock size requirements assume that the flow in the culvert is subcritical. It is possible to use Equations 9-16 and 9-17 when the flow in the culvert is supercritical (and less than full) if the value of D_c or H is modified for use in Figures 9-38 and 9-39. Note that rock sizes referenced in these figures are defined in the *Open Channels* chapter. Whenever the flow is supercritical in the culvert, substitute D_a for D_c and H_a for H, in which D_a is defined as:

$$D_a = \frac{(D_c + Y_n)}{2}$$ Equation 9-18

Where the maximum value of D_a shall not exceed D_c, and

$$H_a = \frac{(H + Y_n)}{2}$$ Equation 9-19

Where the maximum value of H_a shall not exceed H, and:

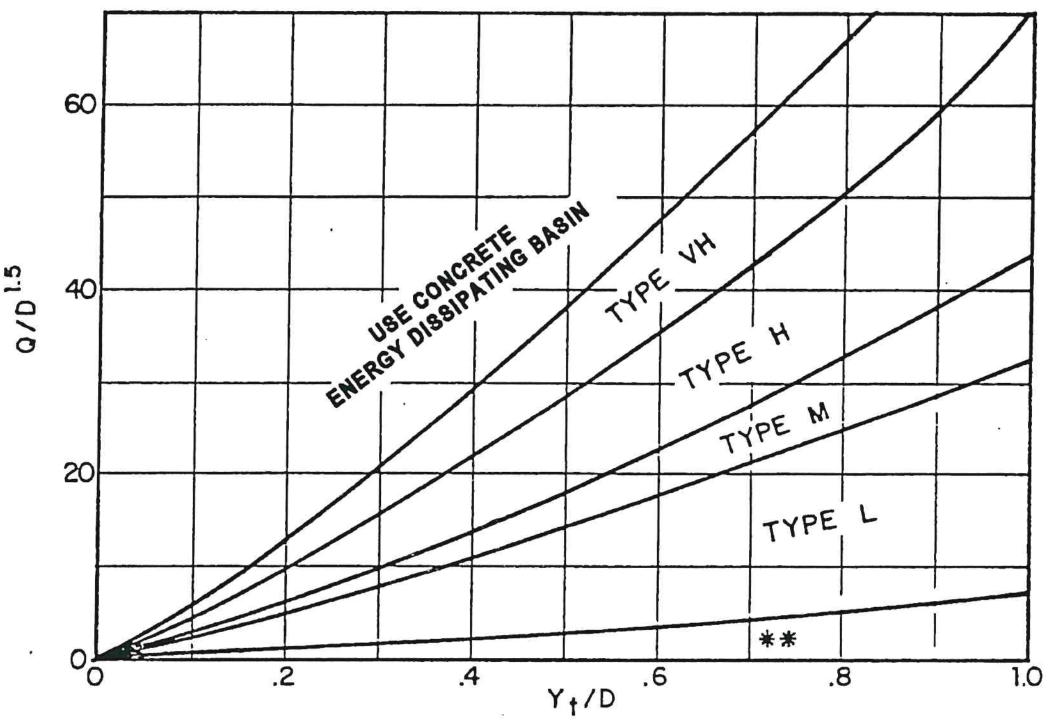
D_a = parameter to use in place of D in Figure 9-38 when flow is supercritical (ft)

D_c = diameter of circular culvert (ft)

H_a = parameter to use in place of H in Figure 9-39 when flow is supercritical (ft)

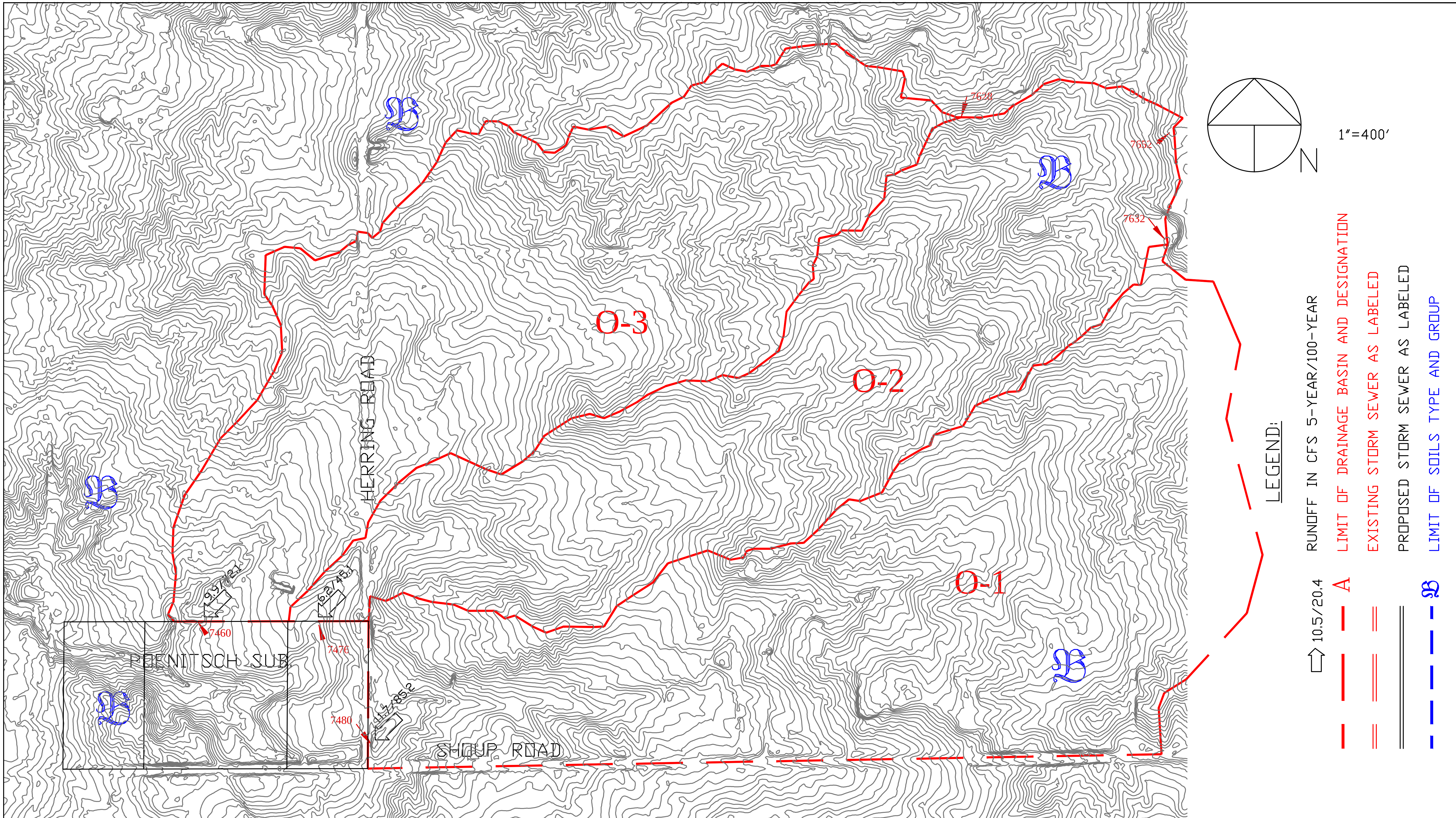
H = height of rectangular culvert (ft)

Y_n = normal depth of supercritical flow in the culvert (ft)



Use D_a instead of D whenever flow is supercritical in the barrel.
** Use Type L for a distance of 3D downstream.

Figure 9-38. Riprap erosion protection at circular conduit outlet (valid for $Q/D_{2.5} \leq 6.0$)

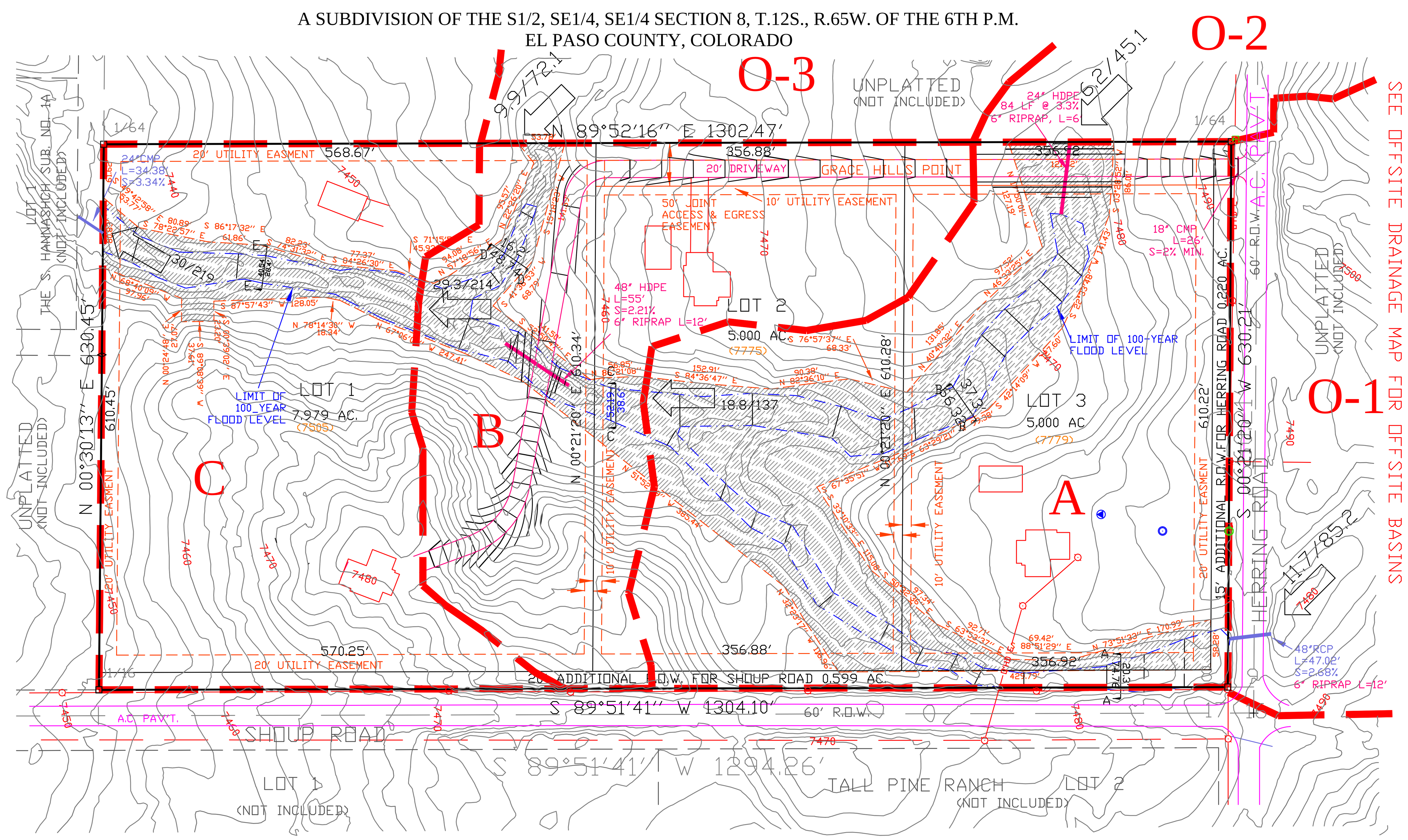


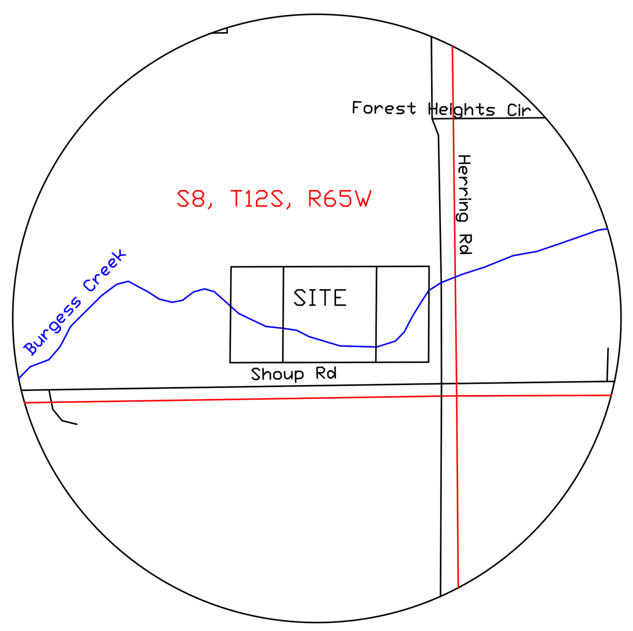
DRAWN BY: O.E. WATTS DATE: 11-22-18 DWG. NO.: 18-5184-09 TOPOGRAPHY BY EL PASO COUNTY INFO. TECH.	REVISIONS	OLIVER E. WATTS CONSULTING ENGINEER COLORADO SPRINGS	PROJECT 7680 SHOUP ROAD S1/2, SE, SE, 8-12-65 EL PASO COUNTY	SHT. NAME **OFFSITE DRAINAGE**

SHT. NO.
1
OF
1

DRAINAGE PLAN
POENITSCH SUBDIVISION

A SUBDIVISION OF THE S1/2, SE1/4, SE1/4 SECTION 8, T.12S., R.65W. OF THE 6TH P.M.
EL PASO COUNTY, COLORADO





VICINITY MAP

1"=1000'

Scale 1" = 100'

Contour Interval: 2'

ELEV. DATUM: NGVD, 1929 ADJUSTMENT

LEGEND:

- FOUND #33649 AL. CAP ON #5 REBAR
- POWER POLE
- WELL
- FIBER OPTIC VAULT
- CYSTERN
- PUBLIC DRAINAGE EASEMENT NO BUILD AND NO STORAGE OF MATERIALS. THE SOLE RESPOSIBILITY FOR MAINTENANCE IS VESTED WITH THE INDIVIDUAL PROPERTY OWNER
- ( ) ADDRESS

LEGEND:

- 10.5/20.4 RUNOFF IN CFS 5-YEAR/100-YEAR
- A LIMIT OF DRAINAGE BASIN AND DESIGNATION
- EXISTING STORM SEWER AS LABELED
- PROPOSED STORM SEWER AS LABELED
- B LIMIT OF SOILS TYPE AND GROUP
- 74.76 / 20.3' CHANNEL SECTION WS ELEV. TOP WIDTH LIMIT OF 100-YEAR RUNOFF
- TYPICAL DWELLING FOR DRAINAGE FEE PURPOSES

Legal Description:
The South half of the Southeast quarter of the Southeast quarter of Section 8, Township 12 South, Range 65 West of the 6th P.M., County of El Paso, State of Colorado.
And containing 18.86 acres

PREPARED BY THE OFFICE OF:
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