

Final Storm Water Report

For

6400 Arapahoe

6400 Arapahoe
Boulder, Colorado

3 March 2012

Revised June 1, 2012

Revised July 2, 2012

Revised August 13, 2012

Prepared for:

PEH Architects

1319 Spruce Street
Boulder, CO 80302
Contact: Peter Heinz
(303) 442-0408

Prepared by:

Drexel Barrell & Co.

1800 38th Street
Boulder, Colorado 80301
Contacts: Deborah A. Fisher, P.E. CFM
(303) 442-4338

Job Number: 20024-00BLCV

(H:\20024-00BLCV\Reports\Drainage\Final (tecdoc)\5th tec doc
submittal\20024DRN-F rev.docx)

ENGINEER'S STATEMENT:

"I hereby certify that this report (plan) for the final drainage design of the 6400 Arapahoe site was prepared by me (or reviewed by me) in accordance with the provisions of City of Boulder Design and Construction Standards for the owners thereof."

For, and on Behalf of, Drexel, Barrell & Co.

Deborah A. Fisher, Colorado P.E. #41679

Final Storm Water Report
6400 Arapahoe
6400 Arapahoe Ave.
Boulder, CO

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1.0 INTRODUCTION

This report is prepared in accordance with the City of Boulder "Design and Construction Standards", Section 7.0 Final Storm Water Report and Plan and is required as part of the 6400 Arapahoe Technical Document Review Application.

The proposed 6400 Arapahoe project is a proposed 9.7+/-acre re-development and sub-division generally located on the south side of Arapahoe Avenue, east of 63rd Street. An existing commercial building, warehouses and storage buildings along with parking currently occupy the site. A vicinity map is provided in Appendix A. The site drainage generally sheet flows from south to north with a number of existing inlets and storm pipes directing flows to the ditch along the south side of Arapahoe Avenue. The legal description for the property is:

That portion of the northwest ¼ of the northwest ¼ of Section 35, Township 1 North, Range 70 West of the 6th P.M.; described as follows: Beginning at a point on the north line of Section 35, Township 1 North, Range 70 West of the 6th P.M.; whence the northwest corner of said section of 35 bears north 89°49' west, 458.00 feet; thence south 637.00 feet; thence south 81°37' east, 644.67 feet; thence north 728.95 feet to the north line of said section 35; thence along the north line of said section 35, north 89°49' west, 637.78 feet to the point of beginning, County of Boulder, State of Colorado.

Per FEMA map number 08013CO415F dated June 2, 1995, the site is not located within a regulatory floodplain.

2.0 PROPOSED DEVELOPMENT

The proposed re-development of the site will be phased. This report will address full build-out as shown on the phase II drawings of the Site Review submittal package. The proposed pond shall be constructed as part of Phase I, but shall be sized for full build-out of the project, including an assumed imperviousness for lot 2, and the Phase II development area. All existing major structures on the site are proposed to remain. Two new warehouses, a new covered storage area and an expanded showroom and warehouse are proposed. The majority of storm runoff from the site will be collected via

sheet flow and curb and gutter and inlets and directed to the proposed pond. Runoff from the western and northwestern portion of the site cannot feasibly be directed to the pond and will continue to free release to the ditch on the south side of Arapahoe Avenue. The pond shall release runoff to a storm sewer stub proposed as part of the Arapahoe Avenue improvement project by CDOT. See the basin descriptions in section 3.2 for additional detail.

3.0 HYDROLOGY

The Rational Method as outlined in Section 7.05D of the City of Boulder “Design and Construction Standards” was used to determine the rainfall and runoff conditions for the existing and proposed development of the site. The runoff rates for the 5 year, 10 year, and 100 year design storm events were calculated. The proposed detention pond is sized to detain both the 10 year and 100 year events and provide water quality. The resulting runoff rates are summarized below in Table 3.1.

Table 3.1: Hydrology Summaries

Basin	Runoff Rates [CFS]	
	10-YR	100-YR
A-HISTORIC	6.18	17.47
A-EXISTING	18.29	34.88
B-EXISTING	5.97	11.74
Site-EXISTING	24.14	46.38
A-PROPOSED	18.2	34.7
PHASE 1/ PHASE 2	24.82	43.16
Pond-PROPOSED	1.31(max)	7.75 (max)
B-PROPOSED	5.97	11.74
PHASE 1/ PHASE 2	4.83	9.52
Site-PROPOSED	6.18(max)*	17.47 (max)*

*proposed site release rates are detained to be equal to or less than historic release rates

The supporting calculations for the runoff rates presented above are provided in Appendix C of this report. The Storm Water Plans provided in the back pocket of this report shows the tributary basin delineation for the design points for three conditions: existing, Phase I, and Phase II.

3.1 EXISTING HYDROLOGICAL CONDITIONS

Drainage calculations were made for two basins on the current and historic site. Very little to no offsite runoff appears to enter the property and total site discharges are summarized below.

Design Point A

Basin A covers the majority of the site including the south, east and central portions. The basin is 6.68 acres, is currently 71% impervious and is developed with buildings and large amounts of paved area. Runoff from the basin is conveyed to the swale along Arapahoe road via sheet flow, inlets and private storm sewer. Design Point A is located at the connection to the proposed storm sewer by CDOT on the north side of the site near the entrance drive.

Design Point B

Basin B covers the remainder of the site including the western and northern pieces. The basin is 2.27 acres, is currently 64% impervious and is developed with buildings and parking area. Runoff from the basin is conveyed to the swale along Arapahoe road via sheet flow, curb and gutter and a swale along the western edge of the property. Design Point B is located at the connection to the proposed storm sewer by CDOT at the northwest corner of the site.

The existing run-off rates for the site are presented in Table 3.1. The site currently does not provide any formal water quality control or detention of onsite runoff. No major drainage problems are evident on the site. The proposed improvements of Arapahoe Road by DCOT include storm sewer that was sized for the existing site conditions. Currently there are no apparent offsite flows entering the site that need to be accounted for in the design process.

3.2 PROPOSED HYDROLOGICAL CONDITIONS

The proposed site redevelopment generally maintains the existing drainage patterns. Phase I, Phase II and Phase III runoff calculations are included in the appendix. There is very little change from the existing condition to Phase I development: existing asphalt and concrete are removed to provide for some additional buildings, and a small landscaped areas is added, but the overall imperviousness is essentially the same. Phase II development is only conceptual, potentially adding buildings, reconfiguring the pavement, and adding landscaped islands. The anticipated development of Lot 2, or Phase III, would replace the existing open space with building, parking, and landscaped areas, thus increasing the overall imperviousness of the site. The drainage patterns will remain essentially the same as in Phase I development, with improvements to capture more of Basin B to the detention pond, resulting in less undetained runoff. The detention pond is sized for the anticipated full build-out of the site, including Lot 2. Plans in the back pocket show the proposed drainage basins and Design Points for three scenarios: Existing conditions, Phase I, and Phase II. A separate Phase III plan is not included, because the anticipated improvements for Lot 2 are too conceptual.

Design Point A

Basin A covers the majority of the site including the south, east and central portions. The basin increases from 6.68 in Phase I development to 7.10 acres with Phase II development, capturing more of the developed runoff and directing it to the proposed detention pond. Basin A contains Lot 2, which is anticipated for future development. Lot 2 has been assumed to be 15% landscaping, 40% roof, 40% asphalt, and 5% concrete, which increases the imperviousness for Basin A from approximately 70% impervious with Phase I development to approximately 86% with the development of Phase II and Lot 2. Runoff calculations are presented for all phases, and detention calculations are presented for the full build-out condition, including Phase II and lot 2. Until full development occurs, the detention pond will over-detain. Runoff from the basin is conveyed to the pond via sheet flow, inlets and private storm sewer. Design Point A is located at the pond outfall connection to the proposed storm sewer by CDOT on the north side of the site near the entrance drive.

Design Point B

Basin B covers the remainder of the site including the western and northern areas. The basin decreases from 2.27 acres in the existing and Phase I conditions, to 1.85 acres with the full build-out of Phase II, as more runoff is diverted into Basin A and detained. Phase I is approximately 64% impervious and is developed with buildings and parking area. The addition of some landscaped areas will decrease Basin B to approximately 62% impervious when Phase II is built. Runoff from the basin is conveyed to the proposed CDOT storm sewer via sheet flow and a swale along the western edge of the property. Design Point B is located at the connection to the proposed storm sewer by CDOT at the northwest corner of the site. The undetained runoff from Basin B is accounted for in the release rates for the detention pond. An additional 0.75 acres of the site is being dedicated as right-of-way by the CDOT projects and drainage facilities for this portion of the site have been designed by CDOT.

The proposed run-off rates from the site are presented in Table 3.1. Supporting calculations are included in Appendix C.

4.0 HYDRAULICS

The storm sewer system for the property is made up of mostly existing improvements. Phase I storm sewer includes a new 18" RCP storm sewer extension from the currently on-site outfall point to the new detention pond, an outlet structure for the detention pond, and a new 30" storm sewer from the detention pond to the manhole to be constructed by CDOT as part of the Arapahoe improvements. Supporting calculations for storm sewer sizing are included in Appendix D. All future storm sewer shall be designed at time of future development.

5.0 STORM WATER DETENTION

The storm drainage from the property is currently being released un-detained. With the proposed redevelopment of the property, the imperviousness will increase slightly. The detention pond has been designed for full build-out through Phase II as well as future

development of Lot 2. See runoff calculations in Appendix C. The FAA method was used to calculate the required detention volumes for the 10-Year and 100-Year events. Runoff from Basin B can not easily and economically be conveyed to the detention pond. Release rates from the detention pond are limited to historic runoff from the site, less the un-detained runoff released from Basin B. The maximum release rates are based on the pre-developoment release rates of 6.18 and 17.47 cfs for the 10-year and 100 year storm events. Pond outlet sizing calculations are included in Appendix D. During the interim, the detention pond is considered to be oversized. However, no future improvements to the detention pond will be necessary assuming that Phase II and development of Lot 2 follow the runoff rates and basins as outlined in this report. Pond sizing calculations are included in Appendix C.

6.0 STORM WATER QUALITY AND EROSION CONTROL

Impacts of the proposed development on downstream properties and drainage facilities will be minimized by the installation and maintenance of erosion and sediment control Best Management Practices (BMPs) during the construction of the proposed improvements. The BMPs will be installed in accordance with City of Boulder "Design and Construction Standards" and Urban Drainage Volume 3. Temporary construction BMPs will include perimeter silt fencing, inlet and outlet protection, check dams, dust mitigation, and revegetation (temporary and permanent).

Permanent erosion control measures will be provided by the proposed extended detention basin. Supporting calculations for initial pond sizing are included in Appendix C. Final pond outlet sizing shall be included with the final design for the site.

7.0 WETLANDS IMPACT

There are currently no known wetland areas on the property. Therefore no wetlands will be impacted by this development.

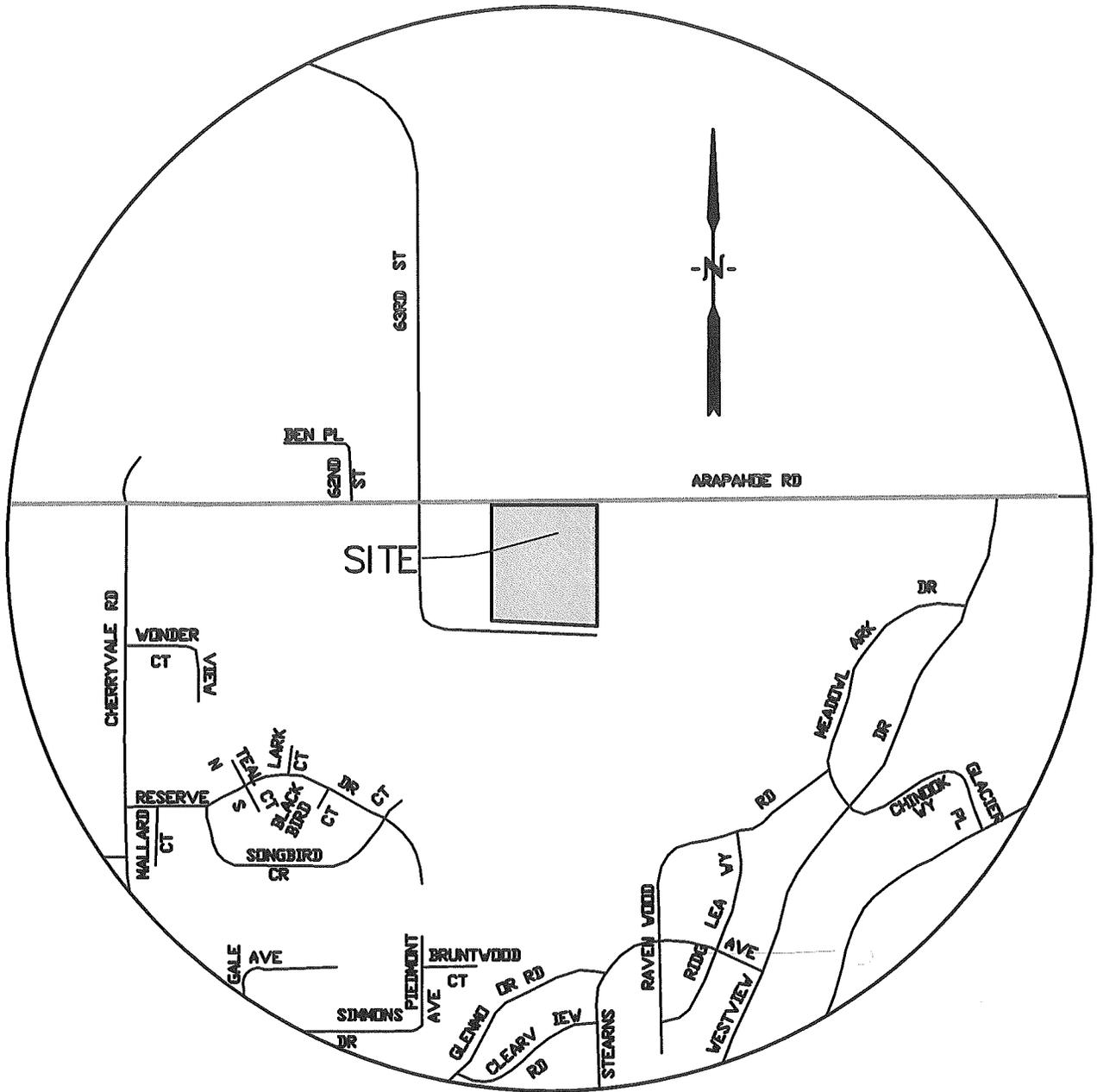
8.0 CONCLUSION

This report discusses the information requirements for a Final Storm Water Report and Plan as defined by the City of Boulder "Design and Construction Standards", Section 7.04. The redevelopment of the property maintains the existing drainage patterns on the site and installation of a detention pond will detain runoff from a large portion of the site to historic, pre-developed rates. Erosion control BMP's will be implemented during construction in an effort to prevent adverse impacts on downstream properties and drainage facilities. Water quality treatment will be installed to permanently help treat runoff before leaving the site through an extended detention basin. The proposed development will not adversely affect the surrounding properties or existing storm drainage system.

9.0 REFERENCES

- [1] "Design and Construction Standards" prepared by the City of Boulder, effective 16 November 2000.
- [2] "Urban Storm Drainage Criteria Manual, Volume 3-Best Management Practices" prepared by the Urban Drainage and Flood Control District, effective September 1999.

APPENDIX A: VICINITY MAP



VICINITY MAP
N.T.S.

APPENDIX B: FLOODPLAIN MAP



NATIONAL FLOOD INSURANCE PROGRAM

FIRM FLOOD INSURANCE RATE MAP
BOULDER COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 415 OF 595

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:
COMMUNITY

NUMBER PANEL SUFFIX

BOULDER COUNTY UNINCORPORATED AREAS
BOULDER CITY OF

080023 0415 F
080024 0415 F

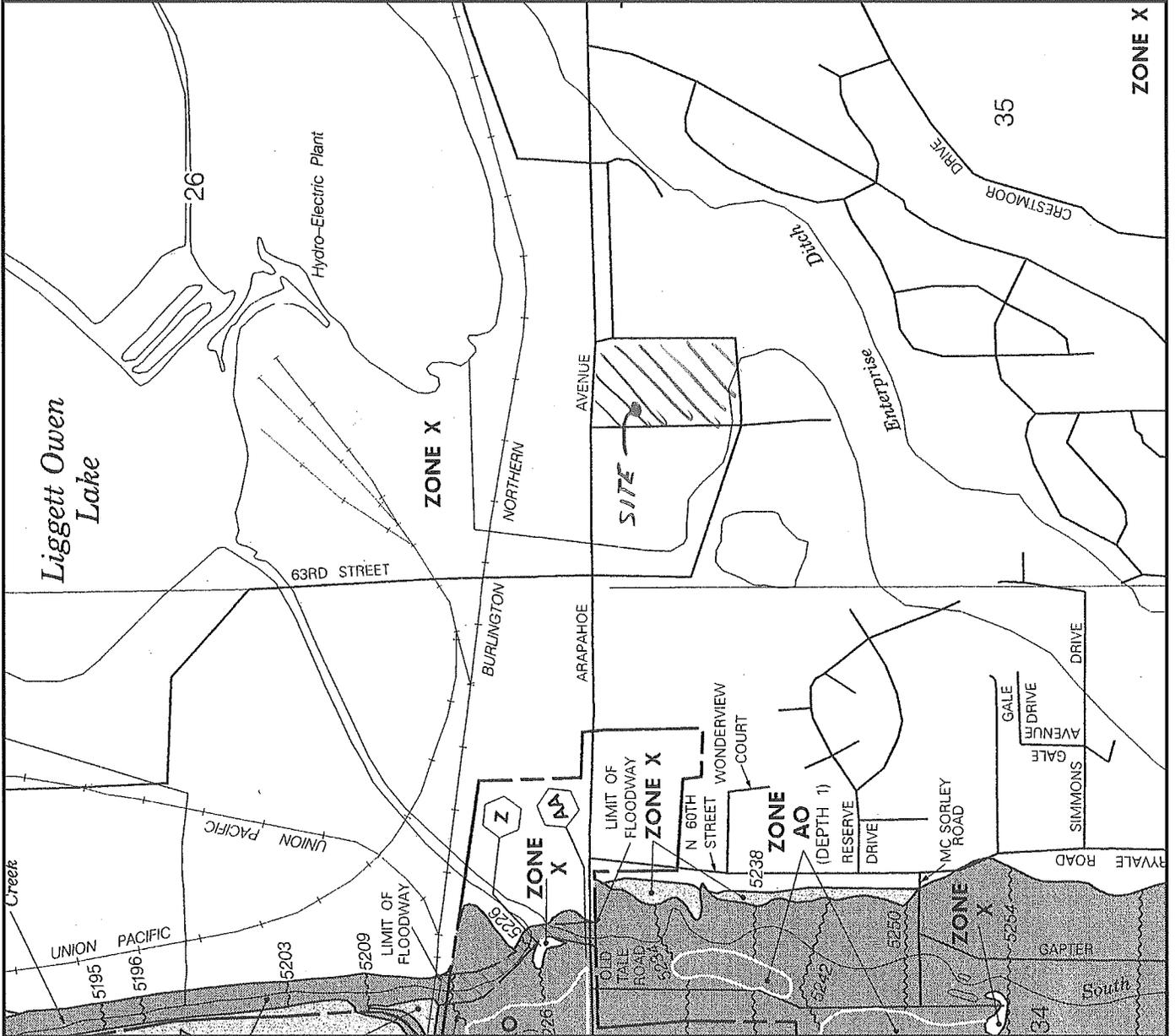
MAP NUMBER 08013C0415 F

EFFECTIVE DATE: JUNE 2, 1995



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 FEIMA Flood Map Store at www.msc.fema.gov



ZONE X

APPENDIX C: HYDROLOGY CALCULATIONS



Basin Characteristics

Run-off Analysis

HISTORIC

Drexel, Barrell & Co.

Project: 6400 Arapahoe
Project No: 20024-00BLCV

Date: 02/17/11
Calculated By: MAA

Tributary Basins:

Description: FULL SITE HISTRIC FLOW ANALYSIS

Soil Type: C

Area [acres] = 8.95

Catchment Composition:

Surface Characteristic ¹	Sub-Area [acres]	I [%]	Runoff Coefficients		
			C ₅	C ₁₀	C ₁₀₀
Historic Flow Analysis	8.95	2	0.20	0.30	0.60
Drives and Walks	0.00	96	0.87	0.90	0.92
Roofs	0.00	90	0.85	0.90	0.90
Lawns	0.00	0	0.20	0.30	0.60

¹ Table RO-3, UDFCD Drainage Criteria Manual V.1

Weighted Percent Imperviousness [%]: I = 2.00

Weighted Runoff Coefficients:
 C₅ = 0.20
 C₁₀ = 0.30
 C₁₀₀ = 0.60

BASIN CHARACTERISTICS	CRITERIA REFERENCE ¹	Site Historic
IMPERVIOUSNESS, [%]	-	2.00
AREA, A [ACRE]	-	7.10
RUN-OFF COEFFICIENT, C ₅	TABLE 7-2	0.20
OVERLAND FLOW LENGTH, L _i [FT]	-	500.00
OVERLAND SLOPE, S _i [%]	-	2.00
OVERLAND FLOW TIME, t _i [MIN]	FIGURE 7-2	28.75
TOTAL TRAVEL FLOW LENGTH, L _t [FT]	-	400.00
TRAVEL SLOPE, S _t [%]	-	2.00
AVERAGE TRAVEL VELOCITY, V _t [FT/SEC]	FIGURE 7-3	2.50
TRAVEL TIME, t _t [MIN]	-	2.67
COMPUTED TIME OF CONCENTRATION, t _c	L/180 + 10	31.42
TIME OF CONCENTRATION, t _c [MIN=5.0]	t _i +t _t	31.42
5-YR RUN-OFF COEFFICIENT, C ₅	TABLE 7-2	0.20
5-YR RAINFALL INTENSITY, I ₅ [IN/HR]	FIGURE 7-1	2.20
5-YR MAXIMUM RUN-OFF, Q ₅ [CFS]	Q=CIA	3.12
10-YR RUN-OFF COEFFICIENT, C ₁₀	TABLE 7-2	0.30
10-YR RAINFALL INTENSITY, I ₁₀ [IN/HR]	FIGURE 7-1	2.90
10-YR MAXIMUM RUN-OFF, Q ₁₀ [CFS]	Q=CIA	6.18
100-YR RUN-OFF COEFFICIENT, C ₁₀₀	TABLE 7-2	0.60
100-YR RAINFALL INTENSITY, I ₁₀₀ [IN/HR]	FIGURE 7-1	4.10
100-YR MAXIMUM RUN-OFF, Q ₁₀₀ [CFS]	Q=CIA	17.47

¹ City of Boulder Design and Construction Manual

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
 PROJECT NO: 20024
 DESIGN BY: DF
 REV. BY: DF
 AGENCY: Boulder
 REPORT TYPE: Final
 DATE: 8/13/2012



Drexel, Barrell & Co.

	C2*	C5*	C10*	C100*	% IMPERV
Lawns, Clayey Soil	0.10	0.20	0.30	0.60	0
Roof	0.80	0.85	0.90	0.90	90
Concrete Drives and Walks	0.87	0.87	0.88	0.89	96
Streets/Parking - Asphalt	0.87	0.88	0.90	0.93	100

*C-Values and Basin Imperviousness based on Table 602, Boulder County "Storm Drainage Criteria Manual"

SUB-BASIN	SURFACE DESIGNATION	AREA ACRE	COMPOSITE RUNOFF COEFFICIENTS				% IMPERV
			C2	C5	C10	C100	
A	Lawns, Clayey Soil	1.90	0.10	0.20	0.30	0.60	0
	Roof	0.33	0.80	0.85	0.90	0.90	90
	Concrete Drives and Walks	0.51	0.87	0.87	0.88	0.89	96
	Streets/Parking - Asphalt	3.94	0.87	0.88	0.90	0.93	100.00
	WEIGHTED AVERAGE		0.65	0.68	0.73	0.83	70.8
TOTAL A		6.68					
B	Lawns, Clayey Soil	0.76	0.10	0.20	0.30	0.60	0
	Roof	0.50	0.80	0.85	0.90	0.90	90
	Concrete Drives and Walks	0.34	0.87	0.87	0.88	0.89	96
	Streets/Parking - Asphalt	0.67	0.87	0.88	0.90	0.93	100.00
	WEIGHTED AVERAGE		0.60	0.64	0.70	0.81	63.7
TOTAL B		2.27					
TOTAL SITE		8.95	0.63	0.67	0.72	0.83	68.97

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Drexel, Barrell & Co

Table RO-2*

Type of Land Surface	Conveyance Coefficient, Cv
Heavy meadow	2.5
Tillage/Field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*Drainage Criteria Manual, Urban Drainage and Flood Control District, 2010

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED TIME OF CONCENTRATION STANDARD FORM SF-2

SUB-BASIN DATA				INITIAL/OVERLAND TIME (t _i)			TRAVEL TIME (t _t)				t _c CHECK (URBANIZED BASINS)			FINAL t _c
BASIN	DESIGN PT:	C _s	AREA	LENGTH	SLOPE	t _i	LENGTH	SLOPE	VEL.	t _t	COMP.	TOT. LENGTH	t _c =(L/180)+10	
			Ac	Ft	%	Min	Ft	%	FPS	Min	t _c	Ft	Min	Min
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
A	A	0.68	6.68	300	2.0	10.5	535	1.4	2.37	3.8	14.2	835	14.6	14.2
B	B	0.64	2.27	115	2.3	6.8	535	0.4	1.26	7.0	13.9	650	13.6	13.6

*Note - travel time velocity was calculated using a conveyance coefficient taken from Table RO-2 UDFCD

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RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 5 YR STORM P1= 1.45

BASIN (S)	DIRECT RUNOFF								TOTAL RUNOFF			
	DESIGN POINT	AREA	AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	6.68	0.68	14.2	4.57	3.37	15.42				
B	B	dev	2.27	0.64	13.6	1.46	3.44	5.04				
Total on-site									14.2	6.03	3.37	20.35

Note: Basin B is not tributary to pond

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RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 10 YR STORM P1= 1.72

BASIN (S)	DIRECT RUNOFF								TOTAL RUNOFF			
	DESIGN POINT	AREA	AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	6.68	0.68	14.2	4.57	4.00	18.29				
B	B	dev	2.27	0.64	13.6	1.46	4.08	5.97				
Total on-site									14.2	6.03	4.00	24.14

Note: Basin B is not tributary to pond

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RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 100 YR STORM P1= 2.70

BASIN (S)	DIRECT RUNOFF								TOTAL RUNOFF			
	DESIGN POINT	AREA	AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	6.68	0.83	14.2	5.56	6.28	34.88				
B	B	dev	2.27	0.81	13.6	1.83	6.41	11.74				
Total on-site									14.2	7.39	6.28	46.38

Note: Basin B is not tributary to pond

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RUNOFF SUMMARY				
BASIN (S)	AREA (AC)	Q5	Q10	Q100
A	6.68	15.42	18.29	34.88
B	2.27	5.04	5.97	11.74
Total on-site				46.4

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	C2*	C5*	C10*	C100*	% IMPERV
Lawns, Clayey Soil	0.10	0.20	0.30	0.60	0
Roof	0.80	0.85	0.90	0.90	90
Concrete Drives and Walks	0.87	0.87	0.88	0.89	96
Streets/Parking - Asphalt	0.87	0.88	0.90	0.93	100

*C-Values and Basin Imperviousness based on Table 602, Boulder County "Storm Drainage Criteria Manual"

SUB-BASIN	SURFACE DESIGNATION	AREA ACRE	COMPOSITE RUNOFF COEFFICIENTS				% IMPERV
			C2	C5	C10	C100	
A	Lawns, Clayey Soil	1.91	0.10	0.20	0.30	0.60	0
	Roof	0.49	0.80	0.85	0.90	0.90	90
	Concrete Drives and Walks	0.75	0.87	0.87	0.88	0.89	96
	Streets/Parking - Asphalt	3.53	0.87	0.88	0.90	0.93	100.00
	WEIGHTED AVERAGE		0.64	0.68	0.73	0.83	70.2
TOTAL A		6.68					
B	Lawns, Clayey Soil	0.76	0.10	0.20	0.30	0.60	0
	Roof	0.51	0.80	0.85	0.90	0.90	90
	Concrete Drives and Walks	0.33	0.87	0.87	0.88	0.89	96
	Streets/Parking - Asphalt	0.67	0.87	0.88	0.90	0.93	100.00
	WEIGHTED AVERAGE		0.60	0.64	0.70	0.81	63.7
TOTAL B		2.27					
TOTAL SITE		8.95	0.63	0.67	0.72	0.82	68.57

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Table RO-2*

Type of Land Surface	Conveyance Coefficient, Cv
Heavy meadow	2.5
Tillage/Field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*Drainage Criteria Manual, Urban Drainage and Flood Control District, 2010

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED TIME OF CONCENTRATION STANDARD FORM SF-2

SUB-BASIN DATA				INITIAL/OVERLAND TIME (t _i)			TRAVEL TIME (t _t)				t _c CHECK (URBANIZED BASINS)			FINAL t _c
BASIN	DESIGN PT:	C _s	AREA	LENGTH	SLOPE	t _i	LENGTH	SLOPE	VEL.	t _t	COMP.	TOT. LENGTH	t _c =(L/180)+10	
			Ac	Ft	%	Min	Ft	%	FPS	Min	t _c	Ft	Min	Min
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
A	A	0.68	6.68	300	2.0	10.5	535	1.4	2.37	3.8	14.3	835	14.6	14.3
B	B	0.64	2.27	115	2.3	6.8	535	0.4	1.26	7.0	13.9	650	13.6	13.6

*Note - travel time velocity was calculated using a conveyance coefficient taken from Table RO-2 UDFCD

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
 PROJECT NO: 20024
 DESIGN BY: DF
 REV. BY: DF
 AGENCY: Boulder
 REPORT TYPE: Final
 DATE: 8/13/2012



Drexel, Barrell & Co.

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 5 YR STORM P1= 1.45

BASIN (S)	DIRECT RUNOFF								TOTAL RUNOFF			
	DESIGN POINT	AREA	AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	6.68	0.68	14.3	4.56	3.37	15.34				
B	B	dev	2.27	0.64	13.6	1.46	3.44	5.03				
Total on-site									14.3	6.02	3.37	20.26

Note: Basin B is not tributary to pond

PROJECT INFORMATION

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Drexel, Barrell & Co.

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 10 YR STORM P1= 1.72

BASIN (S)	DESIGN POINT	AREA	DIRECT RUNOFF						TOTAL RUNOFF			
			AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	6.68	0.68	14.3	4.56	3.99	18.20				
B	B	dev	2.27	0.64	13.6	1.46	4.08	5.97				
Total on-site									14.3	6.02	3.99	24.04

Note: Basin B is not tributary to pond

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Drexel, Barrell & Co.

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 100 YR STORM P1= 2.70

BASIN (S)	DIRECT RUNOFF								TOTAL RUNOFF			
	DESIGN POINT	AREA	AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	6.68	0.83	14.3	5.54	6.27	34.71				
B	B	dev	2.27	0.81	13.6	1.83	6.41	11.74				
Total on-site									14.3	7.37	6.27	46.19

Note: Basin B is not tributary to pond

PROJECT INFORMATION

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Drexel, Barrell & Co.

RUNOFF SUMMARY				
BASIN (S)	AREA (AC)	Q5	Q10	Q100
A	6.68	15.34	18.20	34.71
B	2.27	5.03	5.97	11.74
Total on-site				46.2
Note: Basin B is not tributary to pond				

PROJECT INFORMATION

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Drexel, Barrell & Co.

	C2*	C5*	C10*	C100*	% IMPERV
Lawns, Clayey Soil	0.10	0.20	0.30	0.60	0
Roof	0.80	0.85	0.90	0.90	90
Concrete Drives and Walks	0.87	0.87	0.88	0.89	96
Streets/Parking - Asphalt	0.87	0.88	0.90	0.93	100

*C-Values and Basin Imperviousness based on Table 602, Boulder County "Storm Drainage Criteria Manual"

SUB-BASIN	SURFACE DESIGNATION	AREA ACRE	COMPOSITE RUNOFF COEFFICIENTS				% IMPERV
			C2	C5	C10	C100	
A	Lawns, Clayey Soil	2.25	0.10	0.20	0.30	0.60	0
	Roof	0.64	0.80	0.85	0.90	0.90	90
	Concrete Drives and Walks	1.05	0.87	0.87	0.88	0.89	96
	Streets/Parking - Asphalt	3.16	0.87	0.88	0.90	0.93	100.00
	WEIGHTED AVERAGE		0.62	0.66	0.71	0.82	66.8
TOTAL A		7.10					
B	Lawns, Clayey Soil	0.67	0.10	0.20	0.30	0.60	0
	Roof	0.68	0.80	0.85	0.90	0.90	90
	Concrete Drives and Walks	0.25	0.87	0.87	0.88	0.89	96
	Streets/Parking - Asphalt	0.30	0.87	0.88	0.90	0.93	100.00
	WEIGHTED AVERAGE		0.57	0.63	0.69	0.80	60.6
TOTAL B		1.90					
TOTAL SITE		9.00	0.61	0.65	0.70	0.81	65.51

PROJECT INFORMATION

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Table RO-2*

Type of Land Surface	Conveyance Coefficient, Cv
Heavy meadow	2.5
Tillage/Field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20



Drexel, Barrell & Co

*Drainage Criteria Manual, Urban Drainage and Flood Control District, 2010

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED TIME OF CONCENTRATION STANDARD FORM SF-2

SUB-BASIN DATA				INITIAL/OVERLAND TIME (t _i)			TRAVEL TIME (t _t)				t _c CHECK (URBANIZED BASINS)			FINAL t _c
BASIN	DESIGN PT:	C _s	AREA	LENGTH	SLOPE	t _i	LENGTH	SLOPE	VEL.	t _t	COMP.	TOT. LENGTH	t _c =(L/180)+10	
			Ac	Ft	%	Min	Ft	%	FPS	Min	t _c	Ft	Min	Min
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
A	A	0.66	7.10	300	2.0	11.1	535	1.4	2.37	3.8	14.8	835	14.6	14.6
B	B	0.63	1.90	115	2.3	7.1	535	0.4	1.26	7.0	14.1	650	13.6	13.6

*Note - travel time velocity was calculated using a conveyance coefficient taken from Table RO-2 UDFCD

PROJECT INFORMATION

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Drexel, Barrell & Co.

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 5 YR STORM P1= 1.45

BASIN (S)	DIRECT RUNOFF								TOTAL RUNOFF			
	DESIGN POINT	AREA	AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	7.10	0.66	14.6	4.69	3.33	15.61				
B	B	dev	1.90	0.63	13.6	1.19	3.44	4.11				
Total on-site									14.6	5.88	3.33	19.58

Note: Basin B is not tributary to pond

PROJECT INFORMATION

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Drexel, Barrell & Co.

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 10 YR STORM P1= 1.72

BASIN (S)	DIRECT RUNOFF								TOTAL RUNOFF			
	DESIGN POINT	AREA	AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	7.10	0.66	14.6	4.69	3.95	18.52				
B	B	dev	1.90	0.63	13.6	1.19	4.08	4.87				
Total on-site									14.6	5.88	3.95	23.23

Note: Basin B is not tributary to pond

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Drexel, Barrell & Co.

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 100 YR STORM P1= 2.70

BASIN (S)	DIRECT RUNOFF								TOTAL RUNOFF			
	DESIGN POINT	AREA	AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	7.10	0.82	14.6	5.80	6.20	35.96				
B	B	dev	1.90	0.80	13.6	1.52	6.41	9.72				
Total on-site									14.6	7.31	6.20	45.35

Note: Basin B is not tributary to pond

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
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Drexel, Barrell & Co.

RUNOFF SUMMARY				
BASIN (S)	AREA (AC)	Q5	Q10	Q100
A	7.10	15.61	18.52	35.96
B	1.90	4.11	4.87	9.72
Total on-site				45.4
Note: Basin B is not tributary to pond				

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
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Drexel, Barrell & Co.

	C2*	C5*	C10*	C100*	% IMPERV
Lawns, Clayey Soil	0.10	0.20	0.30	0.60	0
Roof	0.80	0.85	0.90	0.90	90
Concrete Drives and Walks	0.87	0.87	0.88	0.89	96
Streets/Parking - Asphalt	0.87	0.88	0.90	0.93	100

*C-Values and Basin Imperviousness based on Table 602, Boulder County "Storm Drainage Criteria Manual"

SUB-BASIN	SURFACE DESIGNATION	AREA ACRE	COMPOSITE RUNOFF COEFFICIENTS				% IMPERV	
			C2	C5	C10	C100		
A	Lawns, Clayey Soil	0.82	0.10	0.20	0.30	0.60	0	
	Roof	1.31	0.80	0.85	0.90	0.90	90	
	Concrete Drives and Walks	1.13	0.87	0.87	0.88	0.89	96	
	Streets/Parking - Asphalt	3.84	0.87	0.88	0.90	0.93	100.00	
	WEIGHTED AVERAGE		0.77	0.79	0.83	0.88	86.0	
TOTAL A		7.10						
B	Lawns, Clayey Soil	0.62	0.10	0.20	0.30	0.60	0	
	Roof	0.68	0.80	0.85	0.90	0.90	90	
	Concrete Drives and Walks	0.25	0.87	0.87	0.88	0.89	96	
	Streets/Parking - Asphalt	0.30	0.87	0.88	0.90	0.93	100.00	
	WEIGHTED AVERAGE		0.59	0.64	0.70	0.80	62.3	
TOTAL B		1.85						
TOTAL SITE			8.95	0.73	0.76	0.80	0.86	81.07

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
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Table RO-2*

Type of Land Surface	Conveyance Coefficient, Cv
Heavy meadow	2.5
Tillage/Field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20



Drexel, Barrell & Co

*Drainage Criteria Manual, Urban Drainage and Flood Control District, 2010

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED TIME OF CONCENTRATION STANDARD FORM SF-2

SUB-BASIN DATA				INITIAL/OVERLAND TIME (t _i)			TRAVEL TIME (t _t)				t _c CHECK (URBANIZED BASINS)			FINAL t _c
BASIN	DESIGN PT:	C _s	AREA	LENGTH	SLOPE	t _i	LENGTH	SLOPE	VEL.	t _t	COMP.	TOT. LENGTH	t _c =(L/180)+10	
			Ac	Ft	%	Min	Ft	%	FPS	Min	t _c	Ft	Min	Min
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
A	A	0.79	7.10	300	2.0	7.7	535	1.4	2.37	3.8	11.5	835	14.6	11.5
B	B	0.64	1.85	115	2.3	6.9	535	0.4	1.26	7.0	14.0	650	13.6	13.6

*Note - travel time velocity was calculated using a conveyance coefficient taken from Table RO-2 UDFCD

PROJECT INFORMATION

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RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 5 YR STORM P1= 1.45

BASIN (S)	DIRECT RUNOFF								TOTAL RUNOFF			
	DESIGN POINT	AREA	AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	7.10	0.79	11.5	5.64	3.71	20.92				
B	B	dev	1.85	0.64	13.6	1.18	3.44	4.07				
Total on-site									13.6	6.82	3.44	23.49

Note: Basin B is not tributary to pond

PROJECT INFORMATION

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Drexel, Barrell & Co.

RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 10 YR STORM P1= 1.72

BASIN (S)	DESIGN POINT	AREA	DIRECT RUNOFF						TOTAL RUNOFF			
			AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	7.10	0.79	11.5	5.64	4.40	24.82				
B	B	dev	1.85	0.64	13.6	1.18	4.08	4.83				
Total on-site									13.6	6.82	4.08	27.87

Note: Basin B is not tributary to pond

PROJECT INFORMATION

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RATIONAL METHOD CALCULATIONS FOR STORM WATER RUNOFF

DEVELOPED RUNOFF 100 YR STORM P1= 2.70

BASIN (S)	DIRECT RUNOFF								TOTAL RUNOFF			
	DESIGN POINT	AREA	AREA (AC)	RUNOFF COEFF	t _c (MIN)	C * A	I (IN/HR)	Q (CFS)	t _c (MIN)	S (C * A)	I (IN/HR)	Q (CFS)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	A	dev	7.10	0.88	11.5	6.25	6.91	43.16				
B	B	dev	1.85	0.80	13.6	1.49	6.41	9.52				
Total on-site									13.6	7.73	6.41	49.58

Note: Basin B is not tributary to pond

PROJECT INFORMATION

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Drexel, Barrell & Co.

RUNOFF SUMMARY				
BASIN (S)	AREA (AC)	Q5	Q10	Q100
A	7.10	20.92	24.82	43.16
B	1.85	4.07	4.83	9.52
Total on-site				49.6
Note: Basin B is not tributary to pond				

Design Procedure Form: Extended Detention Basin (EDB) - Sedimentation Facility

Sheet 1 of 3

Designer: DF
Company: Drexel, Barrell & Co
Date: August 13, 2012
Project: 20024
Location: 6400 arapahoe

<p>1. Basin Storage Volume</p> <p>A) Tributary Area's Imperviousness Ratio ($i = I_a / 100$)</p> <p>B) Contributing Watershed Area (Area)</p> <p>C) Water Quality Capture Volume (WQCV) ($WQCV = 1.0 * (0.91 * I^3 - 1.19 * I^2 + 0.78 * I)$)</p> <p>D) Design Volume: $Vol = (WQCV / 12) * Area * 1.2$</p>	<p>$I_a =$ <u>86.00</u> %</p> <p>$i =$ <u>0.86</u></p> <p>Area = <u>7.100</u> acres</p> <p>WQCV = <u>0.37</u> watershed inches</p> <p>Vol = <u>0.2623</u> acre-feet</p>
<p>2. Outlet Works</p> <p>A) Outlet Type (Check One)</p> <p>B) Depth at Outlet Above Lowest Perforation (H)</p> <p>C) Recommended Maximum Outlet Area per Row, (A_o)</p> <p>D) Perforation Dimensions: i) Circular Perforation Diameter or ii) Width of 2" High Rectangular Perforations</p> <p>E) Number of Columns (nc, See Table 6a-1 For Maximum)</p> <p>F) Actual Design Outlet Area per Row (A_o)</p> <p>G) Number of Rows (nr)</p> <p>H) Total Outlet Area (A_{ot})</p>	<p><input checked="" type="checkbox"/> Orifice Plate</p> <p><input type="checkbox"/> Perforated Riser Pipe</p> <p><input type="checkbox"/> Other: _____</p> <hr/> <p>H = <u>2.70</u> feet</p> <p>$A_o =$ <u>0.5</u> square inches</p> <p>D = <u>0.625</u> inches</p> <p>W = _____ inches</p> <p>nc = <u>1</u> number</p> <p>$A_o =$ <u>0.3</u> square inches</p> <p>nr = <u>8</u> number</p> <p>$A_{ot} =$ <u>2.5</u> square inches</p>
<p>3. Trash Rack</p> <p>A) Needed Open Area: $A_t = 0.5 * (\text{Figure 7 Value}) * A_{ot}$</p> <p>B) Type of Outlet Opening (Check One)</p> <p>C) For 2", or Smaller, Round Opening (Ref.: Figure 6a): i) Width of Trash Rack and Concrete Opening (W_{conc}) from Table 6a-1 ii) Height of Trash Rack Screen (H_{TR})</p>	<p>$A_t =$ <u>89</u> square inches</p> <p><input checked="" type="checkbox"/> $\leq 2"$ Diameter Round</p> <p><input type="checkbox"/> 2" High Rectangular</p> <p><input type="checkbox"/> Other: _____</p> <hr/> <p>$W_{conc} =$ <u>3</u> inches</p> <p>$H_{TR} =$ <u>65</u> inches</p>

PROJECT INFORMATION

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STORM 10 YEAR DEVELOPED P1= 1.72
 AREA ACRES 7.10 I= $(28.5 * P1 / (10 + t_c))^{.786}$
 RUNOFF C 0.80
 Adjusted release rate= 6.18 = exist rate tc to pond 11.5
 Compensating rel = 4.87
Allowable release rate= 1.31

TIME MIN	RAINFAL IN/HR	VOL. IN CU. FT.	ADJUST FACTOR	REL. RAT CFS	ADJ REL RATE	VOL. OUT CU. FT.	STORAGE CU. FT.	STORAG AC. FT.	COMMENTS
5	6.02	10348	1.00	1.31	1.31	393	9955	0.229	
10	4.67	16056	1.00	1.31	1.31	786	15270	0.351	
15	3.94	20319	0.88	1.31	1.16	1179	19140	0.439	
20	3.38	23265	0.79	1.31	1.03	1572	21693	0.498	
25	3.00	25762	0.73	1.31	0.96	1965	23797	0.546	
30	2.73	28157	0.69	1.31	0.91	2358	25799	0.592	
35	2.46	29602	0.66	1.31	0.87	2751	26851	0.616	
40	2.26	31142	0.64	1.31	0.84	3144	27998	0.643	
45	2.10	32507	0.63	1.31	0.82	3537	28970	0.665	
50	1.96	33731	0.61	1.31	0.81	3930	29801	0.684	
55	1.84	34841	0.60	1.31	0.79	4323	30518	0.701	
60	1.73	35687	0.60	1.31	0.78	4716	30971	0.711	
65	1.73	38661	0.59	1.31	0.77	5109	33552	0.770	
70	1.73	41635	0.58	1.31	0.76	5502	36133	0.829	
75	1.73	44608	0.58	1.31	0.76	5895	38713	0.889	PEAK
80	1.33	36581	0.57	1.31	0.75	6288	30293	0.695	
85	1.01	29516	0.57	1.31	0.74	6681	22835	0.524	
90	1.01	31252	0.56	1.31	0.74	7074	24178	0.555	
95	1.01	32988	0.56	1.31	0.73	7467	25521	0.586	
100	1.01	34724	0.56	1.31	0.73	7860	26864	0.617	
105	1.01	36460	0.55	1.31	0.73	8253	28207	0.648	
110	1.01	38197	0.55	1.31	0.72	8646	29551	0.678	
115	0.9	35584	0.55	1.31	0.72	9039	26545	0.609	
120	0.69	28467	0.55	1.31	0.72	9432	19035	0.437	

TOTAL REQUIRED VOLUME = PEAK + WQ= **0.889 + 0.2623 = 1.15 AC FT**

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
 PROJECT NO: 20024
 DESIGN BY: DF
 REV. BY: DF
 AGENCY: Boulder
 REPORT TYPE: Final
 DATE: 8/10/2012



STORM 100 YR DEVELOPED PHASE II P1= 2.70
 AREA ACRES 7.10 I= (28.5*P1)/(10+t_c)^{.786}
 RUNOFF C 0.80
 Adjusted release rate= 17.47 = exist rate cfs/ac tc to pond 11.5
 Compensating rel = 9.72
Allowable release rate= 7.75

TIME	RAINFALL	VOL. IN	ADJUST	REL. RAT	ADJ REL	VOL. OUT	STORAGE	STORAG	COMMENTS
MIN	IN/HR	CU. FT.	FACTOR	CFS	RATE	CU. FT.	CU. FT.	AC. FT.	
5	6.02	10348	1.00	7.75	7.75	2325	8023	0.184	
10	4.67	16056	1.00	7.75	7.75	4650	11406	0.262	
15	3.94	20319	0.88	7.75	6.84	6975	13344	0.306	
20	5.31	36520	0.79	7.75	6.10	9300	27220	0.625	
25	4.71	40441	0.73	7.75	5.65	11625	28816	0.662	
30	2.73	28157	0.69	7.75	5.36	13950	14207	0.326	
35	3.86	46469	0.66	7.75	5.15	16275	30194	0.693	
40	3.55	48886	0.64	7.75	4.99	18600	30286	0.695	PEAK
45	3.30	51028	0.63	7.75	4.86	20925	30103	0.691	
50	3.08	52949	0.61	7.75	4.76	23250	29699	0.682	
55	2.89	54693	0.60	7.75	4.68	25575	29118	0.668	
60	1.73	35687	0.60	7.75	4.62	27900	7787	0.179	

TOTAL REQUIRED VOLUME = PEAK + 1/2 WQ= 0.695 + 0.13115 = 0.83 AC FT

FINAL REQUIRED VOLUME = MAX OF 10 YR OR 100 YR = 1.15 AC FT

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
 PROJECT NO: 20024
 DESIGN BY: DF
 REV. BY: DF
 AGENCY: Boulder
 REPORT TYPE: Final
 DATE: 8/10/2012



Drexel, Barrell & Co.

ELEV.	AREA	VOL	ACCUM.	ACCUM
		CF	VOL CF	VOL AF
5241.7	1		0	
5242.0	300	32	32	0.001
5243.0	4150	1855	1887	0.043
5244.0	7610	5793	7680	0.176
5245.0	9120	8354	16034	0.368
5246.0	10775	9936	25970	0.596
5247.0	12515	11634	37604	0.863
5248.0	14375	13434	51038	1.172

5244.4 =WQ WSEL

5247.1 =10-yr WSEL

5247.9 =100-yr WSEL

	WQCV =	0.2623 AC FT =	11426 CU FT
--	--------	----------------	-------------

APPENDIX D: HYDRAULIC CALCULATIONS

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
 PROJECT NO: 20024
 DESIGN BY: DF
 REV. BY: DF
 AGENCY: Boulder
 REPORT TYPE: Final
 DATE: 8/10/2012



Drexel, Barrell & Co.

WEIR CALCS

Return interval (yr) 10.0
 Crest elevation 5244.4
 Weir eq $Q=CLH^{1.5}$
 DEPTH INCREMENT 0.10
 Allowable release rate (cfs) 1.31
 Weir coefficient 3.40

10 YEAR WEIR

Solve for length (ft)		$L=Q/(CH^{1.5})$
WS. ELEV	C	Q
5244.5	3.40	12.2
5244.6	3.40	4.3
5244.7	3.40	2.3
5244.8	3.40	1.5
5244.9	3.40	1.1
5245.0	3.40	0.8
5245.1	3.40	0.7
5245.2	3.40	0.5
5245.3	3.40	0.5
5245.4	3.40	0.4

Solve for height		$H=(Q/CL)^{(2/3)}$
trial length	ft	0.39
WS. ELEV	C	H
5245.4	3.40	0.99

NOTE:
 SOLUTION FOR HEIGHT WAS USED

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
 PROJECT NO: 20024
 DESIGN BY: DF
 REV. BY: DF
 AGENCY: Boulder
 REPORT TYPE: Final
 DATE: 8/10/2012



Drexel, Barrell & Co.

WEIR CALCS

Return interval (yr) 100.0
 Crest elevation 5247.1
 Weir eq $Q=CLH^{1.5}$
 DEPTH INCREMENT 0.10
 Allowable release rate (cfs) 7.75
 Weir coefficient 3.40

100.0 YEAR GRATE CHECK

Solve for length (ft)		$L=Q/(CH^{1.5})$
WS. ELEV	C	Q
5247.2	3.40	72.1
5247.3	3.40	25.5
5247.4	3.40	13.9
5247.5	3.40	9.0
5247.6	3.40	6.4
5247.7	3.40	4.9
5247.8	3.40	3.9
5247.9	3.40	3.2
5248.0	3.40	2.7
5248.1	3.40	2.3
5248.2	3.40	2.0
5248.3	3.40	1.7
5248.4	3.40	1.5
5248.5	3.40	1.4
5248.6	3.40	1.2
5248.7	3.40	1.1
5248.8	3.40	1.0
5248.9	3.40	0.9

Solve for height		$H=(Q/CL)^{(2/3)}$
trial length	ft	6.50
WS. ELEV	C	H
5247.6	3.40	0.50

NOTE:
 SOLUTION FOR LENGTH WAS USED
 REQUIRED LENGTH < TYPE C GRATE

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
 PROJECT NO: 20024
 DESIGN BY: DF
 REV. BY: DF
 AGENCY: Boulder
 REPORT TYPE: Final
 DATE: 8/10/2012



Drexel, Barrell & Co.

WEIR CALCS

Return interval (yr) 100.0
 Crest elevation 5247.93
 Weir eq $Q=CLH^{1.5}$
 DEPTH INCREMENT 0.10
 Allowable release rate (cfs) 7.75
 Weir coefficient 3.40

100 YEAR OVERFLOW WEIR

Solve for length (ft)		$L=Q/(CH^{1.5})$
WS. ELEV	C	Q
5248.0	3.40	72.1
5248.1	3.40	25.5
5248.2	3.40	13.9
5248.3	3.40	9.0
5248.4	3.40	6.4
5248.5	3.40	4.9
5248.6	3.40	3.9
5248.7	3.40	3.2
5248.8	3.40	2.7
5248.9	3.40	2.3

Solve for height		$H=(Q/CL)^{(2/3)}$
trial length	ft	6.50
WS. ELEV	C	H
5248.4	3.40	0.50

NOTE:
 SOLUTION FOR HEIGHT WAS USED

PROJECT INFORMATION

PROJECT: 6400 Arapahoe
 PROJECT NO: 20024
 DESIGN BY: DF
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 AGENCY: Boulder
 REPORT TYPE: Final
 DATE: 8/10/2012



ORIFICE CALCULATIONS

Formulas

$$(3) = \arccos \left[\frac{(2) - (1)}{(2)} \right]$$

$$(4) = (3) - \sin(3) * \cos(3)$$

$$(5) = (2)^2 * (4)$$

$$(6) = (5) / 144$$

$$(7) = \text{pipe inv} + (2)$$

$$(8) = \text{WSEL} - (7) + [2/3 * (2) * \sin(3)^3 / (4)]$$

$$(9) = 0.6 * (6) * [2 * g * (8)]^{0.5}$$

CALCULATIONS IN RADIANS

100 YEAR ORIFICE PLATE OVER OUTFLOW PIPE

input

RELEASE RATE =

7.75 cfs

5247.93 Water Surface Elev (WSEL)
 30.00 Pipe Diam (in)
 5241.60 Invert

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Inv to Plate (in)	Pipe Radius (in)	alpha (rad)	alpha - sin(alpha)* cos(alpha) (rad)	Area (sq in)	Area (sq ft)	Spring Elev	Head H (ft)	Q (cfs)
0.50	15	0.258922	0.011418	2.57	0.018	5242.85	6.31	0.22
1.00	15	0.367208	0.032131	7.23	0.050	5242.85	6.28	0.60
1.50	15	0.451027	0.058726	13.21	0.092	5242.85	6.26	1.11
2.00	15	0.522315	0.089946	20.24	0.141	5242.85	6.23	1.69
2.50	15	0.585686	0.125043	28.13	0.195	5242.85	6.21	2.34
3.00	15	0.643501	0.163501	36.79	0.255	5242.85	6.18	3.05
3.50	15	0.697163	0.204928	46.11	0.320	5242.85	6.16	3.82
4.00	15	0.747584	0.249013	56.03	0.389	5242.85	6.13	4.64
4.50	15	0.795399	0.295499	66.49	0.462	5242.85	6.11	5.50
5.00	15	0.841069	0.344165	77.44	0.538	5242.85	6.09	6.39
5.50	15	0.884943	0.394819	88.83	0.617	5242.85	6.06	7.31
6.00	15	0.927295	0.447295	100.64	0.699	5242.85	6.04	8.27
6.50	15	0.968342	0.501439	112.82	0.783	5242.85	6.01	9.24
7.00	15	1.008260	0.557111	125.35	0.870	5242.85	5.99	10.25

Table Rating Table for Circular Channel

Project Description	
Worksheet	RCP
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Full Flow Capacity

Input Data	
Mannings Coefficient	0.015

Attribute	Minimum	Maximum	Increment
Slope (ft/ft)	0.005000	0.020000	0.005000
Diameter (in)	18	36	6

Slope (ft/ft)	Diameter (in)	Discharge (cfs)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.005000	18	6.44	1.50	3.64	1.8	4.71	0.00
0.010000	18	9.10	1.50	5.15	1.8	4.71	0.00
0.015000	18	11.15	1.50	6.31	1.8	4.71	0.00
0.020000	18	12.87	1.50	7.29	1.8	4.71	0.00
0.005000	24	13.86	2.00	4.41	3.1	6.28	0.00
0.010000	24	19.61	2.00	6.24	3.1	6.28	0.00
0.015000	24	24.01	2.00	7.64	3.1	6.28	0.00
0.020000	24	27.73	2.00	8.83	3.1	6.28	0.00
0.005000	30	25.13	2.50	5.12	4.9	7.85	0.00
0.010000	30	35.55	2.50	7.24	4.9	7.85	0.00
0.015000	30	43.54	2.50	8.87	4.9	7.85	0.00
0.020000	30	50.27	2.50	10.24	4.9	7.85	0.00
0.005000	36	40.87	3.00	5.78	7.1	9.42	0.00
0.010000	36	57.80	3.00	8.18	7.1	9.42	0.00
0.015000	36	70.79	3.00	10.02	7.1	9.42	0.00
0.020000	36	81.74	3.00	11.56	7.1	9.42	0.00

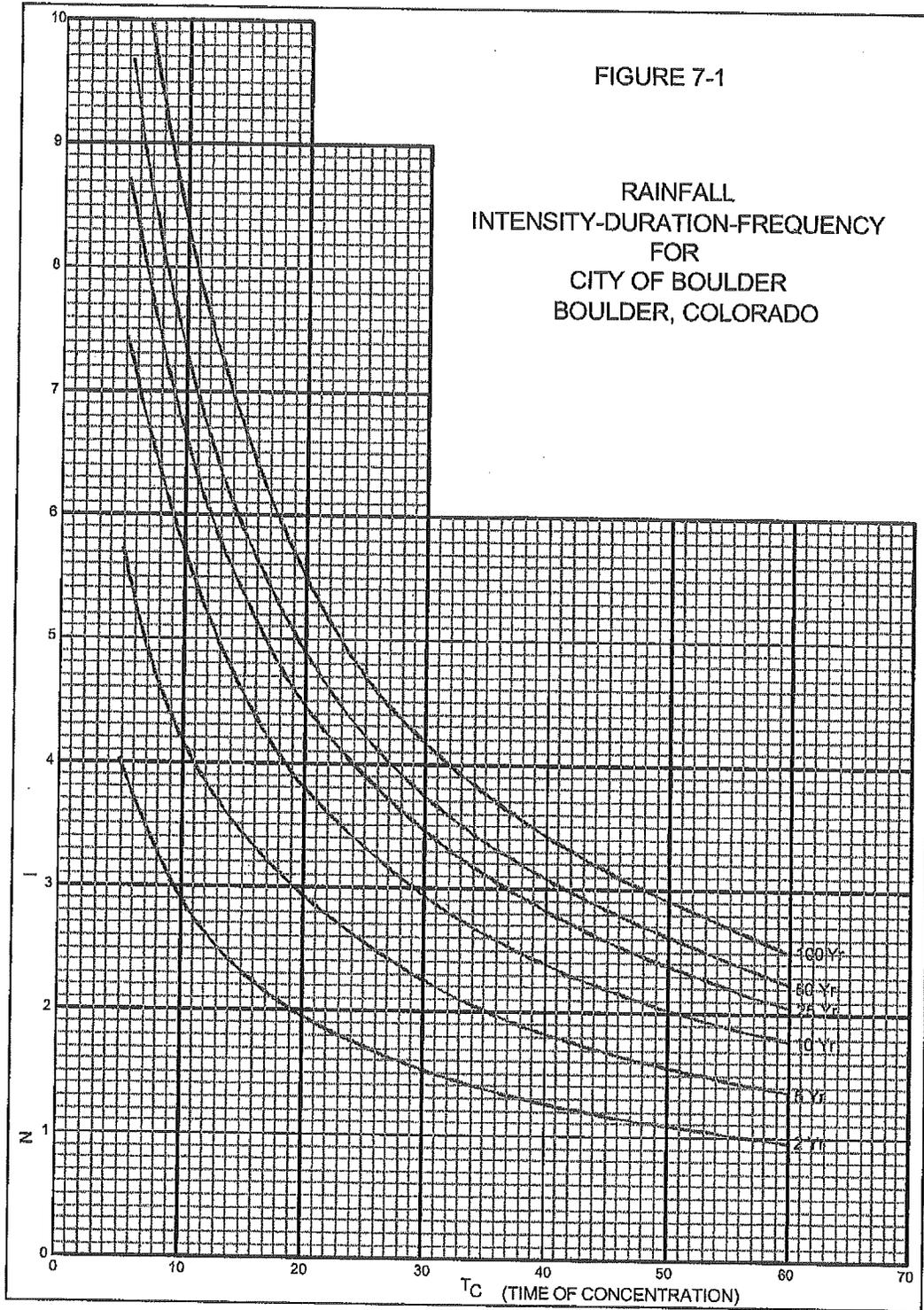
← NEW 18" ON SITE (PRIVATE)

← POND OUT

APPENDIX E: STANDARD TABLES AND FIGURES

FIGURE 7-1

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



T

FIGURE 7-3: TIME OF TRAVEL

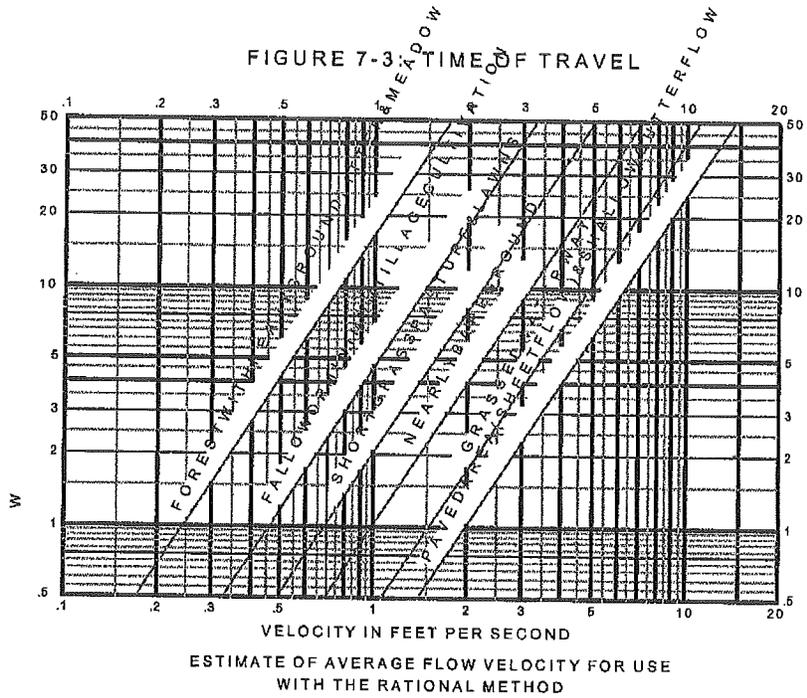
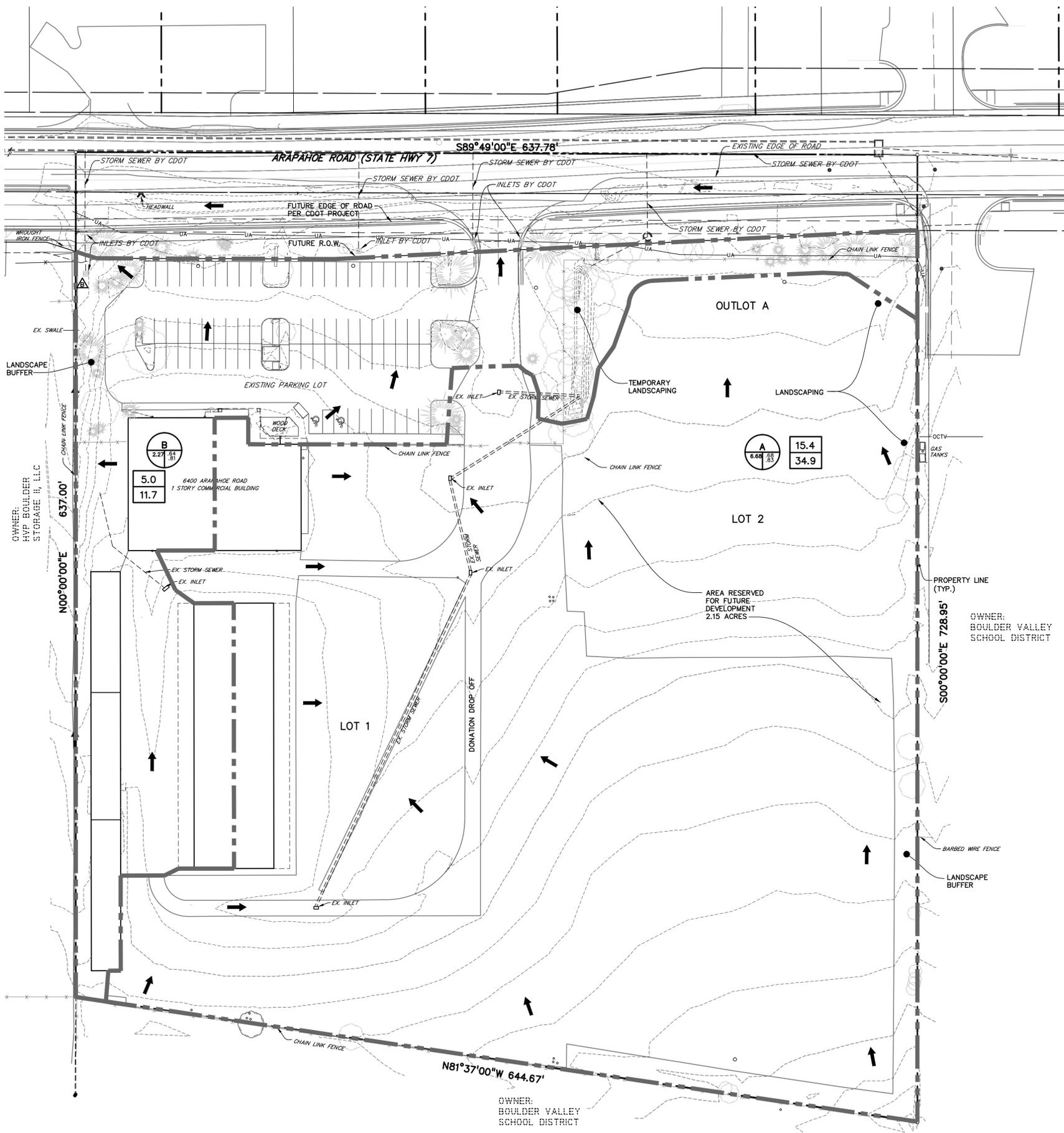


Table 7-2: Runoff Coefficients for the Rational Method

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	0.87	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.

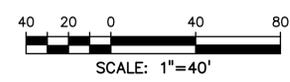
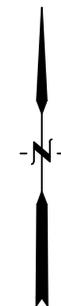
(Source: Urban Drainage and Flood Control District)



LEGEND

- DRAINAGE BASIN BOUNDARY.....
- DRAINAGE BASIN DESIGN POINT.....
- 10 YEAR PROPOSED FLOW (cfs).....
- 100 YEAR PROPOSED FLOW (cfs).....
- BASIN I.D. (A-3).....
- BASIN AREA (Acres).....
- 10 YEAR RUNOFF COEFFICIENT.....
- 100 YEAR RUNOFF COEFFICIENT.....
- PROPOSED INTERMEDIATE CONTOUR..... 5588
- PROPOSED INDEX CONTOUR..... 5590
- PROPOSED SPOT ELEVATION (ALL C&G ELEVATIONS ARE E U.N.D.)..... x 54.67
- EX. INTERMEDIATE CONTOUR..... 5364
- EX. INDEX CONTOUR..... 5365
- EX. SPOT ELEVATIONS..... x 45.34
- DIRECTION OF FLOW.....
- 100 YEAR DETENTION POND OVERFLOW.....
- FLOWLINE..... E or FL
- PROPOSED STORM SEWER..... 18" RCP
- EX. STORM CULVERT OR LARGE DIAMETER STORM SEWER..... EX. 54" CMP
- EX. STORM SEWER..... EX. 18" RCP STORM ST
- EX. MANHOLE.....

RUNOFF SUMMARY				
BASIN (S)	AREA (AC)	Q5	Q10	Q100
A	6.68	15.42	18.29	34.88
B	2.27	5.04	5.97	11.74
Total on-site				46.4



4.	8/06/12	TECH DOC REVISIONS PER CITY OF BOULDER
3.	7/02/12	TECH DOC REVISIONS PER CITY OF BOULDER
2.	6/04/12	TECH DOC REVISIONS PER CITY OF BOULDER
1.	3/5/12	TECH DOC SUBMISSION
NO.	DATE	REVISION

PEH ARCHITECTS
 1319 Spruce Street Suite 207
 Boulder, CO 80302
 303-442-0408, fax: 303-447-1905
 e-mail: peheinz@peharchitects.com

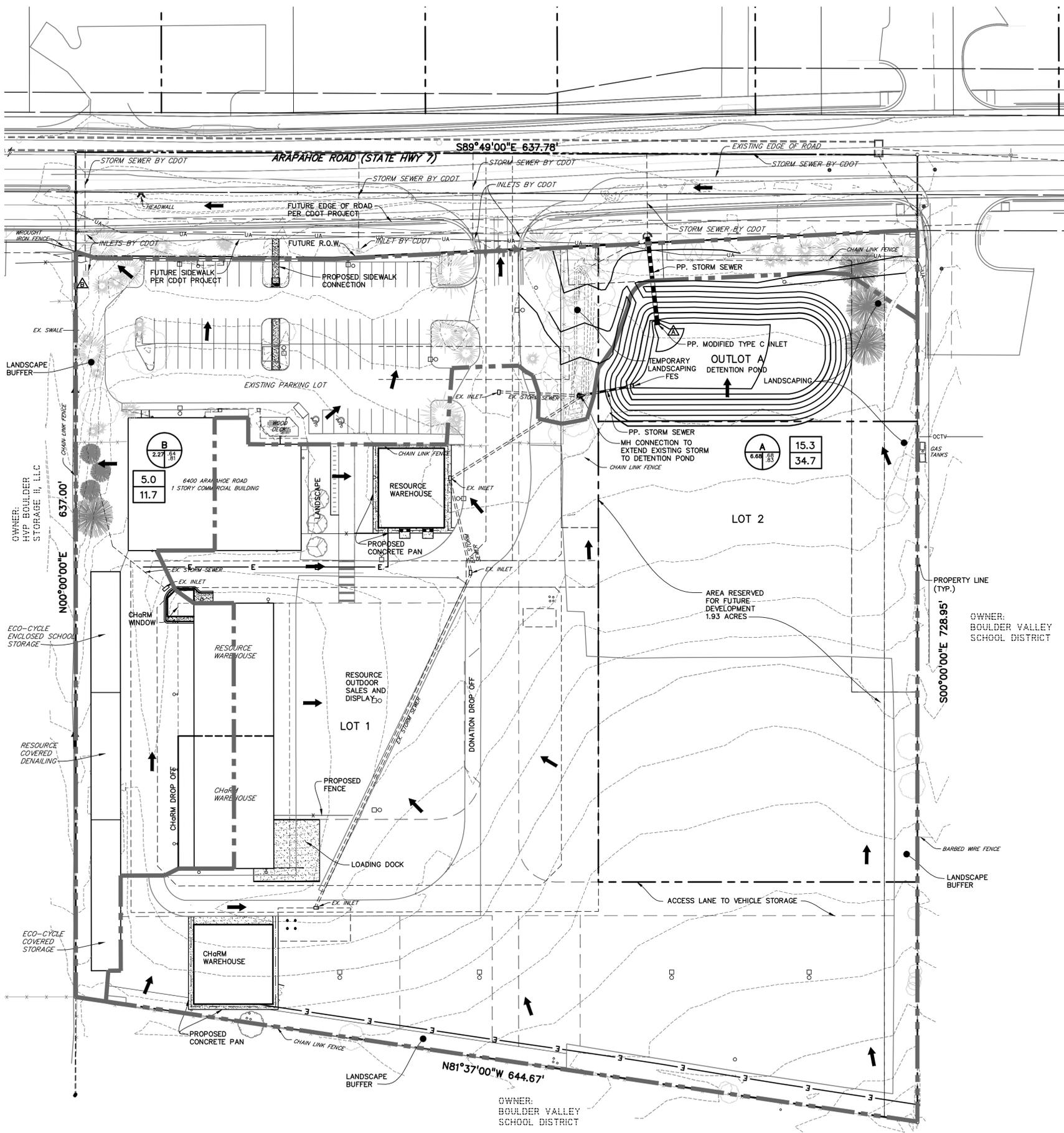
City of Boulder, Eco-Cycle, CHaRM, ReSource

6400 ARAPAHOE ROAD
 BOULDER, CO 80303

TECHNICAL DOCUMENTS
 C.O.B. CASE # _____

SHEET TITLE
STORMWATER PLAN
EXISTING

PROJECT: 2010.02		SHEET NUMBER
DATE: 2/13/12		DR O
DRAWN BY: MAA		OF
CHECKED BY: MH		



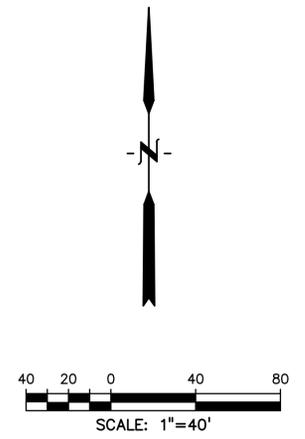
LEGEND

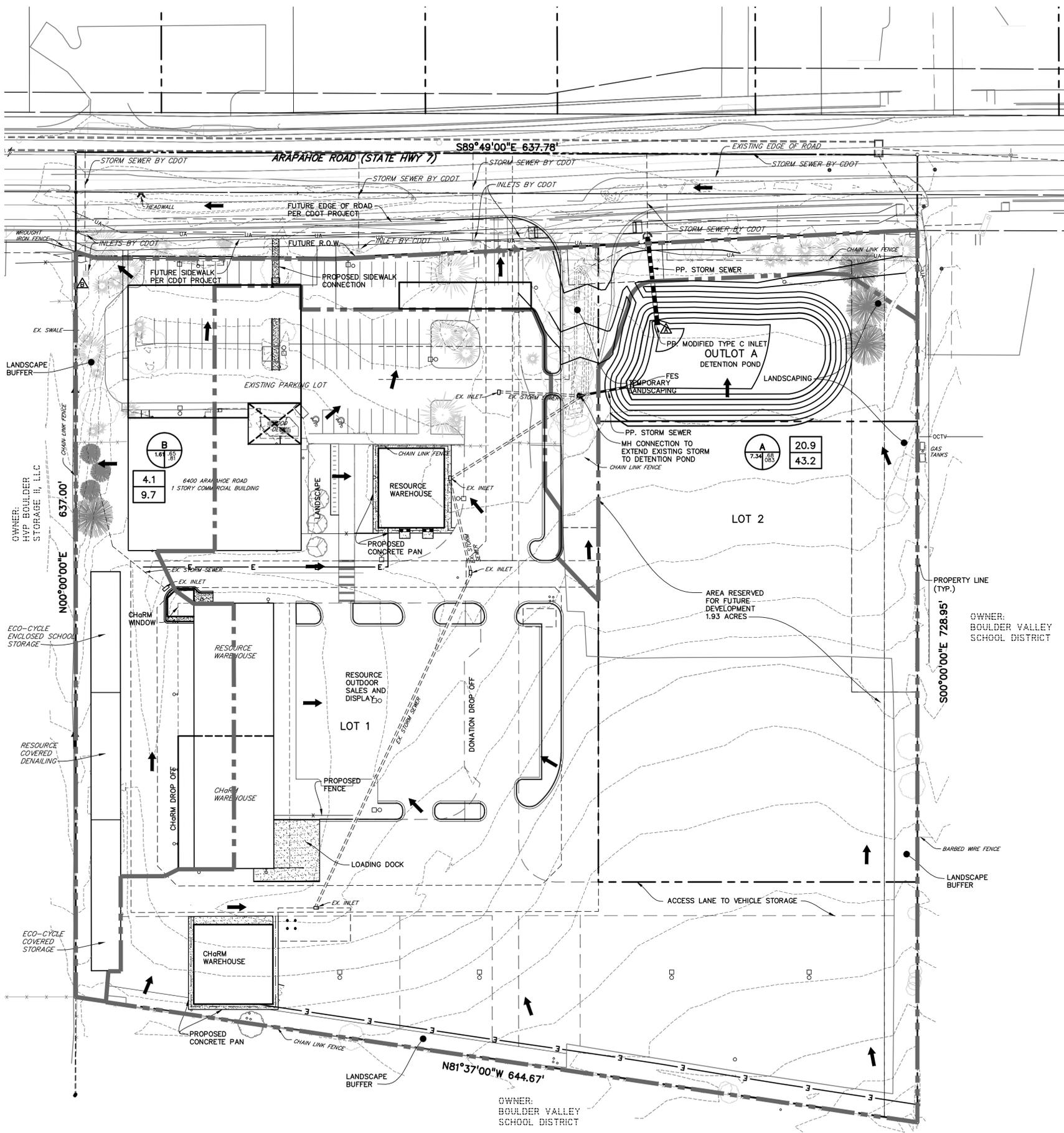
- DRAINAGE BASIN BOUNDARY.....
- DRAINAGE BASIN DESIGN POINT.....
- 10 YEAR PROPOSED FLOW (cfs).....
- 100 YEAR PROPOSED FLOW (cfs).....
- BASIN I.D. (A-3).....
- BASIN AREA (Acres).....
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- DIRECTION OF FLOW.....
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- EX. STORM CULVERT OR LARGE DIAMETER STORM SEWER..... EX. 54" CMP
- EX. STORM SEWER..... EX. 18" RCP STORM ST
- EX. MANHOLE.....

RUNOFF SUMMARY				
BASIN (S)	AREA (AC)	Q5	Q10	Q100
A	6.68	15.34	18.20	34.71
B	2.27	5.03	5.97	11.74
Total on-site				46.2

Note: Basin B is not tributary to pond

5. 8/10/12 TECH DOC REVISIONS PER CITY OF BOULDER 4. 8/06/12 TECH DOC REVISIONS PER CITY OF BOULDER 3. 7/02/12 TECH DOC REVISIONS PER CITY OF BOULDER 2. 6/04/12 TECH DOC REVISIONS PER CITY OF BOULDER 1. 3/5/12 TECH DOC SUBMISSION NO. DATE REVISION		
PEH ARCHITECTS 1319 Spruce Street Suite 207 Boulder, CO 80302 303-442-0408, fax: 303-447-1905 e-mail: peheinz@peharchitects.com		
City of Boulder, Eco-Cycle, ChARM, ReSource 6400 ARAPAHOE ROAD BOULDER, CO 80303 TECHNICAL DOCUMENTS C.O.B. CASE # _____		
SHEET TITLE STORMWATER PLAN PHASE I		
PROJECT: 2010.02 DATE: 2/13/12 DRAWN BY: MAA CHECKED BY: MH		SHEET NUMBER DR1 OF





LEGEND

- DRAINAGE BASIN BOUNDARY.....
- DRAINAGE BASIN DESIGN POINT.....
- 10 YEAR PROPOSED FLOW (cfs).....
- 100 YEAR PROPOSED FLOW (cfs).....
- BASIN I.D. (A-3).....
- BASIN AREA (Acres).....
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- 100 YEAR RUNOFF COEFFICIENT.....
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- EX. STORM SEWER..... EX. 18" RCP ST
- EX. MANHOLE.....

RUNOFF SUMMARY				
BASIN (S)	AREA (AC)	Q5	Q10	Q100
A	7.10	20.92	24.82	43.16
B	1.85	4.07	4.83	9.52
Total on-site				49.6

Note: Basin B is not tributary to pond

5. 8/10/12 TECH DOC REVISIONS PER CITY OF BOULDER
4. 8/06/12 TECH DOC REVISIONS PER CITY OF BOULDER
3. 7/02/12 TECH DOC REVISIONS PER CITY OF BOULDER
2. 6/04/12 TECH DOC REVISIONS PER CITY OF BOULDER
1. 5/5/12 TECH DOC SUBMISSION

PEH ARCHITECTS
 1319 Spruce Street Suite 207
 Boulder, CO 80302
 303-442-0408, fax: 303-447-1905
 e-mail: peheinz@peharchitects.com

City of Boulder, Eco-Cycle, ChARM, ReSource
6400 ARAPAHOE ROAD
 BOULDER, CO 80303

TECHNICAL DOCUMENTS
 C.O.B. CASE # _____

SHEET TITLE
STORMWATER PLAN
PHASE II

PROJECT: 2010.02
 DATE: 2/13/12
 DRAWN BY: MAA
 CHECKED BY: MH

SHEET NUMBER
DR2
 OF

