Miacomet Pond Watershed Study

Town of Nantucket, Massachusetts

980 Washington Street | Suite 325
Dedham, Massachusetts 02026
800-446-5518

224428.00

September 2014

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APPENDICES

1. INTRODUCTION

The Miacomet Pond Watershed Study was undertaken to examine the development of the area contributing to Miacomet Pond between 1985 to the present day and to evaluate options available to reduce localized flooding in areas of concern. The objectives of the work were as follows:

- Identify the extent of the Miacomet Pond Watershed
- Evaluate the changes in land uses since 1985
- Evaluate the impact of development (flood related) on the Pond
- Understand flooding within the watershed
- Identify and evaluate short and long term mitigation measures

Through this analysis, Woodard & Curran has found that flooding within the watershed is due in large part to development in low-lying areas with shallow depths to groundwater and to the development of residential and commercial areas without formal stormwater runoff infrastructure. Additionally, it was found that the water level in Miacomet Pond does not have a significant impact on groundwater levels upstream, but rather, that it is a receiving pond for both groundwater and surface water.

Overall, Woodard & Curran recommends that the Town complete a watershed management plan to educate residents and developers on how best to preserve the ecological features of Miacomet Pond and recommends that best management practices be implemented for stormwater mitigation measures for private properties.

2. BACKGROUND INFORMATION

2.1 DATA COMPILATION

Woodard & Curran has compiled and reviewed various studies, plan sets, ArcGIS Database layers, FEMA floodplain mapping, Miacomet Pond Annual Reports, aerial photography, and historical Google Earth imagery to complete the tasks outlined in the following sections. References are listed in Table 1.

Table 1: References

Document Number	Title	Document Date	Author
1	Nantucket Water Resources Management Plan	3/1/1990	Prepared by Horsley & Witten
2	FEMA Flood Insurance Rate Maps	11/6/1996	FEMA
3	Miacomet Pond Management Chronology	Updated 2010	Town
4	Miacomet Pond Annual Report	2002	Town Biologist
5	Miacomet Pond Annual Report	2003	Town Biologist
6	Miacomet Pond Annual Report	2004	Town Biologist
7	Miacomet Pond Annual Report	2005	Town Biologist
8	Miacomet Pond Sampling Stations	5/1/2006	Town Biologist
9	Nantucket Drainage Outfall Evaluation	1/1/2005	Earth Tech
10	Flood Insurance Study	11/6/1996	FEMA
11	Hydrologic Soils Group	3/24/2011	NRCS
12	StreamStats Output	4/1/2011	USGS
13	Contour Maps	4/1/2011	Town of Nantucket WebGIS
14	Aerial Photographs	1994	MassGIS
15	Aerial Photographs	2009	MassGIS
16	Water Quality Strategic Plan Update	3/9/2011	Town
17	List of Water Quality Reports for Nantucket	N/A	N/A
18	Coastal Management Principles	3/9/2011	Town
19	Stormwater Improvement Program	Unknown	AECOM
20	Nantucket Water Resources Parts 1 and 2	July 2009	Yesterday's Island, Today's Nantucket
21	Sharp Interface Models of Salt Water Intrusion and Wellhead Delineation on Nantucket Island, MA	September & October 1998	Groundwater Journal

2.2 FIELD INVESTIGATIONS

Woodard & Curran completed field visits on November 20, 2013, February 20, 2014, April 4, 2014, and June 10, 2014. During the visits, Woodard & Curran collected relevant data from the Town and completed field investigations required for the delineation and characterization of the watershed.

2.3 MEETINGS & INTERVIEWS

Woodard & Curran held several meetings with Town officials on the dates noted above and completed an interview on April 15, 2014 with a resident who has experienced localized flooding on their property. The information gathered through these meetings has been reviewed and incorporated into this report.

3. AREAS OF CONCERN

Four areas of concern, identified by the Town, as having experienced repeated flooding in the past were reviewed as part of the work to determine sources of isolated flooding. A summary of the four areas is provided below.

3.1 MIACOMET ROAD AND WEST MIACOMET ROAD

The Town identified several low lying portions of town-owned roads, Miacomet Road and West Miacomet Road, which have experienced flooding during and following periods of heavy rain. The low-lying areas are immediately adjacent to Miacomet Pond. Flooding has been reported to be the result of the pond overtopping the roadway. Woodard & Curran conducted a site visit on April 4, 2014, following a rainfall event, and observed the elevation difference between the water level in the Pond and the road surface to be approximately 2-3 inches.

3.2 MIZZENMAST ROAD DEVELOPMENT

Private roadway and property located at the end of Mizzenmast Road, immediately south of the intersection with Rudder Lane. This area is a low-lying portion of private road. Roadway drainage collects at the low point and is conveyed to an existing drainage basin located to the southwest. A raised berm exists along the roadway shoulder, between the roadway and private driveway, to inhibit roadway runoff from entering the private drive. Photographs of this area can be found in Appendix A.

3.3 ALLENS LANE WETLAND AREA

Wetland area located to the west of Allens Lane, at the end of 2nd Way, 3rd Way, 4th Way, and 5th Way. The Town has received complaints from a property owner located on 2nd Way regarding basement flooding during periods of high groundwater. No surface water was observed during Woodard and Curran's site visits. Photographs of 2nd Way and wetland area are provided in Appendix B.

3.4 PLEASANT STREET AREA

The commercial area located between Sanford Road and the Lower Pleasant Street/Sparks Avenue Rotary. The Town has received complaints from a property owner regarding basement flooding during periods of high groundwater. No recent flooding in this location has been reported since a number of remedial measures undertaken. Subsequently, the Town removed this area of concern. Therefore, this report does not provide further assessment of this location.

The location of each of these areas are shown on Figure 1.

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COMMITMENT & INTEGRITY DRIVE RESULTS

AREAS OF CONCERN

TOWN OF NANTUCKET, MA

MIACOMET POND
WATERSHED STUDY

JOB NO.: 224428.00

DRAWN BY: PBF/DAL

DATE: SEPTEMBER 2014

FIGURE 1

4. WATERSHED ASSESSMENT

Woodard & Curran conducted a watershed assessment to establish the pond's watershed boundary, evaluate the changes to land uses within the watershed that have occurred since 1985, and assess what, if any, impacts development in the watershed may have on flooding experienced in the areas of concern. The following provides a summary of the assessment, findings and resulting conclusions.

4.1 WATERSHED BOUNDARY DELINEATION

Woodard & Curran developed the contributing watershed boundary to Miacomet Pond utilizing site visits, topography and contours, drainage infrastructure, roadway infrastructure, and existing land uses. Woodard & Curran delineated a preliminary watershed using 2-foot contours and the drainage infrastructure information provided by the Town. Additionally, site visits were performed to confirm the locations of various culverts, infiltration systems, catch basins, and manholes. The boundary was adjusted based on these observations. In order to finalize the northern edge of the watershed boundary, a detailed analysis of existing land uses, topography, wetlands, and infrastructure was performed to account for any slight details that could have a more significant impact on localized hydrologic flows.

An important consideration for the location of the watershed boundary is the direction of groundwater flow to Miacomet Pond. The total area of the watershed was determined to be approximately 1,040 acres. The watershed boundary is depicted on Figure 2. Approximately 653 acres of the watershed contributes flow to the pond through direct surface runoff. The upper reaches of the watershed are comprised of isolated depressions. Runoff from these areas of the watershed, the remaining 387 acres, is collected in the depressions and infiltrates into the soil to the underlying groundwater aquifer, thus reaching Miacomet Pond through groundwater flow (See Section 4.4). The portion of the watershed that directly contributes surface runoff to the Pond is depicted on Figure 3.

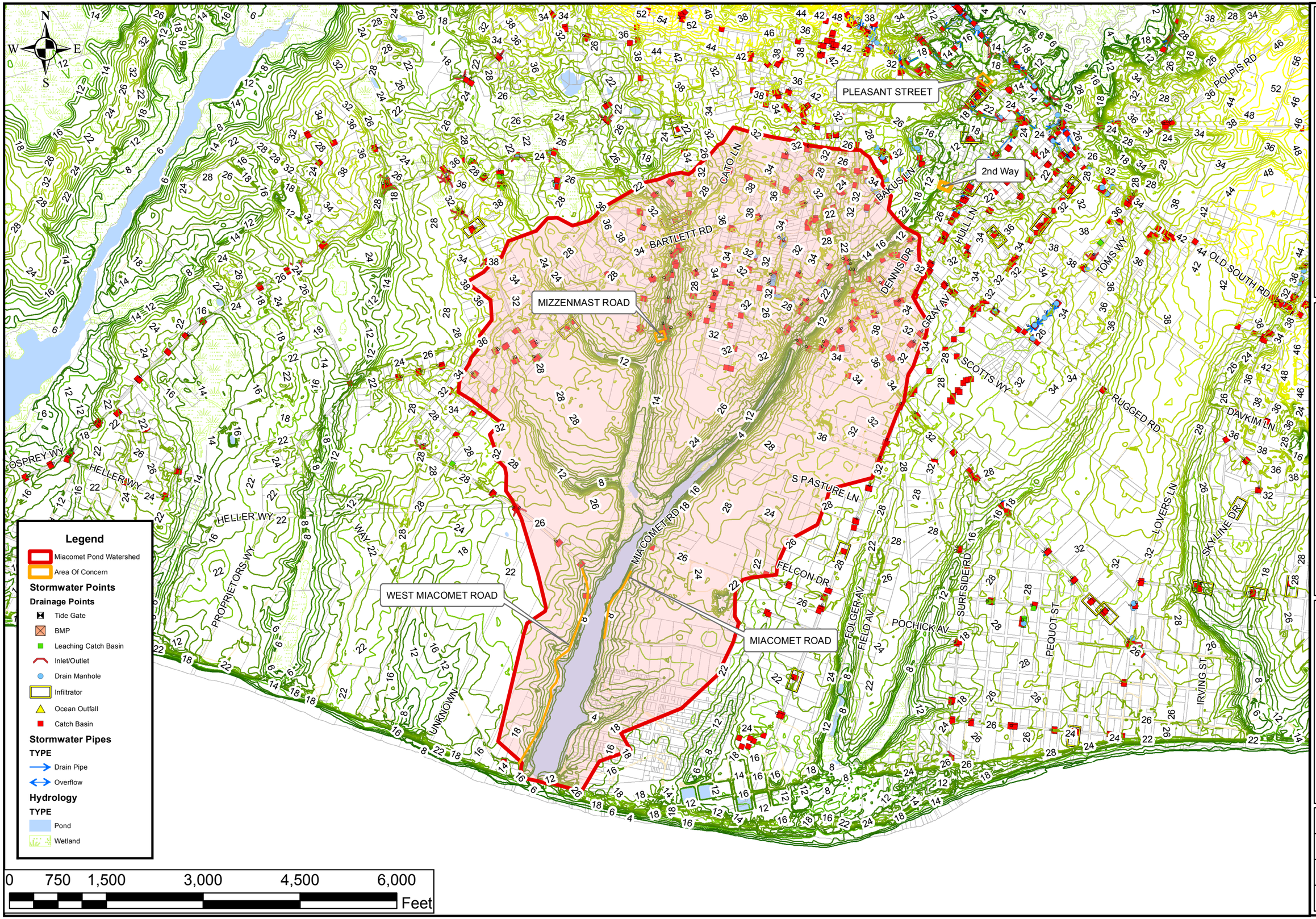
4.2 LAND USE TREND

Woodard & Curran analyzed the changes in land uses from 1985 to 2005 using available ArcGIS Database layers and development plans collected from the Town. The ArcGIS analysis consisted of comparing land use data from 1985 and from 2005. This information was evaluated in Excel to calculate the changes in land use over time in the contributing area. For the purposes of this study, ArcGIS Land Use Codes were used to correlate the 1985 data with the 2005 data to ensure consistency in the calculations. ArcGIS maps portraying the land uses can be found in Figures 4 and 5, respectively.

Additionally, Woodard & Curran analyzed engineering plan sets for the following developments. The location of each development is depicted on Figure 6. The years listed correspond to the date of the approved plan set, and not necessarily to the date of construction.

- 1997 - Essex Road Subdivision (PB #6158)
- 2000 - Nantucket Ice Rink (PB #2-00)
- 2005 - Pt. Judith Lane (PB #6480)
- 2006 - Ellen's Way Subdivision (PB #6968)
- 2008 - Bartlett Road Subdivision (PB #6960)

The stormwater infrastructure installed in conjunction with these developments consisted of leaching fields, above ground infiltration basins, leaching basins, and infiltrators. It has been assumed that each of these measures contributes to Miacomet Pond via groundwater flow.



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COMMITMENT & INTEGRITY DRIVE RESULTS

MIACOMET POND WATERSHED MAP

TOWN OF NANTUCKET, MA

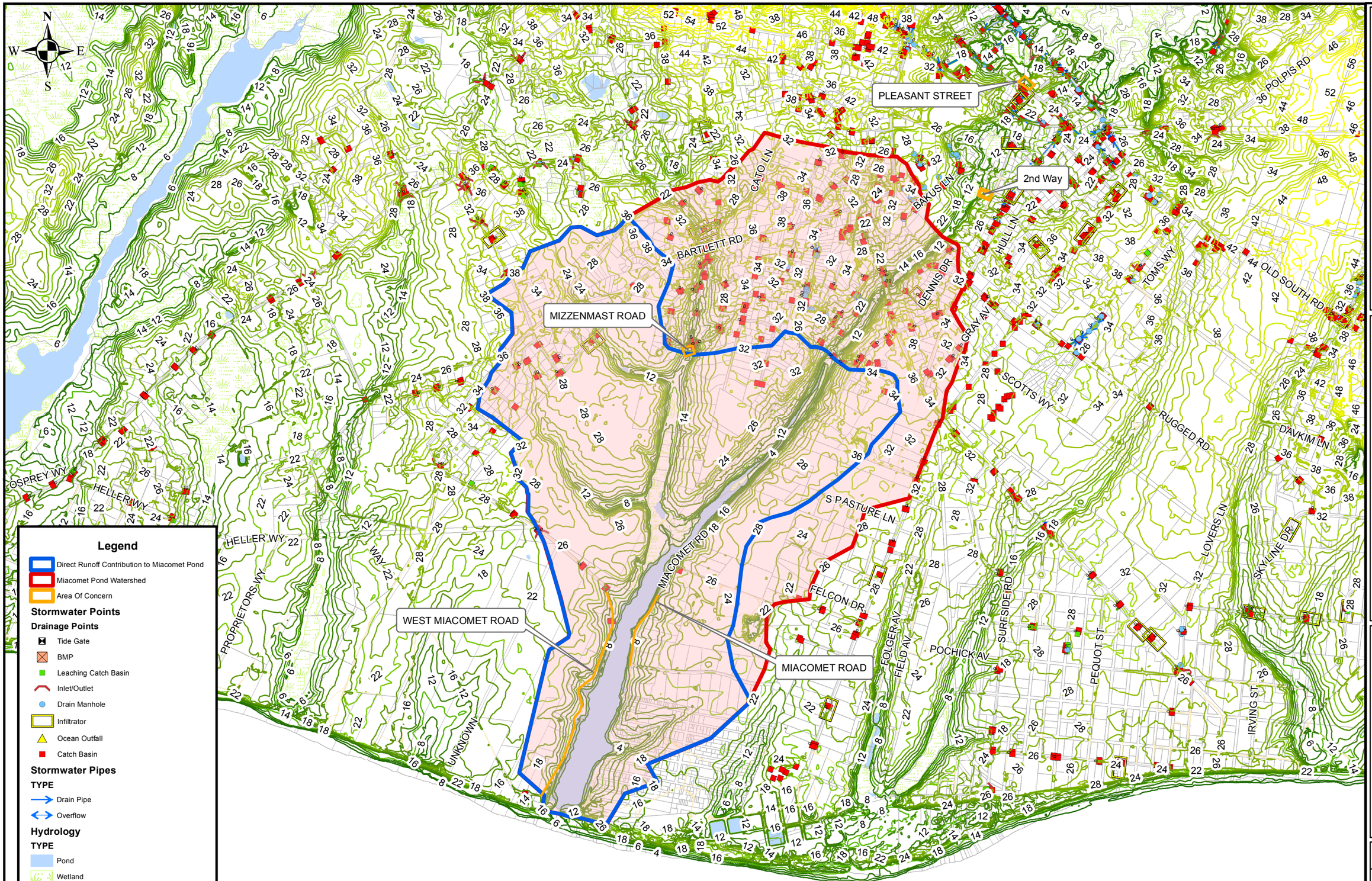
MIACOMET POND
WATERSHED STUDY

JOB NO.: 224428.00

DRAWN BY: PBF/DAL

DATE: SEPTEMBER 2014

FIGURE 2



Legend

- Direct Runoff Contribution to Miacomet Pond
- Miacomet Pond Watershed
- Area Of Concern

Stormwater Points

Drainage Points

- Tide Gate
- BMP
- Leaching Catch Basin
- Inlet/Outlet
- Drain Manhole
- Infiltrator
- Ocean Outfall
- Catch Basin

Stormwater Pipes

TYPE

- Drain Pipe
- Overflow

Hydrology

TYPE

- Pond
- Wetland

0 750 1,500 3,000 4,500 6,000 Feet

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COMMITMENT & INTEGRITY DRIVE RESULTS

DIRECT SURFACE CONTRIBUTION TO MIACOMET POND

TOWN OF NANTUCKET, MA

MIACOMET POND WATERSHED STUDY

JOB NO.: 224428.00

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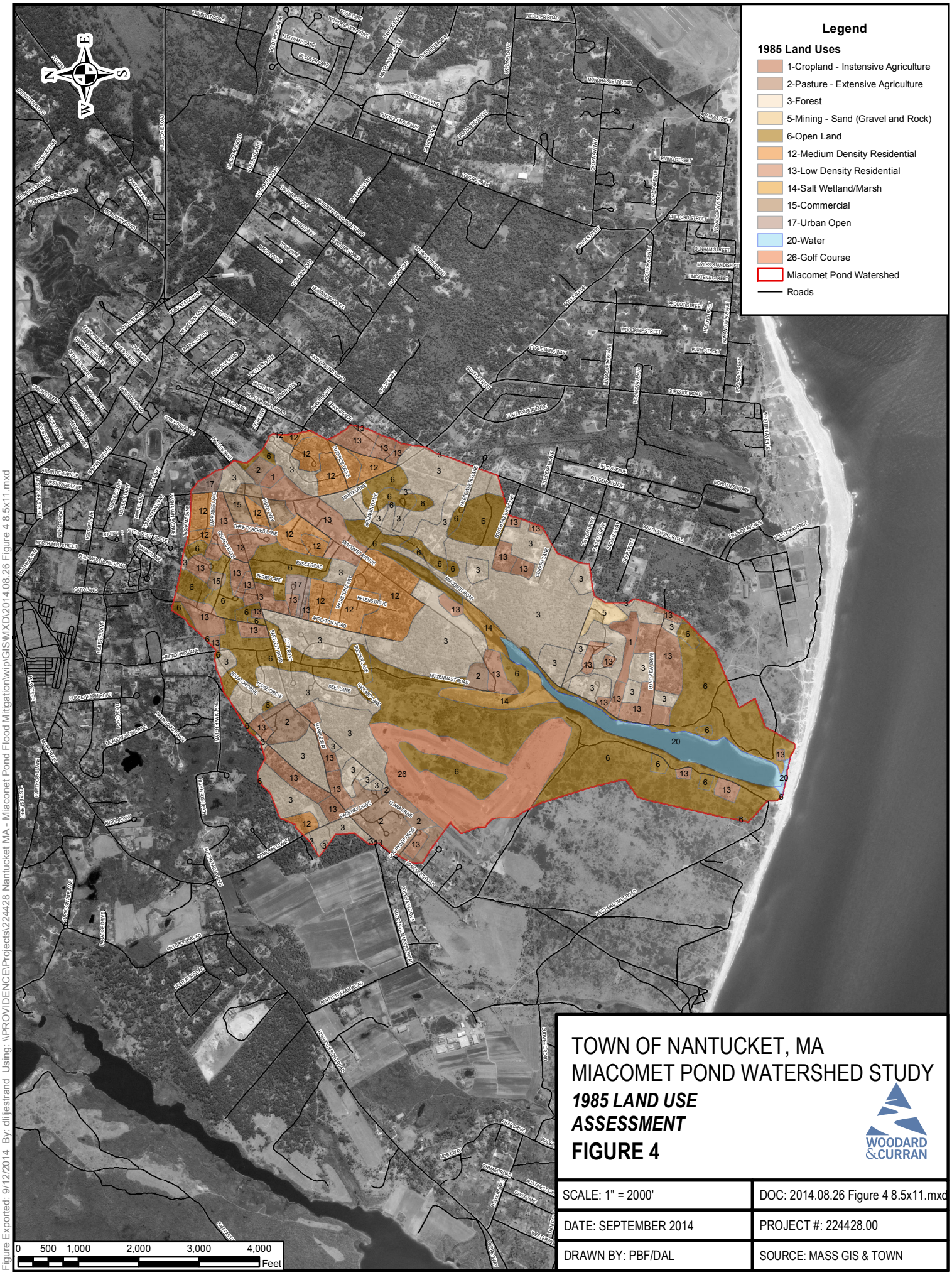
DATE: SEPTEMBER 2014

FIGURE 3

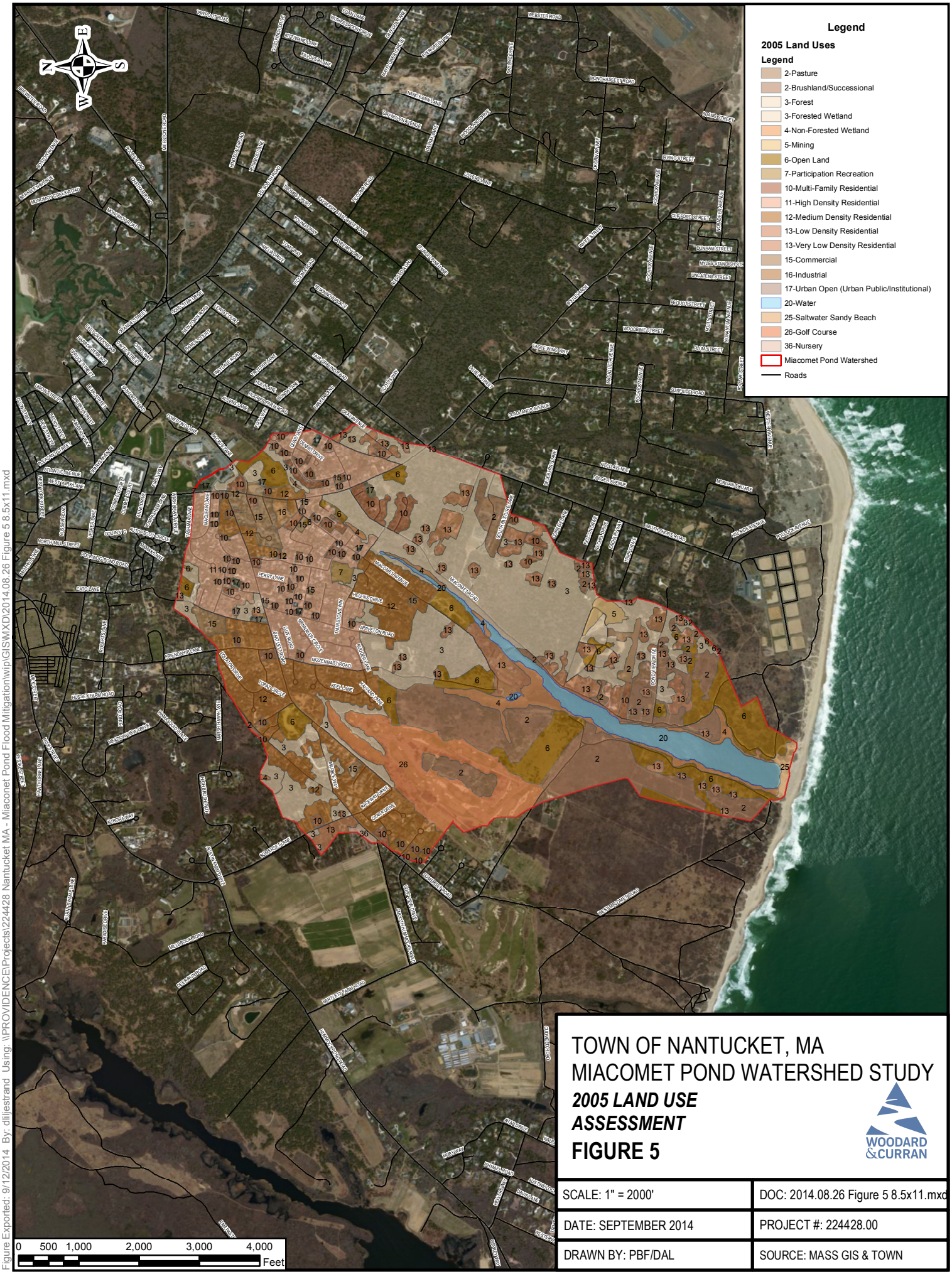


TOWN OF NANTUCKET, MA
MIACOMET POND WATERSHED STUDY
1985 LAND USE ASSESSMENT
FIGURE 4

WOODARD &CURRAN

SCALE: 1" = 2000'	DOC: 2014.08.26 Figure 4 8.5x11.mxd
DATE: SEPTEMBER 2014	PROJECT #: 224428.00
DRAWN BY: PBF/DAL	SOURCE: MASS GIS & TOWN

Figure Exported: 9/12/2014 By: dlilljestrand Using: \\PROVIDENCE\Projects\224428 Nantucket MA - Miaconet Pond Flood Mitigation\wip\GIS\MXD\2014.08.26 Figure 4 8.5x11.mxd



TOWN OF NANTUCKET, MA
MIACOMET POND WATERSHED STUDY
2005 LAND USE ASSESSMENT
FIGURE 5

WOODARD &CURRAN

SCALE: 1" = 2000'	DOC: 2014.08.26 Figure 5 8.5x11.mxd
DATE: SEPTEMBER 2014	PROJECT #: 224428.00
DRAWN BY: PBF/DAL	SOURCE: MASS GIS & TOWN

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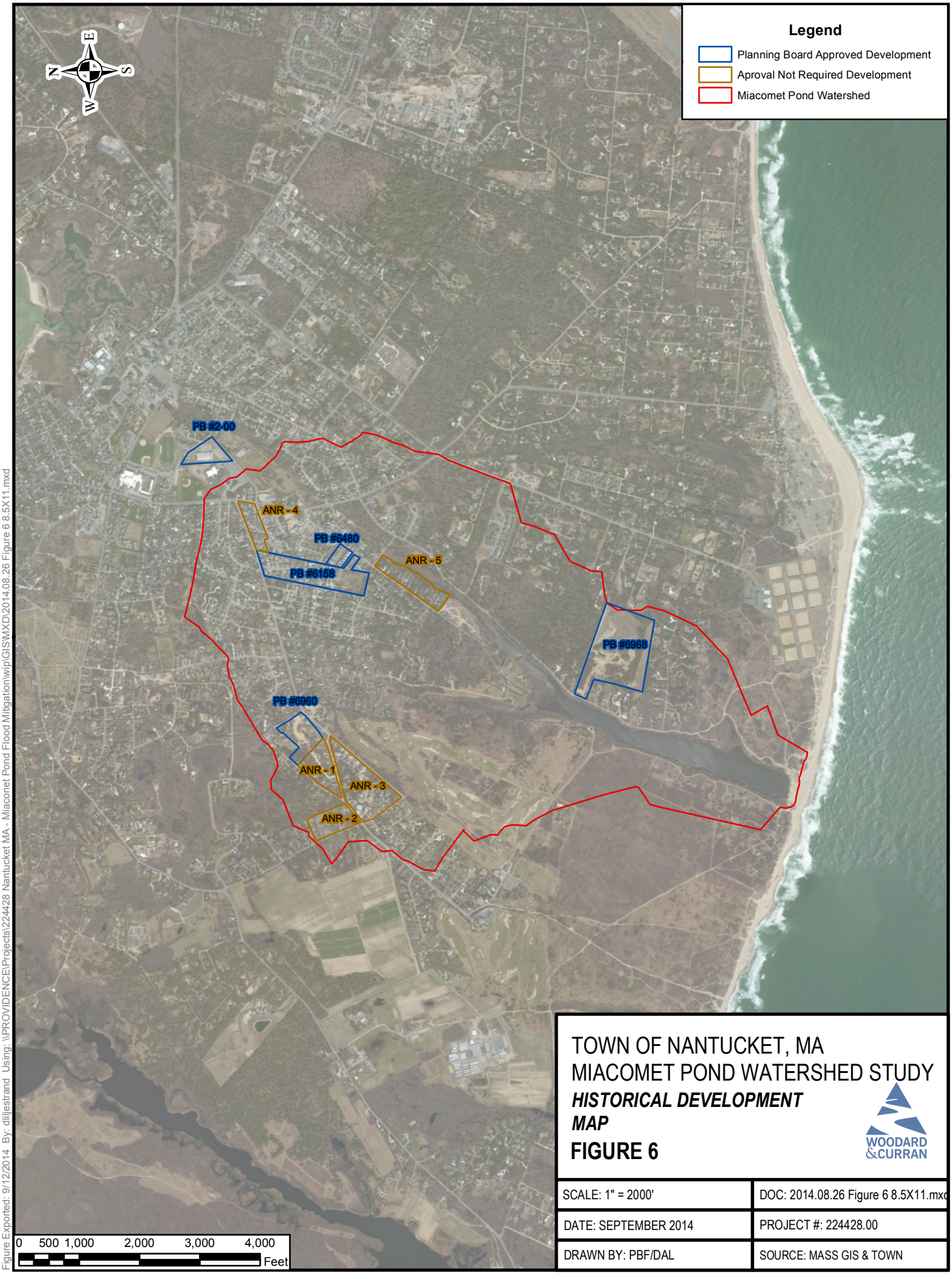

TOWN OF NANTUCKET, MA
MIACOMET POND WATERSHED STUDY
HISTORICAL DEVELOPMENT MAP
FIGURE 6

WOODARD &CURRAN

SCALE: 1" = 2000'	DOC: 2014.08.26 Figure 6 8.5X11.mxd
DATE: SEPTEMBER 2014	PROJECT #: 224428.00
DRAWN BY: PBF/DAL	SOURCE: MASS GIS & TOWN

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Several areas throughout the watershed were developed as Approval Not Required (ANR) subdivision of land. The location of each of these areas can also be found on Figure 6. Woodard & Curran used Google Earth historical imagery to classify the key periods of development in several of these areas, as listed below:

- 1998 – 2001 – Development South of Marble Way and Northwest of Bartlett Road
- 1998 – 2001 – Development Northwest of Somerset Road
- 2005 – 2008 – Development Northeast of Marble Way and South of Somerset Road
- 1998 – 2001, 2007 – Development North of Boynton Lane and South of Bartlett Road
- 1998 – 2001, 2008 – Development East of Miacomet Avenue and South of Otokomi Road

In addition to the subdivisions and developments listed above, there has been smaller, more, discrete construction that is not listed, but is reflected in the overall characterization and historical analysis of the watershed through the ArcGIS data obtained by Woodard & Curran.

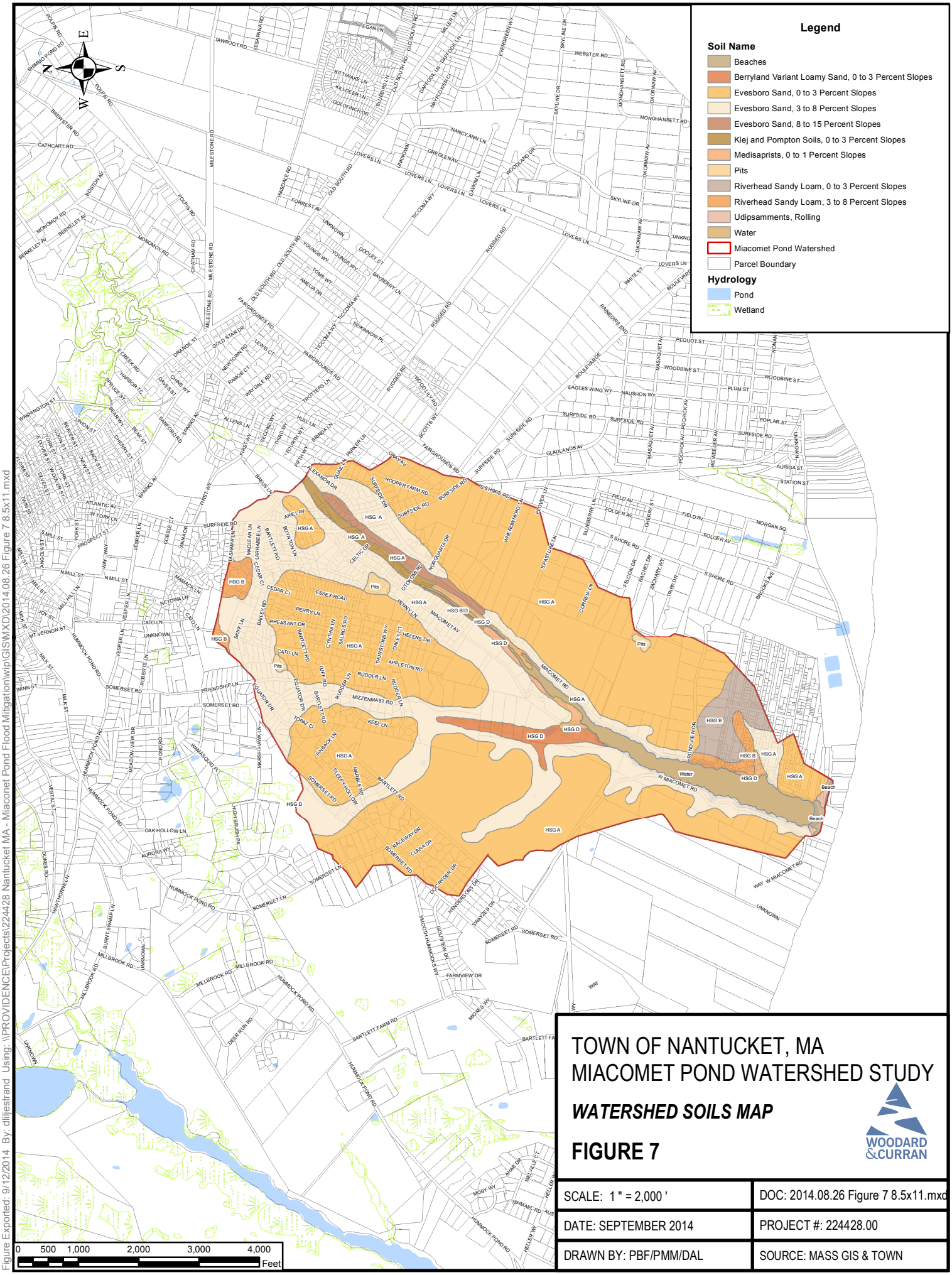
4.3 SOILS

Soil characteristics play a significant role manner in which precipitation generates surface water runoff water or groundwater contribution to a receiving water body. The Natural Resources Conservation Service (NRCS) classifies soils into hydrologic soil groups (HSG's) as a means to measure of rate at which water enters the soil. The four groups are defined as follows:

Table 2: Characteristics of Soils

HSG	Characteristics
Group A	Low runoff potential and high infiltration rate
Group B	Moderate infiltration rate
Group C	Low infiltration rate
Group D	High runoff potential

Soils information used in the analysis was compiled from data layers available on the Massachusetts Geographic Information System (Mass GIS) website (http://www.mass.gov/mgis/.htm). The Soils data layer has been automated from 1:25,000 published soils surveys as provided on various media by the United States Department of Agriculture Natural Resources Conservation Service. All soils data released by Mass GIS have been "SSURGO-certified," which means they have been reviewed and approved by the NRCS and meet all standards and requirements for inclusion in the national release of county-level digital soils data. The soils and corresponding HSGs are illustrated in Figure 7. The quantity of the soils, by HSG, within the watershed is summarized in Table 3.



TOWN OF NANTUCKET, MA
MIACOMET POND WATERSHED STUDY

WATERSHED SOILS MAP

FIGURE 7

SCALE: 1 " = 2,000 '	DOC: 2014.08.26 Figure 7 8.5x11.mxd
DATE: SEPTEMBER 2014	PROJECT #: 224428.00
DRAWN BY: PBF/PMM/DAL	SOURCE: MASS GIS & TOWN

Figure Exported: 9/12/2014 By: dilljestrand Using: \\PROVIDENCE\Projects\224428 Nantucket MA - Miacomet Pond Flood Mitigation\wip\GIS\MXD\2014.08.26 Figure 7 8.5x11.mxd

Table 3: Soils by HSG

HSG	Area (Acres)	% of Watershed
Group A	940	90%
Group B	40	4%
Group C	0	
Group D	25	2%
Open Water	35	4%

4.4 GROUNDWATER MAPPING

The groundwater delineation used in this effort was completed by Horsley Witten Hegemann, Inc. (HWH) in January 1990 as a part of the Nantucket Water Resources Management Plan. The maps included with the 1990 report were developed with the intent of providing detailed groundwater flow field maps from which the areas of groundwater contributing to various groundwater resources. As a result, these maps were developed with great effort at including all available data points for groundwater elevations and with additional effort with the use of Ground Penetrating Radar to supplement data gaps in the groundwater elevation database. A few additional observation wells were added at critical locations where there were data gaps.

According to the text, which describes the effort and intent used in the HWH groundwater mapping, it appears to be the best mapping product for use in the Miacomet Pond Watershed. This conclusion was based on an assessment by a Woodard & Curran Senior Hydrogeologist. A copy of HWH's groundwater flow map and Miacomet Pond contribution area is shown on Figure 8.

Woodard & Curran used the data in the report to complete a cross section of Nantucket Island from South-to-North to analyze what impacts, if any, Miacomet Pond has on upstream groundwater levels. This cross section can be found in Figure 9, and shows the elevation of groundwater relative to the surface elevations through the low-lying geological formation bisecting the island. The section clearly shows high point in the groundwater surface. Groundwater flow to the south of the high point, or flow divide, contributes to Miacomet Pond whereas flow north of the divide contributes to Nantucket Harbor. The elevation of the groundwater in the HWH report indicates at the divide is approximately elevation 10. This elevation is approximately six feet higher than the elevation of Miacomet Pond, indicating a positive flow gradient to the pond. As such, Woodard & Curran concluded Miacomet Pond does not contribute groundwater flow upstream, but rather, is a receiving water body for all groundwater within the watershed.

4.5 WATERSHED CHARACTERIZATION

Woodard & Curran characterized the watershed using surficial soils, land uses and cover, and drainage patterns. This information was compiled and analyzed in ArcGIS Software. The land uses found within the watershed changed over time to reflect the increased development within the watershed. The study found that the largest increase in land use area was medium and high density residential areas, whereas open land, forest, and low density residential land uses decreased the most over the same time period. The land uses within the watershed in 1985 and 2005 are summarized in Tables 4 and 5, respectively. A comparison of the changes over time is provided in Table 6.

N
W
E
S

GROUNDWATER DIVIDE (TYP.)

GROUNDWATER CONTOUR (TYP.)

Legend

- Miacomet Pond Watershed
- Groundwater Flow Direction
- Pond
- Wetland

0 600 1,200 2,400 3,600 4,800 Feet

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COMMITMENT & INTEGRITY DRIVE RESULTS

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HWH 1990 GROUNDWATER MAP

TOWN OF NANTUCKET, MA

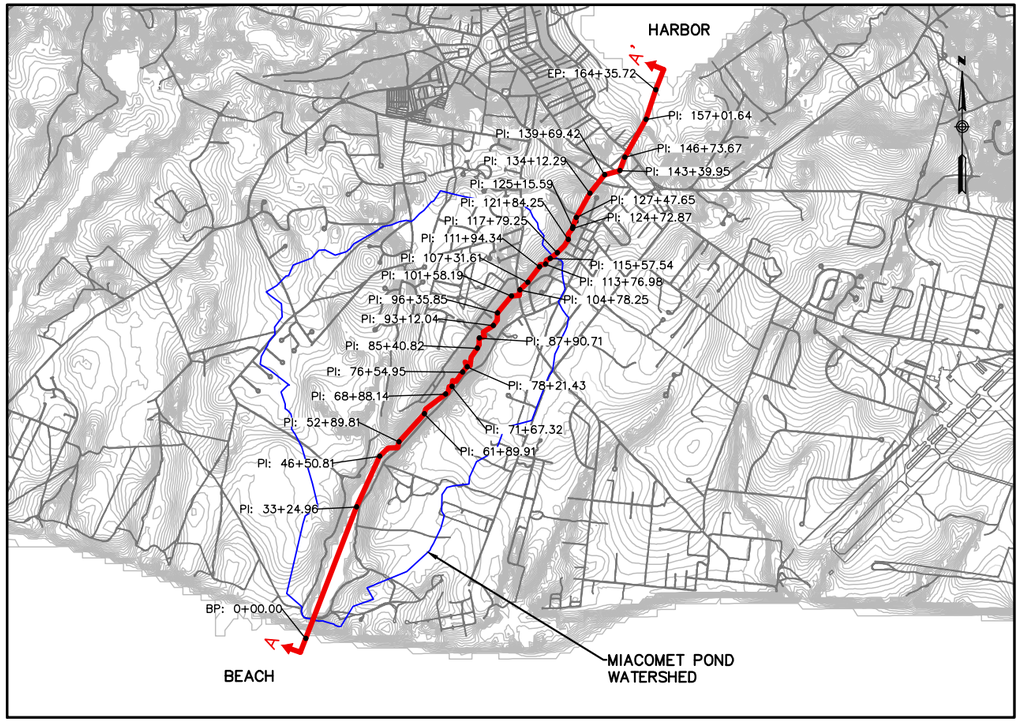
MIACOMET POND WATERSHED STUDY

JOB NO.: 224428.00

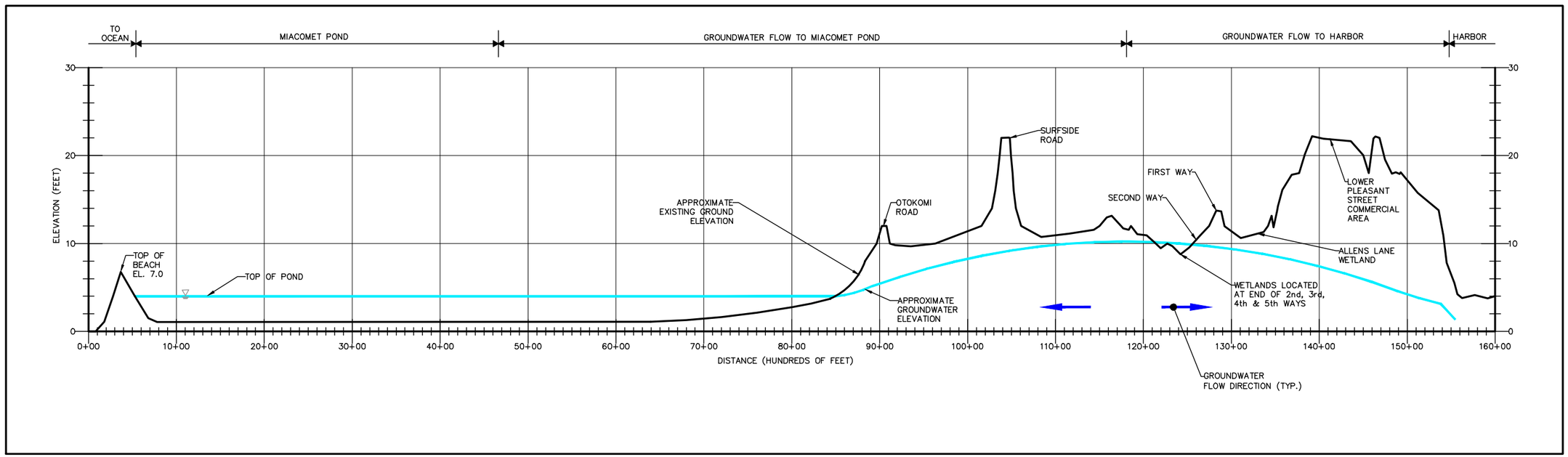
DRAWN BY: PBF/DAL

DATE: AUGUST 2014

FIGURE 8



PLAN



PROFILE A–A'

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COMMITMENT & INTEGRITY DRIVE RESULTS

WOODARD & CURRAN

NANTUCKET ISLAND
SOUTH-TO-NORTH CROSS SECTION

DESIGNED BY: DW
DRAWN BY: PBF/DAL
CHECKED BY:
2014.07.09 Full Island Cross Section.dwg

TOWN OF NANTUCKET, MA

MIACOMET POND WATERSHED STUDY

JOB NO: 224428.00
DATE: AUGUST 2014
SCALE: VARIES

FIGURE 9

The change in runoff potential resulting from the change in land use between 1985 and 2005 was evaluated. The NRCS utilizes the Soil Conservation Services (SCS) runoff curve number method to measure watershed runoff potential. The curve number indicates the estimated level of runoff from a storm event, and is a function of the soil type and land uses. A higher curve number indicates decreased retention and infiltration, and therefore increased runoff. A comparison of the curve numbers in 1985 with 2005 indicates an increased curve number from 53 to 57. Tables 7 and 8 show the information used to determine the curve numbers for the watershed in 1985 and 2005 respectively.

Table 4: 1985 Miacomet Pond Watershed Land Uses

LU Code	1985 Land Use	Area (SF)	Area (Acres)
1	Cropland - Intensive Agriculture	334,410.78	7.68
2	Pasture - Extensive Agriculture	1,740,041.78	39.95
3	Forest	13,607,104.28	312.38
5	Mining - Sand; Gravel & Rock	223,082.03	5.12
6	Open Land	13,190,734.97	302.82
12	1/4 - 1/2 Acre Lots Residential	3,815,573.73	87.59
13	Larger Than 1/2 Acre Lots Residential	6,220,177.14	142.80
14	Salt Wetland/Marsh	780,027.33	17.91
15	Commercial	489,245.56	11.23
17	Urban Open	285,554.28	6.56
20	Water	1,577,579.26	36.22
26	Golf Course	2,996,412.92	68.79
	TOTAL	**45,259,944.06**	**1,039.03**

Table 5: 2005 Miacomet Pond Watershed Land Uses

LU Code	2005 Land Use	Area (SF)	Area (Acres)
2	Pasture (Brushland/Successional)	5,809,313.18	133.36
3	Forest	10,986,732.89	252.22
4	Non-Forested Wetland	1,054,729.66	24.21
5	Mining	200,531.96	4.60
6	Open Land	4,073,637.80	93.52
7	Participation Recreation	109,088.69	2.50
10	Multi-Family Residential	1,691,079.75	38.82
11	High Density Residential	5,735,846.54	131.68
12	Medium Density Residential	6,404,399.89	147.02
13	Low Density Residential	3,073,138.83	70.55
15	Commercial	792,905.28	18.20
16	Industrial	107,693.81	2.47
17	Urban Open (Urban Public/Institutional)	253,289.65	5.81
20	Water	1,750,490.06	40.19
25	Saltwater Sandy Beach	151,821.08	3.49
26	Golf Course	3,008,924.20	69.08
36	Nursery	56,320.80	1.29
	TOTAL	**45,259,944.06**	**1,039.03**

Table 6: Miacomet Pond Watershed Historical Land Use Comparison

LU Code	Land Use	Change in Area (SF)	Change in Area (Acres)	Appears In
1	Cropland - Intensive Agriculture	-334,410.78	-7.68	1985
2	Pasture - Extensive Agriculture	4,069,271.40	93.42	1985 & 2005
3	Forest	-2,620,371.39	-60.16	1985 & 2005
4	Non-Forested Wetland	1,054,729.66	24.21	2005
5	Mining	-22,550.07	-0.52	1985 & 2005
6	Open Land	-9,117,097.18	-209.30	1985 & 2005
7	Participation Recreation	109,088.69	2.50	2005
10	Multi-Family Residential	1,691,079.75	38.82	2005
11	High Density Residential	5,735,846.54	131.68	2005
12	Medium Density Residential	2,588,826.16	59.43	1985 & 2005
13	Low Density Residential	-3,147,038.30	-72.25	1985 & 2005
14	Salt Wetland/Marsh	-780,027.33	-17.91	1985
15	Commercial	303,659.72	6.97	1985 & 2005
16	Industrial	107,693.81	2.47	2005
17	Urban Open (Urban Public/Institutional)	-32,264.63	-0.74	1985 & 2005
20	Water	172,910.80	3.97	1985 & 2005
25	Saltwater Sandy Beach	151,821.08	3.49	2005
26	Golf Course	12,511.27	0.29	1985 & 2005
36	Nursery	56,320.80	1.29	2005
	NET CHANGE IN TOTAL AREA	**0.00**	**0.00**	**1985 & 2005**

Table 7: 1985 Miacomet Pond Watershed Curve Number Analysis

LU Code	1985 Land Use	HSG	Area (SF)	Area (Acres)	CN
1	Cropland - Intensive Agriculture	A	334,410.78	7.68	67
2	Pasture - Extensive Agriculture	A	1,740,041.78	39.95	49
3	Forest	A	13,475,024.16	309.34	45
3	Forest	B	78,987.64	1.81	66
3	Forest	D	19,712.01	0.45	83
3	Forest	B/D	17,193.52	0.39	83
3	Forest	Pits	14,650.59	0.34	83
3	Forest	Water	1,536.36	0.04	83
5	Mining - Sand; Gravel & Rock	A	172,256.88	3.95	76
5	Mining - Sand; Gravel & Rock	Pits	50,825.15	1.17	91
6	Open Land	A	11,208,094.51	257.30	49
6	Open Land	B	1,213,477.62	27.86	69
6	Open Land	D	511,058.38	11.73	84
6	Open Land	B/D	19,870.09	0.46	84
6	Open Land	Beach	30,507.27	0.70	84
6	Open Land	Pits	37,264.08	0.86	84
6	Open Land	Water	170,463.03	3.91	84
12	1/4 - 1/2 Acre Lots Residential	A	3,719,098.11	85.38	57
12	1/4 - 1/2 Acre Lots Residential	B	76,956.24	1.77	72
12	1/4 - 1/2 Acre Lots Residential	B/D	14,496.76	0.33	86
12	1/4 - 1/2 Acre Lots Residential	Pits	298.02	0.01	86
12	1/4 - 1/2 Acre Lots Residential	Water	4,724.60	0.11	86
13	Larger Than 1/2 Acre Lots Residential	A	5,724,996.23	131.43	51
13	Larger Than 1/2 Acre Lots Residential	B	334,814.74	7.69	68
13	Larger Than 1/2 Acre Lots Residential	D	51,927.80	1.19	79
13	Larger Than 1/2 Acre Lots Residential	B/D	2,942.41	0.07	79
13	Larger Than 1/2 Acre Lots Residential	Pits	104,887.88	2.41	79
13	Larger Than 1/2 Acre Lots Residential	Water	608.08	0.01	79
14	Salt Wetland/Marsh	A	144,363.77	3.31	98
14	Salt Wetland/Marsh	D	540,228.88	12.40	98
14	Salt Wetland/Marsh	Water	95,434.69	2.19	98
15	Commercial	A	489,245.56	11.23	89
17	Urban Open	A	285,554.28	6.56	49
20	Water	Water	1,577,579.26	36.22	98
26	Golf Course	A	2,996,412.92	68.79	49
	TOTAL		**45,259,944.06**	**1,039.03**	**53**

Table 8: 2005 Miacomet Pond Watershed Curve Number Analysis

LU Code	2005 Land Use	HSG	Area (SF)	Area (Acres)	CN
2	Brushland/Successional	A	4,841,129.43	111.14	35
2	Brushland/Successional	B	562,708.14	12.92	56
2	Brushland/Successional	D	217,298.71	4.99	77
2	Pasture	A	188,176.91	4.32	49
3	Forest	A	10,494,712.47	240.93	45
3	Forest	B	233,591.44	5.36	66
3	Forest	D	94,196.15	2.16	83
3	Forest	B/D	28,765.60	0.66	83
3	Forest	Pits	1,507.87	0.03	83
3	Forest	Water	1,474.52	0.03	83
3	Forested Wetland	A	132,046.76	3.03	98
3	Forested Wetland	D	438.07	0.01	98
4	Non-Forested Wetland	A	368,964.76	8.47	98
4	Non-Forested Wetland	B	34,062.57	0.78	98
4	Non-Forested Wetland	D	603,342.97	13.85	98
4	Non-Forested Wetland	Beach	2,137.81	0.05	98
4	Non-Forested Wetland	Water	46,221.54	1.06	98
5	Mining	A	151,214.68	3.47	76
5	Mining	Pits	49,317.28	1.13	91
6	Open Land	A	3,564,828.53	81.84	49
6	Open Land	B	430,139.00	9.87	69
6	Open Land	D	68,172.07	1.57	84
6	Open Land	B/D	10,389.76	0.24	84
6	Open Land	Beach	108.43	0.00	84
7	Participation Recreation	A	108,164.54	2.48	49
7	Participation Recreation	Pits	924.15	0.02	84
10	Multi-Family Residential	A	1,649,501.20	37.87	54
10	Multi-Family Residential	Pits	41,578.54	0.95	85
11	High Density Residential	A	5,410,201.57	124.20	77
11	High Density Residential	B	255,465.84	5.86	85
11	High Density Residential	Pits	70,179.13	1.61	92
12	Medium Density Residential	A	6,359,740.73	146.00	57
12	Medium Density Residential	B/D	240.41	0.01	86
12	Medium Density Residential	Pits	44,418.76	1.02	86
13	Low Density Residential	A	1,432,091.36	32.88	54
13	Low Density Residential	B	188,040.96	4.32	70
13	Low Density Residential	Water	54.99	0.00	85
13	Very Low Density Residential	A	1,384,145.07	31.78	51
13	Very Low Density Residential	B	16,020.18	0.37	68
13	Very Low Density Residential	D	52,786.29	1.21	84
15	Commercial	A	792,367.84	18.19	89
15	Commercial	B	537.44	0.01	92
16	Industrial	A	107,693.81	2.47	81
17	Urban Public/Institutional (Transitional)	A	253,289.65	5.81	68
20	Water	Water	1,750,490.06	40.19	98
25	Saltwater Sandy Beach	A	29,159.47	0.67	68
25	Saltwater Sandy Beach	D	47,959.11	1.10	89
25	Saltwater Sandy Beach	Beach	74,702.50	1.71	89
26	Golf Course	A	3,008,924.20	69.08	49
36	Nursery	A	56,320.80	1.29	49
	TOTAL		**45,259,944.06**	**1,039.03**	**57**

The increase impervious area does not appear to be a significant contributor to higher water surface elevations and subsequent increases in frequency or extent of flooding in Miacomet Pond. Utilizing the SCS Technical Release 55 (TR-55) methodology, Woodard and Curran estimated the change in water surface elevation that may be attributed to the land use changes for the 2-yr and 10-yr, 24-hour storm events. The changes are summarized in Table 9.

Table 9: Change in Miacomet Pond Water Surface Elevation

Storm Event	Total Precipitation (Inches)*	Increase in Pond Elevation from Runoff (inches)
2-year, 24-hour	3.5	2.3
10-year, 24-hour	4.8	3.2

*Derived from National Weather Service Technical Paper 40.

4.6 CONCLUSIONS

Woodard & Curran has completed the characterization of the Miacomet Pond watershed and the local groundwater elevations and concludes the following.

- Groundwater mapping indicates Miacomet Pond is a receiving water body for surface water runoff and groundwater.
- Groundwater elevations in the upper reaches of the watershed can be as high as five to six feet above Miacomet Pond's water surface elevations.
- Changes in Land Use patterns since 1985 have not resulted a significant contribution to increased runoff or water surface elevations in the pond.

Additionally, the following conclusions were drawn for each of the areas of concern.

4.6.1 Miacomet Road and West Miacomet Road

Low-lying portions of Miacomet and West Miacomet Roads adjacent to Miacomet Pond are subject to inundation due to limited difference in the roadway's elevation and the pond's water surface elevations during and immediately following storm events. Although, not significant in magnitude, these roadways will be more susceptible to flooding due to changes of land uses within the watershed, particularly from portions of the watershed that contribute direct surface water to the pond.

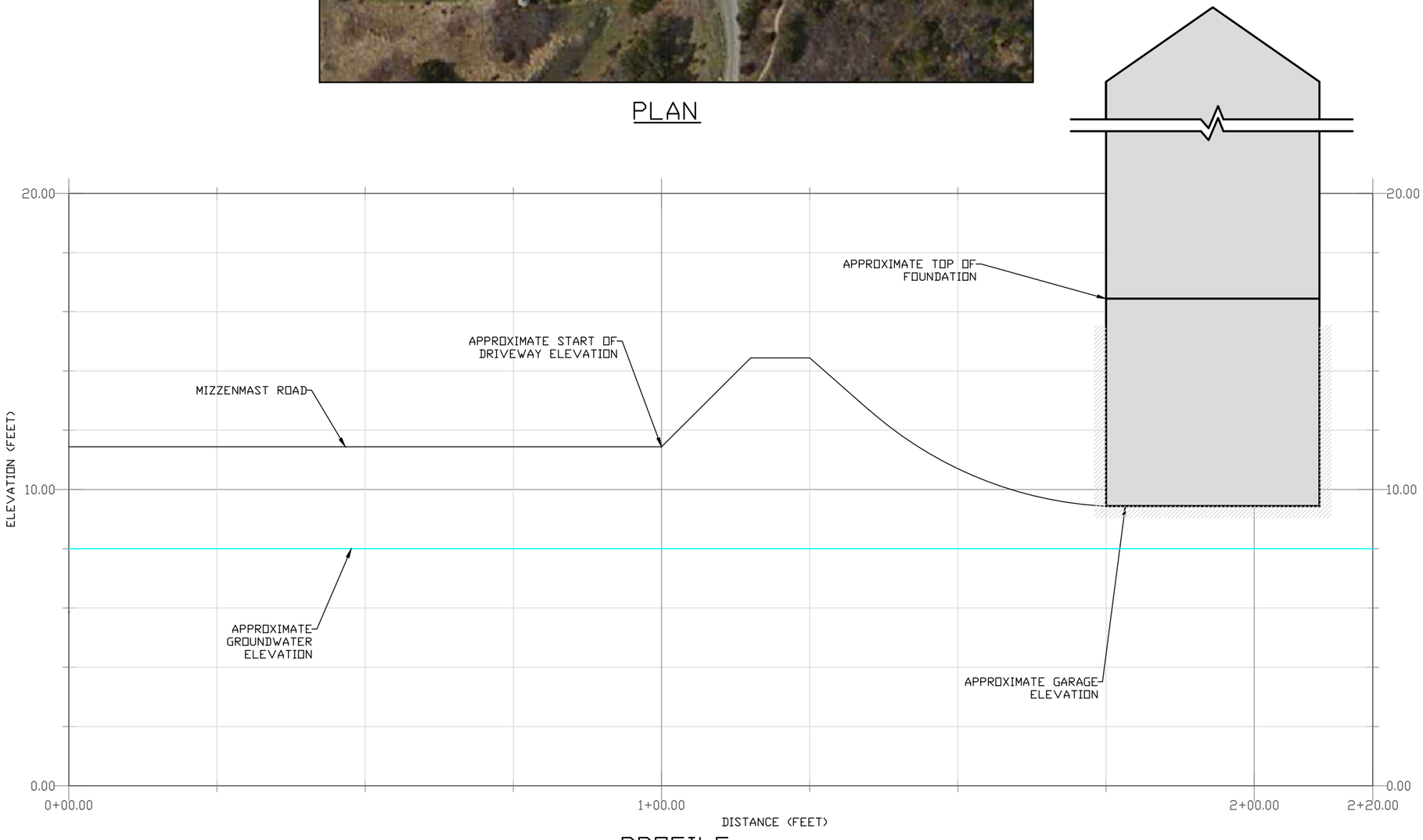
4.6.2 Mizzenmast Road Development

Flooding in the lower area of Mizzenmast Road appears to be the result of inadequate surface drainage as well as shallow depth to groundwater. Runoff from higher elevations of Mizzenmast Road collects at the low point in the road, as evidenced by measures taken to prevent the ponded water in the roadway from entering the adjacent driveway. This area is also located at position in the watershed that appears to have groundwater elevations a couple feet higher than water surface elevations of Miacomet Pond. As such, during and immediately following storm events, groundwater elevations can be expected to rise and have the potential to impact low-lying basement areas. Figure 10 provides a cross section through the private road and residence in this location. This is a private development; therefore, it is the responsibility of the homeowners and/or developer to modify existing surface drainage system and storage structures to address the flooding concerns.

4.6.3 Allens Lane Wetland Area

The Allens Lane Wetland Area is not located in the Miacomet Pond Watershed. Rather, runoff and groundwater from this area contribute to Nantucket Harbor. This area is located where groundwater elevations are highest. As a result, low-lying locations, such as the wetland area to the west of Allens Lane, have shallow depths to groundwater. The groundwater elevations would be expected to rise during and immediately following rainfall events as soil receives precipitation and infiltrates into the underlying soils. When the groundwater rises to surface, ponding results. Similarly, if the groundwater rises above the elevation of low-lying basements, seepage into the basement can occur. Figure 11 provides a cross section through the wetland area and residence in this location.

PLAN



PROFILE

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COMMITMENT & INTEGRITY DRIVE RESULTS

WOODARD &CURRAN

MIZZENMAST ROAD
CROSS SECTION

DESIGNED BY: DW
DRAWN BY: PBF/DAL
CHECKED BY:
2014.09.12 Mizzenmast Road.dwg

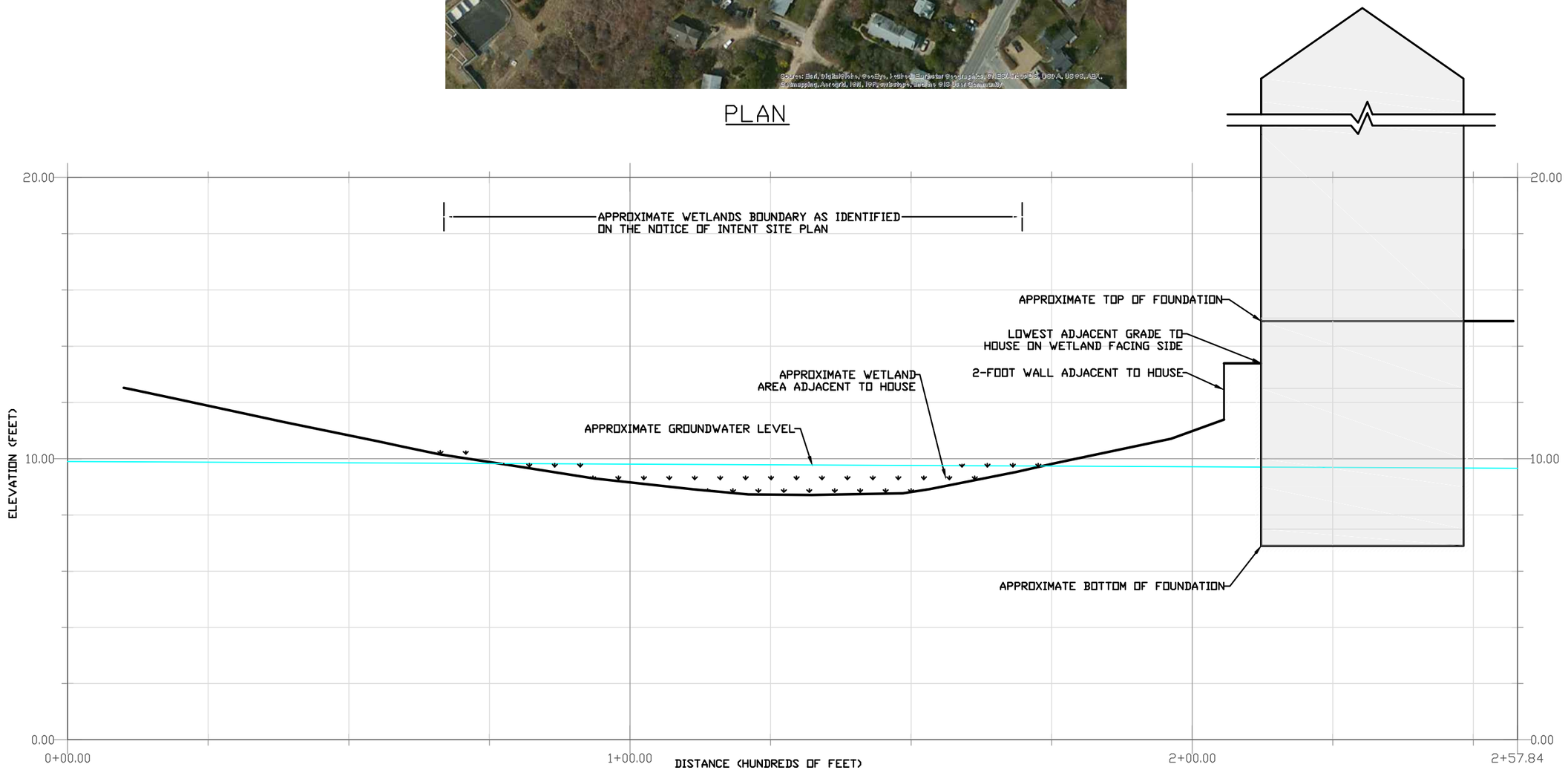
TOWN OF NANTUCKET, MA

MIACOMET POND WATERSHED STUDY

JOB NO: 224428.00
DATE:SEPTEMBER 2014
SCALE: VARIES

FIGURE 10

PLAN



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COMMITMENT & INTEGRITY DRIVE RESULTS

WOODARD &CURRAN

SECOND WAY WETLAND CROSS SECTION

CHECKED BY: 2014.09.12 2nd Way Cross Section.dwg
DESIGNED BY: DW
DRAWN BY: PBF/DAL

TOWN OF NANTUCKET, MA

MIACOMET POND WATERSHED STUDY

JOB NO: 224428.00
DATE: AUGUST 2014
SCALE: VARIES

FIGURE 11

5. RECOMMENDATIONS

Woodard & Curran has reviewed the information contained in this report, and makes the following recommendations based on the results.

No further hydrologic or hydraulic modeling be completed as a part of this report. The watershed characterization shows only a moderate increase in runoff potential over the twenty-year period of the study, meaning that there has not been a major increase in surface water runoff over the area of the Miacomet Pond Watershed. Additionally, the well-draining soils and infiltration measures found throughout the watershed generally mitigate surface water runoff in most localized areas. Lastly, the land adjacent to the Pond consists of well-draining soils and open land, meaning that direct runoff to the Pond is not a significant contributing factor to the localized flooding upstream.

Woodard & Curran recommends that the Town develop a Miacomet Pond Watershed Management Plan. Through the analysis completed in this report, Woodard & Curran found that residents and developers would be able to make better decisions regarding runoff quantities and qualities if guidelines were put in place to plan for future development activities within the watershed. This plan could also include general information about Miacomet Pond, and the ecological roles that it plays for the Town. Such guidelines may focus on Best Management Practices (BMPs) suited for the location within the watershed. For example some BMPs may be more effective for the areas of the watershed that contribute direct runoff to the pond while other BMPs may be more suitable for the areas which contribute solely through groundwater. Furthermore, such a plan would address water quality considerations for the pond that were beyond the scope of this study.

Stormwater conveyance measures on private developments be improved to reduce localized flooding. In developments such as the one on Mizzenmast Road, it is the responsibility of the homeowner(s) and/or developer(s) to control stormwater runoff to reduce flooding and pollutant loading. This problem can also be seen in the photographs in Appendix B, where a lack of stormwater infrastructure on Second Way has caused natural gullies to form in the road, leading to its disrepair and the runoff of untreated stormwater directly into the wetland.

Residents with properties in areas with high groundwater take the appropriate measures to flood proof their homes. Even after a house is constructed, measures can be taken to reduce the impact of high groundwater on individual properties. Common measures include elevating the structure or installment of underdrains adjacent to the foundation with the use of a properly sized sump pump leading to an approved discharge pipe. Additionally, redirecting downspouts away from foundations and reducing exposure of foundation elements to direct precipitation can further reduce seepage into basements.

Assess the benefits and costs associated with raising the low points along West Miacomet Road and Miacomet Road in order to reduce the extents, frequency and/or duration of flooding in those areas. There are several points where the Pond has the potential to inundate these roads, which could lead to nuisance flooding or roadways becoming impassable at times. An assessment of the benefits and impacts (i.e. construction costs, availability of right-of-way, permitting constraints, etc.) may assist the Town with examining if such a project would be appropriate.

APPENDIX A: MIZZENMAST ROAD DEVELOPMENT PHOTOGRAPHS

APPENDIX B: ALLENS LANE AND SECOND WAY WETLAND

APPENDIX C: MIACOMET POND PHOTOGRAPHS

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