DRAINAGE LETTER REPORT

for

WOODFORD MANUFACTURING BUILDING ADDITION
LOT 1, BLOCK 1, WAYNOKA ROAD INDUSTRIAL
2121 WAYNOKA ROAD, COLORADO SPRINGS, CO

Prepared for:

Hammers Construction, Inc.
1411 Woolsey Heights
Colorado Springs, CO 80915

July 24, 2018
Revised September 14, 2018
Revised October 12, 2018

Prepared by:

JPS
ENGINEERING

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JPS Project No. 051801
PPR-18-037

WOODFORD MANUFACTURING BUILDING ADDITION
LOT 1, BLOCK 1, WAYNOKA ROAD INDUSTRIAL
DRAINAGE REPORT STATEMENTS

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 master plan for the drainage basin. I accept responsibility for liability caused by negligent acts, errors or omissions on my part in preparing this report:

COLORADO REGISTERED JOHN P. SCHWAB 29891 PROFESSIONAL ENGINEER

10/25/18

John P. Schwab, Colorado P.E. No. 29891

2. Developer's Statement:

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

By:

10.29-18
Date

Printed Name: JOE O. BUTLER
Title: PROJECT MANAGER, HC

3. El Paso County Statement:

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

Approved
by Elizabeth Nijkamp
El Paso County Planning and Community Development
on behalf of Jennifer Irvine, County Engineer, ECM Administrator
11/05/2018 10:41:46 AM

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

Conditions:

I. INTRODUCTION

A. Property Location and Description

Woodford Manufacturing is planning to construct an addition on the south side of the existing manufacturing building at 2121 Waynoka Road in El Paso County, Colorado. The project site is an existing 8.9-acre developed lot described as Lot 1, Block 1, Waynoka Road Industrial Subdivision. Woodford Manufacturing also owns the adjoining vacant lot to the south (Lot 2, Block 1, Waynoka Road Industrial). The two adjoining lots (El Paso County Assessor's No. 54062-05-001 and 54063-03-001) comprise a total area of 13.5 acres located on the east side of Waynoka Road, north of Palmer Park Boulevard. The properties are zoned Heavy Industrial (I-3).

Waynoka Road is a paved public street adjoining the west boundary of the properties. Waynoka Road curves to the east along both the north boundary of Lot 1 and the south boundary of Lot 2. The existing Cherokee Ridge Golf Course adjoins the east boundary of the two lots.

The site development plan consists of proposed 18,000 square-foot building addition at the southeast corner of the existing industrial building, with associated parking and site improvements impacting a total disturbed area of approximately 3.5 acres. Access will continue to be provided by the two existing driveways on the south side of the building, connecting to Waynoka Road on the west side of the property. There will be no changes to the parking lot on the north side of the existing building. The proposed internal parking area improvements on the south side of the building will be paved with a combination of asphalt, recycled asphalt, and concrete.

B. Scope

In support of the El Paso County Site Development Plan submittal for this project, this report is intended to meet the requirements of a site-specific "Letter Type" drainage report in accordance with El Paso County drainage criteria. This report will provide a summary of site drainage issues impacting the proposed development, including analysis of upstream drainage patterns, site-specific developed drainage patterns, and impacts on downstream facilities. This report is based on the guidelines and criteria presented in the City of Colorado Springs and El Paso County "Drainage Criteria Manual."

C. References

City of Colorado Springs & El Paso County "Drainage Criteria Manual, Volumes 1 and 2," revised May, 2014.

G.L. Williams & Partners, Ltd., "Drainage Study and Supplemental Site Information, Waynoka Road Industrial," January 16, 1978.

II. EXISTING / PROPOSED DRAINAGE CONDITIONS

According to the Natural Resources Conservation Services (NRCS) web soil survey, on-site soils are comprised of Ellicott loamy coarse sand. These soils are classified as hydrologic soils group A. The existing site topography slopes downward to the southwest with grades of approximately 1-3 percent.

Drainage planning for this lot was previously addressed in a report entitled "Drainage Study and Supplemental Site Information, Waynoka Road Industrial," by G.L. Williams & Partners, Ltd., dated January 16, 1978. The subdivision drainage report assumed full coverage of Lots 1 and 2 with "medium industrial lot areas." As discussed in the Williams drainage report, fully developed drainage from the majority of the site (Basins A-D) has been planned to sheet flow in a southwesterly direction and then follow the curb and gutter along the east side of Waynoka Road south to the existing public storm sewer system at Palmer Park Boulevard. Developed drainage from Basin E in the southeast corner of the site was planned to flow into an existing drainage channel within the adjoining golf course, also flowing south to the existing public storm sewer system at Palmer Park Boulevard. Current field conditions indicate that Basin E also flows southerly into the curb and gutter along the east side of Waynoka Road.

The existing drainage patterns are depicted on the enclosed Historic Drainage Plan (Figure EX1, Appendix C). Consistent with the approved subdivision drainage report, the majority of the developed north end of the site has been delineated as Basin A1, which includes the west side of the existing Woodford Manufacturing building and north parking lot. Basin A1 sheet flows southwesterly to Waynoka Road, with developed peak flows calculated as $Q_5 = 7.4$ cfs and $Q_{100} = 14.8$ cfs. The roadway of Waynoka Road along the frontage of the north end of the Woodford Manufacturing site has been delineated as Basins B1 and B2. Drainage from Basin B1 flows south along the east curb line of Waynoka Road, combining with Basin A1 at Design Point #B1.1 with developed peak flows calculated as $Q_5 = 8.8$ cfs and $Q_{100} = 17.6$ cfs. Drainage from Basin B2 flows south along the west curb line of Waynoka Road to Design Point #B2, with developed peak flows calculated as $Q_5 = 1.6$ cfs and $Q_{100} = 3.2$ cfs. Drainage from Basins A1, B1, and B2 combines at Design Point #1, with developed peak flows calculated as $Q_5 = 10.1$ cfs and $Q_{100} = 20.4$ cfs. As detailed in Appendix B, the existing 5' Type R storm inlets B1 and B2 intercept flow at Design Point #1, and the carryover flow from these on-grade inlets continues south in Waynoka Road.

The east side of the Woodford Manufacturing Building has been delineated as Basin A2, which sheet flows to an existing drainage swale along the eastern site boundary, draining towards the southeast corner of the building. Developed peak flows at Design Point #A2 are calculated as $Q_5 = 2.2$ cfs and $Q_{100} = 4.5$ cfs.

Proposed Building Addition Project (South Side of Lot 1)

As shown on the enclosed Developed Drainage Plan (Figure D1, Appendix C), the proposed development area on the south side of the existing manufacturing building has been delineated as three on-site drainage basins (D1, D2, and E) for general consistency with the subdivision drainage report. Surface runoff from the developed site will continue to follow the drainage patterns established in the subdivision drainage report. Basins A2, D1, and D2 will flow southwesterly across the site to Waynoka Road.

Recognizing that current County drainage criteria require permanent stormwater quality best management practices for disturbed areas greater than one acre in size, a private Rain Garden will be constructed at the southwest corner of Basin D1 to mitigate developed drainage impacts and meet the current County water quality requirements. The proposed Rain Garden has been sized for fully developed flows from Basin D1, as well as the existing developed flow from Basin A2.

A grated inlet will be installed at the southeast corner of the existing building to intercept surface drainage from Basin A2 (east side of existing building), and private Storm Drain A2 (12") will convey the flow from Basin A2 around the new building addition to daylight in a grass-lined drainage swale flowing southwesterly to the proposed Rain Garden.

The proposed building addition will be graded with protective slopes to provide positive drainage away from the building. Concrete crosspans and drainage swales within the on-site parking areas will convey developed flows to the new Rain Garden at the southwest corner of Lot 1.

Developed flows have been calculated based on the impervious areas associated with the ultimate full industrial development of Basin D1 (south end of the existing Woodford Manufacturing facility on Lot 1). Developed drainage from Basins A2 and D1 will flow southwesterly to the proposed Rain Garden at Design Point #D1.1, with developed peak flows calculated as $Q_5 = 11.7$ cfs and $Q_{100} = 23.3$ cfs. The outlet chase from the Rain Garden will flow into Waynoka Road in accordance with the subdivision drainage report.

The subdivision drainage report assumed full industrial development of this site, and the proposed site development plan is entirely consistent with the approved subdivision drainage plan.

Hydrologic calculations for the parcel are detailed in the attached spreadsheet (Appendix A), and peak flows are identified on Figure D1. The contractor will need to implement standard best management practices for erosion control during construction.

Lot 2 Drainage (Possible Future Development Area)

The vacant areas within Lot 2 at the south end of the site (Basins D2 and E) will sheet flow south towards Design Point #2 at the south end of Lot 2.

Developed drainage from the vacant future development area within Basin D2 (west side of Lot 2) will flow southwesterly to the existing curb and gutter along Waynoka Road. Peak flows at Design Point #D2 are calculated as Q_5 = 0.6 cfs and Q_{100} = 4.2 cfs.

Developed drainage from the vacant future development area within Basin E (east side of Lot 2) is anticipated to sheet flow to the south corner of Lot 2, with peak flows at Design Point #E calculated as Q_5 = 0.6 cfs and Q_{100} = 4.5 cfs.

Drainage from Basins A2, D1, D2, and E combines at Design Point #2, with developed peak flows calculated as Q_5 = 11.8 cfs and Q_{100} = 29.4 cfs.

An additional future water quality and/or stormwater detention facility will be required at the south end of Lot 2 to mitigate the future developed drainage impacts from Basins D2 and E.

Suitable Outfall Analysis

Waynoka Road provides a suitable outfall to the existing downstream public drainage system. As shown in the street capacity calculations in Appendix B, the east side of Waynoka Road has a minor storm allowable street capacity of Q_5 = 36.7 cfs and a major storm allowable street capacity Q_{100} = 137.9 cfs. The existing street capacity is well above the calculated developed flows from the project site.

Basin C consists of Waynoka Road downstream of DP#1, flowing south to Design Point #C1 at the intersection of Waynoka Road and Palmer Park Boulevard. Developed flows from Basins A1, B1, B2, C, D1, D2, and E combine at Design Point #C1, with historic peak flows calculated as Q_5 = 20.1 cfs and Q_{100} = 52.3 cfs. The proposed Woodford Manufacturing Building Addition project will increase the developed peak flows at Design Point #C1 to Q_5 = 25.8 cfs and Q_{100} = 57.4 cfs (less than 10 percent increase). With the carryover flows from upstream Inlets B1 and B2, the total developed flows at Design Point #C1.1 are calculated as Q_5 = 31.9 cfs and Q_{100} = 72.3 cfs.

As detailed in Appendix B, the existing 10’ Type R storm inlet at the northeast corner of Waynoka Road and Palmer Park Boulevard has a capacity of approximately Q_5 = 13.4 cfs and Q_{100} = 23.4 cfs, which is below both the existing and developed peak flows calculated in this report. However, there is an existing concrete headwall on the east side of the storm inlet (north side of the Palmer Park Boulevard right-of-way) providing a stable overflow path to the existing 36” culvert inlet in the large sump area adjoining the golf course at the northeast of the intersection. There are no indications of erosion or drainage capacity problems at the existing intersection, so no improvements appear to be warranted at this time.

III. DRAINAGE PLANNING FOUR STEP PROCESS

El Paso County Drainage Criteria require drainage planning to include a Four Step Process for receiving water protection that focuses on reducing runoff volumes, treating the water quality capture volume (WQCV), stabilizing drainageways, and implementing long-term source controls.

As stated in DCM Volume 2, the Four Step Process is applicable to all new and re-development projects with construction activities that disturb 1 acre or greater or that disturb less than 1 acre but are part of a larger common plan of development. The Four Step Process has been implemented as follows in the planning of this project:

<u>Step 1: Employ Runoff Reduction Practices</u>

- Grass Swales: The proposed drainage plan incorporates grass swales in unpaved areas to encourage stormwater infiltration.

<u>Step 2: Stabilize Drainageways</u>

- There are no major drainageways directly adjacent to this site. Routing flows through the on-site Rain Garden will minimize off-site impacts to existing downstream drainageways.

<u>Step 3: Provide Water Quality Capture Volume (WQCV)</u>

- Site drainage from the building addition area will be routed through a proposed Rain Garden (RG), which will capture and slowly release the WQCV over a 12-hour design release period.

<u>Step 4: Consider Need for Industrial and Commercial BMPs</u>

- On-site drainage will be routed through the private Rain Garden (RG) to minimize introduction of contaminants to the County's public drainage system.
- The Owner will be responsible to implement and maintain a stormwater management plan (SWMP), which will include proper housekeeping practices for the industrial facility.

IV. STORMWATER QUALITY

The proposed drainage and grading plan for this site includes a private Rain Garden (RG) at the southwest corner of Lot 1 to provide the required stormwater quality mitigation for the site in accordance with current El Paso County drainage criteria.

According to the calculations in Appendix A, the required Water Quality Capture Volume (WQCV) for Design Point D1.1 (Basins A2 and D1) is 5,625 cubic feet, and the proposed Rain Garden provides a volume of 6,017 cubic feet.

The outlet of the Rain Garden will consist of an overflow chase draining to the existing driveway at the northwest corner of Lot 2, and an underdrain will be extended to daylight to the south within Lot 2.

The proposed stormwater quality facilities will be privately owned and maintained by the property owner, and maintenance access is readily available from the existing street.

This site is a platted and previously developed lot with the existing manufacturing facility originally constructed in 1979. Stormwater detention was not required for this site in the previously approved subdivision drainage report, and the allowable street capacity of the existing curb and gutter along Waynoka Road provides a suitable outfall for developed drainage from the site in accordance with the subdivision drainage report. The site is located in the Sand Creek Drainage Basin, and the subdivision drainage report identifies fully developed flows from this site draining south within Waynoka Road to the existing downstream public drainage system flowing into the upper reach of the Sand Creek Center Tributary Channel. The Sand Creek Drainage Basin Planning Study (DBPS) identifies the existing downstream drainage facilities immediately south of this site as adequate.

The Sand Creek DBPS identifies the downstream design point for the Sand Creek Center Tributary Channel (DP45 at Galley Road) as having a future peak 100-year flow of 1,340 cfs, so the developed flow from the Woodford Manufacturing site is negligible (less than 4 percent) in comparison to the major basin flow.

As previously noted, the existing street capacity of Waynoka Road is more than sufficient to convey the developed flow from the project site.

V. FLOODPLAIN IMPACTS

This site is located beyond the limits of the FEMA 100-year floodplain boundaries for the West Fork Sand Creek channel according to the FEMA floodplain map for this area, FIRM Panel No. 08041C0751F dated March 17, 1997 (see Appendix B).

VI. DRAINAGE BASIN FEES

This site is located within the Sand Creek Drainage Basin. No public drainage improvements are required for development of this site. Required drainage fees have been paid during the previous subdivision platting process, so there are no applicable drainage fees required with the Site Development Plan.

VII. SUMMARY

The developed drainage patterns associated with the proposed Woodford Manufacturing Building Addition project (Lot 1, Block 1, Waynoka Road Industrial Subdivision) will remain consistent with the overall drainage plan for this industrial subdivision. The proposed Rain Garden at the southwest corner of Lot 1 will provide water quality mitigation as required for the new site improvements. Proper construction and maintenance of the proposed on-site drainage facilities, in conjunction with proper erosion control practices, will ensure that this developed site has no significant adverse drainage impact on downstream or surrounding areas.

APPENDIX A

HYDROLOGIC CALCULATIONS

Hydrologic Soil Group—El Paso County Area, Colorado
(Woodford Manufacturing)

Map Scale: 1:1,100 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 15, 30, 60, 90

Feet: 0, 50, 100, 200, 300

N

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: Jun 3, 2014—Jun 17, 2014

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
28	Ellicott loamy coarse sand, 0 to 5 percent slopes	A	4.7	100.0%
Totals for Area of Interest			**4.7**	**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

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.

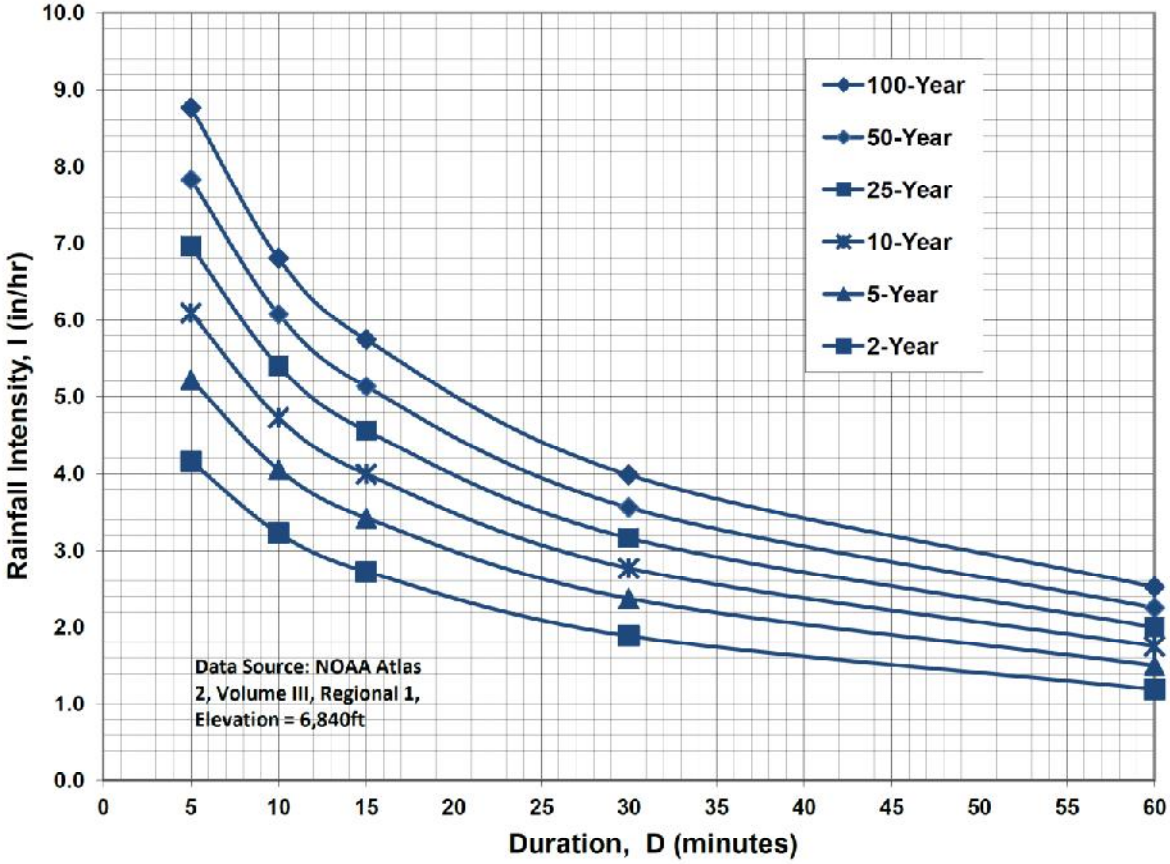
3.2.4 Minimum Time of Concentration

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.

WOODFORD MANUFACTURING
COMPOSITE RUNOFF COEFFICIENTS

HISTORIC CONDITIONS

5-YEAR C VALUES

BASIN	TOTAL AREA (AC)	(AC)	SUB-AREA 1 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	C	(AC)	SUB-AREA 3 DEVELOPMENT/ COVER	C	WEIGHTED C VALUE
A1	3.09	3.09	LIGHT INDUSTRIAL	0.59							0.590
B1	0.56	0.35	BUILDING / PAVEMENT	0.90	0.21	LANDSCAPED	0.08				0.593
A1,B1	3.65										0.590
B2	0.56	0.35	BUILDING / PAVEMENT	0.90	0.21	LANDSCAPED	0.08				0.593
A1,B1,B2	4.21										0.591
A2	1.00	1.00	LIGHT INDUSTRIAL	0.59							0.590
D1	4.90	4.90	VACANT	0.08							0.080
D2	2.16	2.16	VACANT	0.08							0.080
E	2.38	2.38	VACANT	0.08							0.080
A2,D1,D2,E	10.44										0.129
C	5.65	3.53	BUILDING / PAVEMENT	0.90	2.12	LANDSCAPED	0.08				0.593
A1,B1,B2,C,D1,D2,E	20.30										0.354

100-YEAR C VALUES

BASIN	TOTAL AREA (AC)	(AC)	SUB-AREA 1 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	C	(AC)	SUB-AREA 3 DEVELOPMENT/ COVER	C	WEIGHTED C VALUE
A1	3.09	3.09	LIGHT INDUSTRIAL	0.70							0.700
B1	0.56	0.35	BUILDING / PAVEMENT	0.96	0.21	LANDSCAPED	0.35				0.731
A1,B1	3.65										0.705
B2	0.56	0.35	BUILDING / PAVEMENT	0.96	0.21	LANDSCAPED	0.35				0.731
A1,B1,B2	4.21										0.708
A2	1.00	1.00	LIGHT INDUSTRIAL	0.70							0.700
D1	4.90	4.90	VACANT	0.35							0.350
D2	2.16	2.16	VACANT	0.35							0.350
E	2.38	2.38	VACANT	0.35							0.350
A2,D1,D2,E	10.44										0.384
C	5.65	3.53	BUILDING / PAVEMENT	0.96	2.12	LANDSCAPED	0.35				0.731
A1,B1,B2,C,D1,D2,E	20.30										0.548

WOODFORD MANUFACTURING BUILDING ADDITION - LOT 1, BLOCK 1, WAYNOKA ROAD INDUSTRIAL
RATIONAL METHOD

HISTORIC FLOWS

BASIN	DESIGN POINT	AREA (AC)	C 5-YEAR	C 100-YEAR	Overland Flow LENGTH (FT)	Overland Flow SLOPE (FT/FT)	Overland Flow Tco (1) (MIN)	Channel flow CHANNEL LENGTH (FT)	Channel flow CONVEYANCE COEFFICIENT C	Channel flow SLOPE (FT/FT)	Channel flow SCS (2) VELOCITY (FT/S)	Channel flow Tt (3) (MIN)	TOTAL Tc (4) (MIN)	TOTAL Tc (4) (MIN)	INTENSITY (5) 5-YR (IN/HR)	INTENSITY (5) 100-YR (IN/HR)	PEAK FLOW Q5 (6) (CFS)	PEAK FLOW Q100 (6) (CFS)
A1	A1	3.09	0.590	0.700	100	0.02	7.4	500	20	0.020	2.83	2.9	10.4	10.4	4.08	6.84	7.43	14.80
B1	B1	0.56	0.593	0.731	20	0.02	3.3	600	20	0.020	2.83	3.5	6.8	6.8	4.70	7.89	1.56	3.23
A1,B1	B1.1	3.65	0.590	0.705									10.4	10.4	4.08	6.84	8.78	17.61
B2	B2	0.56	0.593	0.731	20	0.02	3.3	600	20	0.020	2.83	3.5	6.8	6.8	4.70	7.89	1.56	3.23
A1,B1,B2	1	4.21	0.591	0.708									10.4	10.4	4.08	6.84	10.14	20.40
A2	A2	1.00	0.590	0.700	100	0.02	7.4	300	10	0.010	1.00	5.0	12.4	12.4	3.81	6.39	2.24	4.47
D1	D1	4.90	0.080	0.350			0.0	680	20	0.018	2.68	4.2	4.2	5.0	5.17	8.68	2.03	14.88
Tt-D1 to DP2								650	20	0.022	2.95	3.7						
D2	D2	2.16	0.080	0.350	100	0.02	14.8	450	20	0.020	2.83	2.7	17.5	17.5	3.29	5.53	0.57	4.18
E	E	2.38	0.080	0.350	100	0.02	14.8	550	20	0.020	2.83	3.2	18.1	18.1	3.24	5.44	0.62	4.53
A2,D1,D2	2	10.44	0.129	0.384									20.3	20.3	3.07	5.15	4.13	20.63
C		5.65	0.593	0.731	100	0.02	7.4	550	20	0.020	2.83	3.2	10.6	10.6	4.04	6.78	13.54	28.02
Tt-DP2 to C1								1050	20	0.020	2.83	6.2						
A1,B1,B2,C,D1,D2,E	C1	20.30	0.354	0.548									24.3	24.3	2.80	4.70	20.12	52.28

1) OVERLAND FLOW Tco = (0.395*(1.1-RUNOFF COEFFICIENT)*(OVERLAND FLOW LENGTH^(0.5)/(SLOPE^(0.333))
2) SCS VELOCITY = C * ((SLOPE(FT/FT)^0.5)
C = 2.5 FOR HEAVY MEADOW
C = 5 FOR TILLAGE/FIELD
C = 7 FOR SHORT PASTURE AND LAWNS
C = 10 FOR NEARLY BARE GROUND
C = 15 FOR GRASSED WATERWAY
C = 20 FOR PAVED AREAS AND SHALLOW PAVED SWALES
3) MANNING'S CHANNEL TRAVEL TIME = L/V (WHEN CHANNEL VELOCITY IS KNOWN)
4) Tc = Tco + Tt
*** IF TOTAL TIME OF CONCENTRATION IS LESS THAN 5 MINUTES, THEN 5 MINUTES IS USED
5) INTENSITY BASED ON I-D-F EQUATIONS IN CITY OF COLORADO SPRINGS DRAINAGE CRITERIA MANUAL
$I_5 = -1.5 * \ln(Tc) + 7.583$
$I_{100} = -2.52 * \ln(Tc) + 12.735$
6) Q = CiA

WOODFORD MANUFACTURING
COMPOSITE RUNOFF COEFFICIENTS

DEVELOPED CONDITIONS

5-YEAR C VALUES

BASIN	TOTAL AREA (AC)	(AC)	SUB-AREA 1 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	C	(AC)	SUB-AREA 3 DEVELOPMENT/ COVER	C	WEIGHTED C VALUE
A1	3.09	3.09	LIGHT INDUSTRIAL	0.59							0.590
B1	0.56	0.35	BUILDING / PAVEMENT	0.90	0.21	LANDSCAPED	0.08				0.593
A1,B1	3.65										0.590
B2	0.56	0.35	BUILDING / PAVEMENT	0.90	0.21	LANDSCAPED	0.08				0.593
A1,B1,B2	4.21										0.591
A2	1.00	1.00	LIGHT INDUSTRIAL	0.59							0.590
D1	4.90	4.90	LIGHT INDUSTRIAL	0.59							0.590
D2	2.16	2.16	VACANT	0.08							0.080
E	2.38	2.38	VACANT	0.08							0.080
A2,D1,D2,E	10.44										0.368
C	5.65	3.53	BUILDING / PAVEMENT	0.90	2.12	LANDSCAPED	0.08				0.593
A1,B1,B2,C,D1,D2,E	20.30										0.477

100-YEAR C VALUES

BASIN	TOTAL AREA (AC)	(AC)	SUB-AREA 1 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	C	(AC)	SUB-AREA 3 DEVELOPMENT/ COVER	C	WEIGHTED C VALUE
A1	3.09	3.09	LIGHT INDUSTRIAL	0.70							0.700
B1	0.56	0.35	BUILDING / PAVEMENT	0.96	0.21	LANDSCAPED	0.35				0.731
A1,B1	3.65										0.705
B2	0.56	0.35	BUILDING / PAVEMENT	0.96	0.21	LANDSCAPED	0.35				0.731
A1,B1,B2	4.21										0.708
A2	1.00	1.00	LIGHT INDUSTRIAL	0.70							0.700
D1	4.90	4.90	LIGHT INDUSTRIAL	0.70							0.700
D2	2.16	2.16	VACANT	0.35							0.350
E	2.38	2.38	VACANT	0.35							0.350
A2,D1,D2,E	10.44										0.548
C	5.65	3.53	BUILDING / PAVEMENT	0.96	2.12	LANDSCAPED	0.35				0.731
A1,B1,B2,C,D1,D2,E	20.30										0.632

WOODFORD MANUFACTURING BUILDING ADDITION - LOT 1, BLOCK 1, WAYNOKA ROAD INDUSTRIAL
RATIONAL METHOD

DEVELOPED FLOWS

					Overland Flow			Channel flow										
			C					CHANNEL	CONVEYANCE		SCS [2]		TOTAL	TOTAL	INTENSITY [5]		PEAK FLOW	
BASIN	DESIGN POINT	AREA (AC)	5-YEAR	100-YEAR	LENGTH (FT)	SLOPE (FT/FT)	Tco [1] (MIN)	LENGTH (FT)	COEFFICIENT C	SLOPE (FT/FT)	VELOCITY (FT/S)	Tt [3] (MIN)	Tc [4] (MIN)	Tc [4] (MIN)	5-YR (IN/HR)	100-YR (IN/HR)	Q5 [6] (CFS)	Q100 [6] (CFS)
A1	A1	3.09	0.590	0.700	100	0.02	7.4	500	20	0.020	2.83	2.9	10.4	10.4	4.08	6.84	7.43	14.80
B1	B1	0.56	0.593	0.731	20	0.02	3.3	600	20	0.020	2.83	3.5	6.8	6.8	4.70	7.89	1.56	3.23
A1,B1	B1.1	3.65	0.590	0.705									10.4	10.4	4.08	6.84	8.78	17.61
B2	B2	0.56	0.593	0.731	20	0.02	3.3	600	20	0.020	2.83	3.5	6.8	6.8	4.70	7.89	1.56	3.23
A1,B1,B2	1	4.21	0.591	0.708									10.4	10.4	4.08	6.84	10.14	20.40
A2	A2	1.00	0.590	0.700	100	0.02	7.4	300	10	0.010	1.00	5.0	12.4	12.4	3.81	6.39	2.24	4.47
D1		4.90	0.590	0.700			0.0	680	20	0.018	2.68	4.2	4.2	5.0	5.17	8.68	14.94	29.77
A2,D1	D1.1	5.90	0.590	0.700									16.6	16.6	3.37	5.65	11.72	23.33
Tt-D1 to DP2								650	20	0.022	2.95	3.7						
D2	D2	2.16	0.080	0.350	100	0.02	14.8	450	20	0.020	2.83	2.7	17.5	17.5	3.29	5.53	0.57	4.18
E	E	2.38	0.080	0.350	100	0.02	14.8	550	20	0.020	2.83	3.2	18.1	18.1	3.24	5.44	0.62	4.53
A2,D1,D2,E	2	10.44	0.368	0.548									20.3	20.3	3.07	5.15	11.78	29.44
Inlet B1.1 carryover																	5.8	13.6
A2,D1,D2,E	2.1																17.58	43.04
C		5.65	0.593	0.731	100	0.02	7.4	550	20	0.020	2.83	3.2	10.6	10.6	4.04	6.78	13.54	28.02
Tt-DP2 to C1								1050	20	0.020	2.83	6.2						
A1,B1,B2,C,D1,D2,E	C1	20.30	0.477	0.632									26.5	26.5	2.67	4.48	25.83	57.43
Inlet B1.1,B2 carryover																	6.1	14.9
A1,B1,B2,C,D1,D2,E	C1.1																31.93	72.33

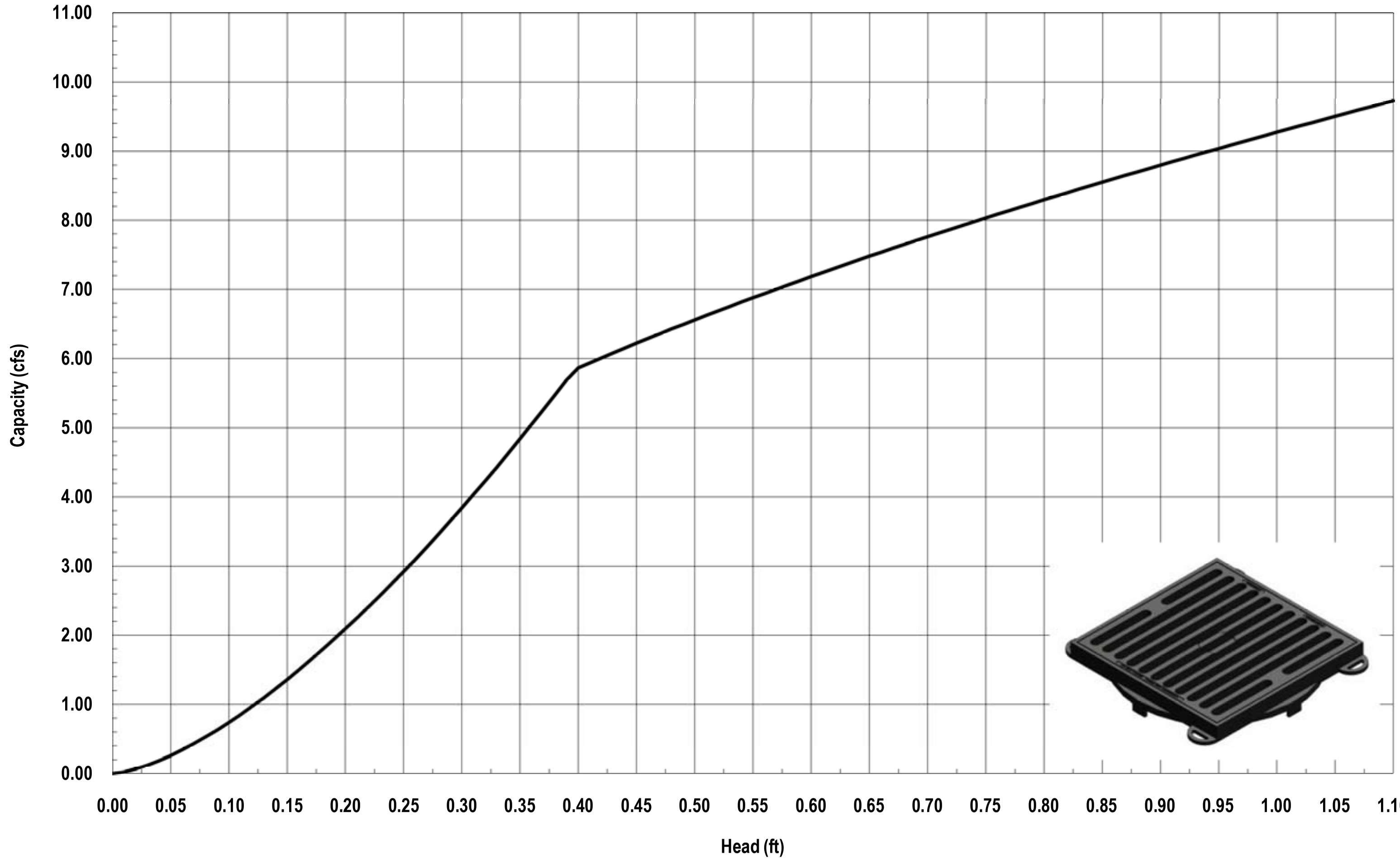
1) OVERLAND FLOW Tco = (0.395*(1.1-RUNOFF COEFFICIENT)*(OVERLAND FLOW LENGTH^(0.5)/(SLOPE^(0.333))
2) SCS VELOCITY = C * ((SLOPE(FT/FT)^0.5)
C = 2.5 FOR HEAVY MEADOW
C = 5 FOR TILLAGE/FIELD
C = 7 FOR SHORT PASTURE AND LAWNS
C = 10 FOR NEARLY BARE GROUND
C = 15 FOR GRASSED WATERWAY
C = 20 FOR PAVED AREAS AND SHALLOW PAVED SWALES
3) MANNING'S CHANNEL TRAVEL TIME = L/V (WHEN CHANNEL VELOCITY IS KNOWN)
4) Tc = Tco + Tt
*** IF TOTAL TIME OF CONCENTRATION IS LESS THAN 5 MINUTES, THEN 5 MINUTES IS USED
5) INTENSITY BASED ON I-D-F EQUATIONS IN CITY OF COLORADO SPRINGS DRAINAGE CRITERIA MANUAL
$I_5 = -1.5 * \ln(Tc) + 7.583$
$I_{100} = -2.52 * \ln(Tc) + 12.735$
6) Q = CiA

APPENDIX B

HYDRAULIC CALCULATIONS

INLET A2

Nyloplast 2' x 2' Road & Highway Grate Inlet Capacity Chart



INLET CAPACITY:
HW = 1.0 FT
Q = 9.2 CFS
CLOGGING FACTOR = 50%
Q = 4.6 CFS (CAPACITY)
DP-A2 Q100 = 4.5 CFS

Nyloplast®
3130 Verona Avenue • Buford, GA 30518
(866) 888-8479 / (770) 932-2443 • Fax: (770) 932-2490

Hydraulic Analysis Report

Project Data

Project Title: Woodford

Designer: JPS

Project Date: Thursday, October 11, 2018

Project Units: U.S. Customary Units

Notes:

Channel Analysis: SD-A2

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.0000 ft

Longitudinal Slope: 0.0160 ft/ft

Manning's n: 0.0130

Depth: 1.0000 ft

Result Parameters

Flow: 4.5066 cfs **= Q100 = 4.5 cfs (DP-A2)**

Area of Flow: 0.7854 ft^2

Wetted Perimeter: 3.1416 ft

Hydraulic Radius: 0.2500 ft

Average Velocity: 5.7380 ft/s

Top Width: 0.0000 ft

Froude Number: 0.0000

Critical Depth: 0.8867 ft

Critical Velocity: 6.1204 ft/s

Critical Slope: 0.0143 ft/ft

Critical Top Width: 0.63 ft

Calculated Max Shear Stress: 0.9984 lb/ft^2

Calculated Avg Shear Stress: 0.2496 lb/ft^2

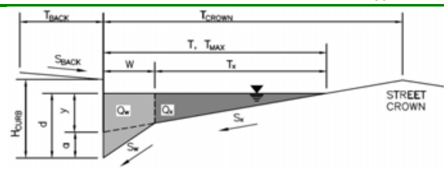
Version 4.05 Released March 2017

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

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

Project: Waynoka Road - Inlet B1.1

Inlet ID: Inlet B1.1



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	15.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	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} =	8.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	24.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	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 =	0.020	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} =	24.0	24.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	8.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

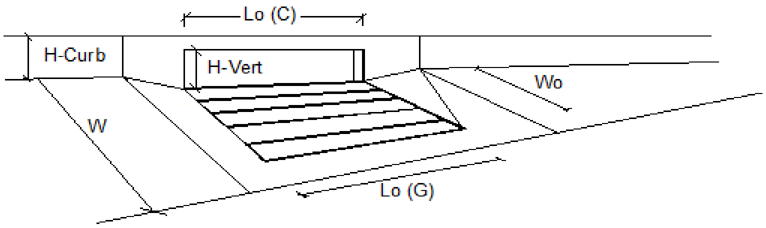
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**36.7**	**137.9**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.05 Released March 2017



Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	1.0	1.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C_f-C =	0.10	0.10	

Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**3.0**	**4.0**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**5.8**	**13.6**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**34**	**23**	**%**

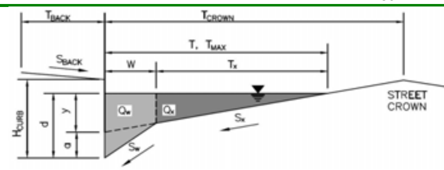
Version 4.05 Released March 2017

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

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

Project: Waynoka Road - Inlet B2

Inlet ID: Inlet B2



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	15.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	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} =	8.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	24.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	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 =	0.020	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} =	24.0	24.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	8.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

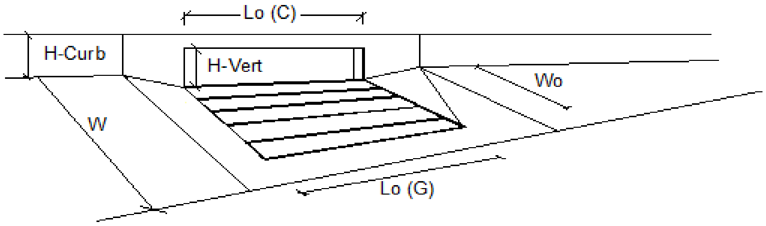
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**36.7**	**137.9**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.05 Released March 2017



Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT Type R Curb Opening)	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	1.0	1.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**1.3**	**1.9**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.3**	**1.3**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**83**	**60**	**%**

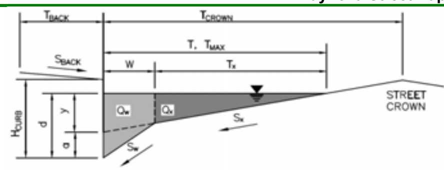
Version 4.05 Released March 2017

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

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

Project: Waynoka Road - DP-2.1 (Street Capacity Analysis)

Inlet ID: Waynoka Street Capacity



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	15.0		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020		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} =	8.00		inches
Distance from Curb Face to Street Crown	T_{CROWN} =	24.0		ft
Gutter Width	W =	2.00		ft
Street Transverse Slope	S_X =	0.020		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 =	0.020		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} =	24.0	24.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	8.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**36.7**	**137.9**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

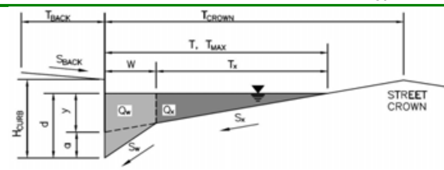
Version 4.05 Released March 2017

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

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

Project: Waynoka Road - Inlet C1.1 (Palmer Park Blvd)

Inlet ID: Inlet C1.1



Gutter Geometry (Enter data in the blue cells)

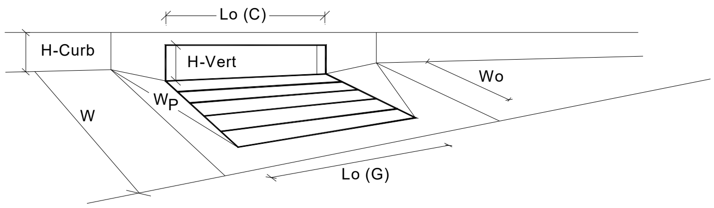
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	15.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	8.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	24.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	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} =	24.0	24.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	8.0	12.0	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



		MINOR	MAJOR	
Design Information (Input) — CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	1.00	1.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	7.3	12.0	inches
Grate Information		MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate	L_o (G) =	N/A	N/A	feet
Width of a Unit Grate	W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	N/A	N/A	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	10.00	10.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)	Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	2.00	2.00	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) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.67	0.67	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.44	0.83	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.69	1.00	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	1.00	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**13.4**	**23.4**	**cfs**
WARNING: Inlet Capacity less than Q Peak for Minor and Major Storms	$Q_{PEAK\ REQUIRED}$ =	31.9	72.3	cfs

Design Procedure Form: Rain Garden (RG)

UD-BMP (Version 3.06, November 2016)

Designer: JPS
Company: JPS
Date: October 11, 2018
Project: Woodford Manufacturing Building Addition
Location: Lot 1, Block 1, Waynoka Road Industrial Subdivision (2121 Waynoka Road, Colorado Springs, CO)

1. Basin Storage Volume	
A) Effective Imperviousness of Tributary Area, I_a (100% if all paved and roofed areas upstream of rain garden)	I_a = 80.0 %
B) Tributary Area's Imperviousness Ratio ($i = I_a/100$)	i = 0.800
C) Water Quality Capture Volume (WQCV) for a 12-hour Drain Time (WQCV= 0.8 * ($0.91* i^3 - 1.19 * i^2 + 0.78 * i$)	WQCV = 0.26 watershed inches
D) Contributing Watershed Area (including rain garden area)	Area = 257,004 sq ft
E) Water Quality Capture Volume (WQCV) Design Volume Vol = (WQCV / 12) * Area	V_{WQCV} = 5,625 cu ft
F) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm	d_6 = ______ in
G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume	$V_{WQCV\ OTHER}$ = ______ cu ft
H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired)	$V_{WQCV\ USER}$ = ______ cu ft
2. Basin Geometry	
A) WQCV Depth (12-inch maximum)	D_{WQCV} = 12 in
B) Rain Garden Side Slopes (Z = 4 min., horiz. dist per unit vertical) (Use "0" if rain garden has vertical walls)	Z = 4.00 ft / ft
C) Mimimum Flat Surface Area	A_{Min} = 4112 sq ft
D) Actual Flat Surface Area	A_{Actual} = 5275 sq ft
E) Area at Design Depth (Top Surface Area)	A_{Top} = 6759 sq ft
F) Rain Garden Total Volume (V_T= ((A_{Top} + A_{Actual}) / 2) * Depth)	V_T= 6,017 cu ft
3. Growing Media	Choose One ◉ 18" Rain Garden Growing Media ○ Other (Explain):
4. Underdrain System	
A) Are underdrains provided?	Choose One ◉ YES ○ NO
B) Underdrain system orifice diameter for 12 hour drain time	
i) Distance From Lowest Elevation of the Storage Volume to the Center of the Orifice	y = 2.0 ft
ii) Volume to Drain in 12 Hours	Vol_{12} = 5,625 cu ft
iii) Orifice Diameter, 3/8" Minimum	D_O = 1 3/4 in

Design Procedure Form: Rain Garden (RG)

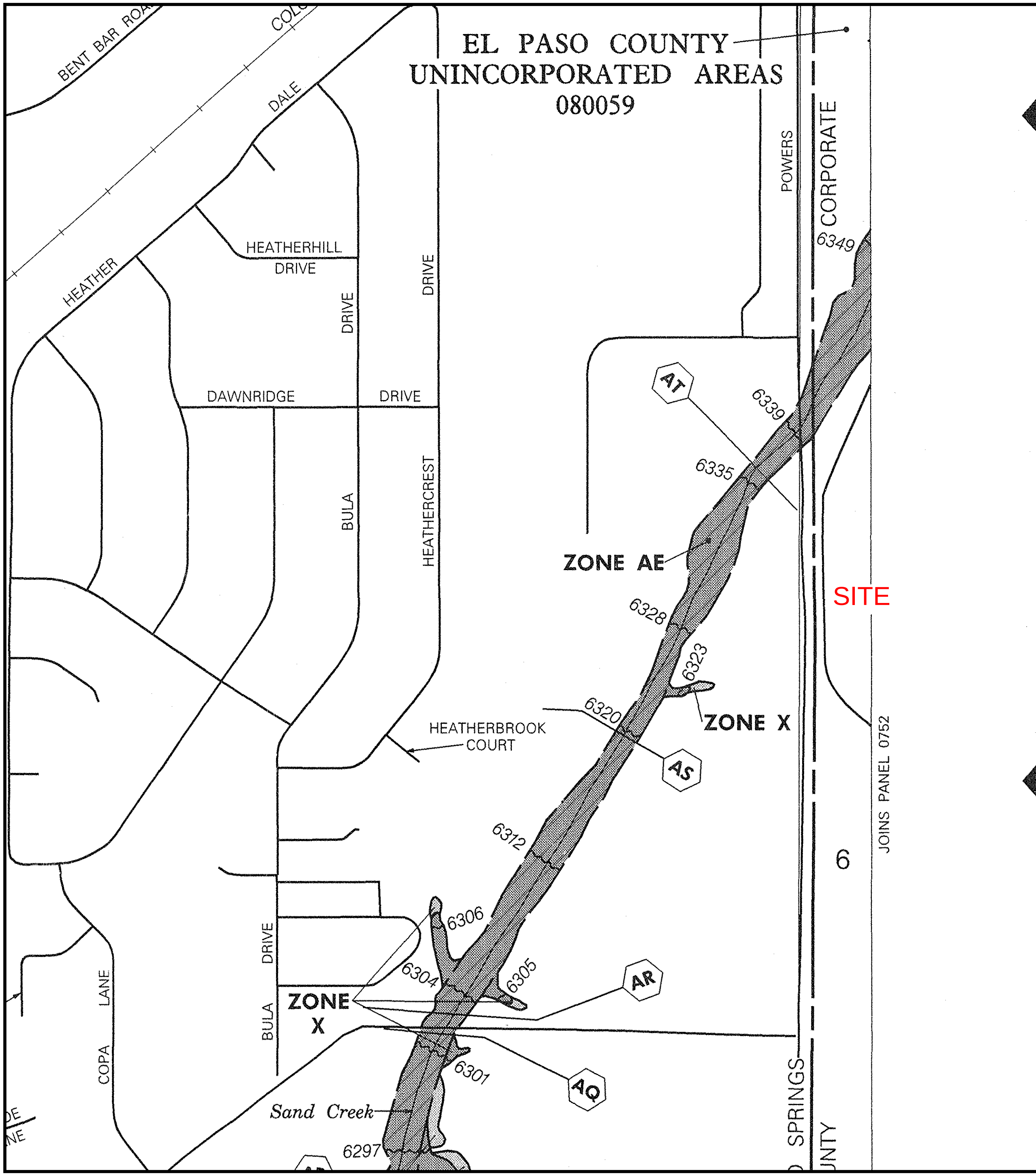
Designer:	**JPS**
Company:	**JPS**
Date:	**October 11, 2018**
Project:	**Woodford Manufacturing Building Addition**
Location:	**Lot 1, Block 1, Waynoka Road Industrial Subdivision (2121 Waynoka Road, Colorado Springs, CO)**

5. Impermeable Geomembrane Liner and Geotextile Separator Fabric A) Is an impermeable liner provided due to proximity of structures or groundwater contamination?	Choose One ○ YES ◉ NO
6. Inlet / Outlet Control A) Inlet Control	Choose One ○ Sheet Flow- No Energy Dissipation Required ◉ Concentrated Flow- Energy Dissipation Provided
7. Vegetation	Choose One ◉ Seed (Plan for frequent weed control) ○ Plantings ○ Sand Grown or Other High Infiltration Sod
8. Irrigation A) Will the rain garden be irrigated?	Choose One ○ YES ○ NO

Notes:

APPENDIX C

FIGURES



APPROXIMATE SCALE IN FEET

500 0 500

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

EL PASO COUNTY,
COLORADO AND
INCORPORATED AREAS

PANEL 751 OF 1300

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:

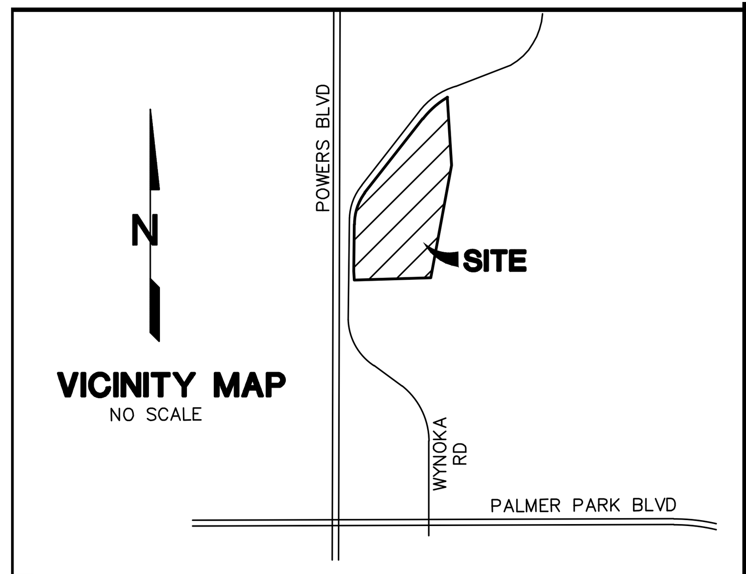
COMMUNITY	NUMBER	PANEL	SUFFIX
COLORADO SPRINGS, CITY OF	080060	0751	F
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0751	F

MAP NUMBER
08041C0751 F

EFFECTIVE DATE:
MARCH 17, 1997

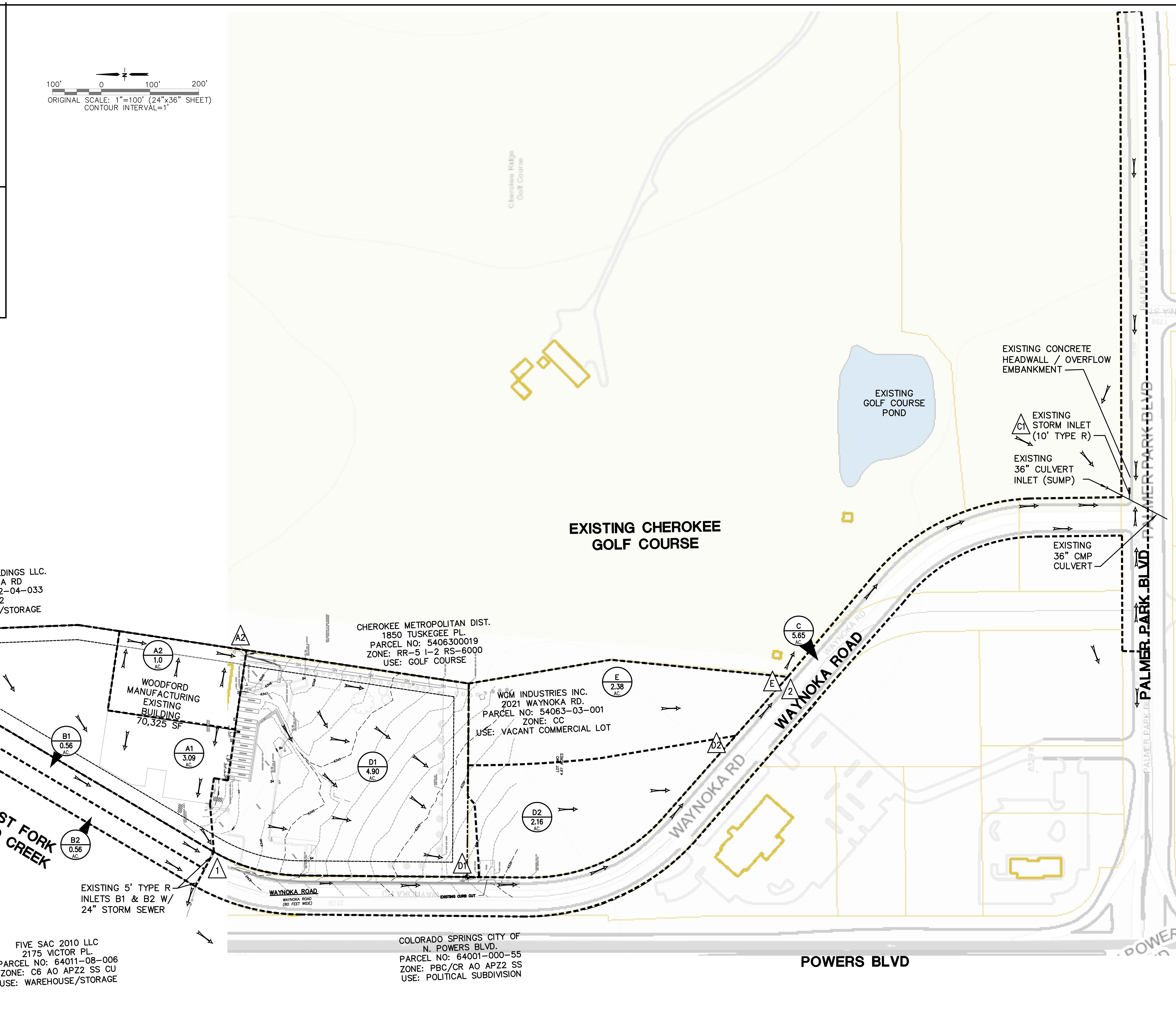
Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



SUMMARY HYDROLOGY TABLE

DESIGN POINT	Q_5 (CFS)	Q_{100} (CFS)
A2	2.2	4.5
D1	2.0	14.9
D2	0.6	4.2
E	0.6	4.5
1	10.1	20.4
2	4.1	20.6
C1	20.1	52.3



BENCHMARK:
NGS BENCHMARK "R 76".
ELEVATION=6289.86 (NAVD-1988)

WOODFORD MANUFACTURING BUILDING ADDITION

2121 WAYNOKA RD, COLORADO SPRINGS, COLORADO 80915

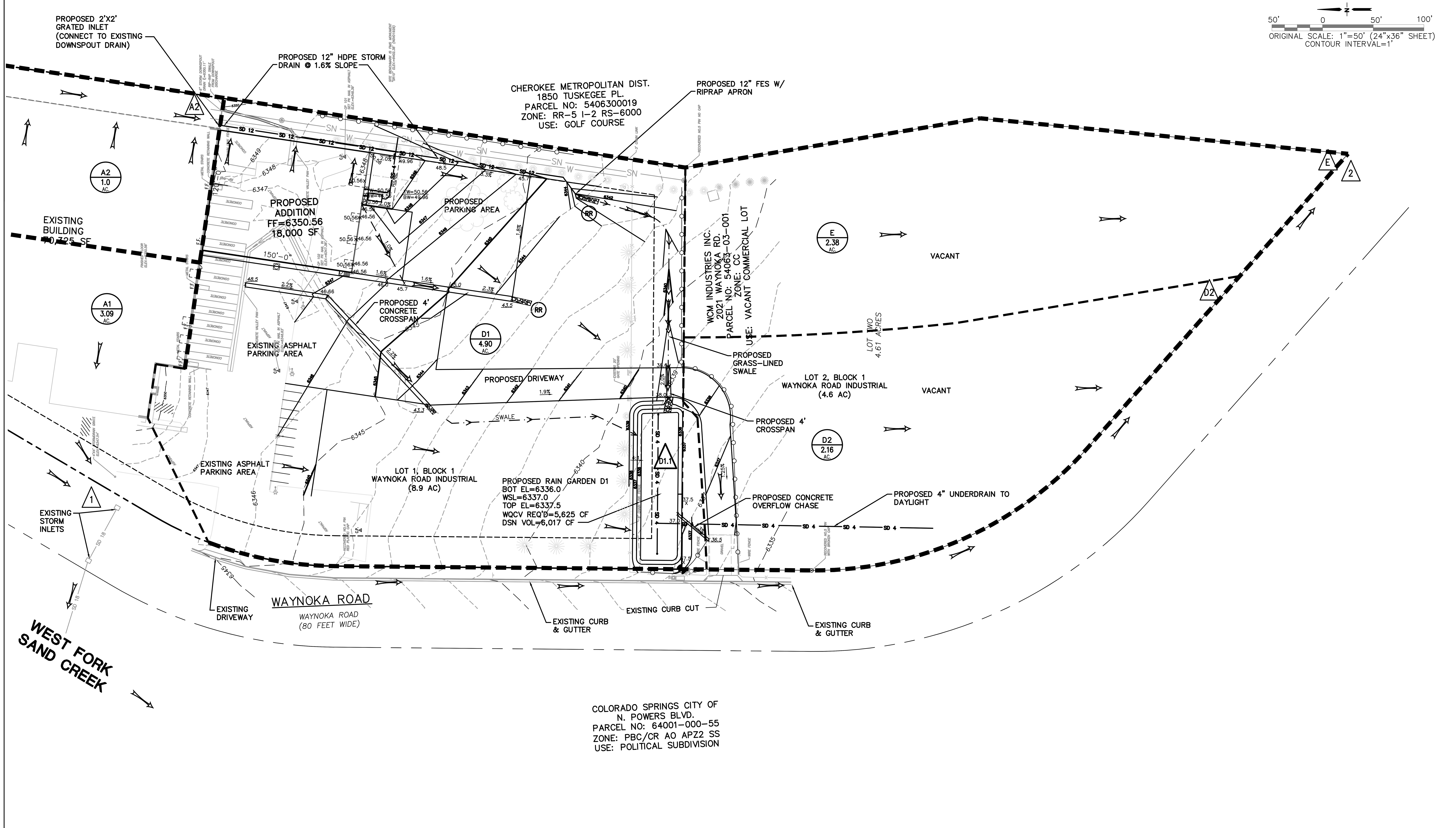
HISTORIC DRAINAGE PLAN

JPS ENGINEERING
19 E. Willamette Ave.
Colorado Springs, CO 80903
PH: 719-477-9429
FAX: 719-471-0766
www.jpsengr.com

CALL UTILITY NOTIFICATION CENTER OF COLORADO
1-800-922-1987
CALL 2-BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE, OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

No.	REVISION	BY	DATE

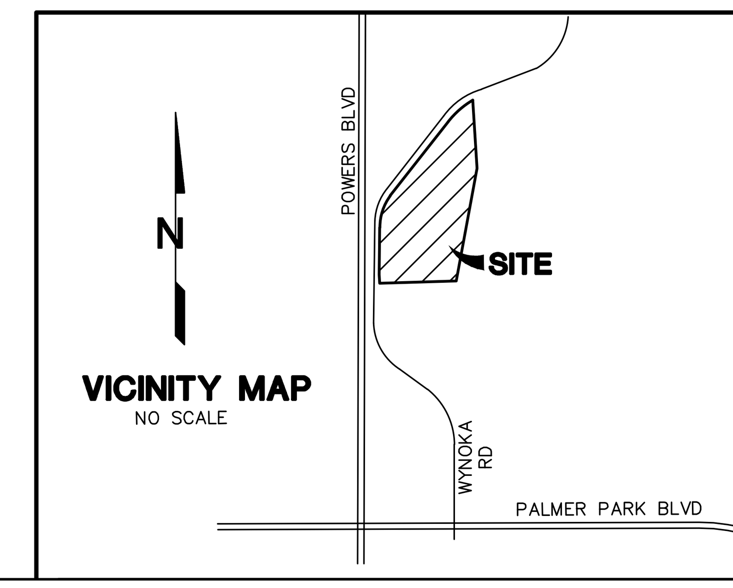
HORZ. SCALE:	1"=100'	DRAWN:	BJJ
VERT. SCALE:	N/A	DESIGNED:	JPS
SURVEYED:	-	CHECKED:	JPS
CREATED:	9/12/18	LAST MODIFIED:	10/12/18
PROJECT NO:	051801	MODIFIED BY:	BJJ
SHEET:	EX1		



SUMMARY HYDROLOGY TABLE

DESIGN POINT	Q_5 (CFS)	Q_{100} (CFS)
A2	2.2	4.5
D1.1	11.7	23.3
D2	0.6	4.2
E	0.6	4.5
1	10.1	20.4
2	11.8	29.4

BENCHMARK:
NGS BENCHMARK "R 76".
ELEVATION=6289.86 (NAVD-1988)



VICINITY MAP
NO SCALE

WOODFORD MANUFACTURING BUILDING ADDITION

2121 WAYNOKA RD, COLORADO SPRINGS, COLORADO 80915

DEVELOPED DRAINAGE PLAN

JPS ENGINEERING
19 E. Willamette Ave.
Colorado Springs, CO 80903
PH: 719-477-9429
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No.	REVISION	BY	DATE

HORZ. SCALE: 1"=50'	DRAWN: BJJ
VERT. SCALE: N/A	DESIGNED: JPS
SURVEYED: –	CHECKED: JPS
CREATED: 7/06/18	LAST MODIFIED: 10/12/18
PROJECT NO: 051801	MODIFIED BY: BJJ
SHEET:	D1