To:	Ray Cody (US EPA Region 1)
From:	Khalid Alvi, Ryan Murphy (Paradigm Environmental)
CC:	Project Team
Date:	December 15, 2018
Re:	Watershed Characterization & Spatial Data Analysis (Task 4a)

This memorandum presents a review of an initial GIS data inventory of readily available GIS datasets representing landscape characteristics for the Town of Tisbury, MA. These datasets will support GIS analyses for the development of a watershed source area characterization and identification of potential stormwater control measure (SCM) management categories. Source area characterization and SCM management categories will serve as the primary inputs for configuring and developing boundary conditions for an Opti-Tool model representing Tisbury.

This memorandum is organized into the following sections:

- Watershed Characterization (**Section 1**)
- Management Categories (**Section 2**)
- Summary (**Section 3**)

1 WATERSHED CHARACTERIZATION

Watershed characterization for Tisbury will rely on key landscape-featured GIS datasets that influence runoff and pollutant loading such as land use, slope, soils, and impervious cover. GIS data for this project was primarily obtained from the Massachusetts Bureau of Geographic Information Systems (MassGIS) website. Other local data sources identified may be used throughout the project to supplement the regional data available from MassGIS. A full inventory of the GIS datasets identified and compiled to support this memorandum are presented in the appendix as **Table** A-1. The following datasets were identified as primary inputs for the watershed characterization and are discussed further in this section:

- Elevation & Slope
- Soil Survey Geographic Database
- Confining Layers (Bedrock & Water Table)
- Land Use & Zoning
- Impervious Cover
- Building Footprints

1.1 Elevation & Slope [1 meter (m) = 3.28084 feet (ft)]

MassGIS published a 1:5,000 resolution Digital Elevation Model (DEM) which represents the surface elevation for the entire Commonwealth of Massachusetts. This dataset expresses the landscape elevation through a raster grid data product with 5-meter by 5-meter (16.4 ft by 16.4 ft) resolution (MassGIS 2007). The value of each raster cell represents the landscape elevation for a 25 square-meter (82 ft^2) area. Within Tisbury, the landscape elevation ranges from approximately 1-meter (3.28 ft) along the coastline to approximately 40 meters (131.2 ft) at the highest elevation along inland portions of the town. As a geoprocessing input, this DEM will be used to calculate the landscape slope which will be used to derive Hydrologic Response Units (HRUs), stormwater management categories, and screen BMP opportunity areas for the Opti-Tool model. The ground slope will be classified into three groups as shown in **Table 1-1**. A map of the elevation dataset is presented in **Figure A-1**.

Table 1-1. Proposed landscape slope classifications

Landscape Slope	Reclassified Slope Category
<= 5%	Low
> 5% - 15%	Medium
> 15%	High

1.2 Hydrologic Soil Group

The soils dataset available from MassGIS included the NRCS SSURGO-Certified dataset. The gridded SSURGO (gSSURGO) dataset was also downloaded which provides attributes tables that can be linked by the *mapunit* identifier to the NRCS SSURGO layer. This data includes hydrologic soil groups (HSG) used to characterize soil runoff potential. HSG is divided into four primary categories using an A through D designation. HSG-A generally has the lowest runoff potential whereas HSG-D has the highest runoff potential. Some *mapunits* may contain a compound soil grouping containing multiple HSGs which will be reclassified for the purposes of future analyses. Soil characteristics of each HSG within Tisbury and a proposed reclassification are presented in **Table 1-2**.

Table 1-2. NRCS Hydrologic Soil Group summary for the Town of Tisbury, MA.

Hydrologic Soil Group	Reclassified Soil Group	Total Area (acres)	Percent of Total Area
A	A	3,616	86%
Pits	A	4	<1%
B	B	327	8%
Urban (unknown)	C	59	1%
Beaches	D	17	<1%
B/D	D	12	<1%
D	D	60	1%
Water	D	92	2%
Total		**4,187**	**100%**

The dominant soil group in the watershed representing 86% of Tisbury is Group A which typically has highest infiltration rates. HSG is unknown for Tisbury urban area and will be considered as HSG-C for analysis purposes. A map of the dataset categorized by HSG is presented in **Figure A-2**.

It should be noted that the NRCS SSURGO-Certified soils layer downloaded from MassGIS contains a field for "slope" which is a reclassification of the landscape slope into six categories using the A through E designation with a value of zero used for water. These reclassification codes are similar to values one would expect to see in a soils database representing HSG, therefore care should be given when navigating this dataset as not to confuse the attributes.

1.3 Confining Layers: Water Table & Bedrock

The gSSURGO dataset also contains attributes characterizing other aggregated soil properties in the *muaggett* table summarized by *mapunit* (gSSURGO 2018). Some key attributes relevant to this study include characterization of confining layers including the depth to bedrock and the minimum expected depth to water table. For a majority of Martha's Vineyard these attributes contained no data. For Tisbury, the minimum depth to water table contained a few values along the north coast; However, depth to bedrock values were non-existent across Martha's Vineyard. Map presenting the depth to water table is presented as **Figure A-3**.

1.4 Land Use

A 2005 land use dataset was obtained from MassGIS which used 0.5-meter (1.6 ft) resolution digital orthophotography from 2005 to represent land use across the Commonwealth using forty (40) unique categories (MassGIS 2009). These categories were adapted from the Massachusetts land use datasets schema. Within the Town of Tisbury there were 26 land use categories. **Table 1-3** presents the original land use categories along with a proposed reclassification ten (10) categories consistent with the scheme used in the Massachusetts MS4 permit. A map of the land use dataset is presented in **Figure A-4**.

Table 1-3. Summary of MassGIS land cover classifications and areas for the Town of Tisbury

Original Land Use Class	Reclassified Land Use	Total Area (acres)	Percent of Total Area
Brushland/Successional	Agriculture	147	4%
Cropland			
Pasture			
Commercial	Commercial	113	3%
Transitional			
Urban Public/Institutional			
Forest	Forest	2,397	57%
Transportation	Highway	3	0%
Industrial	Industrial	42	1%
Waste Disposal			
Low Density Residential	Low Density Residential	552	13%
Very Low Density Residential			
Medium Density Residential	Medium Density Residential	478	11%
High Density Residential	High Density Residential	28	1%
Multi-Family Residential			
Cemetery	Open Land	335	8%
Forested Wetland			
Golf Course			
Non-Forested Wetland			
Open Land			
Participation Recreation			
Powerline/Utility			

Original Land Use Class	Reclassified Land Use	Total Area (acres)	Percent of Total Area
Saltwater Sandy Beach			
Saltwater Wetland			
Water-Based Recreation			
Water	Water	92	2%
Total		**4,187**	**100%**

1.5 Impervious Cover

MassGIS provides a spatial layer representing impervious surfaces which was developed from 2005 orthophotos at the 1-meter (3.28 ft) pixel resolution. This coverage represents surfaces which are deemed impervious to rainwater and therefore generate a higher rate of runoff than pervious surfaces. Example features identified in this layer include buildings, roads, parking lots, brick, asphalt, concrete, and highly compacted soils without vegetative cover including mining operations (MassGIS 2007). A map of the impervious cover dataset is presented in **Figure A-5**.

1.6 Building Structures

A GIS data layer of building structures representing rooftops was derived for the eastern half of Massachusetts using 2011-2012 orthophotos and Light Detection and Ranging (LiDAR) data collected during the 2002-2011 period. Typical structures represented in this dataset include residential, commercial, and industrials buildings. Garages, sheds, and other isolated structures of at least 150 square feet (45.7 m) in size are also included (MassGIS 2017). This building structures dataset can be used in conjunction with the impervious cover dataset to identify rooftops separately from other impervious surfaces. A map of the building structures dataset is presented in **Figure A-6**.

1.7 Hydrologic Response Units

Hydrologic Response Units (HRUs) are the core hydrologic modeling land unit that drives runoff and pollutant loading in the Opti-Tool watershed model. Each HRU represents areas of similar physical characteristics attributable to core processes identified through GIS overlays of the spatial datasets described in the previous sections. The HRU layer will combine the following datasets into a single layer with unique categories for (1) landscape slope, (2) land use, and (3) soil group.

Multiplying the three (3) reclassified slope categories by the four (4) reclassified soil categories and the ten (10) reclassified land use categories yields a total of 120 possible HRU types. Some possible combinations may not physically be present or may be insignificant in size within Tisubry, which may make the actual number of HRU types less than 120. Further evaluation will be made based on the available footprints and land cover to select a representative number of unique HRU categories for use in the Opti-Tool model. There are currently 15 HRU categories available in the Opti-Tool as shown in **Table 1-4**. The slope will be added to the existing HRU categories to better characterize the high slope areas that have significant impact to the surface runoff and pollutant loadings.

Table 1-4. Available HRU Types in the Opti-Tool

Land Use	Land Cover	Hydrologic Soil Group
Agriculture	Pervious	B
Agriculture	Impervious	n/a

Land Use	Land Cover	Hydrologic Soil Group
Forest	Pervious	B
Forest	Impervious	n/a
Developed	Pervious	A
Developed	Pervious	B
Developed	Pervious	C
Developed	Pervious	C/D
Developed	Pervious	D
Open Space	Impervious	n/a
Commercial/Industrial	Impervious	n/a
Low Density Residential	Impervious	n/a
Medium Density Residential	Impervious	n/a
High Density Residential	Impervious	n/a
Highway/Roads	Impervious	n/a

2 MANAGEMENT CATEGORIES

A GIS spatial data analysis will be performed to identify potential storm water control technologies that would be technically feasible based on the available GIS data discussed in **Section 1**. Landscape slope will be derived from the DEM discussed in **Section 1.1**. Management categories will include consideration of the following physical characteristics:

- Land use
- Impervious Cover
- Landscape slope
- Hydrologic soil group
- Distance to coastline
- Parcels (public/private)

Management categories will preferably be considered for areas with pervious cover based on the suitability of site conditions for BMPs to treat stormwater runoff from impervious cover and reduce nitrogen loads. The suitability of site conditions is assessed using a combination of thresholds and attributes describing the physical characteristics represented in the GIS data. **Table 2-1** presents the proposed matrix of suitability criteria and management categories for this study.

Table 2-1. Proposed matrix of site condition suitability and management categories

Land Use	Landscape Slope (%)	Within 100 feet of Coastline?	Within 25 feet of Structure?	Soil Group	Management Category	BMP Type(s) in Opti-Tool
Pervious Area	<= 15	Yes	Yes	All	Less likely for onsite BMP	--
		No	No	A/B/C	Infiltration	Surface Infiltration Basin (e.g., Rain Garden)

Land Use	Landscape Slope (%)	Within 100 feet of Coastline?	Within 25 feet of Structure?	Soil Group	Management Category	BMP Type(s) in Opti-Tool
				D	Biofiltration	Biofiltration (e.g., Enhanced Bioretention with ISR and underdrain option)
	> 15	--	--	--	Less likely for onsite BMP	--
Impervious Area	<= 5	Yes	Yes	All	Less likely for onsite BMP	--
		No	No	A/B/C	Infiltration	Infiltration Trench
				D	Shallow filtration	Porous Pavement
	> 5	--	--	--	Less likely for onsite BMP	--

The opportunity areas will further be overlaid with ownership parcels to filter the extent of opportunities which are located on the private parcels. The option to use impervious cover will also be explored in this analysis and includes (1) eliminating the paved surfaces and restoring the underlying high infiltration pervious soil (2) installing subsurface infiltration facilities, and (3) implementing green street programs. These practices are costly compared to the structural practices associated with pervious cover but could be beneficial where opportunity space is limited. Green streets programs, for example, may help treat direct source areas (e.g. porous pavements and bioretention cells within road right-of-way). These practices have been used in southern California to reduce Zinc load, which is ultimately required under the state's TMDL for metals.

3 SUMMARY

The GIS analysis under this subtask will characterize the source areas that are prone to high runoff and pollutant loading. GIS analysis will involve overlaying soil, slope, and land cover attributes within the Town of Tisbury boundary to generate HRUs for use in the Opti-Tool model. This subtask will also provide the spatial distribution of SCM opportunity areas (i.e., BMP footprints) by land use category group. This distribution will represent the maximum available BMP footprint in the town. For planning purposes, the total impervious areas by land use group can be proportionally distributed to the BMP drainage areas based on 1) the available percentage of opportunity area of the BMP type and 2) by land use type determined through the Management Category analysis.

For example, if the opportunity area of a Bio-filtration BMP is 20% of the total available opportunity area in commercial land, then 20% of the impervious area in the commercial land could be treated by Bio-filtration practices located in that land use category. The potential opportunity areas will guide the field investigation task in identification of sites on the ground that are most feasible for SCM controls, ultimately mitigating local drainage problems and achieving the water quality objectives of the Town of Tisbury.

4 REFERENCES

gSSURGO (Soil Survey Staff. Gridded Soil Survey Geographic). 2018. Database for State name. United States Department of Agriculture, Natural Resources Conservation Service. Available online at https://gdg.sc.egov.usda.gov/. May 2, 2018.

MassGIS (Massachusetts Bureau of Geographic information Systems). 2005. *MassGIS Data: Digital Elevation Model (1:5,000)*. February 2005. Accessed October 8, 2018. < https://docs.digital.mass.gov/dataset/massgis-data-digital-elevation-model-15000>.

MassGIS (Massachusetts Bureau of Geographic information Systems). 2007. *MassGIS Data: Impervious Surface 2005*. February 2007. Accessed October 8, 2018. < https://docs.digital.mass.gov/dataset/massgis-data-impervious-surface-2005>.

MassGIS (Massachusetts Bureau of Geographic information Systems). 2007. *MassGIS Data: Land Use (2005)*. June 2009. Accessed October 8, 2018. < https://docs.digital.mass.gov/dataset/massgis-data-land-use-2005>.

MassGIS (Massachusetts Bureau of Geographic information Systems). 2005. *MassGIS Data: Building Structures (2-D)*. October 2017. Accessed October 8, 2018. < https://docs.digital.mass.gov/dataset/massgis-data-building-structures-2-d>.

APPENDIX A: LAND USE AND LAND COVER CATEGORIES

Table A-1. Initial inventory of GIS datasets identified for developing the watershed characterization (MassGIS)

GIS Layer	Description	Raw File Name
Digital Elevation Model	2005 – 5 x 5 meters	Elevation_hillshade_5k.zip
LiDAR Terrain	2014 – 1 x 1 meter	MV_Lidar.zip
Building Structures	2017 – polygon layer	Structures_poly.zip
Impervious Surface	2005 – 1 x 1 meter	Imp_mvin.zip
Land Use	2017 – polygon layer	Landuse2005_poly.zip
USGS Drainage Sub-basins	2008 – polygon layer	Subbas.zip
NRCS HUC12 Subwatersheds	2017 – polygon layer	Nrcshuc.zip
MassDEP Hydrogeography	2017 – polygon layer	Hydro100k.zip
MassDEP Wetlands	2017 – polygon layer	Wetlands.zip
MassDEP CWA Regulated Receiving Waters and Attainment Classes	2014 – polygon layer	Wbs2014_shp.zip
FEMA National Flood Hazard Layer (50 + 100 Year Flood Zones)	2017 – polygon layer	Nfhl.zip
NRCS SSURGO-Certified Soils	2012 – polygon layer	Soi_dukes.zip
Standardized Assessors' Parcels	2018 – polygon layer	L3_SHP_M296_TISBURY.zip
Department of Transportation (MassDOT) Roads	2014 – line layer	MassDOT_Roads_SHP.zip
MassDEP Oil and/or Hazardous Material Sites with AUL	2018 – point layer	Aul_pt.zip
Aquifers	2007 – polygon layer	Aquifers.zip
Surficial Geology	2014 – polygon layer	Surfgeo250k.zip
Tisbury City Boundary	2014 – polygon layer	Towns.zip

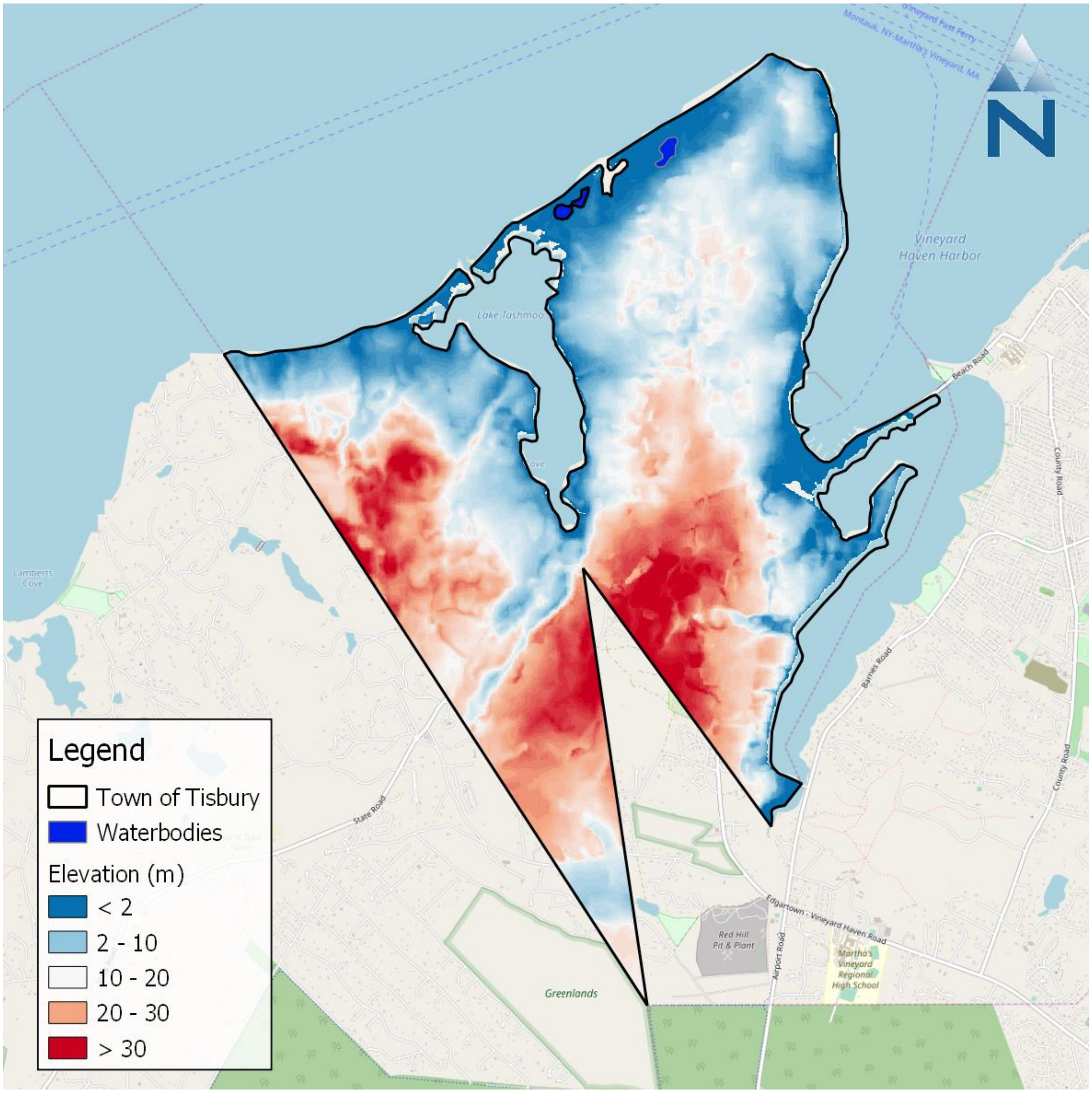

Figure A-1. Landscape elevation for the Town of Tisbury, MA.

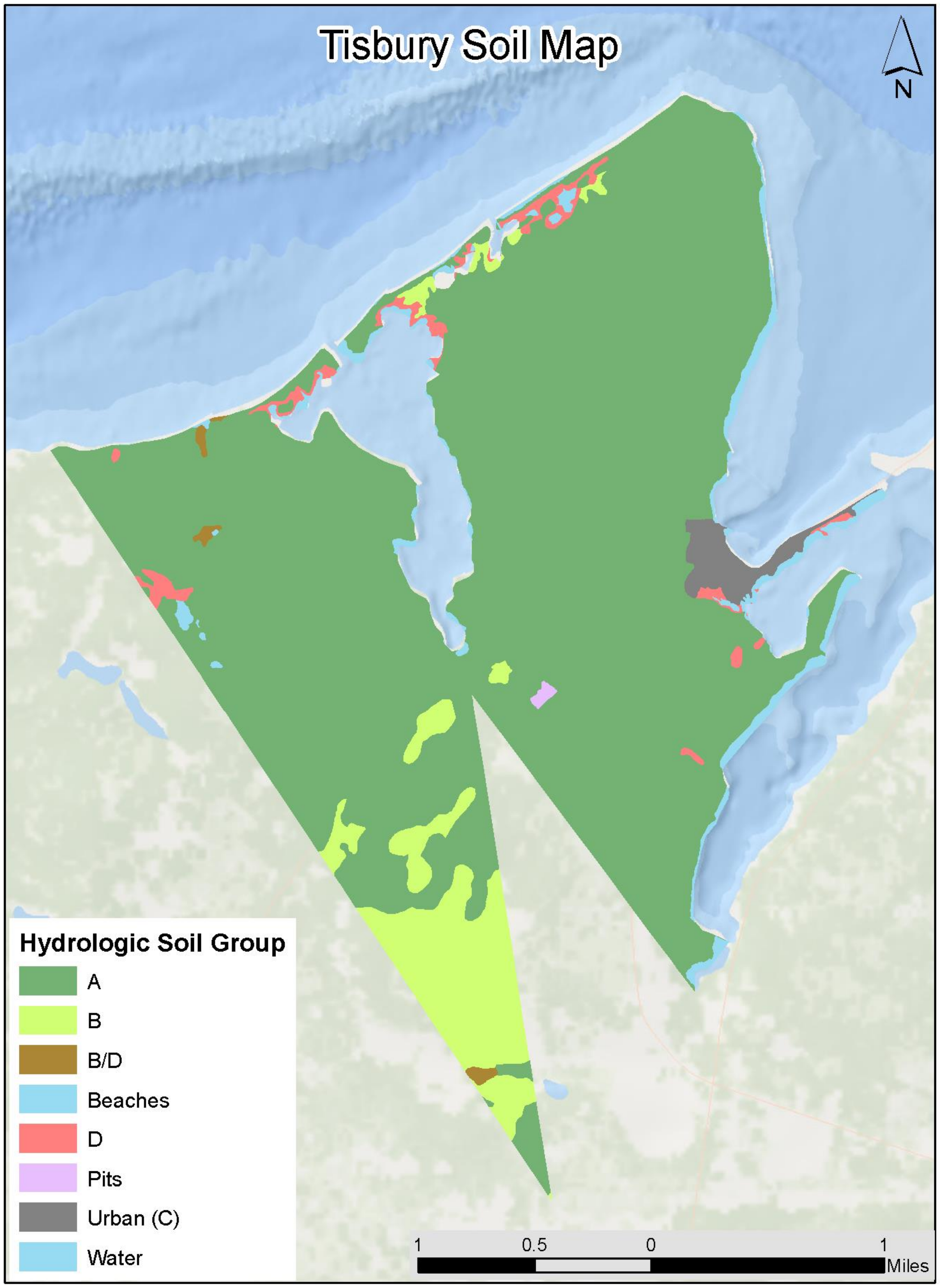

Figure A-2. Hydrologic soil groups for the Town of Tisbury, MA.

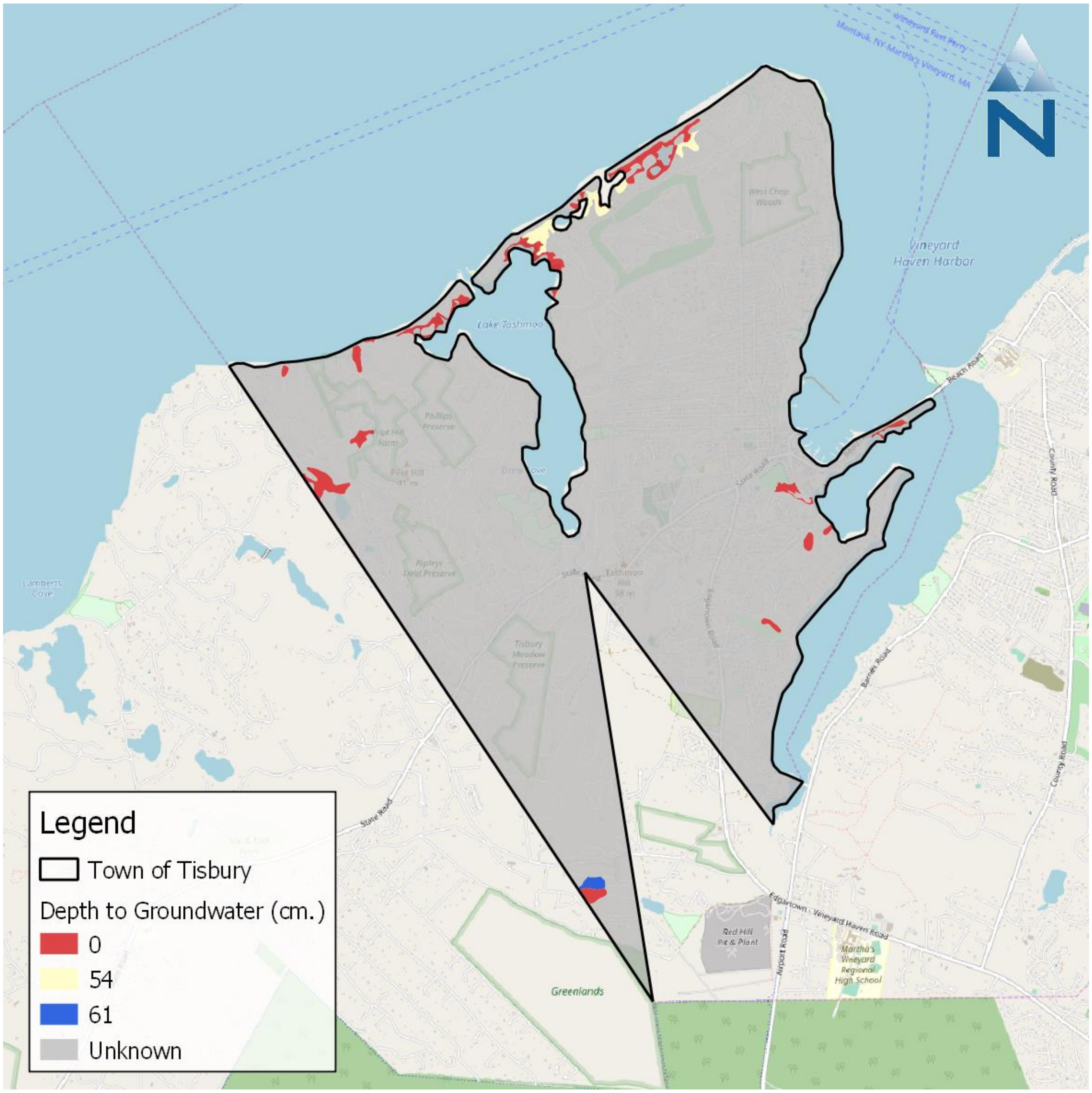

Figure A-3. Annual minimum depth to water table for the Town of Tisbury, MA.

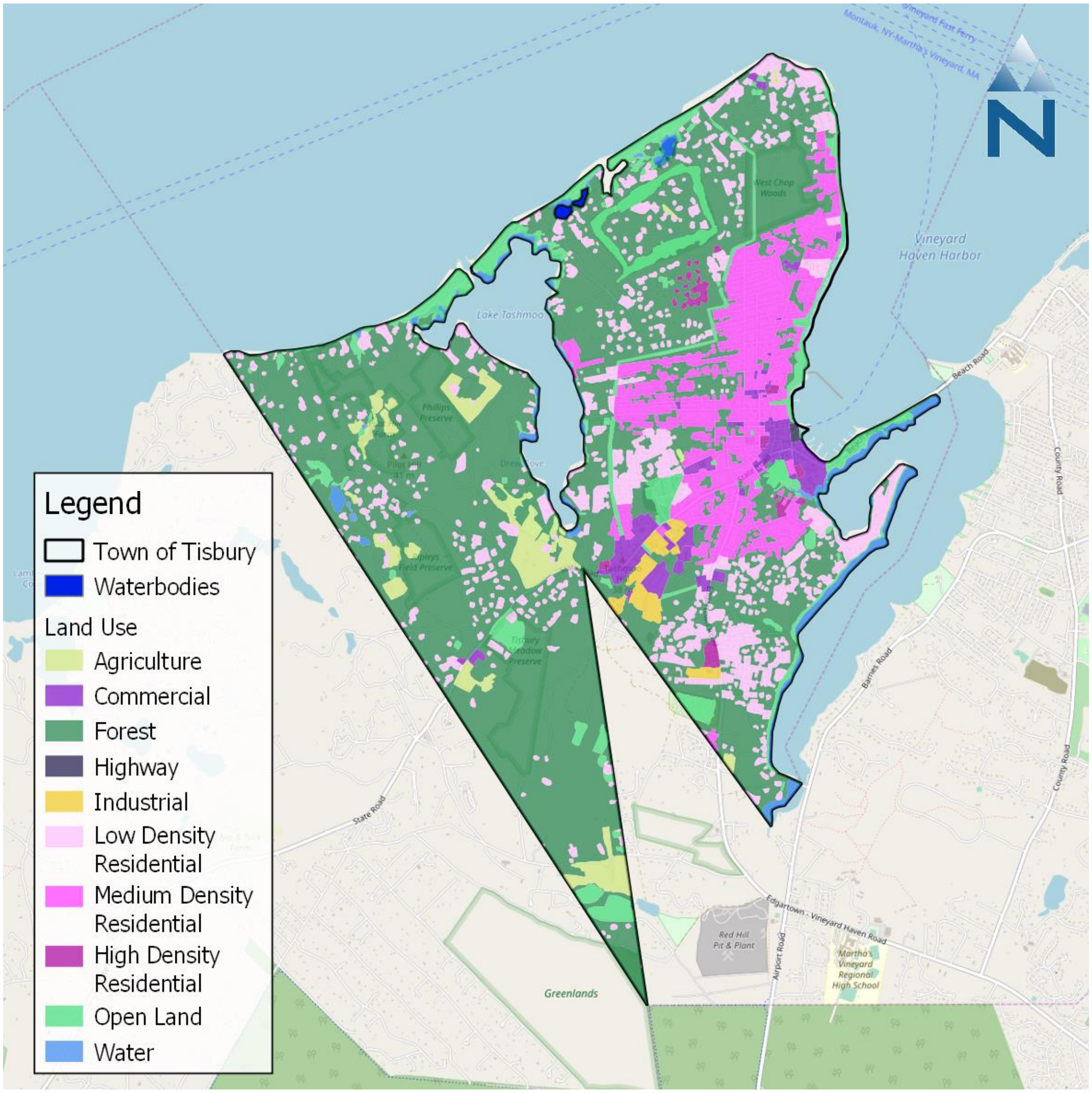

Figure A-4. Reclassified land cover categories for the Town of Tisbury, MA.

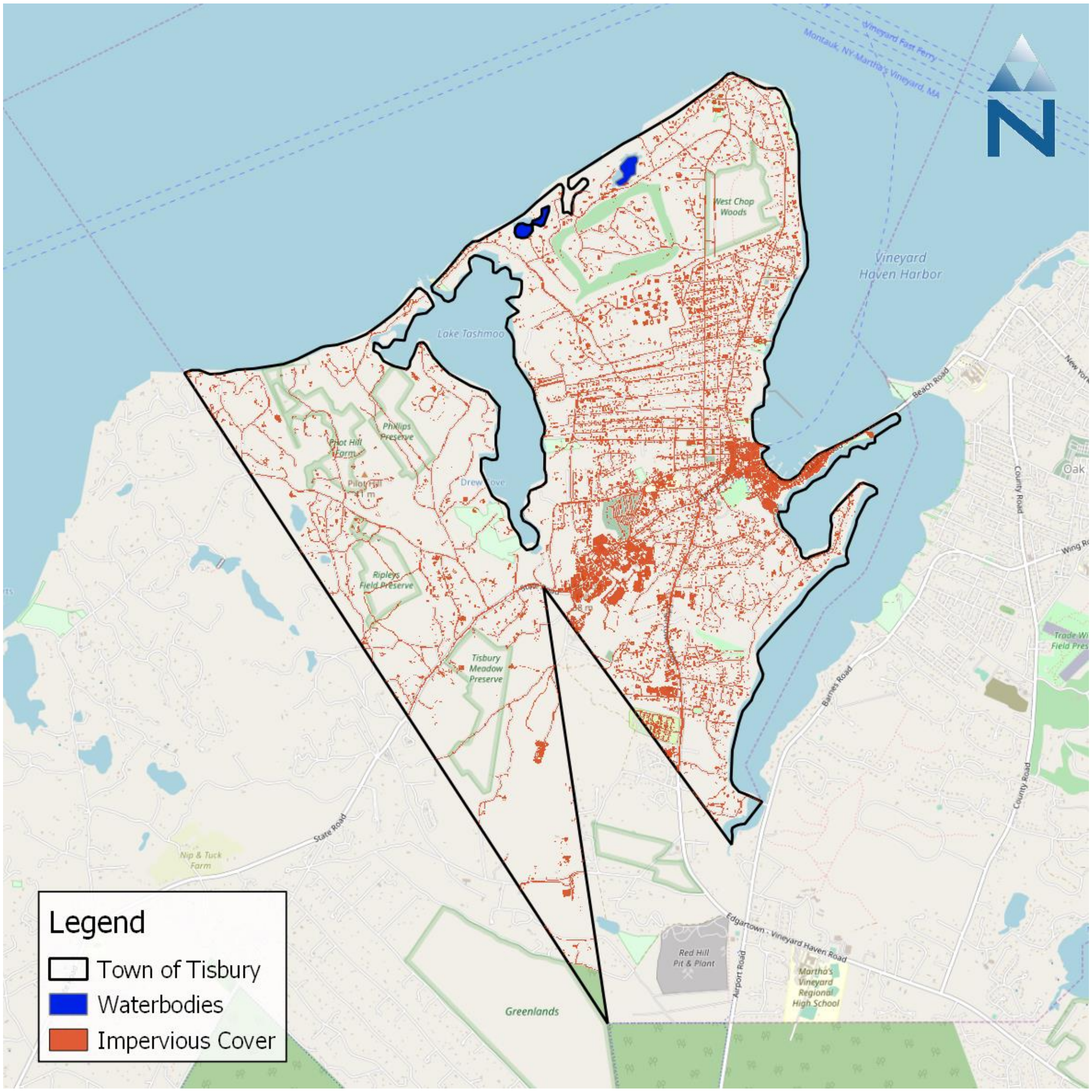

Figure A-5. Mapped impervious cover for the Town of Tisbury, MA.

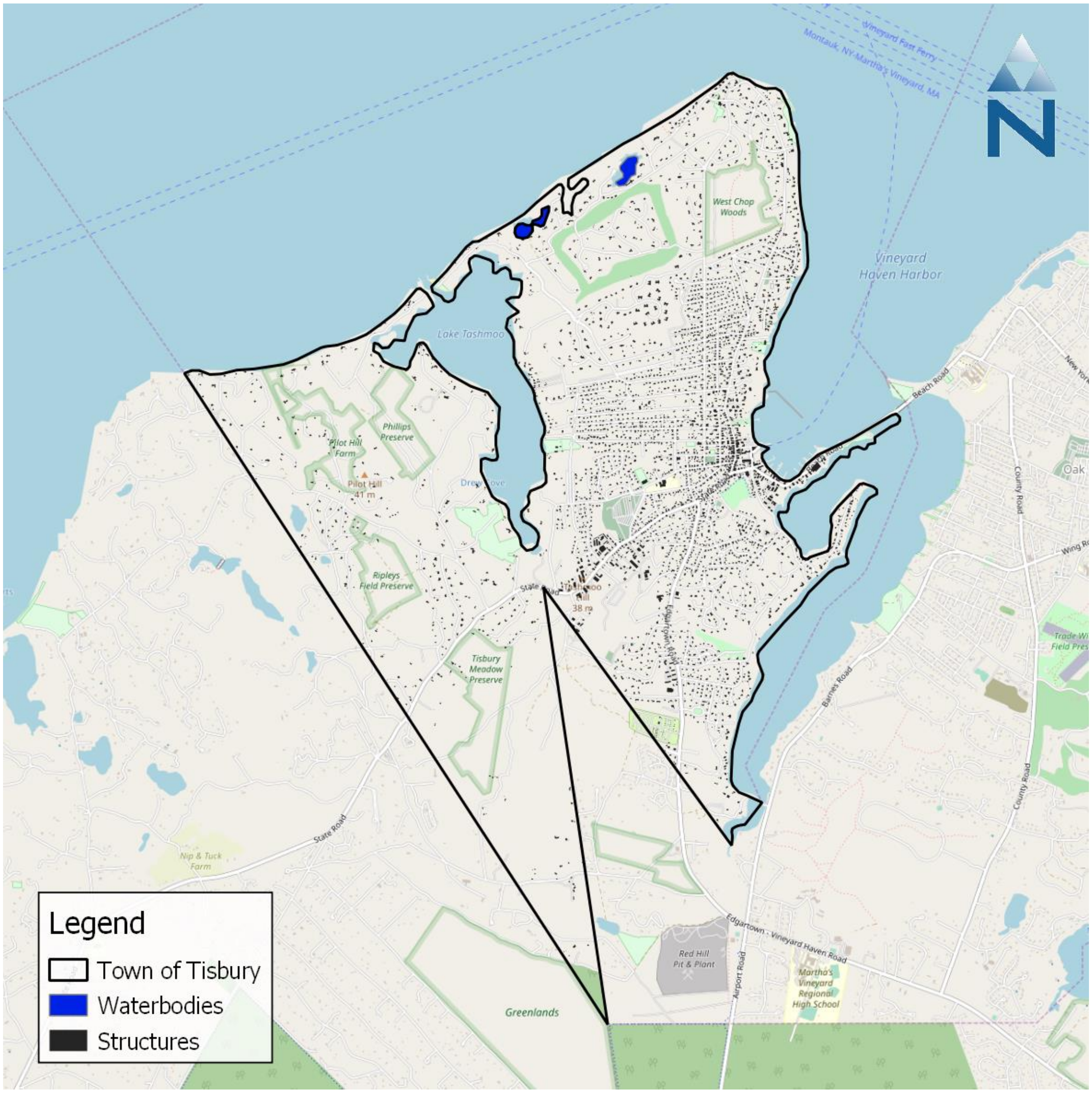

Figure A-6. Building and structure footprints for the Town of Tisbury, MA.