PRELIMINARY DRAINAGE REPORT

FOR THE

4403 BROADWAY

AT

4403 BROADWAY
BOULDER, COLORADO 80304

FOR

EMERALD DEVELOPMENT

OCTOBER 8, 2015
REVISED OCTOBER 19, 2015

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October 19, 2015

Edward Stafford, Development Review Manager
City of Boulder - Planning and Development Services
1739 Broadway, Third Floor
P.O. Box 791
Boulder, CO 80306-0791

RE: 4403 Broadway Avenue Boulder, Colorado
Preliminary Drainage Report
JVA Job No. 1508.5c

Dear Edward:

The following *Preliminary Drainage Report* and attached drainage map for this project have been prepared for the above referenced project. The drainage report and drainage map have been produced in accordance with the "City of Boulder Design and Construction Standards," 2000 Edition, and comply with provisions thereof. This report has been revised based on City of Boulder comments dated January 23, 2015.

It is our understanding that the information provided herein meets all requirements of the City of Boulder's drainage criteria.

Please contact us if you have any questions regarding this submission.

Sincerely,
JVA, Inc.

Kenneth J. Clifford, PE
Project Manager

Danielle I. D. Breedlove, P.E.
Project Engineer

CONSULTING ENGINEERS

ENGINEER'S STATEMENT:

"I hereby certify that this report and the enclosed plan for the preliminary drainage design of the 4403 Broadway project was prepared by me (or under my direct supervision) in accordance with the provisions of City of Boulder Design and Construction Standards for the Responsible Parties thereof. I understand that the City Boulder does not and will not assume liability for drainage facilities design."

_____

Charles R Hager, IV
Registered Professional Engineer
State of Colorado No. 37146

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PRELIMINARY DRAINAGE REPORT

INTRODUCTION

GENERAL LOCATION AND DESCRIPTION

Emerald Development is proposing to redevelop the property located at 4403 Broadway Avenue in Boulder Colorado to create a mixed used development including two townhome complexes and three mixed use facilities. The site is approximately 2.50 acres located in the northeast quarter of Section 13, Township 1 North, Range 71 West of the 6th P.M., City of Boulder, County of Boulder, State of Colorado. More specifically, the site is bound by a commercial development to the north, 10th Street to the west, Violet Avenue to the south, and Broadway Avenue to the east. A vicinity map is included in the Appendix of this report.

The primary purpose of this report is to address the impacts of the site construction, to provide preliminary proposed runoff information, and to address water quality enhancement. Reference is made to the attached "Figure 1 – Historic Drainage Plan", "Figure 2 – Developed Drainage Plan", and "Figure 3 – Off-Site Drainage Basin Plan".

PROPOSED DEVELOPMENT

The proposed project will consist of removing the existing metal building, wood frame building, asphalt parking lot and existing utilities located at 4403 Broadway Avenue in order to construct two townhome complexes and three mixed use buildings as well as associated parking areas, landscaping, and amenities. Portions of the site will be designated for water quality enhancements. The developed drainage basins will generally match the existing basins in terms of drainage pattern. The proposed project will increase the overall imperviousness of the site. A proposed water quality basin will be constructed in order to handle the runoff associated with the development. The water quality pond will provide water quality treatment for the western section of the site. Porous pavers are proposed to the east of the development which will provide water quality treatment for the site's parking lots and access drives. Landscape buffers will be placed on the east side of the site adjacent to Broadway Ave in order to provide water quality treatment for the site's runoff associated with the mixed use building's roofs and pedestrian courtyard areas located in front of the mixed use buildings.

EXISTING CONDITIONS

MASTER DRAINAGE BASIN (MAJOR BASIN) DESCRIPTION

The site's ultimate outfall is Fourmile Canyon Creek located to the north and east of the subject development.

JVA reviewed FEMA Flood Insurance Rate Map Community Panel Number FM08013C0391J, dated December 18, 2012 and determined that the site lies within Zone AE of FEMA's Special

Flood Hazard Area (Base Flood or 100-year floodplain.) A copy of a portion of the referenced flood map is included in the Appendix.

U.S. Department of Agriculture, Soil Conservation Service mapping of the area indicates that the soils are predominantly Valmont cobbly clay loam (VcC), 1 to 5 percent slopes with a very small portion of Nederland very cobbly sandy loam (NdD). VcC soils are classified as hydrological soil group (HGS) C. Soils with an HSG of C have a very slow infiltration rate when thoroughly wet and therefore have high runoff potential. A copy of the NRCS soils classification map is included in the Appendix.

Existing Site Drainage and Facilities

The existing site consists of a large parking lot and several buildings with paved access drives and landscaped areas. In general, the site slopes from northwest to the southeast with elevations varying from ±5533 to ±5518 on the North American Vertical Datum 88 (NAVD 88). Slopes across the site range from 1% to 5% and averages at a 2.0% slope. The storm runoff from the majority of the existing site currently drains to the southeast corner of the site into an existing public storm system in North Broadway.

There are no existing storm drainage or water quality enhancement features on the site. No delineated wetlands have been located on the site.

Existing Site Basins

The existing site has been divided into two on-site drainage basins and two off-site drainage basins. Locations of the existing drainage basins are shown on the Historic Drainage Map and Off-Site Drainage Map. Drainage flows across the site toward the south and east where is flows are captured by a public storm system in Broadway and Violet Avenues. No private storm systems exist on site. The existing percent imperviousness for the site is 57.4%.

Basin H1 (0.79 acres) is located to the south of the site and consists of grassy areas, gravel parking, paved areas, and a portion of the building located on the south side of the property. Runoff from H1 is directed overland to the southeast and into an existing inlet located at the intersection of Violet and Broadway. This inlet directs runoff into the existing public storm system within Broadway.

Basin H2 (1.71 acres) is located to the north of the site and captures runoff from three existing buildings, asphalt parking as well as some grassy areas. Runoff from H2 is directed south into an existing culvert located along Broadway which directs runoff into the existing public storm system within Broadway.

Basin OS1 (6.36 acres) consists of landscaped areas, a trailer residential area, and gravel drives. This basin is located to the northwest of the proposed development. Runoff from OS1 travels to the south and east and enters the development along the northern and western boundary lines. Once runoff passes into the site it travels overland through basin H2.

Basin OS2 (0.69 acres) is located to the north of the site and consists of a commercial development which is primarily buildings and pavement. Runoff from OS2 travels to the southeast and enters the development along the northern property line. Once runoff passes into the site it flows overland through basin H2.

Table 1 below presents a summary of the historic storm water peak flows.

Table 1: Historic Peak Flows

Basin	Design Point	Area (acre)	5-Year Flow (cfs)	100-Year Flow (cfs)
H1	1	0.79	1.01	4.14
H2	2	1.71	4.87	11.45
OS1	3	6.36	8.46	28.81
OS2	4	0.69	3.20	6.12

PROPOSED (DEVELOPED) DRAINAGE

DRAINAGE DESIGN CRITERIA

The proposed private storm drainage facilities for the project are designed to comply with the "City of Boulder Design and Construction Standards," 2000 Edition, and the Urban Drainage and Flood Control District's (UDFCD) Urban Storm Drainage Criteria Manual (USDCM), June 2005 Edition, as the secondary reference.

HYDROLOGIC METHOD AND DESIGN STORM FREQUENCIES

The Rational Method (Q=CIA) was used to determine the storm runoff (Q) from the site, with composite runoff coefficients (C) and contributing areas (A) given for design points in sub-basins. Intensities (I) were determined using the Time-Intensity-Frequency Curves for Boulder, Colorado (Figure 7-1) and a calculated Time of Concentration (t_c). Post-development Time of Concentration calculations for each sub-basin, corresponding rainfall intensities, and composite runoff coefficients for each sub-basin are provided in the Appendix. The FAA Method, per the Urban Storm Drainage Criterial Manual, Vol. 2, Storage-Section 5, has been used to size the 10-year and 100-year water quality volume for the site.

Calculations for the pond have been made in accordance with the City of Boulder and included in the Appendix. Final calculations for the storm system, outlet structures, and swales will be included with the final stormwater report. Complete drainage design plans, details, dimensions, etc. will be developed and included in the final engineering plans which will be submitted and approved by the City of Boulder prior to issuance of a development permit.

PROPOSED SITE BASINS AND SUB-BASINS

The proposed site has been divided into seventeen sub-basins. Please refer to the Developed Drainage Map (see attached Fig. 2). Sub-basin boundaries were established based on outfall location. In general, runoff from the site will follow the historic pattern with flows traveling northwest to southeast while being captured by proposed storm system or water quality enhancements.

There are three different classifications of basins included in this report; A, R, and O. Basins A correspond to drainage areas that sheet flow on land and are captured onsite. Basins delineated

as R represent the roof areas of the building. The O basins represent onsite basins whose flows pass offsite.

Basin A1 (0.81 acres) collects runoff from the townhouse roofs and associated walks, access drive, a parking area and landscaping. Flows from A1 are directed into basin O1 as well as basin A11 which is a water quality basin. Curb cuts on the north boundary of basin A1 will direct runoff to flow into basin A11. The northeast section of basin A1 conveys flows over a porous paver system to a curb along the western edge of the parking area, which directs runoff into the drainage channel in basin O1.

Basin A2 (0.13 acres) is located at the northwest corner of the site and collects runoff from covered parking areas and an access drive. Flows from A2 are directed over a porous paver system south into an inlet which directs water into the storm sewer system located in the north drive. The storm sewer system then directs flows into the existing public storm system within Broadway.

Basin A3 (0.16 acres) is located to the north of the site and collects runoff from the northern parking lot, a portion of the covered parking, and pedestrian area. Flows from A3 are directed over a porous paver system into an inlet located to the south of the basin. This inlet directs water into the storm sewer system located in the northern access drive. The storm sewer system then directs flows into the existing public storm system within Broadway.

Basin A4 (0.02 acres) is a small basin located to the west of the commercial buildings. A4 houses a portion of the site's northern access drive. Runoff from A4 is directed south over a porous paver system and into a curb cut which discharges into the drainage channel in basin O1.

Basin A5 (0.31 acres) is located to the west of the commercial buildings and contains a portion of the site's northern access drive, landscaping, a parking area, associated walks, and pedestrian area. Runoff from A5 is directed to the center of the basin, over a paver system located in the parking area, and into an inlet located on the west side of the parking area. This inlet directs water into the storm sewer system located in the northern access drive. The storm sewer system then directs flows into the existing public storm system within Broadway.

Basin A6 (0.06 acres) is located in the center of the site and houses a portion of the site's access drive and a small parking area. Flows from A6 are directed southeast over a porous paver system in the parking area and into an inlet located on the south edge of the parking area. This inlet directs water into a storm sewer system which connects to an existing inlet on the northeast side of Violet Ave.

Basin A7 (0.04 acres) is located to the south of the site collects runoff from the courtyard area in between buildings B and C. Runoff from A7 is directed into a series of area drains which connect directly into the public storm system in North Broadway.

Basin A8 (0.04 acres) is located to the east of the site collects runoff from the northern access drive, associated walks, and landscaping. Runoff from A8 is directed southeast into an inlet which directs water into the storm sewer system located in the northern access drive. The storm sewer system then directs flows into the existing public storm system within Broadway.

Basin A9 (0.08 acres) is located to the east of the site and collects runoff from a pedestrian courtyard area. Runoff from A9 is directed east into landscape buffers located along Broadway. These landscape buffers have an underdrain system which will direct the flows to the south and connect to an existing inlet on the northeast side of Violet Ave.

Basin A10 (0.03 acres) is located to the northeast of the site and collects runoff from a pedestrian courtyard area. Runoff from A10 is directed east into landscape buffers located along Broadway. These landscape buffers have an underdrain system which will direct the flows to the south and connect into the proposed inlet in the southeast corner of basin A8.

Basin A11 (0.14 acres) is a water quality basin and is located to the north of the site. Basin A11 collects runoff from basin A1. Basin A11 outfalls into the proposed storm system that directs flows into the existing public storm system within Broadway.

Basin R1 (0.07 acres) collects runoff from roof of the northernmost commercial building (Building A). Flows from R1 are directed east into the same landscape buffers as A10 located along Broadway.

Basin R2 (0.08 acres) collects runoff from the roof of the middle commercial building (Building B). Flows from R2 are directed east into the same landscape buffers as A9 located along Broadway.

Basin R3 (0.11 acres) collects runoff from the roof of the southernmost commercial building (Building C). Flows from R3 are directed east into the same landscape buffers as A9 located along Broadway.

Basin O1 (0.14 acres) is located on the northern edge of the property. A drainage swale within O1 will be designed to capture offsite runoff from the historic off-site basin OS1 and will transport flow into the site's proposed storm sewer system.

Basin O2 (0.26 acres) is located to the southwest of the site and is primarily landscaped areas. Runoff from O2 will be directed west and south into the 10th Street and Violet Avenue right-of-way.

Basin O3 (0.04 acres) is located to the east of the site and is primarily walks, and a segment of the northern access drive. Runoff from O3 will be directed west into the Broadway Avenue right-of-way.

Runoff and Stormwater Quality Enhancement Facilities

Runoff rates for the design points have been shown on Table 2 and on the included Developed Drainage Maps. Calculations showing how the runoff rates were determined are shown in the Appendix.

Table 2 below presents a summary of the developed storm water peak flows based on the rational method and Table 3 presents a comparison between the historic and developed peak flows.

Table 2: Developed Peak Flows

Basin	Design Point	Area (acre)	5-Year Flow (cfs)	100-Year Flow (cfs)
A1	1	0.81	3.77	7.18
A2	2	0.13	0.48	1.02
A3	3	0.16	0.54	1.22
A4	4	0.02	0.06	0.12
A5	5	0.31	0.82	2.20

A6	6	0.07	0.27	0.55
A7	7	0.04	0.18	0.33
A8	8	0.04	0.19	0.39
A9	9	0.08	0.29	0.63
A10	10	0.03	0.13	0.26
A11	11	0.14	0.14	0.81
R1	12	0.07	0.34	0.64
R2	13	0.08	0.41	0.76
R3	14	0.11	0.53	0.98
O1	15	0.08	0.09	0.49
O2	16	0.26	0.72	1.92
O3	17	0.05	0.26	0.48

Table 3: Historic vs. Developed Peak Flows from Site

	Historic			**Developed**			**Change in Peak Flow (cfs)**	
	Contributing Acres	**Peak Flows (cfs)**		**Contributing Acres**	**Peak Flows (cfs)**			
		5-Year	100-Year		5-Year	100-Year	5-Year	100-Year
Site	2.50	5.88	15.59	2.50	5.16	12.78	-0.72	-2.81

As can be seen in Table 3 the proposed development will decrease flows from the site and thus no detention is required.

Water quality treatment for the western half of the site is provided through a water quality pond. The water quality pond will be constructed in basin A11 to the north of the townhome complexes and will be used to provide water quality treatment for the townhome buildings and drive isle. An outlet structure with an orifice plate and trash rack will be located to the east of the pond. The orifice plate will be used to release runoff from water quality storm events.

Water quality treatment for the eastern half of the site will be provided through a porous paver system located within the site's parking areas and landscape buffers along the west side of Broadway. Porous pavers are a pavement section which allows movement of water into the layers below the pavement surface. They will be used to provide water quality treatment and promote the slow release of the water quality capture volume for the parking areas and the majority of the site's access drives. An underdrain will be located beneath the porous paver system in order to help drain the area beneath the porous paver system. The porous paver system will not be installed in areas directly adjacent to buildings or in areas which will be adversely impacted by the paver system.

Drainage from the mixed-use building's roof and eastern pedestrian courtyard areas will be discharged into proposed landscape buffers that run along the west side of Broadway. Landscape

buffers are densely vegetated strips of landscaping designed to accept flows from upstream development. Grass buffers play a big role in enabling infiltration, slowing runoff, filtering sediment. An underdrain system located under the landscape buffers will help drain the area. The landscape buffers will be used to provide water quality treatment and promote a slow release of the water quality capture volume for the mixed-use building's roofs and front pedestrian courtyard areas.

As previously mentioned the eastern section of site is historically fully developed and houses portions of several existing buildings and a parking area. Runoff from this side of the site is historically released untreated into the public storm sewer system along North Broadway. By treating the runoff from the mixed-use buildings' roofs, the front courtyards, and the installation of the porous paver system, the result is an increase in overall water quality for the site from the historic values.

GROUNDWATER

According to the project's geotechnical report, groundwater was encountered at depths of approximately 21 to 23 feet in the borings at the time of drilling and at depths of approximately 17 to 21 feet in the borings when checked two days after drilling. Based on the geotechnical engineer's option, present groundwater conditions should not present any problems for the proposed structure as long as the ground surface and roof drainage are property cared for. No subsurface drainage systems should be required. Groundwater levels within the site should be at least 5 feet below the site's storm sewer systems. A copy of portions of the project's geotechnical report is included in the appendix of this report.

OFFSITE RUNOFF

Offsite runoff enters the development from offsite drainage basins OS1 and OS2 which are located along the northern and western property lines. This offsite runoff will need to be conveyed safely through the site. In order to capture runoff from OS1 a drainage swale and drainage pan are proposed. The drainage swale will be constructed in basin O1 to the north of the townhouse units. This drainage swale will be designed to capture and carry the major (100-year) storm event without overtopping into an inlet located at the eastern edge of the drainage swale at design point 15. Sizing the swale for the 100-year storm event will keep offsite flows from traveling into the site's water quality pond. The drainage pan is proposed to the west of the parking garage located at the northwest corner of the site. The drainage pan will convey water into the drainage swale to the north of the townhomes and to the inlet located at design point 15. The inlet at design point 15 will direct runoff into a storm sewer system located in the site's northern access drive. A drainage easement will be provided around the drainage swale and storm sewer system in order to convey the offsite runoff through the site.

Offsite runoff from OS2 will be collected in an inlet located to the northeast of Building A. This inlet will direct runoff into the public storm system within Broadway.

STREETS

The Broadway Avenue cross section is being widened by 1ft and on street parking is being added to the west side of the street. The runoff associated with the on street parking and the additional widening of Broadway is assumed to have negligible effects on the existing storm infrastructure.

Open Channel Flow

A drainage swale is proposed to the north of the townhouse units. This drainage swale will be designed to capture and carry offsite drainage flows from offsite drainage basin OS1. The drainage channel will be designed to capture and carry the major (100-year) storm event without overtopping in order to prevent flows from entering the site's water quality pond.

Storm Sewers and Culverts

In general, onsite inlets and storm pipes have been designed to capture and carry the minor (5-year) storm event without surcharging. During the major (100-year) storm the storm systems will surcharge and flows will be routed overland into the public right-of-way. However, in areas where there is a limited overflow path the storm system has been sized for the 100-year storm. The pipe from basin O1 has also been sized for the 100-year storm in order to prevent runoff from entering into the site.

Storm Water Management Plan

Storm water quality and management are the focal points of the proposed grading and drainage plans for this site. To ensure water quality, the proposed plans include a water quality basin, porous pavers, and landscape buffers. The proposed water quality basin has been designed to cumulatively provide the required water quality capture volume for the tributary Basins A1 and A11. Water quality to the east of the site will be provided through a series of porous paver systems within the site's parking lots and landscape buffers along the west side of Broadway.

In addition to the proposed water quality enhancement features described above, erosion control elements will be installed at strategic locations on the site before construction activities commence. These features will include vehicle-tracking control at the site construction entrance, silt fence, and inlet protection at all proposed and existing storm water inlets onsite and directly adjacent to the site. Non-structural erosion control measures, such as reseeding and schedule adjustment are also required per the City of Boulder guidelines.

Conclusions

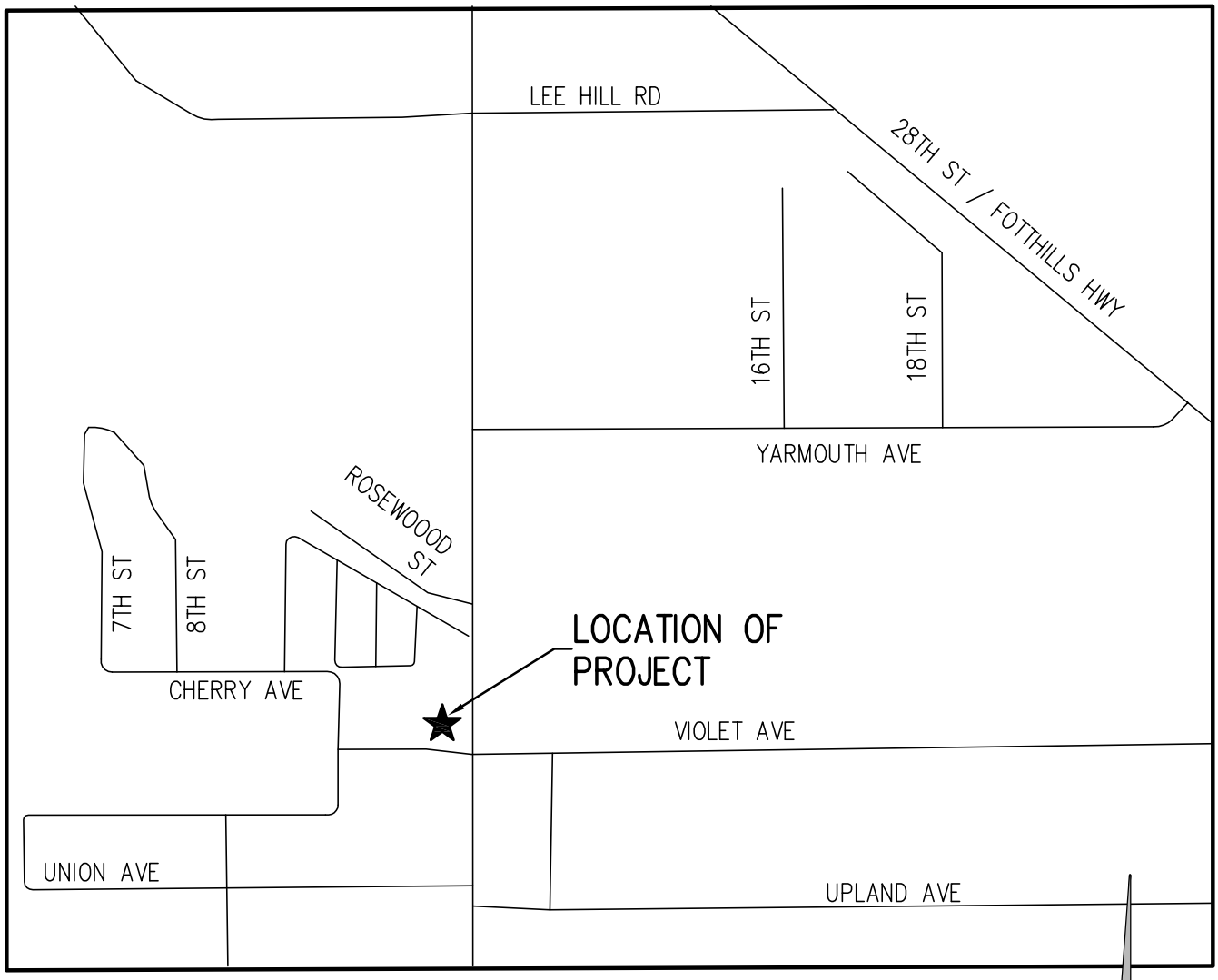
The drainage facilities associated with proposed improvements for the 4403 Broadway project have been designed in accordance with the City of Boulder Standards & Specifications and the latest methods endorsed by the Urban Drainage and Flood Control District.

Developed storm water drainage patterns will closely match historic drainage patterns. Water quality enhancement will be provided for the site to alleviate flows leaving the site . Because of the water quality facilities and proposed storm system, overall storm water runoff quality will be enhanced as a result of this development.

REFERENCES

1. "City of Boulder Design and Construction Standards," 2000 Edition.
2. "Urban Storm Drainage Criteria Manual," Urban Drainage and Flood Control District, 2010.

APPENDIX A – SITE MAPS



VICINITY MAP

1"=400'

4403 BROADWAY, BOULDER, CO
VICINITY MAP

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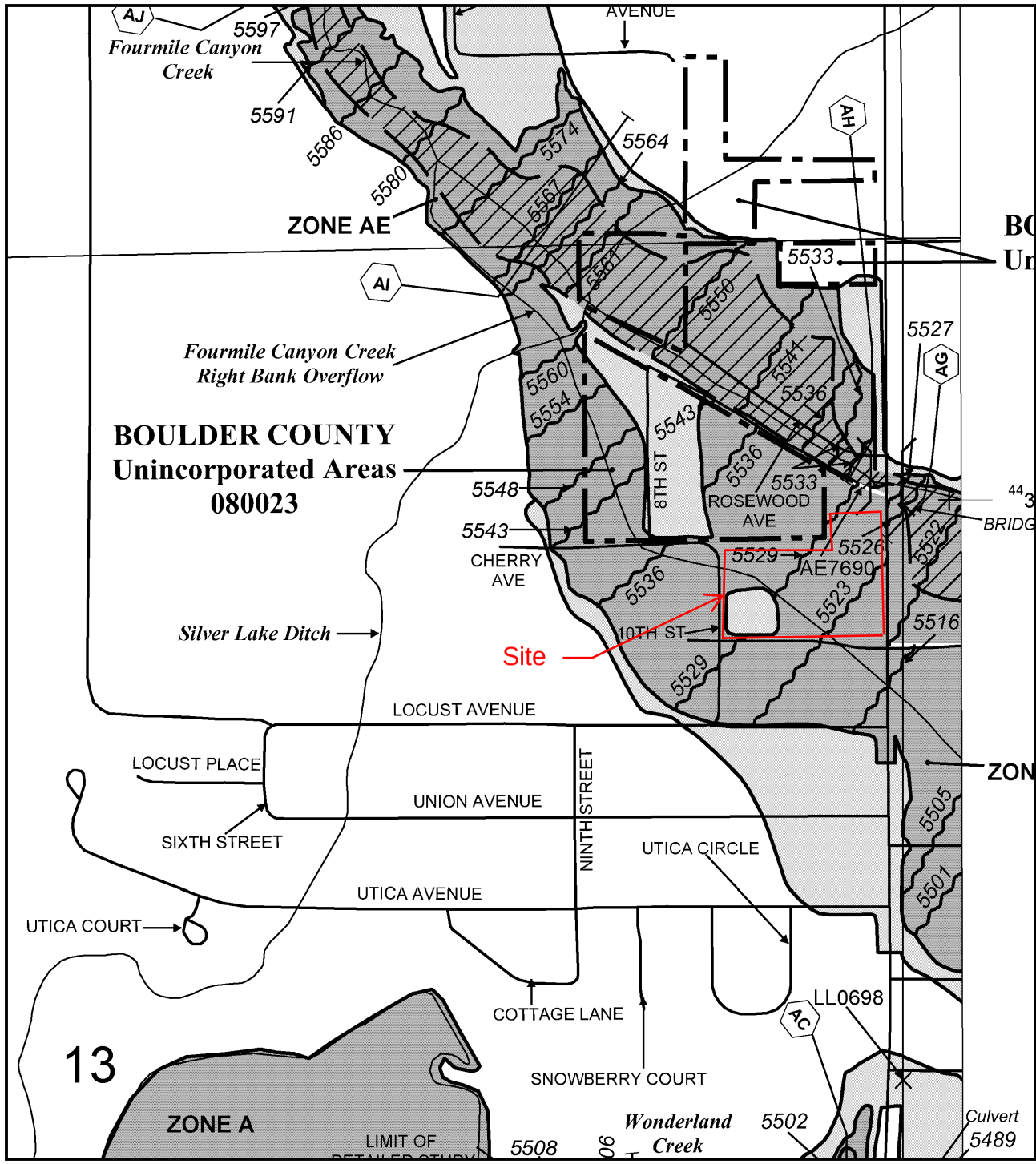


MAP SCALE 1" = 500'

250 0 500 1000 FEET

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0391J

FIRM

FLOOD INSURANCE RATE MAP

BOULDER COUNTY, COLORADO

AND INCORPORATED AREAS

PANEL 391 OF 615

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BOULDER, CITY OF	080024	0391	J
BOULDER COUNTY	080023	0391	J

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

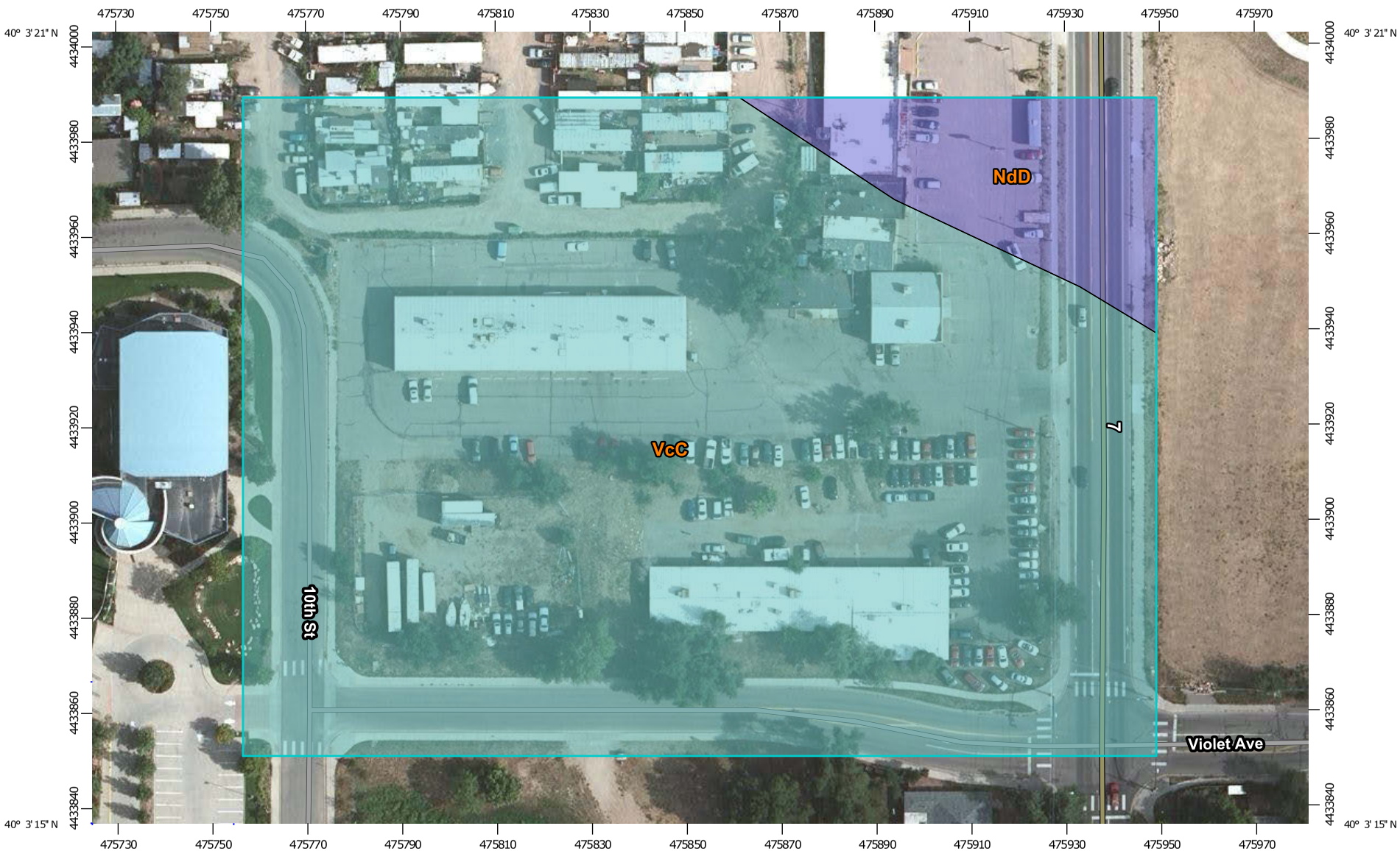
MAP NUMBER
08013C0391J

MAP REVISED
DECEMBER 18, 2012

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

Hydrologic Soil Group—Boulder County Area, Colorado
(4403 Broadway NRCS Soil Survey)



Map Scale: 1:1,170 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 15 30 60 90

Feet: 0 50 100 200 300

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 1:20,000.

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: http://websoilsurvey.nrcs.usda.gov
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: Boulder County Area, Colorado
Survey Area Data: Version 11, Sep 22, 2014

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

Date(s) aerial images were photographed: Apr 28, 2011—Aug 29, 2012

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

Hydrologic Soil Group— Summary by Map Unit — Boulder County Area, Colorado (CO643)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
NdD	Nederland very cobbly sandy loam, 1 to 12 percent slopes	B	0.6	8.5%
VcC	Valmont cobbly clay loam, 1 to 5 percent slopes	C	6.0	91.5%
Totals for Area of Interest			**6.6**	**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

APPENDIX B – CALCULATIONS

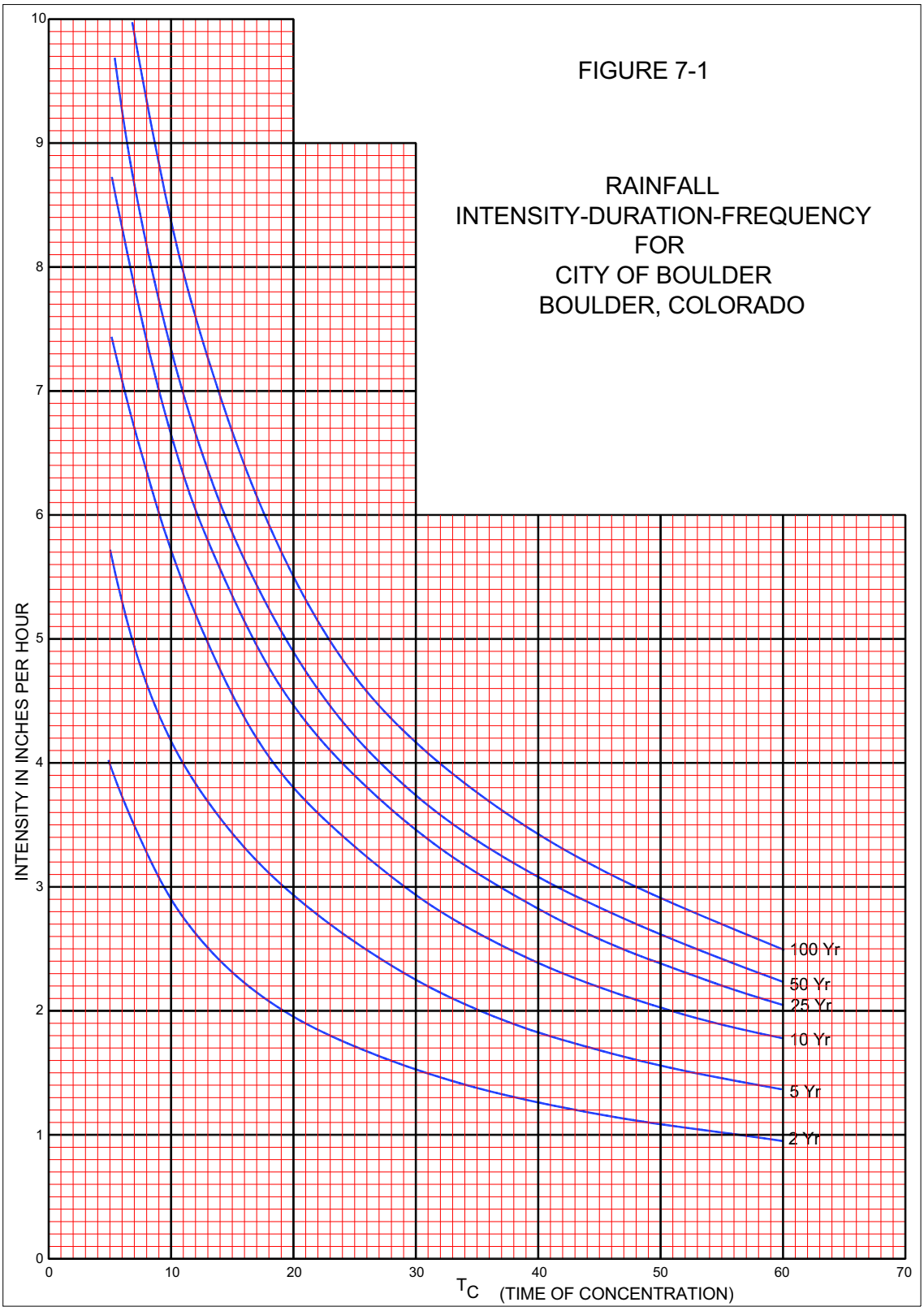


FIGURE 7-1
RAINFALL
INTENSITY-DURATION-FREQUENCY
FOR
CITY OF BOULDER
BOULDER, COLORADO
INTENSITY IN INCHES PER HOUR
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
70
TC (TIME OF CONCENTRATION)
100 Yr
50 Yr
25 Yr
10 Yr
5 Yr
2 Yr

Table 7-2: Runoff Coefficients for the Rational Method

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	STORM FREQUENCY			
		2-Yr	5-Yr	10-Yr	100-Yr
Business:					
Commercial Areas	95	0.87	0.88	0.90	0.93
Neighborhood Areas	65	0.60	0.65	0.70	0.80
Residential:					
Single-Family	40	0.40	0.45	0.50	0.70
Multi-Unit (detached)	50	0.50	0.55	0.60	0.75
Multi-Unit (attached)	70	0.65	0.70	0.70	0.80
½ Acre Lot	30	0.30	0.40	0.45	0.65
Apartments	70	0.65	0.70	0.70	0.80
Industrial:					
Light Areas	80	0.75	0.80	0.80	0.85
Heavy Areas	90	0.80	0.80	0.85	0.90
Parks, Cemeteries:	7	0.15	0.25	0.35	0.60
Playgrounds:	13	0.20	0.30	0.40	0.70
Schools:	50	0.50	0.55	0.60	0.75
Railroad Yard Areas:	40	0.40	0.45	0.50	0.70
Undeveloped Areas:					
Historic Flow Analysis	2	0.10	0.20	0.30	0.60
Greenbelts, Agricultural	-	-	-	-	-
Offsite Flow Analysis (when offsite land use is not defined)	45	0.45	0.50	0.55	0.72
Streets:					
Paved	100	0.87	0.88	0.90	0.93
Gravel	7	0.15	0.25	0.35	0.65
Drives and Walks:	96	0.85	.087	0.90	0.92
Roofs:	90	0.80	0.85	0.90	0.90
Lawns:					
Sandy Soil	0	0.00	0.10	0.20	0.50
Clayey Soil	0	0.10	0.20	0.30	0.60

NOTE: These rational formula coefficients do not apply for larger basins where the time-of-concentration exceeds 60 minutes.

(Source: Urban Drainage and Flood Control District)

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Job Name: Violet & Broadway
Job Number: 1508.5c
Date: 10/8/15
By: AMF

	I%	C2	C5	C10	C100
Streets Paved	100%	0.87	0.88	0.90	0.93
Concrete Drives/Walks	96%	0.85	0.87	0.90	0.92
Roof	90%	0.80	0.85	0.90	0.90
Gravel	7%	0.15	0.25	0.35	0.65
Landscaping (B soil)	0%	0.00	0.10	0.20	0.50
Landscaping (C/D soil)	0%	0.10	0.20	0.30	0.60
Playground	13%	0.20	0.30	0.40	0.70
Artificial Turf	25%	0.28	0.38	0.43	0.62

Violet & Broadway

Historic Runoff Coefficient & Time of Concentration Calculations

Location: Boulder
Minor Design Storm: 5
Major Design Storm: 100
Soil Type: C/D

Basin Design Data

	I (%) =	100%	96%	90%	7%	13%	25%	0%	0%			I (%)	Runoff Coeff's				Initial Overland Time (t_i)			Travel Time (t_t) x 60)		t_t=Length/(Velocity				t_c Comp	tc Urbanized Check ON		t_c Final
Basin Name	Design Point	A_{paved} streets (sf)	$A_{drives/conc}$ (sf)	A_{roof} (sf)	A_{gravel} (sf)	A_{plygnd} (sf)	$A_{art.\ turf}$ (sf)	$A_{lscape\ (B\ soil)}$ (sf)	$A_{lscape\ (C/D\ soil)}$ (sf)	A_{Total} (sf)	A_{Total} (ac)	Imp (%)	C2	C5	C10	C100	Upper most Length (ft)	Slope (%)	t_i (min)	Length (ft)	Slope (%)	Type of Land Surface	C_v	Velocity (fps)	t_t (min)	Time of Conc $t_i + t_t = t_c$	Total Length (ft)	t_c=(L/180)+ 10 (min.)	Min t_c
H1	1	1,110	0	4,490	10,750	0	0	0	17,950	34,300	0.79	17.2%	0.23	0.32	0.41	0.67	235	2.8%	15.2	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	15.2	235	11.3	11.3
H2	2	46,910	0	10,734	0	0	0	0	16,956	74,600	1.71	75.8%	0.68	0.72	0.76	0.85	300	1.6%	10.1	195	1.6%	Paved areas & shallow paved swales	20	2.5	1.3	11.4	495	12.8	11.4
OS1	3	0	0	80,672	47,309	0	0	0	148,843	276,824	6.36	27.4%	0.31	0.40	0.48	0.70	300	2.8%	15.5	700	2.8%	Paved areas & shallow paved swales	20	3.3	3.5	19.0	1000	15.6	15.6
OS2	4	0	15,843	12,024	0	0	0	0	2,098	29,965	0.69	86.9%	0.78	0.82	0.86	0.89	0	0.0%	0.0	220	2.7%	Paved areas & shallow paved swales	20	3.3	1.1	1.1	220	11.2	5.0
ONSITE TOTAL		48,020	0	15,224	10,750	0	0	0	34,906	108,900	2.50	57.4%	0.54	0.60	0.65	0.79													
OFFSITE TOTAL		0	15,843	92,696	47,309	0	0	0	150,941	306,789	7.04	33.2%	0.36	0.44	0.52	0.71													

			Runoff Coeff's				Rainfall Intensities (in/hr)				Area		Flow Rates (cfs)			
Basin Name	Design Point	Time of Conc (tc)	C2	C5	C10	C100	2	5	10	100	A_{Total} (sf)	A_{Total} (ac)	Q2	Q5	Q10	Q100
H1	1	11.3	0.23	0.32	0.41	0.67	2.74	3.96	5.38	7.90	34,300	0.79	0.50	1.01	1.75	4.14
H2	2	11.4	0.68	0.72	0.76	0.85	2.73	3.94	5.35	7.86	74,600	1.71	3.20	4.87	7.00	11.45
OS1	3	15.6	0.31	0.40	0.48	0.70	2.26	3.35	4.46	6.51	276,824	6.36	4.48	8.46	13.70	28.81
OS2	4	5.0	0.78	0.82	0.86	0.89	4.00	5.70	7.45	10.00	29,965	0.69	2.14	3.20	4.40	6.12
										ONSITE TOTAL	108,900	2.50	3.70	5.87	8.75	15.59
										OFFSITE TOTAL	306,789	7.04	6.62	11.66	18.10	34.93

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	I%	C2	C5	C10	C100
Streets Paved	100%	0.87	0.88	0.90	0.93
Concrete Drives/Walks	96%	0.85	0.87	0.90	0.92
Roof	90%	0.80	0.85	0.90	0.90
Gravel	7%	0.15	0.25	0.35	0.65
Landscaping (B soil)	0%	0.00	0.10	0.20	0.50
Landscaping (C/D soil)	0%	0.10	0.20	0.30	0.60
Playground	13%	0.20	0.30	0.40	0.70
Artificial Turf	25%	0.28	0.38	0.43	0.62

Violet & Broadway

Composite Runoff Coefficient Calculations

Location: Boulder
Minor Design Storm: 5
Major Design Storm: 100
Soil Type: C/D

Basin Design Data

	I (%) =	100%	96%	90%	7%	13%	40%	0%	0%			I (%)	Runoff Coeff's			
Basin Name	Design Point	A_{paved} streets (sf)	$A_{drives/conc}$ (sf)	A_{roof} (sf)	A_{gravel} (sf)	A_{plygnd} (sf)	A_{pavers} (sf)	A_{lscape} (B soil) (sf)	A_{lscape} (C/D soil) (sf)	A_{Total} (sf)	A_{Total} (ac)	Imp (%)	C2	C5	C10	C100
A1	1	0	8,934	24,144	0	0	545	0	1,683	35,306	0.81	86.5%	0.77	0.82	0.86	0.89
A2	2	0	124	3,230	0	0	2,041	0	237	5,632	0.13	68.2%	0.58	0.65	0.70	0.79
A3	3	0	1,702	1,540	0	0	3,318	0	519	7,079	0.16	61.4%	0.52	0.59	0.64	0.75
A4	4	0	262	0	0	0	0	0	0	262	0.01	96.0%	0.85	0.87	0.90	0.92
A5	5	0	5,666	0	0	0	5,658	0	2,101	13,425	0.31	57.4%	0.49	0.56	0.61	0.74
A6	6	0	1,995	0	0	0	613	0	319	2,927	0.07	73.8%	0.65	0.69	0.74	0.82
A7	7	0	1,552	0	0	0	0	0	0	1,552	0.04	96.0%	0.85	0.87	0.90	0.92
A8	8	0	1,626	0	0	0	0	0	312	1,938	0.04	80.5%	0.73	0.76	0.80	0.87
A9	9	0	2,361	0	0	0	0	0	987	3,348	0.08	67.7%	0.63	0.67	0.72	0.83
A10	10	0	1,098	0	0	0	0	0	183	1,281	0.03	82.3%	0.74	0.77	0.81	0.87
A11	11	0	0	0	0	0	0	0	5,890	5,890	0.14	0.0%	0.10	0.20	0.30	0.60
R1	12	0	0	3,085	0	0	0	0	0	3,085	0.07	90.0%	0.80	0.85	0.90	0.90
R2	13	0	0	3,668	0	0	0	0	0	3,668	0.08	90.0%	0.80	0.85	0.90	0.90
R3	14	0	0	4,723	0	0	0	0	0	4,723	0.11	90.0%	0.80	0.85	0.90	0.90
O1	15	0	0	0	0	0	0	0	3,817	3,817	0.09	0.0%	0.10	0.20	0.30	0.60
O2	16	0	5,191	0	0	0	17	0	5,953	11,161	0.26	44.7%	0.45	0.51	0.58	0.75
O3	17	0	2,231	0	0	0	0	0	77	2,308	0.05	92.8%	0.82	0.85	0.88	0.91
OS1	18	0	0	80,672	47,309	0	0	0	148,843	276,824	6.36	27.4%	0.31	0.40	0.48	0.70
OS2	19	0	15,843	12,024	0	0	0	0	2,098	29,965	0.69	86.9%	0.78	0.82	0.86	0.89

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By: AMF

Violet & Broadway

Time of Concentration Calculations

Location:	Boulder
Minor Design Storm:	5
Major Design Storm:	100
Soil Type:	C/D

Sub-Basin Data				Initial Overland Time (t_i)			Travel Time (t_t) t_t=Length/(Velocity x 60)						t_c Comp	tc Urbanized Check ON		t_c Final
Basin Name	Design Point	A_{Total} (ac)	C5	Upper most Length (ft)	Slope (%)	t_i (min)	Length (ft)	Slope (%)	Type of Land Surface	C_v	Velocity (fps)	t_t (min)	Time of Conc $t_i + t_t = t_c$	Total Length (ft)	t_c=(L/180)+ 10 (min)	Min t_c
A1	1	0.81	0.82	60	1.7%	3.3	62	1.9%	Paved areas & shallow paved swales	20	2.8	0.4	3.7	122	10.7	5.0
A2	2	0.13	0.65	26	2.0%	3.3	58	1.8%	Paved areas & shallow paved swales	20	2.7	0.4	3.6	84	10.5	5.0
A3	3	0.16	0.59	34	1.7%	4.5	58	1.5%	Paved areas & shallow paved swales	20	2.4	0.4	4.9	92	10.5	5.0
A4	4	0.01	0.87	28	2.1%	1.7	17	1.0%	Paved areas & shallow paved swales	20	2.0	0.1	1.9	45	10.3	5.0
A5	5	0.31	0.56	97	2.4%	7.2	61	0.8%	Paved areas & shallow paved swales	20	1.8	0.6	7.7	158	10.9	7.7
A6	6	0.07	0.69	73	2.5%	4.6	44	1.2%	Paved areas & shallow paved swales	20	2.2	0.3	4.9	117	10.7	5.0
A7	7	0.04	0.87	35	1.3%	2.2	8	1.5%	Paved areas & shallow paved swales	20	2.4	0.1	2.3	43	10.2	5.0
A8	8	0.04	0.76	36	2.8%	2.6	27	1.7%	Paved areas & shallow paved swales	20	2.6	0.2	2.8	63	10.4	5.0
A9	9	0.08	0.67	12	2.0%	2.1	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	2.1	12	10.1	5.0
A10	10	0.03	0.77	13	5.0%	1.2	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	1.2	13	10.1	5.0
A11	11	0.14	0.20	23	16.0%	3.1	274	1.2%	Grassed waterway	15	1.6	2.8	5.9	297	11.7	5.9
R1	12	0.07	0.85	48	3.0%	2.2	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	2.2	48	10.3	5.0
R2	13	0.08	0.85	34	2.0%	2.1	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	2.1	34	10.2	5.0
R3	14	0.11	0.85	40	2.0%	2.3	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	2.3	40	10.2	5.0
O1	15	0.09	0.20	15	16.0%	2.5	274	1.3%	Grassed waterway	15	1.7	2.7	5.2	289	11.6	5.2
O2	16	0.26	0.51	86	5.5%	5.6	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	5.6	86	10.5	5.6
O3	17	0.05	0.85	50	2.7%	2.3	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	2.3	50	10.3	5.0
OS1	18	6.36	0.40	300	2.8%	15.5	700	2.8%	Paved areas & shallow paved swales	20	3.3	3.5	19.0	1000	15.6	15.6
OS2	19	0.69	0.82	0	0.0%	0.0	220	2.7%	Paved areas & shallow paved swales	20	3.3	1.1	1.1	220	11.2	5.0

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By: AMF

Violet & Broadway

Developed Storm Runoff Calculations

Design Storm : **100 Year**

Point Hour Rainfall (P_1) : **2.50**

	Direct Runoff							Total Runoff				Inlets				Pipe					Pipe/Swale Travel Time				
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Q bypass	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)	Notes
A1	1	0.81	0.89	5.00	0.72	10.00	7.18																		
A11	11	0.14	0.60	5.90	0.08	10.00	0.81																		
					total surface flow (A1, A11)			5.90	0.80	10.00	8.00	1 Type C	8.00	0.00	0.00	15 in	RCP	0.6%	8.0	5.4	50	4.0	0.21	6.11	
					total pipe flow (A1, A11)			5.90	0.80	10.00	8.00	Pipe Capacity	5.37	2.62	0.00	15 in	RCP	0.6%	5.4	5.4	50	4.0	0.21	6.11	CO to A6
A5	5	0.31	0.74	7.70	0.23	9.58	2.20																		
					total surface flow (A1, A5, A11			7.70	1.03	9.58	9.86	1 Dbl Type 16	9.86	0.00	0.00	18 in	RCP	0.6%	9.9	8.7	51	4.0	0.21	7.91	
					total pipe flow (A1, A5, A11)			7.70	1.03	9.58	9.86	Pipe Capacity	8.74	1.12	0.00	18 in	RCP	0.6%	9.9	8.7	51	4.0	0.21	7.91	CO to A6
OS1	18	6.36	0.70	15.60	4.42	6.51	28.81																		
O1	15	0.09	0.60	5.20	0.05	10.00	0.53																		
A4	4	0.01	0.92	5.00	0.01	10.00	0.06																		
					total surface flow (OS1, O1, A4)			15.60	4.48	6.51	29.19	1 Type D inlet	29.19	0.00	0.00	24 in	PVC	0.9%	29.2	29.1	23	4.0	0.10	15.70	
A2	2	0.13	0.79	5.00	0.10	10.00	1.02	5.00	0.10	10.00	1.02	1 Type 13 inlet	1.02	0.00	0.00	15 in	RCP	1.0%	1.0	6.9	30	4.0	0.13	5.13	
					total pipe flow (OS1, O1, A4, A2)			15.70	4.58	6.51	29.85	Pipe Capacity				30 in	RCP	0.5%	29.9	31.1	60	4.0	0.25	15.95	
A3	3	0.16	0.75	5.00	0.12	10.00	1.22	5.00	0.12	10.00	1.22	1 Type 13 Inlet	1.22	0.00	0.00	15 in	RCP	1.0%	1.2	6.9	29	4.0	0.12	5.12	
					total pipe flow (A1, A5, A11, O1, OS1, A2, A4, A3)			15.70	5.73	6.51	37.35	Pipe Capacity	37.35	0.00	0.00	30 in	RCP	0.5%	37.4	31.1	90	4.0	0.38	16.07	
A8	8	0.04	0.87	5.00	0.04	10.00	0.39					1 5' Type R	0.39	0.00	0.00										
					total pipe flow (A1, A5, A11, O1, OS1, A4, A2, A3, A8)			16.07	5.77	6.42	37.08	Pipe Capacity				30 in	RCP	0.5%	37.1	31.1	33	4.0	0.14	16.21	
OS2	19	0.69	0.89	5.00	0.61	10.00	6.12	5.00	0.61	10.00	6.12	1 Type 13 Inlet	6.12	0.00	0.00	18 in	RCP	2.0%	6.1	16.0	30	4.0	0.13	5.13	
A6	6	0.07	0.82	5.00	0.06	10.00	0.55	5.00	0.06	10.00	0.55	1 Type 16 Inlet	0.55	0.00	0.00	15 in	RCP	2.0%	0.6	9.8	26	4.0	0.11	5.11	
A7	7	0.04	0.92	5.00	0.03	10.00	0.33	5.00	0.03	10.00	0.33	2 18" Area Drains	0.33	0.00	0.00	10 in	PVC	2.0%	0.3	4.3	48	4.0	0.20	5.20	
R1	12	0.07	0.90	5.00	0.06	10.00	0.64	5.00	0.06	10.00	0.64														
A10	10	0.03	0.87	5.00	0.03	10.00	0.26	5.00	0.09	10.00	0.89														
R2	13	0.08	0.90	5.00	0.08	10.00	0.76	5.00	0.08	10.00	0.76														
R3	14	0.11	0.90	5.00	0.10	10.00	0.98	5.00	0.10	10.00	0.98														
A9	9	0.08	0.83	5.00	0.06	10.00	0.63	5.00	0.24	10.00	2.37														

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Violet & Broadway

Developed Storm Runoff Calculations

Design Storm : **100 Year**

Point Hour Rainfall (P_1) : **2.50**

	Direct Runoff							Total Runoff				Inlets				Pipe					Pipe/Swale Travel Time				
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Q bypass	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)	Notes
O2	16	0.26	0.75	5.60	0.19	10.00	1.92	5.60	0.19	10.00	1.92														
O3	17	0.05	0.91	5.00	0.05	10.00	0.48	5.00	0.05	10.00	0.48														
					TOTAL FLOW SITE			16.21	2.00	6.38	12.78														

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Date: 10/9/15
By: AMF

Violet & Broadway

Developed Storm Runoff Calculations

Design Storm : **10 Year**

Point Hour Rainfall (P_1) : **1.80**

	Direct Runoff							Total Runoff				Inlets				Pipe					Pipe/Swale Travel Time				
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Q bypass	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)	Notes
A1	1	0.81	0.86	5.00	0.70	7.45	5.22																		
A11	11	0.14	0.30	5.90	0.04	7.14	0.29																		
					total surface flow (A1, A11)			5.90	0.74	7.14	5.29	1 Type C	5.29	0.00	0.00	15 in	RCP	0.6%	5.3	5.4	50	2.0	0.42	6.32	
					total pipe flow (A1, A11)			5.90	0.74	7.14	5.29	Pipe Capacity	5.29	0.00	0.00	15 in	RCP	0.6%	5.3	5.4	50	2.0	0.42	6.32	
A5	5	0.31	0.61	7.70	0.19	6.46	1.21																		
					total surface flow (A1, A5, A11			7.70	0.93	6.46	5.99	1 Dbl Type 16	5.99	0.00	0.00	18 in	RCP	0.6%	6.0	8.7	51	2.0	0.43	8.13	
					total pipe flow (A1, A5, A11)			7.70	0.93	6.46	5.99	Pipe Capacity	5.99	0.00	0.00	18 in	RCP	0.6%	6.0	8.7	51	2.0	0.43	8.13	
OS1	18	6.36	0.48	15.60	3.07	4.46	13.70																		
O1	15	0.09	0.30	5.20	0.03	7.38	0.19																		
A4	4	0.01	0.90	5.00	0.01	7.45	0.04																		
					total surface flow (OS1, O1, A4)			15.60	3.10	4.46	13.84	1 Type D inlet	13.84	0.00	0.00	24 in	PVC	0.9%	13.8	29.1	23	2.0	0.19	15.79	
A2	2	0.13	0.70	5.00	0.09	7.45	0.68	5.00	0.09	7.45	0.68	1 Type 13 inlet	0.68	0.00	0.00	15 in	RCP	1.0%	0.7	6.9	30	2.0	0.25	5.25	
					total pipe flow (OS1, O1, A4, A2)			15.79	3.19	4.45	14.20	Pipe Capacity				30 in	RCP	0.5%	14.2	31.1	60	2.0	0.50	16.29	
A3	3	0.16	0.64	5.00	0.10	7.45	0.77	5.00	0.10	7.45	0.77	1 Type 13 Inlet	0.77	0.00	0.00	15 in	RCP	1.0%	0.8	6.9	29	2.0	0.24	5.24	
					total pipe flow (A1, A5, A11, O1, OS1, A2, A4, A3)			15.79	4.23	4.45	18.79	Pipe Capacity	18.79	0.00	0.00	30 in	RCP	0.5%	18.8	31.1	90	2.0	0.75	16.54	
A8	8	0.04	0.80	5.00	0.04	7.45	0.27					1 5' Type R													
					total pipe flow (A1, A5, A11, O1, OS1, A4, A2, A3, A8)			16.54	4.26	4.33	18.43	Pipe Capacity				30 in	RCP	0.5%	18.4	31.1	33	2.0	0.28	16.82	
OS2	19	0.69	0.86	5.00	0.59	7.45	4.40	5.00	0.59	7.45	4.40	1 Type 13 Inlet	4.40	0.00	0.00	18 in	RCP	2.0%	4.4	16.0	30	2.0	0.25	5.25	
A6	6	0.07	0.74	5.00	0.05	7.45	0.37	5.00	0.05	7.45	0.37	1 Type 16 Inlet	0.37	0.00	0.00	15 in	RCP	2.0%	0.4	9.8	26	2.0	0.22	5.22	
A7	7	0.04	0.90	5.00	0.03	7.45	0.24	5.00	0.03	7.45	0.24	2 18" Area Drains	0.24	0.00	0.00	10 in	PVC	2.0%	0.2	4.3	48	2.0	0.40	5.40	
R1	12	0.07	0.90	5.00	0.06	7.45	0.47	5.00	0.06	7.45	0.47														
A10	10	0.03	0.81	5.00	0.02	7.45	0.18	5.00	0.09	7.45	0.65														
R2	13	0.08	0.90	5.00	0.08	7.45	0.56	5.00	0.08	7.45	0.56														
R3	14	0.11	0.90	5.00	0.10	7.45	0.73	5.00	0.10	7.45	0.73														
A9	9	0.08	0.72	5.00	0.06	7.45	0.41	5.00	0.23	7.45	1.71														

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Job Name: Violet & Broadway
Job Number: 1508.5c
Date: 10/9/15
By: AMF

Violet & Broadway

Developed Storm Runoff Calculations

Design Storm : **10 Year**

Point Hour Rainfall (P_1) : **1.80**

	Direct Runoff							Total Runoff				Inlets				Pipe					Pipe/Swale Travel Time				
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Q bypass	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)	Notes
O2	16	0.26	0.58	5.60	0.15	7.24	1.07	5.60	0.15	7.24	1.07														
O3	17	0.05	0.88	5.00	0.05	7.45	0.35	5.00	0.05	7.45	0.35														
					TOTAL FLOW SITE			16.82	1.78	4.28	7.63														

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Developed Storm Runoff Calculations

Design Storm : **5 Year**

Point Hour Rainfall (P_1) : **1.35**

	Direct Runoff							Total Runoff				Inlets				Pipe					Pipe/Swale Travel Time				
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Q bypass	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)	Notes
A1	1	0.81	0.82	5.00	0.66	5.70	3.77																		
A11	11	0.14	0.20	5.90	0.03	5.34	0.14																		
					total surface flow (A1, A11)			5.90	0.69	5.34	3.68	1 Type C	3.68	0.00	0.00	15 in	RCP	0.6%	3.7	5.4	50	1.0	0.83	6.73	
					total pipe flow (A1, A11)			5.90	0.69	5.34	3.68	Pipe Capacity	3.68	0.00	0.00	15 in	RCP	0.6%	3.7	5.4	50	1.0	0.83	6.73	
A5	5	0.31	0.56	7.70	0.17	4.74	0.82																		
					total surface flow (A1, A5, A11			7.70	0.86	4.74	4.08	1 Dbl Type 16	4.08	0.00	0.00	18 in	RCP	0.6%	4.1	8.7	51	1.0	0.85	8.55	
					total pipe flow (A1, A5, A11)			7.70	0.86	4.74	4.08	Pipe Capacity	4.08	0.00	0.00	18 in	RCP	0.6%	4.1	8.7	51	1.0	0.85	8.55	
OS1	18	6.36	0.40	15.60	2.53	3.35	8.46																		
O1	15	0.09	0.20	5.20	0.02	5.62	0.10																		
A4	4	0.01	0.87	5.00	0.01	5.70	0.03																		
					total surface flow (OS1, O1, A4)			15.60	2.55	3.35	8.54	1 Type D inlet	8.54	0.00	0.00	24 in	PVC	0.9%	8.5	29.1	23	1.0	0.38	15.98	
A2	2	0.13	0.65	5.00	0.08	5.70	0.48	5.00	0.08	5.70	0.48	1 Type 13 inlet	0.48	0.00	0.00	15 in	RCP	1.0%	0.5	6.9	30	1.0	0.50	5.50	
					total pipe flow (OS1, O1, A4, A2)			15.98	2.64	3.32	8.75	Pipe Capacity				30 in	RCP	0.5%	8.7	31.1	60	1.0	1.00	16.98	
A3	3	0.16	0.59	5.00	0.10	5.70	0.54	5.00	0.10	5.70	0.54	1 Type 13 Inlet	0.54	0.00	0.00	15 in	RCP	1.0%	0.5	6.9	29	1.0	0.48	5.48	
					total pipe flow (A1, A5, A11, O1, OS1, A2, A4, A3)			15.98	3.59	3.32	11.92	Pipe Capacity	11.92	0.00	0.00	30 in	RCP	0.5%	11.9	31.1	90	1.0	1.50	17.48	
A8	8	0.04	0.76	5.00	0.03	5.70	0.19					1 5' Type R													
					total pipe flow (A1, A5, A11, O1, OS1, A4, A2, A3, A8)			17.48	3.63	3.18	11.55	Pipe Capacity				30 in	RCP	0.5%	11.5	31.1	33	1.0	0.55	18.03	
OS2	19	0.69	0.82	5.00	0.56	5.70	3.20	5.00	0.56	5.70	3.20	1 Type 13 Inlet	3.20	0.00	0.00	18 in	RCP	2.0%	3.2	16.0	30	1.0	0.50	5.50	
A6	6	0.07	0.69	5.00	0.05	5.70	0.27	5.00	0.05	5.70	0.27	1 Type 16 Inlet	0.27	0.00	0.00	15 in	RCP	2.0%	0.3	9.8	26	1.0	0.43	5.43	
A7	7	0.04	0.87	5.00	0.03	5.70	0.18	5.00	0.03	5.70	0.18	2 18" Area Drains	0.18	0.00	0.00	10 in	PVC	2.0%	0.2	4.3	48	1.0	0.80	5.80	
R1	12	0.07	0.85	5.00	0.06	5.70	0.34	5.00	0.06	5.70	0.34														
A10	10	0.03	0.77	5.00	0.02	5.70	0.13	5.00	0.08	5.70	0.47														
R2	13	0.08	0.85	5.00	0.07	5.70	0.41	5.00	0.07	5.70	0.41														
R3	14	0.11	0.85	5.00	0.09	5.70	0.53	5.00	0.09	5.70	0.53														
A9	9	0.08	0.67	5.00	0.05	5.70	0.29	5.00	0.22	5.70	1.23														

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Developed Storm Runoff Calculations

Design Storm : **5 Year**

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	Direct Runoff							Total Runoff				Inlets				Pipe					Pipe/Swale Travel Time				
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Q bypass	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)	Notes
O2	16	0.26	0.51	5.60	0.13	5.46	0.72	5.60	0.13	5.46	0.72														
O3	17	0.05	0.85	5.00	0.04	5.70	0.26	5.00	0.04	5.70	0.26														
					TOTAL FLOW SITE			18.03	1.65	3.13	5.16														

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POND VOLUME CALCULATIONS - STAGE / STORAGE

Pond Volume = **Prismoidal Formula**
Volume Equation = (A1+A2+SQRT(A1*A2)*D/3

Stage / Storage Input Table

ELEVATION ft	DEPTH (D) ft	AREA (A1) ft^2	WEIGHTED AVG AREA (A2) ft^2	INCREMENTAL VOLUME ft^3	CUMMULATIVE VOLUME ft^3
5521.5		0			0
5522.0	0.6	69	34	13	13
5523.0	1.0	546	307	269	282
5524.0	1.0	1,552	1,049	1,006	1,288
5525.0	1.0	3,098	2,325	2,281	3,569

Top of Pond

5525.0	3.6	**TOTAL VOLUME**	**3,569 cf**	0.082 ac-ft

Volume Summary Table

	Required Volume (ft^3)	Required Volume (ac-ft)	Water Surface Elevation	Water Depth
WQCV	1,525 cf	0.035 ac-ft	**5524.10 ft**	2.65 ft
V10 + 100% WQCV	1,525 cf	0.035 ac-ft	**5524.10 ft**	2.65 ft
V100 + 50% WQCV	1,525 cf	0.035 ac-ft	**5524.10 ft**	2.65 ft

Volume Interpolation Calculations

WQCV		**V10 + 100% WQCV**		**V100 + 50% WQCV**	
Vol	Elev	Vol	Elev	Vol	Elev
1288.43	5524.00	1288.43	5524.00	1288.43	5524.00
1525.00	5524.10	1525.00	5524.10	1525.00	5524.10
3569.28	5525.00	3569.28	5525.00	3569.28	5525.00

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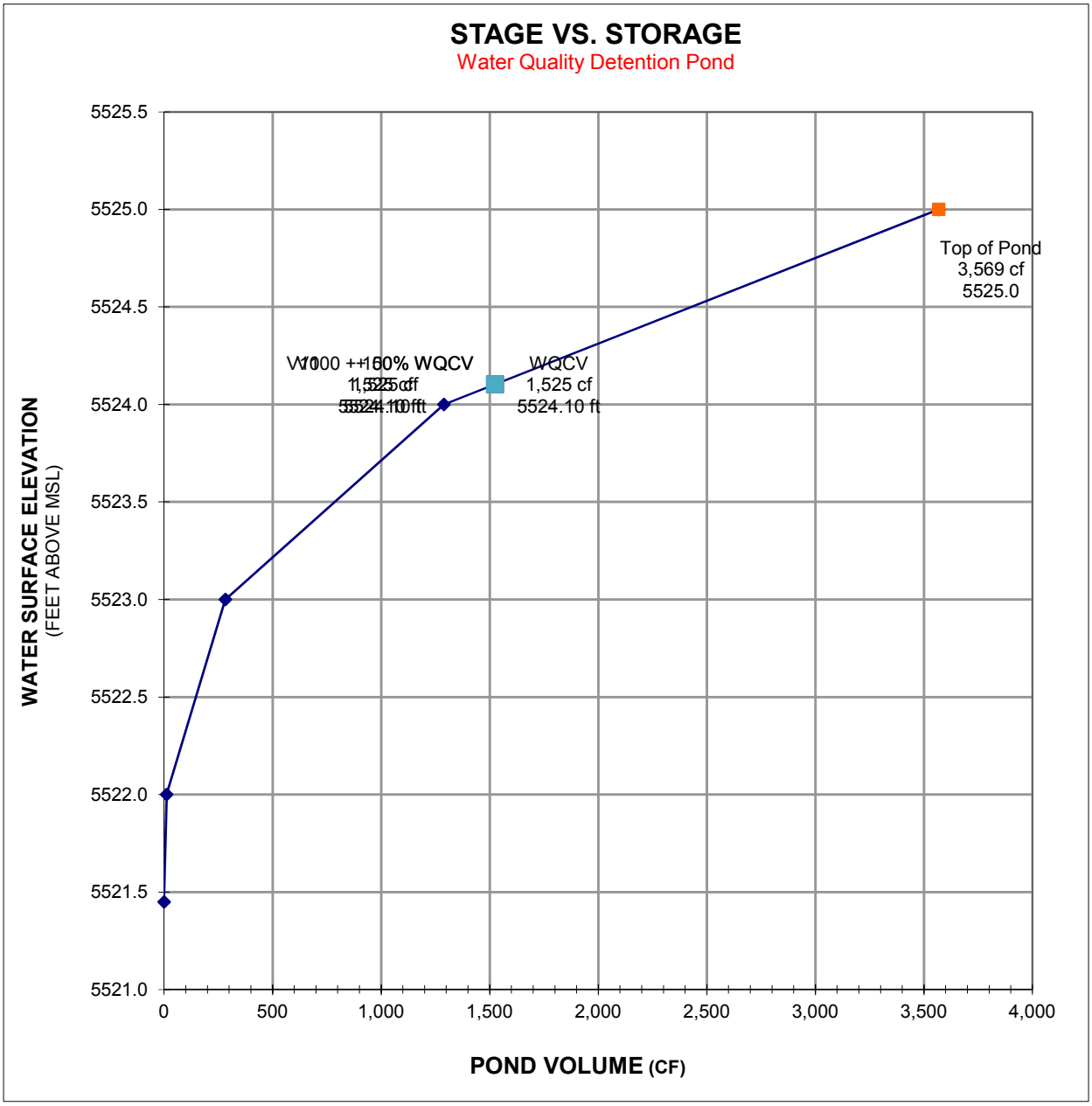

Design Procedure Form: Extended Detention Basin (EDB)

Designer:	**D. Breedlove**
Company:	**JVA, Inc**
Date:	**October 8, 2015**
Project:	**Violet & Broadway**
Location:	**Basin A1**

1. Basin Storage Volume	
A) Effective Imperviousness of Tributary Area, I_a	I_a = 86.5 %
B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$)	i = 0.865
C) Contributing Watershed Area	Area = 0.950 ac
D) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm	d_6 = ____ in
E) Design Concept (Select EURV when also designing for flood control)	Choose One: (●) Water Quality Capture Volume (WQCV) ( ) Excess Urban Runoff Volume (EURV)
F) Design Volume (1.2 WQCV) Based on 40-hour Drain Time ($V_{DESIGN} = (1.0 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i) / 12 * Area * 1.2)$)	V_{DESIGN}= 0.035 ac-ft
G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume ($V_{WQCV\ OTHER} = (d_6*(V_{DESIGN}/0.43))$)	$V_{DESIGN\ OTHER}$= ____ ac-ft
H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired)	$V_{DESIGN\ USER}$= 0.035 ac-ft
I) Predominant Watershed NRCS Soil Group	Choose One: ( ) A ( ) B ( ) C / D
J) Excess Urban Runoff Volume (EURV) Design Volume For HSG A: EURVA = (0.1878i - 0.0104)*Area For HSG B: $EURV_B$ = (0.1178i - 0.0042)*Area For HSG C/D: $EURV_{C/D}$ = (0.1043i - 0.0031)*Area	EURV = ____ ac-f t
2. Basin Shape: Length to Width Ratio (A basin length to width ratio of at least 2:1 will improve TSS reduction.)	L : W = 4.0 : 1
3. Basin Side Slopes	
A) Basin Maximum Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred)	Z = 3.00 ft / ft **DIFFICULT TO MAINTAIN, INCREASE WHERE POSSIBLE**
4. Inlet	
A) Describe means of providing energy dissipation at concentrated inflow locations:	

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FLOW CALCULATIONS - GRATE INLET SUMP CONDITION

(Reference: Urban Drainage and Flood Control District Drainage Criteria Manual, 2001, V.1, Section 3.3.6)
(Note: Spreadsheet assumes orifice condition for fully developed flow.)

INLET TYPE: Type 13 Inlet - Standard **BASIN:** A2

Orifice Equation: Q = Cd*Ao*(2gH)^0.5

Adjust Ao (open area) due to clogging as follows:

Effective Area Opening Ae = (1-C) Ao, where:
C = K * Co / N
N = Number of Inlets
Co = Single Inlet Clogging Factor:
Co(grate) = 0.5 (50% clogging)

K = Clogging Coefficent value for multiple inlets

N	Grate
1	1
2	1.5
3	1.75
4	1.88
5	1.94
6	1.97
7	1.98
8	1.99

Number of inlets: **N = 1**

Inlet Dimensions and Effective Open Area:

Grate Opening:

Ao(g) = 2.32 ft^2
Total Ao(g) = 2.32 ft^2
K = 1.00
C = K*Co/N = 0.50
Ae(g) = (1-C)Ao = 1.16 ft^2

Allowable depth: **H =** 12.0 in = **1 ft**

Constants: g = 32.20 ft/s^2
Cd = 0.67

Flow Calculations:

Grate Flow: Q = Cd * Ae(g) * (2g*H)^0.5
Qg= 6.24 CFS

Total Intercepted Flow with 1 inlet(s) and
an allowable depth of 12 inches is 6.2 cfs

Required Flow (Q 5) = 0.48 cfs **Bypass = 0.0 cfs**
Required Flow (Q 100) = 1.02 cfs **Bypass = 0.0 cfs**

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FLOW CALCULATIONS - GRATE INLET SUMP CONDITION

(Reference: Urban Drainage and Flood Control District Drainage Criteria Manual, 2001, V.1, Section 3.3.6)
(Note: Spreadsheet assumes orifice condition for fully developed flow.)

INLET TYPE: Type 13 Inlet - Standard **BASIN:** A3

Orifice Equation: Q = Cd*Ao*(2gH)^0.5

Adjust Ao (open area) due to clogging as follows:

Effective Area Opening Ae = (1-C) Ao, where:
C = K * Co / N
N = Number of Inlets
Co = Single Inlet Clogging Factor:
Co(grate) = 0.5 (50% clogging)

K = Clogging Coefficent value for multiple inlets

N	Grate
1	1
2	1.5
3	1.75
4	1.88
5	1.94
6	1.97
7	1.98
8	1.99

Number of inlets: **N = 1**

Inlet Dimensions and Effective Open Area:

Grate Opening:

Ao(g) = 2.32 ft^2
Total Ao(g) = 2.32 ft^2
K = 1.00
C = K*Co/N = 0.50
Ae(g) = (1-C)Ao = 1.16 ft^2

Allowable depth: **H =** 12.0 in = **1 ft**

Constants: g = 32.20 ft/s^2
Cd = 0.67

Flow Calculations:

Grate Flow: Q = Cd * Ae(g) * (2g*H)^0.5
Qg= 6.24 CFS

Total Intercepted Flow with 1 inlet(s) and
an allowable depth of 12 inches is 6.2 cfs

Required Flow (Q 5) = 0.54 cfs **Bypass = 0.0 cfs**
Required Flow (Q 100) = 1.22 cfs **Bypass = 0.0 cfs**

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FLOW CALCULATIONS - COMBINATION INLET SUMP CONDITION

(Reference: Urban Drainage and Flood Control District Drainage Criteria Manual, 2001, V.1, Section 3.3.6)
(Note: Spreadsheet assumes orifice condition for fully developed flow. Vertical curb opening only.)

INLET TYPE: Double Combination Inlet **BASIN:** A5

Orifice Equation: Q = Cd*Ao*(2gH)^0.5

Adjust Ao (open area) due to clogging as follows:

Effective Area Opening Ae = (1-C) Ao, where:
C = K * Co / N
N = Number of Inlets
Co = Single Inlet Clogging Factor:

Co(grate) =	0.5	(50% clogging)
Co(curb opening) =	0.1	(10% clogging)

K = Clogging Coefficent value for multiple inlets

N	Grate	Curb
1	1	1
2	1.5	1.25
3	1.75	1.31
4	1.88	1.33
5	1.94	1.33
6	1.97	1.33
7	1.98	1.33
8	1.99	1.33

Number of inlets: **N = 2**

Inlet Dimensions and Effective Open Area:

Grate Opening:

Ao(g) = 2.32 ft^2 (per inlet)
Total Ao(g) = 4.64 ft^2 (total, all inlets)
K = 1.50
C = K*Co/N = 0.38
Ae(g) = (1-C)Ao = 2.90 ft^2

Curb Opening:

length (l) = 70 in = 5.83 ft (per inlet)
height (h) = 6 in = 0.50 ft
Total Ao(c) = 5.83 ft^2 (total, all inlets)
K = 1.25
C = K*Co/N = 0.06
Ae(c) = (1-C)Ao = 5.47 ft2

Allowable depth: **H = 6.0 in = 0.5 ft**

Constants:
g = 32.20 ft/s^2
Cd = 0.67

Flow Calculations:

Grate Flow: Q = Cd * Ae(g) * (2g*H)^0.5
Qg= 11.03 CFS

Curb Flow: Q = Cd * Ae(c) * (2g*D)^0.5
D = H - h/2 = 0.25
Qc= 14.70 CFS

Total Intercepted Flow with 2 inlets and
an allowable depth of 6 inches is 25.7 cfs

Required Flow (Q 5) = 0.82 cfs **Bypass = 0.0 cfs**
Required Flow (Q 100) = 9.86 cfs **Bypass = 0.0 cfs**

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Job Name: Violet & Broadway
Job Number: 1508.5c
Date: 10/8/15
By: AMF

FLOW CALCULATIONS - COMBINATION INLET SUMP CONDITION

(Reference: Urban Drainage and Flood Control District Drainage Criteria Manual, 2001, V.1, Section 3.3.6)
(Note: Spreadsheet assumes orifice condition for fully developed flow. Vertical curb opening only.)

INLET TYPE: Single Combination Inlet **BASIN:** A6

Orifice Equation: Q = Cd*Ao*(2gH)^0.5

Adjust Ao (open area) due to clogging as follows:

Effective Area Opening Ae = (1-C) Ao, where:
C = K * Co / N
N = Number of Inlets
Co = Single Inlet Clogging Factor:

Co(grate) =	0.5	(50% clogging)
Co(curb opening) =	0.1	(10% clogging)

K = Clogging Coefficent value for multiple inlets

N	Grate	Curb
1	1	1
2	1.5	1.25
3	1.75	1.31
4	1.88	1.33
5	1.94	1.33
6	1.97	1.33
7	1.98	1.33
8	1.99	1.33

Number of inlets: **N = 1**

Inlet Dimensions and Effective Open Area:

Grate Opening:

Ao(g) = 2.32 ft^2 (per inlet)
Total Ao(g) = 2.32 ft^2 (total, all inlets)
K = 1.00
C = K*Co/N = 0.50
Ae(g) = (1-C)Ao = 1.16 ft^2

Curb Opening:

length (l) = 36 in = 3.00 ft (per inlet)
height (h) = 6 in = 0.50 ft
Total Ao(c) = 1.50 ft^2 (total, all inlets)
K = 1.00
C = K*Co/N = 0.10
Ae(c) = (1-C)Ao = 1.35 ft2

Allowable depth: **H = 6.0 in = 0.5 ft**

Constants:
g = 32.20 ft/s^2
Cd = 0.67

Flow Calculations:

Grate Flow: Q = Cd * Ae(g) * (2g*H)^0.5
Qg= 4.41 CFS

Curb Flow: Q = Cd * Ae(c) * (2g*D)^0.5
D = H - h/2 = 0.25
Qc= 3.63 CFS

Total Intercepted Flow with 1 inlets and
an allowable depth of 6 inches is 8.0 cfs

Required Flow (Q 5) = 0.27 cfs **Bypass = 0.0 cfs**
Required Flow (Q 100) = 0.55 cfs **Bypass = 0.0 cfs**

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FLOW CALCULATIONS - GRATE INLET SUMP CONDITION

(Reference: Urban Drainage and Flood Control District Drainage Criteria Manual, 2001, V.1, Section 3.3.6)
(Note: Spreadsheet assumes orifice condition for fully developed flow.)

INLET TYPE: 18" Area Drain **BASIN:** A7

Orifice Equation: Q = Cd*Ao*(2gH)^0.5

Adjust Ao (open area) due to clogging as follows:

Effective Area Opening Ae = (1-C) Ao, where:
C = K * Co / N
N = Number of Inlets
Co = Single Inlet Clogging Factor:
Co(grate) = 0.5 (50% clogging)

K = Clogging Coefficent value for multiple inlets

N	Grate
1	1
2	1.5
3	1.75
4	1.88
5	1.94
6	1.97
7	1.98
8	1.99

Number of inlets: **N = 2**

Inlet Dimensions and Effective Open Area:

Grate Opening:

Ao(g) = 0.61 ft^2
Total Ao(g) = 1.22 ft^2
K = 1.50
C = K*Co/N = 0.38
Ae(g) = (1-C)Ao = 0.76 ft^2

Allowable depth: **H =** 12.0 in = **1 ft**

Constants: g = 32.20 ft/s^2
Cd = 0.67

Flow Calculations:

Grate Flow: Q = Cd * Ae(g) * (2g*H)^0.5
Qg= 4.10 CFS

Total Intercepted Flow with 2 inlet(s) and
an allowable depth of 12 inches is 4.1 cfs

Required Flow (Q 5) = 0.18 cfs **Bypass = 0.0 cfs**
Required Flow (Q 100) = 0.33 cfs **Bypass = 0.0 cfs**

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FLOW CALCULATIONS - CURB INLET SUMP CONDITION

(Reference: Urban Drainage and Flood Control District Drainage Criteria Manual, 2001, V.1, Section 3.3.6)
(Note: Spreadsheet assumes orifice condition for fully developed flow. Vertical curb opening only.)

INLET TYPE: 5' Type R Inlet **BASIN:** A8

Orifice Equation: Q = Cd*Ao*(2gH)^0.5

Adjust Ao (open area) due to clogging as follows:

Effective Area Opening Ae = (1-C) Ao, where:
C = K * Co / N
N = Number of Inlets
Co = Single Inlet Clogging Factor:
Co(curb opening) = 0.1 (10% clogging)

K = Clogging Coefficent value for multiple inlets

N	Curb
1	1
2	1.25
3	1.31
4	1.33
5	1.33
6	1.33
7	1.33
8	1.33

Number of inlets: **N = 1**

Inlet Dimensions and Effective Open Area:

Curb Opening:

length (l) =	60	in =	5.00	ft
height (h) =	6	in =	0.50	ft
Total Ao(c) =	2.50	ft^2		
K =	1.00			
C = K*Co/N =	0.10			
Ae(c) = (1-C)Ao =	**2.25**	**ft2**		

Allowable depth: **H =** 9.0 in = **0.75** **ft**
(6" open plus 3" conc to top of curb/box)

Constants:
g = 32.20 ft/s^2
Cd = 0.67

Flow Calculations:

Curb Flow: Q = Cd * Ae(c) * (2g*D)^0.5
D = H - h/2 = 0.5
Qc= 8.55 CFS

Total Intercepted Flow with 1 inlets and an allowable depth of 9 inches is 8.6 cfs

Required Flow (Q 5) =	**0.19**	**cfs**	**Bypass =**	**0.0**	**cfs**
Required Flow (Q 100) =	**0.39**	**cfs**	**Bypass =**	**0.0**	**cfs**

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FLOW CALCULATIONS - GRATE INLET SUMP CONDITION

(Reference: Urban Drainage and Flood Control District Drainage Criteria Manual, 2001, V.1, Section 3.3.6)
(Note: Spreadsheet assumes orifice condition for fully developed flow.)

INLET TYPE: Type C Inlet - Standard **BASIN:** A11

Orifice Equation: Q = Cd*Ao*(2gH)^0.5

Adjust Ao (open area) due to clogging as follows:

Effective Area Opening Ae = (1-C) Ao, where:
C = K * Co / N
N = Number of Inlets
Co = Single Inlet Clogging Factor:
Co(grate) = 0.5 (50% clogging)

K = Clogging Coefficent value for multiple inlets

N	Grate
1	1
2	1.5
3	1.75
4	1.88
5	1.94
6	1.97
7	1.98
8	1.99

Number of inlets: **N = 1**

Inlet Dimensions and Effective Open Area:

Grate Opening:

Ao(g) = 5.75 ft^2
Total Ao(g) = 5.75 ft^2
K = 1.00
C = K*Co/N = 0.50
Ae(g) = (1-C)Ao = 2.88 ft^2

Allowable depth: **H =** 12.0 in = **1 ft**

Constants: g = 32.20 ft/s^2
Cd = 0.67

Flow Calculations:

Grate Flow: Q = Cd * Ae(g) * (2g*H)^0.5
Qg= 15.46 CFS

Total Intercepted Flow with 1 inlet(s) and
an allowable depth of 12 inches is 15.5 cfs

Required Flow (Q 5) = 0.14 cfs **Bypass = 0.0 cfs**
Required Flow (Q 100) = 8.00 cfs **Bypass = 0.0 cfs**

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FLOW CALCULATIONS - GRATE INLET SUMP CONDITION

(Reference: Urban Drainage and Flood Control District Drainage Criteria Manual, 2001, V.1, Section 3.3.6)
(Note: Spreadsheet assumes orifice condition for fully developed flow.)

INLET TYPE: Type D Inlet **BASIN:** O1

Orifice Equation: Q = Cd*Ao*(2gH)^0.5

Adjust Ao (open area) due to clogging as follows:

Effective Area Opening Ae = (1-C) Ao, where:
C = K * Co / N
N = Number of Inlets
Co = Single Inlet Clogging Factor:
Co(grate) = 0.5 (50% clogging)

K = Clogging Coefficent value for multiple inlets

N	Grate
1	1
2	1.5
3	1.75
4	1.88
5	1.94
6	1.97
7	1.98
8	1.99

Number of inlets: **N = 1**

Inlet Dimensions and Effective Open Area:

Grate Opening:

Ao(g) = 13.8 ft^2
Total Ao(g) = 13.80 ft^2
K = 1.00
C = K*Co/N = 0.50
Ae(g) = (1-C)Ao = 6.90 ft^2

Allowable depth: **H =** 12.0 in = **1 ft**

Constants: g = 32.20 ft/s^2
Cd = 0.67

Flow Calculations:

Grate Flow: Q = Cd * Ae(g) * (2g*H)^0.5
Qg= 37.10 CFS

Total Intercepted Flow with 1 inlet(s) and
an allowable depth of 12 inches is 37.1 cfs

Required Flow (Q 5) = 0.10 cfs **Bypass = 0.0 cfs**
Required Flow (Q 100) = 29.19 cfs **Bypass = 0.0 cfs**

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FLOW CALCULATIONS - GRATE INLET SUMP CONDITION

(Reference: Urban Drainage and Flood Control District Drainage Criteria Manual, 2001, V.1, Section 3.3.6)
(Note: Spreadsheet assumes orifice condition for fully developed flow.)

INLET TYPE: Type 13 Inlet - Standard **BASIN:** OS2

Orifice Equation: Q = Cd*Ao*(2gH)^0.5

Adjust Ao (open area) due to clogging as follows:

Effective Area Opening Ae = (1-C) Ao, where:
C = K * Co / N
N = Number of Inlets
Co = Single Inlet Clogging Factor:
Co(grate) = 0.5 (50% clogging)

K = Clogging Coefficent value for multiple inlets

N	Grate
1	1
2	1.5
3	1.75
4	1.88
5	1.94
6	1.97
7	1.98
8	1.99

Number of inlets: **N = 1**

Inlet Dimensions and Effective Open Area:

Grate Opening:

Ao(g) = 2.32 ft^2
Total Ao(g) = 2.32 ft^2
K = 1.00
C = K*Co/N = 0.50
Ae(g) = (1-C)Ao = 1.16 ft^2

Allowable depth: **H =** 12.0 in = **1 ft**

Constants: g = 32.20 ft/s^2
Cd = 0.67

Flow Calculations:

Grate Flow: Q = Cd * Ae(g) * (2g*H)^0.5
Qg= 6.24 CFS

Total Intercepted Flow with 1 inlet(s) and
an allowable depth of 12 inches is 6.2 cfs

Required Flow (Q 5) = 3.20 cfs **Bypass = 0.0 cfs**
Required Flow (Q 100) = 6.12 cfs **Bypass = 0.0 cfs**