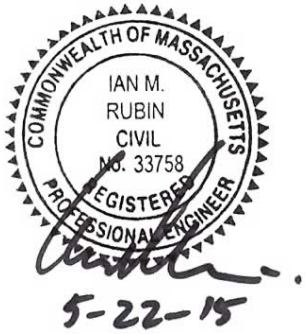
DRAINAGE REPORT

FOR

"JAIME'S WAY & THOMAS DRIVE"
456 MASSACHUSETTS AVENUE & 143 PROSPECT STREET
ACTON, MA



Prepared for:
KEENAN & SON, LLP
54 GRISTMILL ROAD
LITTLETON, MASSACHUSETTS 01460

Prepared by:
MARKEY & RUBIN, INC.
360 MASSACHUSETTS AVENUE
ACTON, MASSACHUSETTS

MARKEY & RUBIN, INC.
360 MASS. AVENUE, ACTON, MA 01720
PHONE: (978)264-4600

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Jaime's Way & Thomas Drive
Project Report
May 22, 2015

MARKEY & RUBIN, INC.
360 MASS. AVENUE, ACTON, MA 01720
PHONE: (978)264-4600

1. DRAINAGE REPORT

1.1 Introduction

The purpose of these calculations is to show that with development there is no increase in peak runoff when comparing pre- vs. post-conditions.

1.2 Site Description

The land consists of two abutting single family home lots. At 456 Massachusetts Avenue, the lot hash a typical colonial house, a paved driveway and a septic system in the front yard. The septic system is a raised system. At 143 Prospect Street, the house is a Cape, with town sewer and water. The rear of the lots is mostly wooded, with an isolated wetland towards the south-easterly corner of the property. Most of the land slopes to the rear of the lot, the high point being towards the front of the lots. The two lots combined have an area of about 3.05 Acres, or 133,156 sq. ft., of land.

With development, the parcel on Mass. Ave. is being subdivided in three lots, while on Prospect Street, the land is divided into two lots. Though the runoff is essentially ends at the same design point, the calculations are done for each parcel (one on Mass. Ave. and the other on Prospect Street) independently.

On Mass. Ave., Lot 1 will have the existing house relocated. The two lots in the rear are proposed with new houses. A common driveway, with a turnaround suitable for an Acton fire-truck, is proposed serving all three lots. The existing house has a drive-under garage. In the design of lot one, the location of the raised septic system is to be lowered a couple of feet as well as further removal of soils to accommodate the drive-under garage. Most of the cut is moved to the back of the lot to provide leveled back yards for the houses on lots 2 and 3. These houses have walk-out basements.

On Prospect Street, the existing house will be razed, the front land lowered somewhat leveling off the land towards the back, and creating two new lots each with a typical colonial home.

In the drainage design, for both parcels, to allow for the decrease in wooded area, increase in lawn, and increase in impervious surfaces (common driveways, roofs and walkways in the front yards), two retention ponds are proposed intercepting the new runoff.

The soils as referenced in National Resource Conservation Commission (NRCS) are Udorthents-Urban land complex and Charlton-Hollis-Rock outcrop complex. The Udorthents section, which is towards the front of the property, is designed as a C-soil (hydrological soil group) and the Charlton-Hollis section is designed as a B-soil. (In the referenced material from NRCS the Charlton-Hollis soils are classified as an A-soil . However, the soils are described as sandy loam. And for infiltration rate as classified by Rawls Rates, this is a B-soil.) Similarly, the infiltration rate the retention ponds used is 1.02 in/hr (see Rawls Rates). For the Udorthents, the soils are

assumed to be C-soils, which is relatively conservative considering that with development, the catchment area towards the rear of the lot is increased with additional C-soils.

1.3 Comparison of Pre- and Post-Development Areas

On the site as a whole, comparing pre-development to post-development, here are the areas in percentages:

Current Conditions	
Woods	63.4%
Exposed Ledge	0.8%
Lawn	21.2%
Houses	2.8%
Walkways	0.2%
Driveways	3.6%
Wetlands	8.0%

Proposed Conditions	
Woods	22.0%
Exposed Ledge	0.6%
Lawn	51.3%
Houses	7.1%
Walkways	1.0%
Driveways	10.0%
Wetlands	8.0%

1.4 Methods of Calculations

Calculations are based upon standard methodologies set forth in U.S. Soil Conservation Service TR-55 and TR-20 and performed by *HydroCAD Software*. More specifically, the rainfall is based upon a design storm in 24 hours, and a Type III Rainfall. The size of storm is as follows:

Storm Event	24-hr Precipitation
100-yr	6.6”
10-yr	4.5”
2-yr	3.2”

As in standard practice, the Antecedent Moisture Content (AMC) is assumed normal in the calculations, that being AMC 2.

Formulae Used:

Time of Concentration, $\mathbf{T_c}$, is calculated by summing different travel times, T_t, for each consecutive different type of flow from runoff. The types of flow in the design considered are as follows:

TR-55 Sheet Flow,

$$T_t = 0.007(nL)^{0.8} / (P_2^{0.5}.s^{0.4})$$

where:

T_t =Travel time [hours]
n = Manning's coefficient for sheet flow (See table)
L = Flow length [feet]
P_2 = 2-year, 24-hour rainfall [inches]
S = Land slope (along flow path) [ft/ft]

TR-55 Shallow Concentrated Flow,

$$T_t = L/V \text{ and } V = K_v.S^{1/2}$$

where:

V = Average velocity
K_v = Velocity factor
S = Land slope (along flow path) [rise/run]

and Channel Flow which is calculated using Manning's Equation.

The minimum Time of Concentration for a subcatchment is taken as 0.1 hrs as defined in TR-55.

The **amount of runoff** for a given storm event is determined by the SCS Runoff Equation is:

$$Q = (P-0.2S)^2/(P+0.8S) \text{ and } S = 1000/CN - 10,$$

where:

Q = Precipitation excess (runoff) [inches or mm]
P = Cumulative precipitation [inches or mm]
S = Potential maximum retention [inches]
CN = Curve number (TR-55)

1.5 Drainage Subcatchment Areas

There are three subcatchments for parcel on Mass. Ave., subcatchments 1 to 3: Subcatchments 1 and 2 drain towards the front of the lot, while subcatchment 3 drains towards the rear of the lot. With development, subcatchment 3 is divided into two sections: 3a and 3b. Subcatchment 3a drains through the retention basin while 3b drains directly to the design point for subcatchment 3.

There are two subcatchments for Parcel on Prospect Street, subcatchments 4 and 5: Subcatchment 4 drains towards the street, while subcatchment 5 drains towards the rear of the lot. With development, sub 5 is divided into two areas, 5a and 5b. Subcatchment 5a is intercepted by the retention pond, and the overflow meets runoff from subcatchment 5b at the original design point.

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360 MASS. AVENUE, ACTON, MA 01720
PHONE: (978)264-4600

Here are the areas tabulated:

Pre-development Conditions

		SUB 1	SUB 2	SUB 3	SUB 4	SUB 5	TOTALS
SOILS B	Lawn	0	0	9621	5783	7719	23123
	House	0	0	1635	794	1257	3685
	Walkway	0	0	270	0	0	270
	Pavement	0	0	2352	1342	0	3694
	Woods	0	0	46596	2870	27348	76815
	Ledge	0	0	0	413	673	1086
	Wetlands	0	0	7868	0	2747	10615
	TOTAL	0	0	68342	11202	39744	119287
SOILS C	Lawn	2529	2599	0	0	0	5128
	Pavement	1085	0	0	0	0	1085
	Woods	2785	4871	0	0	0	7656
	TOTAL	6399	7470	0	0	0	13869
	TOTAL	6399	7470	68342	11202	39744	133156

Post-development Conditions

		SUB 1	SUB 2	SUB 3a	SUB 3b	SUB 4	SUB 5a	SUB 5b	TOTALS
SOILS B	Lawn	0	0	17615	20682	4364	17790	2157	62609
	House	0	0	2186	1946	0	4032	0	8164
	Walkway	0	0	274	270	0	650	0	1194
	Pavement	0	0	4049	2632	1852	3247	0	11781
	Ledge	0	0	0	0	394	425	0	819
	Woods	0	0	1306	10593	0	0	12207	24107
	Wetlands	0	0	0	7868	0	0	2747	10615
	TOTAL	0	0	25431	43991	6609	26145	17112	119288
SOILS C	Lawn	1527	2296	1747	167	0	0	0	5737
	House	0	0	1297	0	0	0	0	1297
	Walkway		46	110	0	0	0	0	156
	Pavement	1003	0	502	0	0	0	0	1505
	Woods	1644	3351	0	178	0	0	0	5173
	TOTAL	4174	5693	3656	345	0	0	0	13868
	TOTAL	4174	5693	29087	44336	6609	26145	17112	133156

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Runoff Tabulated Results

		Pre	Post	Pre	Post	Pre	Post
		2 yr		10 yr		100 yr	
Sub 1	Flow (cfs)	0.21	0.15	0.39	0.27	0.71	0.47
	Vol. (af)	0.016	0.011	0.028	0.019	0.050	0.034
Sub 2	Flow (cfs)	0.19	0.17	0.38	0.30	0.72	0.57
	Vol. (af)	0.014	0.011	0.027	0.021	0.051	0.040
Sub 3	Flow (cfs)	1.06	0.95	2.55	2.04	5.46	4.92
	Vol. (af)	0.090	0.074	0.191	0.188	0.391	0.418
Sub 4	Flow (cfs)	0.21	0.17	0.47	0.35	0.96	0.66
	Vol. (af)	0.017	0.013	0.034	0.025	0.068	0.047
Sub 5	Flow (cfs)	0.56	0.25	1.40	0.60	3.06	3.06
	Vol. (af)	0.049	0.021	0.106	0.088	0.220	0.218

1.6 Conclusion

The calculations show that the rate of runoff is reduced with development and volume of runoff is reduced in all cases except for subcatchment 3 in a 100-yr storm event where there's a slight increase.

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360 MASS. AVENUE, ACTON, MA 01720
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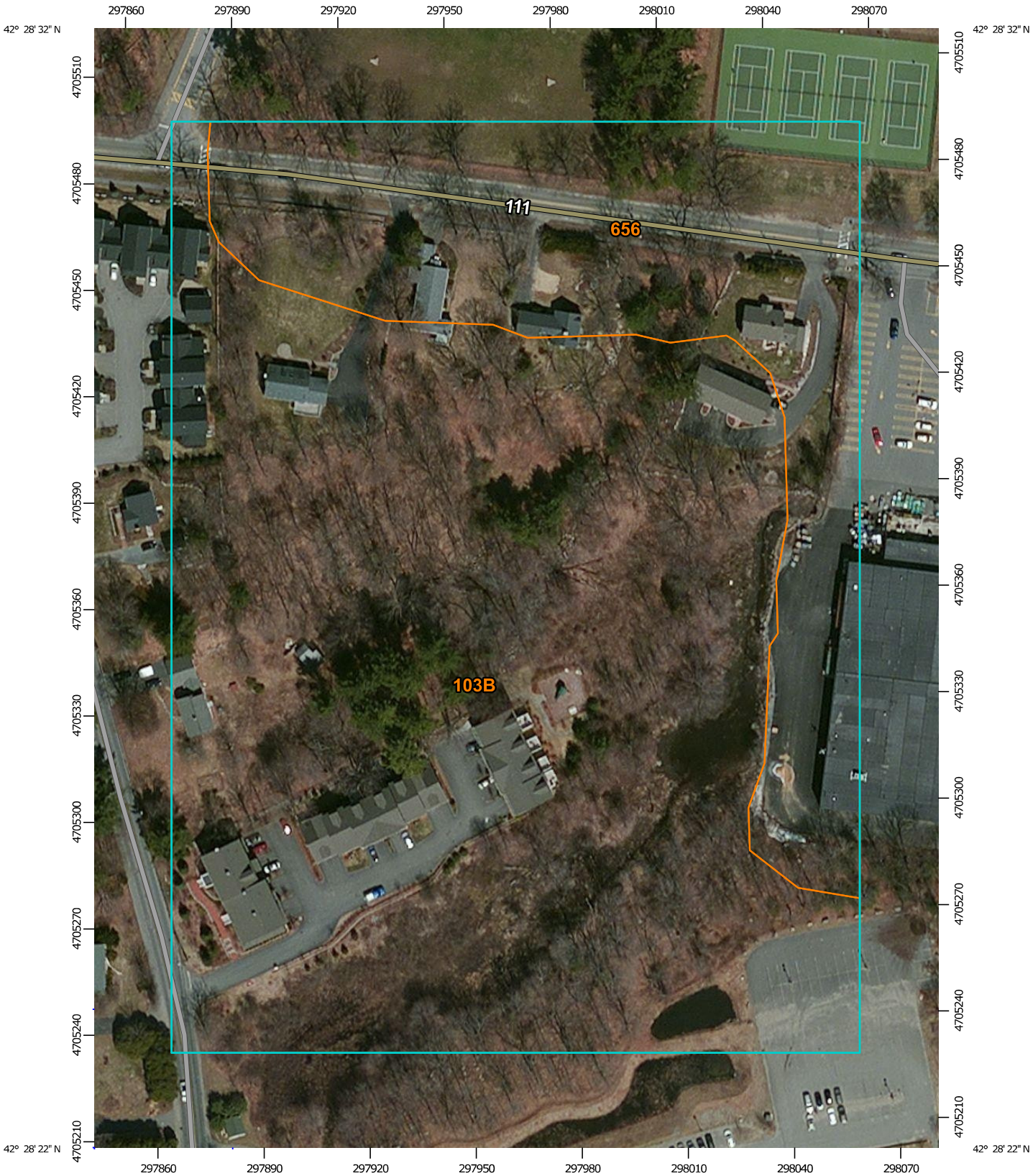
APPENDIX 2.1
NRCS SOIL MAP

Soil Map—Middlesex County, Massachusetts
(456 Massachusetts Ave., Acton)



Map Scale: 1:1,540 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 20 40 80 120

Feet
0 50 100 200 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

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: Middlesex County, Massachusetts
Survey Area Data: Version 14, Sep 19, 2014

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

Date(s) aerial images were photographed: Mar 30, 2011—May 1, 2011

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 — Middlesex County, Massachusetts (MA017)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
103B	Charlton-Hollis-Rock outcrop complex, 3 to 8 percent slopes	A	9.1	72.1%
656	Udorthents-Urban land complex		3.5	27.9%
Totals for Area of Interest			**12.7**	**100.0%**

Description

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

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

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

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

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

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

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

Middlesex County, Massachusetts

103B—Charlton-Hollis-Rock outcrop complex, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 98yc
Elevation: 0 to 1,000 feet
Mean annual precipitation: 45 to 54 inches
Mean annual air temperature: 43 to 54 degrees F
Frost-free period: 110 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Charlton and similar soils: 50 percent
Hollis and similar soils: 25 percent
Rock outcrop: 15 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Charlton

Setting

Landform: Ground moraines, drumlins
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Friable loamy eolian deposits over friable loamy basal till derived from granite and gneiss

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 22 inches: sandy loam
H3 - 22 to 65 inches: gravelly sandy loam

Properties and qualities

Slope: 3 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s

Hydrologic Soil Group: A

Description of Hollis

Setting

Landform: Hills, ridges
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Crest
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Friable, shallow loamy basal till over granite and gneiss

Typical profile

H1 - 0 to 2 inches: fine sandy loam
H2 - 2 to 14 inches: fine sandy loam
H3 - 14 to 18 inches: unweathered bedrock

Properties and qualities

Slope: 3 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 2.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D

Description of Rock Outcrop

Setting

Landform: Ledges
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Head slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Granite and gneiss

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 0 inches to lithic bedrock

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s

Minor Components

Canton

Percent of map unit: 2 percent
Landform: Hills
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Head slope
Down-slope shape: Convex
Across-slope shape: Convex

Woodbridge

Percent of map unit: 2 percent
Landform: Hillslopes
Landform position (two-dimensional): Shoulder, toeslope, summit
Landform position (three-dimensional): Head slope, base slope, nose slope
Down-slope shape: Linear
Across-slope shape: Concave

Scituate

Percent of map unit: 2 percent
Landform: Depressions, hillslopes
Landform position (two-dimensional): Toeslope, summit
Landform position (three-dimensional): Head slope, base slope
Down-slope shape: Linear
Across-slope shape: Concave

Narragansett

Percent of map unit: 2 percent
Landform: Hills, ridges
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Convex

Unnamed

Percent of map unit: 1 percent

Montauk

Percent of map unit: 1 percent
Landform: Hillslopes
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Head slope, nose slope
Down-slope shape: Convex
Across-slope shape: Convex

Data Source Information

Soil Survey Area: Middlesex County, Massachusetts
Survey Area Data: Version 14, Sep 19, 2014

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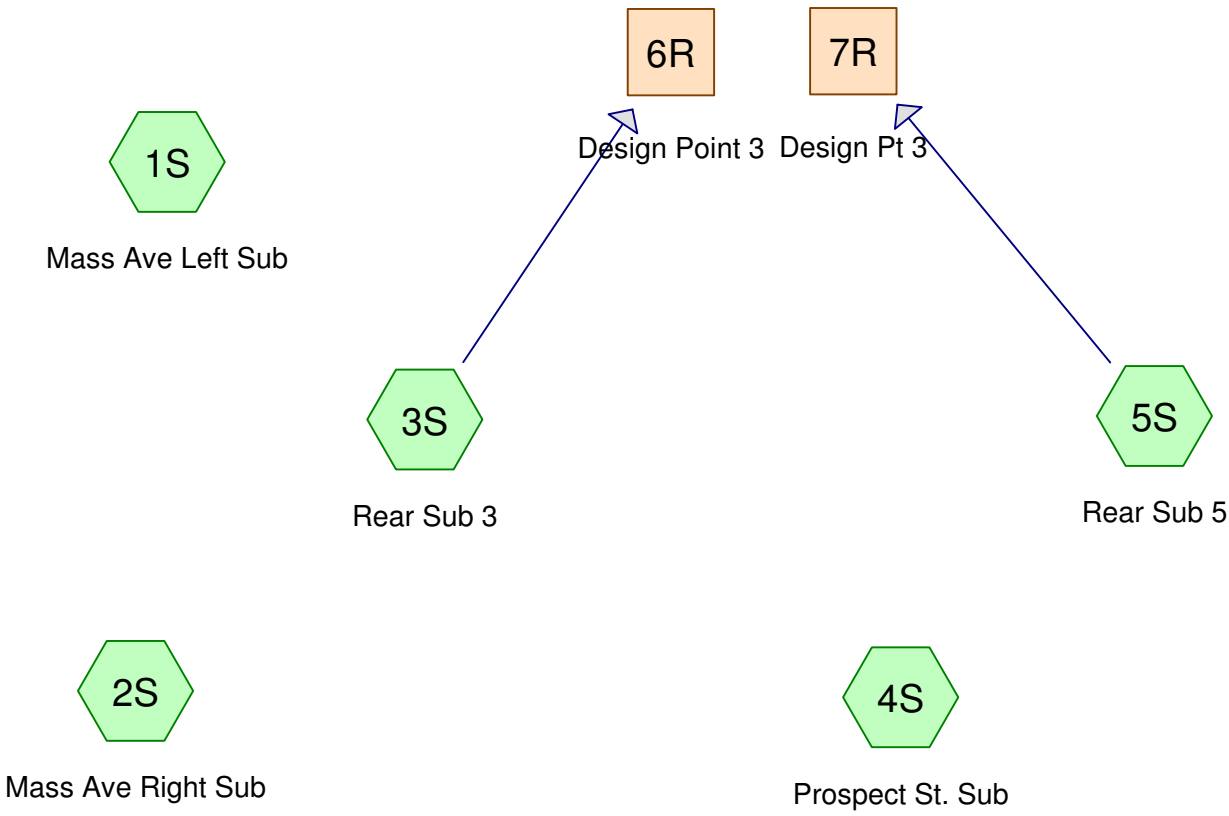
PHONE: (978)264-4600

APPENDIX 2.2
DRAINAGE CALCULATIONS

Jaime's Way & Thomas Drive
Project Report
May 22, 2015



Subcat Reach Pond Link

Routing Diagram for Existing Conditions r2
Prepared by Toshiba, Printed 5/20/2015
HydroCAD® 10.00 s/n 07347 © 2011 HydroCAD Software Solutions LLC

Summary for Subcatchment 1S: Mass Ave Left Sub

Runoff = 0.21 cfs @ 12.09 hrs, Volume= 0.016 af, Depth= 1.27"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

	Area (sf)	CN	Description
	2,529	74	>75% Grass cover, Good, HSG C
*	1,085	98	Driveway, HSG C
	2,784	73	Woods, Fair, HSG C
	6,398	78	Weighted Average
	5,313		83.04% Pervious Area
	1,085		16.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, 0.1 hr. min**

Summary for Subcatchment 2S: Mass Ave Right Sub

Runoff = 0.19 cfs @ 12.10 hrs, Volume= 0.014 af, Depth= 0.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

Area (sf)	CN	Description
2,599	74	>75% Grass cover, Good, HSG C
4,871	73	Woods, Fair, HSG C
7,470	73	Weighted Average
7,470		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, 0.1 hr. min**

Summary for Subcatchment 3S: Rear Sub 3

Runoff = 1.06 cfs @ 12.10 hrs, Volume= 0.090 af, Depth= 0.69"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

	Area (sf)	CN	Description
	9,621	61	>75% Grass cover, Good, HSG B
	1,635	98	Roofs, HSG B
*	270	98	Walkway, HSG B
*	2,352	98	Driveway, HSG B
	46,587	60	Woods, Fair, HSG B
*	7,868	98	Wetlands
	68,333	67	Weighted Average
	56,208		82.26% Pervious Area
	12,125		17.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, 0.1 hr. min**

Summary for Subcatchment 4S: Prospect St. Sub

Runoff = 0.21 cfs @ 12.10 hrs, Volume= 0.017 af, Depth= 0.78"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

	Area (sf)	CN	Description
	5,783	61	>75% Grass cover, Good, HSG B
	794	98	Roofs, HSG B
	1,342	98	Paved parking, HSG B
	2,870	60	Woods, Fair, HSG B
*	413	98	Ledge
	11,202	69	Weighted Average
	8,653		77.25% Pervious Area
	2,549		22.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, 0.1 hr min.**

Summary for Subcatchment 5S: Rear Sub 5

Runoff = 0.56 cfs @ 12.11 hrs, Volume= 0.049 af, Depth= 0.64"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

	Area (sf)	CN	Description
*	2,747	98	Wetlands
	27,348	60	Woods, Fair, HSG B
	1,257	98	Roofs, HSG B
	7,719	69	50-75% Grass cover, Fair, HSG B
*	673	98	Ledge
	39,744	66	Weighted Average
	35,067		88.23% Pervious Area
	4,677		11.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, 0.1 hr. min.**

Summary for Reach 6R: Design Point 3

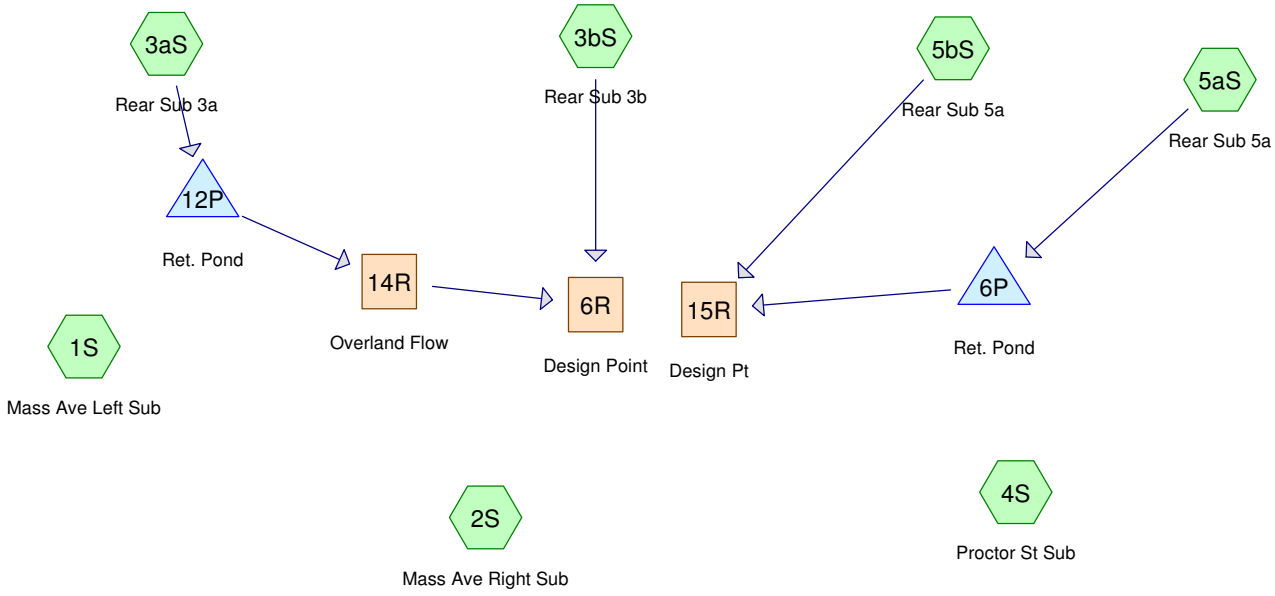
Inflow Area = 1.569 ac, 17.74% Impervious, Inflow Depth = 0.69" for 2 yr event
Inflow = 1.06 cfs @ 12.10 hrs, Volume= 0.090 af
Outflow = 1.06 cfs @ 12.10 hrs, Volume= 0.090 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Reach 7R: Design Pt 3

Inflow Area = 0.912 ac, 11.77% Impervious, Inflow Depth = 0.64" for 2 yr event
Inflow = 0.56 cfs @ 12.11 hrs, Volume= 0.049 af
Outflow = 0.56 cfs @ 12.11 hrs, Volume= 0.049 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs



Subcat Reach Pond Link

Routing Diagram for Proposed Conditions r2
Prepared by Toshiba, Printed 5/20/2015
HydroCAD® 10.00 s/n 07347 © 2011 HydroCAD Software Solutions LLC

Summary for Subcatchment 1S: Mass Ave Left Sub

Runoff = 0.15 cfs @ 12.09 hrs, Volume= 0.011 af, Depth= 1.34"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

Area (sf)	CN	Description
1,527	74	>75% Grass cover, Good, HSG C
1,003	98	Paved parking, HSG C
1,644	73	Woods, Fair, HSG C
4,174	79	Weighted Average
3,171		75.97% Pervious Area
1,003		24.03% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, 0.1 hr. min.**

Summary for Subcatchment 2S: Mass Ave Right Sub

Runoff = 0.15 cfs @ 12.10 hrs, Volume= 0.011 af, Depth= 1.04"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

	Area (sf)	CN	Description
	2,296	74	>75% Grass cover, Good, HSG C
	3,351	73	Woods, Fair, HSG C
*	46	98	Walkway, HSG C
	5,693	74	Weighted Average
	5,647		99.19% Pervious Area
	46		0.81% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, .1 hr. min.**

Summary for Subcatchment 3aS: Rear Sub 3a

Runoff = 0.58 cfs @ 12.10 hrs, Volume= 0.046 af, Depth= 0.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

	Area (sf)	CN	Description
	17,615	61	>75% Grass cover, Good, HSG B
	1,747	74	>75% Grass cover, Good, HSG C
*	2,186	98	Unconnected roofs, HSG B
	1,297	98	Unconnected roofs, HSG C
*	274	98	Unconnected walkways, HSG B
*	110	98	Unconnected walkway, HSG C
*	4,049	98	Drive, HSG B
*	502	98	Drive, HSG C
	1,306	60	Woods, Fair, HSG B
	29,086	72	Weighted Average, UI Adjusted CN = 70
	20,668		71.06% Pervious Area
	8,418		28.94% Impervious Area
	3,867		45.94% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Summary for Subcatchment 3bS: Rear Sub 3b

Runoff = 0.95 cfs @ 12.10 hrs, Volume= 0.074 af, Depth= 0.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

	Area (sf)	CN	Description
	20,682	61	>75% Grass cover, Good, HSG B
	167	74	>75% Grass cover, Good, HSG C
*	270	98	Walkway, HSG B
	10,593	60	Woods, Fair, HSG B
	178	73	Woods, Fair, HSG C
*	7,868	98	Wetlands
*	1,946	98	Unconnected roofs, HSG A
*	2,632	98	Drive, HSG A
	44,336	71	Weighted Average
	31,620		71.32% Pervious Area
	12,716		28.68% Impervious Area
	1,946		15.30% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Summary for Subcatchment 4S: Proctor St Sub

Runoff = 0.17 cfs @ 12.10 hrs, Volume= 0.013 af, Depth= 1.04"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

	Area (sf)	CN	Description
	4,364	61	>75% Grass cover, Good, HSG B
	1,852	98	Unconnected pavement, HSG B
*	394	98	Ledge
	6,610	74	Weighted Average
	4,364		66.02% Pervious Area
	2,246		33.98% Impervious Area
	1,852		82.46% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, 0.1 hr. min.**

Summary for Subcatchment 5aS: Rear Sub 5a

Runoff = 0.65 cfs @ 12.10 hrs, Volume= 0.049 af, Depth= 0.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

	Area (sf)	CN	Description
	17,790	61	>75% Grass cover, Good, HSG B
	4,032	98	Unconnected roofs, HSG B
*	650	98	Walkway
	3,247	98	Paved parking, HSG B
*	425	98	Ledge
	0	60	Woods, Fair, HSG B
*	0	98	Wetlands
	26,144	73	Weighted Average
	17,790		68.05% Pervious Area
	8,354		31.95% Impervious Area
	4,032		48.26% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, 0.1 hr. min.**

Summary for Subcatchment 5bS: Rear Sub 5a

Runoff = 0.25 cfs @ 12.10 hrs, Volume= 0.021 af, Depth= 0.69"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr Rainfall=3.20"

	Area (sf)	CN	Description
	2,157	61	>75% Grass cover, Good, HSG B
	0	98	Unconnected roofs, HSG B
*	0	98	Walkway
	0	98	Paved parking, HSG B
*	0	98	Ledge
	11,207	60	Woods, Fair, HSG B
*	2,747	98	Wetlands
	16,111	67	Weighted Average
	13,364		82.95% Pervious Area
	2,747		17.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, 0.1 hr. min.**

Summary for Reach 6R: Design Point

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 1.686 ac, 28.78% Impervious, Inflow Depth = 0.53" for 2 yr event
Inflow = 0.95 cfs @ 12.10 hrs, Volume= 0.074 af
Outflow = 0.95 cfs @ 12.10 hrs, Volume= 0.074 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Reach 14R: Overland Flow

Inflow Area = 0.668 ac, 28.94% Impervious, Inflow Depth = 0.00" for 2 yr event
Inflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.00 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 0.00 fps, Avg. Travel Time= 0.0 min

Peak Storage= 0 cf @ 0.00 hrs
Average Depth at Peak Storage= 0.00'
Bank-Full Depth= 0.10' Flow Area= 2.0 sf, Capacity= 6.00 cfs

20.00' x 0.10' deep channel, n= 0.030
Length= 125.0' Slope= 0.0800 '/'
Inlet Invert= 228.00', Outlet Invert= 218.00'

Summary for Reach 15R: Design Pt

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.970 ac, 26.27% Impervious, Inflow Depth = 0.26" for 2 yr event
Inflow = 0.25 cfs @ 12.10 hrs, Volume= 0.021 af
Outflow = 0.25 cfs @ 12.10 hrs, Volume= 0.021 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Pond 6P: Ret. Pond

Inflow Area = 0.600 ac, 31.95% Impervious, Inflow Depth = 0.98" for 2 yr event
Inflow = 0.65 cfs @ 12.10 hrs, Volume= 0.049 af
Outflow = 0.01 cfs @ 11.53 hrs, Volume= 0.030 af, Atten= 98%, Lag= 0.0 min
Discarded = 0.01 cfs @ 11.53 hrs, Volume= 0.030 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 219.14' @ 24.04 hrs Surf.Area= 1,352 sf Storage= 1,681 cf

Plug-Flow detention time= 1,033.0 min calculated for 0.030 af (62% of inflow)
Center-of-Mass det. time= 913.8 min (1,779.2 - 865.4)

Volume	Invert	Avail.Storage	Storage Description
#1	217.00'	3,109 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
217.00	403	0	0
218.00	673	538	538
219.00	1,257	965	1,503
220.00	1,954	1,606	3,109

Device	Routing	Invert	Outlet Devices
#1	Primary	219.20'	**5.0' long x 8.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.43 2.54 2.70 2.69 2.68 2.68 2.66 2.64 2.64 2.64 2.65 2.65 2.66 2.66 2.68 2.70 2.74
#2	Discarded	217.00'	**0.01 cfs Exfiltration at all elevations**

Discarded OutFlow Max=0.01 cfs @ 11.53 hrs HW=217.03' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=217.00' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 12P: Ret. Pond

Inflow Area = 0.668 ac, 28.94% Impervious, Inflow Depth = 0.83" for 2 yr event
Inflow = 0.58 cfs @ 12.10 hrs, Volume= 0.046 af
Outflow = 0.01 cfs @ 11.70 hrs, Volume= 0.030 af, Atten= 98%, Lag= 0.0 min
Discarded = 0.01 cfs @ 11.70 hrs, Volume= 0.030 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 228.07' @ 24.04 hrs Surf.Area= 1,234 sf Storage= 1,556 cf

Plug-Flow detention time= 1,027.9 min calculated for 0.030 af (65% of inflow)
Center-of-Mass det. time= 911.8 min (1,787.6 - 875.7)

Volume	Invert	Avail.Storage	Storage Description
#1	226.00'	2,998 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
226.00	284	0	0
228.00	1,182	1,466	1,466
229.00	1,882	1,532	2,998

Device	Routing	Invert	Outlet Devices
#1	Primary	228.20'	**5.0' long x 8.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.43 2.54 2.70 2.69 2.68 2.68 2.66 2.64 2.64 2.64 2.65 2.65 2.66 2.66 2.68 2.70 2.74
#2	Discarded	226.00'	**0.01 cfs Exfiltration at all elevations**

Discarded OutFlow Max=0.01 cfs @ 11.70 hrs HW=226.03' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=226.00' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

MARKEY & RUBIN, INC.
360 MASS. AVENUE, ACTON, MA 01720
PHONE: (978)264-4600

APPENDIX 2.3
DRAINAGE SKETCHES

Jaime's Way & Thomas Drive
Project Report
May 22, 2015

GRAPHIC SCALE

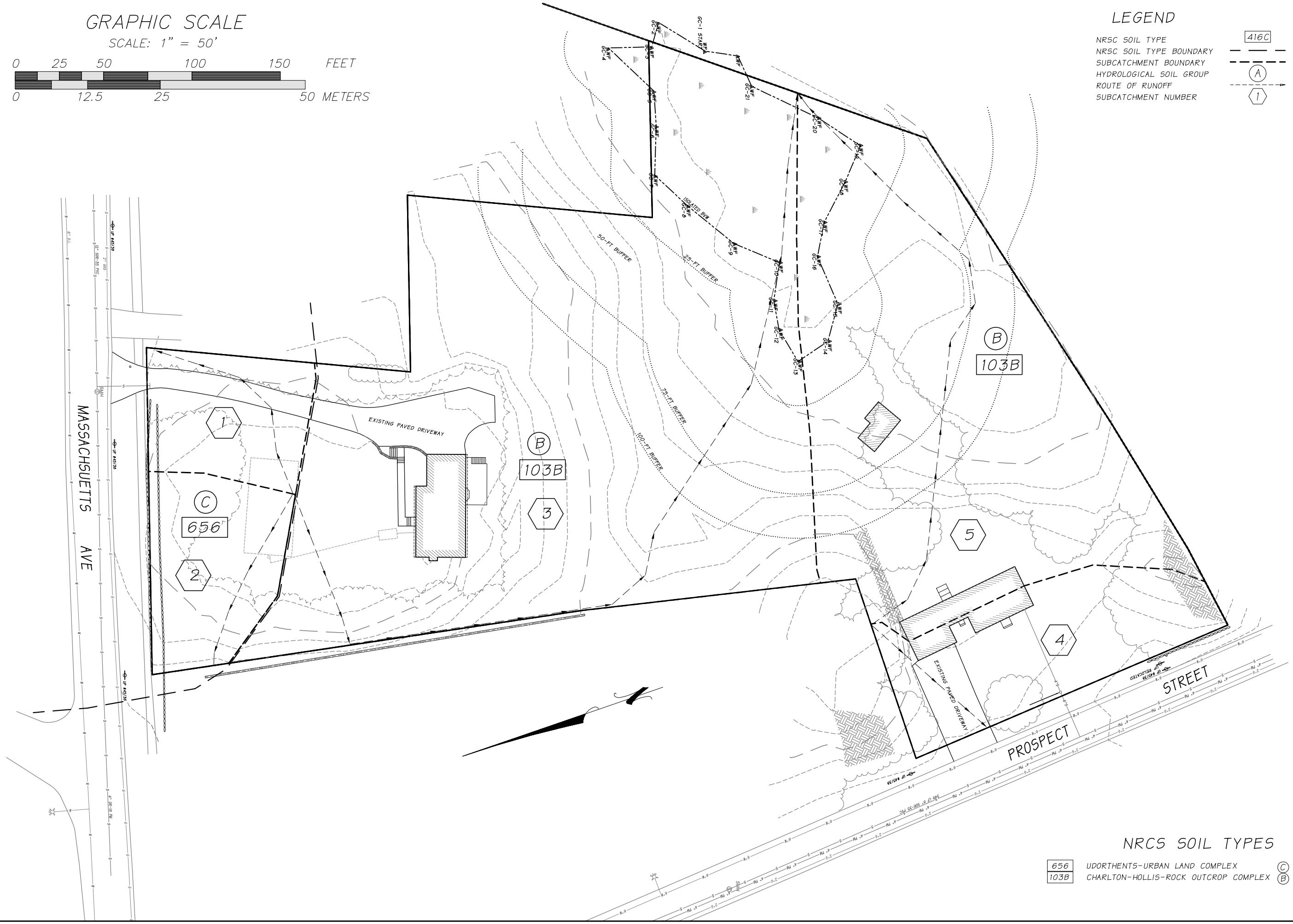
SCALE: 1" = 50'

0 25 50 100 150 FEET

0 12.5 25 50 METERS

LEGEND

NRSC SOIL TYPE	416C
NRSC SOIL TYPE BOUNDARY	
SUBCATCHMENT BOUNDARY	
HYDROLOGICAL SOIL GROUP	A
ROUTE OF RUNOFF	
SUBCATCHMENT NUMBER	1



NRCS SOIL TYPES

656	UDORTHENTS-URBAN LAND COMPLEX	C
103B	CHARLTON-HOLLIS-ROCK OUTCROP COMPLEX	B

#	DATE	REVISION COMMENT
		DATE: 05/22/15

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TITLE:
PROPOSED DRAINAGE CALCULATIONS
456 MASSACHUSETTS AVENUE
& 143 PROSPECT STREET
ACTON, MASSACHUSETTS

CLIENT:
KEENAN & SON, LLP
54 GRISTMILL RD.
LITTLETON, MASSACHUSETTS

360 MASSACHUSETTS AVE, SUITE 200
ACTON, MASSACHUSETTS 01720
P(978) 263-0430 F(978) 263-0447
www.MarkeyAndRubin.com
Markey & Rubin
CIVIL ENGINEERING

D1

SHEET 1 OF 2

JOB# 5109

GRAPHIC SCALE

SCALE: 1" = 50'

0 25 50 100 150 FEET

0 12.5 25 50 METERS

LEGEND

NRSC SOIL TYPE 416C

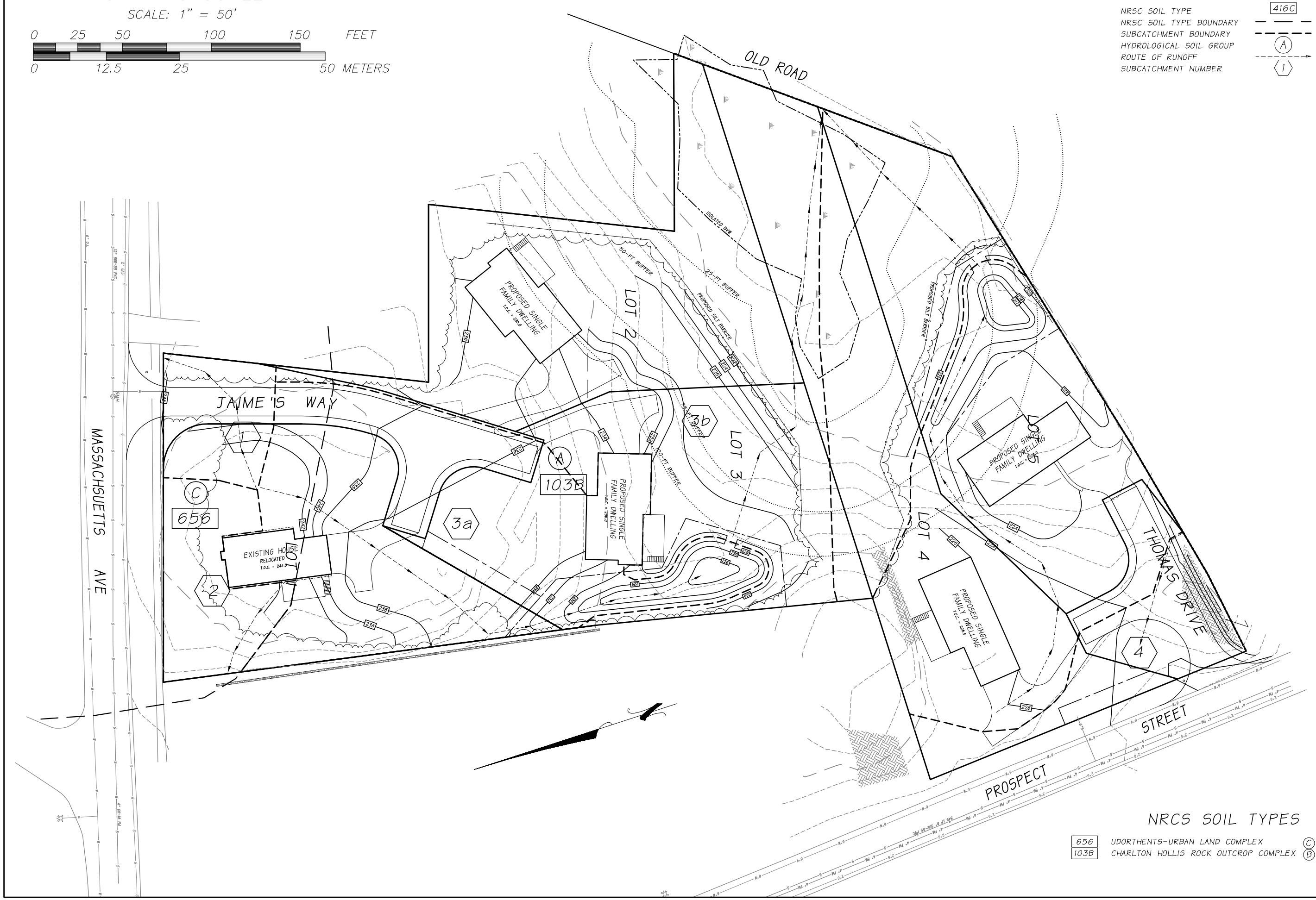
NRSC SOIL TYPE BOUNDARY

SUBCATCHMENT BOUNDARY

HYDROLOGICAL SOIL GROUP (A)

ROUTE OF RUNOFF

SUBCATCHMENT NUMBER (1)



NRCS SOIL TYPES

656	UDORTHENTS-URBAN LAND COMPLEX	C
103B	CHARLTON-HOLLIS-ROCK OUTCROP COMPLEX	B

#	DATE	REVISION COMMENT

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360 MASSACHUSETTS AVE, SUITE 200
ACTON, MASSACHUSETTS 01720
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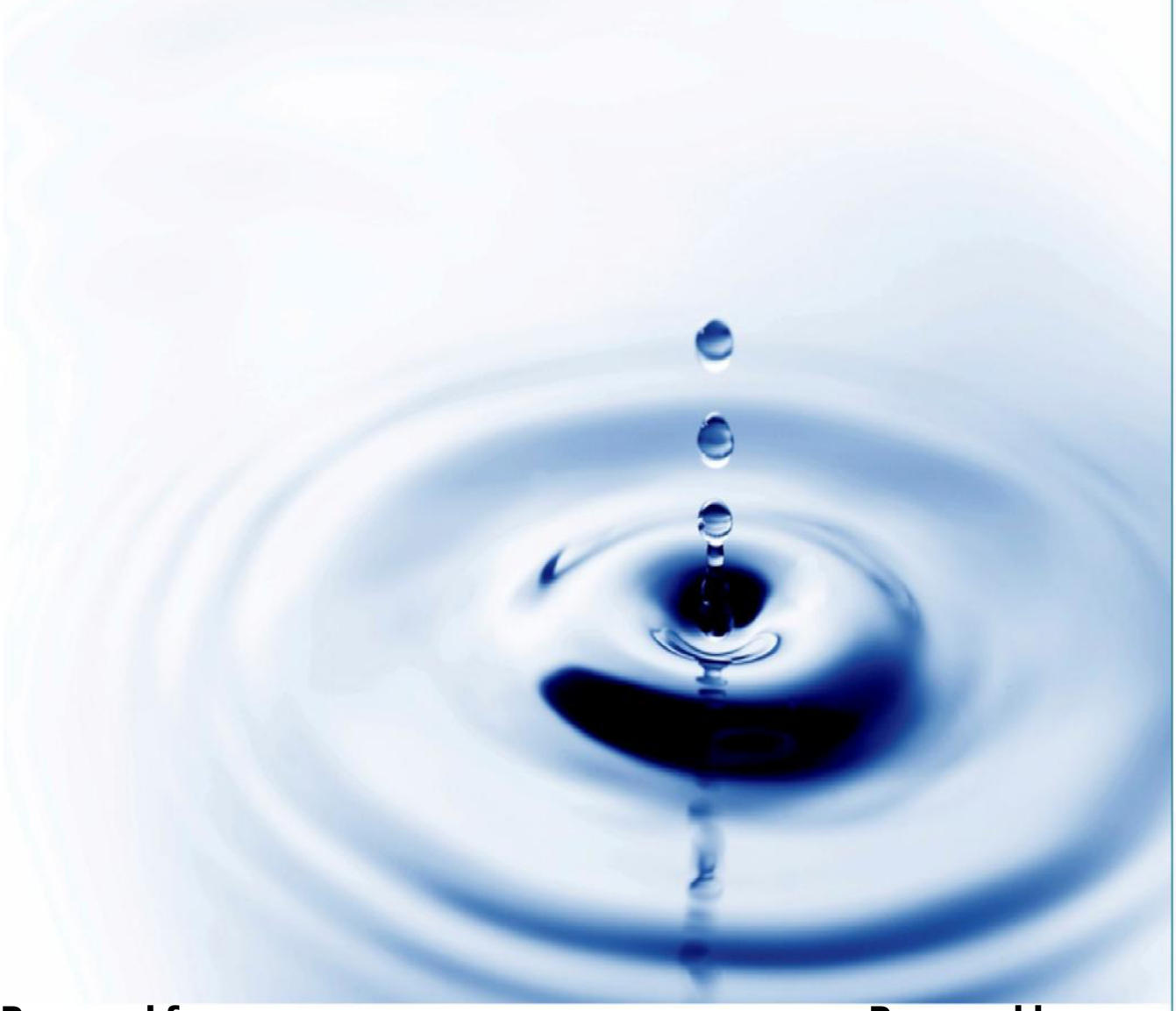
D2

JOB# 5109

STORMWATER SYSTEM OPERATION & MAINTENANCE

Jaime's Way, 456 Massachusetts Avenue, & Thomas Drive, 143 Prospect Street, Acton MA



Prepared for:
Keenan and Son, LLP
54 Gristmill Rd.,
Littleton, MA

Prepared by:
Markey & Rubin, Inc.
360 Massachusetts Ave.
Acton, MA

May 22, 2015

Table of Contents

A.0 Introduction

In general, stormwater runoff from developed areas contains a number of contaminants which can have an adverse impact on receiving waters. The installation of stormwater management systems that are properly designed, installed and maintained can significantly reduce the point and non-point discharges from developed areas.

The stormwater management system can protect and enhance the stormwater runoff water quality through the removal of sediments and pollutants, and source control significantly reduces the amount of pollutants entering the system. Preventative maintenance of the system will include a comprehensive source reduction program of regular vacuuming and litter removal, prohibitions on the use of pesticides and maintenance of designated waste and recycling areas.

This long-term Stormwater Management System Operations and Maintenance (O&M) Manual, filed with the Town of Acton, shall be implemented at Jaime's Way and Thomas Drive to ensure that the stormwater management system functions as designed. The Owner possesses the primary responsibility for overseeing and implementing the O&M plan and assigning a property manager who will be responsible for the proper operation and maintenance of the stormwater structures.

In case of the transfer of property ownership, future property owners shall be notified of the presence of the stormwater management system and the requirements for proper implementation of the O&M plan.

Included in this manual is an overall site plan which identifies the locations of the key components of the stormwater management system.

A.1 Responsibility

The purpose of the Stormwater Operations and Maintenance Manual is to ensure the inspection of the system, removal of accumulated sediments, oils and debris, and implementation of corrective action and record keeping activities. The ongoing responsibility is the Owner, its successors and assignees. Adequate maintenance is defined in this document as good working condition.

Contact information is provided below:

Responsibility for Operation and Maintenance

Name: Keenan and Son, LLP
Address: 54 Gristmill Road
City, State: Littleton, Massachusetts
Contact: Sean Keenan
Email: sawitbuildit@gmail.com

These documents shall be signed by owner below:

"I have read these documents and shall be responsible for their implementation:

Signed_____ Date_____"

In the event that the responsible party changes, these records shall be changed accordingly and signed by new party in charge.

B.0 Maintenance Program

The Owner shall conduct the Operation and Maintenance program set forth in this document. The Owner will ensure that inspections timely and accurate and that cleaning and maintenance are performed in accordance with the recommended frequency for each stormwater component.

B.1 Inspection and Maintenance Frequency and Corrective Measures

The following areas, facilities and measures will be inspected by the Owner maintained as specified below. Identified deficiencies will be corrected. Accumulated sediments and debris will be properly handled and disposed of off-site, in accordance with local, state and federal guidelines and regulations.

B.1.1 Routine Maintenance Tasks

- Routine maintenance of lawns, gardens, and other landscaped areas shall occur as necessary to maintain the property in a neat and orderly fashion. Clippings and/or mulch shall not be washed into the drainage infrastructure.

- Maintenance of the Stormwater Management System shall be in accordance with the Operations and Maintenance Checklist below.

- Snow shall be stored on the site in designated areas.

- Good housekeeping – all areas should be kept free of trash and debris. Any storage of materials and waste products shall be inside or under cover. Fertilizers, herbicides and pesticides, if stored on site, shall be stored properly contained and under cover. Storage of salt or deicing chemicals, if any, shall be on impervious area, covered and protected from runoff.

B.1.2 Illicit Discharges

During construction, and all illicit connections from the property shall be cut and capped. The proposed site stormwater management system shall be checked for signs of illicit discharge during regular operation and maintenance activities. This will include but not be limited to checking for connections other than stormwater to the drainage system. Should connections other than stormwater be found, they will be immediately removed.

B.1.3 Retention Ponds

Retention Pond requires regular inspection and maintenance to ensure no accumulation of silt, or any other foreign material. Other materials, leaves or twigs, dead vegetation need removal on a regular basis. Discharge rip-rap weir requires attention ensuring effectiveness. Vegetation within and surrounding pond requires cutting and upkeep ensuring no erosion and stability of slopes. Grass clippings must be removed.

Retention pond should be inspected immediately after site construction ensuring vegetation and land forms are well established for long term stability. Once in normal service, the system should be inspected bi-annually until full confidence of the site stability is recognized. The site's maintenance manager can then revise the inspection schedule based on experience or local requirements.

Also, runoff to the retention pond from roadways, roofs and surrounding land should be inspected after construction to ensure that the whole subcatchment area for the runoff is as designed, in both stability and land shape. Once in operation, the subcatchment areas shall remain essentially in their original formation, and shall be in the inspection schedule in an ongoing manner.

B.2 Winter Maintenance Program

Ensure structures are not blocked by ice, snow, debris or trash during winter months. Snow storage locations must be designated and drainage from melting well understood to ensure no scouring or erosion. All locations must be outside of the 100-foot wetland buffer zone.

B.3 Fertilizer Selection and Use

The goal of fertilizer use should be to enhance the ground cover of the facility, yet not result in adverse water quality impacts. The following guidelines are recommended.

B.3.1 Fertilizer Selection

The selection of fertilizer should be based upon site-specific requirements. Recommendations for the fertilizer will be made upon completion of the project and actual tests of the soil mix. The benefit of the use of a soil mix is the ability of the soil to absorb and store nutrients for subsequent plant growth better than a sandy loam.

It is recommended that the soil be re-sampled every three (3) years and the plan adjusted accordingly.

In locations considered a sensitive natural area only slow-release organic low phosphorus fertilizers should be used in any landscaped areas to limit the amount of nutrients that could enter the stormwater management system.

B.3.2 Fertilizer Storage

Fertilizer should be stored in a weatherproof area with containers protected from damage. Fertilizer from any damaged containers should be placed in appropriate weatherproof containers.

B.3.3 Fertilizer Application

Fertilizer should be applied with appropriate mechanical equipment properly calibrated to meet the recommended application rates of the soil

tests and manufacturer. The Owner or his agents should instruct personnel on the use of equipment and the proper measurement of the fertilizer.

Personnel assigned to application should be instructed that over-application of fertilizer is adverse to the landscaped areas and environment. Fertilizer should not be applied to steep slopes, saturated ground, during periods of precipitation, or immediately prior to major rain events.

Appendix A

Stormwater Management System
Maintenance Program Summary Checklist

Stormwater Management System Maintenance Program Summary Checklist					
		Frequency			
Item	Commentary	Monthly	Quarterly	Semi-Annual	Annual
Retention Ponds	Inspect monthly for first six months; inspect for sediment accumulation quarterly of first year - annually thereafter; inspect immediately after spills		X	X	

Appendix B

Stormwater Management System
Operation and Maintenance Forms

STORM WATER MANAGEMENT SYSTEM
OPERATIONS AND MAINTENANCE MANUAL

RETENTION POND

JAIME'S WAY

Name of Inspector: _____ Title of Inspector:_____

Inspector's Signature: _____

Inspection Date	Satisfactory			Location	Maintenance Needed and Description	Implementation Date of Maintenance
	Yes	No	N/A			

STORM WATER MANAGEMENT SYSTEM
OPERATIONS AND MAINTENANCE MANUAL

RETENTION POND

THOMAS DRIVE

Name of Inspector: _____ Title of Inspector:_____

Inspector's Signature:_____

Inspection Date	Satisfactory			Location	Maintenance Needed and Description	Implementation Date of Maintenance
	Yes	No	N/A			