JR ENGINEERING
A Westrian Company

May 18, 2018

County of El Paso
Engineering Division
2880 International Circle, Suite 110
Colorado Springs, Colorado 80910

Re: Lot 2, Woodmen Hills Filing 7J - Drainage Addendum Letter for Christian Brothers Automotive Site

Design Engineer's Statement:

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

COLORADO LICENSED GLENN DEAN ELLIS 38861 PROFESSIONAL ENGINEER

Glenn D. Ellis — 18 May '18

Glenn Ellis, Colorado P.E. # 38861 — Date
For and On Behalf of JR Engineering, LLC

Owner/Developer's Statement:

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

5/21/18

Jonathan Wakefield — Date
Christian Brothers Automotive Corporation
17725 Katy Freeway, Suite 200
Houston, TX 77094

El Paso County:

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

Approved
by Elizabeth Nijkamp
El Paso County Planning and Community Development
on behalf of Jennifer Irvine, County Engineer, ECM Administrator
05/24/2018 4:56:41 PM

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

Conditions: Coordination with EPC Parks, including the temporary access agreement, is required prior to and during construction.

PPR 18-003

To Whom It May Concern:

This letter is an addendum to the *Final Stormwater Management and Drainage Plan for Lot 2 Woodmen Filing No. 7F*, dated July 2006, prepared by Inter-Mountain Engineering. It should be noted that Filing 7F was replatted in 2007 into two separate lots, now part of Woodmen Hills Filing No.7J. An exhibit showing the subject property including the Filing 7F plat and Filing 7J plat is attached to this letter, refer to Appendix A. This addendum will update the above mentioned report to reflect the proposed developed condition of Lot 2 of Filing 7J, and the impacts these conditions will have on drainage patterns, quantities, existing infrastructure, and the Regional Detention and Water Quality Pond 4 (Woodmen Hills Pond No. 4).

It should be noted that a *Preliminary Drainage Letter for Falcon Town Center Replat Third IDGAS, LLC Parcel A, Lot 2 Filing 7J – Lot 1 & Lot 2*, dated August 14th, 2007, was prepared by Hefta Group, Inc. after the replat. Despite our best efforts, an approved version of this letter was never found by us or El Paso County personnel. However, Lot 1 of Filing 7J is now developed so it is reasonable to assume that one exists. Because the above mentioned letter is preliminary, it will not be referenced by this addendum letter.

The existing condition of Pond 4 was discussed in the "*Pond 4 of the Falcon Area Stormwater Assessment for El Paso County, Colorado,"* dated March 2011, prepared by Wilson and Company, Inc. In this assessment, the proposed and existing conditions of Pond 4 were compared, and it was determined that the condition of Pond 4 does not satisfy the original design intent. For an explanation of the inadequacies of Pond 4, see Appendix C. After discussion with El Paso County staff, it was acknowledged that there are issues associated with the pond, however, development of the proposed site will not be impeded, and the site will follow previously approved drainage reports and outfall to Pond 4.

General Location

The legal description for the property is as follows: Lot 2, Woodmen Hills Filing No. 7J, a parcel in the northwest one-quarter of Section 7, Township 13 South, Range 64 West of the 6th P.M., County of El Paso, State of Colorado. The site is part of the Falcon Town Center Plaza. Lot 1 of Filing 7J contains approximately 12,000 sf of retail space and borders the site on the north side. Lot 2 of Filing 7H borders the site on the west side and currently contains an O'Reilly Auto Parts store. The south side of the site is bounded by Woodmen Road, and the east side of the site is bounded by U.S. Highway 24.

Description of Property

The site is 1.3 acres in size and currently is open space covered by native vegetation. The site generally slopes from northwest to southeast with slopes ranging from 0-4%. A NRCS Soil Map identifies the site as 100% Hydrologic Type A Soil, classified as Blakeland Loamy Sand. A copy of the soil map is attached in Appendix A. Within the site, existing easements take up nearly half of the lot's area and are located bordering the south, east, and north side of the lot with the exception of a drainage easement that bisects the northwest corner of the lot. The southern easement is a 30' easement for the El Paso County Trail, and the eastern easement is a 60' drainage and utility easement. Development has been limited to grading changes in these locations. The northern 20' easement is for access and utilities for the site. The bisecting drainage easement is 20' wide, and contains a 36" drainage pipe that outfalls to the existing Regional Detention and Water Quality Pond No. 4 (Pond 4). Existing sanitary sewer, gas, and electric utilities are also found on the site in the above mentioned easements.

The site is located within the Falcon drainage basin. In September, Matrix Design Group completed the *Falcon Drainage Basin Planning Study*. The study determined that the drainage fee of $23,217 per impervious acre, and bridge fee of $3,189 per impervious acre would be charged against site development within the basin. The site has no drainage or bridge fee associated with the site development plan application.

Hydrology

All hydrologic data was obtained from the "El Paso County Drainage Criteria Manual," Volume 1 (EPCDCM), and the "Urban Drainage and Flood Control District Urban Drainage Criteria Manual" Volumes 1, 2, and 3. Onsite drainage improvements were designed based on the 5-year (minor) storm event and the 100-year (major) storm event. Runoff was calculated using the Rational Method, and rainfall intensities for the 5-year and the 100-year storm return frequencies were obtained from Table 6-2 of the EPCDCM. One hour point rainfall data for the storm events is identified in the Table below. Runoff coefficients were determined based on proposed land use and from data in Table 6-6 from the EPCDCM. Time of concentrations were developed using equations from the EPCDCM. All runoff calculations and applicable charts and graphs are attached in Appendix B.

Table 1- 1-hr Point Rainfall Data

Storm	Rainfall (in.)
5-year	1.50
100-year	2.52

Previous Reports

The proposed improvements have been designed with the intent to maintain the hydrology of the approved reports for this property. The original report for this property is titled *Phase III Preliminary & Filing 7 Final Drainage and Erosion Control Report for Woodmen Hills Subdivision*, dated December 23, 1998, prepared by URS Greiner. In this report, the project site was part of Basin 33f which was characterized with a runoff coefficient of 0.9, which is a higher and more conservative value than the current 5-year and 100-year runoff coefficients for commercial areas listed in the current El Paso County Drainage Criteria Manual. This report also stated that Pond 4 was designed to accept all flows from Basin 33F and was designed for water quality and to release flows at or below historic rates for the 5-year and 100-year storms per the Urban Drainage Criteria Manual at that time.

The July 2006 report, titled *Final Stormwater Management and Drainage Plan for Lot 2 Woodmen Filing No. 7F*, prepared by Inter-Mountain Engineering confirms that Pond 4 was designed to accept flows from the project site, and the basin containing the site was characterized with a runoff coefficient of 0.9. This report was prepared at the time when Filing 7J Lot 1 was developed into its current condition containing a 12,000 square-foot retail building, paved parking and drive areas, along with landscaping in undeveloped areas. This report also contains the design for the 36" RCP that traverses the project site in the 20' drainage easement and ultimately outfalls to Pond 4. Prior to the storm sewer being installed, an open channel transported flows to Pond 4 along the same alignment the pipe travels today. The Inter-Mountain Engineering report identified a peak flow of 36 cfs in this pipe, with a capacity of approximately 70 cfs.

Drainage calculations for the proposed developed condition of the project site indicate a peak flow of less than 5 cfs tributary to the 36" RCP outfalling to Pond 4. This would result in a new peak flow for the pipe of approximately 41 cfs, far below the pipes capacity of 70 cfs. Rational Method calculations and pipe flow calculations from Hydraflow are attached to this report, refer to Appendix B. A basin summary table is included below:

BASIN SUMMARY TABLE

Tributary Sub-basin	Area (acres)	Percent Impervious	C_5	C_{100}	t_c (min)	Q_5 (cfs)	Q_{100} (cfs)
A	0.29	95%	0.81	0.88	5.0	1.2	2.3
B	0.31	95%	0.81	0.88	5.0	1.3	2.4
C	0.24	5%	0.23	0.46	6.7	0.3	1.0

Drainage Design

The proposed development includes concrete parking areas and access road, a 5,800 square-foot building, and retaining walls on the south and west side of the site. All other site areas are to be left as landscaping and open space. Due to large easements on-site that limit the developable area, the actual total site impervious area is far less than the original assumption made by URS Genier in their 1998 report.

Surface flows from Basins A and B will all be conveyed via curb and gutter to on-site storm inlets including all flows from roof drains. Flows are then piped in 18" HDPE from the inlets to a single proposed manhole. From there, a final run of 18" HDPE conveys the flows into the existing 36" RCP that outfalls into Pond 4. As previously stated, Pond 4 was originally designed to capture flows from this developed site. All proposed on-site storm sewer will be 18" HDPE. Inlets will be Denver Type 16 (grated). Refer to Appendix B for capacity calculations. All other surface flows originating from the site outside of Basins A and B and the developed area, will surface flow to the existing swales and wetland areas that border the site on the south and east sides. A new swale is proposed on the south side of the property to intersect flows coming from the north, before they cross the existing Cinder Trail. This swale will transport flows to an existing 18" corrugated metal pipe that outfalls on the south side of the trail. Refer to the drainage map and swale calculations included in Appendix D.

Conclusion
The proposed changes to the hydrologic configuration and drainage calculations including storm sewer pose no significant changes to the concepts presented within the "*Phase III Preliminary & Filing 7 Final Drainage and Erosion Control Report for Woodmen Hills Subdivision*," dated December 23, 1998, prepared by URS Greiner as well as the "*Final Stormwater Management and Drainage Plan for Lot 2 Woodmen Filing No. 7F*," dated July 2006, prepared by Inter-Mountain Engineering. This addendum is in conformance with the originally intended design and meets the latest criteria requirements.

If you have any questions regarding any of the above comments please do not hesitate to contact me at 303-267-6241.

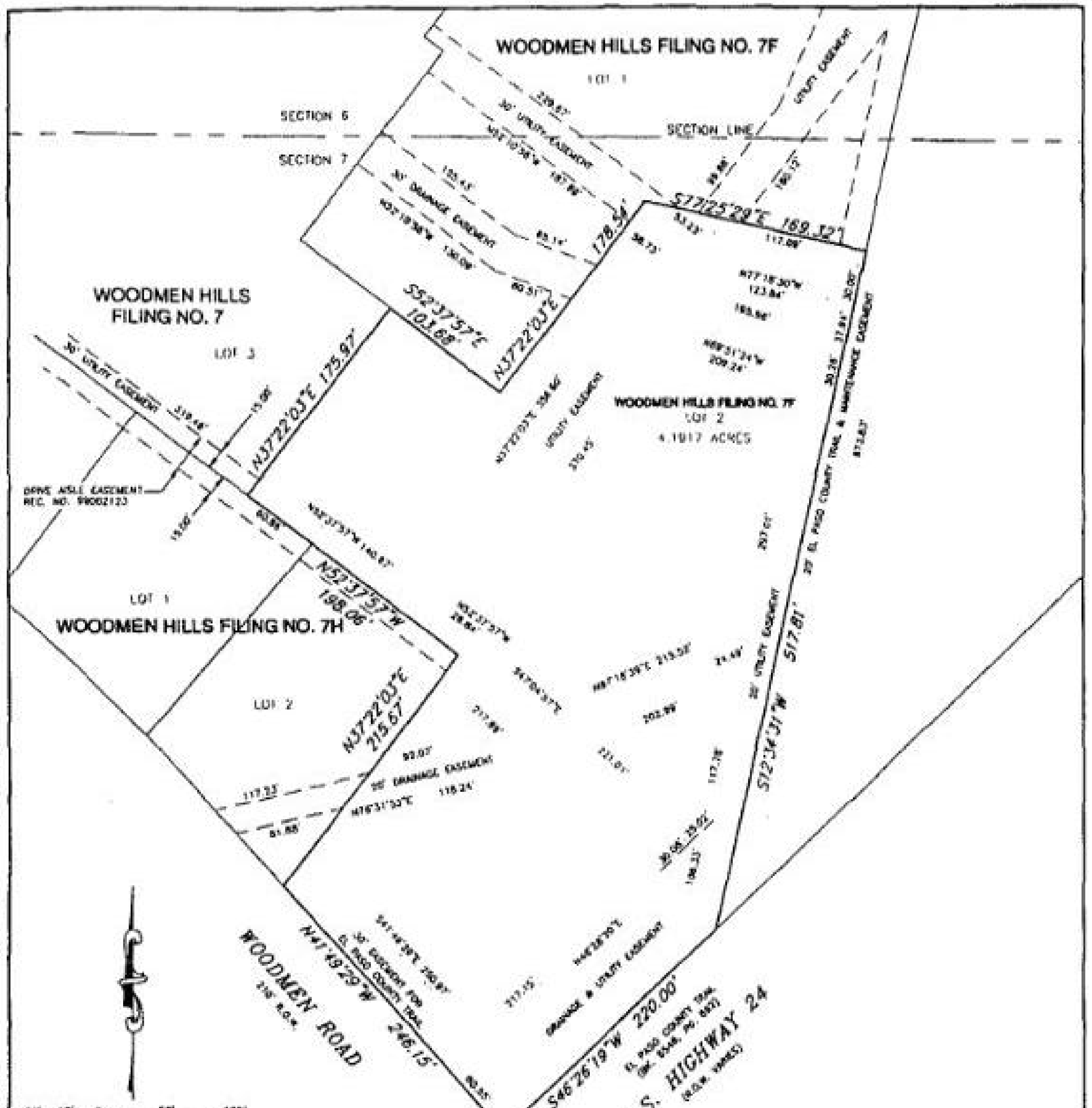
Sincerely,
JR Engineering, LLC

Glenn P. Ellis
Glenn Ellis, P.E.

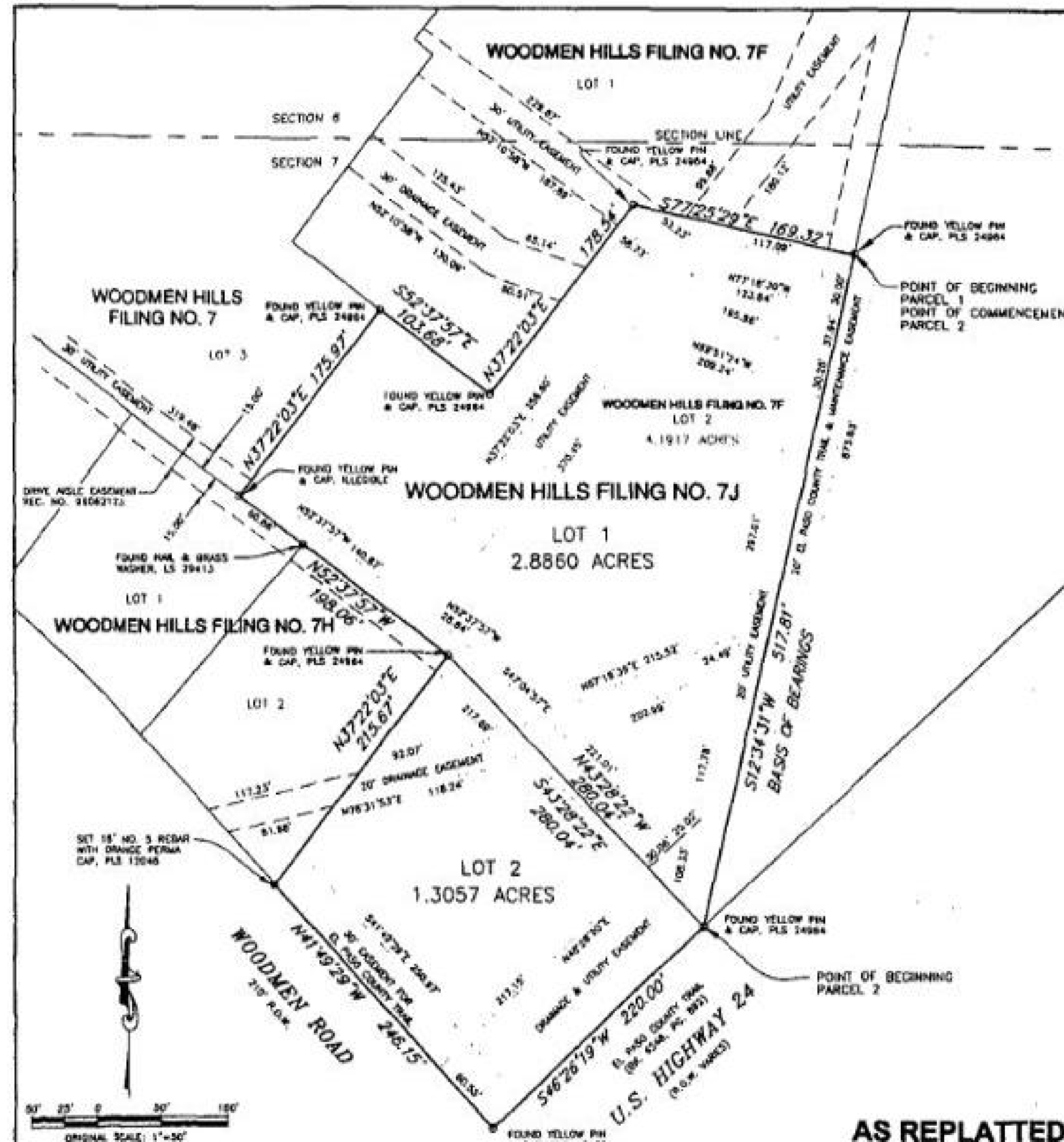
Appendix A

WOODMEN HILLS FILING NO. 7J

A VACATION AND REPLAT OF LOT 2, WOODMEN HILLS FILING NO. 7F
A PARCEL IN THE NORTHWEST ONE-QUARTER OF SECTION 7, TOWNSHIP 13 SOUTH, RANGE 64 WEST OF THE SIXTH PRINCIPAL MERIDIAN
COUNTY OF EL PASO, STATE OF COLORADO
SHEET 2 OF 2



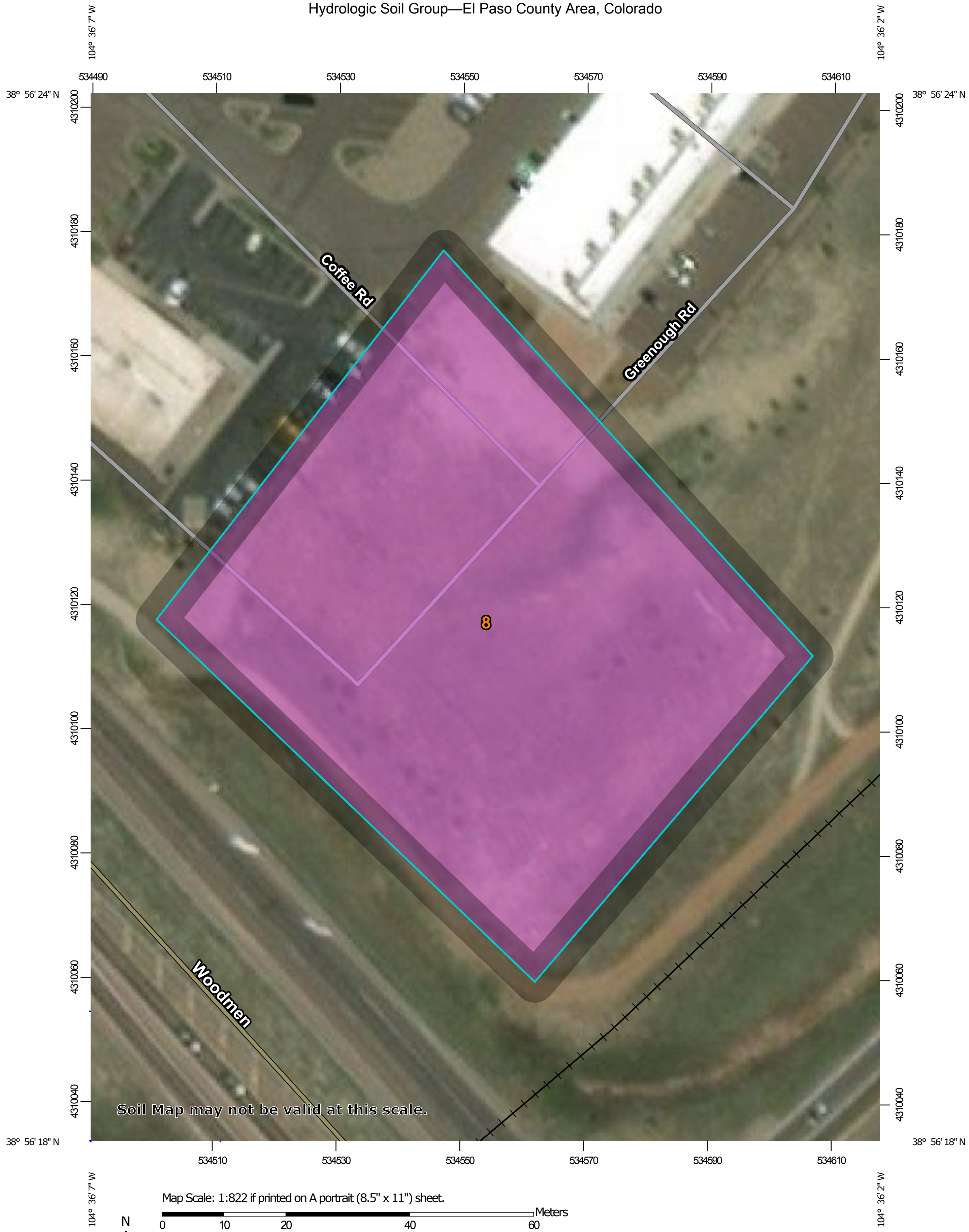
AS PLATTED



AS REPLATTED

REVISED: 7-24-07
REVISED: 5-18-07
DATE: 11-20-06

KELLY SURVEYING & DESIGN GROUP, LTD.



Map Scale: 1:822 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 10, 20, 40, 60

Feet: 0, 35, 70, 140, 210

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
8	Blakeland loamy sand, 1 to 9 percent slopes	A	1.5	100.0%
Totals for Area of Interest			**1.5**	**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.

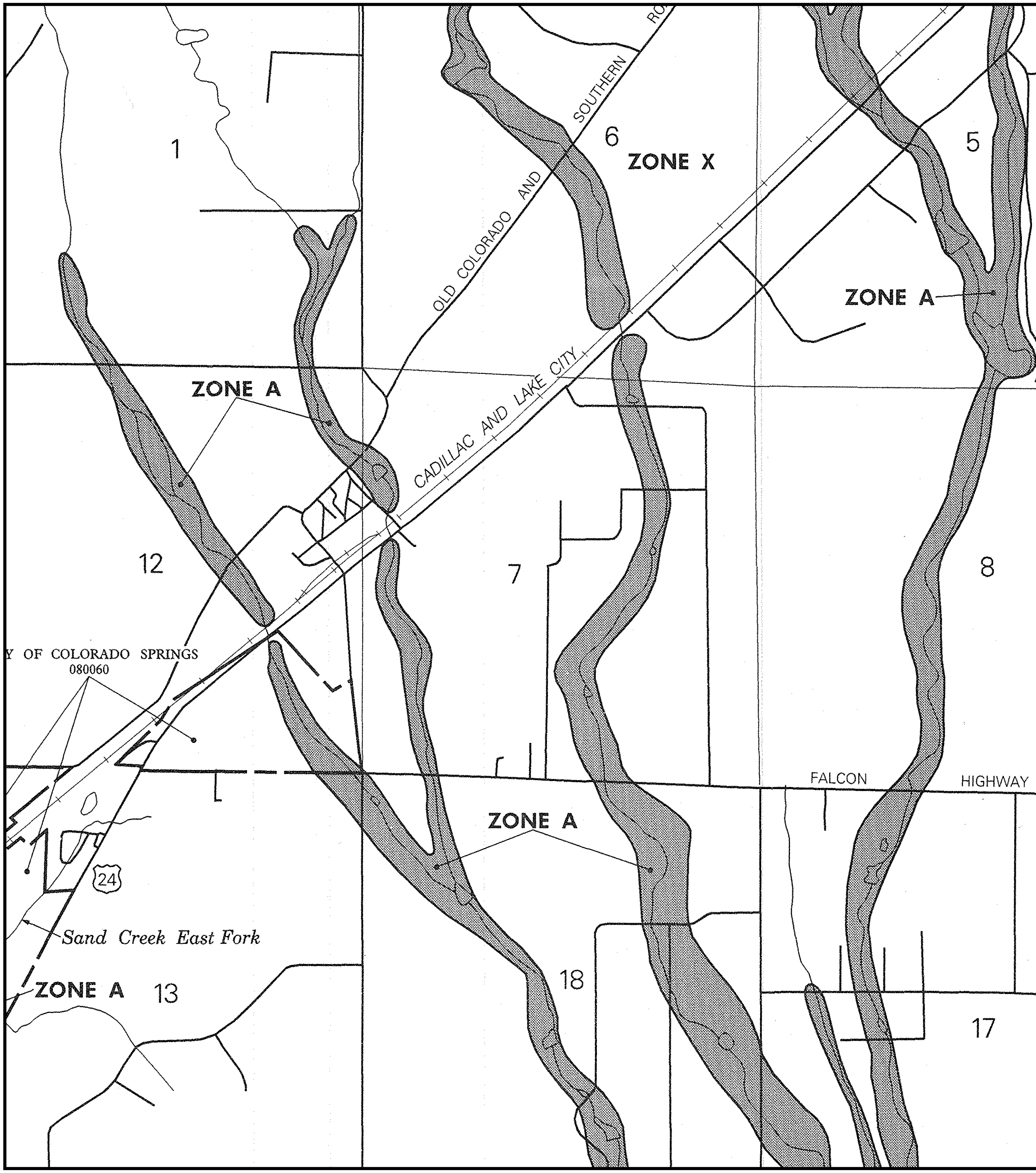
Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over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



APPROXIMATE SCALE IN FEET

2000 0 2000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

EL PASO COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 575 OF 1300

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
COLORADO SPRINGS, CITY OF	080060	0575	F
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0575	F

MAP NUMBER
08041C0575 F

EFFECTIVE DATE:
MARCH 17, 1997

Federal Emergency Management Agency

Appendix B

COMPOSITE % IMPERVIOUS & RUNOFF COEFFICIENT CALCULATIONS

ivision: Christian Brothers Automotive - Falcon
cation: El Paso County

Project Name: Christian Brothers Automotive - Falcc
Project No.: 25127.00
Calculated By: REB
Checked By:
Date: 3/6/18

Basin ID	Total Area (ac)	Paved Roads							Commercial Site							Lawns							Basins Total	Basins Total	Basins Total
		% Imp.	C5	C100	Area (ac)	Weighted % Imp.	Weighted C5	Weighted C100	% Imp.	C5	C100	Area (ac)	Weighted % Imp.	Weighted C5	Weighted C100	% Imp.	C5	C100	Area (ac)	Weighted % Imp.	Weighted C5	Weighted C100	Weighted % Imp.	Weighted C5	Weighted C100
A	0.29	100%	0.90	0.96	0.00	0.0%	0.00	0.00	95%	0.81	0.88	0.29	95.0%	0.81	0.88	0%	0.08	0.35	0.00	0.0%	0.00	0.00	95.0%	0.81	0.88
B	0.31	100%	0.90	0.96	0.00	0.0%	0.00	0.00	95%	0.81	0.88	0.31	95.0%	0.81	0.88	0%	0.08	0.35	0.00	0.0%	0.00	0.00	95.0%	0.81	0.88
TOTAL	**0.60**																						**95.0%**	**0.81**	**0.88**
C	0.24	100%	0.90	0.96	0.04	18.0%	0.16	0.17	95%	0.81	0.88	0.00	0.0%	0.00	0.00	2%	0.08	0.35	0.20	2.0%	0.07	0.29	4.8%	0.23	0.46
TOTAL	**0.24**																						**4.8%**	**0.23**	**0.46**

STANDARD FORM SF-2
TIME OF CONCENTRATION

Subdivision: Christian Brothers Automotive - Falcon
Location: El Paso County

Project Name: Christian Brothers Automotive - Falcon
Project No.: 25127.00
Calculated By: REB
Checked By:
Date: 3/6/18

SUB-BASIN DATA						INITIAL/OVERLAND (T_i)			TRAVEL TIME (T_t)					*tc* CHECK (URBANIZED BASINS)			FINAL
BASIN ID	D.A. (ac)	Hydrologic Soils Group	Impervious (%)	C_5	C_{100}	L (ft)	S_o (%)	t_i (min)	L_t (ft)	S_o (%)	K	VEL. (ft/s)	t_t (min)	COMP. t_c (min)	TOTAL LENGTH (ft)	Urbanized t_c (min)	t_c (min)
A	0.29	A	95%	0.81	0.88	40	1.6%	2.8	110	0.5%	20.0	1.4	1.3	4.1	150.0	4.8	5.0
B	0.31	A	95%	0.81	0.88	30	2.3%	2.2	185	0.5%	20.0	1.4	2.2	4.4	215.0	5.2	5.0
C	0.24	A	5%	0.23	0.46	20	10.0%	3.3	192	0.4%	15.0	0.9	3.4	6.7	212.0	21.5	6.7

NOTES:

$t_c = t_i + t_t$ *(Equation 6-2)*

t_i = (0.395*(1.1 - C_5)*(L)^0.5)/((S_o)^0.33) *(Equation 6-3)*

t_i = overland (initial) flow time (minutes)

S = Average Slope along the overland flow path, ft/ft

t_t=L/(60K*(S_o)^0.5 *(Equation 6-4)*

t_t = channelized flow time (minutes)

S = waterway slope, ft/ft

V_t = travel time velocity (ft/sec) = K*S_o^0.5

First Design Point Time of Concentration:

t_c=(18-15*i)+L/(60*(24*i+12)*(S_o)^0.5) *(Equation 6-5)*

i = imperviousness (expressed as a decimal)

t_c is lesser of Equation 6-2 and Equation 6-5.

For Urbanized basins a minimum t_c of 5.0 minutes is required.

For non-urbanized basins a minimum t_c of 10.0 minutes is required.

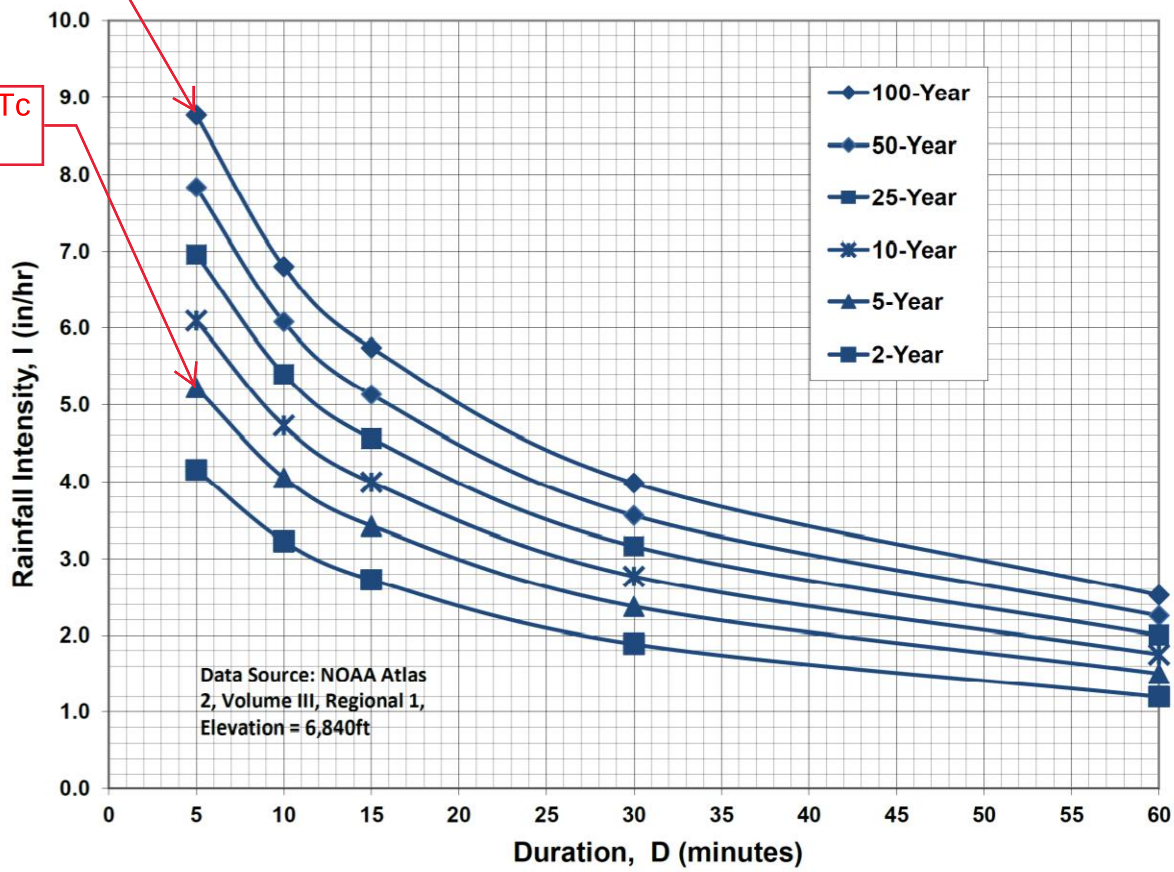
Table 6-2. NRCS Conveyance Factors, K

Type of Land Surface	K
Heavy Meadow	2.5
Tillage/field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

D = 5min =Tc
I = 8.8

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency

D = 5min = Tc
I = 5.2



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.

STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Project Name: Christian Brothers Automotive - Falcon
Subdivision: Christian Brothers Automotive - Falcon
Project No.: 25127.00
Location: El Paso County
Calculated By: REB
Design Storm: 5-Year
Checked By:
Date: 3/6/18

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			REMARKS
		Basin ID	Area (Ac)	Runoff Coeff.	t_c (min)	C*A (Ac)	I (in/hr)	Q (cfs)	tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	t_t (min)	
	1	A	0.29	0.81	5.0	0.23	5.20	1.2													Surface flow to Inlet
	2	B	0.31	0.81	5.0	0.25	5.20	1.3													Surface Flow to Inlet
	3								5.0	0.48	5.20	2.5									Combined Flow from DP1 and 2 in pipe/MH 1
	4	C	0.24	0.23	6.7	0.06	5.20	0.3													Flow to grass swale

STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Project Name: Christian Brothers Automotive - Falcon
Project No.: 25127.00
Calculated By: REB
Checked By:
Date: 3/6/18

Subdivision: Christian Brothers Automotive - Falcon
Location: El Paso County
Design Storm: 100-Year

STREET		DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			REMARKS
	Design Point	Basin ID	Area (Ac)	Runoff Coeff.	t_c (min)	C*A (Ac)	*I* (in/hr)	Q (cfs)	*tc* (min)	C*A (Ac)	*I* (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	t_t (min)	
	1	A	0.29	0.88	5.0	0.26	8.80	2.3													Surface flow to Inlet
	2	B	0.31	0.88	5.0	0.27	8.80	2.4													Surface Flow to Inlet
	3								5.0	0.53	8.80	4.7									Combined Flow from DP1 and 2 in pipe/MH 1
	4	C	0.24	0.46	6.7	0.11	8.80	1.0													

DESIGN POINT SUMMARY TABLE		
DESIGN POINT	**Q_5 (cfs)**	**Q_{100} (cfs)**
1	1.2	2.3
2	1.3	2.4
3	2.5	4.7
4	0.3	1.0

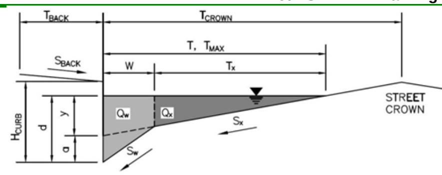
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Christian Brother's Automotive - Falcon

Inlet ID: Inlet - SW + NW Parking Lot Inlets



Gutter Geometry (Enter data in the blue cells)

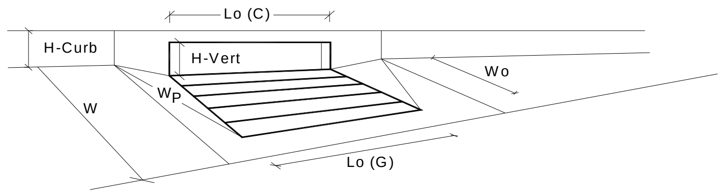
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	5.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.022	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	50.0	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.014	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	35.0	35.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)			MINOR	MAJOR	
Type of Inlet	Denver No. 16 Combination	Type =	Denver No. 16 Combination		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	2.00	2.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
Grate Information			MINOR	MAJOR	Override Depths
Length of a Unit Grate		L_o (G) =	3.00	3.00	feet
Warning 5 Width of a Unit Grate		W_o =	1.73	1.73	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	0.31	0.31	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	0.50	0.50	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	3.60	3.60	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	0.60	0.60	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	3.00	3.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.50	6.50	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	5.25	5.25	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	0.00	0.00	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	1.00	1.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.70	3.70	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.66	0.66	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	0.451	0.451	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.42	0.42	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.94	0.94	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	1.00	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	0.94	0.94	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**4.1**	**4.1**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	1.3	2.4	cfs

Warning 5: The width of unit is greater than the gutter width.

18" HDPE (Q100=2.4 cfs)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00520	ft/ft
Diameter	1.50	ft
Discharge	2.40	ft³/s

Results

Normal Depth	0.58	ft
Flow Area	0.63	ft²
Wetted Perimeter	2.01	ft
Top Width	1.46	ft
Critical Depth	0.59	ft
Percent Full	38.7	%
Critical Slope	0.00501	ft/ft
Velocity	3.80	ft/s
Velocity Head	0.22	ft
Specific Energy	0.80	ft
Froude Number	1.02	
Maximum Discharge	8.15	ft³/s
Discharge Full	7.57	ft³/s
Slope Full	0.00052	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	38.68	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s

18" HDPE (Q100=2.4 cfs)

GVF Output Data

Normal Depth	0.58	ft
Critical Depth	0.59	ft
Channel Slope	0.00520	ft/ft
Critical Slope	0.00501	ft/ft

18" HDPE (Q100=4.7cfs)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00520	ft/ft
Diameter	1.50	ft
Discharge	4.70	ft³/s

Results

Normal Depth	0.86	ft
Flow Area	1.04	ft²
Wetted Perimeter	2.57	ft
Top Width	1.49	ft
Critical Depth	0.83	ft
Percent Full	57.0	%
Critical Slope	0.00566	ft/ft
Velocity	4.51	ft/s
Velocity Head	0.32	ft
Specific Energy	1.17	ft
Froude Number	0.95	
Maximum Discharge	8.15	ft³/s
Discharge Full	7.57	ft³/s
Slope Full	0.00200	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	57.02	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s

18" HDPE (Q100=4.7cfs)

GVF Output Data

Normal Depth	0.86	ft
Critical Depth	0.83	ft
Channel Slope	0.00520	ft/ft
Critical Slope	0.00566	ft/ft

EX. 36" OUTFALL PIPE

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.01120	ft/ft
Diameter	3.00	ft
Discharge	40.60	ft³/s

Results

Normal Depth	1.63	ft
Flow Area	3.93	ft²
Wetted Perimeter	4.98	ft
Top Width	2.99	ft
Critical Depth	2.08	ft
Percent Full	54.4	%
Critical Slope	0.00545	ft/ft
Velocity	10.33	ft/s
Velocity Head	1.66	ft
Specific Energy	3.29	ft
Froude Number	1.59	
Maximum Discharge	75.93	ft³/s
Discharge Full	70.58	ft³/s
Slope Full	0.00371	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	54.39	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s

EX. 36" OUTFALL PIPE

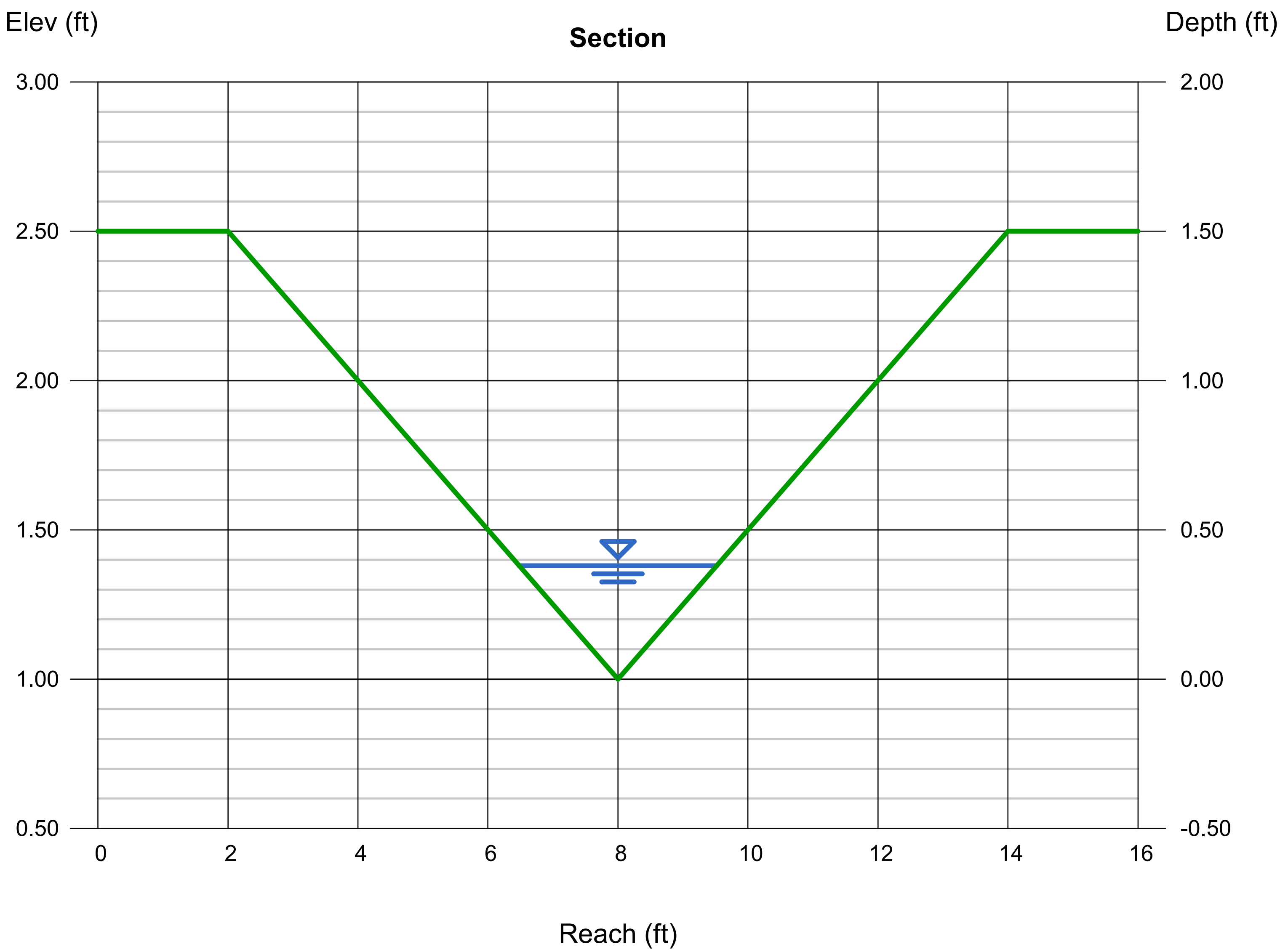
GVF Output Data

Normal Depth	1.63	ft
Critical Depth	2.08	ft
Channel Slope	0.01120	ft/ft
Critical Slope	0.00545	ft/ft

Channel Report

5 Year - Grass Lined Swale

Triangular		**Highlighted**	
Side Slopes (z:1)	= 4.00, 4.00	Depth (ft)	= 0.38
Total Depth (ft)	= 1.50	Q (cfs)	= 0.300
		Area (sqft)	= 0.58
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 0.52
Slope (%)	= 0.30	Wetted Perim (ft)	= 3.13
N-Value	= 0.050	Crit Depth, Yc (ft)	= 0.21
		Top Width (ft)	= 3.04
Calculations		EGL (ft)	= 0.38
Compute by:	Known Q		
Known Q (cfs)	= 0.30		



Channel Report

100 Year - Grass Lined Swale

Triangular

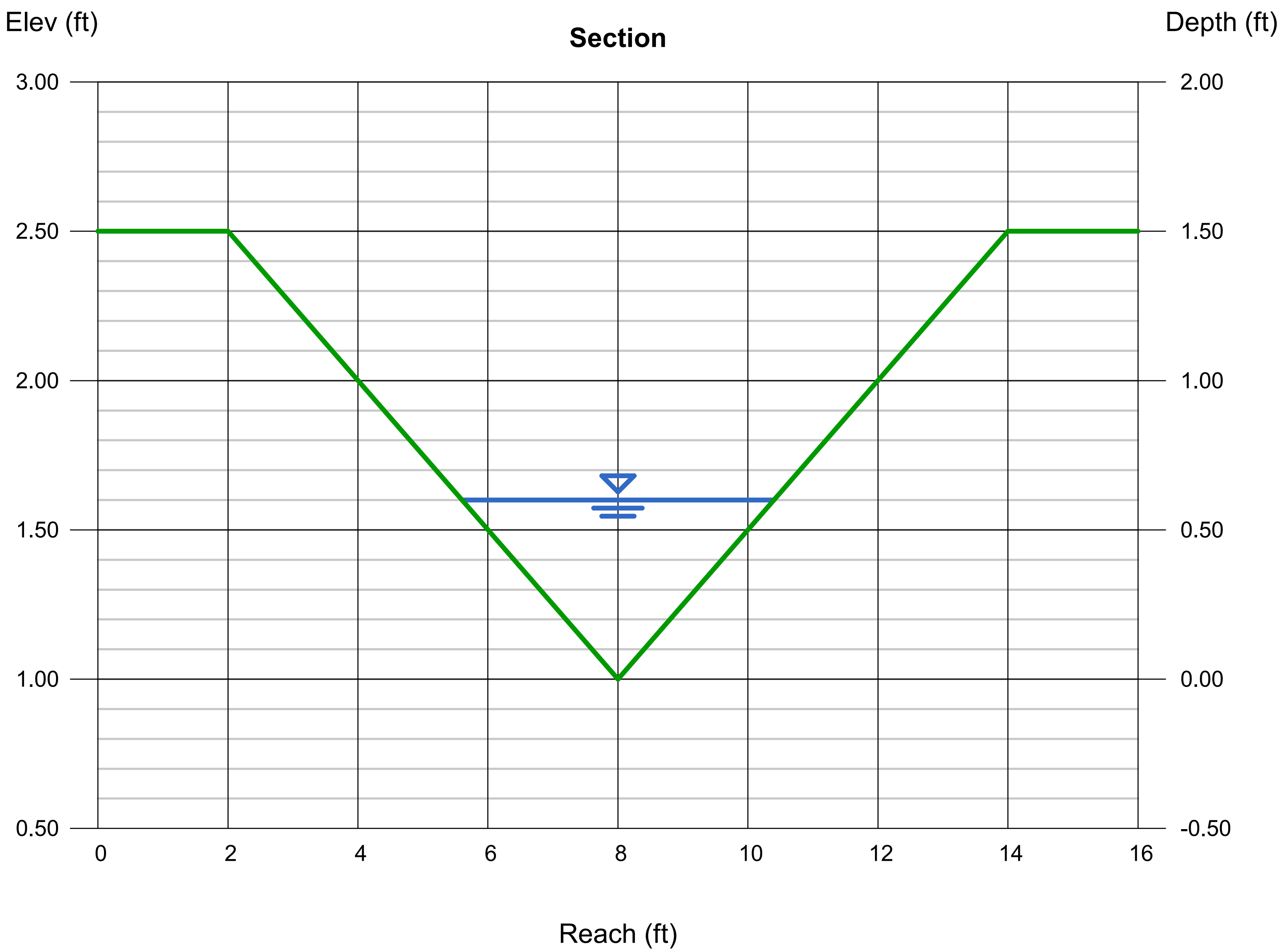
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 1.50
Invert Elev (ft)	= 1.00
Slope (%)	= 0.30
N-Value	= 0.050

Calculations

Compute by:	Known Q
Known Q (cfs)	= 1.00

Highlighted

Depth (ft)	= 0.60
Q (cfs)	= 1.000
Area (sqft)	= 1.44
Velocity (ft/s)	= 0.69
Wetted Perim (ft)	= 4.95
Crit Depth, Yc (ft)	= 0.33
Top Width (ft)	= 4.80
EGL (ft)	= 0.61



Appendix C

Pond 4 of the Falcon Area
Stormwater Assessment
For
El Paso County, Colorado

March 2011

PREPARED BY:

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The plans indicate that a 12” CMP riser and 12” CMP outfall pipe were to be constructed to serve as the water quality outlet for the pond. The riser was to have 2 rows of 5-2” diameter orifices in it with the center of the rows at 0.5 feet and 1.0 feet lower than the invert of the 12” orifices of the normal outlet. A 12” diameter, capped, CMP riser was observed in the pond during a February 2011 site visit. The orifices were not apparent on the exposed portion of the riser.

Based on the aerial survey prepared for the 2011 update for to the Falcon Basin DBPS, the pond has very little storage capacity below the lowest normal outlet. The WH7-FDR indicted that the pond was planned to have 3.6 acre feet of storage capacity below the normal outlet.

The current calculations indicate that the existing storage capacity between the lowest normal outlet and the emergency spillway crest is very similar to the planned capacity. Current approximate measurements of the existing structure indicate that the existing distance between the lowest normal outlet and the emergency spillway crest is very close to that indicated in the WH7-FDR and the plans for the pond.

Current hydraulic calculations indicate that the existing normal outlet has considerably less capacity than calculated in the WH7-FDR. The current hydrologic model indicates that flow will pass over the emergency spillway in the 100 year event with the watershed in the fully developed condition. The spillway was planned as a 25’ wide trapezoidal riprap lined section. An existing sidewalk crosses the spillway in a parabolic curve and likely changes the hydraulic characteristics of the spillway. The current hydrologic model indicates that peak outflow rates from the pond in the 5 and 100 year events are similar to those predicted in the WH7-FDR.

Pond 4

Peak Flow Rate Mitigation- According to the Woodmen Hills Filing 7, Final Drainage Report (WH7-FDR) the pre-development condition 5 and 100 year peak flow rates at the outfall from Pond 4 were 37 cfs and 376 cfs respectively. While control of the 2 year runoff was discussed, the historic rate from the 2 year event does not appear to have been quantified in the WH7-FDR. Text on Page 4 of the report, regarding the channel downstream of US-24, includes a statement: “Historically this channel has seen very little in terms of high frequency flows because of the many SCS berms across the drainageway in the upstream area”.

The WH7-FDR indicated that in an effort to minimize downstream impacts, Detention Pond 4 would discharge at or below historic rates for the 5-year and 100-year storms. On Page 10 of the report, a discussion under the heading “Detention Ponds” includes “Retention of the 2-year runoff in Ponds 3 and 4 will greatly enhance downstream water quality by minimizing the amount of sediment leaving the pond.” It is speculated that this statement was in error and was intended to refer to the water quality capture volume instead of the 2-year runoff.

Notes contained in the appendix of the “Master Development Drainage Plan for Woodmen Hills Subdivision, Phase III” indicate that the curve number (CN) for hydrologic analysis of the watershed in pre-development condition was originally determined to be 51 based on the significant amount of Hydrologic Soil Group (HSG) ‘A’ soils that were present. The note indicates that FEMA was uncomfortable with the CN of 51, in their review of the LOMR processed in the watershed. Thus the CN was raised to 60. The current analysis calculated a pre-development CN of 53 based on 20% HSG ‘B’, 80% HSG ‘A’ with pasture land cover in fair condition. Higher CNs are associated with higher predicted runoff rates and runoff volumes.

The HEC-1 model output and tables within the WH7-FDR indicate fully developed condition 2, 5, and 100 year peak outflow rates for Pond 4 at 11, 34, and 270 cfs respectively. The current HEC-HMS model prepared for this investigation predicts fully developed 2, 5, and 100 year condition peak outflow rates from Pond 4 at 30, 55, and 182 cfs, respectively, with the watershed ponds in their existing condition. The current model assumes the pond full to rim of the lowest outlet riser at the beginning of the storm. The discharge curve utilized in the current model utilizes lower stage-discharge rates for the outlet structure than the WH7-FDR, as the previous calculations appear to be flawed as noted in the “Woodmen Hills Pond No. 4 Evaluation” memo, dated 9-26-2006, prepared by EPC-DOT, Dan Bare.

The WH7-FDR Model indicated that the 100-year maximum water surface elevation (MWSE) in the pond would be nearly a foot lower than the planned crest of the emergency spillway. The current model predicts that the 100-year MWSE in the pond will be approximately equal to the crest of the existing emergency spillway.

Existing Versus Planned Characteristics - The current survey indicates that the emergency spillway crest is constructed approximately 1’ higher than originally planned. This provides a greater live storage volume than planned below the crest of the emergency spillway, but provides less freeboard between the emergency spillway crest and the top of the dam. The emergency spillway is lined with riprap, and thus the elevation of the crest is somewhat variable and subject to interpretation.

Storage volume calculations based on the current survey indicate that the existing pond has approximately 4.7 acre feet less storage capacity below the lowest normal outlet riser rim than planned for in the WH7-FDR. This may be due to sediment accumulation in the pond. The current volume calculations for the pond indicate that 4.8 acre feet of storage is available below the lowest normal outlet.

According to the WH7-FDR the pond was proposed to provide water quality treatment. However, the design procedure was flawed in that only the watershed directly tributary to Pond 4 was considered and tributary runoff routed through upstream ponds was ignored. This was noted in the “Woodmen Hills Pond No. 4 Evaluation” memo. Calculations provided in the Appendix of the WH7-FDR indicate that water quality capture volumes (WQCV) were calculated individually for the proposed watersheds of Ponds 1, 2, 3 and 4. The sum of the watershed areas included in the calculations was 1,207 acres and the sum of the WQCVs calculated for the individual watersheds was 13.9 acre feet. According to the calculations and report, only 4.65 acre-feet of WQCV was required to be provided in Pond 4. However, the stage-storage calculations indicate that approximately 9.0 acre-feet of storage was to be provided between the planned water quality outlet orifices and the rim of the lowest normal outlet riser as shown on the construction drawings for the pond.

The existing water quality outlet was not included in the current survey as it was either covered by snow or dirt and rocks at the time of the survey. Visual inspection indicated that the existing outlet structure does not match either the plans or the calculations provided in the WH7-FDR. The calculations in the FDR call for 2 rows of eight 2" diameter orifices with the center of orifice elevations at 2.75' and 3.25' below the rim of the lowest normal outlet riser. The report text and plans call for one row of ten 2" diameter orifices with the center of orifice elevations at 3.0' below the rim of the lowest normal outlet riser.

The water quality outlet was planned to be covered with 4" rock. The water quality outlet was found exposed and was viewed during a late February 2011 site visit. The top of the water quality outlet pipe was also visible and the 10 planned orifice holes in the riser should have been evident at the same elevation as the top of the outlet pipe according to the plan. However, only a crude hole ripped in the plate covering the top of the riser and a small patch of sunlight visible near the base of the water quality riser were apparent evidence of openings in the water quality outlet riser.

Calculation methods and tools associated with water quality facilities have advanced significantly since the time that Pond 4 was designed. The current Drainage Criteria Manual and associated spreadsheets indicate that 9 rows of 2 columns of 2" diameter holes spaced 4" on center vertically would be required to drain the 4.7 acre feet of water quality volume that was planned for the pond in the normal 40 hour drain time.

Another potential issue associated with the water quality outlet is the fact that the discharge pipe is small (12" diameter), and the outlet end sits low in the stilling basin below the pond. The stilling basin contains sediment and heavy growth of cattails. The outlet end of the 12" pipe was not visible at the time of site visits in February 2011. It is likely that the outlet pipe is at least partially blocked by sediment in the stilling basin.

Another issue with the water quality outlet is that a base flow likely contributes to the pond during the spring and summer months, due to irrigation and rainfall. When the pond was viewed in the summer of 2010 it was full to the rim of the lowest normal outlet riser. This was the same condition noted in the "Woodmen Hills Pond No. 4 Evaluation" memo, dated 9-26-2006. This condition is predictable based on the issues described above and summarized on the following page.

- The WQCV storage is only about a third of the required size for the watershed.
- The orifices as designed for the water quality outlet structure are too small to discharge even the provided storage volume in 40 hours and it is not evident that the orifices were constructed as designed.
- The outlet discharge pipe may be partially clogged.
- Base flow from groundwater may replace flow discharged through the water quality outlet keeping the pond full below the lowest normal outlet riser during summer months.
- If the pond remains full to the rim of the lowest outlet structure, even very small rainfall events push runoff out the normal outlet at rates higher than planned.

It should be noted that the current model is based on approximate outlet measurements for ponds 1 through 3, and storage volume estimates for these same ponds are based on an aerial survey that did not map contours in heavily vegetated areas. Some inaccuracies in the model may exist due to these factors. It should also be noted that these ponds discharge flow over their emergency spillways and in cases the tops of their dams. The spillways and dams are not constructed with hard and regular control surfaces so accurate stage discharge relationships are difficult to establish. The current model utilizes estimates of these relationships based on generalizations of physical characteristics. Discharge over the un-armored dam crests could lead to dam failure releasing a flood wave with peak flow rates much higher than predicted by the current models.

The following table provides a tabulation and comparison of several characteristics of the existing ponds to the characteristics of the ponds as reported in the Woodmen Hills Filing 7, Final Drainage Report.

Existing Pond Characteristics Comparison

Characteristic	Pond 1		Pond 2		Pond 3		Pond 4	
	Existing	F. 7 FDR	Existing	F. 7 FDR	Existing	F. 7 FDR	Existing	F. 7 FDR
Depth (ft)								
Emergency Spillway Crest - Normal Outlet	4.3	4.2	4.6	1.8	2.9	3	4.4	3.5
Dam Crest -Emergency Spillway Crest	2	2	0.8	2	2.1	N.P.	1.8	N.P.
Surface Area (acres)								
At Normal Outlet Elevation	1.48	2.4	2	3.2	0.77	3	4.45	5.2
At Spillway Crest Elevation	2.57	3.1	3.18	3.45	6.78	4.1	10.19	8.2
Volume (acre feet)								
Normal Outlet to Emergency Spillway Crest (ac Ft)	8.8	11.6	12	6	10.7	11	33.9	23.5
Below Normal Outlet (ac ft)	3.1	5.9	2.5	12.5	0	3.6	4.9	9.6
Outlet Capacity (cfs)								
At Dam Crest	160	N.P.	53	249	82	N.P.	495	1396
At Spillway Crest	28	175	13	56	71	148	180	475

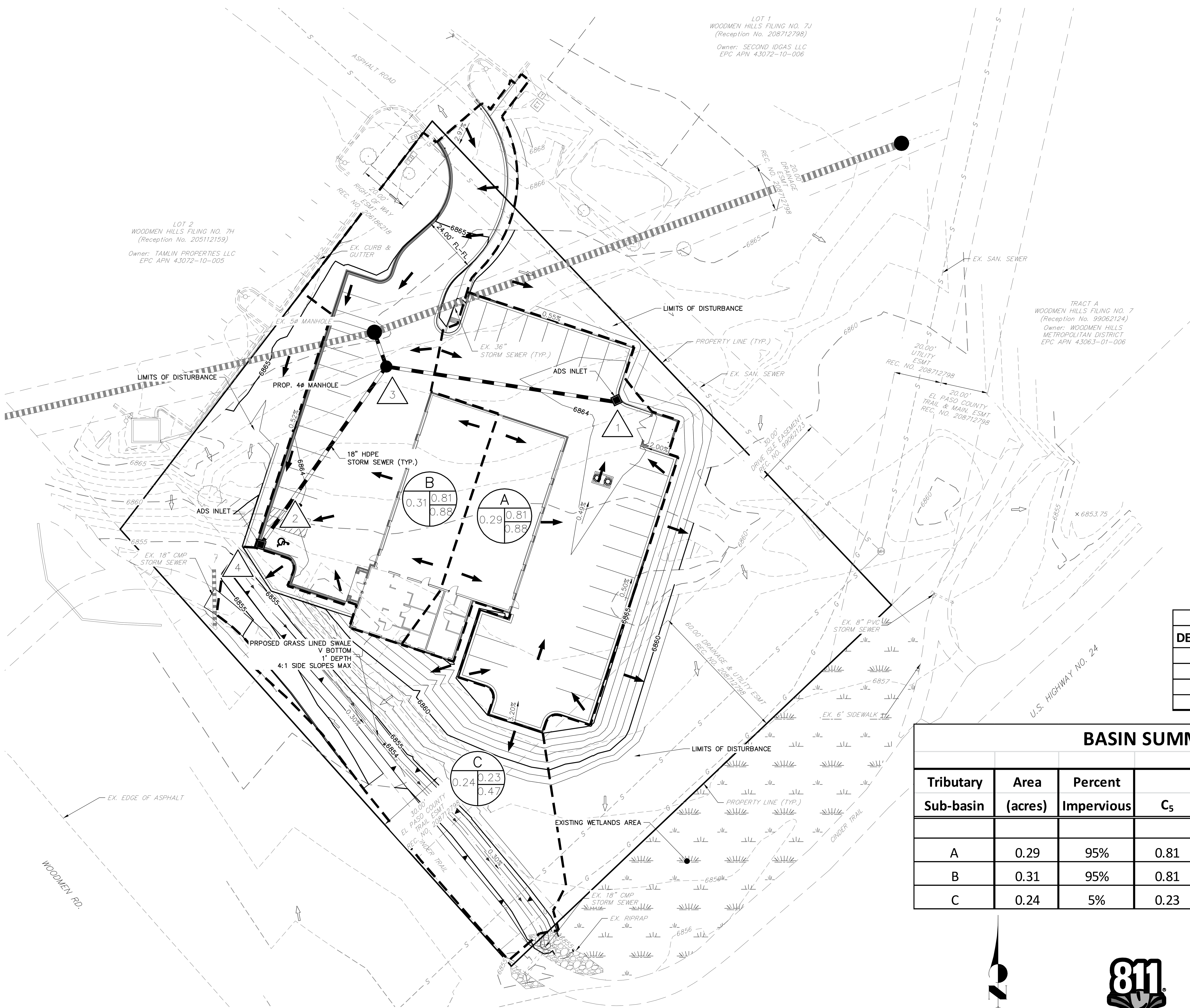
Note:

"Existing" refers to ground surface elevations reflected in topographic mapping prepared for the 2011 update to the Falcon Basin and outlet structure configurations based on approximate measurements of existing structures taken in February 2011. The topographic mapping that the "Existing" pond volumes are based on lacks contour data in areas that are heavily vegetated. The locations of contours in these areas were estimated based on general topographic trends and the best information available in the mapping

Appendix D

NOTES

1. THE LOCATIONS OF EXISTING ABOVE GROUND AND UNDERGROUND UTILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK. THE CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE CAUSED BY HIS FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL ABOVE GROUND AND UNDERGROUND UTILITIES.
2. ALL ROOF DRAINS WILL DRAIN TO PAVED AREAS OR STORM DRAINS.



DESIGN POINT SUMMARY TABLE

DESIGN POINT	Q_5 (cfs)	Q_{100} (cfs)
1	1.2	2.3
2	1.3	2.4
3	2.5	4.7
4	0.3	1.0

BASIN SUMMARY TABLE

Tributary Sub-basin	Area (acres)	Percent Impervious	C_5	C_{100}	t_c (min)	Q_5 (cfs)	Q_{100} (cfs)
A	0.29	95%	0.81	0.88	5.0	1.2	2.3
B	0.31	95%	0.81	0.88	5.0	1.3	2.4
C	0.24	5%	0.23	0.46	6.7	0.3	1.0

UNTIL SUCH TIME AS THESE DRAWINGS ARE APPROVED BY THE APPROPRIATE REVIEWING AGENCIES, JR ENGINEERING APPROVES THEIR USE ONLY FOR THE PURPOSES DESIGNATED BY WRITTEN AUTHORIZATION.

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No.	REVISION	BY	DATE

H-SCALE	1"=20'
V-SCALE	N/A
DATE	04/20/18
DESIGNED BY	RAB
DRAWN BY	NQJ
CHECKED BY	

CBAC FALCON
DRAINAGE MAP

SHEET 1 OF 1
JOB NO. 15063.04