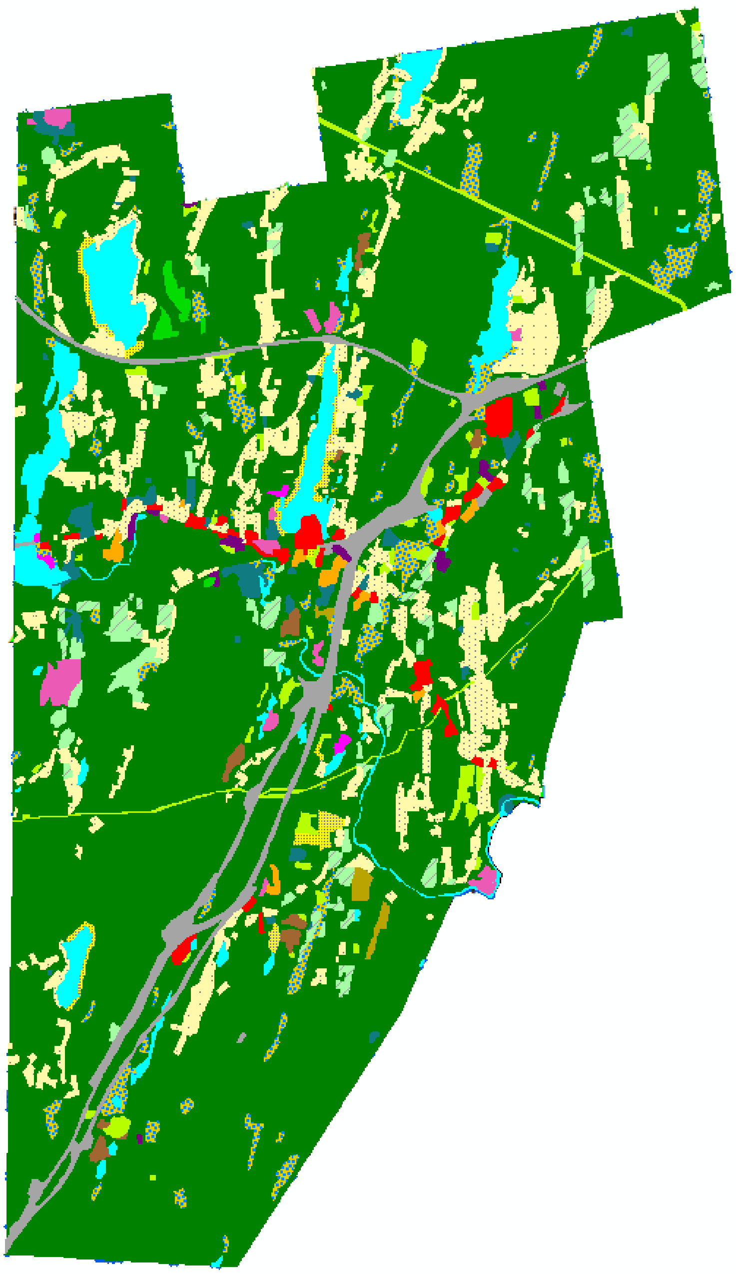
NITROGEN SOURCE IDENTIFICATION REPORT

TOWN OF STURBRIDGE, MASSACHUSETTS



Introduction

The Town of Sturbridge is primarily located within the Quinebaug River watershed which is in the Southern Part of central Massachusetts. Covering 850 square miles, the watershed extends through Connecticut and into western Rhode Island. The Chicopee River watershed is located to the north/north west of the Quinebaug River watershed, to the west is the Connecticut River watershed and to the east is the French River watershed. The Quinebaug River stretches approximately 65 miles, 19 miles are located in Massachusetts. The watershed includes 54 lakes and ponds. Together with the French River watershed and the Quinebaug-Shetucket River valley, it forms the Thames River watershed. The list of waterways in Sturbridge are listed below:

IMPAIRED RECEIVING WATERS

WATER BODY	SEGMENT ID	DESCRIPTION	SIZE	UNITS	IMPAIRMENT & CATEGORY
East Brimfield Reservoir	MA41029_2008	The body of water is a dam on the Quinebaug River and lies north of the river	228.54	acres	4C exotic species & mercury
Cedar Pond	MA41008_2008	Cedar Pond is located in the center of Sturbridge and is a large lake	148.31	acres	4C
Piston Pond	MA1057_2008	Pistol Pond is located centrally in Sturbridge and flows to Hobbs Brook	5.27	acres	(5) noxious aquatic plans
Quinebaug River (2)	MA41-02_2008	The Quinebaug River originates from East Brimfield Lake in Sturbridge north section of river	4.5	miles	Category 2
Quinebaug River (5)	MA41-01_2008	The Quinebaug River originates from East Brimfield Lake in Sturbridge south section of river	3.5	miles	(5) metal and pathogens
Leadmine Pond	MA41027_2008	Average size two story pond west Route 84	51.5	acres	Category 3
Alum Pond	MA41001_2008	200 acre great pond located off Route 148 in northwest Sturbridge	198.2	acres	(5) organic enrichment lo DO
Walker Pond	MA41052_2008	Pond is located of Route 148 adjacent to Wells State Park area	103.89	acres	4C

In regards to the waterways in Sturbridge, the pollutant of concern is nitrogen. In high amounts the nutrient pollutes lakes, streams and wetlands. Nitrogen is essential to the environment in many ways but too much entering lakes in town feeds the growth of algae, bacteria, and other organisms. Die off and dissolved oxygen issues can suffocate fish. For example, Alum Pond in Sturbridge has organic enrichment and low dissolved oxygen (DO). Some forms of algae are even toxic along with nitrates. Sources into the waterways may be from septic systems, animal feed lots, agricultural fertilizers, landfills, and garbage dumps. A small percentage of land in Sturbridge is used for farming but several water bodies in Sturbridge have impairments such as noxious aquatic plants and exotic species.

Land Use Classification

Table 3-9: Land Use Classification 1971-1999

Land Use	1971 acres of land	1971 % of land total	1985 acres of land	1985 % of land total	1999 acres of land	1999 % of land total	% Increase (1971-99)
Other	20,337	81.6%	19,754	79.3%	17,925	71.9%	-11.9%
Agriculture	983	3.9%	814	3.3%	707	2.8%	-28.1%
Urban open	192	0.8%	192	0.8%	192	0.8%	0.0%
Waste disposal	49	0.2%	49	0.2%	49	0.2%	0.0%
Water	961	3.9%	963	3.9%	963	3.9%	0.0%
Commercial	118	0.5%	154	0.6%	239	1.0%	+102.5%
Industrial	45	0.2%	57	0.2%	63	0.3%	+40.0%
Mining	83	0.3%	115	0.5%	95	0.4%	+14.5%
Recreation	134	0.5%	151	0.6%	177	0.7%	+32.1%
Transportation	697	2.8%	714	2.9%	723	2.9%	+3.7%
Residential	1,326	5.3%	1,886	7.6%	2,594	10.4%	+95.6%

The Sturbridge Lakes Advisory Committee has found that the four top concerns for the Sturbridge Lakes are boating congestion, invasive aquatic plants, stormwater runoff, and shoreline erosion. Lesser concerns identified were wildlife control (i.e., Beaver and Canada Geese), bacterial counts, litter/waste, non-native baitfish, and dock issues. These water quality concerns are being addressed by the promotion of good environmental stewardship practices such as riparian vegetation buffer zones, use of low or no phosphorus fertilizers, low or no wake zones, etc. The Sturbridge Conservation Commission also organizes a volunteer water quality-monitoring program to track adverse trends or localized problems.

For this report, our data sources included the Town of Sturbridge Land Use Plan. Within that plan there was an environmental analysis done on the soil in Sturbridge as well as the topography of the area. Sturbridge is situated in the southwest corner of Worcester County. The land is typical of New England glaciated landscape. The terrain is hilly with ridge lines extending through the town and there are wetlands in low areas. The town is overlain with thick deposits of glacial till and stratified deposits can be found in the center of the town. Elevations range from 1,150 feet above sea level down to 510 feet. The major river as talked about before is the Quinebaug River and flows west to east with many smaller streams distributed through the town. The soil in Sturbridge is generally unsuited for agricultural purposes.

Identifying Nitrogen Loading

Urban development leads to an added impervious area, in Sturbridge that in turn increases run off and nitrogen loads into the waterways. The land use study done for Sturbridge and several GIS layers were used to calculate impervious area and eventually nitrogen loading. It is critical to calculate impervious area primarily in order to calculate directly connected impervious area (DCIA).

Percentage of impermeable areas in Sturbridge

Impervious area is the area of municipality that is paved where water is unable to naturally infiltrate from urbanization. We calculated impervious areas using the Mass GIS layers, the land use study Sturbridge completed and it was done by data sources previously stated. Data layers for drainage and major stormwater discharge points in the town were entered onto the map. The stormwater point data was utilized to estimate impervious areas in stormwater catchments as well as to calculate impervious areas that head into waterways that have high nutrient levels and pollutants.

To estimate those pollutant loads, specifically for nitrogen in each catchment, land use type, cover, and soil type were applied. The loading rates were based on the stormwater discharge points and that in turn lead to an overall nitrogen loading.

Table 1. Sutherland Equations to Determine DCIA (%)

Watershed Selection Criteria	Assumed Land Use	Equation *(where IA(%) ≥1)*
Average: Mostly storm sewered with curb & gutter, no dry wells or infiltration, residential rooftops not directly connected	Commercial, Industrial, Institutional, Open land, and Med. density residential	$DCIA=0.1(IA)^{1.5}$
Highly connected: Same as above, but residential rooftops are connected	High density residential	$DCIA=0.4(IA)^{1.2}$
Totally connected: 100% storm sewered with all IA connected	--	$DCIA=IA$
Somewhat connected: 50% not storm sewered, but open section roads, grassy swales, residential rooftops not connected, some infiltration	Low density residential	$DCIA=0.04(IA)^{1.7}$
Mostly disconnected: Small percentage of urban area is storm sewered, or 70% or more infiltrate/disconnected	Agricultural; Forested	$DCIA=0.01(IA)^{2}$

Calculations used:

Total amount of Urbanized /Regulated area for the MS4

The total area of Sturbridge is 24,930 acres and within that a total of 4,588 acres area located in the urbanized /MS4 regulated area. The MS4 regulated area is with the Quinebaug River watershed. The urbanized area shown in the outfall waterway map below has 234 catchment areas for drainage.

Stormwater Discharge Points Impervious Area Totals Below

The table below summarizes the impervious area (IA) and estimated directly connected impervious area (DCIA) within the City's MS4 regulated area.

Total Impervious Area within the MS4 area = 1,352 acres

Total Estimated DCIA within the MS4 area = 883 acres

Based on data from Sturbridge.maps.arcgis.com

Table below includes information on catchments in the MS4 area with the most impervious area. The catchments are in the urbanized area. Additionally, the table contains DCIA in acres. Information was taken from GIS land use maps, stormwater imagery, square feet of rooftops /roadway of the most impervious catchments.

Catchment number	Impervious area in acres	DCIA in acres
SHEPARD-WESTVILLE-281	8.74	0.82
BURGESS SCHOOL-	7.87	0.7
PUBLIC- WORKS REC-700	5.49	0.41
PRESERVE-86	5.38	0.39
EVERGREEN/HIGHLAND-18	4.5	0.3
DRAPER -80	4.2	0.27
TANNERY-811	3.35	0.19
FAIRVIEW-748	3.29	0.19
RIVER ROAD-258	2.55	0.13
CEDAR REC AREA-663	2.43	0.12

See the estimated nitrogen loading below. N load export rate, lbs. /acre /year. All residential directly connected impervious uses 14.1 to calculate.

(IA index NLER index), (acres x 14.1). Using Appendix F and other on-line resources, estimates were created for each of the town's largest drainage catchments. The next table shows the catchments with the highest nitrogen loading.

Determining Nitrogen Loading for Drainage Points with the Largest Impervious Area

To calculate nitrogen loading, we used the appendix from the EPA website outlining the MS4 permit. Estimated amounts for nitrogen loading in a year were added for each town drainage catchment. The soil type in these selected catchments is determined the constant used to calculate pounds per year and the area of the majority of these drainage points in Sturbridge is residential.

Nitrogen Loading Table

Catchment number	Impervious area in acres	ESTIMATED LOAD RATES Nitrogen Load (lbs/yr)
SHEPARD-WESTVILLE-281	8.74	123.23
BURGESS SCHOOL-	7.87	110.97
PUBLIC- WORKS REC-700	5.49	77.41
PRESERVE-86	5.38	75.86
EVERGREEN/HIGHLAND-18	4.5	63.45
DRAPER -80	4.2	59.22

Prioritizing catchments:

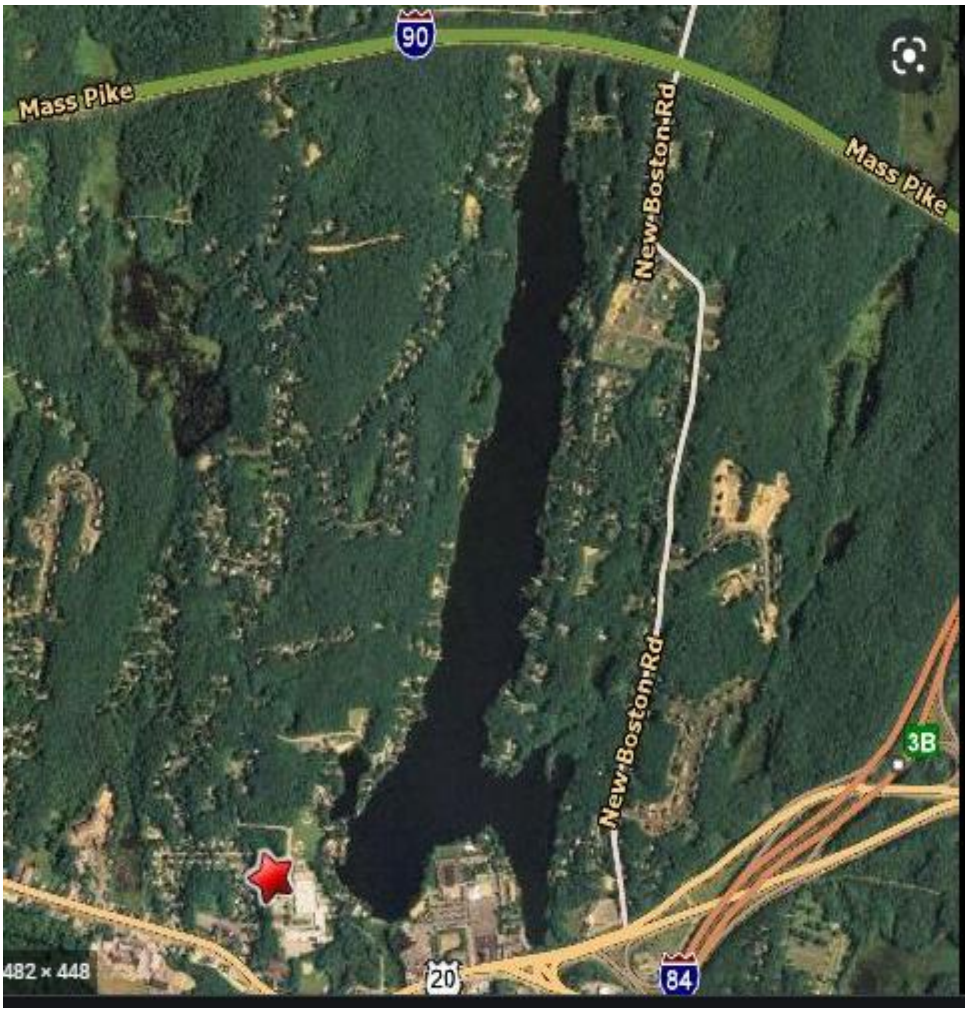
In review of the high nitrogen catchments and drainage points that were sampled it appears that some catchments can be prioritized. For example, Shepard –Westville catchment was high on nitrogen loading in regards to acres but also from sampling outfalls in the field and seeing lab results. Therefore, a correlation can be seen in large catchments and sampling results. Although the field samples of nitrogen are in mg/liter. The nitrogen loads estimations are based mostly on land use and would change depending on the area in town and soil type various in Sturbridge but nevertheless the estimates show the areas of the town that are high priority to reduce pollutant loads. An area of town that had a high estimation for nitrogen loading happens to be an area of high ecological value and is a major recreation area called Westville Lake so that will be a starting spot for control of pollutant loading.

Potential Retrofit Opportunities

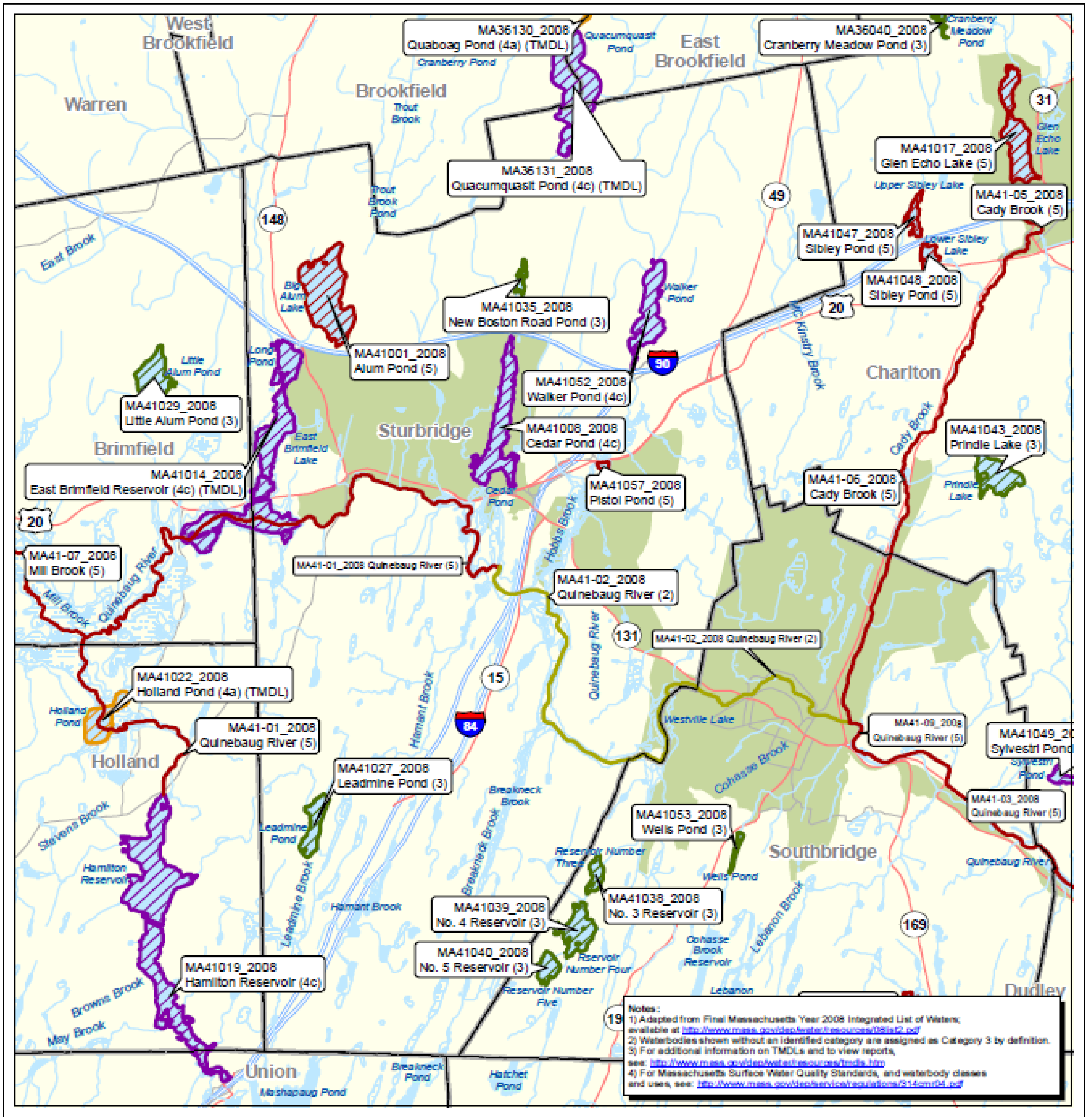
We considered and identified properties that might be most appropriate for green infrastructure storm water retrofit locations. Moreover, we used a number of factors that determined these locations. The surface water list of integrated water bodies is very important in pin pointing areas of town that are priority for green infrastructure improvements. The list of integrated waters is included below. Another important component in determining any retrofit parcel is where it is located within the MS4 regulated area. We also looked at loading rates and imperious area cover of catchments in drainage points that are near each other as part of a larger network.

One of the stormwater catchments with the highest estimated nitrogen load in Sturbridge was near the Westville Lake recreation area. The outfall catchments and drainage discharge points outlet to the Quinebaug River which is category five on the list impaired waters. This area near Westville Lake is also a major recreation area and has ecological value in terms of wetlands. Therefore, the parcel in the Westville outfall catchment will be a great candidate for any retrofit opportunities. Currently, there are very few SCM in this area. Another impaired water way in town is in Cedar Lake which is a 4c, see map. This catchment area is in close proximity to another outfall catchment with a high impervious area therefore it would also be a good candidate for stormwater control measures. The drainage structures in the priority area are directly connected from the road right into Cedar Lake and that area should be retrofitted with a better structure before entering the lake. The catchment is a Cedar Recreation area and is also the site of the town recreation area which gives it ecological importance and quality of life importance. We have installed CDS units as control measures in other discharge points before the Quinebaug River and tributaries to Cedar Lake. For the Cedar Lake catchments, we have, coordinated with the lake association to come up with a plan to discuss retrofits and upgrades to drainage. Another nearby outfall catchment named Burgess School has underground retention systems installed, which is also a consideration. This report was the starting point for the next requirements for the permit. Subsequent evaluations will further investigate feasibility, cost, engineering, and plans for retrofits of stormwater structures.

Cedar Lake



Integrated Map of Waters in Sturbridge



MS4 Sampling Lab Results for 2018

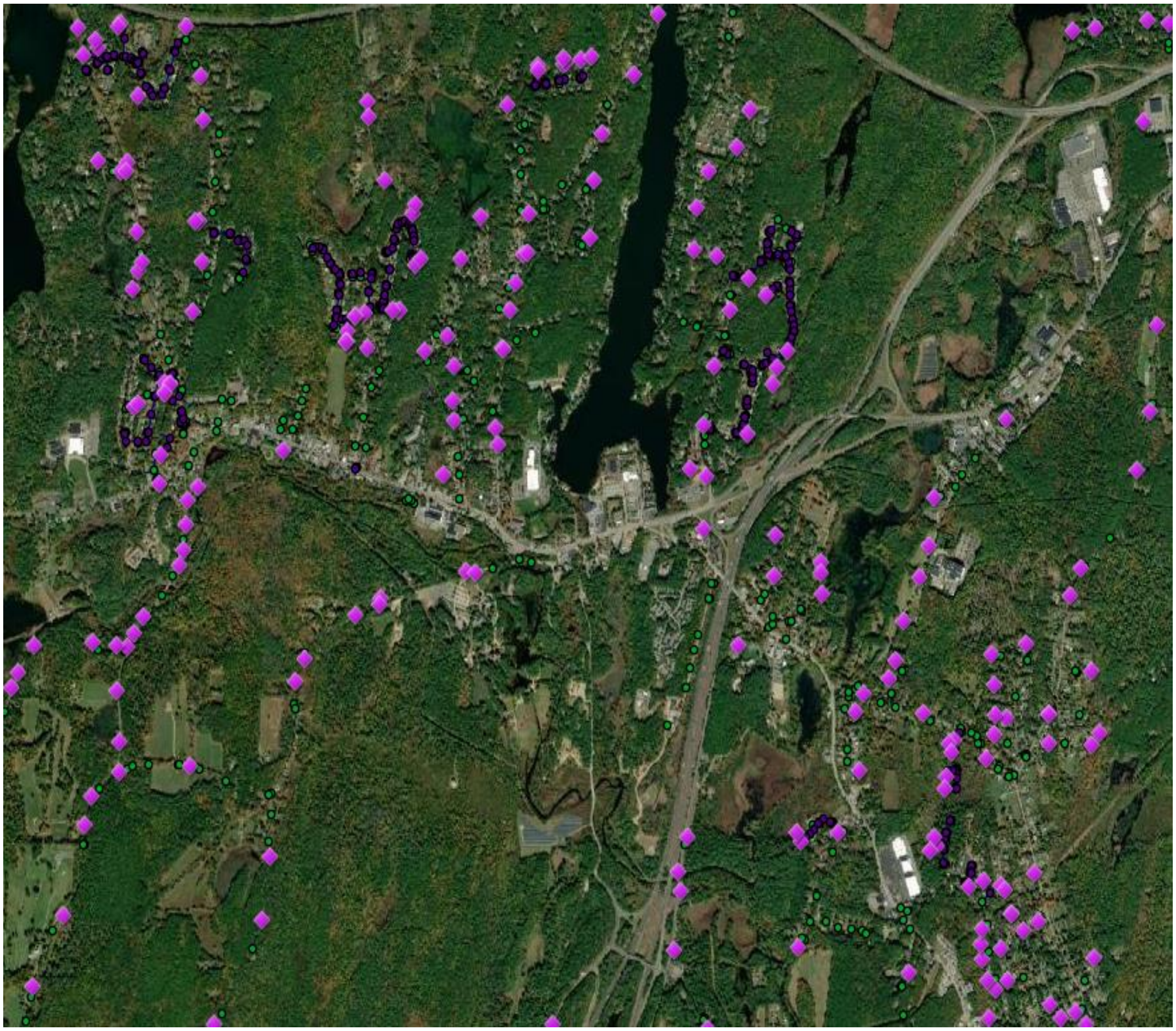
Sample Date	Location ID	pH *SU*	DO *mg/L*	Temp *° C*	Turbidity *NTU*	Conductivity *us/cm*	Salinity *ppt or ‰*	Chlorine *mg/L*	Ammonia *mg/L*	Total Nitrogen *mg/L*	Surfactants *mg/L*	E coli *cfu/100 ml*
10/22/2018	WALL-OF-01-HP	6.54	9.44	12.5	0.35	160.5	0.08	0.01	<0.015	2.04	0.118	1
10/22/2018	CHAR-01-HP	6.56	9.69	14.4	0.11	234	0.11	0.00	<0.015	<1.00	0.083	8.6
10/26/2018 *	COLL-HP-OF-#1	6.56	9.90	9.4	2.55	200.1	0.09	0.00	0.036	1.10	<0.1	4.1
10/26/2018 *	HOLLAND-RD-OF-#1	6.75	10.79	8.3	5.47	546	0.26	0.01	0.049	<1.0	0.119	2
10/26/2018 *	CEDAR-ST-OF-#1	7.55	11.26	6.0	1.45	259	0.12	0.03	0.022	<1.0	0.106	15.8
10/26/2018 *	HP-ARN-OF-#1	6.61	9.51	10.4	1.75	262	0.12	0.00	0.015	<1.0	<0.1	<1
12/12/2018	SHEPOF#7 HP	6.38	12.62	3.6	0.35	382	0.19	0.01	<0.015	5.26	0.177	2
12/12/2018	BROOKFIELDOF8HP	5.98	12.07	3.3	3.36	8,150	8.24	0.01	<0.015	3.96	0.815	<1
12/12/2018	RIVEROF#1	6.23	10.69	9.1	0.37	178.8	0.08	0.01	<0.015	2.97	0.214	2
12/12/2018	RIVEROF#2	6.27	12.18	4.4	1.2	67	0.03	0.00	<0.015	4.33	0.248	27.5

** the E coli was sampled on 12/12/18*

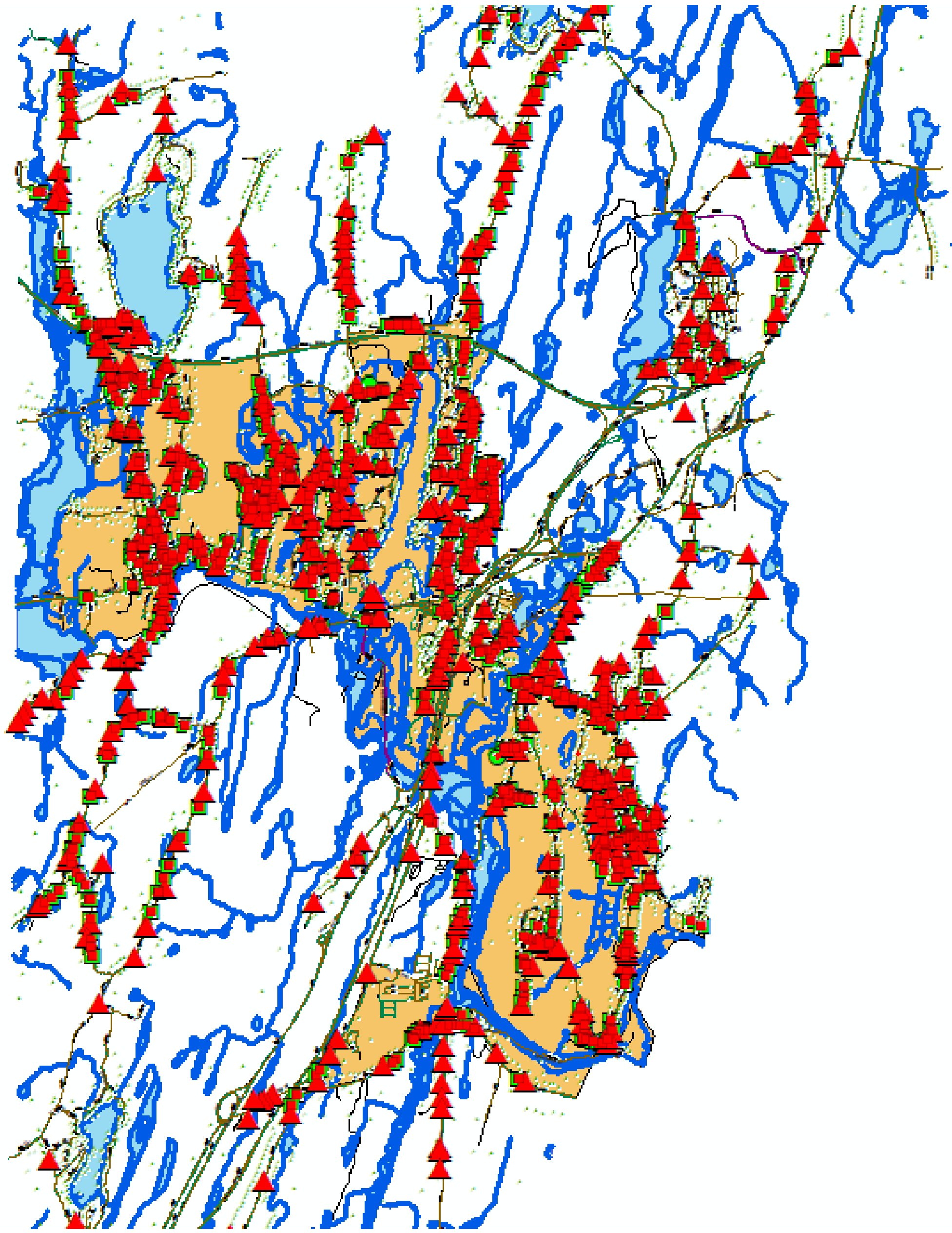
MS4 Sampling - Lab Results for 2021

Sample Date	Location ID	pH	DO	Temp	Turbidity	Conductivity	Salinity	Chlorine	Ammonia	Total Nitrogen	Anionic Surfactants	E. Coli
		SU	*mg/L*	*°C*	*NTU*	*us/cm*	*ppt or ‰*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*MPN/100 ml*
6/2/2021	Outfall 124	7.76	9.32	14.0	0.15	56.2	0.03	0.01	0.004	1.260	0.086	10.0
6/2/2021	Outfall 151	7.66	9.63	12.5	2.03	133.0	0.08	0.01	0.024	1.220	0.237	866.4
6/2/2021	Outfall 679	7.11	7.69	12.4	0.22	204.9	0.13	0.02	0.013	0.785	0.282	4.1
6/2/2021	Outfall 193	5.43	9.50	14.7	0.72	69.9	0.04	0.00	0.009	2.260	0.211	1,046.2
6/9/2021	Outfall 807	4.88	6.40	16.0	0.27	221.0	0.13	0.01	0.009	1.380	0.160	1,354.0
6/9/2021	Outfall 205		8.92	15.9	0.51	155.6	0.09	0.02	0.023	0.747	0.169	216.0
6/9/2021	Outfall 758	6.84	7.82	24.6	0.54	112.0	0.05	0.02	0.011	0.359	0.294	365.4
6/9/2021	Outfall 380	4.76	8.81	17.6	0.74	267.0	0.14	0.07	0.018	1.270	0.192	373.0
6/9/2021	Outfall 207	7.67	8.45	13.4	9.72	608.0	0.39	0.04	0.078	5.020	0.208	41.0
6/9/2021	Outfall 791	7.65	7.50	18.1	4.76	144.7	0.08	0.00	0.014	1.830	0.157	588.0
6/9/2021	Outfall 194	4.95	8.26	19.0	0.91	793.0	0.44	0.00	0.015	0.618	0.334	75.4
6/9/2021	Outfall 811	6.27	7.88	22.7	5.97	263.0	0.15	0.02	0.023	1.170	0.242	187.0
6/9/2021	Outfall 222	6.81	6.82	12.8	0.27	533.0	0.34	0.05	0.000	2.470	0.248	41.0
6/16/2021	Outfall 292	6.58	9.15	17.0	1.81	264.0	0.15	0.02	0.011	1.520	0.358	3,873.0
6/16/2021	Outfall 293	6.55	9.05	16.8	1.45	272.0	0.11	0.00	0.005	1.120	0.285	435.2

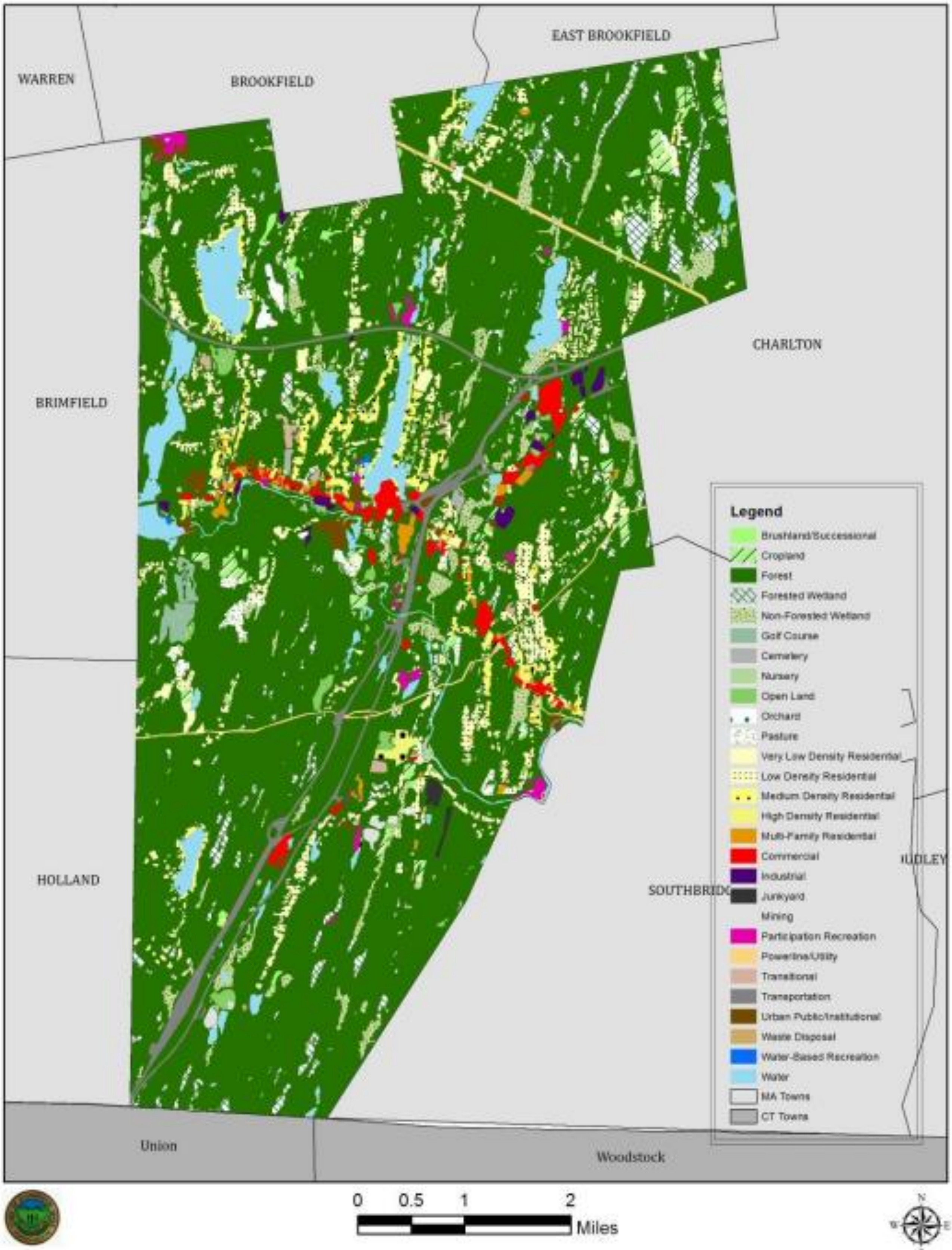
Outfall Waterway for MS4 Catchments



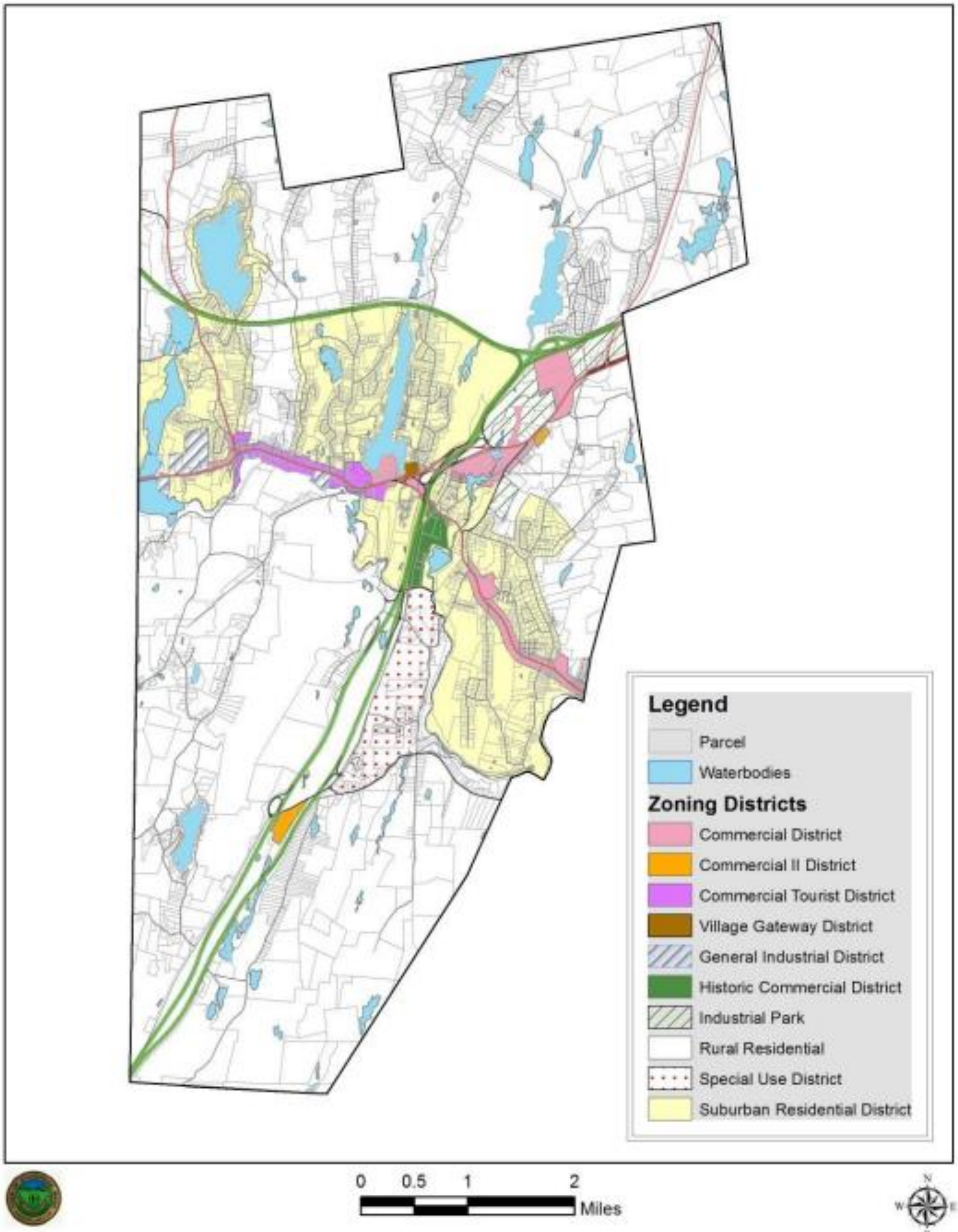
Urbanized MS4 Area Map (orange shaded area)



Town of Sturbridge: Land Use 2005



Town of Sturbridge: Zoning



Town of Sturbridge: Soils