Conceptual/Preliminary Storm Water Report

For
Lincoln Place Duplex
1617, 1625 Lincoln Place
Boulder, Colorado

Prepared For:
Neil and Rose Dykes
1617 Lincoln Place
Boulder, CO 80302
(720) 436-0138

October 7, 2013

FSI# 13-100470

Prepared By:
Flatirons, Inc.
Surveying, Engineering & Geomatics
655 Fourth Avenue
Longmont, Colorado 80501
303-443-7001

CONCEPTUAL/PRELIMINARY STORM WATER REPORT

FOR

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BOULDER, COLORADO

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Neil and Rose Dykes
1617 Lincoln Place
Boulder, CO 80302
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Prepared by:

Flatirons, Inc.
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FSI# 13-100442

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Certification

"I hereby certify that this *Conceptual/Preliminary Storm Water Report* for the design of the Lincoln Place Duplex was prepared by me (or under my direct supervision) in accordance with the provisions of City of Boulder Design and Construction Standards for the owners thereof."

_____

Kenneth W. Curfman PE, PLS
For and on Behalf of Flatirons, Inc.
State of Colorado No. 25620

Vicinity Map

1.0 Location and Description

Background

The project is comprised of two exiting lots on Lincoln Place containing 0.32 acres, more or less. The addresses of the lots are 1617 Lincoln Place (southern parcel) and 1625 Lincoln Place (northern parcel). The legal descriptions of the property are a portion of Outlot 2 and a portion of Outlot 5 in Reeks' Addition to the City of Boulder, County of Boulder, State of Colorado, located in the NW 1/4, Section 31, Township 1 North, Range 70 West of the 6th P.M.

The project is located in the established University Hill neighborhood in Boulder, a half block south of the City of Boulder Public Library on the east side of Lincoln Place. Lincoln Place is a narrow north/south paved street between Marine Street to the south and Arapahoe Avenue to the north. Mature trees cover the property. Much of the property is used for off street parking and is devoid of ground cover. Where grass does grow, it is sparse and in poor health. A one story frame home with a walk out basement is located in the southwest corner of the southern parcel (1617 Lincoln Place). The northern parcel (1625 Lincoln Place) contains a two story frame house seven feet north of the southern property line, a wood frame garage located near the northwest corner of the lot, a wood shed situated in the northwest corner of the property, and a temporary shed located behind the main house in the southwest corner of the property.

The property is located at the base of a steep, east/west trending hillside and slopes in a northeasterly direction with the topographic high point at the southwest property corner at an elevation of 5379 and the low point being located at the northeast property corner at the elevation of 5363.5. The average slope across the property is 9%.

Data from the USDA, Natural Resources Conservation Services', Web Soil Survey indicate the soils on the project are Terrace Escarpments (Te). The soils are associated with Hydrologic Soils Group A, are rated excessively drained, and have a high to very high capacity to transmit water. Soils data can be found in Appendix C.

According to FEMA FIRM Map Number 08013C0393J dated December 18, 2012, the property is located in Zone X, Other Areas and Zone AE, Special Flood Hazard Areas (SFHAs) Subject to Inundation By The 1% Annual Chance Flood. The northwest portion of the property is in Zone AE, and the balance of the property is located in Zone X. The property is in the 100-year and 500-year Boulder Creek floodplain, but the property is neither in the City of Boulder High Hazard Flood Zone, nor the City of Boulder Conveyance Flood Zone. FEMA map information can be found in Appendix D.

There are no wetlands, creeks, irrigation ditches, storm sewers, or drainage swales on the property. The closest drainage way, Boulder Creek, is located approximately 600 feet to the north on the north side of Arapahoe Avenue. Runoff sheet flows across the property in a northeasterly direction. Offsite flows from uphill properties north of Marine Street sheet flow across the property.

Development Proposal
The proposed improvements call for the elimination of the common lot line between the two parcels and for a duplex to be constructed at the southeast corner on the combined lot in front of the existing one story house. The existing buildings will remain, but the site will be graded to allow access to the existing residences. Two parking areas will constructed on the northern portion of the property. One will be built behind the existing two story house on the western property line and the other will be built east of the existing garage along the northern property line. The two parking areas will be connected on the property and access to Lincoln Place will be near the northern part of the property.

The existing surface drainage patterns will be maintained and runoff will be directed to the northeast corner of the property. A detention pond will be constructed at the northeast corner of the site. Most runoff from the property will be directed to the detention pond before being released. Grass lined bio swales will be used to direct surface flows to the detention pond where possible. The parking areas will be constructed with a pervious rock surface to promote onsite infiltration and aid in the removal of contaminants that may be picked up by the surface runoff across the parking areas, thus improving the water quality.

2.0 Existing Basins and Drainage Patterns

Offsite Drainage Patterns
There is one offsite basin that contributes surface runoff to the site. The offsite surface runoff is from an uphill area to the south and west of the property that sheet flows across the site. The southern extent of the offsite basin is defined by the curb, gutter, and drainage pans on the north side of Marine Street. The eastern boundary of the offsite basin is roughly the western property line extended to the south and the eastern and northern offsite basin boundaries are contiguous with the onsite drainage basins. Flows from a second offsite basin directly to the south of the project are intercepted by a swale parallel to the southern property line and directed into the Lincoln Place right of way.

The improvements in the offsite basins are apartment buildings and parking lots with no apparent onsite detention or water quality enhancement features. Offsite runoff from the south and west enters the property as sheet flow and is added to the onsite generated flows. The offsite basin contains 0.32 acres, is 95% impervious, and has 5-year and 100-year runoff coefficients of .80 and 86. The 5-year and 100-year peak flows from the offsite basin are 1.0 cfs and 2.0 cfs.

Onsite Drainage Patterns
There are no onsite drainage improvements on the proposed property or swales to direct concentrated flows. Storm water from roofs is allowed to flow unimpeded once it reaches the surface. Most of surface runoff sheet flows across the property in a northeasterly direction and enters the Lincoln Place right of way. Storm water in the Lincoln Place right of way is directed to the north. A small amount of the surface runoff from the property sheet flows onto the adjacent property to the north of the site. All surface runoff from the site is eventually captured by the storm sewer system in Arapahoe Avenue and conveyed to Boulder Creek.

The historic onsite basin contains 0.32 acres, is 15% impervious, and has 5-year and 100-year runoff coefficients of .10 and 30. The 5-year and 100-year peak flows from the historic onsite basin are 0.1 cfs and 0.7 cfs.

Previous Drainage Studies
There are no apparent drainage reports or studies that include the site. The site is in an old neighborhood that was developed prior to drainage studies being required by the City of Boulder.

Existing Drainage Problems
An issue that affects the whole neighborhood, and not specifically this property, is the lack of drainage infrastructure. Offsite surface runoff from the adjacent property to the south is allowed to enter the property without being detained or having the water quality enhanced. There are no street improvements (ditches, curb and gutter, or storm sewer to convey the surface flows once they enter the Lincoln Place right of way. The road right of way is 25-feet wide, the asphalt road is 16 to 18-feet wide, and the edge of the asphalt road is 2 to 5 feet from the western edge of the right of way along the site frontage.

The northwest corner of the property is in the 100-year and 500-year Boulder Creek floodplain, but the property is neither in the City of Boulder High Hazard Flood Zone, nor the City of Boulder Conveyance Flood Zone. There are indications of flooding issues and damage during the recent historic storms of September 2013. The existing garage and small wood shed at the northwest corner of the property are the only buildings in the flood hazard area, and both appear to have been inundated during the recent storm. The proposed duplex is not in the flood hazard area.

There is a high ground water table in the area as indicted by the geotechnical report, but it does not contribute to the surface runoff from the lot. There is an Agreement recorded December 30, 1927, in Book 559, at Page 141 that allows the Boulder Fish and Game Club the right to use water from a spring on the west slope of Outlot 2, Parcel A and grants an easement a Spring Water Drainage Easement across Outlot 2, Parcel A for the flow of water. The position of the easement or spring is not mathematically defined, but does not appear to encumber the project site. Outlot 2, Parcel A is the adjacent property to the north of the project

3.0 Developed Conditions

Storm Water Quality and Erosion Control Measures
As recommended by the Urban Drainage and Flood Control District (UDFCD) a Four Step Process for receiving water protection that focuses on reducing runoff volumes, treating the Water Quality Capture Volume (WQCV), stabilizing drainage ways, and implementing long-term source controls will be used. The Four Step Process pertains to management of smaller frequently occurring events, as opposed to larger storms for which drainage and flood control infrastructure are sized. Implementing of the Four Step Process will help to achieve required stormwater permit requirements, including new stormwater rules currently

under consideration by the U.S. Environmental Protection Agency. Added benefits of implementing the complete process include improved site aesthetics through functional landscaping features that also provide water quality benefits. The initial calculated WQCV is 126 cubic feet. Calculations can be found in Appendix B.

Currently there are no storm water quality enhancements, erosion control measures, or detention facilities on the site. The proposed site development calls for several green infrastructure improvements to enhance water quality, minimize erosion, and act as natural filters for the storm water. A pond will be constructed at the northeast corner of the property that will serve as both detention and water quality enhancement. Grass lined bio swales will be constructed to convey concentrated flows across the property and to the detention/ water quality pond. Building downspouts will be allowed to flow across landscaped areas before entering the detention pond or bio swales. A pervious rock surface will be installed on the parking areas to decrease runoff and filter contaminants before entering the detention pond. A portion of the untreated offsite storm water runoff entering the site will be captured by a grass lined bioswale along the southern property line and directed around the property and to the Lincoln Place right of way.

Wetland Impacts

There are no delineated wetlands or wetland buffer areas that affect the project site.

Hydrology

As specified by Section 7.05 (D) (2) of the City of Boulder *Design and Construction Standards*, the preliminary site hydrology has been calculated by use of the Rational Method. The 2-year, 5-year, 10-year, and 100-year 1-hour point rainfall rates are 1.04, 1.45, 1.73, and 2.68 inches per hour, respectively.

The five-year frequency storm is used as the initial storm for runoff calculations, and the 100-year storm is used as the major storm for runoff calculations in accordance with Section 7.05 (B) of the City of Boulder *Design and Construction Standards.*

The project is divided into three developed basins, designated A, B, and C. Basins A and C are long, narrow basins along the southern and eastern property lines, respectively. The majority of surface runoff from Basin A is from landscaped areas and is directed to a grass lined bio swale parallel to the southern property boundary. Concentrated flow in the bio swale is conveyed toward the east to the Lincoln Place right of way. Basin C is about 5-feet wide and fronts the project on the west side of Lincoln Place. Runoff is generally from landscaped areas and sheet flows to the Lincoln Place right of way. Basin B, the major onsite developed basin, comprises 88% of the project, and runoff from Basin B is conveyed to the detention/water quality pond at the northeast corner of the project. All runoff from Basin B will treated onsite using grass lined bio swales and/or the pervious rock parking surface to remove contaminants, and directed through the detention/water quality pond to allow onsite infiltration and enhance water quality.

Basin A contains 0.03 acres, is 25% impervious, and has 5-year and 100-year runoff coefficients of .16 and .35. The 5-year and 100-year peak flows from Basin A are 0.0 cfs and 0.1 cfs.

Basin B contains 0.28 acres, is 45% impervious, and has 5-year and 100-year runoff coefficients of .27 and .43. The 5-year and 100-year peak flows from Basin B are 0.4 cfs and 1.1 cfs.

Basin C contains 0.01 acres, is 15% impervious, and has 5-year and 100-year runoff coefficients of .10 and .30. The 5-year and 100-year peak flows from Basin C are 0.0 cfs and 0.0 cfs.

Preliminary storm water runoff calculations are included in Appendix B of this report.

Storm Water Detention

A detention pond will be constructed in the northeast corner of the project site. The detention pond design for the initial storm is based on a 10-year storm, and the 100-year storm is the design storm for the major storm. The detention pond is sized for onsite flows, but some of the offsite flows will directed through the pond for water quality purposes. Based on the City of Bounder, Flood Hazard Mapping, the detention pond is in the 500-year flood zone and possibly in the 100-year flood zone. The calculated detention requirements for the project are 1017 cubic feet. Preliminary detention requirements can be found in Appendix B.

Developed Storm Water Conditions

The proposed storm water drainage improvements will follow the onsite existing drainage patterns to the greatest extent possible. The improvements will convey runoff from the southwest corner of the property towards the northeast, which follows historic patterns. Conveyance will either be accomplished with sheet flow or with grass lined bio swales and other surface drainage features. A pond will be constructed at the northeast corner of the property that will serve as both detention and water quality enhancement. The pond will allow infiltration to take place, and as much onsite runoff as possible will be directed to the detention/water quality pond before being released.

No inlets or connection to the existing storm sewer systems will be required. The swales will be grass lined and function as bio swales. A drainage pan will only be used where it is required to convey runoff across driveways or sidewalks. Runoff from roofs will be disconnected from impervious areas and allowed to flow across landscaped areas before entering the detention/water quality pond or leaving the site.

A pervious surface will be installed on the parking areas to decrease runoff and filter contaminants before entering the detention pond. A portion of the untreated offsite storm water runoff entering the site will be captured by a grass lined bioswale along the southern property line and directed around the property and to the detention/storm water quality pond before being released into the Lincoln Place right of way.

The proposed storm water runoff improvements will be sized and designed to accept and convey offsite runoff that enters the site. Where offsite runoff is not captured by swale, it will sheet flow across the property as it currently does. The offsite basin to the south and

west of the property is assumed to be at build-out conditions, so no increase of the existing runoff is anticipated in the future.

4.0 Conclusions and Recommendations

The proposed storm water drainage system is simple in its proposed layout and design. The improvements will be constructed as an integral part of the development, and will not require major revisions, or potentially any revisions, to the proposed development plan. The green infrastructure components of the drainage improvements will improve onsite water quality, and add treatment to an offsite basin that lacks any storm water quality enhancements. The proposed development plan will be provide easy access to the facilities for repair and maintenance.

References

- City of Boulder, Design and Construction Standards
  Effective: November 16, 2000
  Water Resources Consultants, Inc.

- Urban Storm Drainage Criteria Manual, Volumes 1 and 2
  Urban Drainage and Flood Control District
  2001 edition
  Revised: April 2008.

- Urban Storm Drainage Criteria Manual, Volume 3
  Urban Drainage and Flood Control District
  November 2010

- FEMA Flood Insurance Rate Map
  December 18, 2012
  Map No. 08013C0393J

- City of Boulder, Flood Hazard Mapping
  http://gisweb.ci.boulder.co.us/agswebsites/pds/floodmap/

- USDA, Natural Resources Conservation Service
  National Cooperative Soil Survey
  http://websoilsurvey.nrcs.usda.gov/app/

- Subsurface Investigation, Proposed New Structure and Pavement, 1617 and 1625 Lincoln Place, Boulder, Colorado
  Scott, Cox & Associates, Inc.
  July 2013

APPENDIX A

Exhibits

Please refer to the enclosed 24” x 36” maps of the proposed drainage basins, storm drainage facilities, pipe profiles and details. In this appendix are 8 ½” x 11” copies of these maps.

The drainage map shows the drainage basins and their respective areas. It also shows storm facility locations, and details.

LINCOLN PLACE DUPLEX
SITE DEVELOPMENT REVIEW

A PORTION OF OUTLOT 2 AND A PORTION OF OUTLOT 5, REEKS ADDITION TO THE CITY OF BOULDER, LOCATED IN THE NW 1/4 OF SECTION 31, TOWNSHIP 1 NORTH, RANGE 70 WEST OF THE 6TH P.M., CITY OF BOULDER, COUNTY OF BOULDER, STATE OF COLORADO

EXISTING BASIN RUNOFF SUMMARY

BASIN	AREA (ac)	IMPERVIOUS RATIO	C_2	C_5	C_{100}	Q_2 (CFS)	Q_5 (CFS)	Q_5 (CFS)
X1	0.32	95%	0.78	0.80	0.86	0.7	1.0	2.0
X2	0.32	15%	0.02	0.10	0.30	0.00	0.10	0.70

Legend

- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPERTY LINE
- ADJACENT PROPERTY LINE
- EXISTING MAJOR BASIN BOUNDARY
- EXISTING OFF-SITE MINOR BASIN BOUNDARY
- 100-YEAR FLOODPLAIN LIMITS
- DRAINAGE FLOW ARROW

1 DESIGN POINT

A (X.XX .YY / WW .ZZ)

DENOTES SUB-BASIN DESCRIPTION
- A DENOTES BASIN ID
- X.XX DENOTES BASIN AREA (ACRES)
- .YY DENOTES 5-YR COEFFICIENT
- .ZZ DENOTES 100-YR COEFFICIENT
- WW DENOTES % IMPERVIOUS

GRAPHIC SCALE

20 0 10 20 40

(IN FEET)
1 inch = 20 ft.

REVISION	DATE
1	
2	
3	
4	
5	
6	
7	
8	
9	

JOB NUMBER: 13-100.470
DATE: 10.07.2013
DESIGNED BY: C. STONE
DRAWN BY: C. STONE
CHECKED BY: JD
APPROVED BY: JD

Flatirons, Inc.
Surveying, Engineering & Geomatics
655 FOURTH AVE
LONGMONT, CO 80501
PH: (303) 776-1733
FAX: (303) 776-4355

LINCOLN PLACE DUPLEX
SITE DEVELOPMENT REVIEW
1617 AND 1625 LINCOLN PLACE

EXISTING STORM WATER PLAN

CALL UTILITY NOTIFICATION CENTER OF COLORADO 811
MEMBER UTILITIES CALL ONE BUSINESS DAY IN ADVANCE FOR THE MARKING OF THEIR UNDERGROUND LINES YOU CAN, CANCEL OR INCREASE

(SEAL)

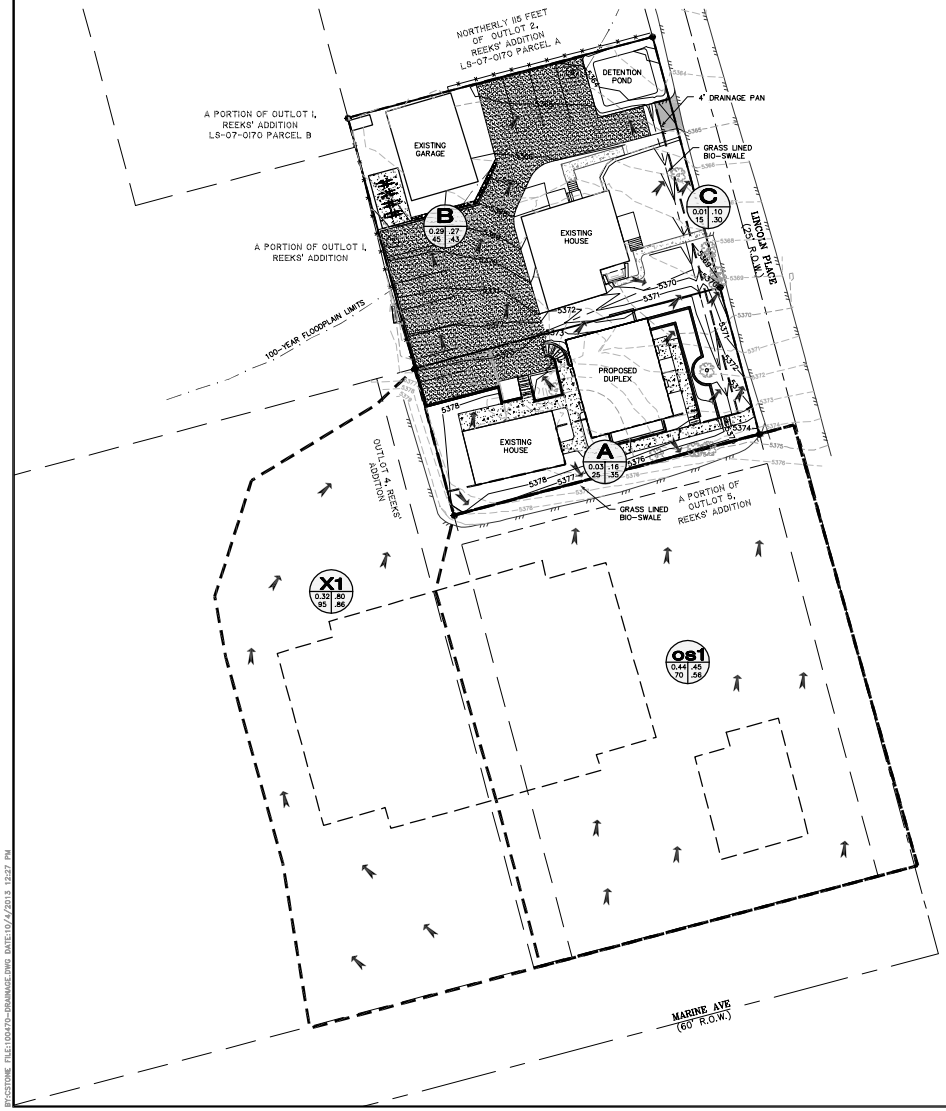
DRAWING
DR-1
SHEET 1 OF 2

BY:CSTONE FILE:100470-DRAINAGE.DWG DATE:10/4/2013 12:22 PM

LINCOLN PLACE DUPLEX

SITE DEVELOPMENT REVIEW

A PORTION OF OUTLOT 2 AND A PORTION OF OUTLOT 5, REEKS ADDITION TO THE CITY OF BOULDER, LOCATED IN THE NW 1/4 OF SECTION 31, TOWNSHIP 1 NORTH, RANGE 70 WEST OF THE 6TH P.M., CITY OF BOULDER, COUNTY OF BOULDER, STATE OF COLORADO



DEVELOPED BASIN RUNOFF SUMMARY

BASIN	AREA (ac)	IMPERVIOUS RATIO	C_2	C_5	C_{100}	Q_2 (CFS)	Q_5 (CFS)	Q_5 (CFS)
X1	0.32	15%	0.02	0.10	0.30	0.0	0.1	0.7
os1	0.44	70%	0.42	0.45	0.56	0.6	0.9	2.0
A	0.03	25%	0.09	0.16	0.35	0.0	0.0	0.1
B	0.28	45%	0.22	0.27	0.43	0.2	0.4	1.1
C	0.01	15%	0.02	0.10	0.30	0.0	0.0	0.0

Legend

- 5000 — EXISTING CONTOURS
- 5000 — PROPOSED CONTOURS
- PROPERTY LINE
- ADJACENT PROPERTY LINE
- EXISTING MAJOR BASIN BOUNDARY
- EXISTING OFF-SITE MINOR BASIN BOUNDARY
- 100-YEAR FLOODPLAIN LIMITS
- DRAINAGE FLOW ARROW

1 DESIGN POINT

A — DENOTES SUB-BASIN DESCRIPTION
- A DENOTES BASIN ID
- X.XX DENOTES BASIN AREA (ACRES)
- .YY DENOTES 5-YR COEFFICIENT
- .ZZ DENOTES 100-YR COEFFICIENT
- WW DENOTES % IMPERVIOUS

GRAPHIC SCALE

20 0 10 20 40

(IN FEET)
1 inch = 20 ft.

REVISION	DATE
1	
2	
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7	
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LINCOLN PLACE DUPLEX
SITE DEVELOPMENT REVIEW
1617 AND 1625 LINCOLN PLACE

DEVELOPED STORM WATER PLAN

CALL UTILITY NOTIFICATION CENTER OF COLORADO 811
MEMBER UTILITIES CALL ONE BUSINESS DAY IN ADVANCE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES YOU DIG, GRADE, OR EXCAVATE

(SEAL)

DRAWING
DR-2
SHEET 2 OF 2

BY:CSTONE FILE:100470-DRAINAGE.DWG DATE:10/4/2013 12:27 PM

APPENDIX B

Calculations

Major Basin calculations using the Rational Method

- Historic Conditions Storm Runoff Calculations
  - Time of Concentration calculations
  - Final Q calculations
- Proposed Storm Runoff Calculations
  - Time of Concentration calculations
  - Final Q calculations
- Detention Pond Calculations
  - Volume Calculations
- Water Quality Capture Calculations
  - Volume Calculations

STORM DRAINAGE CALCULATIONS
Lincoln Place Duplex, Boulder, CO

Existing (Undeveloped) Drainage Basin

Site Information:

Land Use	% Imp.	C_2	C_5	C_{10}	C_{100}	Source
Developed	15	0.02	0.1	0.17	0.3	USDCM Table RO-5
Developed	25	0.09	0.16	0.23	0.35	
Developed	45	0.22	0.27	0.33	0.43	
Developed	70	0.42	0.45	0.49	0.56	
Developed	95	0.78	0.80	0.82	0.86	

Using soil types = **A** from USDA-SCS

	2yr	5yr	10yr	50yr	100yr	
1-hour Point Rainfall	1.04	1.45	1.73	2.40	2.68	USDCM Figures RA-6 through RA-6

Time of Concentration (t_c)

Basin	Overland Flow Time				Travel Time 1					Travel Time 2					Sum	Check		Final
	L [ft]	S [ft/ft]	C_5	T_i [min]	L_1 [ft]	S_w [%]	C_v	V [ft/sec]	T_1 [min]	L_2 [ft]	S_w [%]	C_v	V [ft/sec]	T_2 [min]	T_c [min]	L_{tot} [ft]	T_{chk}(max) [min]	T_c [min]
X1	231	0.095	0.80	3.92				0.00	0.00				0.00	0.00	3.92	231	11.3	**3.9**
X2	9	0.083	0.10	2.69	6	2.00	20	2.83	0.04	142	8	15	4.24	0.56	3.29	157	10.9	**3.3**

Storm Drainage Calculations

Basin	Area [acres	T_c [min]	2 Year C_2	P_1 [in]	I_2 [in/hr]	**Q_2 [cfs]**	5 Year C_5	P_1 [in]	I_5 [in/hr]	**Q_5 [cfs]**	10 Year C_{10}	P_1 [in]	I_{10} [in/hr]	**Q_{10} [cfs]**	100 Year C_{100}	P_1 [in]	I_{100} [in/hr]	**Q_{100} [cfs]**
X1	0.32	10.0	0.78	1.04	2.8	**0.7**	0.80	1.45	3.9	**1.0**	0.82	1.73	4.7	**1.2**	0.86	2.68	7.3	**2.0**
X2	0.32	10.0	0.02	1.04	2.8	**0.0**	0.10	1.45	3.9	**0.1**	0.17	1.73	4.7	**0.3**	0.30	2.68	7.3	**0.7**

Total Basin Acreage = 0.32

Rational Formula
USDCM Eqn RO-1

$$Q = CIA$$

Initial Flow Time (t_i)
USDCM Eqn RO-3

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}}$$

Overland Velocity
USDCM Eqn RO-4

$$V = C_V S_W^{0.5}$$

Max Time of Concentration Check
USDCM Equation RO-5

$$t_{c-chk} = \frac{L}{180} + 10$$

Rainfall Intensity
USDCM Eqn RA-3

$$I = \frac{28.5 P_1}{(10 + T_C)^{0.786}}$$

Q= max rate of runoff (cfs)
C= runoff coefficient
I= Avg rainfall intensity
A= Area (acres)

t_i = initial or overland flow time (min)
t_{chk} = max time of concentration in urbanized catchment (min)
C_5 = runoff coeficient 5-year frequency
L= Length of oveland flow (ft)
500' max for non-urban, 300' max for urban
S= average basin slope (ft/ft)
V= Velocity (ft/sec)
Cv= conveyence coefficient (USDCM Table RO-2)
Sw= watercourse slope (%)

I= Avg rainfall intensity
P_1 = 1-hr point rainfall)(in)
T_c = Final Time of Concentration

USDCM TABLE RO-2	
Type of Land Surface	C_v
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

Note: The minimum value of the time of concentration is 5 min for urbanized areas.
The minimum value of the time of concentration is 10 min for non-urbanized areas.

STORM DRAINAGE CALCULATIONS
Lincoln Place Duplex, Boulder, CO

Proposed (Developed) Drainage Basins

Site Information:

Land Use	% Imp.	C_2	C_5	C_{10}	C_{100}	Source
Developed	15	0.02	0.10	0.17	0.30	USDCM Table RO-5
Developed	25	0.09	0.16	0.23	0.35	
Developed	45	0.22	0.27	0.33	0.43	
Developed	70	0.42	0.45	0.49	0.56	
Developed	95	0.78	0.80	0.82	0.86	Using soil types = **A** from USDA-SCS

	2yr	5yr	10yr	50yr	100yr	
1-hour Point Rainfall	1.04	1.45	1.73	2.4	2.68	USDCM Figures RA-6 through RA-6

Time of Concentration (t_c)

Basin	% Impervious	Initial Flow Time (Overland)				Travel Time 1					Travel Time 2					Sum	Check		Final
		L [ft]	S [FT/FT]	C_5	T_i (2) [min]	L_1 [ft]	S_w [%]	C_{v*}	V (3) [ft/sec]	T_1 [min]	L_2 [ft]	S_w [%]	C_v	V [ft/sec]	T_2 [min]	T_c [min]	L_{tot} [ft]	$T_{c\text{-}chk}$ [min]	T_c [min]
os1	70%	95	0.053	0.45	6.60	51	22	15	7.04	0.12	56	11.0	20	6.63	0.14	6.86	202	11.1	**6.9**
A	25%	105	0.048	0.16	10.36				0.00	0.00				0.00	0.00	10.36	105	10.6	**10.4**
B	45%	24	0.083	0.27	3.65	5	2	20	2.83	0.03	114	8.0	10	2.83	0.67	4.35	143	10.8	**4.4**
C	15%	24	0.25	0.10	3.06				0.00	0.00				0.00	0.00	3.06	24	10.1	**3.1**

Storm Drainage Calculations

Basin	% Impervious	Area [acres]	T_c [min]	2 Year C_2	P_1 [in]	I_2 [in/hr]	**Q_2 [cfs]**	5 Year C_5	P_1 [in]	I_5 [in/hr]	**Q_5 [cfs]**	10 Year C_{10}	P_1 [in]	I_{10} [in/hr]	**Q_{10} [cfs]**	100 Year C_{100}	P_1 [in]	I_{100} [in/hr]	**Q_{100} [cfs]**
os1	70%	0.44	6.9	0.42	1.04	3.2	**0.6**	0.45	1.45	4.5	**0.9**	0.49	1.73	5.4	**1.2**	0.56	2.68	8.3	**2.0**
A	25%	0.03	10.4	0.09	1.04	2.8	**0.0**	0.16	1.45	3.9	**0.0**	0.23	1.73	4.6	**0.0**	0.35	2.68	7.1	**0.1**
B	45%	0.29	5.0	0.22	1.04	3.5	**0.2**	0.27	1.45	4.9	**0.4**	0.33	1.73	5.9	**0.6**	0.43	2.68	9.1	**1.1**
C	15%	0.01	5.0	0.02	1.04	3.5	**0.0**	0.10	1.45	4.9	**0.0**	0.17	1.73	5.9	**0.0**	0.30	2.68	9.1	**0.0**

Total Basin Acreage = 0.77

Rational Formula
USDCM Eqn RO-1

$$Q = CIA$$

Initial Flow Time (t_i)
USDCM Eqn RO-3

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}}$$

Overland Velocity
USDCM Eqn RO-4

$$V = C_V S_W^{0.5}$$

Max Time of Concentration Check
USDCM Equation RO-5

$$t_{c-chk} = \frac{L}{180} + 10$$

Rainfall Intensity
USDCM Eqn RA-3

$$I = \frac{28.5 P_1}{(10 + T_C)^{0.786}}$$

Q= max rate of runoff (cfs)
C= runoff coefficient
I= Avg rainfall intensity
A= Area (acres)

t_i = initial or overland flow time (min)
t_{chk} = max time of concentration in urbanized catchment (min)
C_5 = runoff coeficient 5-year frequency
L= Length of oveland flow (ft)
500' max for non-urban, 300' max for urban
S= average basin slope (ft/ft)
V= Velocity (ft/sec)
Cv= conveyence coefficient (USDCM Table RO-2)
Sw= watercourse slope (%)

I= Avg rainfall intensity
P_1 = 1-hr point rainfall)(in)
T_c = Final Time of Concentration

USDCM TABLE RO-2

Type of Land Surface	C_v
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

Note: The minimum value of the time of concentration is 5 min for urbanized areas.
The minimum value of the time of concentration is 10 min for non-urbanized areas.

Lincoln Place Duplex, Boulder, CO

Detention Volume Calculations (Rational Method)

Pond	Total Area [ac]	Imp %	5 Year Storm Detention**			100 Year StormDetention**			Total Retention***	
			K5	V_5 [ac-ft]	V_5 [ft^3]	K_{100}	V_{100} [ac-ft]	V_{100} [ft^3]	**V_{100} [ac-ft]**	**V_{100} [ft^3]**
A	0.29	45	0.0320	0.009	404	0.0805	0.023	1017	**0.035**	**1526**

* Imp = imperviousness (%) TABLE RO-3 USDCM Volume 1

**Detention Storage Volume

V=KA	USDCM Equation SO-1
K100 = (1.78I - 0.002*I^2 - 3.56)/900	USDCM Equation SO-2
K10 = (0.95I-1.90)/1000	USDCM Equation SO-3
K5 = (0.77*I - 2.65)/1000	USDCM Equation SO-4

***Retention Storage Volume

V_{RET}=1.5 * V_{DET}	USDCM Section 3.3.4 Storage

Water Quality Capture Volume

Lincoln Place Duplex, Boulder, CO

	Total	
Impervious Areas		
Roof Area	3101	sq ft
Gravel Area	3937	sq ft
Other Imperviousness	984	sq ft
Total Non-Factored Imperviousness	8022	sq ft
Factored Imperviousness		
Roof X 0.9	2791	sq ft
Gravel X 0.4	1575	sq ft
Other Imperviousness	984	sq ft
Total Factored Imperviousness	3775	sq ft
Pervious Areas		
Basin Area	12266	sq ft
Pervious Areas	8491	sq ft
Imperviousness Ratio	0.308	
WQCV	0.123	watershed in
Volume (Required)	**126**	cu ft

Current (6/17) Provided volume

Basin	Depth of Pond [ft]	Area [ft^2]	Volume [ft^3]	Factored Volume (To account for sloped walls) 80%
Basin B	1.5	510	765	**612**

APPENDIX C

Soils Information

Attached is a copy of the soils information for this site according to the USDA-NRCS.

Soil Map—Boulder County Area, Colorado
(Lincoln Place Duplex)

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

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 9, May 1, 2009

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.

Map Unit Legend

Boulder County Area, Colorado (CO643)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
NdD	Nederland very cobbly sandy loam, 1 to 12 percent slopes	8.8	66.4%
Nh	Niwot soils	2.3	17.5%
Te	Terrace escarpments	2.2	16.2%
Totals for Area of Interest		**13.3**	**100.0%**

Boulder County Area, Colorado

Te—Terrace escarpments

Map Unit Setting

Elevation: 4,400 to 5,500 feet
Mean annual precipitation: 10 to 16 inches
Mean annual air temperature: 46 to 54 degrees F
Frost-free period: 120 to 160 days

Map Unit Composition

Terrace escarpments and similar soils: 100 percent

Description of Terrace Escarpments

Setting

Landform: Paleoterraces, fan remnants
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Base slope, riser
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Cobbly and stony colluvium over sandstone and shale

Properties and qualities

Slope: 12 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 7s
Hydrologic Soil Group: A

Typical profile

0 to 6 inches: Gravelly sand
6 to 60 inches: Gravelly sand, very gravelly sand, gravelly coarse sand

Data Source Information

Soil Survey Area: Boulder County Area, Colorado
Survey Area Data: Version 9, May 1, 2009

K Factor, Whole Soil—Boulder County Area, Colorado
(Lincoln Place Duplex)

Map Scale: 1:1,830 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 25 50 100 150

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

.02
.05
.10
.15
.17
.20
.24
.28
.32
.37
.43
.49
.55
.64
Not rated or not available

Soil Rating Lines

.02
.05
.10
.15
.17
.20
.24
.28
.32
.37
.43
.49
.55
.64
Not rated or not available

Soil Rating Points

.02
.05
.10
.15
.17
.20
.24
.28
.32
.37
.43
.49
.55
.64
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

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Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
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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.

K Factor, Whole Soil

K Factor, Whole Soil— 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	.05	8.8	66.4%
Nh	Niwot soils	.24	2.3	17.5%
Te	Terrace escarpments	.10	2.2	16.2%
Totals for Area of Interest			**13.3**	**100.0%**

Description

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

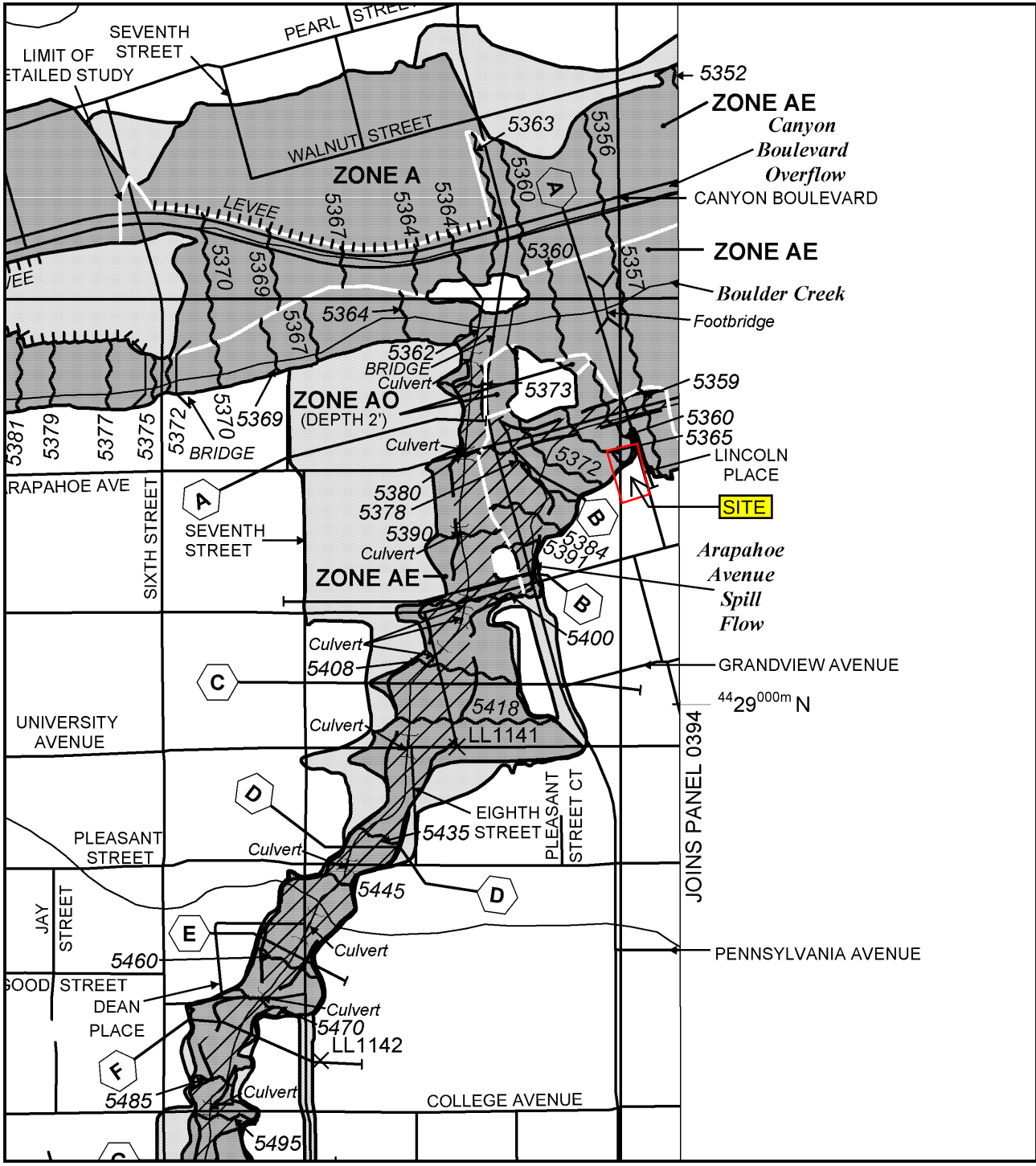
Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

APPENDIX D

Floodplain Information

Attached is copy of the FEMA Floodplain Firmette of the Area



MAP SCALE 1" = 500'

250 0 500 1000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0393J

FIRM

FLOOD INSURANCE RATE MAP

BOULDER COUNTY, COLORADO

AND INCORPORATED AREAS

PANEL 393 OF 615

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BOULDER, CITY OF	080024	0393	J
BOULDER COUNTY	080023	0393	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
08013C0393J

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