CONCEPTUAL STORMWATER REPORT

FOR THE

ARMORY COMMUNITY

AT

4750 BROADWAY STREET
BOULDER, COLORADO 80304

FOR

ARMORY LAND INVESTORS, LLC

February 2, 2015

February 2nd, 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: Conceptual Stormwater Report
Armory Community
Boulder, CO 80302
JVA No. 1587.1c

Dear Edward:

The following *Conceptual Stormwater Report* and attached drainage map for this project have been prepared for the above referenced project. The conceptual stormwater 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.

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

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

Sincerely,
JVA, Inc.

Charlie R. Hager IV, P.E.
Vice President

ENGINEER'S STATEMENT:

"I hereby certify that this report and plan for the Conceptual drainage design of the Armory Community was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Boulder Design and Construction Standards, 2000 Edition, and was designed to comply with the provisions thereof. I understand that the City of Boulder does not and shall not assume liability for drainage facilities designed by others."

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

CONCEPTUAL STORMWATER REPORT
ARMORY COMMUNITY

AT

4750 BROADWAY STREET

BOULDER, COLORADO 80304

FOR

ARMORY LAND INVESTORS, LLC

JVA, Inc.
Consulting Engineers
1319 Spruce Street
Boulder, CO 80302
(303) 444-1951
fax (303) 444-1957

JVA Project No. 1587.1c

February 2nd, 2015

CONTENTS

CONCEPTUAL STORMWATER REPORT

INTRODUCTION

GENERAL LOCATION AND DESCRIPTION

Armory Land Investors, LLC is proposing to redevelop the Boulder Armory site building located at 4750 Broadway Street in Boulder, Colorado. The subject property is approximately 8.55 acres of developed land located in the northwest quarter of the southwest quarter of the southwest quarter of Section 7, Township 1 North, Range 70 West of the 6th Principal Meridian, City of Boulder, County of Boulder, State of Colorado. More specifically, the property is bound by Lee Hill Drive to the north, 14th Street to the east, a residential development to the south, and Broadway Street to the west. The redevelopment is to span the 8.55 acres and is to be divided into four blocks of varying size. A vicinity map is included in the Appendix of this report.

PROPOSED PROJECT

The proposed development will divide the property into four blocks which will include mixed use buildings, art pavilion, underground parking, access drives, and landscaping. A new detention and water quality basin will be constructed with the proposed development at the southeast corner of the site.

The proposed development will divide the property and into four blocks separated by two roads and associated right-of-way which will include mixed use buildings, an art pavilion, underground parking, and future development along with associated parking, access drives, sidewalks and landscaping. Block 1 will consist of three buildings; A, B, & C. Building A is the existing Armory building which will be converted into a brewpub and restaurant. Building B will be an arts pavilion, retail and residential space. Building C will be retail and residential space. Block 2 will consist of one mixed used building, Building D, with retail and residential space. Block 3 and 4 will be available for future development.

HISTORIC DRAINAGE

MAJOR DRAINAGE BASIN DESCRIPTION

The site's ultimate outfall is Fourmile Canyon Creek located southeast of the proposed addition.

JVA reviewed two FEMA Flood Insurance Rate Maps associated with the site, Community Panel Numbers 08013C0391J and 08013C0392J, dated December 18, 2012 and determined that the site lies outside 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.

Site Drainage and Existing Facilities

The subject site is located at the southeast corner of the Broadway Street and Lee Hill Drive intersection. The site generally lies between 5568 feet and 5536 feet on the City of Boulder datum. The current site is developed. Slopes across the site range from approximately 1% to 20% generally from northwest to southeast. The Silver Lake ditch runs from southwest to northeast at the approximate center of the property. Irrigation water enters the site through an existing 30" CMP pipe under Broadway and exits the site through an existing 30" CMP pipe under Lee Hill Drive.

The majority of the soils found onsite are Nederland Soils with an NRCS hydrologic soils group (HGS) of B. Soils with an HSG of B have a moderate infiltration rate when thoroughly wet and have a moderate rate of water transmission. A copy of the NRCS soils classification map is included in the Appendix.

Historic runoff from the site is calculated to be 6.17 cfs for the minor (5-year) storm and 26.18 cfs for the major (100-year) storm. Onsite historic runoff flows from the northwest corner of the site flows southeast into the Silver Lake ditch and is taken offsite. Runoff from the southeast section is flowing overland offsite and into the right of way and property to the south.

Table 1 below presents a detailed summary of historic peak flows.

Basin	Design Point	Area (acre)	5-Year Flow (cfs)	100-Year Flow (cfs)
H1	1	3.79	4.51	12.82
H2	2	4.76	1.67	13.37

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 Urban Storm Drainage Criteria Manual (USDCM), June 2001 Edition.

Hydrologic Method and Design Storm Frequencies

Design storm recurrence intervals for this project are consistent with the City of Boulder requirements for industrial areas: the minor or initial storm will be the 5-year event (for onsite private storm systems), and the major storm will be the 100-year event (for overland and street conveyance).

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 detention volume for the site.

Final calculations for the storm system, outlet structures, roadways, 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

The proposed site has been divided into four preliminary sub-basins. Please refer to the Preliminary Developed Drainage Map (see attached Fig. 2). Sub-basin boundaries were established based on outfall location. Runoff from the site generally flows northwest to southeast with runoff flowing into the detention and water quality basin located at the southeast corner of the site. Once treated and detained, runoff from the basin will be directed into the existing stormwater system in 14th street.

Basin A1 (2.63 acres) is located at northwest corner of the site and corresponds to Block 1 which houses buildings A, B, and C, a portion of Zamia Avenue, a portion of 13th Street, and associated sidewalks, drives, loading areas, parking, and landscaping. The majority of runoff from A1 is collected internally through the building and will be piped into the public storm sewer system within the right-of-way. Runoff from the right-of-way is collect into a series of inlets which direct runoff into the public storm sewer system.

Basin A2 (1.42 acres) is located at the southwest corner of the site. Basin A2 corresponds to Block 2 which contains building D, a portion of Zamia Avenue, a portion of 13th Street, and associated sidewalks, drives, parking, and landscaping. As with A1, the majority of runoff from A2 is collected internally through the building and will be piped into the public storm sewer system within the right-of-way. Runoff from the right-of-way is collect into a series of inlets which direct runoff into the public storm sewer system.

Basin A3 (1.74 acres) is located at the northeast corner of the site and corresponds to Block 3. A portion of Zamia Avenue, a portion of 13th Street, and associated sidewalks and landscaping will be installed within A3. The majority of A3 will be overlot graded. In general, the drainage pattern within A3 will follow the historic pattern with runoff flowing from the northwest to the southeast. Basin A3 has an assumed imperviousness of 75.1%.

Basin A4 (2.75 acres) is located at the southeast corner of the site and corresponds to Block 4. A portion of Zamia Avenue, a portion of 13th Street, a playground, as associated sidewalks and landscaping will be installed within A4. The majority of A4 will be overlot graded. In general, the drainage pattern within A4 will follow the historic pattern with runoff flowing from the northwest to the southeast. The site's detention and water quality basin will be located at the southeast corner of A4. Basin A4 has an assumed imperviousness of 65.3%.

At time of development of lots A3 and A4, additional storm inlets will be required to convey storm runoff to the regional detention pond.

RUNOFF AND STORMWATER QUALITY ENHANCEMENT/DETENTION FACILITIES

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

Table 2 below presents a summary of the developed stormwater peak flows based on the rational method.

Table 2: Developed Peak Flows

Basin	Design Point	Area (acre)	5-Year Flow (cfs)	100-Year Flow (cfs)
A1	1	2.63	9.17	18.79
A2	2	1.42	4.03	8.89
A3	3	1.74	5.36	11.44
A4	4	2.75	7.09	16.29

Table 3 below presents a comparison between the historic and developed peak flows.

Table 3: Historic vs. Developed Peak Flows

	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
DP1	8.55	6.17	26.18	8.55	25.65	55.42	+19.48	+29.24

As can be seen in Table 3 the proposed development will increase flows from the site. In order to ensure that the development does not result in an overall increase in runoff from the site a detention and water quality basin is proposed at the southeast. 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. Restrictor plates will be used in order to release flows from the pond at a rate which does not exceed the historic runoff rates for the site. Flows greater than the major, 100-year storm will be routed through an emergency overflow spillway along the southeastern side of the detention pond and into 14th street. The detention and water quality basin was sized to account for the future development located on Blocks 3 and 4 of the site.

STREETS

The development is proposing construction of two public roads, Zamia Avenue and 13th street. Detailed street drainage calculations will be provided with the final stormwater report.

Open Channel Flow

No new open channel flow is proposed with this development.

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. In general, from the internal blocks during the major (100-year) storm the storm systems will surcharge and flows will be routed overland into the public right-of-way. However, on the upstream side of the site, the storm system within the city right-of-way is capable of handling the 100-year flows due to the city's minimum 18-inch pipe size requirement. On the downstream side of the site the storm system is also capable of handling major flows in order to insure that storm flows from both the major and minor storm are capable of reaching the water quality/detention basin.

Public storm sewer will be routed through A4 in order to direct runoff from the upstream development (basins A1, A2, and A3) into the proposed detention and water quality basin. The public storm sewer will be located within a public drainage easement dedicated to the City of Boulder. It is anticipated that additional private storm system will be required within basins A3 and A4 to capture runoff from future developments.

Stormwater Management Plan

The Stormwater Management Plan (SWMP) will be included in the final engineering plans, with all structural and non-structural Best Management Practices (BMP's) shown as required.

Structural BMP's

Temporary structural erosion control features will be established during overlot grading and prior to the building construction. All erosion control measures will be maintained until vegetation becomes established. Vehicle tracking control and inlet protection BMP's will be included on the construction plans. Silt fencing will be installed at critical locations on the site with respect to current and proposed drainage.

Non-Structural BMP's

Non-structural erosion controls, including project schedule, surface roughening and other pollution prevention measures, will be detailed in the construction activities of the SWMP. Permanent, perennial, native seeding will be established onsite in locations specified by the SWMP and Landscape Architect. The seed mix will be provided in the SWMP reference.

Wetland Impacts

No wetland impacts are proposed with this development.

CONCLUSION

The drainage facilities for the development of the Boulder Armory have been designed in accordance with the City of Boulder Design and Construction Standards, 2000 Edition, the latest methods endorsed the by the Urban Drainage and Flood Control District, and recommendations from the City of Boulder staff. This development will not cause any negative impacts on the upstream or downstream properties.

The referenced drainage maps, Figure 1 and Figure 2, depict the drainage design points, developed runoff sub-basins, and configuration of the proposed storm drainage system.

REFERENCES

1. "City of Boulder Design and Construction Standards," 2000 Edition.

2. "Urban Storm Drainage Criteria Manual," Urban Drainage and Flood Control District, Revised June 2001.

Appendix A – Site Maps

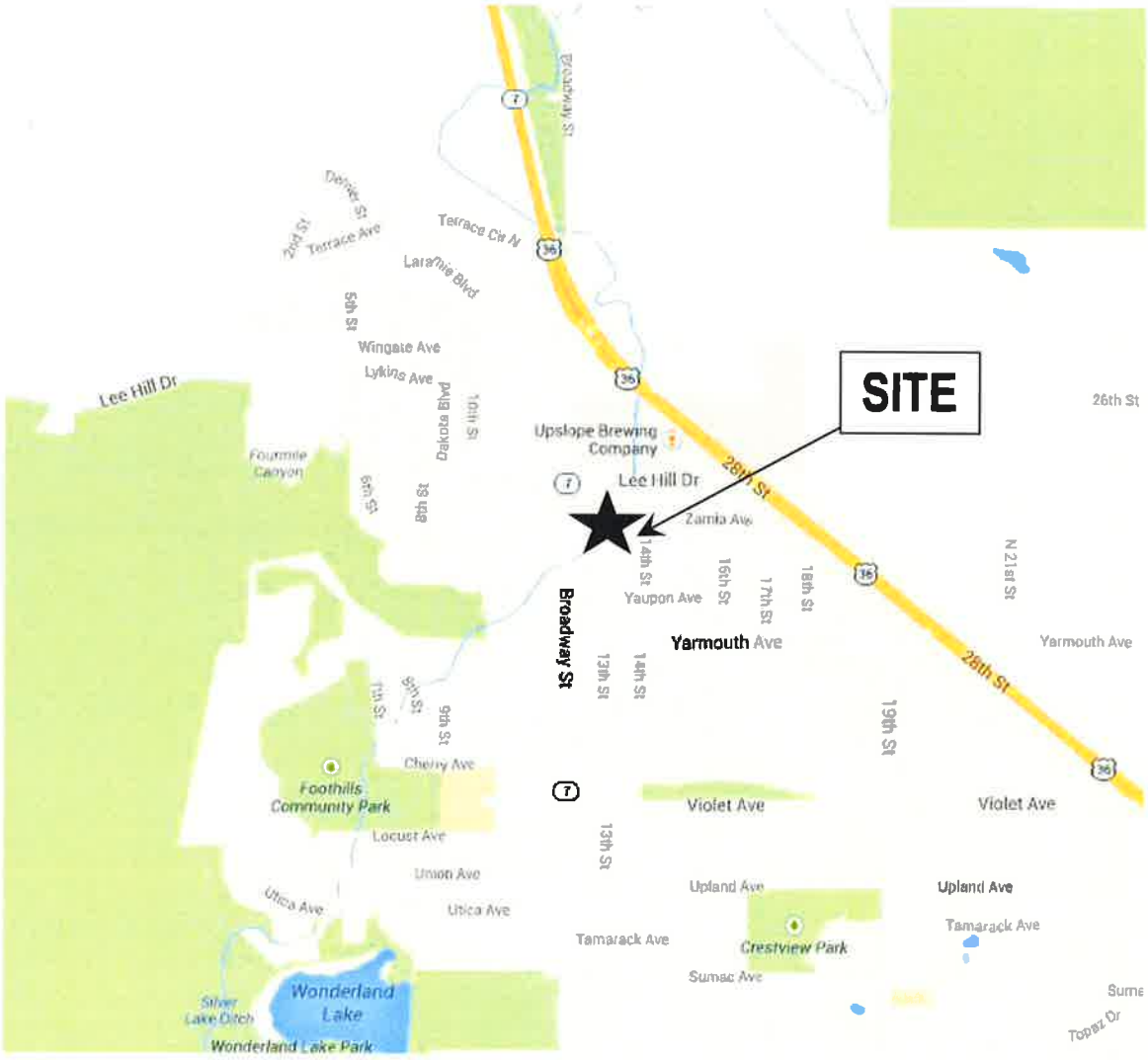
ARMORY COMMUNITY

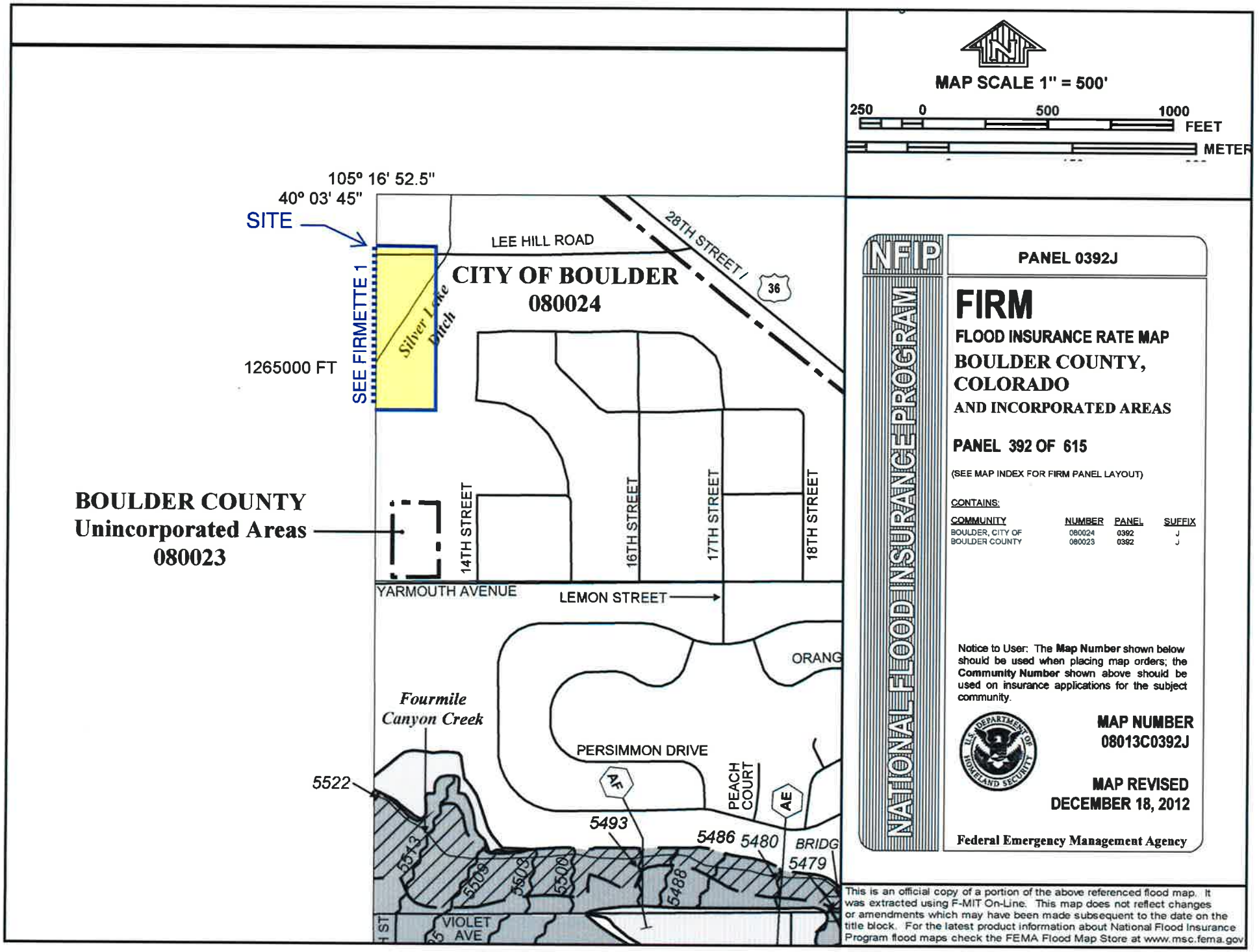
AT

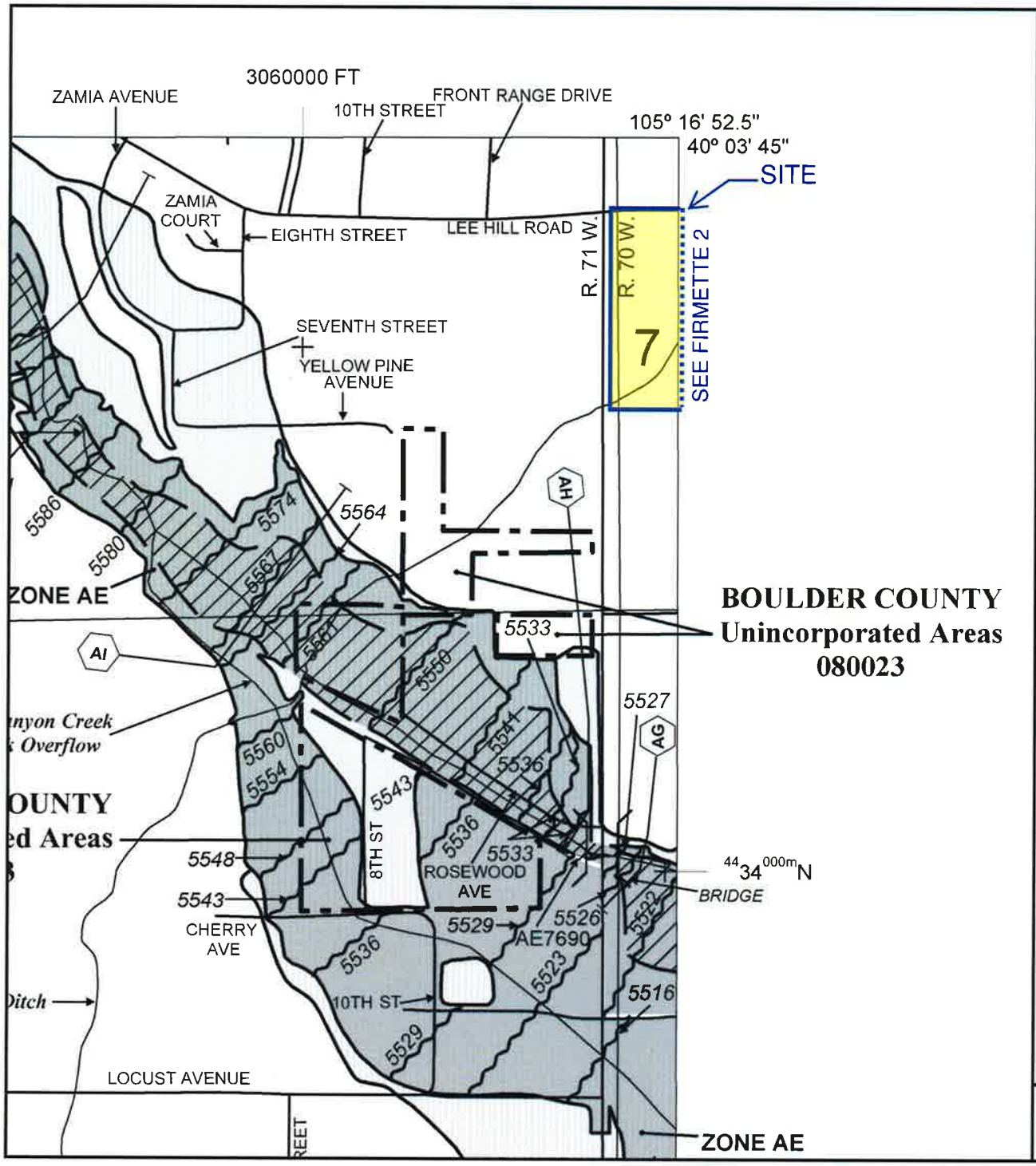
4750 BROADWAY STREET

BOULDER, COLORADO 80304

VICINITY MAP – NOT TO SCALE




MAP SCALE 1" = 500'
250 0 500 1000
FEET
METER
105° 16' 52.5"
40° 03' 45"
SITE
LEE HILL ROAD
28TH STREET
36
CITY OF BOULDER
080024
SEE FIRMETTE 1
Silver Lake Ditch
1265000 FT
BOULDER COUNTY
Unincorporated Areas
080023
14TH STREET
16TH STREET
17TH STREET
18TH STREET
YARMOUTH AVENUE
LEMON STREET
ORANG
Fourmile Canyon Creek
PERSIMMON DRIVE
PEACH COURT
AF
AE
5522
5493
5486
5480
BRIDG
5479
5513
5509
5503
5500
5488
VIOLET AVE
H ST
NFIP
NATIONAL FLOOD INSURANCE PROGRAM
PANEL 0392J
FIRM
FLOOD INSURANCE RATE MAP
BOULDER COUNTY, COLORADO
AND INCORPORATED AREAS
PANEL 392 OF 615
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
BOULDER, CITY OF 080024 0392 J
BOULDER COUNTY 080023 0392 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
08013C0392J
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



MAP SCALE 1" = 500'

250 0 500 1000 FEET

METER

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

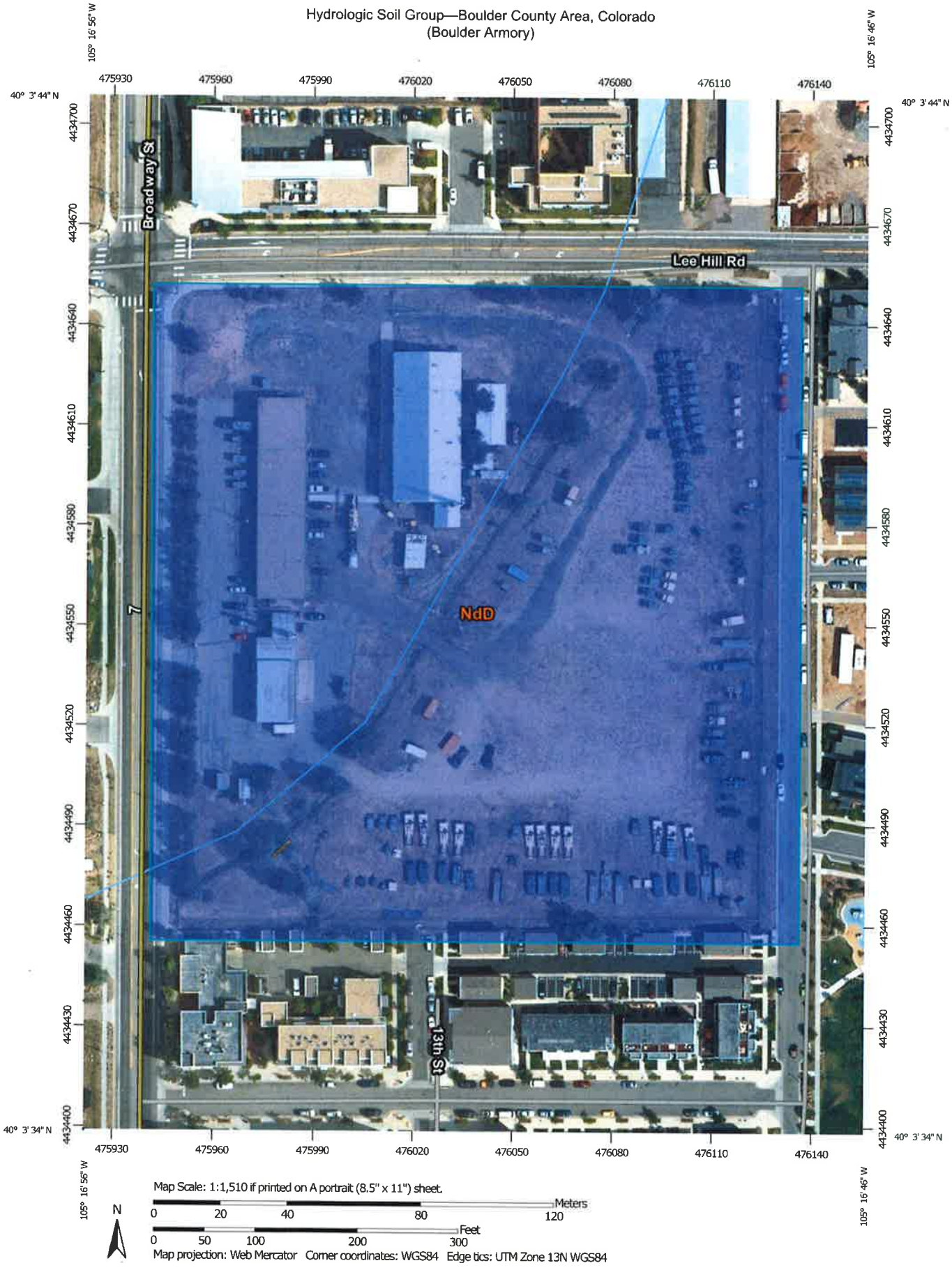
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
08013C0391J

MAP REVISED
DECEMBER 18, 2012

Federal Emergency Management Agency

Hydrologic Soil Group—Boulder County Area, Colorado
(Boulder Armory)



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	9.5	100.0%
Totals for Area of Interest			9.5	100.0%

Description

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

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

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

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

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

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

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

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

APPENDIX B– CALCULATIONS

FIGURE 7-1

RAINFALL
INTENSITY-DURATION-FREQUENCY
FOR
CITY OF BOULDER
BOULDER, COLORADO

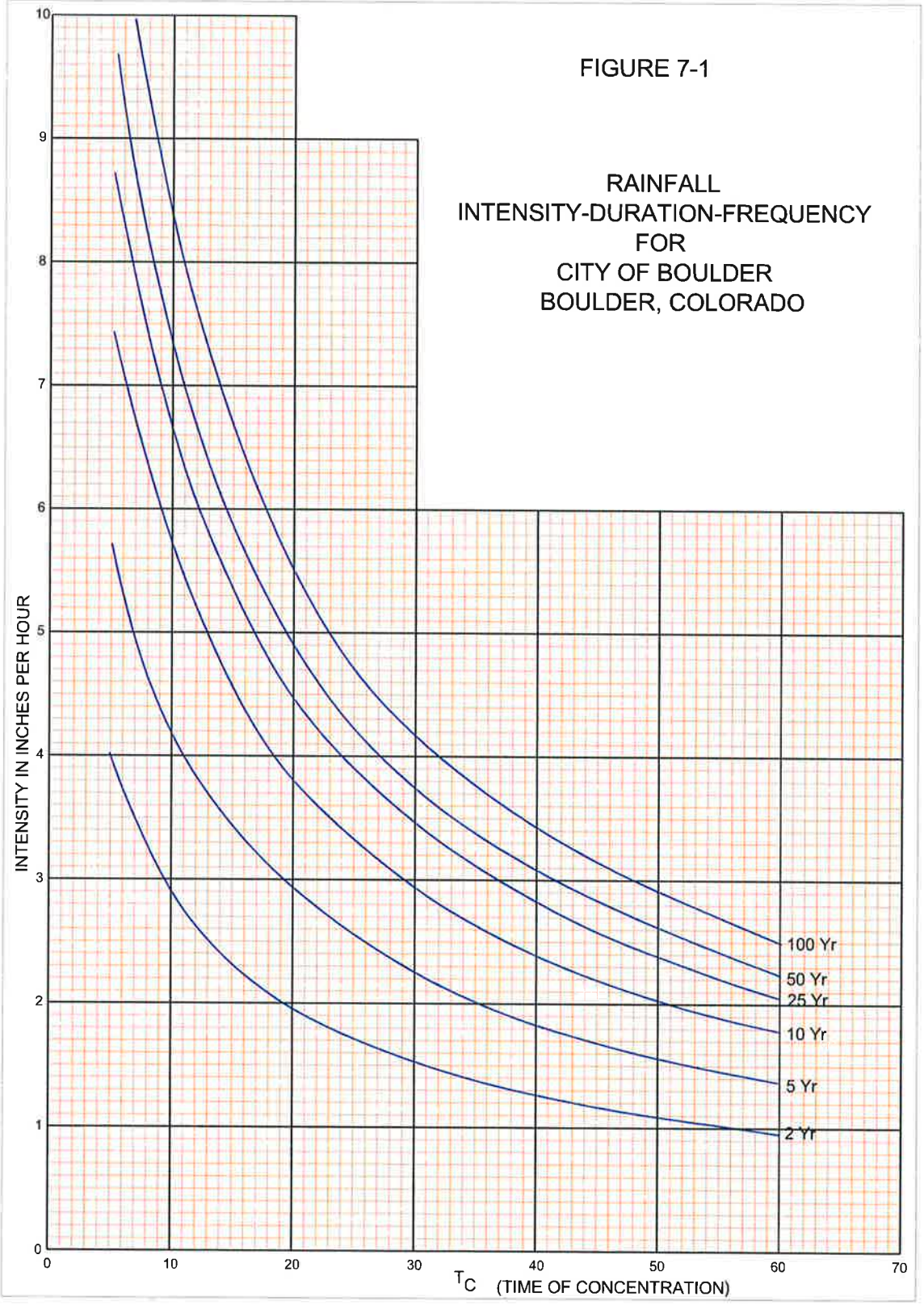


Table 7-2: Runoff Coefficients for the Rational Method

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)

JVA Incorporated
1319 Spruce Street
Boulder, CO 80302
Ph: 303.444.1951
Fax: 303.444.1957

Job Name: Boulder Armory
Job Number: 1587.1c
Date: 1/29/15
By: CHR

Boulder Armory

Historic Runoff Coefficient & Time of Concentration Calculations

Location: Boulder
Minor Design Storm: 5
Major Design Storm: 100
Soil Type: B

$CA = KA + (1.31i3 - 1.44i2 + 1.135i + 0.12)$

$CCD = KCD + (0.858i3 - 0.786i2 + 0.774i + 0.04)$

$CB = (CA + CCD)/2$

Basin Design Data

	I (%) =	100%	90%	90%	40%	10%	25%	0%	0%			I (%)	Runoff Coeff's				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	$A_{paved\ streets}$ (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	31,876	30,872	29,521	0	0	0	72,766	0	165,035	3.79	52.2%	0.31	0.36	0.42	0.53	300	1.1%	22.3	840	0.8%	Paved areas & shallow paved swales	20	1.8	7.8	30.1	1140	16.3	16.3
H2	2	0	9,048	0	0	0	0	198,370	0	207,418	4.76	3.9%	0.00	0.09	0.18	0.37	300	3.8%	20.1	140	4.5%	Paved areas & shallow paved swales	20	4.2	0.5	20.7	440	12.4	12.4
TOTAL SITE		31,876	39,920	29,521	0	0	0	271,136	0	372,453	8.55	25.3%	0.15	0.23	0.30	0.46													

			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	16.3	0.31	0.36	0.42	0.53	2.21	3.28	4.36	6.36	165,035	3.79	2.59	4.51	6.86	12.82
H2	2	12.4	0.00	0.09	0.18	0.37	2.60	3.79	5.11	7.52	207,418	4.76	-0.05	1.67	4.37	13.37
										TOTAL SITE	372,453	8.55	2.54	6.17	11.23	26.18

JVA Incorporated
1319 Spruce Street
Boulder, CO 80302
Ph: 303.444.1951
Fax: 303.444.1957

Job Name: Boulder Armory
Job Number: 1587.1c
Date: 1/29/15
By: CHR

Boulder Armory

Composite Runoff Coefficient Calculations

Location:	Boulder
Minor Design Storm:	5
Major Design Storm:	100
Soil Type:	B

CA = KA + (1.31i3 - 1.44i2 + 1.135i + 0.12)
CCD = KCD + (0.858i3 - 0.786i2 + 0.774i + 0.04)
CB = (CA + CCD)/2

Basin Design Data

	I (%) =	100%	90%	90%	40%	10%	25%	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)	$A_{art.\ turf}$ (sf)	$A_{lscape\ (B\ soil)}$ (sf)	A_{lscape} (C/D soil) (sf)	A_{Total} (sf)	A_{Total} (ac)	Imp (%)	C2	C5	C10	C100
A1	1	11,941	46,314	44,169	0	0	0	0	12,275	114,699	2.63	81.4%	0.58	0.61	0.64	0.71
A2	2	6,994	21,983	18,888	0	0	0	0	14,112	61,977	1.42	70.6%	0.46	0.50	0.54	0.62
A3	3	20,000	19,000	22,000	0	0	0	0	14,778	75,778	1.74	75.1%	0.51	0.54	0.58	0.66
A4	4	27,000	31,000	26,000	0	0	0	0	35,991	119,991	2.75	65.3%	0.41	0.45	0.50	0.59

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By: CHR

Boulder Armory

Time of Concentration Calculations

Location:	Boulder
Minor Design Storm:	5
Major Design Storm:	100
Soil Type:	B

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	2.63	0.61	10	1.0%	2.8	10	1.0%	Paved areas & shallow paved swales	20	2.0	0.1	2.9	20	10.1	5.0
A2	2	1.42	0.50	10	1.0%	3.4	10	1.0%	Paved areas & shallow paved swales	20	2.0	0.1	3.5	20	10.1	5.0
A3	3	1.74	0.54	10	2.0%	2.5	10	1.0%	Paved areas & shallow paved swales	20	2.0	0.1	2.6	20	10.1	5.0
A4	4	2.75	0.45	10	1.0%	3.7	10	1.0%	Paved areas & shallow paved swales	20	2.0	0.1	3.8	20	10.1	5.0

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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	2.63	0.71	5.00	1.88	10.00	18.79																		
A2	2	1.42	0.62	5.00	0.89	10.00	8.89																		
A3	3	1.74	0.66	5.00	1.14	10.00	11.44																		
A4	4	2.75	0.59	5.00	1.63	10.00	16.29																		
					Site Flow Total (A1-A4)			5.00	5.54	10.00	55.42														

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Boulder Armory

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	2.63	0.61	5.00	1.61	5.70	9.17																		
A2	2	1.42	0.50	5.00	0.71	5.70	4.03																		
A3	3	1.74	0.54	5.00	0.94	5.70	5.36																		
A4	4	2.75	0.45	5.00	1.24	5.70	7.09																		
					Site Flow Total (A1-A4)			5.00	4.50	5.70	25.65														

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Detention Pond Volume Calculations: FAA Procedure

Based on FAA Procedure, per Federal Aviation Agency "Airport Drainage" Manual

Drainage Basin	A	
Design Storm	**10 year**	
Composite "C" Factor	0.56	
Basin Size	8.55	

Release Rate Calculations

Allowable Release Rate for Site	11.23 cfs		(Historic Flows for Basin H1)
Less Undetained Offsite Flows	- 0.00 cfs		(From Basin X)
Allowable Release Rate for Pond	11.23 cfs		

Rainfall Intensity Calculations

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

Rainfall Intensity: BoulderIDF

Volume Calculations

Inflow Volume = C * I * A * time (sec)
Outflow Volume = Alowable Release Rate * time (sec)
Storage Volume = Invflow Volume - Outflow Volume

Detention Storage Calculations

Time t (min)	Time t (sec)	Intensity I (in/hr)	Inflow Vin (ft^3)	Outflow Vout (ft^3)	Storage Vstor (ft^3)
5.0	300	7.45	10,695	3,369	7,326
10.0	600	5.70	16,366	6,738	9,628
15.0	900	4.55	19,596	10,108	9,489
20.0	1,200	3.80	21,822	13,477	8,345
25.0	1,500	3.30	23,688	16,846	6,842
30.0	1,800	2.95	25,411	20,215	5,195
35.0	2,100	2.76	27,758	23,585	4,173
40.0	2,400	2.57	29,522	26,954	2,568
45.0	2,700	2.38	30,736	30,323	413
50.0	3,000	2.19	31,400	33,692	-2,293
55.0	3,300	2.00	31,513	37,062	-5,549
60.0	3,600	1.80	31,010	40,431	-9,421

		Maximum Volume (ft^3)	**9,628**	
		City of Boulder Only (110%)	963	ft3
	100%	WQCV	10,237	ft^3
Required 10-yr Volume +	**100%**	**WQCV**	**20,827**	**ft^3**

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Detention Pond Volume Calculations: FAA Procedure

Based on FAA Procedure, per Federal Aviation Agency "Airport Drainage" Manual

Drainage Basin	A	
Design Storm	**100 year**	
Composite "C" Factor	0.64	
Basin Size	8.55	

Release Rate Calculations

Allowable Release Rate for Site		26.18 cfs	(Historic Flows for Basin H1)
Less Undetained Offsite Flows	-	0.00 cfs	(From Basin X)
Allowable Release Rate for Pond		26.18 cfs	

Rainfall Intensity Calculations

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

Rainfall Intensity: BoulderIDF

Volume Calculations

Inflow Volume = C * I * A * time (sec)
Outflow Volume = Alowable Release Rate * time (sec)
Storage Volume = Invflow Volume - Outflow Volume

Detention Storage Calculations

Time t (min)	Time t (sec)	Intensity I (in/hr)	Inflow Vin (ft^3)	Outflow Vout (ft^3)	Storage Vstor (ft^3)
5.0	300	10.00	16,485	7,855	8,630
10.0	600	8.35	27,530	15,710	11,820
15.0	900	6.65	32,888	23,566	9,322
20.0	1,200	5.52	36,399	31,421	4,978
25.0	1,500	4.70	38,740	39,276	-536
30.0	1,800	4.20	41,543	47,131	-5,589
35.0	2,100	3.92	45,262	54,987	-9,724
40.0	2,400	3.64	47,992	62,842	-14,850
45.0	2,700	3.36	49,787	70,697	-20,910
50.0	3,000	3.07	50,648	78,552	-27,904
55.0	3,300	2.79	50,575	86,408	-35,833
60.0	3,600	2.50	49,456	94,263	-44,807

		Maximum Volume (ft^3)	**11,820**	
		City of Boulder Only (110%)	1182	ft3
	50%	WQCV	5,118	ft^3
Required 100-yr Volume +	**50%**	**WQCV**	**18,120**	**ft^3**

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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
34.0		3,170			0
35.0	1.0	4,355	3,763	3,747	3,747
36.0	1.0	5,958	5,157	5,136	8,882
37.0	1.0	8,215	7,087	7,056	15,939
38.0	1.0	9,988	9,102	9,087	25,026
39.0	1.0	12,004	10,996	10,981	36,006

Top of Pond

39.0	5.0	**TOTAL VOLUME**	**36,006 cf**	0.827 ac-ft

Volume Summary Table

	Required Volume (ft^3)	Required Volume (ac-ft)	Water Surface Elevation	Water Depth
WQCV	10,237 cf	0.235 ac-ft	**36.19 ft**	2.19 ft
V10 + 100% WQCV	20,827 cf	0.478 ac-ft	**37.54 ft**	3.54 ft
V100 + 50% WQCV	18,120 cf	0.416 ac-ft	**37.24 ft**	3.24 ft

Volume Interpolation Calculations

WQCV		V10 + 100% WQCV		V100 + 50% WQCV	
Vol	Elev	Vol	Elev	Vol	Elev
8882.46	36.00	15938.82	37.00	15938.82	37.00
10236.60	36.19	20827.08	37.54	18120.09	37.24
15938.82	37.00	25025.89	38.00	25025.89	38.00

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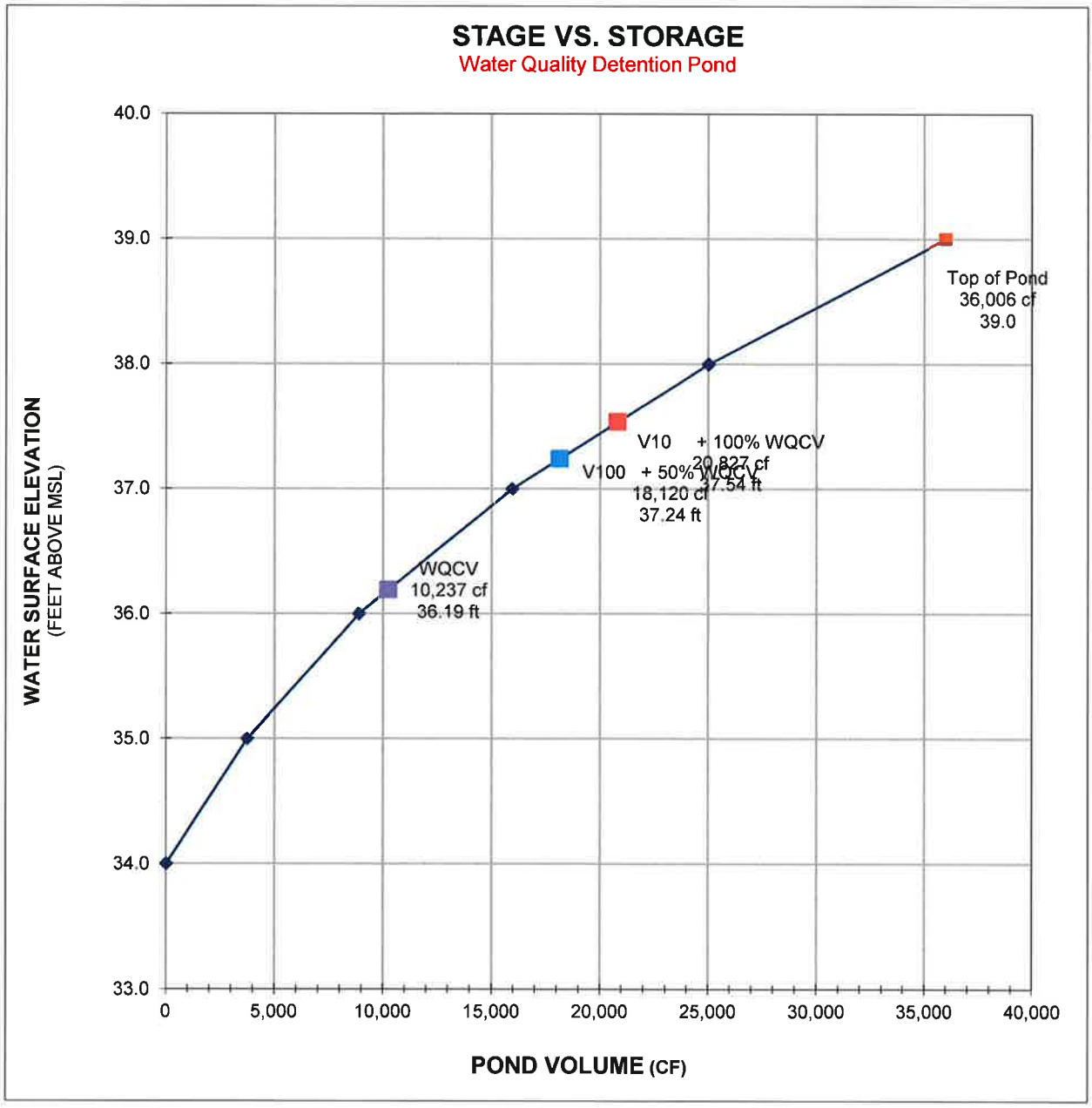

Design Procedure Form: Extended Detention Basin (EDB)

Designer: D. Breedlove
Company: JVA, Inc
Date: January 29, 2015
Project: Boulder Armory
Location: Basin A4

1. Basin Storage Volume

A) Effective Imperviousness of Tributary Area, I_a — I_a = 69.9 %

B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$) — i = 0.699

C) Contributing Watershed Area — Area = 8.550 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} = 0.235 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) — $V_{DESIGN\ USER}$ = ____ ac-ft

I) Predominant Watershed NRCS Soil Group

Choose One
- ( ) A
- ( ) B
- ( ) C / D

2. Basin Shape: Length to Width Ratio
(A basin length to width ratio of at least 2:1 will improve TSS reduction.) — L : W = ____ : 1

3. Basin Side Slopes

A) Basin Maximum Side Slopes
(Horizontal distance per unit vertical, 4:1 or flatter preferred) — Z = ____ ft / ft

4. Inlet

A) Describe means of providing energy dissipation at concentrated inflow locations: