Final Massachusetts Statewide Total Maximum Daily Load for Pathogen-Impaired Waterbodies

Appendix V: Merrimack River Basin & Coastal Drainage Area

Commonwealth of Massachusetts
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Available Online

https://www.mass.gov/lists/total-maximum-daily-loads-by-watershed

Massachusetts Department of Environmental Protection

The mission of the Massachusetts Department of Environmental Protection (MassDEP) is to protect and enhance the Commonwealth's natural resources – air, water, and land – to provide for the health, safety, and welfare of all people, and to ensure a clean and safe environment for future generations. In carrying out this mission MassDEP commits to address and advance environmental justice and equity for all people of the Commonwealth; provide meaningful, inclusive opportunities for people to participate in agency decisions that affect their lives; and ensure a diverse workforce that reflects the communities we serve.

Watershed Planning Program

The mission of the Watershed Planning Program (WPP) in the Massachusetts Department of Environmental Protection is to protect, enhance, and restore the quality and value of the waters of the Commonwealth. Guided by the federal Clean Water Act, WPP implements this mission statewide through five Sections that each have a different technical focus: (1) Surface Water Quality Standards; (2) Surface Water Quality Monitoring; (3) Data Management and Water Quality Assessment; (4) Total Maximum Daily Load; and (5) Nonpoint Source Management. Together with other MassDEP programs and state environmental agencies, WPP shares in the duty and responsibility to secure the environmental, recreational, and public health benefits of clean water for all people of the Commonwealth.

Acknowledgements

FB Environmental Associates, under contractual agreements with MassDEP, previously prepared two separate documents for the Watershed Planning Program: (1) *Massachusetts TMDL for Pathogen-Impaired Inland Fresh Water Rivers* and (2) *Massachusetts Statewide TMDL for Pathogen-Impaired Coastal Waterbodies*. MassDEP combined these two documents into a single statewide approach encompassing both inland fresh water and coastal impairments to prepare the *Final Massachusetts Statewide Total Maximum Daily Load for Pathogen-Impaired Waterbodies*.

Disclaimer

References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendations by the Massachusetts Department of Environmental Protection.

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1. Introduction

This appendix to the Massachusetts Statewide Total Maximum Daily Load (TMDL) for Pathogen-Impaired Waterbodies provides additional information to support the determination of the TMDL for the 34 pathogen-impaired segments in the Merrimack River Basin & Coastal Drainage Area, hereinafter referred to as the Merrimack River watershed (Figure 1-1). The core document and appendix together complete the TMDL for each of these pathogen-impaired segments.

This appendix includes a description of the watershed and maps to identify the segments of focus for the TMDLs; the impaired uses, and the water classification and qualifiers as designated by the Massachusetts Surface Water Quality Standards (SWQS, 314 CMR 4.00); the water quality standards applicable to the impaired uses; the data supporting the pathogen impairment determination; and a description of the sources of pathogen loading with supporting maps.

This appendix also includes a summary of the allocation of the current indicator bacteria load into two categories: point sources (waste load allocation, WLA) and nonpoint sources (load allocation, LA), based on an analysis of watershed percent impervious cover. This appendix identifies the percent reduction in indicator bacteria pollutant load from current conditions required to meet the TMDL, based on the highest levels of indicator bacteria recorded in the monitoring data, if applicable. The TMDLs for the 28 freshwater segments were calculated with the flow-based equation, and those for the six estuarine segments were calculated with the load-based equation. Refer to Tables 1-1 through 1-5.

Finally, for each impaired segment, this appendix presents existing local management efforts to reduce pathogen pollutant loading. General recommended next steps for implementation of this TMDL are provided in the Merrimack River Watershed Overview section.

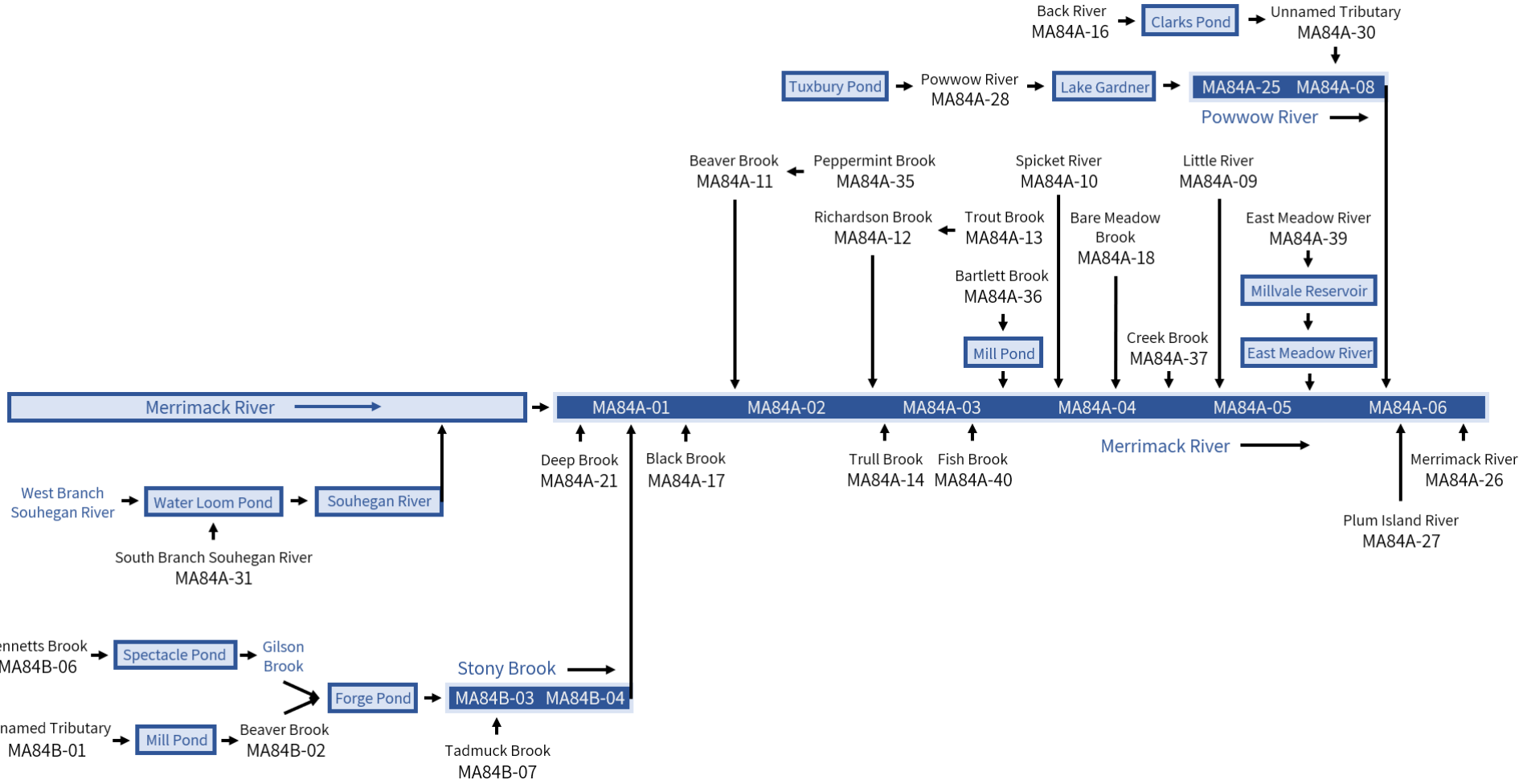


Figure 1-1. Conceptual diagram of water flow through the Merrimack River watershed for the 34 pathogen-impaired segments. The Merrimack River, Stony Brook, and the Powwow River are highlighted in blue. Tributary segments to the Merrimack River are shown with black arrows. Not to scale. Impaired segments are shown with the assessment unit.

Table 1-1. ***E. Coli*** Total Maximum Daily Loads (TMDLs), the percent reductions needed to meet the TMDL target (126 CFU/100ml) based on the Massachusetts Surface Water Quality Standards (SWQS), and the flow-based TMDL allocations for pathogen-impaired **freshwater** assessment units in the Merrimack River Basin and Coastal Drainage Area

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	*Flow (cfs)* 1	10	100	1,000	10,000	100,000
							Flow-Based Target TMDL (CFU/day*10^9)					
Merrimack River MA84A-01	B (TWS, WW, CSO)	R	126	NA	-	WLA (8%) LA (92%)	0.2 2.8	2.3 28.5	23.5 284.8	234.5 2,848.1	2,345.4 28,481.4	23,454.1 284,813.9
Merrimack River MA84A-02	B (TWS, WW, CSO)	R	126	NA	-	WLA (10%) LA (90%)	0.3 2.8	3.2 27.6	31.9 276.3	319.4 2,763.3	3,193.8 27,633.0	31,938.2 276,329.8
Merrimack River MA84A-03	B (TWS, WW, CSO)	R	126	NA	-	WLA (11%) LA (89%)	0.3 2.8	3.3 27.6	32.7 275.6	326.7 2,756.0	3,267.1 27,559.7	32,671.4 275,596.6
Merrimack River MA84A-04	B (WW, CSO)	R	126	NA	-	WLA (12%) LA (88%)	0.4 2.7	3.6 27.2	36.2 272.1	361.6 2,721.1	3,615.8 27,211.0	36,158.4 272,109.6
Little River MA84A-09	B (WW)	R	126	254 (90 day)	50%	WLA (21%) LA (79%)	0.6 2.4	6.4 24.4	64.1 244.1	641.3 2,441.4	6,413.3 24,413.5	64,132.8 244,135.3
Spicket River MA84A-10	B (WW, CSO)	R	126	NA	-	WLA (27%) LA (73%)	0.8 2.3	8.2 22.7	81.8 226.5	817.6 2,265.1	8,175.9 22,650.9	81,759.0 226,509.0
Beaver Brook MA84A-11	B (CW)	R	126	317 (90 day)	60%	WLA (20%) LA (80%)	0.6 2.5	6.3 24.5	62.9 245.4	629.1 2,453.6	6,291.2 24,535.6	62,912.3 245,355.7
Richardson Brook MA84A-12	B	R	126	NA	-	WLA (9%) LA (91%)	0.3 2.8	2.9 27.9	29.1 279.2	290.8 2,791.9	2,908.0 27,918.8	29,079.8 279,188.2
Trout Brook MA84A-13	B	R	126	NA	-	WLA (7%) LA (93%)	0.2 2.9	2.1 28.7	21.5 286.8	214.6 2,868.1	2,145.8 28,681.0	21,457.6 286,810.5
Trull Brook MA84A-14	B	R	126	NA	-	WLA (23%) LA (77%)	0.7 2.4	7.1 23.7	71.5 236.8	714.9 2,367.8	7,148.9 23,677.9	71,488.9 236,779.1
Back River MA84A-16	B	R	126	NA	-	WLA (6%) LA (94%)	0.2 2.9	2.0 28.9	19.5 288.7	195.4 2,887.3	1,953.9 28,872.9	19,539.2 288,728.8
Black Brook MA84A-17	B	R	126	NA	-	WLA (31%) LA (69%)	0.9 2.1	9.5 21.4	94.5 213.7	945.2 2,137.5	9,451.9 21,374.9	94,518.6 213,749.5
Bare Meadow Brook MA84A-18	B	R	126	NA	-	WLA (14%) LA (86%)	0.4 2.7	4.3 26.6	42.5 265.7	425.3 2,657.4	4,252.7 26,574.1	42,526.6 265,741.5
Deep Brook MA84A-21	B	R	126	1,338 (90 day)	91%	WLA (13%) LA (87%)	0.4 2.7	4.1 26.8	40.5 267.8	405.1 2,677.6	4,050.5 26,776.3	40,505.4 267,762.6
Powwow River MA84A-25	B (WW)	R	126	NA	-	WLA (7%) LA (93%)	0.2 2.9	2.2 28.7	21.6 286.7	215.9 2,866.7	2,159.5 28,667.3	21,594.5 286,673.5
Powwow River MA84A-28	A (PWS, ORW)	R*	126	79 (90 day)	-	WLA (6%) LA (94%)	0.2 2.9	1.7 29.1	17.0 291.3	169.6 2,913.1	1,695.6 29,131.2	16,955.8 291,312.2
South Branch Souhegan River MA84A-31	B	R	126	159 (90 day)	21%	WLA (3%) LA (97%)	0.1 3.0	0.9 29.9	9.3 298.9	93.2 2,989.5	932.2 29,894.6	9,321.7 298,946.3
Peppermint Brook MA84A-35	B	R	126	NA	-	WLA (16%) LA (84%)	0.5 2.6	5.1 25.8	50.6 257.7	506.1 2,576.6	5,060.5 25,766.3	50,605.3 257,662.8
Bartlett Brook		R	126	NA	-	WLA (10%)	0.3	3.2	32.2	322.2	3,222.2	32,222.4

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	*Flow (cfs)* 1	10	100	1,000	10,000	100,000
							Flow-Based Target TMDL (CFU/day*10^9)					
MA84A-36	B					LA (90%)	2.8	27.6	276.0	2,760.5	27,604.6	276,045.6
Creek Brook		R	126	NA	-	WLA (11%)	0.3	3.5	34.6	345.8	3,457.9	34,579.1
MA84A-37	B					LA (89%)	2.7	27.4	273.7	2,736.9	27,368.9	273,688.9
East Meadow River		R	126	NA	-	WLA (6%)	0.2	1.7	17.5	174.9	1,749.1	17,491.4
MA84A-39	A (PWS, ORW)					LA (94%)	2.9	29.1	290.8	2,907.8	29,077.7	290,776.6
Fish Brook		R	126	NA	-	WLA (10%)	0.3	3.1	30.8	307.8	3,077.7	30,776.7
MA84A-40	A (PWS, ORW)					LA (90%)	2.8	27.7	277.5	2,774.9	27,749.1	277,491.3
Unnamed Tributary		R*	126	NA	-	WLA (12%)	0.4	3.7	37.4	373.6	3,735.6	37,355.5
MA84B-01	B					LA (88%)	2.7	27.1	270.9	2,709.1	27,091.2	270,912.5
Beaver Brook		R*	126	NA	-	WLA (11%)	0.3	3.4	33.8	338.0	3,380.2	33,802.2
MA84B-02	B					LA (89%)	2.7	27.4	274.5	2,744.7	27,446.6	274,465.8
Stony Brook		R*	126	150	16%	WLA (10%)	0.3	3.1	30.7	306.8	3,068.1	30,681.0
MA84B-03	B (WW)			(90 day)		LA (90%)	2.8	27.8	277.6	2,775.9	27,758.7	277,587.1
Stony Brook		R	126	398	68%	WLA (11%)	0.3	3.4	33.6	336.5	3,364.9	33,649.5
MA84B-04	B (WW)			(90 day)		LA (89%)	2.7	27.5	274.6	2,746.2	27,461.9	274,618.6
Bennetts Brook		R	126	NA	-	WLA (10%)	0.3	3.0	30.1	301.0	3,009.9	30,098.8
MA84B-06	B					LA (90%)	2.8	27.8	278.2	2,781.7	27,816.9	278,169.2
Tadmuck Brook		R	126	NA	-	WLA (13%)	0.4	4.0	40.0	399.6	3,996.2	39,962.1
MA84B-07	B					LA (87%)	2.7	26.8	268.3	2,683.1	26,830.6	268,305.9

Table 1-2. **Enterococci** Total Maximum Daily Loads, the percent reductions needed to meet the TMDL target (35 CFU/100ml) based on the Massachusetts Surface Water Quality Standards (SWQS), and the flow-based TMDL allocations for pathogen-impaired **freshwater** assessment units in the Merrimack River Basin and Coastal Drainage Area

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	*Flow (cfs)* 1	10	100	1,000	10,000	100,000
							Flow-Based Target TMDL (CFU/day*10^9)					
Merrimack River		P	35	NA	-	WLA (8%)	0.1	0.7	6.5	65.2	651.5	6,515.0
MA84A-01	B (TWS, WW, CSO)					LA (92%)	0.8	7.9	79.1	791.1	7,911.5	79,115.0
Merrimack River		P	35	NA	-	WLA (10%)	0.1	0.9	8.9	88.7	887.2	8,871.7
MA84A-02	B (TWS, WW, CSO)					LA (90%)	0.8	7.7	76.8	767.6	7,675.8	76,758.3
Merrimack River		P	35	NA	-	WLA (11%)	0.1	0.9	9.1	90.8	907.5	9,075.4
MA84A-03	B (TWS, WW, CSO)					LA (89%)	0.8	7.7	76.6	765.5	7,655.5	76,554.6
Merrimack River		P	35	NA	-	WLA (12%)	0.1	1.0	10.0	100.4	1,004.4	10,044.0
MA84A-04	B (WW, CSO)					LA (88%)	0.8	7.6	75.6	755.9	7,558.6	75,586.0
Little River		P	35	NA	-	WLA (21%)	0.2	1.8	17.8	178.1	1,781.5	17,814.7
MA84A-09	B (WW)					LA (79%)	0.7	6.8	67.8	678.2	6,781.5	67,815.3
Spicket River		P	35	NA	-	WLA (27%)	0.2	2.3	22.7	227.1	2,271.1	22,710.8
MA84A-10	B (WW, CSO)					LA (73%)	0.6	6.3	62.9	629.2	6,291.9	62,919.2
Beaver Brook		P	35	NA	-	WLA (20%)	0.2	1.7	17.5	174.8	1,747.6	17,475.6

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	*Flow (cfs)* 1	10	100	1,000	10,000	100,000
							Flow-Based Target TMDL (CFU/day*10^9)					
MA84A-11	B (CW)					LA (80%)	0.7	6.8	68.2	681.5	6,815.4	68,154.4
Richardson Brook		P	35	NA	-	WLA (9%)	0.1	0.8	8.1	80.8	807.8	8,077.7
MA84A-12	B					LA (91%)	0.8	7.8	77.6	775.5	7,755.2	77,552.3
Trout Brook		P	35	NA	-	WLA (7%)	0.1	0.6	6.0	59.6	596.0	5,960.4
MA84A-13	B					LA (93%)	0.8	8.0	79.7	796.7	7,967.0	79,669.6
Trull Brook		P	35	NA	-	WLA (23%)	0.2	2.0	19.9	198.6	1,985.8	19,858.0
MA84A-14	B					LA (77%)	0.7	6.6	65.8	657.7	6,577.2	65,772.0
Back River		P	35	NA	-	WLA (6%)	0.1	0.5	5.4	54.3	542.8	5,427.6
MA84A-16	B					LA (94%)	0.8	8.0	80.2	802.0	8,020.2	80,202.4
Black Brook		P	35	NA	-	WLA (31%)	0.3	2.6	26.3	262.6	2,625.5	26,255.2
MA84A-17	B					LA (69%)	0.6	5.9	59.4	593.7	5,937.5	59,374.8
Bare Meadow Brook		P	35	NA	-	WLA (14%)	0.1	1.2	11.8	118.1	1,181.3	11,812.9
MA84A-18	B					LA (86%)	0.7	7.4	73.8	738.2	7,381.7	73,817.1
Deep Brook		P	35	NA	-	WLA (13%)	0.1	1.1	11.3	112.5	1,125.1	11,251.5
MA84A-21	B					LA (87%)	0.7	7.4	74.4	743.8	7,437.9	74,378.5
Powwow River		P	35	NA	-	WLA (7%)	0.1	0.6	6.0	60.0	599.8	5,998.5
MA84A-25	B (WW)					LA (93%)	0.8	8.0	79.6	796.3	7,963.2	79,631.5
Powwow River		P	35	NA	-	WLA (6%)	-	0.5	4.7	47.1	471.0	4,709.9
MA84A-28	A (PWS, ORW)					LA (94%)	0.8	8.1	80.9	809.2	8,092.0	80,920.1
South Branch Souhegan River		P	35	NA	-	WLA (3%)	-	0.3	2.6	25.9	258.9	2,589.4
MA84A-31	B					LA (97%)	0.8	8.3	83.0	830.4	8,304.1	83,040.7
Peppermint Brook		P	35	NA	-	WLA (16%)	0.1	1.4	14.1	140.6	1,405.7	14,057.0
MA84A-35	B					LA (84%)	0.7	7.2	71.6	715.7	7,157.3	71,573.0
Bartlett Brook		P	35	NA	-	WLA (10%)	0.1	0.9	9.0	89.5	895.1	8,950.7
MA84A-36	B					LA (90%)	0.8	7.7	76.7	766.8	7,667.9	76,679.3
Creek Brook		P	35	NA	-	WLA (11%)	0.1	1.0	9.6	96.1	960.5	9,605.3
MA84A-37	B					LA (89%)	0.8	7.6	76.0	760.2	7,602.5	76,024.7
East Meadow River		P	35	NA	-	WLA (6%)	-	0.5	4.9	48.6	485.9	4,858.7
MA84A-39	A (PWS, ORW)					LA (94%)	0.8	8.1	80.8	807.7	8,077.1	80,771.3
Fish Brook		P	35	NA	-	WLA (10%)	0.1	0.9	8.5	85.5	854.9	8,549.1
MA84A-40	A (PWS, ORW)					LA (90%)	0.8	7.7	77.1	770.8	7,708.1	77,080.9
Unnamed Tributary		P	35	NA	-	WLA (12%)	0.1	1.0	10.4	103.8	1,037.7	10,376.5
MA84B-01	B					LA (88%)	0.8	7.5	75.3	752.5	7,525.3	75,253.5
Beaver Brook		P	35	NA	-	WLA (11%)	0.1	0.9	9.4	93.9	939.0	9,389.5
MA84B-02	B					LA (89%)	0.8	7.6	76.2	762.4	7,624.1	76,240.5
Stony Brook		P	35	NA	-	WLA (10%)	0.1	0.9	8.5	85.2	852.2	8,522.5
MA84B-03	B (WW)					LA (90%)	0.8	7.7	77.1	771.1	7,710.8	77,107.5
Stony Brook		P	35	NA	-	WLA (11%)	0.1	0.9	9.3	93.5	934.7	9,347.1
MA84B-04	B (WW)					LA (89%)	0.8	7.6	76.3	762.8	7,628.3	76,282.9
Bennetts Brook		P	35	NA	-	WLA (10%)	0.1	0.8	8.4	83.6	836.1	8,360.8
MA84B-06	B					LA (90%)	0.8	7.7	77.3	772.7	7,726.9	77,269.2
Tadmuck Brook		P	35	NA	-	WLA (13%)	0.1	1.1	11.1	111.0	1,110.1	11,100.6

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	*Flow (cfs)* 1	10	100	1,000	10,000	100,000
							Flow-Based Target TMDL (CFU/day*10^9)					
MA84B-07	B					LA (87%)	0.7	7.5	74.5	745.3	7,452.9	74,529.4

Table 1-3. ***E. Coli*** Total Maximum Daily Loads (TMDLs), the percent reductions needed to meet the TMDL target (126 CFU/100ml) based on the Massachusetts Surface Water Quality Standards (SWQS), and the TMDL allocations for pathogen-impaired **marine** assessment units in the Merrimack River Basin and Coastal Drainage Area

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	Watershed Area (acres)	Impervious Area in Watershed (acres)	TMDL (CFU/day*10^9)
Powwow River		R	126	NA	-	WLA (11%)	7,789	857	13.90
MA84A-08	SB (SF)					LA (89%)			59.08
Unnamed Tributary		R	126	NA	-	WLA (11%)	2,558	274	4.44
MA84A-30	SA (SF)					LA (89%)			19.47

Table 1-4. **Enterococci** Total Maximum Daily Loads, the percent reductions needed to meet the TMDL target (35 CFU/100ml) based on the Massachusetts Surface Water Quality Standards (SWQS), and the TMDL allocations for pathogen-impaired **marine** assessment units in the Merrimack River Basin and Coastal Drainage Area

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	Watershed Area (acres)	Impervious Area in Watershed (acres)	TMDL (CFU/day*10^9)
Merrimack River		R	35	NA	-	WLA (12%)	751,126	87,655	395.15
MA84A-05	SB (SF, CSO)					LA (88%)			1,570.74
Merrimack River		R	35	NA	-	WLA (12%)	772,233	90,022	405.82
MA84A-06	SB (SF, CSO)					LA (88%)			1,615.10
Powwow River		R*	35	NA	-	WLA (11%)	7,789	857	3.86
MA84A-08	SB (SF)					LA (89%)			16.41
Merrimack River		P	35	NA	-	WLA (36%)	276	98	0.44
MA84A-26	SA (SF)					LA (64%)			0.42
Plum Island River		P	35	NA	-	WLA (5%)	1,821	96	0.43
MA84A-27	SA (ORW, SF)					LA (95%)			4.09
Unnamed Tributary		R*	35	NA	-	WLA (11%)	2,558	274	1.23
MA84A-30	SA (SF)					LA (89%)			5.41

Table 1-5. **Fecal Coliform** Total Maximum Daily Loads, the percent reductions needed to meet the TMDL target (14 CFU/100ml for Class SA & 88 CFU/100ml for Class SB) based on the Massachusetts Surface Water Quality Standards (SWQS), and the TMDL allocations for pathogen-impaired **marine** assessment units in the Merrimack River Basin & Coastal Drainage Area

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	Watershed Area (acres)	Impervious Area in Watershed (acres)	TMDL (CFU/day*10^9)
Merrimack River MA84A-05	SB (SF, CSO)	P	88	NA	-	WLA (12%) LA (88%)	751,126	87,655	993.52 3,949.28
Merrimack River MA84A-06	SB (SF, CSO)	R	88	NA	-	WLA (12%) LA (88%)	772,233	90,022	1,020.35 4,060.82
Powwow River MA84A-08	SB (SF)	P	88	NA	-	WLA (11%) LA (89%)	7,789	857	9.71 41.26
Merrimack River MA84A-26	SA (SF)	R	14	NA	-	WLA (36%) LA (64%)	276	98	0.18 0.17
Plum Island River MA84A-27	SA (ORW, SF)	R	14	NA	-	WLA (5%) LA (95%)	1,821	96	0.17 1.63
Unnamed Tributary MA84A-30	SA (SF)	P	14	NA	-	WLA (11%) LA (89%)	2,558	274	0.49 2.16

Class *defined in the Massachusetts Surface Water Quality Standards (SWQS) at 314 CMR 4.02.*
Qualifiers *that identify segments with special characteristics are defined at 314 CMR 4.06(1)(d).*

- ***AQL*** *= Aquatic Life Use; waters with natural background conditions that prevent the attainment of Class B criteria and thus Class C dissolved oxygen and temperature criteria apply*
- ***CSO*** *= Combined Sewer Overflow; waters identified as impacted by the discharge of CSOs without a long-term control plan approved or fully implemented*
- ***CW*** *= Cold Water; waters that meet the cold water fisheries (CWF) definition at 314 CMR 4.02 and are subject to CWF dissolved oxygen and temperature criteria*
- ***HQW*** *= High Quality Water; waters designated for protection under 314 CMR 4.04(2)*
- ***ORW*** *= Outstanding Resource Waters; waters designated for protection under 314 CMR 4.04(2);*
- ***PWS*** *=Public Water Supply; may be subject to more stringent criteria in accordance with 310 CMR 22.00, and may have restricted use;*
- ***SF*** *= Shellfishing; waters subject to more stringent regulation by Massachusetts Division of Marine Fisheries (DMF) pursuant to M.G.L. c. 130, § 75*
- ***TWS*** *= Treated Water Supply; Class B waters used as a source of public water supply after treatment and that may be subject to more stringent site-specific criteria*
- ***WW*** *= Warm Water; waters that meet the warm water fisheries (WWF) definition at 314 CMR 4.02 and are subject to WWF dissolved oxygen and temperature criteria*

Pathogen bacteria units are presented in colony-forming units or CFU per 100 milliliter or ml..
TMDL Type *identifies the restorative or protective action approach:*

- ***R*** *= Restorative TMDL addressing a pathogen impairment identified in the 2018/2020 Integrated List of Waters*
- ***R**** *= Restorative TMDL addressing a historic impairment of former indicator bacteria for which no current applicable criteria are available See Section 2.3 of the core document for summary of water quality criteria and designated uses.*
- ***P*** *= Protective TMDL addressing all applicable uses, regardless of impairment status, for the associated pathogen (refer to the Massachusetts SWQS 314 CMR 4.00)*

Target TMDL or Total Maximum Daily Load is presented as SWQS-Based and Flow-Based.

- ***SWQS-Based TMDL Target*** *is the target concentration applicable to the TMDL pollutant indicator bacteria based on the Surface Water Quality Standards (314 CMR 4.00).*
- ***Flow-Based Target TMDL*** *is the target concentration (CFU/100mL) multiplied by the standard flow volume (cubic feet per second or cfs). See Section 4.2.2 in core document for full equation and conversion factors.*

Maximum Geomean *is the highest calculated 30- or 90- day rolling geometric mean for TMDL pollutant indicator bacteria associated with the segment.*
Geomean Percent Reduction *is the percent reduction from the highest calculated 30- or 90- day rolling geomean needed to achieve the target concentration. Percent reductions are for planning purposes only.*

2. Merrimack River Watershed Overview

The Merrimack River watershed covers an area of approximately 5,008 square miles (mi^2) in New Hampshireand northeastern Massachusetts (Figure 2-1). It includes the mainstem of the Merrimack River, which flows south from central New Hampshire into Massachusetts before turning east in Lowell, MA and continuing northeast to the Atlantic Ocean between the towns of Salisbury, MA and Newburyport, MA. Major tributaries to the Merrimack River include the Nashua, Concord, Shawsheen, Spicket, Little, and Powwow rivers and Stony Brook. Within Massachusetts, there are 391 miles of river and 5,734 acres of lakes, ponds, and reservoirs in the watershed (MassDEP, 2010).

The mainstem of the Merrimack River is formed by the confluence of the Pemigewasset and Winnipesaukee rivers in Franklin, NH and flows roughly 78 miles before entering Massachusetts (MassDEP, 2010). Once in Massachusetts, the river flows approximately 28 miles before transitioning to a tidal estuary after its confluence with Creek Brook in Haverhill, MA. The tidal portion of the Merrimack River has a length of roughly 25 miles with an area of approximately 6.97 mi^2 (MassDEP, 2010). Of the 34 pathogen-impaired segments in the watershed, 28 are freshwater and six are tidally-influenced (estuarine).

Prominent infrastructure along the mainstem of the Merrimack River in Massachusetts includes the Pawtucket Dam in Lowell, and the Essex Dam in Lawrence. Once major industrial centers, the cities of Lowell, Lawrence, and Haverhill used to contribute significant sources of pollution to the Merrimack River in the form of untreated municipal and industrial wastewater discharge (MassDEP, 2010). Although improvements have been made, these three cities continue to impact water quality in the river due to ongoing combined sewer overflows (CSO).

The Merrimack River watershed encompasses all or some of 138 municipalities in New Hampshire and 79 municipalities in Massachusetts. In Massachusetts, 38 of these municipalities are completely located within the watershed, while seven have less than 5% of their land area within the watershed. In New Hampshire, 82 of these municipalities are completely contained within the watershed while 10 have less than 5% of their land area within the watershed.

In Massachusetts, 72 of the 79 municipalities in the Merrimack River watershed operate and maintain municipal separate storm sewer systems (MS4s) in urban areas. These networks of drains and pipes convey polluted runoff from streets and developed areas to the nearest surface water. In addition, these networks are sometimes subject to direct wastewater inflows through illegal cross-connections, leaks from sewer pipes or septic systems, dumping, or other unauthorized wastewater sources, and together these sources are termed illicit discharges.

EPA and MassDEP jointly issued the General Permits for Stormwater Discharges from MS4s, which became effective on July 1, 2018, with modifications effective on January 6, 2021 (USEPA, 2020). Communities that discharge to pathogen-impaired waterbodies with approved TMDLs are required to implement enhanced best management practices (BMPs) for public education and designate the catchments as Problem Catchments or High Priority under the Illicit Discharge Detection and Elimination (IDDE) Program, in addition to the MS4 requirement to reduce pollutants to the Maximum Extent Practicable (USEPA, 2020).

In the Massachusetts portion of the watershed, the geographic range of five Regional Planning Agencies (RPAs) includes portions of the Merrimack River watershed. RPAs are public organizations advising municipalities, private business groups, and state and federal governments on a range of matters. Their research, coordination and technical assistance are especially valuable in addressing watershed-level issues such as pathogen pollutants and stormwater that cross town boundaries. These Merrimack watershed RPAs include:

- Merrimack Valley Planning Commission (MVPC; MVPC, 2021)
- Metropolitan Area Planning Council (MAPC; MAPC, 2021)
- Northern Middlesex Council of Governments (NMCOG; NMCOG, 2021)
- Central Massachusetts Regional Planning Commission (CMRPC; CMRPC, 2021)
- Montachusett Regional Planning Commission (MRPC; MRPC, 2021)

The following RPA initiatives and tools utilized in the Merrimack watershed are especially noteworthy:

- Regional stormwater coalitions operate within the RPAs, including MVPC's Merrimack Valley Stormwater Collaborative, NMCOG's Northern Middlesex Stormwater Collaborative, and CMRPC's Central Massachusetts Regional Stormwater Coalition.
- The MAPC utilizes the Integrated Water Management (IWM) approach to coordinate planning across the wastewater, drinking water, and stormwater sectors.

Beyond these activities, the Massachusetts Statewide Municipal Stormwater Coalition (MSMSC), composed of about 10 stormwater groups around the state, further coordinates with and assists municipalities on pathogen pollutant concerns through their "Think Blue" campaign (Think Blue Massachusetts, 2019).

Additional watershed-scale initiatives are carried out by several organizations, including:

- **The Merrimack Conservation Partnership** (MCP) was formed to "protect the southern portion of the greater Merrimack River watershed in New Hampshire and Massachusetts through accelerated land and water protection, advocacy, restoration, outreach, and education" (MCP, 2021).
- **Merrimack River Watershed Council** (MRWC) aims to "improve and conserve the Merrimack River watershed for people and wildlife through advocacy, education, recreation, and science" (MRWC, 2021).
- **Massachusetts Office of Coastal Zone Management** (CZM) has a North Shore Regional office that "serves the coastal communities from Salisbury to Revere, which are located in the Merrimack, Parker, Ipswich, and North Coastal watersheds." (CZM, 2022a).
- **Society for the Protection of New Hampshire Forests** (SPNHF) is involved in developing bi-state conservation plans for the lower Merrimack River watershed (SPNHF, 2021).
- **Trout Unlimited (TU)** operates four chapters in the geographic area of the Merrimack watershed, including the Central Massachusetts, Greater Boston, Nor'east and the Squan-A-Tissit. Their mission is to conserve, protect and restore the nation's coldwater fisheries and their watersheds; some of their activities include river cleanups, scientific assessments (e.g., trout habitat, culvert connectivity) and restoration projects (TU, 2022).
- **U.S. Environmental Protection Agency** (USEPA) is involved in several collaborative efforts in the Merrimack River watershed aimed at improving water quality (USEPA, 2021).
- **Upper Merrimack River Local Advisory Committee** (UMRLAC) conducts "a variety of projects and programs in the upper Merrimack watershed" (UMRLAC, 2021).

The following actions by identified stakeholders will help reduce pathogen loads to the impaired segments. The list represents a starting point and is not intended to be comprehensive. For a more detailed discussion of pollutant reduction actions, see Section 5, "Implementation" of the Pathogen TMDL core document.

- **Municipalities:** Continue to implement the MS4 permit, which includes specific requirements for waterbodies with an approved Bacteria/Pathogen TMDL, such as prioritization and reporting, enhanced BMPs, IDDE, and education (USEPA, 2020).
- **Regional Planning Agencies (RPAs) and municipalities:** Continue and expand collaboration on MS4 and stormwater issues. Cooperatively develop tools and share knowledge to reduce costs, increase innovation, and generate consistent and effective stream restoration efforts at the watershed scale.
    - Two tools developed by MAPC are potentially valuable in all MS4 communities across the state; municipalities and other RPAs (with permission from MAPC) should consider adapting and/or expanding these tools in their area:
        - Stormwater Utility/Funding Starting Kit (MAPC, 2014); and
        - a GIS toolkit to calculate MS4 outfall catchments, which is a requirement under the MS4 General Permit, created by MAPC and the Neponset River Watershed Association (MAPC, 2018).
- **USDA NRCS and landowners:** Develop comprehensive nutrient management plans for agriculture, reaching farmers through local connections.
- **Parks departments, schools, private landowners, and others** who maintain large, mowed fields with direct connections to surface water should consider maintaining a vegetated buffer along the shoreline.

Buffers slow and filter stormwater runoff, provide a visual screen that can discourage large aggregations of waterfowl, and offer many other water quality benefits at low cost.

Sanitary wastes associated with boating activities are a potential source of pathogens to surface waters. Since 2014, all Massachusetts waters are designated as a No-Discharge Zone (NDZ) in which the discharge of boat sewage is prohibited. Many free boat pump-out services are available at various sites along the coast, funded by the Clean Vessel Act (CZM, 2022b). Massachusetts CZM webpage maintains online maps of these boat pump-out facilities, and the Clean Vessel Act Program offers a *Boaters Pocket Guide to Pumpout Facilities*. Any sewage discharges from boats or boating infrastructure in the waters covered by this TMDL are therefore illicit discharges.

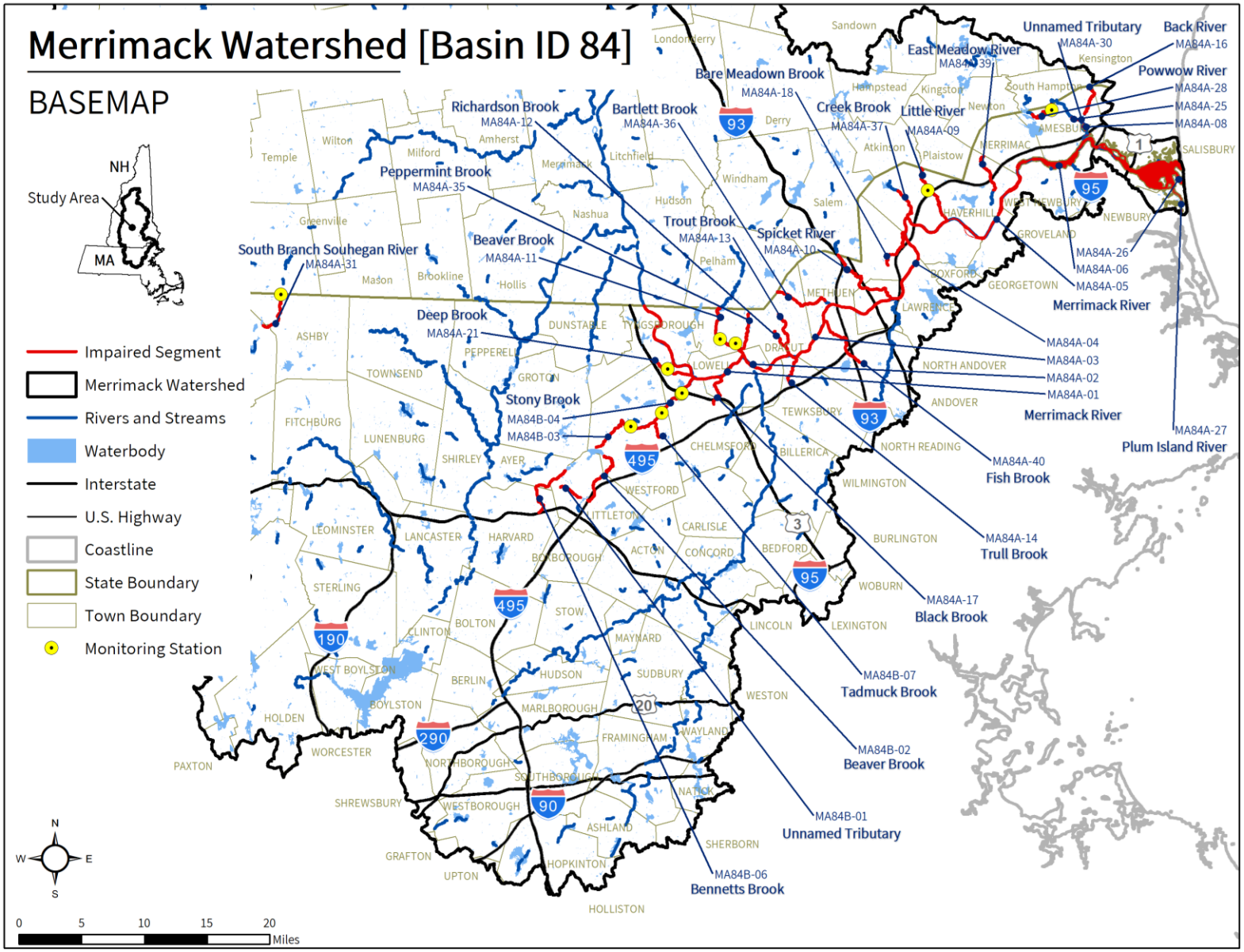


Figure 2-1: Map of all pathogen-impaired segments, water quality monitoring stations, municipal borders, waterbodies, and major roads in the Merrimack River watershed. Massachusetts municipalities are shown in upper case text while New Hampshire municipalities are shown in lower case text.

3. MA84A-01 Merrimack River

3.1. Waterbody Overview

The Merrimack River segment MA84A-01 is 9.0 miles long and begins at the state line between Hudson, NH and Tyngsborough, MA. The segment flows southeast then northeast, ending at the Pawtucket Dam (NAT ID: MA00837) in Lowell, MA.

Tributaries to the Merrimack River segment MA84A-01 include Limit Brook, Lawrence Brook, Deep Brook (MA84A-21), Stony Brook (MA84B-04), Claypit Brook, and Marbles Brook. The contributing watershed includes roughly 230,500 acres of lakes and ponds, the most notable of which are: Lake Winnipesaukee, Lake Winnisquam, Lake Wentworth, Newfound Lake, Squam Lake, and Massabesic Lake in New Hampshire; and Wachusett Reservoir in Massachusetts. Much of the river flows through forested and natural or developed areas.

Key landmarks in the New Hampshire portion of the watershed include the three most-populated cities in New Hampshire (Manchester, Nashua, and Concord); the White Mountain National Forest; Mt. Kearsarge State Forest Park; and Bear Brook State Park. Key landmarks in the Massachusetts portion of the watershed include the centers of Dunstable and Tyngsborough; and the Lowell-Dracut-Tyngsborough state forests. From upstream to downstream, segment MA84A-01 is crossed by the Tyngsborough Bridge/MA-113 (Tyngsborough) and the Rourke Bridge (Lowell).

The Merrimack River (MA84A-01) drains a total area of 4,130 square miles (mi^2), of which 552 mi^2 (13%) are located within Massachusetts. Of these, 42.0 mi^2 (8%) are impervious and 21.7 mi^2 (4%) are directly connected impervious area (DCIA). The watershed is partially served by public sewer[1] and 33% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts (excluding the Nashua watershed), there are seven additional NPDES permits on file governing point source discharges of pollutants to surface waters. Of these seven permits, none are NPDES permits for wastewater treatment facilities. There are 19 MassDEP discharge-to-groundwater permits for on-site

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 353,584

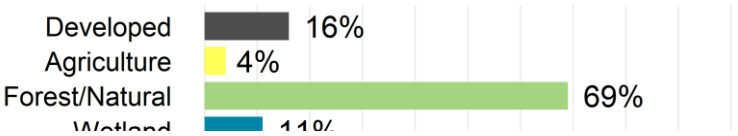
Segment Length (Miles): 9.0

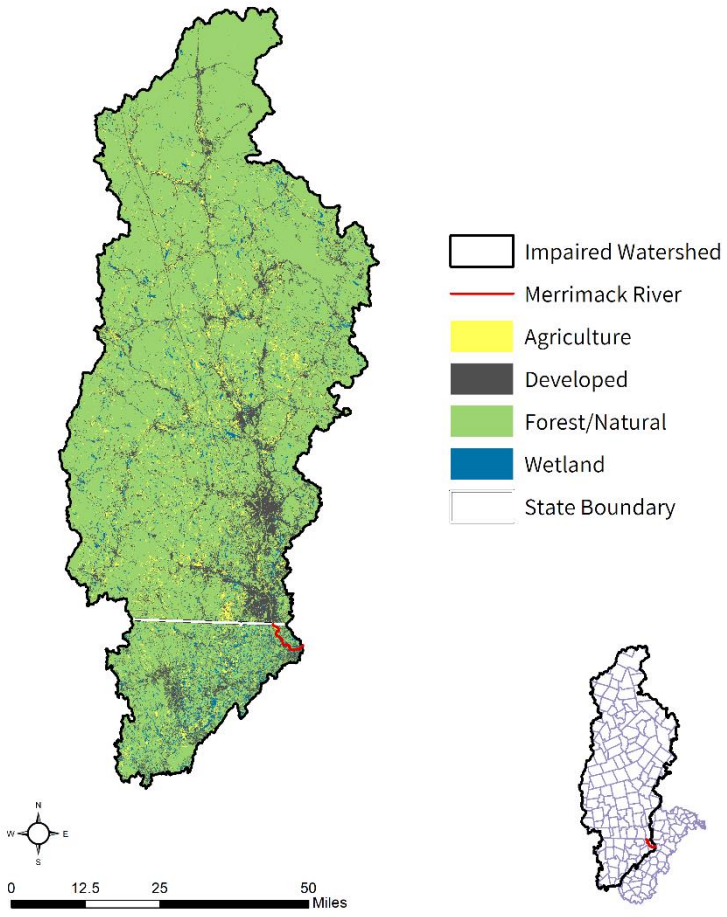
Impairment(s): *E. coli* and Fecal Coliform (Primary Contact Recreation)

Class (Qualifiers): B (Treated Water Supply, Warm Water, CSO Receiving Water)

Impervious Area (Acres, %): 26,902 (8%)

DCIA Area (Acres, %): 13,872 (4%)





[1] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

wastewater discharges within the watershed (two of which are within the immediate drainage area to the impaired segment, Table 3-1). There is one combined sewer overflow (CSO) within the watershed (Table 3-2). There are seven landfills and no unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 3-1.

The watershed draining to Merrimack River segment MA84A-01 includes a moderately-developed part of Massachusetts. The Massachusetts portion of the watershed is covered predominately with forest and natural lands (69%) but contains a substantial amount of development (16%). There are more wetland areas (11%) than agricultural areas (4%) in the watershed. The impaired segment itself is surrounded predominantly by forested and developed areas.

In the Massachusetts portion of the Merrimack River (MA84A-01) watershed, under the Natural Heritage and Endangered Species Program, there are 66,075 acres (19%) of Priority Habitats of Rare Species and 805 acres (<1%) of Priority Natural Vegetation Communities. There are also 30,518 acres (9%) under Public Water Supply protection, 75,984 acres (21%) within three different Areas of Critical Environmental Concern (Central Nashua River Valley, Petapawag, and Squannassit), and 129,176 acres (37%) of Outstanding Resource Waters. There are 99,825 acres (28%) of land protected in perpetuity[2], part of 107,000 acres (30%) of Protected and Recreational Open Space[3]. See Figure 3-1.

Table 3-1. Groundwater discharge permits in the segment watershed. Only permits unique to this segment watershed are shown. PERR = permit number plus renewal number. TYPE = type of groundwater discharge. FLOW = permitted effluent in gallons per day (gpd).

PERR	NAME	TOWN	TYPE	FLOW (GPD)
606-3	TJ MAXX	TYNGSBORO	Sanitary Discharge	27,134
707-2	VILLAGE AT STONE RIDGE	WESTFORD	Sanitary Discharge	25,000

Table 3-2 Combined Sewer Overflows (CSOs) discharging to the segment.

NPDES ID	NAME	TOWN	DEP OUTFALL ID
MA0100633	LOWELL REGIONAL W&WW UTILITY	LOWELL	LOW002

[2] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[3] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

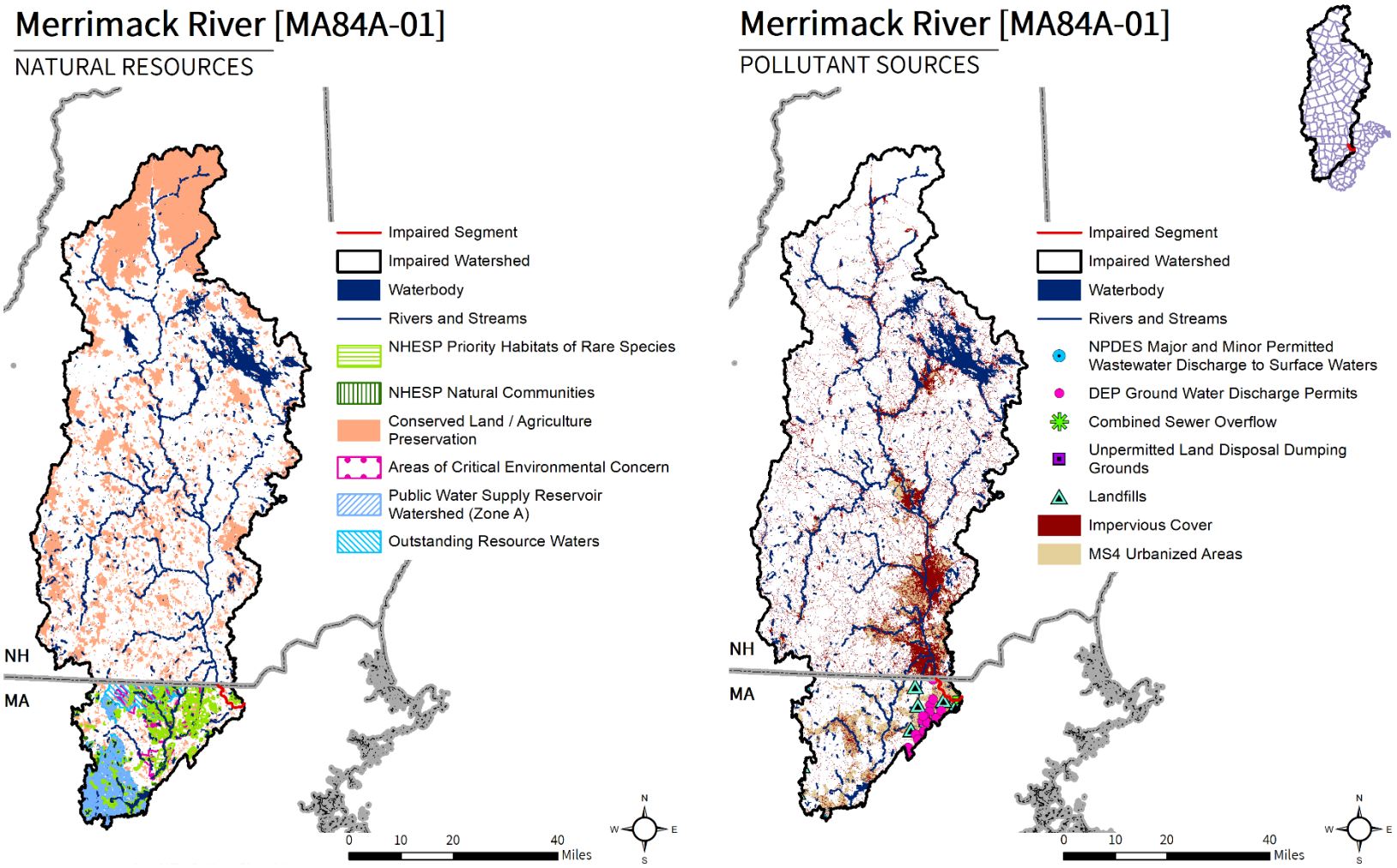


Figure 3-1. Natural resources and potential pollution sources draining to the Merrimack River segment MA84A-01. The map on the left shows critical habitat, water features, and conserved land; Massachusetts-only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A), with NHESP Natural Communities and Outstanding Resource Waters only shown in portions of New Hampshire where these areas extend across the state border. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts-only layers include Impaired Segment and all point features. Point features within the Nashua watershed are omitted from the map as they are not within the immediate drainage area of the Merrimack segments. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from the 2019 National Land Cover Database.

3.2. Waterbody Impairment Characterization

The Merrimack River (MA84A-01) is a Class B, Treated Water Supply, and CSO Receiving Water (MassDEP, 2021a).

No bacteria data were available to assess Primary Contact Recreation use for the Merrimack River segment MA84A-01. There were sufficient evaluations of beach conditions by the Massachusetts Department of Public Health at the one beach in the segment from 2005-2013 to make an assessment (Table 3-3). A segment is considered not supporting Primary Contact Recreation if beach postings are frequent or prolonged during the swimming season (i.e., the number of days posted frequently exceeds 10% during the locally operated swimming season).

- Postings (beach closure/advisory) at the Merrimack River – Closures at the Michael Rynne Bath House Beach (aka Rynne Beach), Lowell did not exceed 10% of days during any of the swimming seasons from 2005-2013. Although the beach posting requirement was not met during sample collection activities, a presumptive impairment decision is being applied for both the Primary and Secondary Recreational Uses since this waterbody does not have a CSO variance in place.

Table 3-3. The percentage of days in the 2005-2013 swimming seasons with beach postings for the one beach located in the Merrimack River segment MA84A-01.

Beach ID	Beach Name	Town	2005	2006	2007	2008	2009	2010	2011	2012	2013
4702	Merrimack River - Bath House	Lowell	0%	0%	NA	0%	0%	3%	0%	0%	0%

NA – Not applicable

3.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Combined Sewer Overflow (CSO): There is one CSO in the watershed that discharges directly into the impaired segment. CSOs by design release untreated wastewater to surface waters when flows exceed system capacity, and therefore must be eliminated. For this reason, addressing this pathogen source is set as the highest priority.

Urban Stormwater: There is a sizable amount of development in the watershed, much of which is concentrated near the river. Within the Massachusetts portion of the watershed, 33% of the land area is subject to MS4 permit conditions, 8% is classified as impervious area, and 4% is classified as DCIA. The river flows through the large urban areas of Concord, Manchester, and Nashua in New Hampshire; in Massachusetts, there is a lot of development directly adjacent to the impaired segment. Stormwater runoff from these areas is likely a significant source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts municipalities of Ayer, Littleton, Lowell, and Westford. Sewer-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Most of the watershed utilizes on-site septic systems for wastewater treatment. There are 19 MassDEP permits for on-site wastewater discharges to groundwater. In addition to the permitted point sources, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed represent a small portion (4%) of the total land use. Most of the land used for agriculture is located far from the river, however, there are a few fields of hay and cultivated crops directly adjacent to the segment. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are many medium- to high-density residential developments near the Merrimack River segment MA84A-01. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open fields are located adjacent to the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

3.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Lowell

All of Lowell is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit, however, no MS4 annual reports, NOI, or approval letter for the NOI were posted to the EPA website for the city.

Lowell has the following ordinances and bylaws, mostly accessible online via the city website https://www.lowellma.gov/ (City of Lowell, 2021):

- Wetland protection bylaw
- Stormwater bylaw
- Stormwater Utility: None found
- Pet Waste: None found

Lowell has a 2013 Master Plan titled “Sustainable Lowell 2025” that contains an Environmental Resilience section. One of the objectives outlined in this section is to improve water quality through multiple initiatives including: supporting local water quality advocates, finding volunteers to assist with water quality sampling, developing an agreement to keep the canals clean, continuing to support wastewater facility improvements, reducing non-point source pollution, encouraging companies that produce hazardous waste to locate their businesses away from waterways, and expanding public awareness to eliminate pharmaceutical disposal into the wastewater system. The city also has a 2013 Open Space Plan that, along with the Master Plan, is intended to inform planning until 2025. This plan contains extensive inventories and analysis of the environmental resources within the city and outlines community goals and objectives for the future (City of Lowell, 2021).

Town of Chelmsford

All of Chelmsford is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041185), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Chelmsford completed an illicit discharge detection and elimination (IDDE) plan in 2010, an erosion and sedimentation control (ESC) plan in 2008, and post-construction stormwater regulations in 2012. According to Chelmsford’s NOI, there are two stormwater outfalls to the Merrimack River (MA84A-01) which is impaired by fecal coliform and *E. coli*, 55 outfalls to Black Brook (MA84A-17) which is impaired by *E. coli*, 14 outfalls to Deep Brook (MA84A-21) which is impaired by *E. coli*, and 29 outfalls to Stony Brook (MA84B-04) which is impaired by *E. coli*.

Chelmsford has the following ordinances and bylaws, mostly accessible online via the town website https://www.townofchelmsford.us/ (Town of Chelmsford, 2021):

- Wetland protection bylaw
- Stormwater bylaw
- Stormwater Utility: None found
- Pet Waste: None found

Chelmsford has a 2010 Master Plan that contains a section on natural, historical, and cultural resources. This section states that there are eleven streams within the town that suffer some sort of impairment and recommends that a program be implemented to improve water quality by reducing the application of road deicing chemicals and fertilizers. The plan also states that the Conservation Commission should work with MassDEP,

environmental organizations, and residents to develop a program to improve water quality and environmental conditions in general (Town of Chelmsford, 2021).

Chelmsford also has an Open Space and Recreation Plan, updated in 2017. It provides a brief updated natural resource inventory, related maps, and notes that the sewer coverage was completed in 2011, and that stormwater and sewer lines are separate. It also sets goals for public education on stormwater and incentivizes low impact development to protect water quality.

In Chelmsford, there have been recent cases of sewage grinder pumps malfunctioning. These pumps are used to pre-grind domestic wastewater prior to discharging into the public sewer, and pump failure represents a source of pathogens to the environment. The responsibility for maintenance of these privately-owned pumps has been the subject of litigation. The Town of Chelmsford has developed outreach materials and an emergency maintenance policy which applies during power outages (Town of Chelmsford, 2021).

Town of Tyngsborough

Most of Tyngsborough is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041229), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. In 2007, Tyngsborough completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. According to the town's NOI, pathogen-impaired MS4 receiving waters include 28 stormwater outfalls into the Merrimack River (MA84A-01), which is impaired by both *E. coli* and fecal coliform.

Tyngsborough has the following ordinances and bylaws, mostly accessible online via the town website https://www.tyngsboroughma.gov/ (Town of Tyngsborough, 2021):

- Wetland protection bylaw
- Stormwater control bylaw and utility fees
- Pet waste disposal bylaws

Tyngsborough has a 2004 Master Plan, with indications of an updated plan considered for development. The current plan (2004) has a natural resources section which identifies and describes water resources. Stormwater is mentioned only briefly as a potential source of pollution to Lake Mascuppic, which has a small town beach. The town's sewer system is identified as a limiting factor to commercial and industrial development. Tyngsborough also has an Open Space and Recreation Plan (2018) which features a more extensive description of the waterbodies mentioned in the Master Plan (Town of Tyngsborough, 2021).

4. MA84A-02 Merrimack River

4.1. Waterbody Overview

The Merrimack River segment MA84A-02 is 3.2 miles long and begins at the Pawtucket Dam (NAT ID: MA00837) in Lowell, MA. The segment flows northeast before bending southeast, ending at the Lowell Regional Wastewater Utilities (NPDES# MA0100633) outfall at Duck Island in Lowell, MA.

Tributaries to the Merrimack River segment MA84A-02 include Bever Brook (MA84A-11) and the Concord River. The contributing watershed includes roughly 248,705 acres of lakes and ponds, the most notable Massachusetts waterbody being Wachusett Reservoir. Most of the river flows through highly-developed areas.

Key landmarks in the Massachusetts portion of the watershed include the centers of Dunstable, Littleton, Lowell, Tyngsborough, and Westford; and the Lowell-Dracut-Tyngsborough state forests. From upstream to downstream, segment MA84A-02 is crossed by Mammoth Road, University Avenue, Aiken Street, Bridge Street, and Hunts Fall Bridge/Nesmith Street/MA-38, all in Lowell.

The Merrimack River (MA84A-02) drains a total area of 4,629 square miles (mi^2), of which 966 mi^2 (21%) are located within Massachusetts. Of these 966 mi^2 in Massachusetts, 100.1 mi^2 (10%) are impervious and 56.1 mi^2 (6%) are directly connected impervious area (DCIA). The watershed is partially served by public sewer[4] and 49% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts (excluding the Nashua and Concord watersheds), there are 10 additional NPDES permits on file governing point source discharges of pollutants to surface waters. Of these 10 permits, none are NPDES permits for wastewater treatment facilities. There are 19 MassDEP discharge-to-groundwater permits for on-site wastewater discharges within the watershed (none of which are within the immediate drainage area to the impaired segment). There are nine combined sewer overflows (CSOs) within the watershed (six discharge directly to the impaired segment and one discharges to a tributary that is

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 618,545

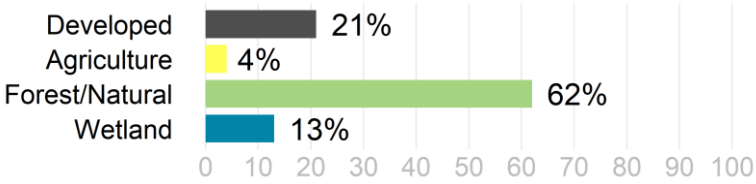
Segment Length (Miles): 3.2

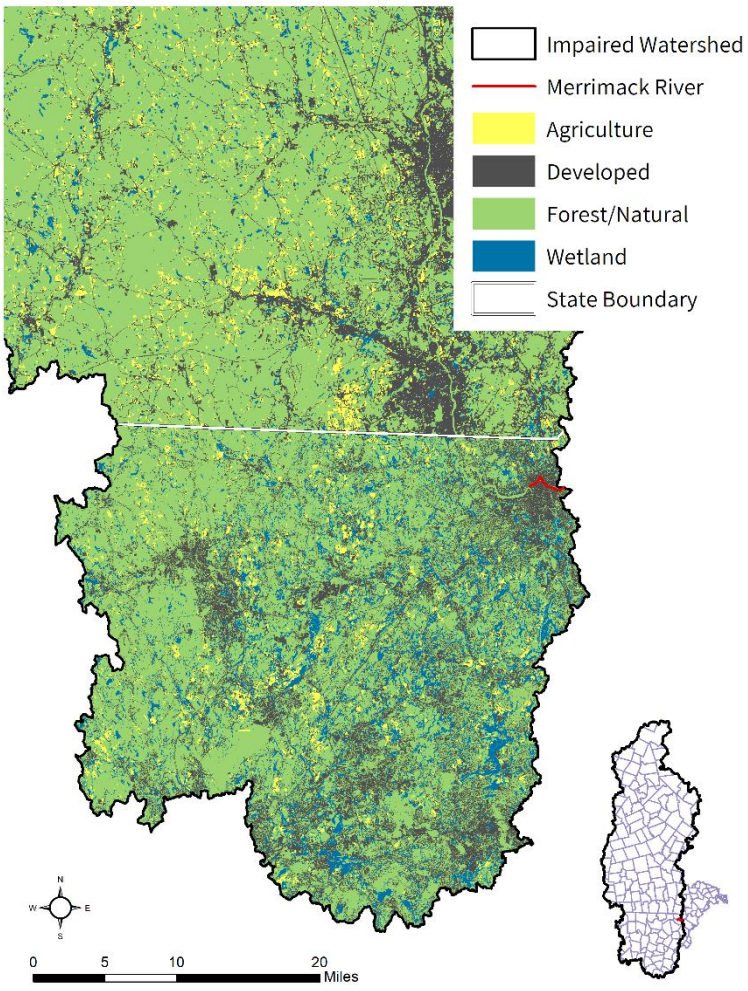
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifiers): B (Treated Water Supply, Warm Water, CSO Receiving Water)

Impervious Area (Acres, %): 64,084 (10%)

DCIA Area (Acres, %): 35.910(6%)





[4] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

not identified as pathogen-impaired, Table 4-1). There are eight landfills and no unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 4-1.

The Merrimack River segment MA84A-02 watershed is located in a moderately-developed part of Massachusetts. The watershed in Massachusetts is covered predominately with forest and natural lands (62%) but contains a substantial amount of development (21%). There is more than triple the amount of wetland area (13%) as agricultural area (4%) in the watershed. The impaired segment itself is surrounded entirely by highly-developed areas.

In the Massachusetts portion of the Merrimack River (MA84A-02) watershed, under the Natural Heritage and Endangered Species Program, there are 87,331 acres (14%) of Priority Habitats of Rare Species and 1,113 acres (<1%) of Priority Natural Vegetation Communities. There are also 32,200 acres (5%) under Public Water Supply protection, 78,405 acres (13%) within five Areas of Critical Environmental Concern (Cedar Swamp; Central Nashua River Valley; Miscoe, Warren and Whitehall Watersheds; Petapawag; and Squannassit), and 153,258 acres (25%) of Outstanding Resource Waters. There are 159,740 acres (26%) of land protected in perpetuity[5], part of 175,512 acres (28%) of Protected and Recreational Open Space[6]. See Figure 4-1.

Table 4-1 Combined Sewer Overflows (CSOs) discharging to the segment.

NPDES ID	NAME	TOWN	DEP OUTFALL ID
MA0100633	LOWELL REGIONAL W&WW UTILITY	LOWELL	LOW008
MA0100633	LOWELL REGIONAL W&WW UTILITY	LOWELL	LOW011
MA0100633	LOWELL REGIONAL W&WW UTILITY	LOWELL	LOW012
MA0100633	LOWELL REGIONAL W&WW UTILITY	LOWELL	LOW027
MA0100633	LOWELL REGIONAL W&WW UTILITY	LOWELL	LOW030.1
MA0100633	LOWELL REGIONAL W&WW UTILITY	LOWELL	LOW030.2

[5] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[6] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

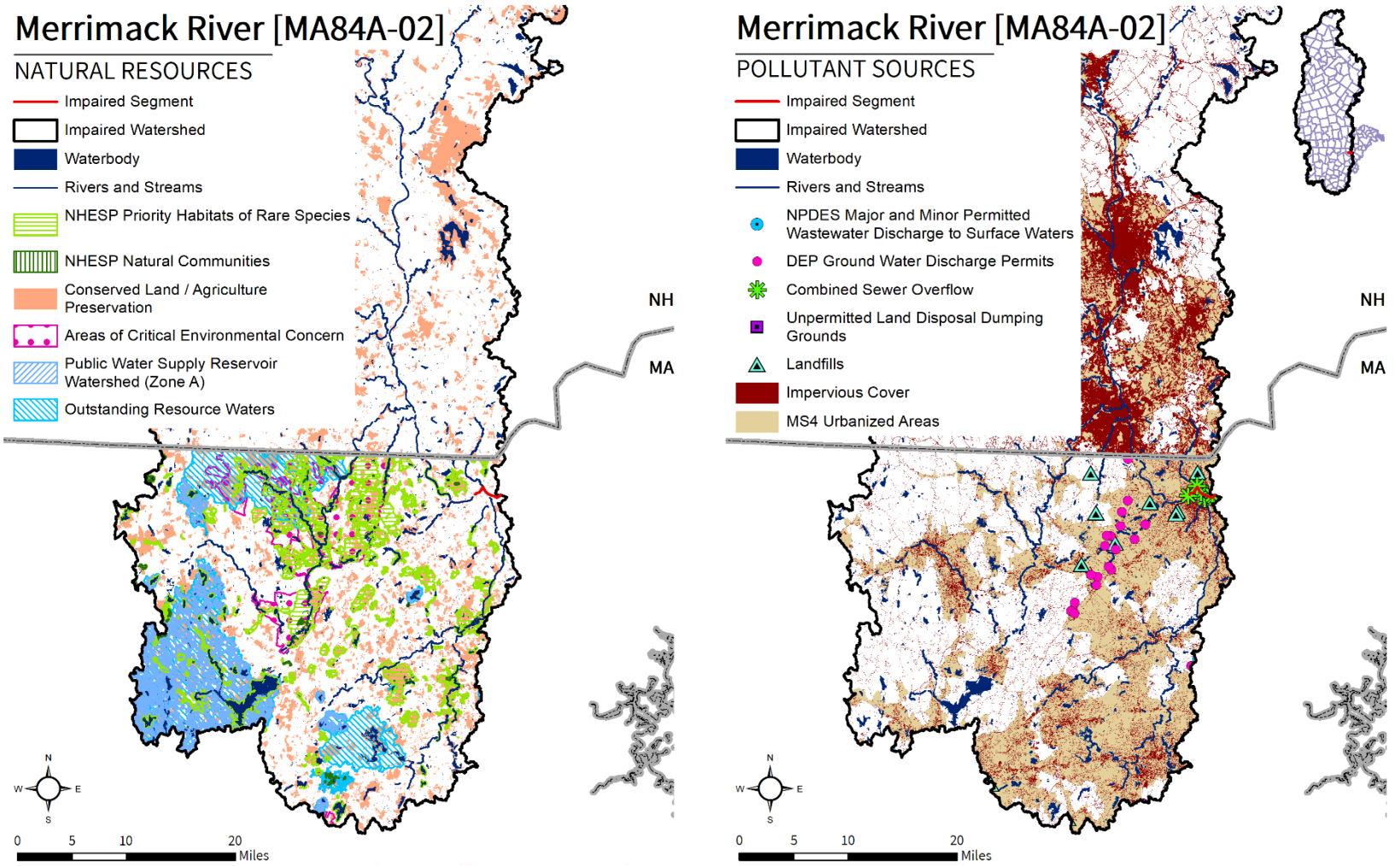


Figure 4-1. Natural resources and potential pollution sources draining to the Merrimack River segment MA84A-02. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A), with NHESP Natural Communities and Outstanding Resource Waters only shown in portions of New Hampshire where these areas extend across the state border. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Point features within the Nashua and Concord watersheds are omitted from the map as they are not within the immediate drainage area of Merrimack segments. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from the 2019 National Land Cover Database.

4.2. Waterbody Impairment Characterization

The Merrimack River (MA84A-02) is a Class B, Treated Water Supply, Warm Water, and CSO Receiving Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). CDM collected *E. coli* samples in the Merrimack River at two sites (M014 and M015) in 2003. The geometric means of *E. coli* at each site were 141 and 351 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010). Additionally, a presumptive impairment decision is being applied for both the Primary and Secondary Recreational Uses since this waterbody does not have a CSO variance in place.

4.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Combined Sewer Overflow (CSO): There are nine CSOs in the watershed, six of which discharge directly into the impaired segment. CSOs by design release untreated wastewater to surface waters when flows exceed system capacity, and therefore must be eliminated. For this reason, addressing this pathogen source is set as the highest priority.

Urban Stormwater: There is a sizable amount of development in the watershed, most of which is concentrated near the river. Within the Massachusetts portion of the watershed, 49% of the land area is subject to MS4 permit conditions, 10% is classified as impervious area, and 6% is classified as DCIA. The river flows through the large urban area of Lowell, Massachusetts. Stormwater runoff from these areas is likely a significant source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts municipalities of Ayer, Dracut, Littleton, Lowell, and Westford. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Most of the watershed utilizes on-site septic systems for wastewater treatment. There are 19 MassDEP permits for on-site wastewater discharges to groundwater. In addition to these permitted point sources, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for only a small portion (4%) of the total land use. Most of this agriculture is located far from the river, therefore stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: There are many high-density residential developments and parks near the Merrimack River segment MA84A-02. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few athletic fields are located adjacent to the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

4.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Lowell. See Section 3.4

5. MA84A-03 Merrimack River

5.1. Waterbody Overview

The Merrimack River segment MA84A-03 is 8.8 miles long and begins at the Lowell Regional Wastewater Utilities (NPDES# MA0100633) outfall at Duck Island in Lowell, MA. The segment generally flows northeast to its terminus at the Essex Dam (NAT ID: MA00234) in Lawrence, MA.

Tributaries to the Merrimack River segment MA84A-03 include Richardson Brook (MA84A-12), Trull Brook (MA84A-14), Nickel Mine Brook, Fish Brook (MA84A-40), Griffin Brook, Sawyer Brook, and Bartlett Brook (MA84A-36). The contributing watershed includes roughly 249,512 acres of lakes and ponds, the most notable Massachusetts waterbody being Wachusett Reservoir. Much of the river flows through forested and natural or developed areas.

Key landmarks in the Massachusetts portion of the watershed include the centers of Dunstable, Littleton, Lowell, Tyngsborough, and Westford; and the Lowell-Dracut-Tyngsborough state forests. Segment MA84A-03 is crossed once by I-93 in Andover.

The Merrimack River (MA84A-03) drains a total area of 4,664 square miles (mi$^{2)}$), of which 1,001 mi^2 (21%) are located within Massachusetts. Of these, 106.1 mi^2 (11%) are impervious and 59.9 mi^2 (6%) are directly connected impervious area (DCIA). The watershed is partially served by public sewer[7] and 50% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts (excluding the Nashua and Concord watersheds), there are 15 additional NPDES permits on file governing point source discharges of pollutants to surface waters. Of these 15 permits, one is a NPDES permit for a wastewater treatment facility (Table 5-1). There are 19 MassDEP discharge-to-groundwater permits for on-site wastewater discharges within the watershed (none of which are within the immediate drainage area to the impaired segment). There are nine combined sewer overflows (CSOs) within the watershed (none of which discharge directly to the impaired segment).

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 640,369

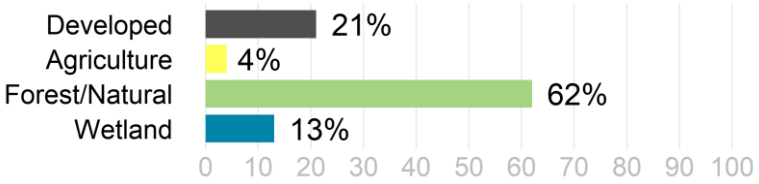
Segment Length (Miles): 8.8

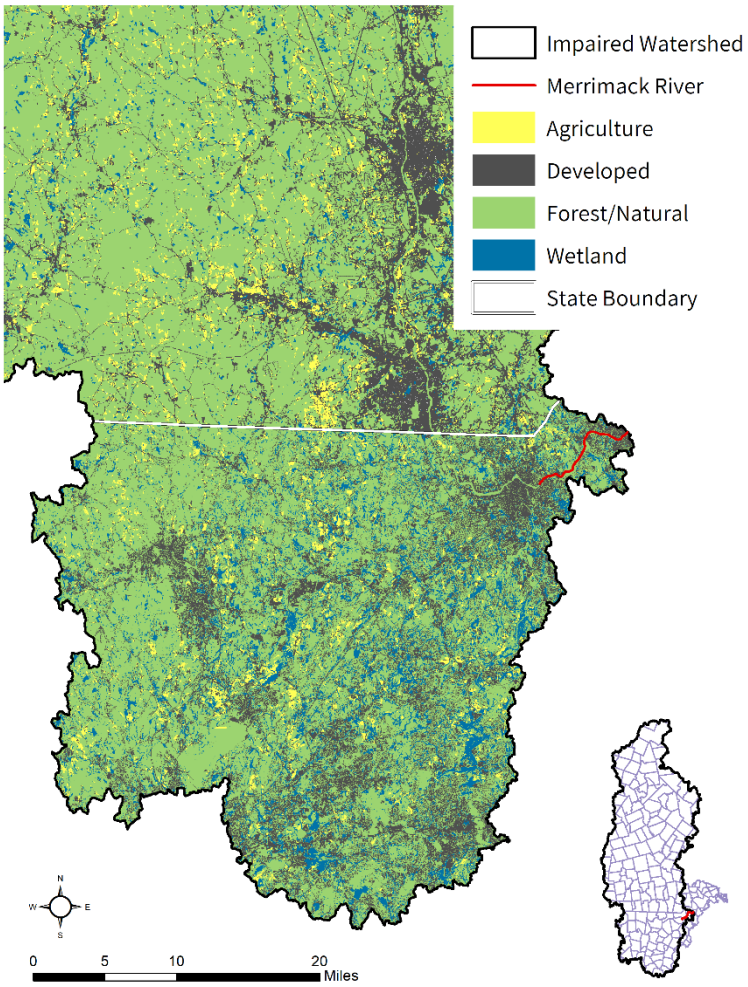
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B (Treated Water Supply, Warm Water, CSO Receiving Water)

Impervious Area (Acres, %): 67,869 (11%)

DCIA Area (Acres, %): 38,315 (6%)





[7] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

There are nine landfills and no unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 5-1.

The Merrimack River segment MA84A-03 watershed is located in a moderately-developed part of Massachusetts. The watershed in Massachusetts is covered predominately with forest and natural lands (62%) but contains a substantial amount of development (21%); there are also wetland (13%) and agricultural areas (4%). The impaired segment itself is surrounded predominately by moderate development and forest and natural areas.

In the Massachusetts portion of the Merrimack River (MA84A-03) watershed, under the Natural Heritage and Endangered Species Program, there are 88,910 acres (14%) of Priority Habitats of Rare Species and 1,173 acres (<1%) of Priority Natural Vegetation Communities. There are also 33,434 acres (5%) under Public Water Supply protection, 78,405 acres (12%) within five Areas of Critical Environmental Concern (Cedar Swamp; Central Nashua River Valley; Miscoe, Warren and Whitehall Watersheds; Petapawag; and Squannassit), and 157,095 acres (25%) of Outstanding Resource Waters. There are 161,949 acres (25%) of land protected in perpetuity[8], part of 178,523 acres (28%) of Protected and Recreational Open Space[9]. See Figure 5-1.

Table 5-1. National Pollutant Discharge Elimination System (NPDES) permits for Wastewater Treatment Facilities (WWTF) in the segment watershed. Only permits unique to this segment watershed are shown. WWTF are identified as either municipal (MUN) or other (OTH), if applicable.

NPDES ID	NAME	TOWN	WWTF
MA0100633	LOWELL REGIONAL W&WW UTILITY	LOWELL	MUN

[8] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[9] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

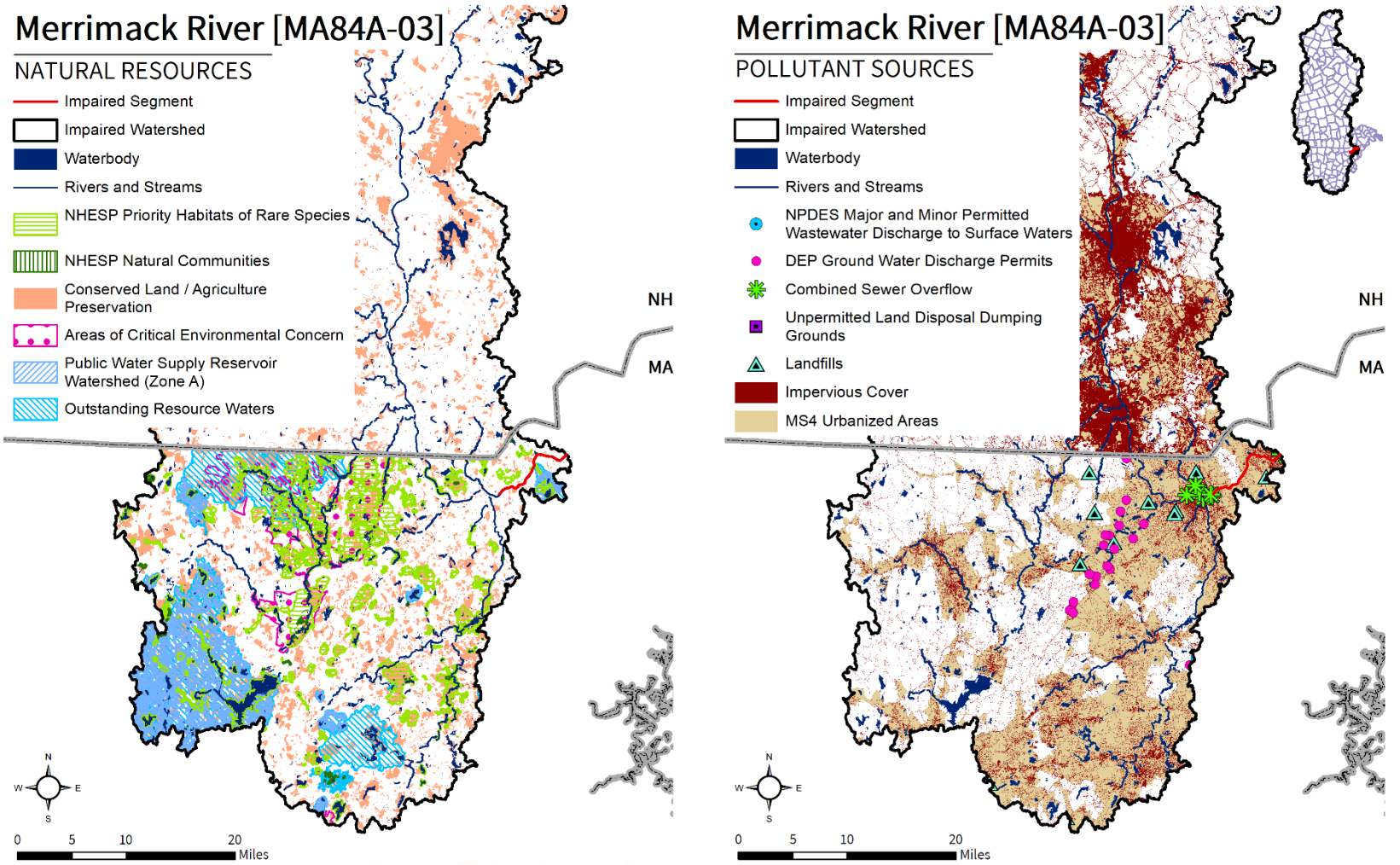


Figure 5-1. Natural resources and potential pollution sources draining to the Merrimack River segment MA84A-03. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A), with NHESP Natural Communities and Outstanding Resource Waters only shown in portions of New Hampshire where these areas extend across the state border. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Point features within the Nashua and Concord watersheds are omitted from the map as they are not within the immediate drainage area of Merrimack segments. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from the 2019 National Land Cover Database.

5.2. Waterbody Impairment Characterization

The Merrimack River (MA84A-03) is a Class B, Treated Water Supply, and CSO Receiving Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). CDM collected *E. coli* samples in the Merrimack River at three sites (M016, M017, M018) in 2003. Only one site (M017) had the minimum number of samples required to determine compliance with water quality criteria. The geometric mean of *E. coli* at this site was 721 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

5.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Combined Sewer Overflow (CSO): There are nine CSOs in the watershed (see Sections 3.1, 4.1, 12.1), none of which discharge directly into the impaired segment. CSOs by design release untreated wastewater to surface waters when flows exceed system capacity, and therefore must be eliminated. For this reason, addressing this pathogen source is set as the highest priority.

Urban Stormwater: There is a sizable amount of development in the watershed, most of which is concentrated near the river. Within the Massachusetts portion of the watershed, 50% of the land area is subject to MS4 permit conditions, 11% is classified as impervious area, and 6% is classified as DCIA. The river flows through the large urban areas of Concord, Manchester, and Nashua in New Hampshire and Lowell in Massachusetts. Stormwater runoff from these areas is likely a significant source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts municipalities of Ayer, Dracut, Littleton, Lawrence, Lowell, Tewksbury, and Westford. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Most of the watershed utilizes on-site septic systems for wastewater treatment. There are 19 MassDEP permits for on-site wastewater discharges to groundwater. In addition to these permitted point sources, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for only a small portion (4%) of the total land use. Most of this agriculture is located far from the river, however, there are a few fields of hay and cultivated crops near tributaries to the impaired segment. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few moderate-density residential developments and parks near the Merrimack River segment MA84A-03. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A golf course and a few other open fields are located adjacent to the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

5.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Lawrence

All of Lawrence is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041201), and the city has an EPA-approved Notice of Intent (NOI). The city has mapped 100% of its

MS4 system and the year-one and year-two Annual Reports have been submitted. In 2015, Lawrence completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. According to the NOI, pathogen-impaired MS4 receiving waters include 18 stormwater outfalls into the Merrimack River (MA84A-03) and seven outfalls into a different segment of the Merrimack River (MA84A-04), both of which are impaired by *E. coli*. Additionally, there are 54 outfalls into the Spicket River (MA84A-10), which is also impaired by *E. coli*.

Lawrence has the following ordinances and bylaws, mostly accessible online via the city website https://www.cityoflawrence.com/ (City of Lawrence, 2021):

- Stormwater control bylaw and stormwater utility fee
- Wetland protection bylaw
- Pet waste disposal ordinance

No city-wide Master Plan was found online for Lawrence. The city has a 2017 Open Space and Recreation Plan that includes an inventory and analysis of environmental needs within the city. Stormwater is mentioned multiple times throughout the plan, specifically regarding wastewater and sewage disposal. Wastewater and stormwater are disposed of using the same systems (City of Lawrence, 2021).

City of Lowell. See Section 3.4

City of Methuen

All of Methuen is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041210), and the city has an EPA-approved Notice of Intent (NOI). The city has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Methuen has not completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, or post-construction stormwater regulations. According to the NOI, pathogen-impaired MS4 receiving waters include 25 stormwater outfalls into Bare Meadow Brook (MA84A-18), 26 outfalls into Bartlett Brook (MA84A-36), 28 outfalls into the Merrimack River (MA84A-03), and 104 outfalls into the Spicket River (MA84A-10). All of these waterbodies are impaired by *E. coli*.

Methuen has the following ordinances and bylaws, mostly accessible online via the city website https://www.cityofmethuen.net/ (City of Methuen, 2021):

- Wetland protection bylaw
- Pet Waste: None found
- Stormwater Regulations and Utility: None found

Methuen has a 2007 Master Plan which mentions draft improvements to the subdivision regulations to require better control and treatment of stormwater, and describes water resources in the city with a focus on the portion of the Merrimack River used as the source of the city's drinking water. There is no mention of the MS4 system or surface water impairments. The city has a 2013 Open Space and Recreation Plan intended for use until 2020. This plan includes an inventory of waterbodies, which identifies specific impairments associated with each waterbody (City of Methuen, 2021).

Town of Andover

All of Andover is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041178), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Andover completed an illicit discharge detection and elimination (IDDE) plan in 2007, an erosion and sedimentation control (ESC) plan in 2009, and post-construction stormwater regulations in 2009, as is required. According to the NOI, pathogen impaired MS4 receiving waters include 19 outfalls into the Merrimack River (MA84A-03), and 12 outfalls into Fish Brook (MA84A-40).

Andover has the following ordinances and bylaws, mostly accessible online via the town website https://andoverma.gov/ (Town of Andover, 2021):

- Stormwater ordinance with Title 5 supplemental regulations

- Stormwater Utility: None found
- Pet Waste: None found

Andover has a 2012 Master Plan, and is developing a new Master Plan in 2022. Within the 2012 plan there is a section about natural resources, with an extensive list of actions that the town is planning to take towards furthering water conservation. The town also plans to divert 80% of rainfall away from town-operated sewer systems through use of pervious pavements, bioswales, and infiltration planters. Andover also has a 2018 Open Space and Recreation Plan that contains a comprehensive environmental inventory and analysis. This inventory contains a specific section on water resources that outlines ongoing protection actions including conserving land within the watershed, hosting regular river cleanups, and dismantling dams along the Shawsheen River to support fish passage (Town of Andover, 2021).

Town of Dracut

The majority of Dracut is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041194), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Dracut completed an illicit discharge detection and elimination (IDDE) plan in 2018, and an erosion and sedimentation control (ESC) plan and post-construction stormwater regulations in 2017. The town also has a 2018 Stormwater Management Plan (SWMP). According to the NOI, Dracut has multiple waterbodies impaired by *E. coli*, which are receiving waters for its MS4 system. These water bodies are Bartlett Brook (MA84A-36, two outfalls), Beaver Brook (MA84A-11, 35 outfalls), Peppermint Brook (MA84A-35, five outfalls), Richardson Brook (MA84A-12, five outfalls), and Trout Brook (MA84A-13, 10 outfalls).

Dracut has the following ordinances and bylaws, mostly accessible online via the town website https://www.dracutma.gov/ (Town of Dracut, 2021):

- Wetland protection and stormwater utility fee bylaw
- Stormwater bylaw
- Pet Waste: None found

Dracut's 2012 Master Plan has extensive sections about the environment and natural resources. This plan inventories current natural resources (pg. 218) and includes a table with waterbody names and impairments (pg. 219). The importance of stormwater regulations is also referenced, specifically regarding control measures and impacts (pg. 239). Dracut also has a 2009 Open Space and Recreation Plan which addresses water resources (pg. 26) (Town of Dracut, 2021).

Town of Tewksbury

All of Tewksbury is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041226), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Tewksbury completed an illicit discharge detection and elimination (IDDE) plan in 2010, and an erosion and sedimentation control (ESC) plan and post-construction stormwater regulations in 2011. According to the town's NOI, pathogen-impaired MS4 receiving waters include two outfalls to the Merrimack River (MA84A-03) and three outfalls to Trull Brook (MA84A-14), both impaired by *E. coli*.

Tewksbury has the following ordinances and bylaws, mostly accessible online via the town website https://www.tewksbury-ma.gov/ (Town of Tewksbury, 2021):

- Wetland protection bylaw
- Stormwater control bylaw and utility fees
- Pet Waste: None found

Tewksbury has a 2016 Master Plan, which includes an inventory of all waterbodies within the town's borders. This section features in-depth descriptions of the issues occurring within the waterbodies, with fecal coliform identified as an issue in the Shawsheen River. Stormwater runoff and control plans are present throughout the Master Plan. The Merrimack River is identified as heavily affected by stormwater runoff. Additional planning includes $1.4 million in stormwater improvements. A section about pollution, and its sources and effects, within

Tewksbury is present within this plan. The town operates 166 miles of public sewers. Tewksbury also has a 2019 Open Space and Recreation Plan, with an in-depth description of waterbodies within Tewksbury (Town of Tewksbury, 2021).

6. MA84A-04 Merrimack River

6.1. Waterbody Overview

The Merrimack River segment MA84A-04 is 10.0 miles long and begins at the Essex Dam (NAT ID: MA00234) in Lawrence, MA. The segment generally flows northeast, ending the Little River (MA84A-09) in Haverhill, MA.

Tributaries to the Merrimack River segment MA84A-04 include the Spicket River (MA84A-10), the Shawsheen River, Bare Meadow Brook (MA84A-18), and Creek Brook (MA84A-37). The contributing watershed includes roughly 255,966 acres of lakes and ponds, the most notable Massachusetts waterbody being Wachusett Reservoir. Much of the river flows through forested and natural or developed areas.

Key landmarks in the Massachusetts portion of the watershed include the centers of Dunstable, Lawrence, Littleton, Lowell, Methuen, Tyngsborough, and Westford; and the Lowell-Dracut-Tyngsborough state forests. From upstream to downstream, segment MA84A-04 is crossed by South Broadway/MA-28 (Lawrence), Joseph W. Casey Bridge (Lawrence), Duck Bridge/Union Street (Lawrence), I-495 (3 times in Lawrence, Methuen, and Haverhill), and the Comeau Bridge (Haverhill).

The Merrimack River (MA84A-04) drains a total area of 4,852 square miles (mi^2), of which 1,122 mi^2 (23%) are located within Massachusetts. Of these, 131.6 mi^2 (12%) are impervious and 76.1 mi^2 (7%) are directly connected impervious area (DCIA). The watershed is partially served by public sewer[10] and 56% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts (excluding the Nashua, Concord, and Shawsheen watersheds), there are 17 additional NPDES permits on file governing point source discharges of pollutants to surface waters. Of these 17 permits, two are NPDES permits for wastewater treatment facilities (one of which is within the immediate drainage area to the impaired segment, Table 6-1). There are 19 MassDEP discharge-to-groundwater permits for on-site wastewater discharges within the watershed (none of

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 718,285

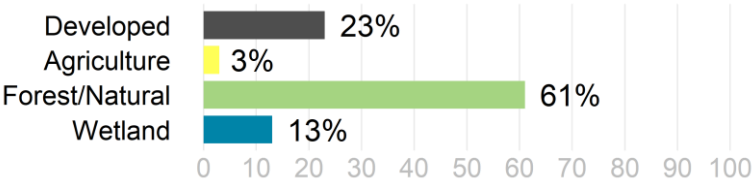
Segment Length (Miles): 10.0

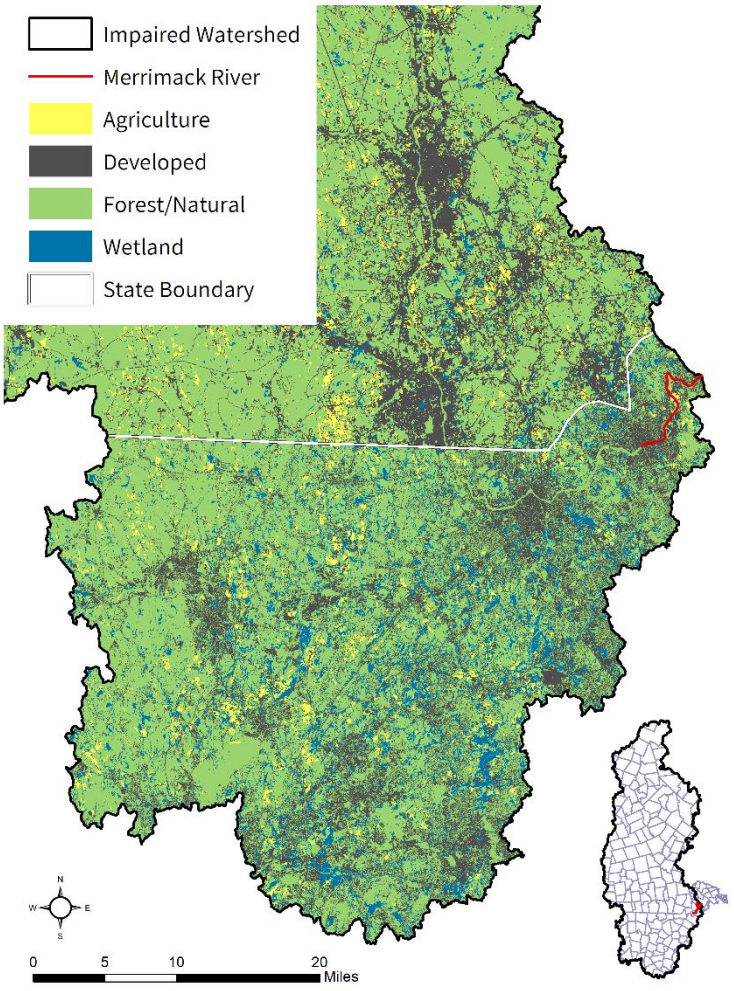
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B (Warm Water, CSO Receiving Water)

Impervious Area (Acres, %): 84,251 (12%)

DCIA Area (Acres, %): 48,700 (7%)





[10] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

which are within the immediate drainage area to the impaired segment). There are 16 combined sewer overflows (CSOs) within the watershed (six of which discharge directly to the impaired segment, Table 6-2). There are 13 landfills and no unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 6-1.

The Merrimack River segment MA84A-04 watershed is located in a moderately-developed part of Massachusetts. The watershed in Massachusetts is covered predominately with forest and natural lands (61%) but contains a substantial amount of development (23%), as well as wetland (13%) and agricultural areas (3%). The impaired segment itself is surrounded predominately by dense development and forest and natural areas.

In the Massachusetts portion of the Merrimack River (MA84A-04) watershed, under the Natural Heritage and Endangered Species Program, there are 94,559 acres (13%) of Priority Habitats of Rare Species and 1,175 acres (<1%) of Priority Natural Vegetation Communities. There are also 35,078 acres (5%) under Public Water Supply protection, 78,405 acres (11%) within five Areas of Critical Environmental Concern (Cedar Swamp; Central Nashua River Valley; Miscoe, Warren and Whitehall Watersheds; Petapawag; and Squannassit), and 161,475 acres (22%) of Outstanding Resource Waters. There are 170,114 acres (24%) of land protected in perpetuity[11], part of 189,747 acres (26%) of Protected and Recreational Open Space[12]. See Figure 6-1.

Table 6-1. National Pollutant Discharge Elimination System (NPDES) permits for Wastewater Treatment Facilities (WWTF) in the segment watershed. Only permits unique to this segment watershed are shown. WWTF are identified as either municipal (MUN) or other (OTH), if applicable.

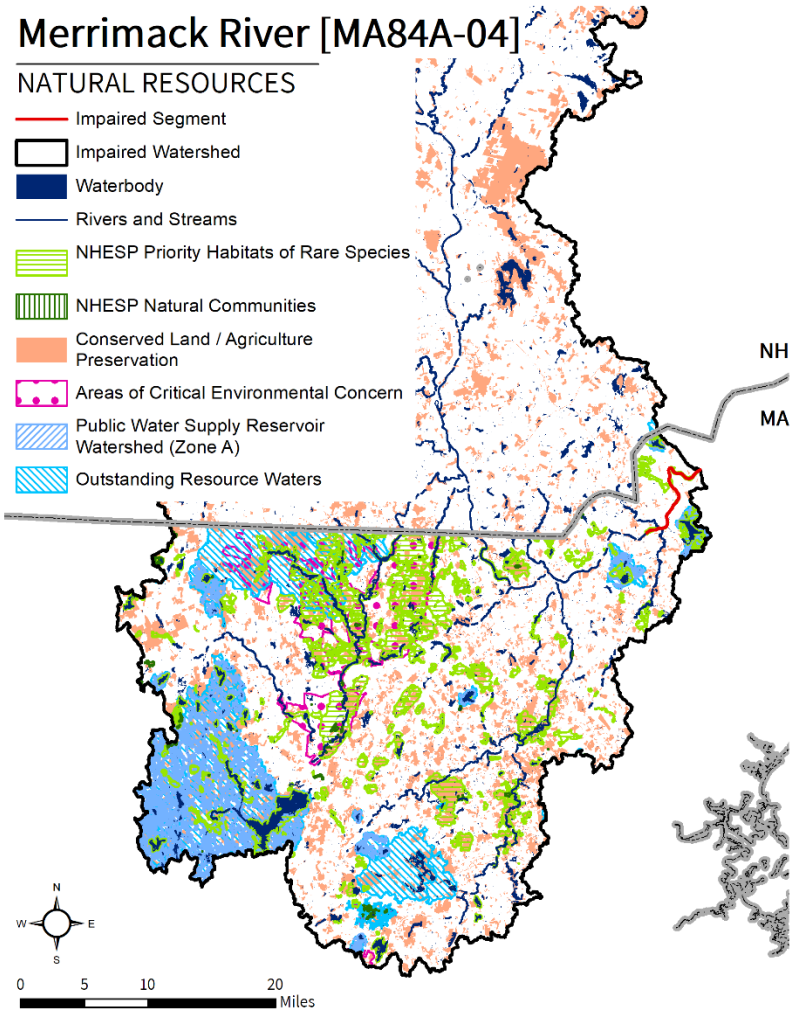
NPDES ID	NAME	TOWN	WWTF
MA0100447	GREATER LAWRENCE SD	NORTH ANDOVER	MUN

Table 6-2 Combined Sewer Overflows (CSOs) discharging to the segment.

NPDES ID	NAME	TOWN	DEP OUTFALL ID
MA0100447	GREATER LAWRENCE SD	LAWRENCE	GLSD002
MA0100447	GREATER LAWRENCE SD	LAWRENCE	GLSD003
MA0100447	GREATER LAWRENCE SD	LAWRENCE	GLSD004
MA0100447	GREATER LAWRENCE SD	LAWRENCE	GLSD005
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV024
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV032

[11] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[12] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



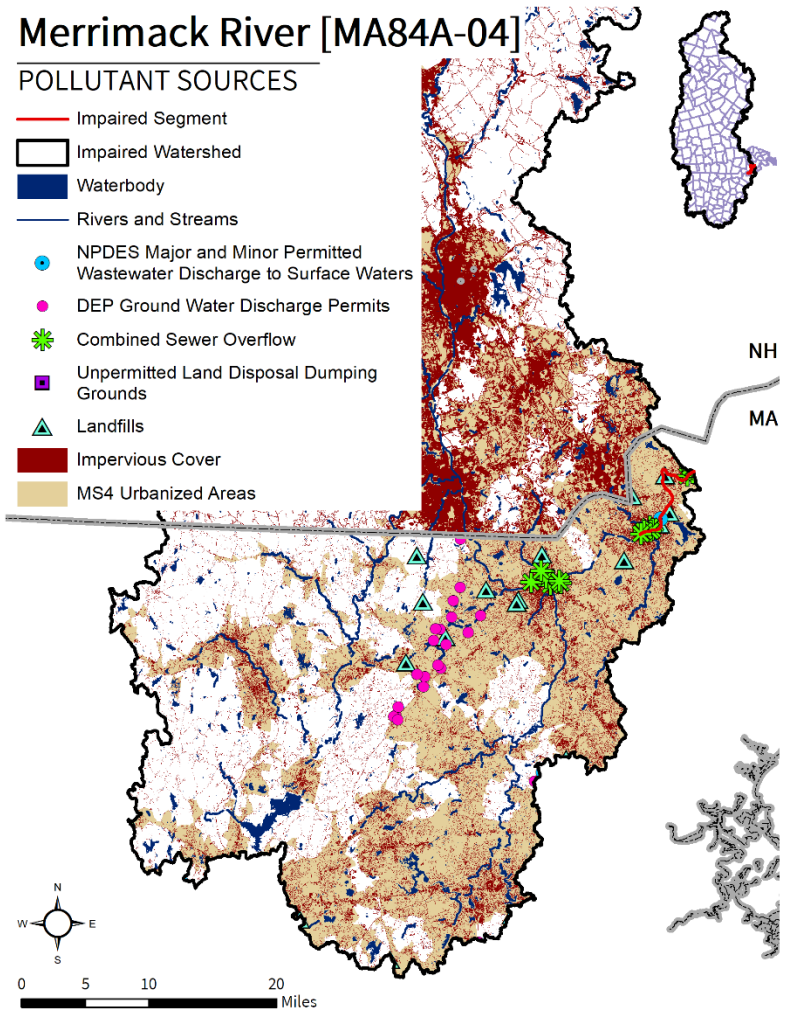


Figure 6-1. Natural resources and potential pollution sources draining to the Merrimack River segment MA84A-04. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A), with NHESP Natural Communities and Outstanding Resource Waters only shown in portions of New Hampshire where these areas extend across the state border. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Point features within the Nashua, Concord, and Shawsheen watersheds are omitted from the map as they are not within the immediate drainage area of Merrimack segments. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from the 2019 National Land Cover Database.

6.2. Waterbody Impairment Characterization

The Merrimack River (MA84A-04) is a Class B, Warm Water, and CSO Receiving Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). Merrimack River Watershed Council (MRWC) collected *E. coli* samples in the Merrimack River at five sites (29.1, 28.2, 26.9, 25.6, 22.3) in 2008. The geometric means of *E. coli* at these sites ranged from 93.3 CFU/100 mL to 151.9 CFU/100 mL. Additionally, CDM collected *E. coli* samples in the Merrimack River at three sites (M019, M021, M022) in 2003. Only two sites (M019 and M022) had the minimum number of samples required to determine compliance with water quality criteria. The geometric means of *E. coli* at these sites were 666 CFU/100 mL (M019) and 215 CFU/100 mL (M022). Both the MRWC and CDM results did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010). Additionally, a presumptive impairment decision is being applied for both the Primary and Secondary Recreational Uses since this waterbody does not have a CSO variance in place.

6.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Combined Sewer Overflow (CSO): There are 16 CSOs in the watershed, six of which discharge directly to the impaired segment. CSOs by design release untreated wastewater to surface waters when flows exceed system capacity, and therefore must be eliminated. For this reason, addressing this pathogen source is set as the highest priority.

Urban Stormwater: There is a sizable amount of development in the watershed, most of which is concentrated near the river. Within the Massachusetts portion of the watershed, 56% of the land area is subject to MS4 permit conditions, 12% is classified as impervious area, and 7% is classified as DCIA. The river flows through the large urban areas of Concord, Manchester, and Nashua in New Hampshire and Lowell and Lawrence in Massachusetts. Stormwater runoff from these areas is likely a significant source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts municipalities of Ayer, Dracut, Haverhill, Lawrence, Littleton, Lowell, Methuen, Tewksbury, and Westford. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Most of the watershed utilizes on-site septic systems for wastewater treatment. There are 19 MassDEP permits for on-site wastewater discharges to groundwater. In addition to these permitted point sources, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for only a small portion (3%) of the total land use. Most of this agriculture is located far from the river, however, there are a few fields of hay and cultivated crops adjacent to the impaired segment. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few high-density residential developments and parks near the Merrimack River segment MA84A-04. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large agricultural fields are located adjacent to the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

6.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Haverhill

Almost all of Haverhill is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041197) and MS4 annual reports for 2019 and 2020 were found, however, no EPA approval letter for the NOI was posted to the EPA website for the city. The city has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Haverhill completed an illicit discharge detection and elimination (IDDE) plan in 2017, and an erosion and sedimentation control (ESC) plan and post-construction stormwater regulations in 2018. According to the NOI, pathogen-impaired MS4 receiving waters include eight stormwater outfalls into Creek Brook (MA84A-37), 23 outfalls into Little River (MA84A-09), and 33 outfalls into the segment of the Merrimack River that is upstream of Little River (MA84A-04), all of which are impaired by *E. coli*. Additionally, there are 81 outfalls into the segment of the Merrimack River downstream of Little River (MA84A-05) which is impaired by enterococci.

Haverhill has the following ordinances and bylaws, mostly accessible online via the city website https://www.cityofhaverhill.com/ (City Haverhill, 2021):

- Wetland protection bylaw
- Stormwater regulation and utility fee bylaws
- Pet Waste: None found

The City of Haverhill has a 2020 Master Plan that focuses extensively on the riverfront areas of Haverhill, mostly the Merrimack River. The plan firmly makes the case that development and natural resource are not opposing goals (pg. 49). Haverhill's Master Plan also focuses on sustainability, proposing citywide carbon neutrality by 2050 (pg. 50). The variety of habitat types within the town are tied to the functionality of the stormwater runoff system and on-site septic systems (pg. 44). The city also has an Open Space and Recreation Plan which gives an in-depth inventory and analysis of natural resources, including water resources (pg. 38) (City of Haverhill, 2021).

City of Lawrence. See Section 5.4

City of Methuen. See Section 5.4

Town of North Andover

The majority of North Andover is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041214), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. In 2009, North Andover completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. According to the NOI, *E. coli*-impaired MS4 receiving waters include a Merrimack River segment (MA84A-04) with 13 stormwater outfalls.

North Andover has the following ordinances and bylaws, mostly accessible online via the town website https://www.northandoverma.gov/ (Town of North Andover, 2021):

- Wetland protection bylaw
- Stormwater control bylaw and utility fee
- Pet Waste: None found

North Andover adopted a Master Plan in 2018 with multiple sections related to the environment, such as natural resources and open space. Within the natural resources section, specific waterbodies are identified but no impairments are noted. Stormwater is mentioned throughout many sections of the Master Plan, with expanding and updating existing infrastructure identified as a goal. North Andover also has a 2016 Open Space and Recreation Plan (Town of North Andover, 2021).

7. MA84A-05 Merrimack River

7.1. Waterbody Overview

The Merrimack River segment MA84A-05 is 1.83 square miles (mi^2) in area and begins at the Little River in Haverhill, MA. The segment is tidally influenced, but generally flows southeast before bending northeast and ending at the Indian River in West Newbury/Amesbury, MA.

Tributaries to the Merrimack River segment MA84A-05 include the Little River (MA84A-09), Johnson Creek, the East Meadow River, Cobbler Brook, and Nichols Creek. The contributing watershed includes roughly 258,470 acres of lakes and ponds, the most notable Massachusetts waterbody being Wachusett Reservoir. Much of the river flows through forested and natural or developed areas.

Key landmarks in the Massachusetts portion of the watershed include the centers of Dunstable, Haverhill, Lawrence, Littleton, Lowell, Merrimac, Methuen, Tyngsborough, West Newbury, and Westford; and the Lowell-Dracut-Tyngsborough state forests. From upstream to downstream, segment MA84A-05 is crossed by Basiliere Bridge/MA-125, Groveland Street, and Rocks Bridge, all in Haverhill.

The Merrimack River (MA84A-05) drains a total area of 4,927 mi^2, of which 1,174 mi^2 (24%) are located within Massachusetts. Of these, 137.0 mi^2 (12%) are impervious and 79.0 mi^2 (7%) are directly connected impervious area (DCIA). The watershed is partially served by public sewer[13] and 56% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts (excluding the Nashua, Concord, and Shawsheen watersheds), there are 20 additional NPDES permits on file governing point source discharges of pollutants to surface waters. Of these 20 permits, four are NPDES permits for wastewater treatment facilities (two of which are within the immediate drainage area to the impaired segment, Table 7-1). There are 20 MassDEP discharge-to-groundwater permits for on-site wastewater discharges within the watershed (none of which are within the immediate drainage area to the impaired segment). There are

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 751,126

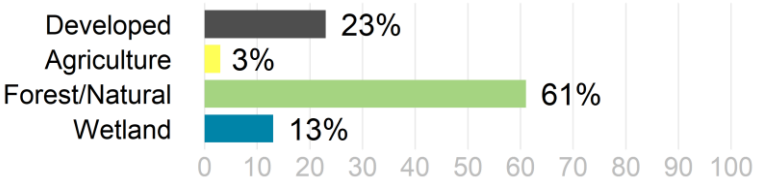
Segment Area (mi^2): 1.83

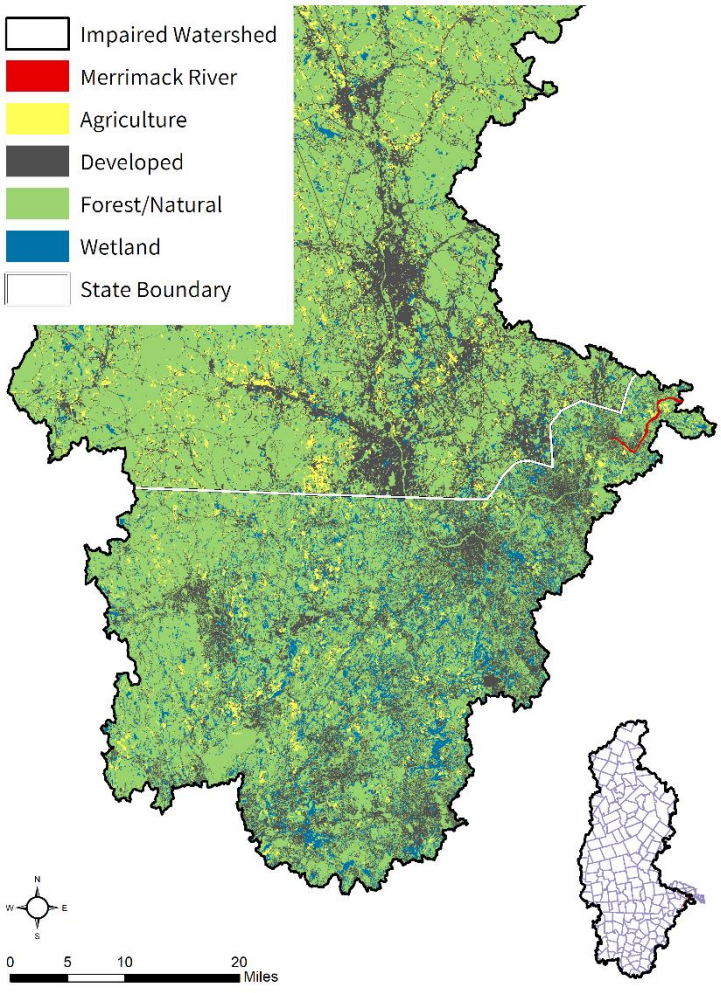
Impairment(s): Enterococci (Primary Contact Recreation)

Class (Qualifier): SB (CSO Receiving Water, Shellfishing)

Impervious Area (Acres, %): 87,655 (12%)

DCIA Area (Acres, %): 50,582 (7%)





[13] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

27 combined sewer overflows (CSOs) within the watershed (seven of which discharge directly to the impaired segment, Table 7-2). There are 15 landfills and one unpermitted land disposal dumping ground within the Massachusetts portion of the watershed. See Figure 7-1.

The Merrimack River segment MA84A-05 watershed is located in a moderately-developed part of Massachusetts. The watershed in Massachusetts is covered predominately with forest and natural lands (61%) but contains a substantial amount of development (23%), as well as wetland (13%) and agricultural areas (3%). The impaired segment itself is surrounded by a combination of forest and natural areas, dense development, and agricultural fields.

In the Massachusetts portion of the Merrimack River (MA84A-05) watershed, under the Natural Heritage and Endangered Species Program, there are 100,154 acres (13%) of Priority Habitats of Rare Species and 1,186 acres (<1%) of Priority Natural Vegetation Communities. There are also 38,532 acres (5%) under Public Water Supply protection, 78,405 acres (10%) within five different Areas of Critical Environmental Concern (Cedar Swamp; Central Nashua River Valley; Miscoe, Warren and Whitehall Watersheds; Petapawag; and Squannassit), and 172,830 acres (23%) of Outstanding Resource Waters. There are 175,674 acres (23%) of land protected in perpetuity[14], part of 196,779 acres (26%) of Protected and Recreational Open Space[15]. See Figure 7-1.

Table 7-1. National Pollutant Discharge Elimination System (NPDES) permits for Wastewater Treatment Facilities (WWTF) in the segment watershed. Only permits unique to this segment watershed are shown. WWTF are identified as either municipal (MUN) or other (OTH), if applicable.

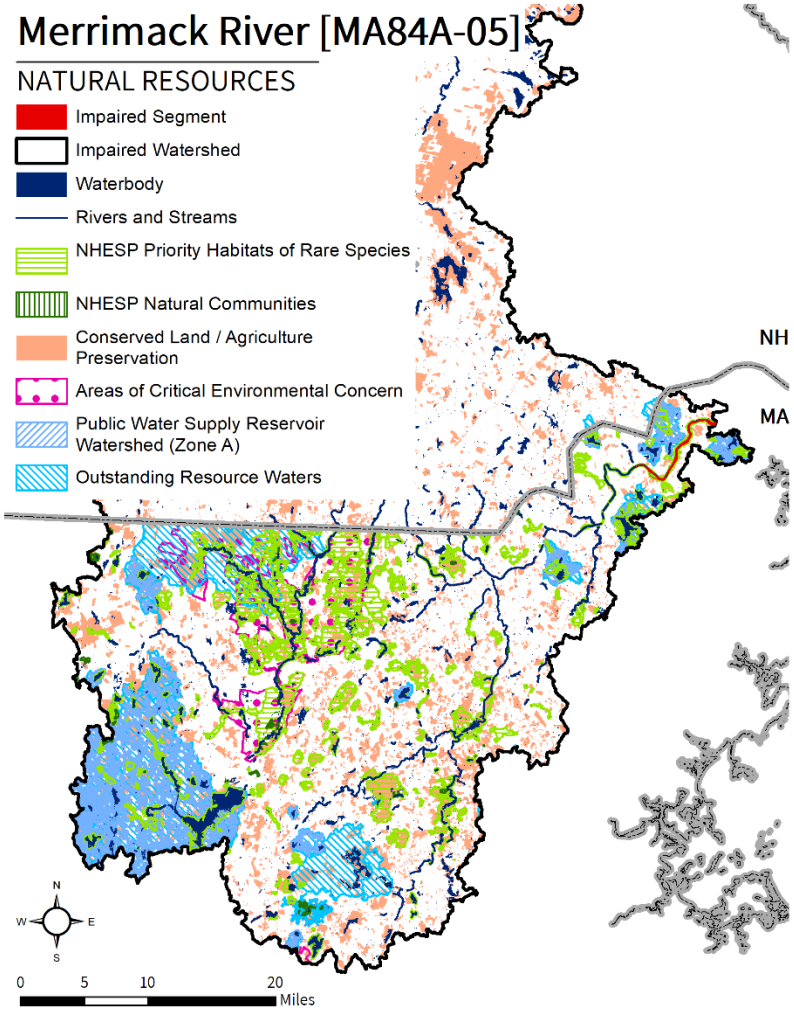
NPDES ID	NAME	TOWN	WWTF
MA0101150	MERRIMAC WWTP	MERRIMAC	MUN
MA0101621	HAVERHILL WPAF	HAVERHILL	MUN

Table 7-2 Combined Sewer Overflows (CSOs) discharging to the segment.

NPDES ID	NAME	TOWN	DEP OUTFALL ID
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV013
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV019
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV021A
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV0034
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV0039
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV0040
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV0041

[14] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[15] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



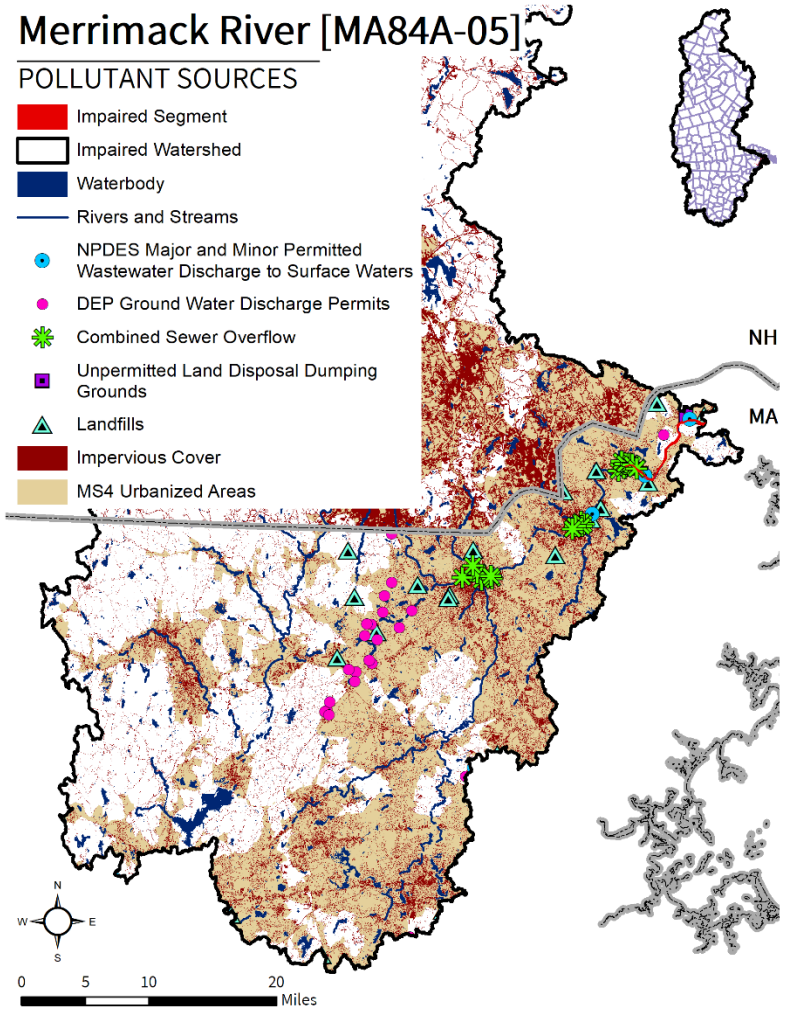


Figure 7-1. Natural resources and potential pollution sources draining to the Merrimack River segment MA84A-05. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A), with NHESP Natural Communities and Outstanding Resource Waters only shown in portions of New Hampshire where these areas extend across the state border. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Point features within the Nashua, Concord, and Shawsheen watersheds are omitted from the map as they are not within the immediate drainage area of Merrimack segments. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from the 2019 National Land Cover Database.

7.2. Waterbody Impairment Characterization

The Merrimack River (MA84A-05) is a Class SB, CSO Receiving Water, with a Shellfishing qualifier (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MRWC collected Enterococcus samples in the Merrimack River at two sites (14.1 and 10.6) in 2008. The geometric means of Enterococcus at these sites ranged from 31.8 CFU/100 mL to 39.2 CFU/100 mL. Additionally, CDM collected Enterococcus samples in the Merrimack River at two sites (M024 and M025) in 2003. Neither site had the minimum number of samples required to determine compliance with water quality criteria, however five out of eight counts at the two sites exceeded 104 colonies/100 mL. Both the MRWC and CDM results did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010). Additionally, a presumptive impairment decision is being applied for both the Primary and Secondary Recreational Uses since this waterbody does not have a CSO variance in place.

7.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Combined Sewer Overflow (CSO): There are 27 CSOs in the watershed, seven of which discharge directly into the impaired segment. CSOs by design release untreated wastewater to surface waters when flows exceed system capacity, and therefore must be eliminated. For this reason, addressing this pathogen source is set as the highest priority.

Urban Stormwater: There is a sizable amount of development in the watershed, most of which is concentrated near the river. Within the Massachusetts portion of the watershed, 56% of the land area is subject to MS4 permit conditions, 12% is classified as impervious area, and 7% is classified as DCIA. The river flows through the large urban areas of Concord, Manchester, and Nashua in New Hampshire and Lowell, Lawrence, and Haverhill in Massachusetts. Stormwater runoff from these areas is likely a significant source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts municipalities of Ayer, Dracut, Haverhill, Lawrence, Littleton, Lowell, Methuen, Tewksbury, and Westford. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Most of the watershed utilizes on-site septic systems for wastewater treatment. There are 20 MassDEP permits for on-site wastewater discharges to groundwater. In addition to these permitted point sources, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Illicit Boat Discharges: The segment is navigable by marine vessels. Vessels with onboard toilets are required to have a marine sanitation device (MSD) to treat or store wastewater. MSDs that treat wastewater may be improperly maintained or malfunctioning and therefore could discharge untreated sewage to coastal waterbodies. For MSDs that store wastewater, this sewage can either be pumped out at shore-based pump-out facilities (CZM, 2022b) or discharged directly into the water when the vessel is more than three miles offshore, beyond the designated No Discharge Zone (NDZ). Boaters who ignore these laws and discharge untreated sewage to coastal waterbodies may be a source of pathogen pollution.

Vessel Pump-Out Facilities: There is one vessel sewage pump-out facility directly adjacent to the Merrimack River segment MA84A-05: West Newbury Harbormaster (West Newbury; CZM, 2022b). Although pump-out facilities provide boaters with a means of disposing onboard sewage without discharging it into coastal waters, these facilities are generally associated with high boating activity. Pump-out facilities which malfunction or leak also represent a potential pathogen source. As a result, waterbodies adjacent to pump-out facilities are likely at high risk of illicit boat discharges.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for only a small portion (3%) of the total land use. Most of this agriculture is located far from the river, however, there are a few fields of

hay and cultivated crops adjacent to the impaired segment. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few high-density residential developments and parks near the Merrimack River segment MA84A-05. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large athletic and agricultural fields are located adjacent to the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

7.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Haverhill. See Section 6.4

City of Amesbury

The entirety of Amesbury is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041177), and the city has an EPA-approved Notice of Intent (NOI). The city has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Amesbury has completed an erosion and sedimentation control (ESC) plan but has not completed an illicit discharge detection and elimination (IDDE) plan or post-construction stormwater regulations, as required. According to Amesbury's NOI there are 28 stormwater outfalls to the Back River (MA84A-16) and 47 outfalls to the Powwow River (MA84A-08, MA84A-25), all of which are impaired by *E. coli*. Additionally, a segment of the Powwow River (MA84A-28) with 14 outfalls is impaired by fecal coliform. Lastly, two segments of the Merrimack River (MA84A-05, MA84A-06) with 42 outfalls are impaired for enterococci.

Amesbury has the following ordinances and bylaws, mostly accessible online via the city website https://www.amesburyma.gov/ (City of Amesbury, 2021):

- Wetland bylaws
- Stormwater bylaws: None found
- Stormwater Utility: None found
- Pet Waste: None found

Amesbury's website features a page highlighting the MS4 stormwater program, which includes the stormwater management plan. The town's Master Plan was published in 2014 and features a water resources report, with a section on stormwater management. The Master Plan also has a section about sewer and septic risks and needs, and natural resources. The Amesbury Master Plan does not mention rivers, specific impaired sites, or bacterial impairment. Additionally, Amesbury has an Open Space and Recreation Plan (2020). This plan includes a section dedicated to waterbodies within the city but does not mention specific impairments (City of Amesbury, 2021).

Town of Groveland

About 90% of Groveland is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041119), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Groveland completed an illicit discharge detection and elimination (IDDE) plan in 2019, and an erosion and sedimentation control (ESC) plan and post-construction stormwater regulations in 2007. According to the NOI, *E. coli*-impaired Johnson Creek (MA84A-15) has five outfalls from the MS4 system.

Groveland has the following ordinances and bylaws, mostly accessible online via the town website https://www.grovelandma.com/ (Town of Groveland, 2021):

- Wetland protection bylaw

- Stormwater regulation bylaw
- Pet waste removal bylaw
- Stormwater Utility: None found

No Master Plan or Open Space and Recreation Plan was found for the town of Groveland, though an Open Space Plan was under development in 2019. The town maintains a stormwater webpage with stormwater bylaws, the stormwater management plan, MS4 annual reports, and the IDDE plan (Town of Groveland, 2021).

Town of Merrimac

The majority of Merrimac is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041209), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. In 2015, Merrimac completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. According to the NOI, pathogen-impaired MS4 receiving waters include 23 stormwater outfalls into the Merrimack River, which is impaired by enterococci. There are also four outfalls into the East Meadow River which is impaired by *E. coli*. While no Assessment Unit IDs were provided in annual reports, references to Merrimack River and East Meadow Brook are likely Merrimack River (MA84A-05) and East Meadow Brook (MA84A-39) respectively.

Merrimac has the following ordinances and bylaws, mostly accessible online via the town website http://www.merrimac01860.info/ (Town of Merrimac, 2021):

- Wetland protection bylaw
- Stormwater control bylaws and utility fees
- Pet Waste: None found

Merrimac has a 2002 Master Plan which addresses environmental issues, mostly regarding ways to develop that consider the environment such as wetland protection. This plan inventories the town's sewer system and identifies goals to expand and improve the system. Merrimac also has a more recent 2016 Open Space and Recreation Plan which specifically identifies impaired streams and mentions stormwater as a non-point source of pollution (Town of Merrimac, 2021).

Town of West Newbury

Only about 42% of West Newbury is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041231), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped its entire MS4 system and the year-one and year-two Annual Reports have been submitted. In 2008, West Newbury completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. According to the town's NOI, pathogen-impaired MS4 receiving waters include four stormwater outfalls into the Merrimack River (no AU reported), impaired by fecal coliform and enterococci.

West Newbury has the following ordinances and bylaws, mostly accessible online via the town website https://www.wnewbury.org/ (Town of West Newbury, 2021):

- Wetland protection bylaw
- Stormwater Control Bylaw and Utility: None Found
- Pet Waste: None found

West Newbury has a 1999 Comprehensive Plan, which includes a water resources section that mentions West Newbury as being identified by DEP as having superior drinking water quality and therefore receiving a waiver from some water quality testing. Stormwater is not specifically mentioned, but non-point source pollution is mentioned as affecting the Merrimack River. As of 1999, the town had no public sewer system. West Newbury also has an Open Space and Recreation Plan from 2018 that includes an inventory of all water resources within the town, though it does not indicate impairment status (Town of West Newbury, 2021).

8. MA84A-06 Merrimack River

8.1. Waterbody Overview

The Merrimack River segment MA84A-06 is 4.46 square miles (mi^2) in area and begins at the Indian River in West Newbury/Amesbury, MA. The segment is tidally influenced, but generally flows northeast before bending southeast and ending at the mouth to the Atlantic Ocean in Newburyport/ Salisbury, MA.

Tributaries to the Merrimack River segment MA84A-06 include the Indian River, the Artichoke River, the Powwow River (MA84A-08), Town Creek, Morrill Creek, Niddle Creek, Shad Creek, Black Rock Creek, and Plumbush Creek. The contributing watershed includes roughly 262,591 acres of lakes and ponds, the most notable Massachusetts waterbody being Wachusett Reservoir. Much of the river flows through wetland or developed areas.

Key landmarks in the Massachusetts portion of the watershed include the centers of Amesbury, Dunstable, Haverhill, Lawrence, Littleton, Lowell, Merrimac, Methuen, Newburyport, Salisbury, Tyngsborough, West Newbury, and Westford; and the Lowell-Dracut-Tyngsborough state forests. From upstream to downstream, segment MA84A-06 is crossed by I-95 (Amesbury/Newburyport), Main Street (Amesbury/ Newburyport), and U.S. Route 1/Bridge Road (Salisbury/Newburyport).

The Merrimack River (MA84A-06) drains a total area of 5,007 mi^2, of which 1,207 mi^2 (24%) are located within Massachusetts. Of these, 140.7 mi^2 (12%) are impervious and 81.2 mi^2 (7%) are directly connected impervious area (DCIA). The watershed is partially served by public sewer[16], and 56% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts (excluding the Nashua, Concord, and Shawsheen watersheds), there are 26 additional NPDES permits on file governing point source discharges of pollutants to surface waters. Of these 26 permits, seven are NPDES permits for wastewater treatment facilities (three of which are within the immediate drainage area to the impaired segment, Table 8-1). There are 21 MassDEP discharge-to-groundwater

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 772,233

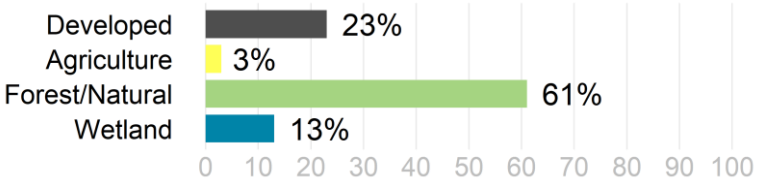
Segment Area (mi^2): 4.46

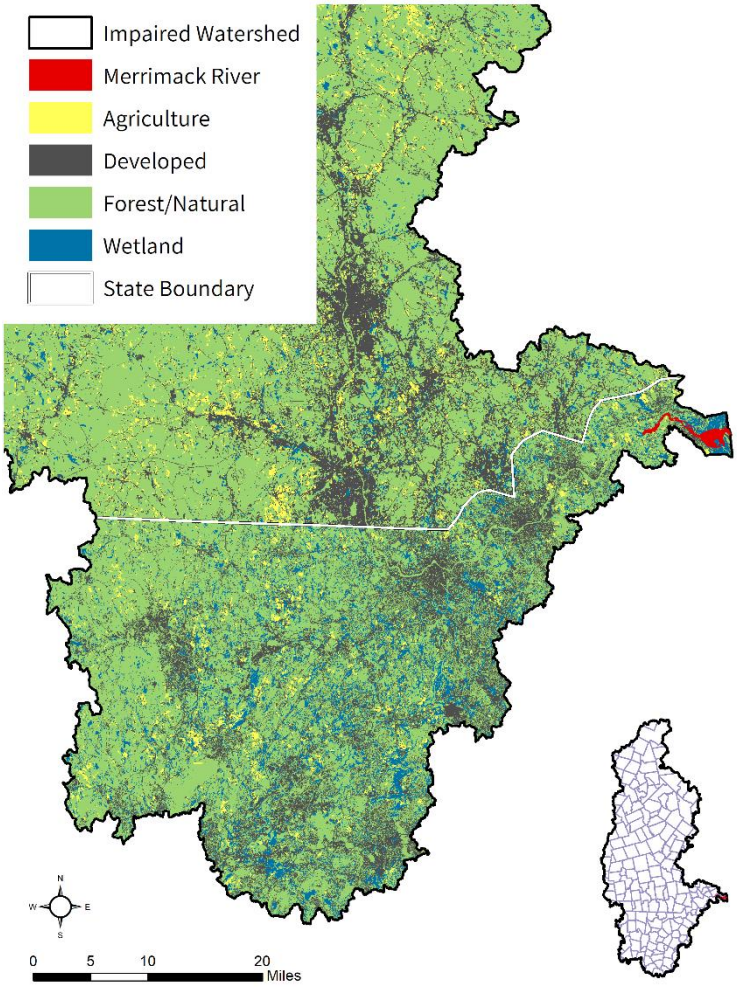
Impairment(s): Enterococci, Fecal Coliform (Primary Contact Recreation, Shellfish)

Class (Qualifier): SB (CSO Receiving Water, Shellfishing)

Impervious Area (Acres, %): 90,022 (12%)

DCIA Area (Acres, %): 51,946 (7%)





[16] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

permits for on-site wastewater discharges within the watershed (one of which is within the immediate drainage area to the impaired segment, Table 8-2). There are 27 combined sewer overflows (CSOs) within the watershed (none of which discharge directly to the impaired segment). There are 18 landfills and one unpermitted land disposal dumping ground within the Massachusetts portion of the watershed. See Figure 8-1.

The Merrimack River segment MA84A-06 watershed is located in a moderately-developed part of Massachusetts. The watershed in Massachusetts is covered predominately with forest and natural lands (61%) but contains a substantial amount of development (23%), as well as wetland (13%) and agricultural areas (3%). The impaired segment itself is surrounded by wetland areas and moderate development.

In the Massachusetts portion of the Merrimack River (MA84A-06) watershed, under the Natural Heritage and Endangered Species Program, there are 105,578 acres (14%) of Priority Habitats of Rare Species and 4,743 acres (1%) of Priority Natural Vegetation Communities. There are also 39,725 acres (5%) under Public Water Supply protection, 79,376 acres (10%) within six Areas of Critical Environmental Concern (Cedar Swamp; Central Nashua River Valley; Great Marsh; Miscoe, Warren and Whitehall Watersheds; Petapawag; and Squannassit), and 176,131 acres (23%) of Outstanding Resource Waters. There are 179,072 acres (23%) of land protected in perpetuity[17], part of 200,844 acres (26%) of Protected and Recreational Open Space[18]. See Figure 8-1.

Table 8-1. National Pollutant Discharge Elimination System (NPDES) permits for Wastewater Treatment Facilities (WWTF) in the segment watershed. Only permits unique to this segment watershed are shown. WWTF are identified as either municipal (MUN) or other (OTH), if applicable.

NPDES ID	NAME	TOWN	WWTF
MA0101427	NEWBURYPORT WPCF	NEWBURYPORT	MUN
MA0101745	AMESBURY WWTP	AMESBURY	MUN
MA0102873	SALISBURY WWTF	SALISBURY	MUN

Table 8-2. Groundwater discharge permits in the immediate drainage area to the impaired segment. PERR = permit number plus renewal number. TYPE = type of groundwater discharge. FLOW = permitted effluent in gallons per day (gpd).

PERR	NAME	TOWN	TYPE	FLOW (GPD)
611-3	SALISBURY BEACH	SALISBURY	Other	36,000

[17] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[18] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

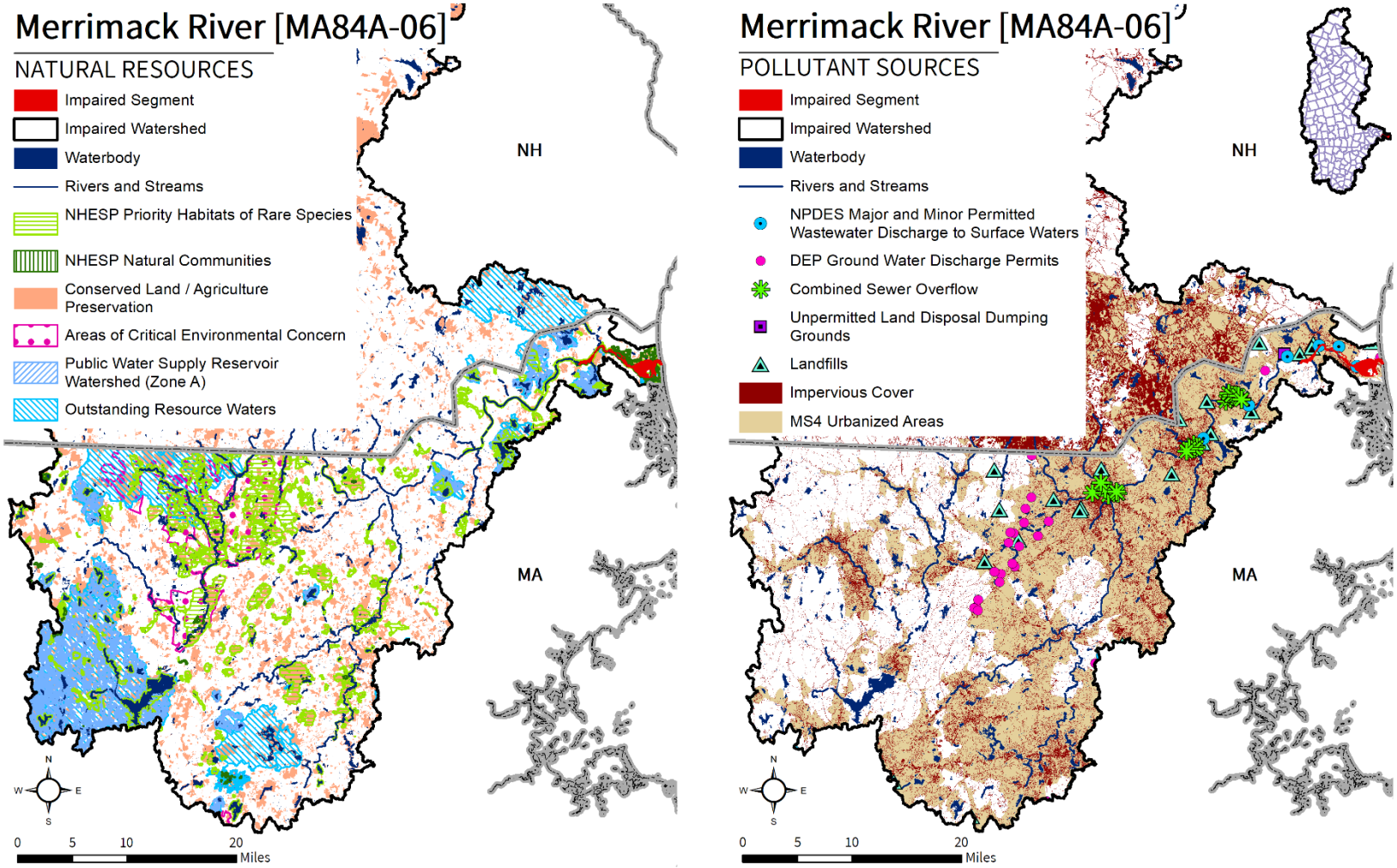


Figure 8-1. Natural resources and potential pollution sources draining to the Merrimack River segment MA84A-06. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A), with NHESP Natural Communities and Outstanding Resource Waters only shown in portions of New Hampshire where these areas extend across the state border. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Point features within the Nashua, Concord, and Shawsheen watersheds are omitted from the map as they are not within the immediate drainage area of Merrimack segments. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from the 2019 National Land Cover Database.

8.2. Waterbody Impairment Characterization

The Merrimack River (MA84A-06) is a Class SB tidal estuary, CSO Receiving Water with a Shellfishing qualifier (MassDEP, 2021a).

No recent bacteria data were available to assess the Primary Contact Recreation use for the Merrimack River segment MA84A-06. There were sufficient evaluations of beach conditions by the Massachusetts Department of Public Health at two beaches in the segment from 2005-2013 to make an assessment (Table 8-3). A segment is considered not supporting Primary Contact Recreation if beach postings are frequent or prolonged during the swimming season (i.e., the number of days posted frequently exceeds 10% during the locally operated swimming season). Postings at the beaches, Plum Island Point and Plum Island – end of island two, did not exceed 10% of days during any of the swimming seasons from 2005-2013.

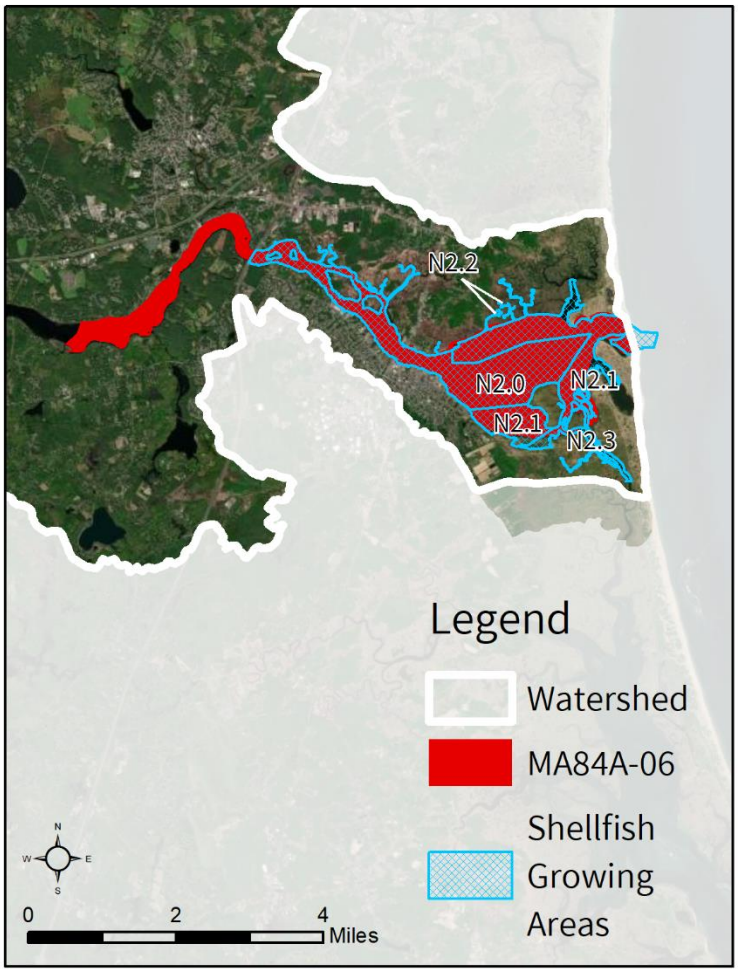


Figure 8-2. Location of shellfish growing areas associated with the impaired segment.

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MRWC collected Enterococcus samples in the Merrimack River at six sites (9.4, 8.3, 6.8, 4.4, 3.8, 2.7) in 2008. The geometric means of Enterococcus at these sites ranged from 16.9 CFU/100 mL to 42.1 CFU/100 mL. Additionally, CDM collected Enterococcus samples in the Merrimack River at five sites (M26, M27, M28, M29, M30) in 2003. Only one site (M27) had the minimum number of samples required to determine compliance with water quality criteria. The geometric mean of Enterococcus at this site was 43 CFU/100 mL. Three of the other four sampling sites also had more than one Enterococcus count greater than 104 CFU/100 mL. Both the MRWC and CDM results did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

Table 8-3. The percentage of days in the 2005-2013 swimming seasons with beach postings for the two beaches located in the Merrimack River segment MA84A-06.

Beach ID	Beach Name	Town	2005	2006	2007	2008	2009	2010	2011	2012	2013
3030	Plum Island Point	Newburyport	0%	8%	0%	0%	0%	0%	1%	0%	0%
5636	Plum Island - end of island two	Newburyport	0%	0%	0%	0%	0%	0%	0%	0%	0%

The Shellfish Harvesting use was assessed for attainment of SWQS using fecal coliform indicator bacteria at four shellfish growing areas that cover 3.33 mi^2 (75% of the segment area; refer to Figure 8-2). MassDEP assessed the Shellfish Harvesting use as not supporting since the growing area normalized to the segment area is less than 100% approved by the Massachusetts Division of Marine Fisheries (Table 8-4).

Table 8-4. Summary of MA DFG-Division of Marine Fisheries classification data from January 2014 for four shellfish growing areas in the Merrimack River segment MA84A-06. Percentage indicates the relative area within the segment covered by each shellfish growing area. Shellfish Harvesting is classified as not supporting if the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries.

Name	Area Description	Class	Area (mi^2)	Percentage
N2.0	Merrimack River - the mainstem	Prohibited	1.8941	42%
N2.1	Merrimack River Estuary	Conditionally Restricted	1.3860	31%
N2.2	Middle and Morrill Creeks	Conditionally Restricted	0.0016	<1%
N2.3	Northern Plum Island River and Approaches	Conditionally Restricted	0.0531	1%

8.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Combined Sewer Overflow (CSO): There are 27 CSOs in the watershed (see Sections 3.1, 4.1, 6.1, 7.1, 10.1, 11.1, 12.1), none of which discharge directly into the impaired segment. CSOs by design release untreated wastewater to surface waters when flows exceed system capacity, and therefore must be eliminated. For this reason, addressing this pathogen source is set as the highest priority.

Urban Stormwater: There is a sizable amount of development in the watershed, most of which is concentrated near the river. Within the Massachusetts portion of the watershed, 56% of the land area is subject to MS4 permit conditions, 12% is classified as impervious area, and 7% is classified as DCIA. The river flows through the large urban areas of Concord, Manchester, and Nashua in New Hampshire and Lowell, Lawrence, and Haverhill in Massachusetts. Stormwater runoff from these areas is likely a significant source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts municipalities of Amesbury, Ayer, Dracut, Haverhill, Lawrence, Littleton, Lowell, Methuen, Newbury, Newburyport, Salisbury Tewksbury, and Westford. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Most of the watershed utilizes on-site septic systems for wastewater treatment. There are 21 MassDEP permits for on-site wastewater discharges to groundwater. In addition to these permitted point sources, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Illicit Boat Discharges: The segment is navigable by marine vessels. Vessels with onboard toilets are required to have a marine sanitation device (MSD) to treat or store wastewater. MSDs that treat wastewater may be improperly maintained or malfunctioning and therefore could discharge untreated sewage to coastal waterbodies. For MSDs that store wastewater, this sewage can either be pumped out at shore-based pump-out facilities (CZM, 2022b) or discharged directly into the water when the vessel is more than three miles offshore, beyond the designated No Discharge Zone (NDZ). Boaters who ignore these laws and discharge untreated sewage to coastal waterbodies may be a source of pathogen pollution.

Vessel Pump-Out Facilities: There are four vessel sewage pump-out facilities directly adjacent to the Merrimack River segment MA84A-06: Cashman Park (Newburyport), Marina at Hatter's Point (Amesbury), Newburyport Harbormaster (Newburyport), and Salisbury Harbormaster (Salisbury; CZM, 2022b). Although pump-out facilities provide boaters with a means of disposing onboard sewage without discharging it into coastal

waters, these facilities are generally associated with high boating activity. Pump-out facilities which malfunction or leak also represent a potential pathogen source. As a result, waterbodies adjacent to pump-out facilities are likely at high risk of illicit boat (and facility) discharges.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for only a small portion (3%) of the total land use. Most of this agriculture is located far from the river, however, there are a few fields of hay and cultivated crops adjacent to the impaired segment and its direct tributaries. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few high-density residential developments and parks near the Merrimack River segment MA84A-06. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: Large wetland areas are located directly adjacent to the segment near the river mouth. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

8.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Newburyport

Almost all of Newburyport is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041213), and the city has an EPA-approved Notice of Intent (NOI). 80% of the MS4 system within the city has been mapped and the year-one Annual Report has been submitted. In 2010, Newburyport completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. According to the NOI, pathogen-impaired MS4 receiving waters include 100 stormwater outfalls into the Merrimack River (MA84A-06), impaired by both enterococci and fecal coliform. Another segment of the Merrimack River (MA84A-26) has 20 outfalls, and the Little River (MA91-11) has 30 outfalls, both impaired by fecal coliform.

Newburyport has the following ordinances and bylaws, mostly accessible online via the city website https://www.cityofnewburyport.com/ (City of Newburyport, 2021):

- Wetland protection bylaw
- Stormwater control bylaw
- Pet waste control and disposal bylaw
- Stormwater Utility: None found

The City of Newburyport has a 2017 Master Plan, which includes an environmental inventory of natural resources. This inventory includes a water resources section (NR-3), which describes multiple surface waterbodies, but does not mention impairment status. Improved control and regulation of Newburyport's stormwater control system is identified as a goal in the municipal facilities section, the economic development section, and in the implementation strategies. There is no stormwater management plan available online. A 2020 Open Space and Recreation Plan is available. This plan includes an updated and expanded environmental inventory and analysis (City of Newburyport, 2021).

City of Amesbury. See Section 7.4

Town of Newbury

About 55% of Newbury is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041212), and the town has an EPA-approved Notice of Intent (NOI). The entire MS4 system within the town has been mapped and the year-one Annual Report has been submitted. Newbury completed an illicit discharge detection and elimination (IDDE) plan and an erosion and sedimentation control (ESC) plan in 2009, and post-construction stormwater regulations in 2013. According to the NOI, pathogen impaired MS4

receiving waters include 15 outfalls into the Plum Island River (MA84A-27) and one outfall into the Merrimack River (MA84A, segment not specified), both impaired by enterococci and fecal coliform.

Newbury has the following ordinances and bylaws, mostly accessible online via the town website https://www.townofnewbury.org/ (Town of Newbury, 2021):

- Wetland protection bylaw
- Stormwater control bylaw
- Stormwater Utility: None found
- Pet Waste: None found

Newbury has a 2009 Master Plan, which includes a natural resources section featuring environmental inventories and identified goals. One specific goal is to protect and enhance coastal water quality; another is to reduce non-point source pollution. The plan also identifies weaknesses and obstacles to achieving these goals, specifically the town's limited water and sewer infrastructure. Additionally, the plan identifies some impaired waterbodies (Town of Newbury, 2021).

Town of Salisbury

All of Salisbury is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR041220), and the town has an EPA-approved Notice of Intent (NOI). 90% of the MS4 system within the town has been mapped and the year-one Annual Report has been submitted. Salisbury completed an illicit discharge detection and elimination (IDDE) plan and post-construction regulations in 2012, and an erosion and sedimentation control (ESC) plan in 2013. According to the NOI, a segment of the Merrimack River (MA84A-06) is impaired by both fecal coliform and enterococci, but there are no stormwater outfalls into this segment of the river.

Salisbury has no relevant bylaws on the town's online e-page. This page does not appear to be up to date, and no more recent bylaw publications were found.

Salisbury has a 2008 Master Plan, which is split into two sections: an existing resources section, and an implementation plan. The existing resources section includes an inventory of natural resources, specifically rivers and streams, as well as planning to protect the town's natural resources. The planning section also mentions stormwater and the stormwater management plan (SWMP). Salisbury lacks a town wide sewer system, which is identified as a constraint to development. The town also has an Open Space and Recreation Plan (OSRP) from 2006-2007, which includes an in-depth environmental inventory and analysis and establishes a five-year action plan. It appears an updated OSRP is under development (Town of Salisbury, 2021).

Town of West Newbury. See Section 7.4

9. MA84A-08 Powwow River

9.1. Waterbody Overview

The Powwow River segment MA84A-08 is 0.06 square miles (mi^2) in area and begins just downstream of Main Street in Amesbury, MA. The segment is tidally influenced, but generally flows south before bending southwest and ending at the Merrimack River in Amesbury, MA.

Tributaries to the Powwow River segment MA84A-08 include the nontidal portion of the Powwow River (MA84A-25) and an unnamed tributary (MA84A-30). Lakes and ponds in the watershed include Lake Attitash, Lake Gardner, Clarks Pond, Tuxbury Pond, and Meadowbrook Pond in Massachusetts. Much of the river flows through forested and natural or developed areas.

Key landmarks in the Massachusetts portion of the watershed include the town center of Amesbury; Amesbury Golf and Country Club, the Amesbury Town Forest, and Woodsom Farm and Batchelder parks. From upstream to downstream, segment MA84A-08 is crossed by Macy Street/MA-110, I-495, and Main Street, all in Amesbury.

The Powwow River (MA84A-08) drains a total area of 59.2 mi^2, of which 12.2 mi^2 (21%) are located within Massachusetts. Of these, 1.3 mi^2 (11%) are impervious and 0.8 mi^2 (6%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Amesbury[19] and 94% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are two additional NPDES permits on file governing point source discharges of pollutants to surface waters. Of these two permits, neither are NPDES permits for wastewater treatment facilities. There are no MassDEP discharge-to-groundwater permits for on-site wastewater discharges or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 9-1.

The Powwow River segment MA84A-08 watershed is located in a moderately-developed

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 7,789

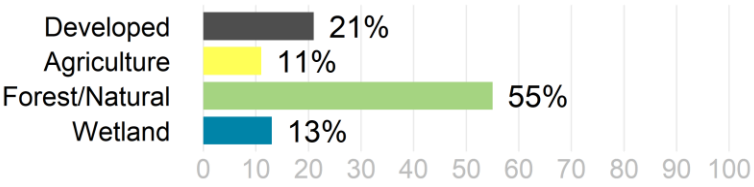
Segment Area (mi^2): 0.06

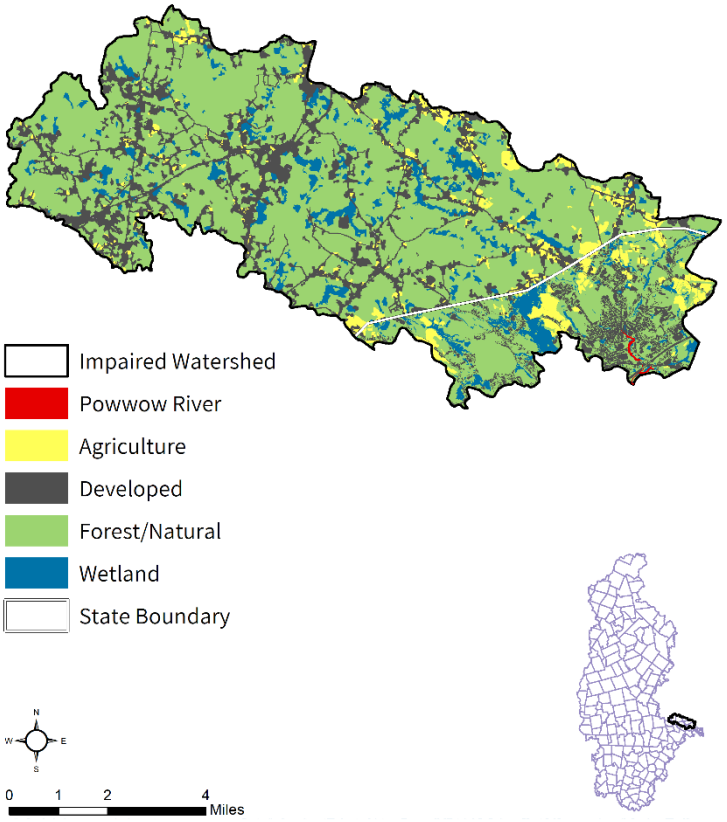
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): SB (Shellfishing)

Impervious Area (Acres, %): 857 (11%)

DCIA Area (Acres, %): 492 (6%)





[19] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

part of Massachusetts. The watershed in Massachusetts is covered predominately with forest and natural lands (55%) but contains a substantial amount of development (21%), as well as wetland (13%) and agricultural areas (11%). The highest density of development is located directly adjacent to the impaired segment in the City of Amesbury.

In the Massachusetts portion of the Powwow River (MA84A-08) watershed, under the Natural Heritage and Endangered Species Program, there are 234 acres (3%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also 1,095 acres (14%) under Public Water Supply protection, no Areas of Critical Environmental Concern, and 2,450 acres (31%) of Outstanding Resource Waters. There are 777 acres (10%) of land protected in perpetuity[20], part of 1,162 acres (15%) of Protected and Recreational Open Space[21]. See Figure 9-1.

[20] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[21] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

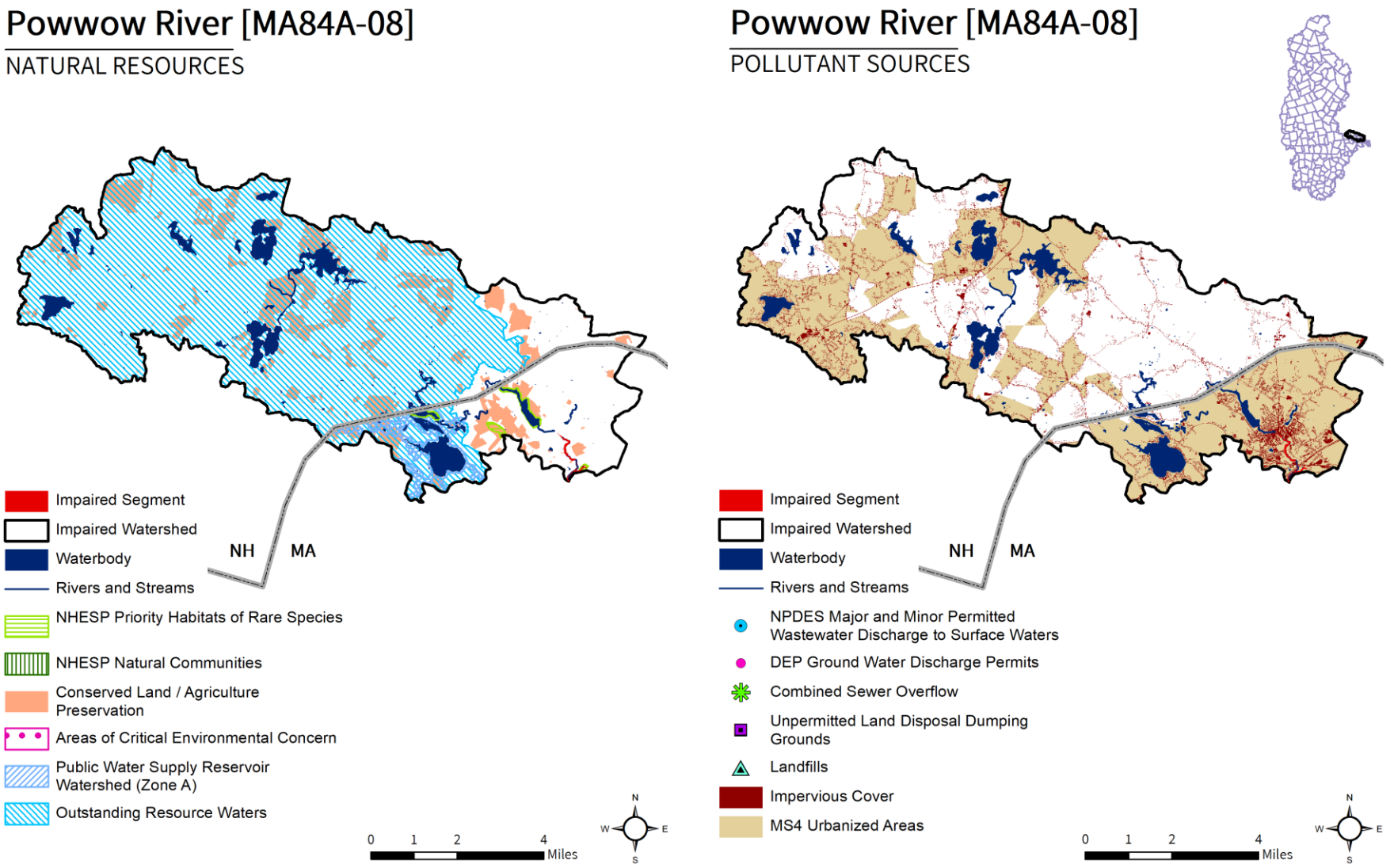


Figure 9-1. Natural resources and potential pollution sources draining to the Powwow River segment MA84A-08. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land shown reflects land protected in perpetuity only and the impervious cover shown is from a high-resolution product available for Rockingham and Strafford counties in New Hampshire.

9.2. Waterbody Impairment Characterization

The Powwow River (MA84A-08) is a Class SB, tidal estuary, with a Shellfishing qualifier (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). CDM collected *E. coli* samples in the Powwow River at one site (T011) in 2003. The geometric mean of *E. coli* at this site was 566 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

9.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (21%), with the greatest density of development located directly adjacent to the segment in the City of Amesbury. Within the Massachusetts portion of the watershed, 94% of the land area is subject to MS4 permit conditions, 11% is classified as impervious area, and 6% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts City of Amesbury. Sewerage-related risks include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Illicit Boat Discharges: The segment is navigable by marine vessels. Vessels with onboard toilets are required to have a marine sanitation device (MSD) to treat or store wastewater. MSDs that treat wastewater may be improperly maintained or malfunctioning and therefore could discharge untreated sewage to coastal waterbodies. For MSDs that store wastewater, this sewage can either be pumped out at shore-based pump-out facilities (CZM, 2022b) or discharged directly into the water when the vessel is more than three miles offshore, beyond the designated No Discharge Zone (NDZ). Boaters who ignore these laws and discharge untreated sewage to coastal waterbodies may be a source of pathogen pollution.

Vessel Pump-Out Facilities: There are no vessel sewage pump-out facilities directly adjacent to the Powwow River segment MA84A-08 (CZM, 2022b). Although pump-out facilities provide boaters with a means of disposing onboard sewage without discharging it into coastal waters, these facilities are generally associated with high boating activity. Pump-out facilities which malfunction or leak also represent a potential pathogen source. As a result, waterbodies adjacent to pump-out facilities are likely at high risk of illicit boat (and facility) discharges.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for a sizable portion (11%) of the total land use. There are multiple large fields of hay and cultivated crops located adjacent to the impaired segment and its tributaries. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few high-density residential developments and parks near the Powwow River segment MA84A-08. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few small open fields are located directly adjacent to the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

9.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Amesbury. See Section 7.4

MassDEP awarded the City of Amesbury a Section 604(b) grant in 2021 for a project entitled “Comprehensive Watershed-Based Planning for a Sustainable Future”. The city will develop a community-wide comprehensive plan of prioritized water quality restoration recommendations that can be used as a road map over the next 10 years, with a focus on climate change impacts, sustainability and long-term resiliency, and agricultural/backyard farming pollution abatement. Watershed-based plans will be developed or updated for the Powwow River and Lake Gardner, Back River and Lake Attitash watersheds. Five conceptual BMP design plans will also be developed and a preliminary Green Streets survey will be conducted for the downtown (MassDEP, 2021c).

10. MA84A-09 Little River

10.1. Waterbody Overview

The Little River segment MA84A-09 is 4.6 miles long and begins at the state line between Plaistow, NH and Haverhill, MA. The segment flows southeast before ending at the Merrimack River in Haverhill, MA.

Tributaries to the Little River segment MA84A-09 include Fishin Brook, an unnamed tributary, and Snows Brook. Lakes and ponds in the Massachusetts portion of the watershed include a few unnamed waterbodies. Much of the river flows through wetland or developed areas.

Key landmarks in the Massachusetts portion of the watershed include part of the city center of Haverhill; Haverhill High School; Haverhill Country Club; and John's Woods at Tattersall Farm. From upstream to downstream, segment MA84A-09 is crossed by Rosemont Street, I-495, Winter Street/MA-97, Locke Street, Locust Street, Essex Street, Wingate Street, Washington Street/MA-110, Phoenix Row, and Wall Street, all in Haverhill.

The Little River (MA84A-09) drains a total area of 29.1 square miles (mi^2), of which 7.3 mi^2 (25%) are located within Massachusetts. Of these, 1.5 mi^2 (21%) are impervious and 1.0 mi^2 (14%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Haverhill[22], and 100% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, no MassDEP discharge-to-groundwater permits for on-site wastewater discharges, and four combined sewer overflows (CSOs) within the watershed (Table 10-1). There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 10-1.

The Little River segment MA84A-09 watershed is located in a highly-developed part of Massachusetts. Roughly half of the watershed in

Reduction from Highest Calculated Geomean: 65%

Watershed Area (Acres): 4,668

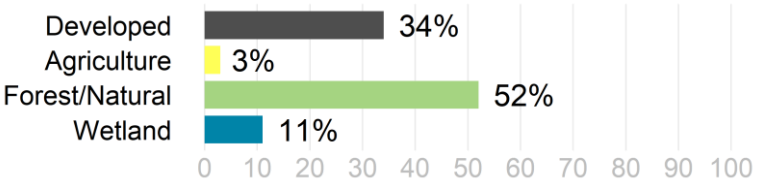
Segment Length (Miles): 4.6

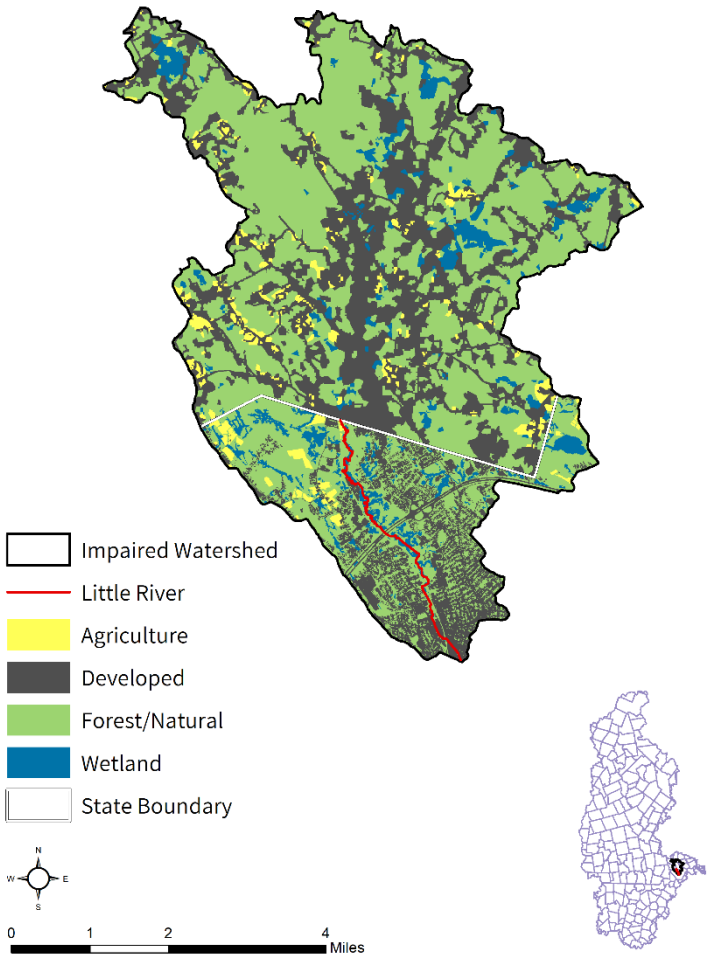
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B (Warm Water)

Impervious Area (Acres, %): 971 (21%)

DCIA Area (Acres, %): 644 (14%)





[22] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

Massachusetts consists of forest and natural lands (52%), while a little over a third consists of development (34%); wetland (11%) and agricultural areas (3%) are also present. The highest density of development is located in the lower portion of the watershed in the city of Haverhill.

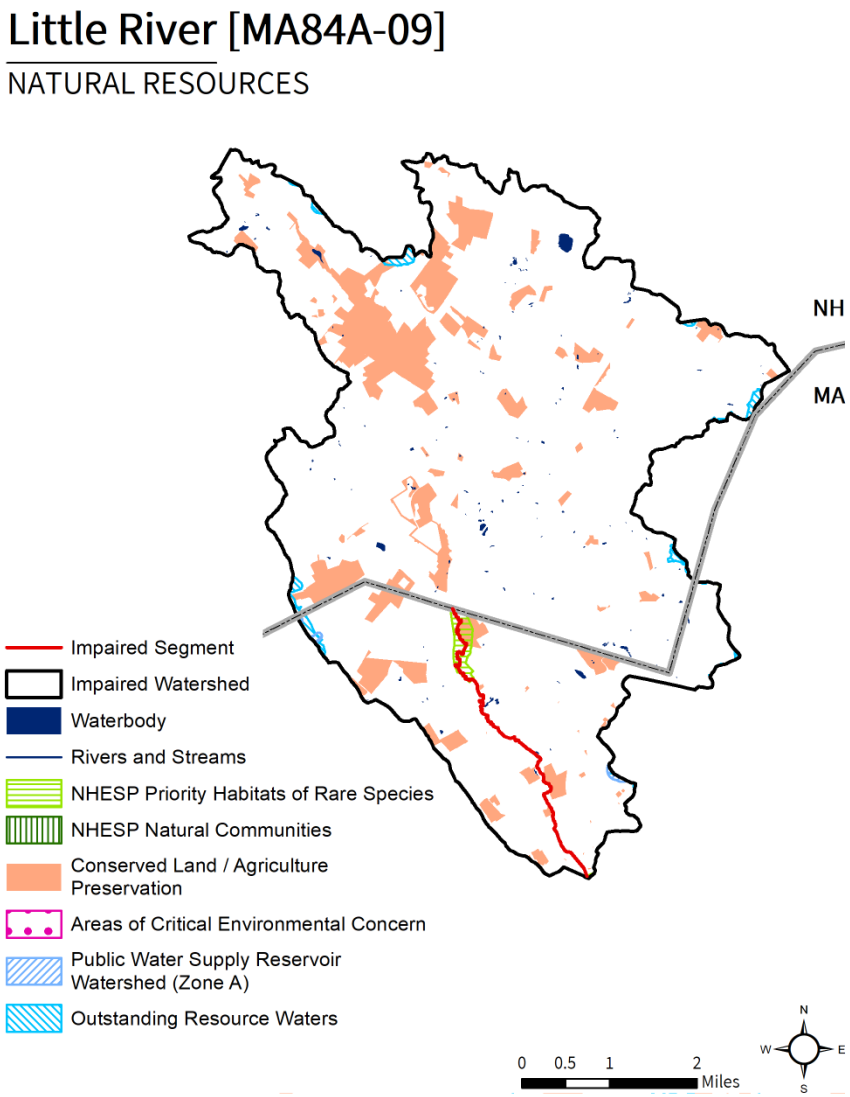
In the Massachusetts portion of the Little River (MA84A-09) watershed, under the Natural Heritage and Endangered Species Program, there are 90 acres (2%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also 16 acres (<1%) under Public Water Supply protection, no Areas of Critical Environmental Concern, and six acres (<1%) of Outstanding Resource Waters. There are 203 acres (4%) of land protected in perpetuity[23], part of 439 acres (9%) of Protected and Recreational Open Space[24]. See Figure 10-1.

Table 10-1. Combined Sewer Overflows (CSOs) discharging to the segment.

NPDES ID	NAME	TOWN	DEP OUTFALL ID
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV021B
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV021F
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV021H
MA0101621	HAVERHILL WPAF	HAVERHILL	HAV038

[23] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[24] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



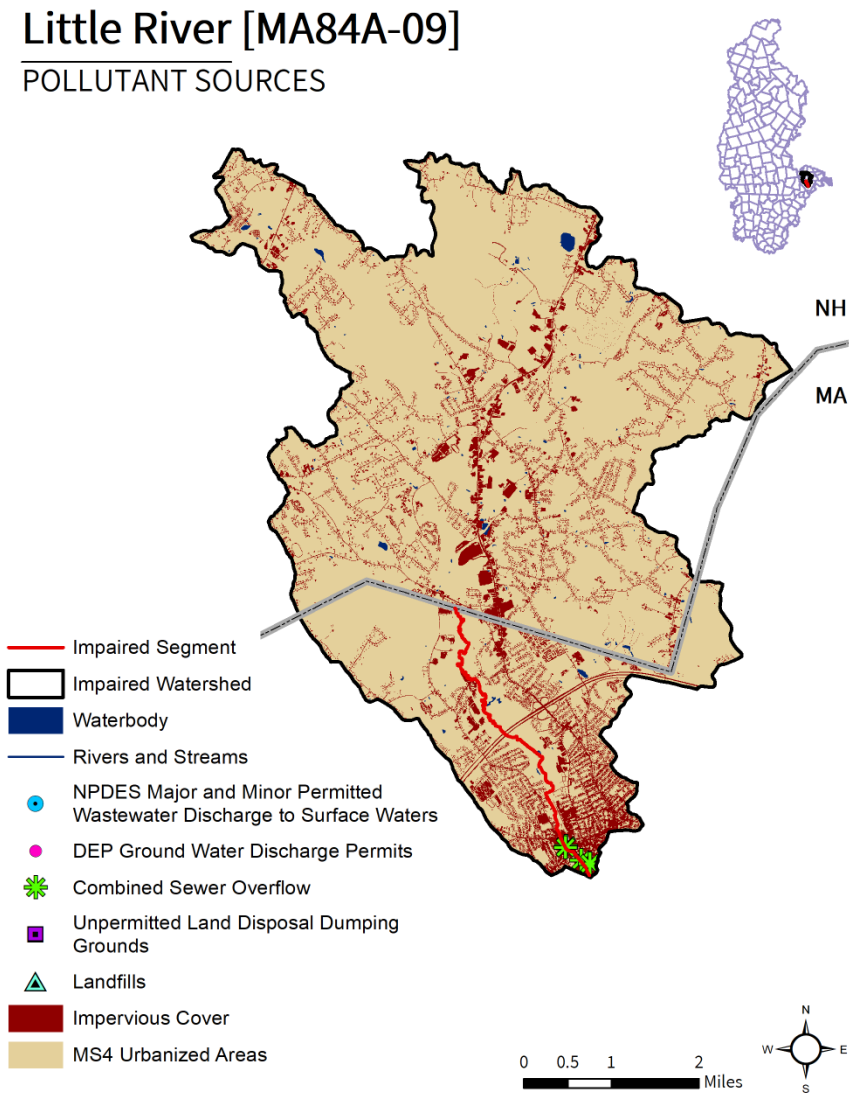


Figure 10-1. Natural resources and potential pollution sources draining to the Little River segment MA84A-09. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from a high-resolution product available for Rockingham and Strafford counties in New Hampshire.

10.2. Waterbody Impairment Characterization

The Little River (MA84A-09) is a Class B, Warm Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the station listed below (refer to Tables 10-2, 10-3; Figure 10-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the Statistical Threshold Value (STV) criterion of 410 CFU/100 mL for *E. coli.* The geomean and STV criteria for the impaired segment apply to data on a year-round, 30-day rolling basis.

- In 2010, six samples were collected at W2162 data indicated five days when the 30-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of six samples, none exceeded the STV criterion.

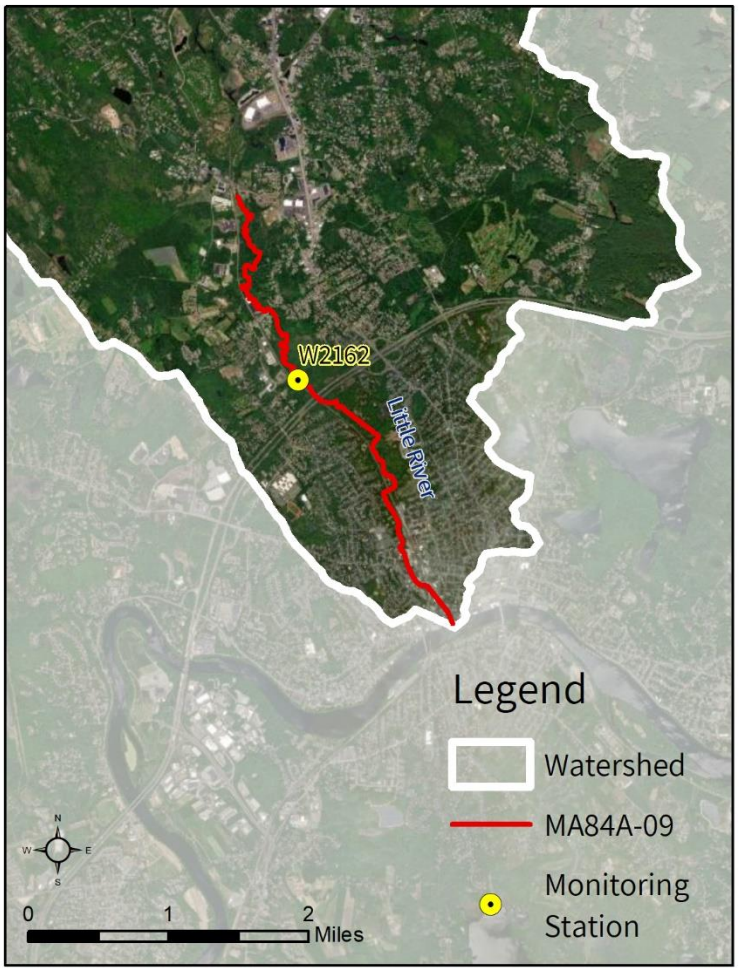


Figure 10-2. Location of monitoring station(s) along the impaired segment.

Table 10-2. Summary of indicator bacteria sampling results by station for the Little River (MA84A-09). The maximum 30-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 30-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 30-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W2162	5/25/2010	10/5/2010	6	359	5	0

Table 10-3. Indicator bacteria data by station, indicator, and date for the Little River (MA84A-09). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 30-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	30-Day Rolling Geomean (CFU/100mL)	30-Day Rolling STV (CFU/100mL)
W2162	*E. coli*	5/25/2010	DRY	150	150	
W2162	*E. coli*	6/17/2010	DRY	190	169	
W2162	*E. coli*	6/29/2010	DRY	170	180	
W2162	*E. coli*	8/3/2010	DRY	340	340	
W2162	*E. coli*	8/30/2010	DRY	380	359	
W2162	*E. coli*	10/5/2010	DRY	81	81	

10.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to surface waters via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and direct wildlife and domesticated animal waste (including pets).

Indicator bacteria data for the Little River (MA84A-09) were elevated during dry weather (wet weather data were not available). Elevated results during dry weather suggest that baseflow sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be major sources of pathogens. Given the relatively small sample set collected only dry weather conditions, additional sampling under both wet and dry conditions, ideally at more than one location, would likely help identify pollutant sources.

Each potential pathogen source is described in further detail below.

Combined Sewer Overflow (CSO): There are four CSOs in the watershed that discharge directly into the impaired segment. CSOs by design release untreated wastewater to surface waters when flows exceed system capacity, and therefore must be eliminated. For this reason, addressing this pathogen source is set as the highest priority.

Urban Stormwater: There is a substantial amount of development in the watershed (34%), with the greatest density of development located in the lower portion of the watershed in the city of Haverhill. Within the Massachusetts portion of the watershed, 100% of the land area is subject to MS4 permit conditions, 21% is classified as impervious area, and 14% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts city of Haverhill. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for only a small portion (3%) of the total land use, with a few small fields located in the upper watershed. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few high-density residential developments and parks near the Little River segment MA84A-09. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: Most of the impaired segment flows through a corridor of wetland areas. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

10.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Haverhill. See Section 6.4

11. MA84A-10 Spicket River

11.1. Waterbody Overview

The Spicket River segment MA84A-10 is 5.8 miles long and begins at the state line between Salem, NH and Methuen, MA. The segment flows southeast before ending at the Merrimack River in Lawrence, MA.

Tributaries to the Spicket River segment MA84A-10 include World End Brook and Harris Brook. Lakes and ponds in the watershed include Forest Lake and Mystic Pond in Massachusetts. Much of the river flows through wetland or developed areas.

Key landmarks in the Massachusetts portion of the watershed include the city centers of Methuen and Lawrence; Methuen High School; Central Catholic High School; Holy Family Hospital Methuen; Lawrence General Hospital; and Merrimack Valley Golf Club. From upstream to downstream, segment MA84A-10 is crossed by Hampshire Road (Methuen), Albert Slack Highway/MA-213 (Methuen), Lowell Street/MA-113 (Methuen), Osgood Street (Methuen), Broadway/MA-28 (twice in Methuen, once in Lawrence), Spruce Street (Lawrence), Hampshire Street (Lawrence), Bennington Street (Lawrence), Lawrence Street (Lawrence), Short Street (Lawrence), Jackson Street/MA-110 (Lawrence), East Haverhill Street (Lawrence), Newbury Street (Lawrence), Haverhill Street (Lawrence), General Street (Lawrence), and Canal Street (Lawrence).

The Spicket River (MA84A-10) drains a total area of 55.0 square miles (mi^2), of which 11.4 mi^2 (21%) are located within Massachusetts. Of these, 3.0 mi^2 (27%) are impervious and 2.1 mi^2 (18%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Lawrence and Methuen[25], and 100% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, no MassDEP discharge-to-groundwater permits for on-site wastewater discharges, and one combined sewer overflow (CSO) within the watershed (Table 11-1).

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 7,304

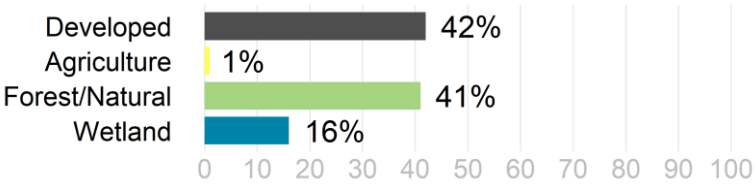
Segment Length (Miles): 5.8

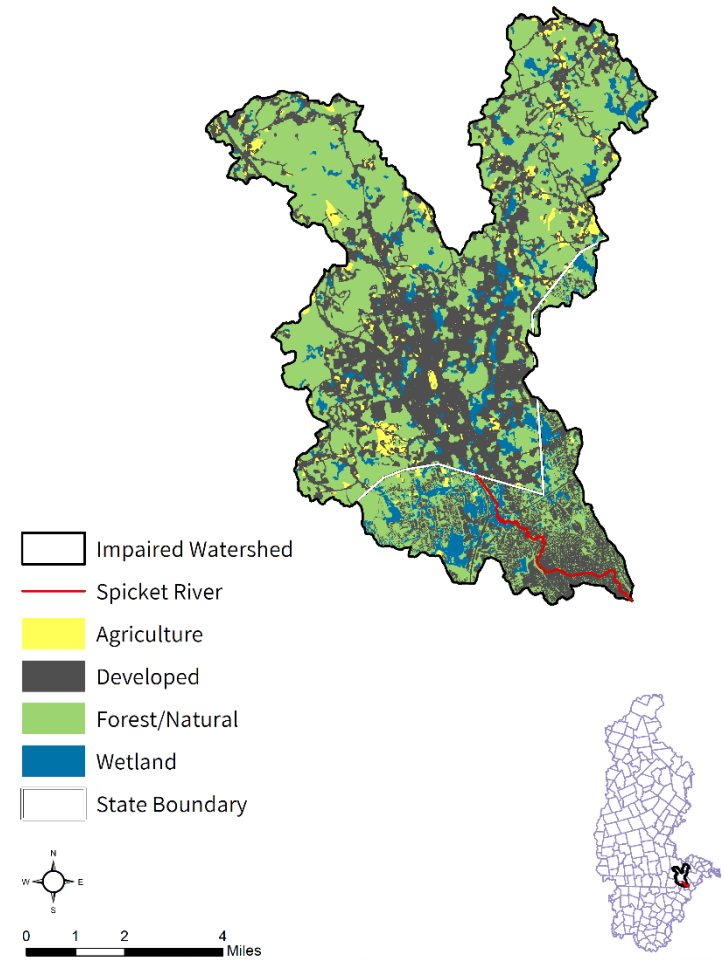
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B (Warm Water, CSO Receiving Water)

Impervious Area (Acres, %): 1,937 (27%)

DCIA Area (Acres, %): 1,328 (18%)





[25] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

There is one landfill and no unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 11-1.

The Spicket River segment MA84A-10 watershed is located in a highly-developed part of Massachusetts. There are roughly equal amounts of forest and natural land (41%) and developed land (42%) in the Massachusetts portion of the watershed. Most of the remaining land is covered by wetland areas (16%), as there is little agricultural land (1%) in Massachusetts. The highest density of development is located in the lower portion of the watershed in the City of Lawrence.

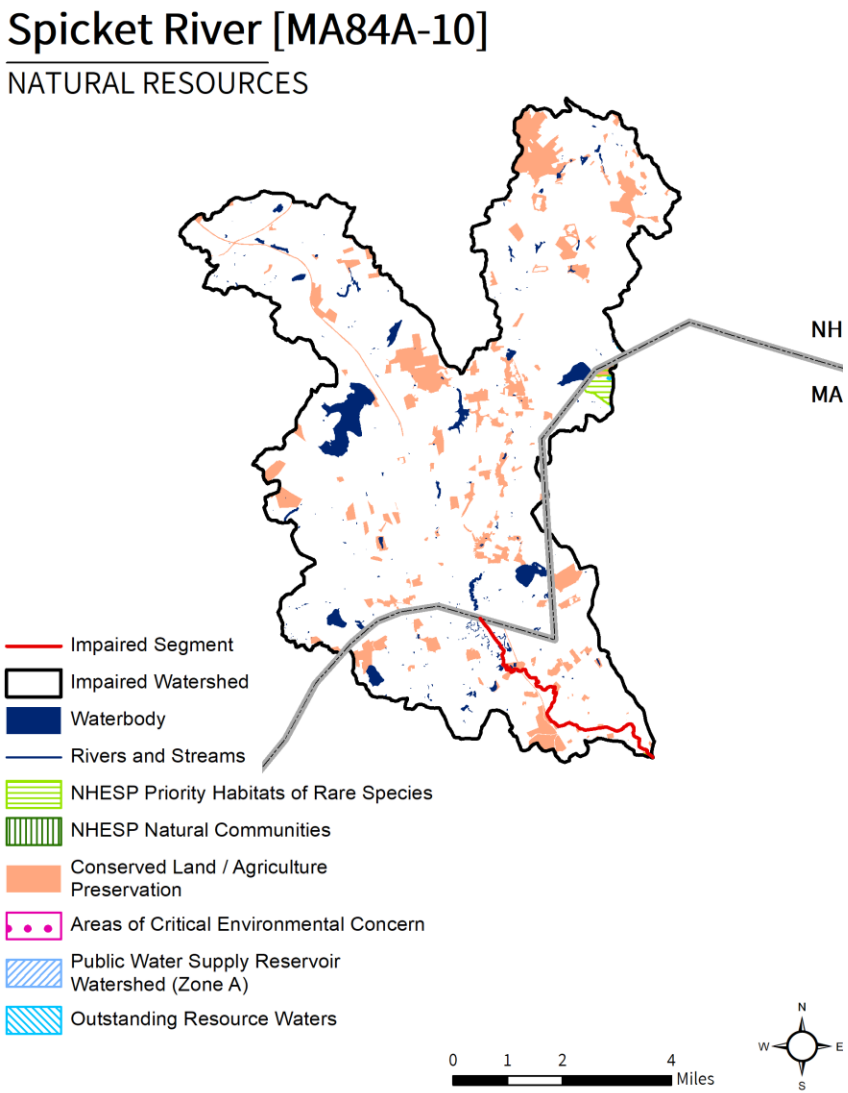
In the Massachusetts portion of the Spicket River (MA84A-10) watershed, under the Natural Heritage and Endangered Species Program, there are 172 acres (2%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There is less than one acre (<1%) under Public Water Supply protection, no Areas of Critical Environmental Concern, and six acres (<1%) of Outstanding Resource Waters. There are 370 acres (7%) of land protected in perpetuity[26], part of 772 acres (11%) of Protected and Recreational Open Space[27]. See Figure 11-1.

Table 11-1 Combined Sewer Overflows (CSOs) discharging to the segment.

NPDES ID	NAME	TOWN	DEP OUTFALL ID
MA0100447	GREATER LAWRENCE SD	LAWRENCE	GLSD006

[26] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[27] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



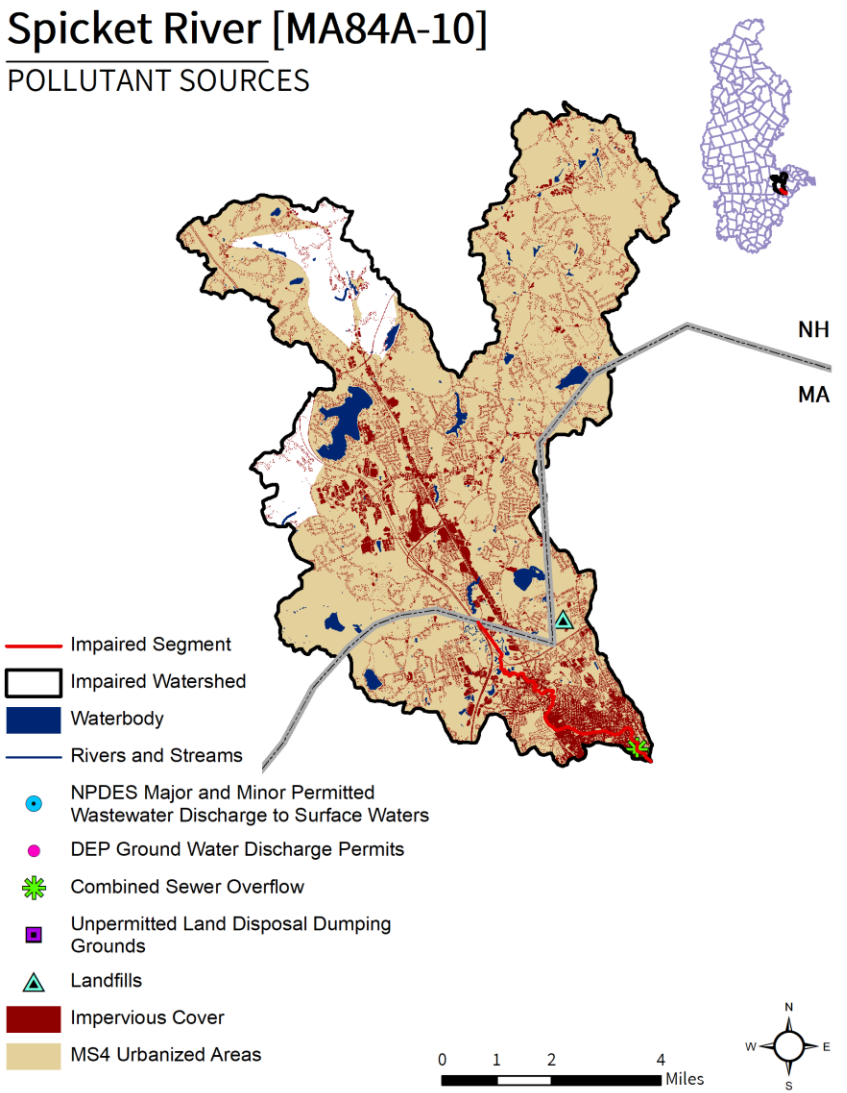


Figure 11-1. Natural resources and potential pollution sources draining to the Spicket River segment MA84A-10. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from a high-resolution product available for Rockingham and Strafford counties in New Hampshire.

11.2. Waterbody Impairment Characterization

The Spicket River (MA84A-10) is a Class B, Warm Water, and CSO Receiving Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). CDM collected *E. coli* samples in the Spicket River at one site (T011) in 2003. The geometric mean of *E. coli* at this site was 566 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010). Additionally, a presumptive impairment decision is being applied for both the Primary and Secondary Recreational Uses since this waterbody does not have a CSO variance in place.

11.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Combined Sewer Overflow (CSO): There is one CSO in the watershed that discharges directly into the impaired segment. CSOs by design release untreated wastewater to surface waters when flows exceed system capacity, and therefore must be eliminated. For this reason, addressing this pathogen source is set as the highest priority.

Urban Stormwater: There is a substantial amount of development in the watershed (42%), with the greatest density of development located in the lower portion of the watershed in the city of Lawrence. Within the Massachusetts portion of the watershed, 100% of the land area is subject to MS4 permit conditions, 27% is classified as impervious area, and 18% is classified as DCIA. Stormwater runoff from urban areas is likely a significant source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts cities of Lawrence and Methuen. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: There are few agricultural activities (1%) in the Massachusetts portion of the watershed. As a result, stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: There are multiple parks and high-density residential developments directly adjacent to the Spicket River segment MA84A-10. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few athletic fields and a large cemetery are located directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

11.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Lawrence. See Section 5.4

City of Methuen. See Section 5.4

MassDEP awarded the City of Methuen a Section 604(b) grant in 2021 for a project entitled “Spicket River Nutrient and Pathogen Reduction”. The city will partner with the City of Lawrence, the Merrimack Valley Planning Commission, the Merrimack River Watershed Council and Groundwork Lawrence to investigate and develop solutions for pathogen and nutrient impairments in the Spicket River. The project will conduct a land use assessment, collect water quality data, develop a watershed-based plan, prepare preliminary designs for five-

to-eight best management practices (BMPs), and implement a multi-lingual water quality outreach campaign (MassDEP, 2021c).

12. MA84A-11 Beaver Brook

12.1. Waterbody Overview

Beaver Brook segment MA84A-11 is 4.8 miles long and begins at the state line between Pelham, NH and Dracut, MA. The segment flows southeast before ending at the Merrimack River in Lowell, MA.

Tributaries to Beaver Brook segment MA84A-11 include Gumpas Pond Brook, Double Brook, an unnamed tributary, and Peppermint Brook (MA84A-35). Lakes and ponds in the watershed include Long Pond in Massachusetts. Much of the river flows through wetland or developed areas.

Key landmarks in the Massachusetts portion of the watershed include the town center of Dracut; Dracut High School; Justus C. Richardson Middle School; Englesby Elementary School; Brookside Elementary School; the University of Massachusetts Lowell; and the Lowell-Dracut-Tyngsboro State Forest. From upstream to downstream, segment MA84A-11 is crossed by Lakeview Avenue (Dracut), Phineas Street (Dracut), Parker Avenue (Dracut), Pleasant Street/MA-113 (Dracut), Beaver Street (Lowell), and Veterans of Foreign Wars Highway (Lowell).

Beaver Brook (MA84A-11) drains a total area of 21.4 square miles (mi^2), of which 9.7 mi^2 (45%) are located within Massachusetts. Of these, 2.0 mi^2 (20%) are impervious and 1.3 mi^2 (13%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Dracut and Lowell[28], and 99% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, no MassDEP discharge-to-groundwater permits for on-site wastewater discharges, and one combined sewer overflow (CSO) within the watershed (Table 12-1). There is one landfill and no unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 12-1.

The Beaver Brook segment MA84A-11 watershed is located in a highly-developed part of

Reduction from Highest Calculated Geomean: 86%

Watershed Area (Acres): 6,200

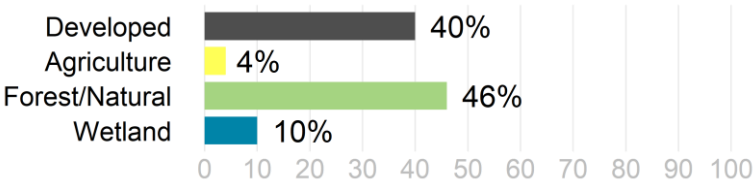
Segment Length (Miles): 4.8

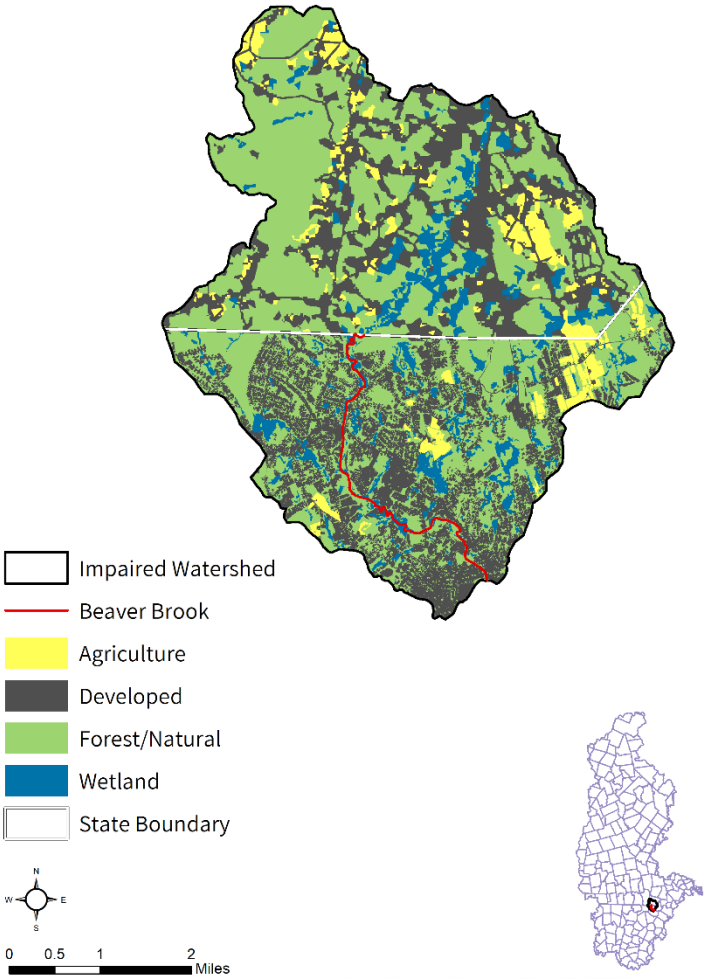
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B (Cold Water)

Impervious Area (Acres, %): 1,265 (20%)

DCIA Area (Acres, %): 805 (13%)





[28] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

Massachusetts. There are roughly equal amounts of forest and natural land (46%) and developed land (40%) in the Massachusetts portion of the watershed; wetland (10%) and agricultural areas (4%) are also present. The highest density of development is located in the lower portion of the watershed in the City of Lowell.

In the Massachusetts portion of the Beaver Brook (MA84A-11) watershed, under the Natural Heritage and Endangered Species Program, there are 657 acres (11%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. There are 776 acres (13%) of land protected in perpetuity[29], part of 870 acres (14%) of Protected and Recreational Open Space[30]. See Figure 12-1.

Table 12-1 Combined Sewer Overflows (CSOs) discharging to the segment.

NPDES ID	NAME	TOWN	DEP OUTFALL ID
MA0100633	LOWELL REGIONAL W&WW UTILITY	LOWELL	LOW007

[29] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[30] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

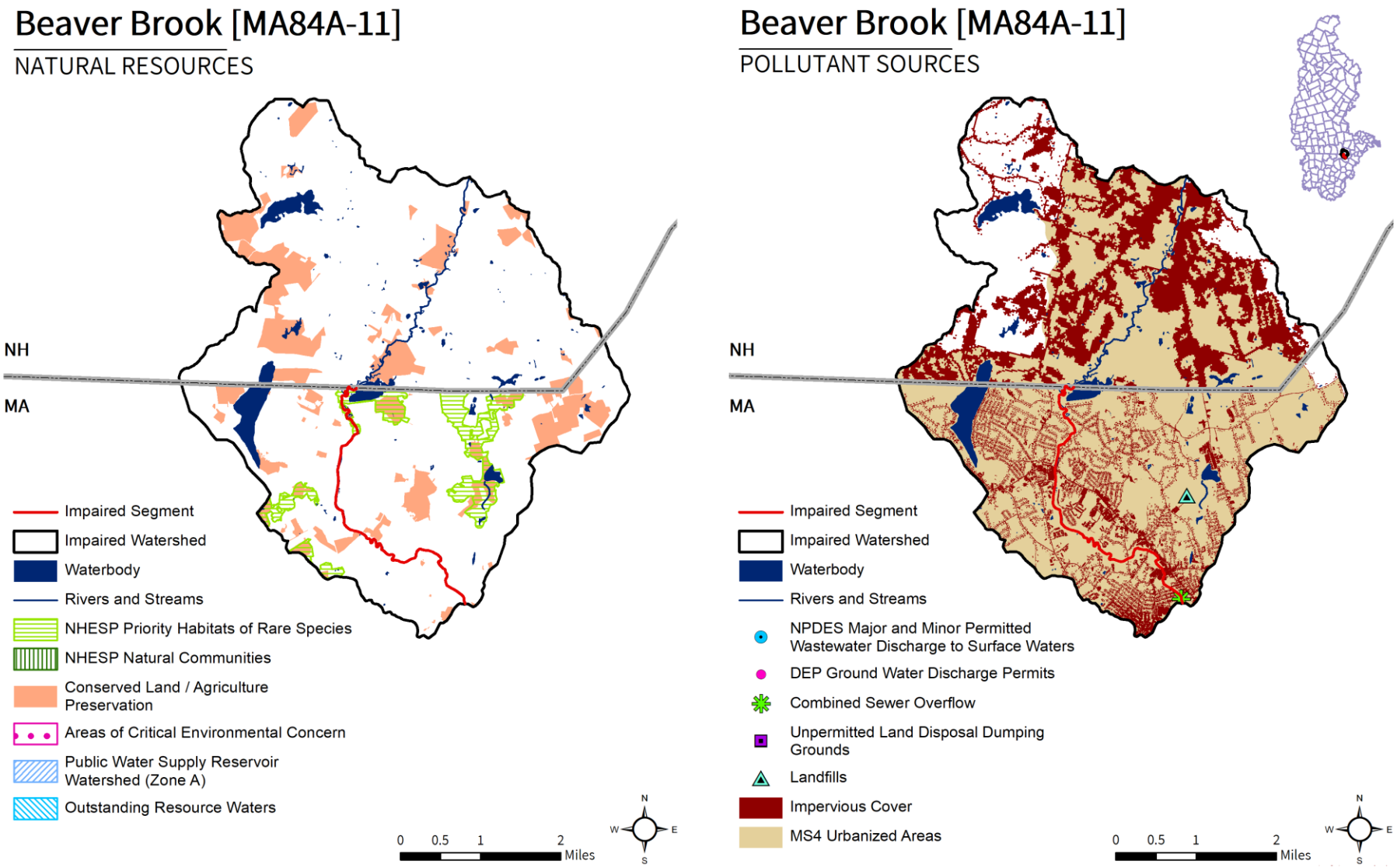


Figure 12-1. Natural resources and potential pollution sources draining to the Beaver Brook segment MA84A-11. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from the 2019 National Land Cover Database.

12.2. Waterbody Impairment Characterization

Beaver Brook (MA84A-11) is a Class B, Cold Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the stations listed below (refer to Tables 12-2, 12-3; Figure 12-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the STV criterion of 410 CFU/100 mL for *E. coli*. The geomean and STV criteria for the impaired segment apply to data on a year-round, 30-day rolling basis.

- In 2015, five samples were collected at W2510; data indicated three days when the 30-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of five samples, none exceeded the STV criterion.
- In 2015, five samples were collected at W2533; data indicated three days when the 30-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the STV criterion was applied to single sample results. Out of five samples, one exceeded the STV criterion during dry weather.

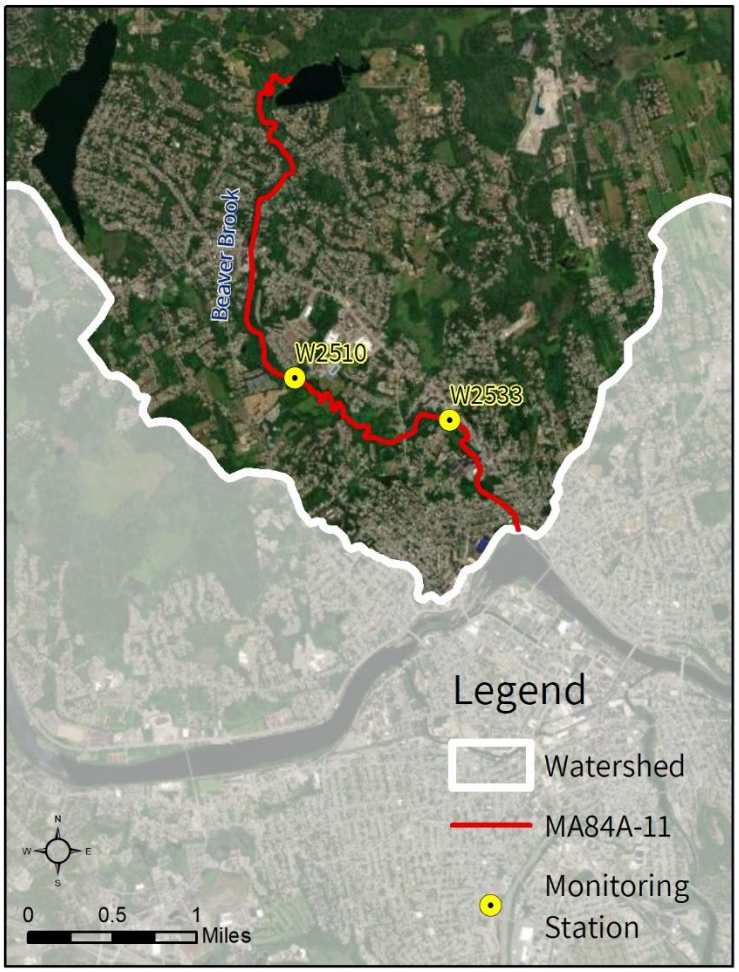


Figure 12-2. Location of monitoring station(s) along the impaired segment.

Table 12-2. Summary of indicator bacteria sampling results by station for Beaver Brook (MA84A-11). The maximum 30-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 30-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 30-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W2510	5/12/2015	9/2/2015	5	240	3	0
W2533	5/12/2015	9/2/2015	5	883	3	1

Table 12-3. Indicator bacteria data by station, indicator, and date for Beaver Brook (MA84A-11). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 30-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	30-Day Rolling Geomean (CFU/100mL)	30-Day Rolling STV (CFU/100mL)
W2510	*E. coli*	5/12/2015	DRY	74	74	
W2510	*E. coli*	6/4/2015	WET	250	136	
W2510	*E. coli*	7/14/2015	DRY	98	98	
W2510	*E. coli*	8/5/2015	DRY	340	183	
W2510	*E. coli*	9/2/2015	DRY	170	240	
W2533	*E. coli*	5/12/2015	DRY	31	31	
W2533	*E. coli*	6/4/2015	WET	210	81	
W2533	*E. coli*	7/14/2015	DRY	130	130	
W2533	*E. coli*	8/5/2015	DRY	6,000	883	
W2533	*E. coli*	9/2/2015	DRY	41	496	

12.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to the river via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and direct wildlife and domesticated animal waste (including pets).

Indicator bacteria levels for Beaver Brook (MA84A-11) were elevated during both wet and dry weather. Both MassDEP water quality stations (W2510, W2533) were located upstream of the one CSO discharge on this segment. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources. Certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation, may also result in elevated levels of indicator bacteria during wet weather events. Elevated results during dry weather suggest that baseflow sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be major sources of pathogens. Additional sampling under wet conditions may lead to identification of pollutant sources.

Each potential pathogen source is described in further detail below.

Combined Sewer Overflow (CSO): There is one CSO in the watershed that discharges directly to the impaired segment. CSOs by design release untreated wastewater to surface waters when flows exceed system capacity, and therefore must be eliminated. For this reason, addressing this pathogen source is set as the highest priority.

Urban Stormwater: There is a substantial amount of development in the watershed (40%), with the greatest density of development located in the lower portion of the watershed in the city of Lowell. Within the Massachusetts portion of the watershed, 99% of the land area is subject to MS4 permit conditions, 20% is classified as impervious area, and 13% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts municipalities of Dracut and Lowell. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for only a small portion (4%) of the total land use, with hay and cultivated fields scattered throughout the watershed. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few high-density residential developments and parks near Beaver Brook segment MA84A-11. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few parks and open fields are located adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

12.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Lowell. See Section 3.4

Town of Dracut. See Section 5.4

13. MA84A-12 Richardson Brook

13.1. Waterbody Overview

Richardson Brook segment MA84A-12 is 1.9 miles long and begins near Blueberry Hill Road in Dracut, MA. The segment flows southeast before ending at the Merrimack River in Dracut, MA.

Tributaries to Richardson Brook segment MA84A-12 include Potash Brook and Trout Brook (MA84A-13). There are no named lakes or ponds in the watershed, however, there are a few small unnamed waterbodies near wetland areas. Much of the river flows through forested and low-density residential areas.

Key landmarks in the watershed include Joseph A. Campbell Elementary School; Dracut Police Department; and Four Oaks Country Club. From upstream to downstream, segment MA84A-12 is crossed by Cranberry Road, Methuen Street, and Merrimack Avenue/MA-110, all in Dracut.

Richardson Brook (MA84A-12) drains a total area of 4.3 square miles (mi^2), of which 0.4 mi^2 (9%) are impervious and 0.2 mi^2 (5%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Dracut[31], and 62% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the segment watershed. See Figure 13-1.

The Richardson Brook segment MA84A-12 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (55%), while around a quarter of the land consists of development (23%), as well as wetland (16%) and agricultural areas (6%). Most of the development is concentrated in the western portion of the watershed, consisting of single-family residential neighborhoods, a golf course, and commercial and industrial buildings.

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 2,734

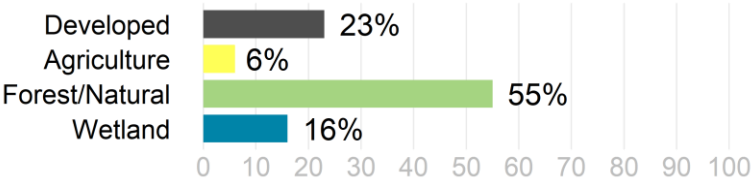
Segment Length (Miles): 1.9

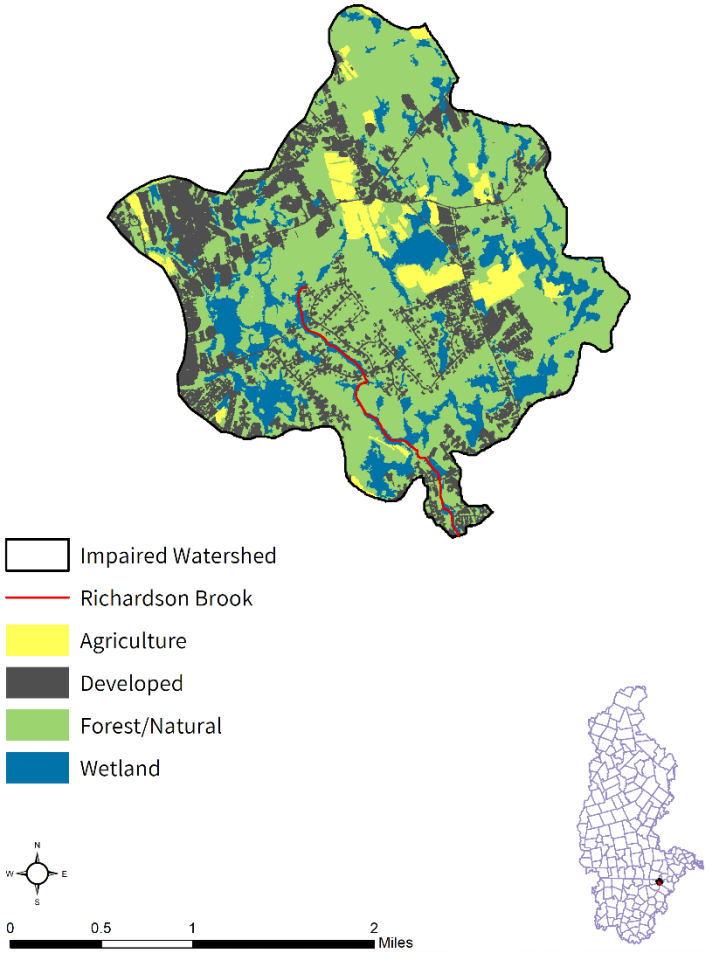
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 258 (9%)

DCIA Area (Acres, %): 139 (5%)



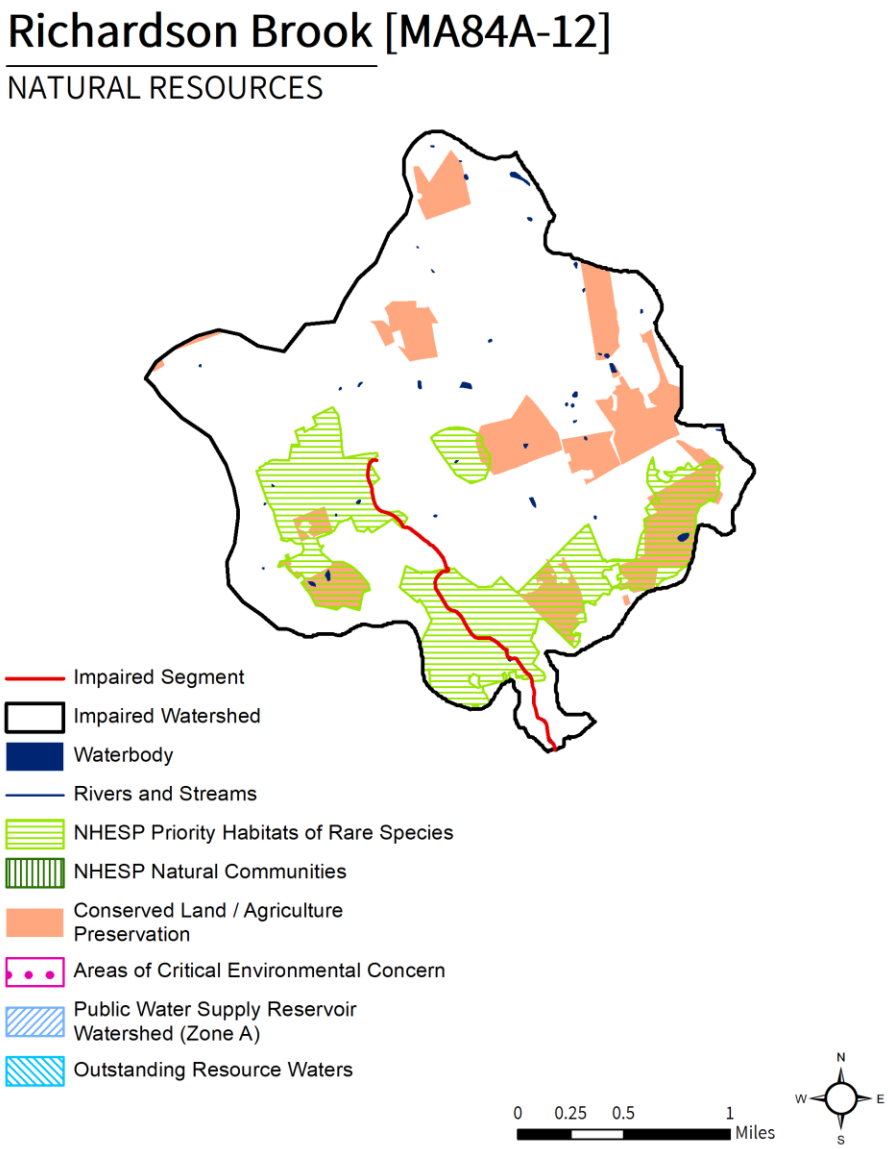


[31] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

In the Richardson Brook (MA84A-12) watershed, under the Natural Heritage and Endangered Species Program, there are 577 acres (21%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 390 acres (14%) of land protected in perpetuity[32], part of 426 acres (16%) of Protected and Recreational Open Space[33]. See Figure 13-1.

[32] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[33] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



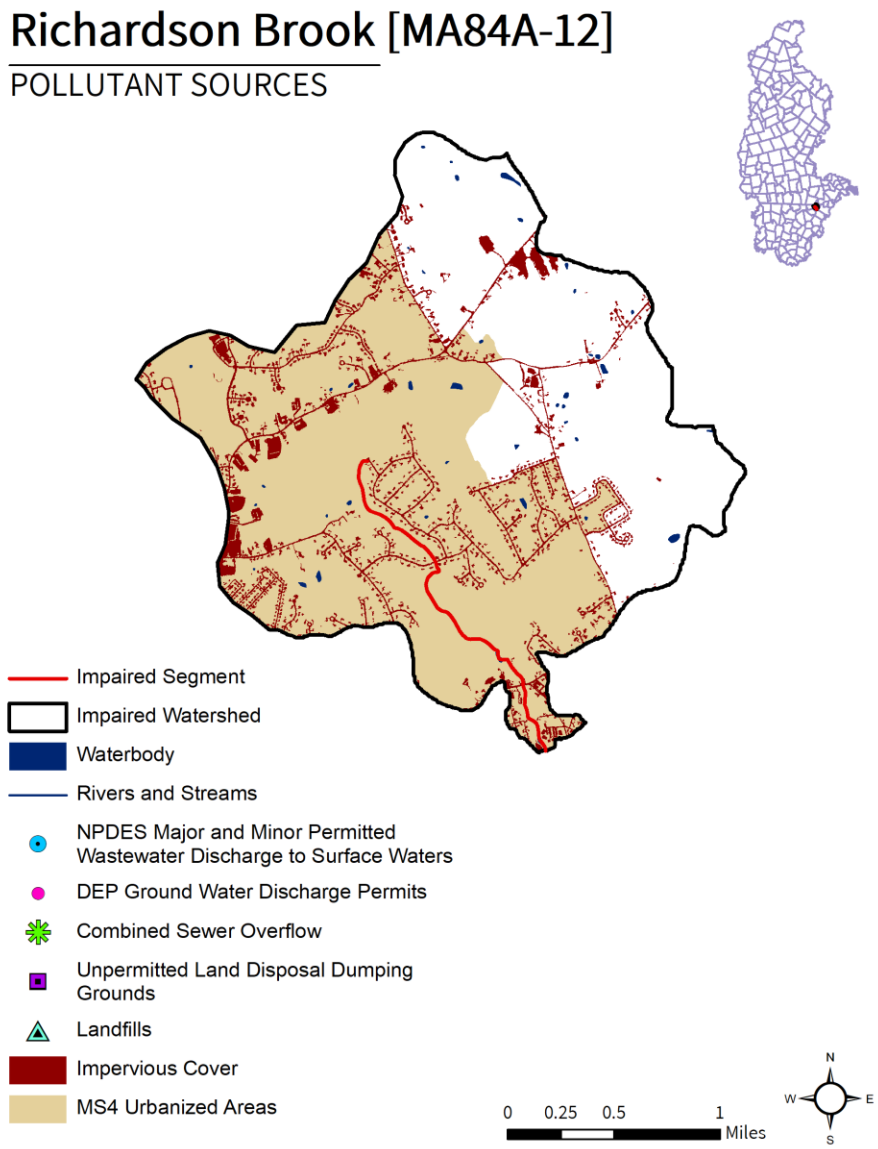


Figure 13-1. Natural resources and potential pollution sources draining to the Richardson Brook segment MA84A-12. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

13.2. Waterbody Impairment Characterization

Richardson Brook (MA84A-12) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Richardson Brook at one site (W1192) in 2004 (Figure 13-2). The geometric mean of *E. coli* at this site was 162 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

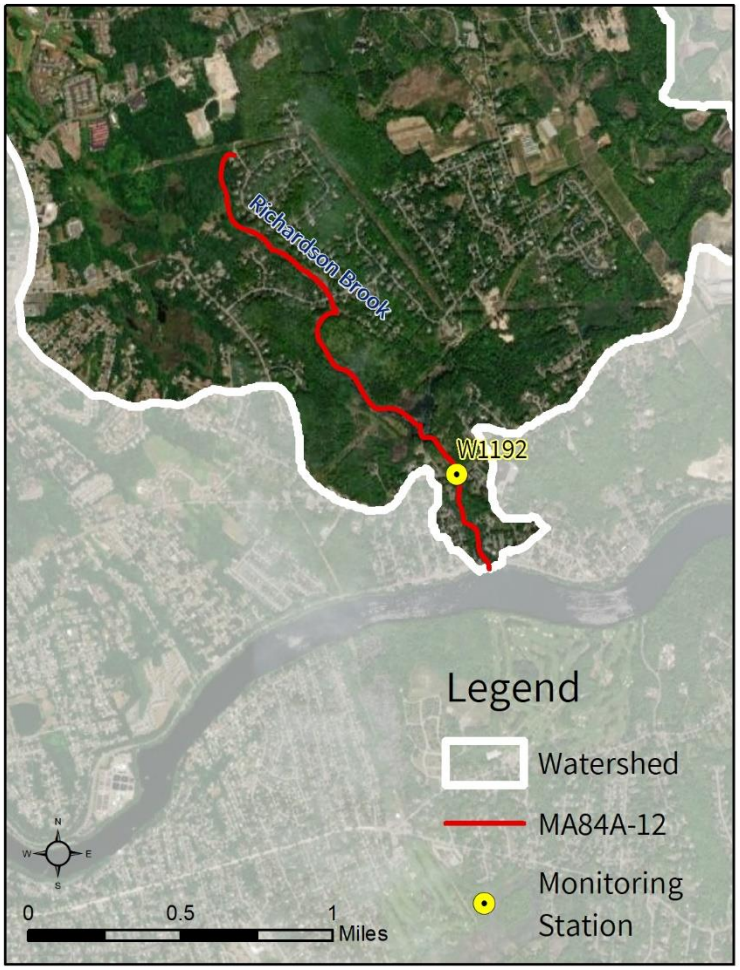


Figure 13-2. Location of monitoring station(s) along the impaired segment.

13.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (23%), with the greatest density located in the western portion near the city of Lowell. Within the watershed, 62% of the land area is subject to MS4 permit conditions, 9% is classified as impervious area, and 5% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts town of Dracut. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the watershed account for only a small portion (6%) of the total land use. Large fields of hay and cultivated land are in the eastern portion of the watershed, next to Trout Brook (MA84A-13), but away from Richardson Brook. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: A few moderate-density residential developments are located directly adjacent to the Richardson Brook segment MA84A-12. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: One small agricultural field is located directly adjacent to the impaired segment near its confluence with Trout Brook (MA84A-13). Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

13.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Dracut. See Section 5.4

14. MA84A-13 Trout Brook

14.1. Waterbody Overview

Trout Brook segment MA84A-13 is 2.6 miles long and begins near the intersection of Jones Avenue and Regency Drive in Dracut, MA. The segment flows south before ending at Richardson Brook in Dracut, MA.

Tributaries to Trout Brook segment MA84A-13 include a few unnamed streams. There are no named lakes or ponds in the watershed, however, a few small unnamed waterbodies are located near wetland areas. Much of the river flows through a combination of forested, wetland, and low-density residential areas.

Key landmarks in the watershed include Dracut Fire Department Station 2; Centralville Sportsman's Club; and Farmer Dave's fruit and vegetable farm. From upstream to downstream, segment MA84A-13 is crossed by Broadway Road/MA-113, Wheeler Road, Parker Road, Kenwood Road, and Pelczar Road, all in Dracut.

Trout Brook (MA84A-13) drains a total area of 2.4 square miles (mi^2), of which 0.2 mi^2 (7%) are impervious and 0.1 mi^2 (3%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Dracut[34], and 33% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the segment watershed. See Figure 14-1.

The Trout Brook segment MA84A-13 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (59%) and 15% is wetland areas. There is roughly half as much land devoted to agriculture (9%) as there is to development (17%) in the watershed. Most of the agricultural fields and development in the

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 1,545

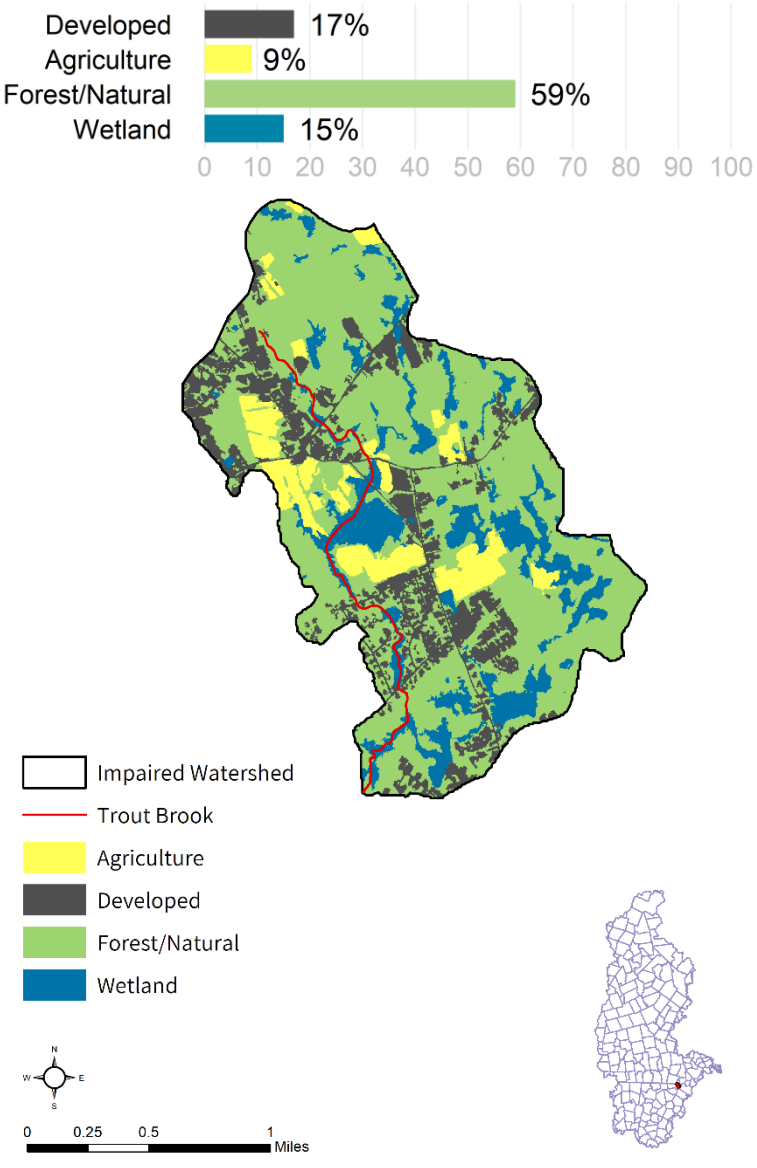
Segment Length (Miles): 2.6

Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 108 (7%)

DCIA Area (Acres, %): 53 (3%)



[34] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

watershed are located close to the impaired segment.

In the Trout Brook (MA84A-13) watershed, under the Natural Heritage and Endangered Species Program, there are 228 acres (15%) of Priority Habitats of Rare Species and Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 343 acres (22%) of land protected in perpetuity[35], part of 379 acres (25%) of Protected and Recreational Open Space[36]. See Figure 14-1.

[35] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[36] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

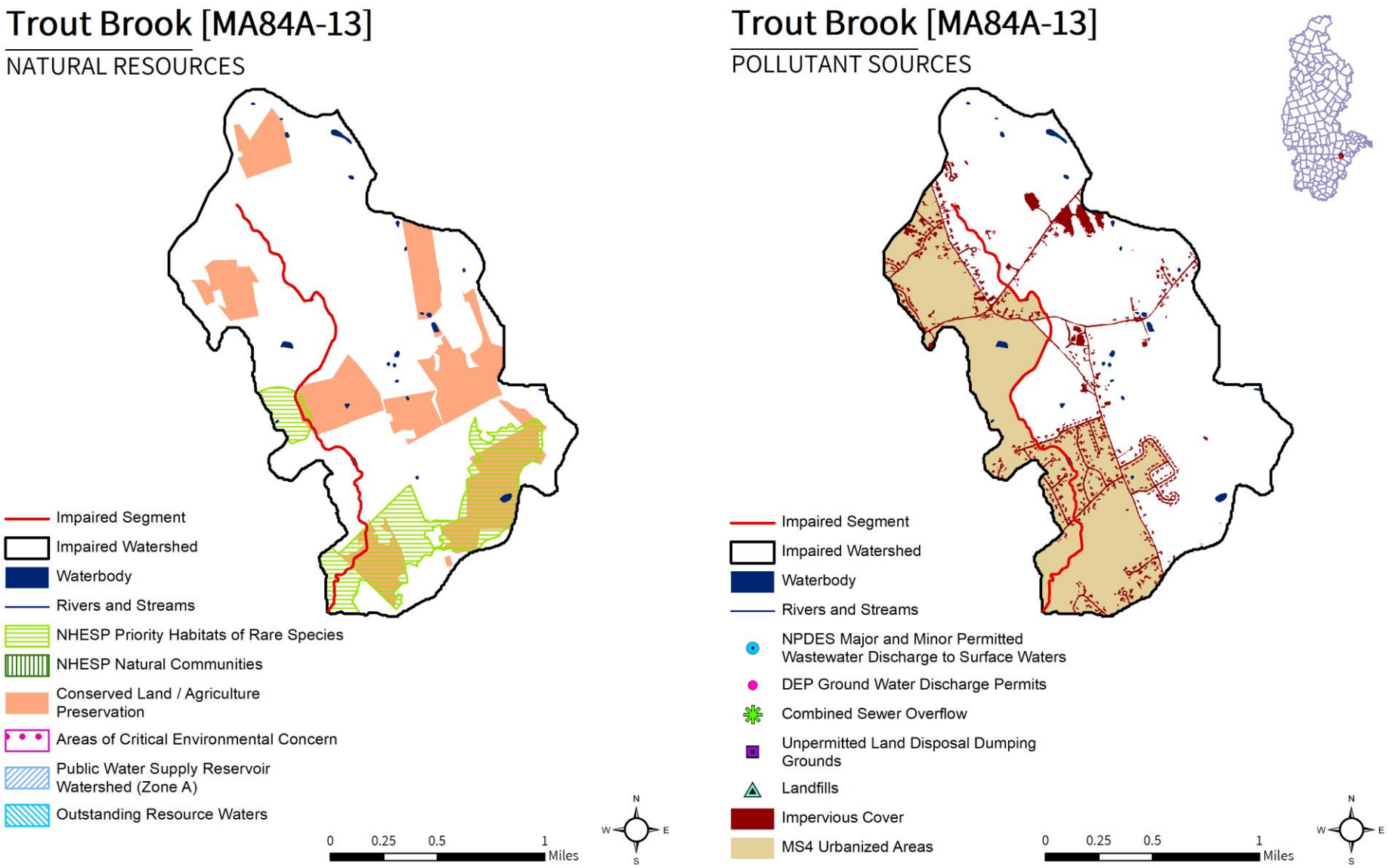


Figure 14-1. Natural resources and potential pollution sources draining to the Trout Brook segment MA84A-13. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

14.2. Waterbody Impairment Characterization

Trout Brook (MA84A-13) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Trout Brook at one site (W1193) in 2004 (Figure 14-2). The geometric mean of *E. coli* at this site was 353 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

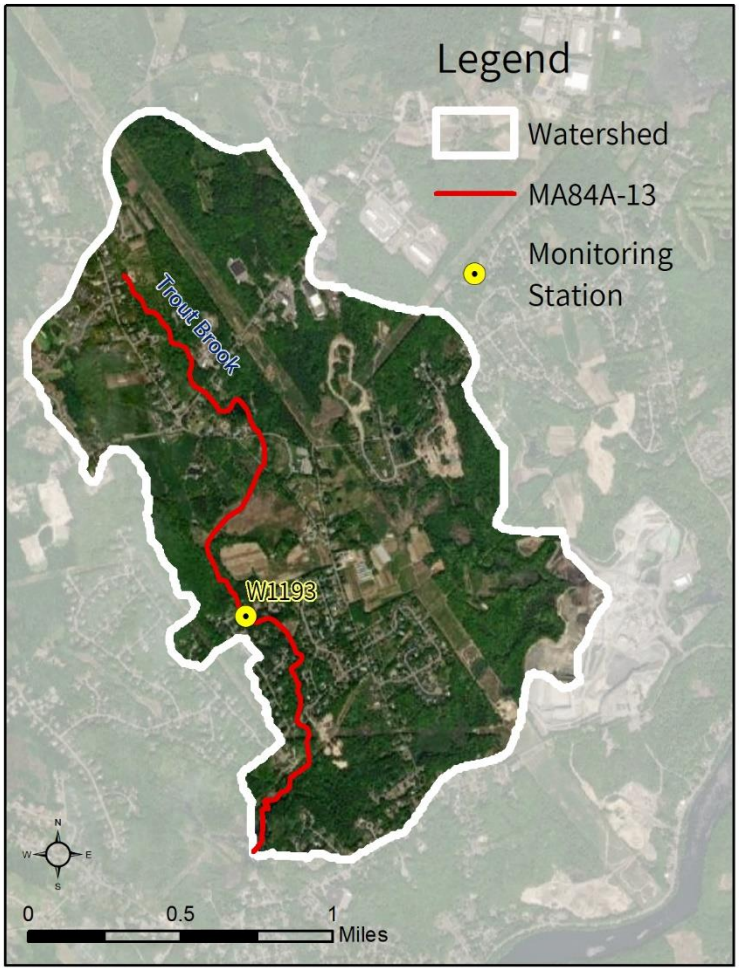


Figure 14-2. Location of monitoring station(s) along the impaired segment.

14.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (17%), most of which is located close to the impaired segment. Within the watershed, 33% of the land area is subject to MS4 permit conditions, 7% is classified as impervious area, and 3% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts town of Dracut. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the watershed account for a sizeable portion (9%) of the total land use. Large fields of hay and cultivated land are located next to the wetland areas directly surrounding the impaired segment. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: A few moderate-density residential developments are located directly adjacent to Trout Brook segment MA84A-13. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large agricultural fields and open wetland areas are located directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

14.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Dracut. See Section 5.4

15. MA84A-14 Trull Brook

15.1. Waterbody Overview

Trull Brook segment MA84A-14 is 2.1 miles long and begins near the Trull Road bridge over I-495 in Tewksbury, MA. The segment flows north before ending at the Merrimack River in Tewksbury, MA.

Tributaries to Trull Brook segment MA84A-14 include a few unnamed tributaries. There are no named lakes or ponds in the watershed, however, a few small unnamed ponds are found on two golf courses in the watershed, as well as near wetland areas. Much of the river flows through wetland and high-density residential areas.

Key landmarks in the watershed include Cawley Memorial Stadium; Long Meadow Golf Club; and Trull Brook Golf Course. From upstream to downstream, segment MA84A-14 is crossed by Andover Street/MA-133, Hood Road, and River Road, all in Tewksbury.

Trull Brook (MA84A-14) drains a total area of 4.9 square miles (mi^2), of which 1.1 mi^2 (23%) are impervious and 0.7 mi^2 (15%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Lowell and Tewksbury[37], and 100% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the segment watershed. See Figure 15-1.

The Trull Brook segment MA84A-14 watershed is located in a highly-developed part of Massachusetts. Development covers more land area within the watershed (42%) than forest and natural areas (35%) and wetland areas (23%); there is no agricultural activity (identified) in the watershed. Most of the development in the watershed is located directly adjacent to wetland areas that surround the impaired segment.

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 3,113

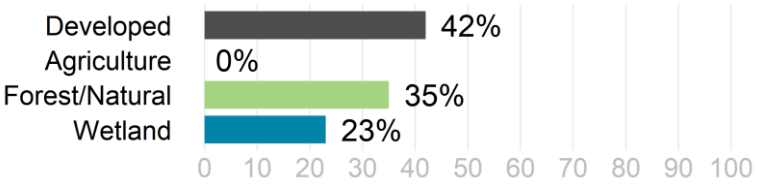
Segment Length (Miles): 2.1

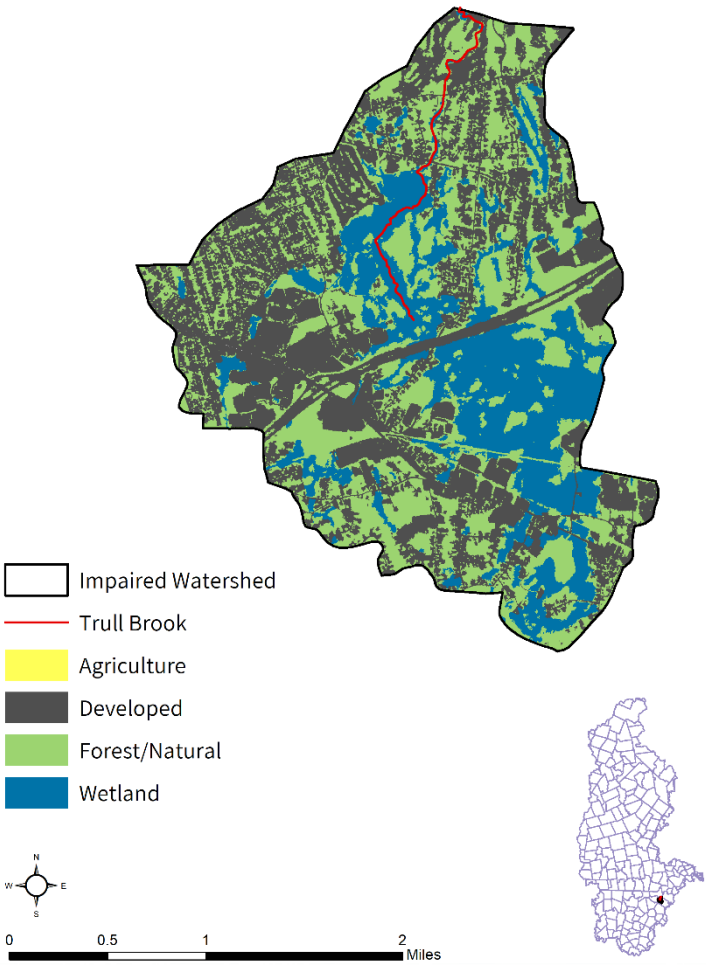
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 722 (23%)

DCIA Area (Acres, %): 472 (15%)





[37] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

In the Trull Brook (MA84A-14) watershed, under the Natural Heritage and Endangered Species Program, there are no Priority Habitats of Rare Species or Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 223 acres (7%) of land protected in perpetuity[38], part of 411 acres (13%) of Protected and Recreational Open Space[39]. See Figure 15-1.

[38] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[39] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

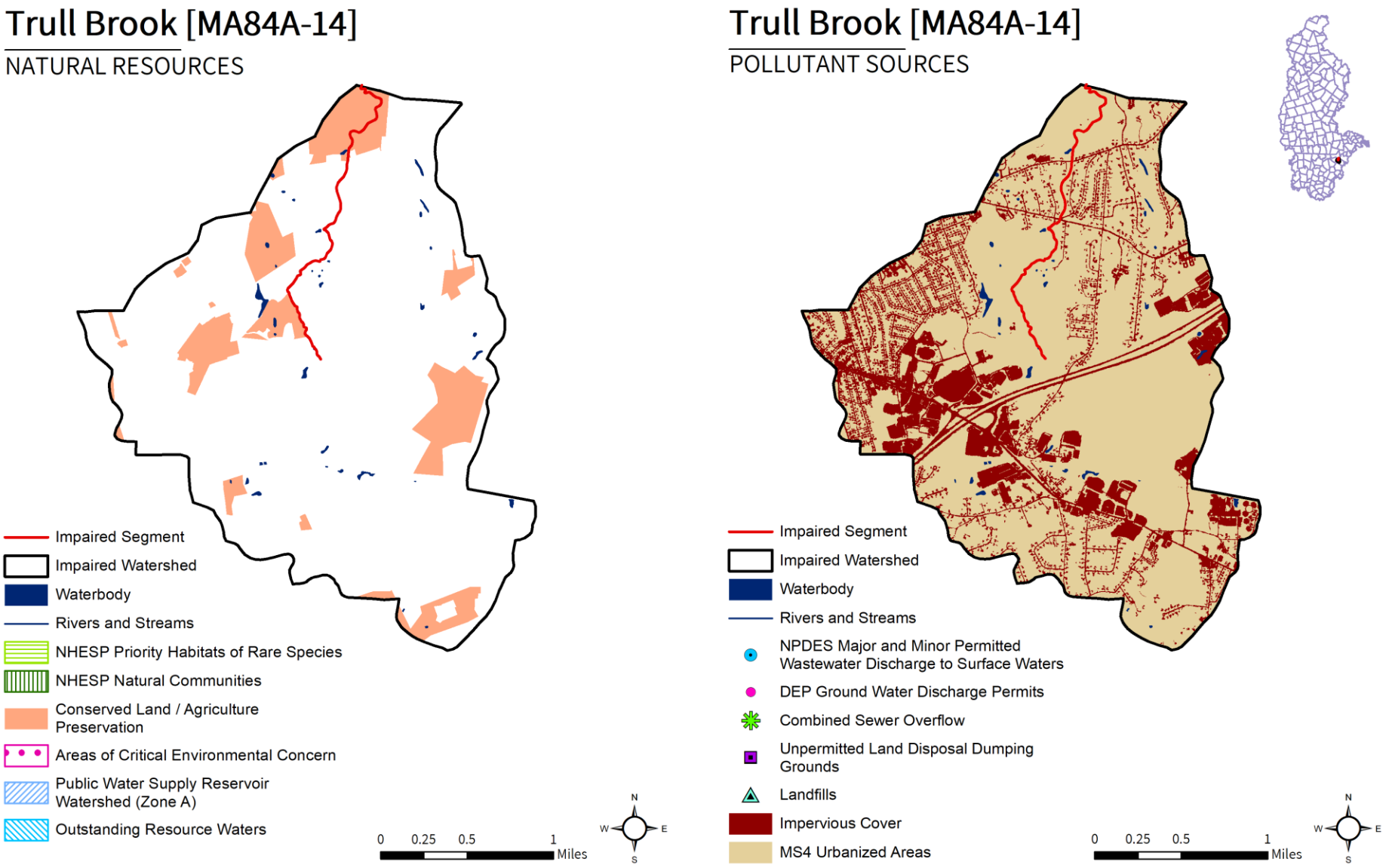


Figure 15-1. Natural resources and potential pollution sources draining to the Trull Brook segment MA84A-14. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

15.2. Waterbody Impairment Characterization

Trull Brook (MA84A-14) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Trull Brook at one site (W1194) in 2004 (Figure 15-2). The geometric mean of *E. coli* at this site was 740 CFU/100 mL exceeding the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

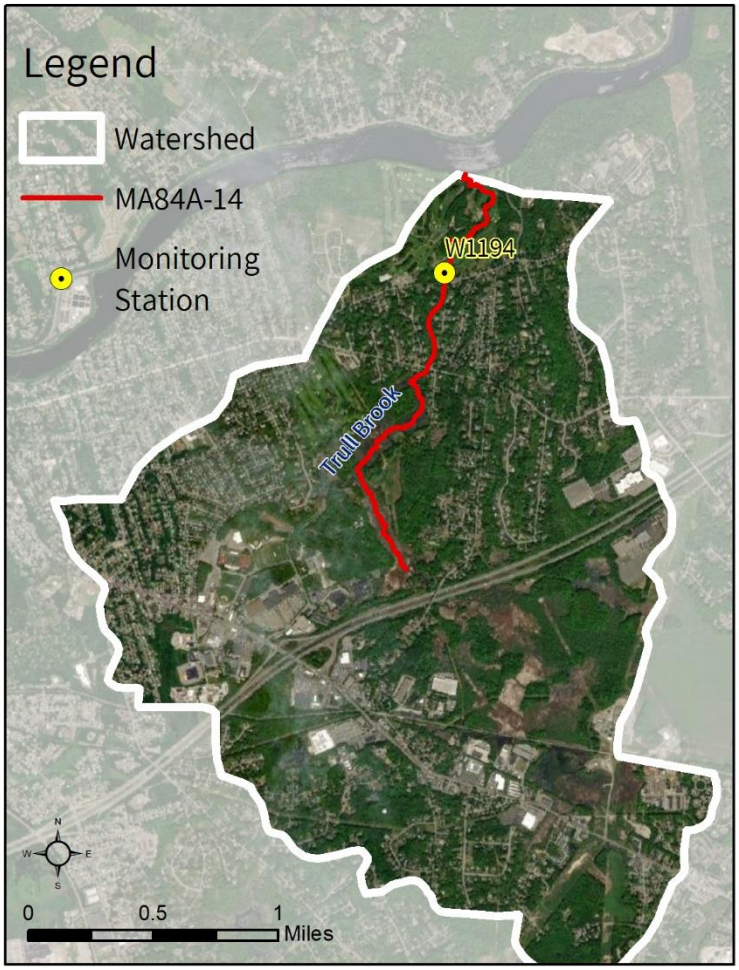


Figure 15-2. Location of monitoring station(s) along the impaired segment.

15.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a substantial amount of development in the watershed (42%), most of which is adjacent to wetland areas directly connected to the impaired segment. Within the watershed, the entire land area is subject to MS4 permit conditions, 23% is classified as impervious area, and 15% is classified as DCIA. Stormwater runoff from urban areas is likely a substantial source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts municipalities of Lowell and Tewksbury. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: There is no agricultural activity in the watershed. As a result, stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: A few moderate-density residential developments are located directly adjacent to the Trull Brook segment MA84A-14. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: Large, open wetland areas are located directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

15.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Lowell. See Section 3.4

Town of Tewksbury. See Section 5.4

16. MA84A-16 Back River

16.1. Waterbody Overview

The Back River segment MA84A-16 is 2.7 miles long and begins at the state line between South Hampton, NH and Amesbury, MA. The segment flows southeast before bending southwest and ending at the inlet to Clarks Pond in Amesbury, MA.

Tributaries to the Back River segment MA84A-16 include Lucy Brook and two unnamed tributaries. There are no named lakes or ponds in the watershed, however, a few small unnamed waterbodies are found in forested and wetland areas in Massachusetts. Much of the river flows through wetland areas.

Key landmarks in the Massachusetts portion of the watershed include the Amesbury Golf and Country Club and Cider Hill Farm. From upstream to downstream, segment MA84A-16 is crossed by Fern Avenue and Clinton Street, both in Amesbury.

The Back River (MA84A-16) drains a total area of 6.1 square miles (mi^2), of which 3.0 mi^2 (48%) are located within Massachusetts. Of these, 0.2 mi^2 (6%) are impervious and 0.1 mi^2 (3%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Amesbury[40], and 100% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 16-1.

The Back River segment MA84A-16 watershed is located in a moderately-developed part of Massachusetts. Over half of the watershed in Massachusetts consists of forest and natural lands (55%), with a roughly even amount of agricultural land (20%) and developed land (16%). The

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 1,897

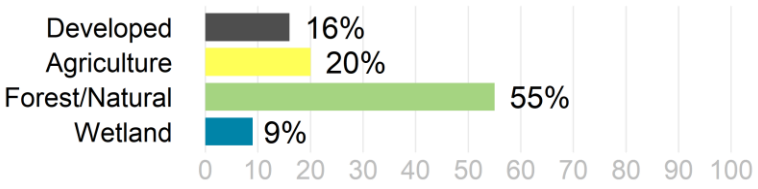
Segment Length (Miles): 2.7

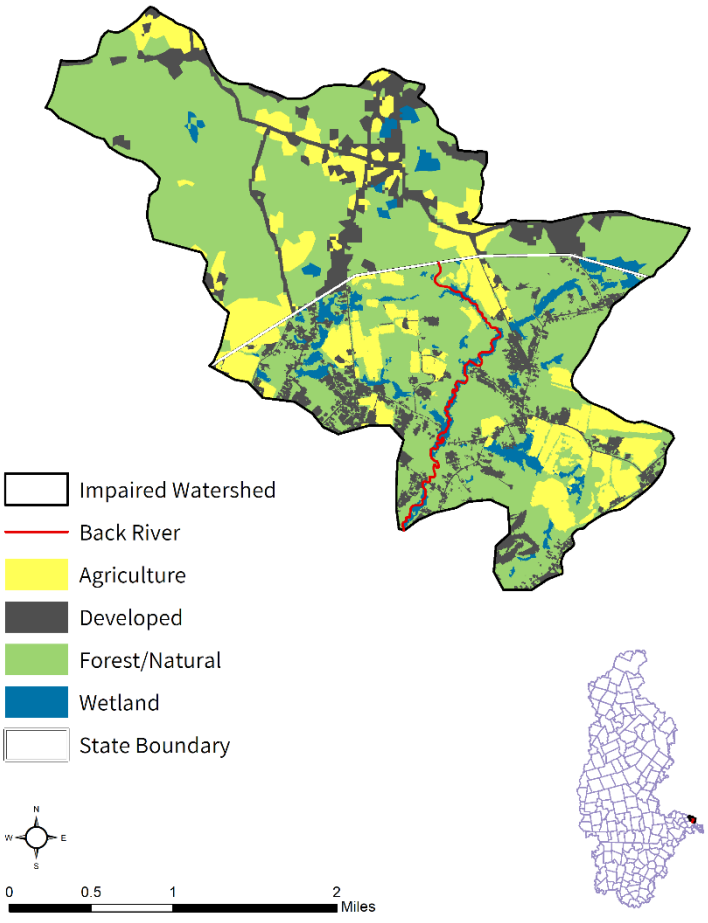
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 120 (6%)

DCIA Area (Acres, %): 58 (3%)





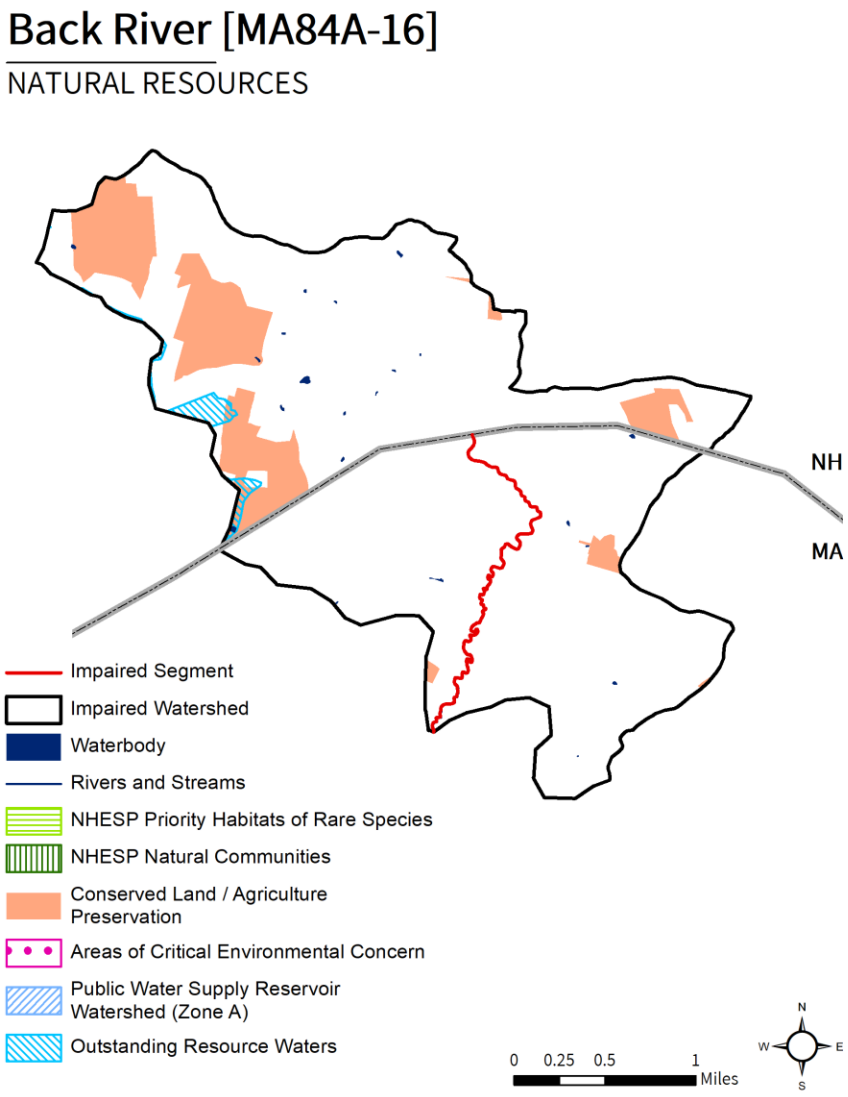
[40] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

remaining 9% of land area is covered by wetlands, the majority of which is located directly adjacent to the impaired segment and its tributaries. The agricultural fields and developed areas are scattered evenly throughout the watershed.

In the Massachusetts portion of the Back River (MA84A-16) watershed, under the Natural Heritage and Endangered Species Program, there are no Priority Habitats of Rare Species or Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. There are 21 acres (1%) of land protected in perpetuity[41], part of 24 acres (1%) of Protected and Recreational Open Space[42]. See Figure 16-1.

[41] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[42] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



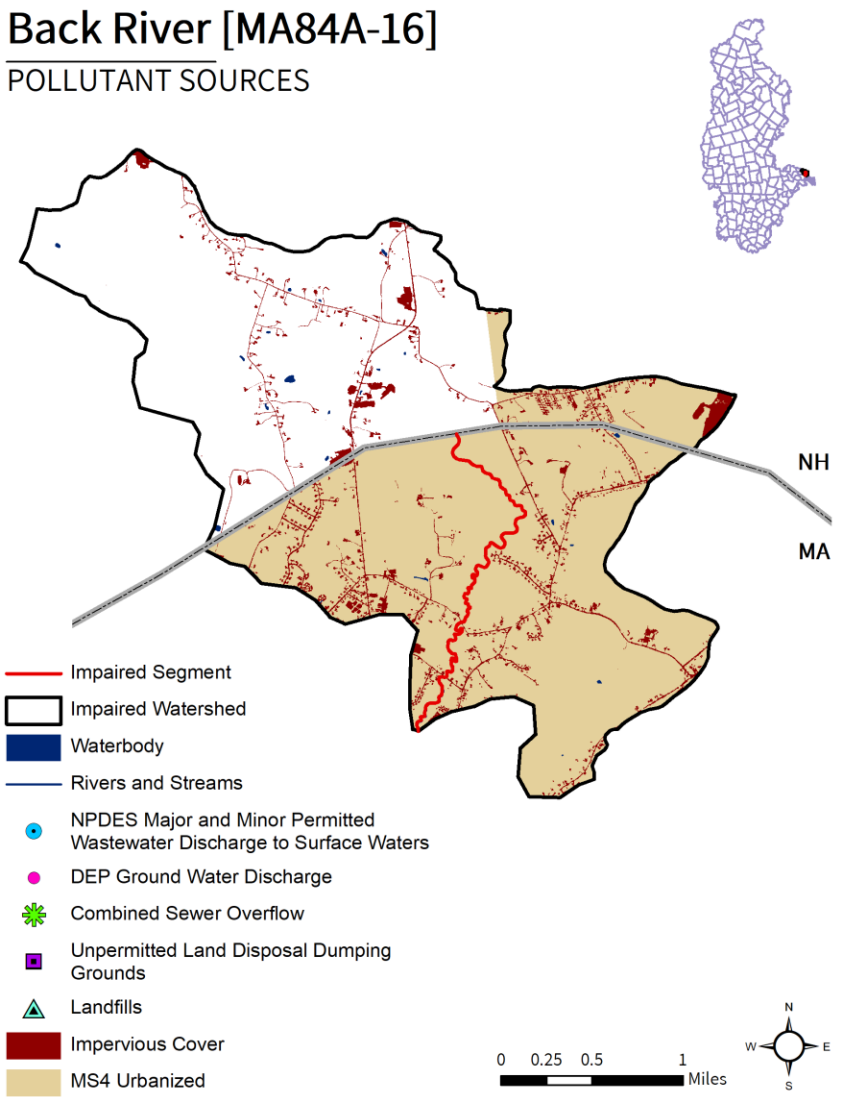


Figure 16-1. Natural resources and potential pollution sources draining to the Back River segment MA84A-16. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from a high-resolution product available for Rockingham and Strafford counties in New Hampshire.

16.2. Waterbody Impairment Characterization

The Back River (MA84A-16) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in the Back River at one site (W1212) in 2004 (Figure 16-2). The geometric mean of *E. coli* at this site was 862 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

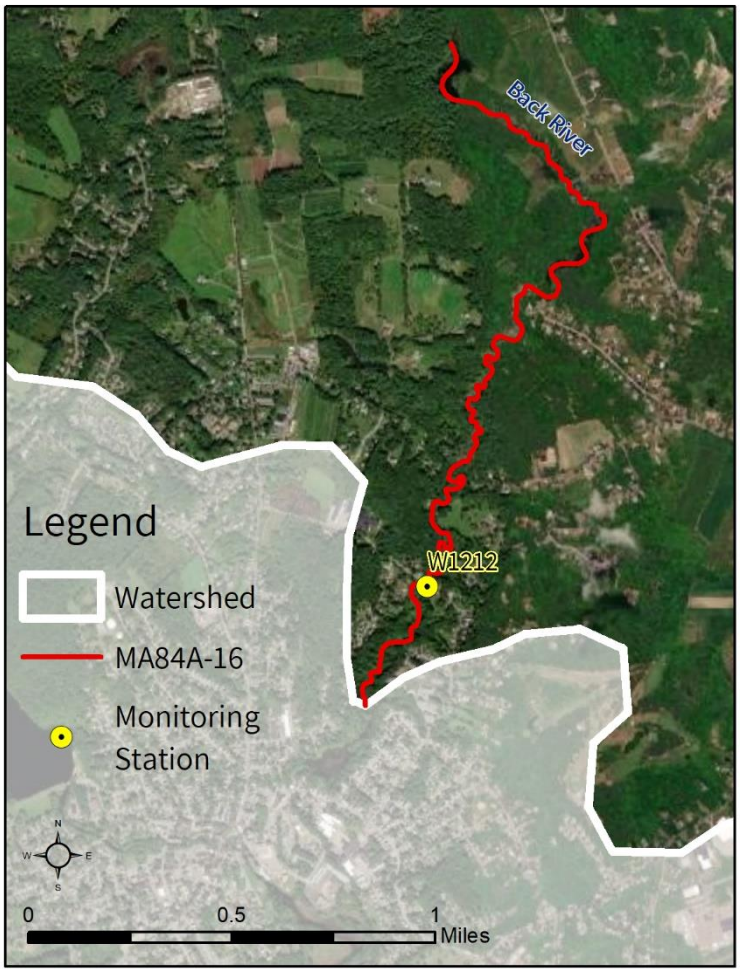


Figure 16-2. Location of monitoring station(s) along the impaired segment.

16.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (16%) that is evenly distributed. Within the Massachusetts portion of the watershed, the entire land area is subject to MS4 permit conditions, 6% is classified as impervious area, and 3% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts town of Amesbury. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for a substantial portion (20%) of the total land use. The agricultural land is comprised predominately of pasture/hay fields, with some cultivated fields as well. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few low-density residential neighborhoods near the Back River segment MA84A-16. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few small open fields and wetland areas are located directly adjacent to the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

16.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Amesbury. See Section 7.4

Town of Salisbury. See Section 8.4

17. MA84A-17 Black Brook

17.1. Waterbody Overview

Black Brook segment MA84A-17 is 2.3 miles long and begins near the Stedman Street bridge over U.S. Route 3 in Chelmsford, MA. The segment meanders in a northeasterly direction before ending at the Merrimack River in Lowell, MA.

Tributaries to Black Brook segment MA84A-17 include a few unnamed tributaries. There are no named lakes or ponds in the watershed, however, a few small unnamed waterbodies are found near wetland areas. Much of the river flows through wetland and high-density residential areas.

Key landmarks in the watershed include McCarthy Middle School; Murdoch Middle Public Charter School; Chelmsford Police Department; Mt Pleasant Golf Club; and Hadley Park. From upstream to downstream, segment MA84A-17 is crossed by Smith Street (Chelmsford), U.S. Route 3 (Chelmsford), Stedman Street (Chelmsford), Old Canal Drive (Lowell), Westford Street (Lowell), Princeton Boulevard/MA-3A (Lowell), Pratt Avenue (Lowell), Baldwin Street (Lowell), Webber Street (Lowell), and Middlesex Street (Lowell).

Black Brook (MA84A-17) drains a total area of 3.3 square miles (mi^2), of which 1.0 mi^2 (31%) is impervious and 0.7 mi^2 (22%) are directly connected impervious area (DCIA). The watershed may be served by public sewer systems in Chelmsford and Lowell[43], and 100% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are two landfills and no unpermitted land disposal dumping grounds within the segment watershed. See Figure 17-1.

The Black Brook segment MA84A-17 watershed is located in a highly-developed part of Massachusetts. Development covers more than half of the land area (55%), with forest and natural (35%) and wetland (10%) areas covering the

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 2,099

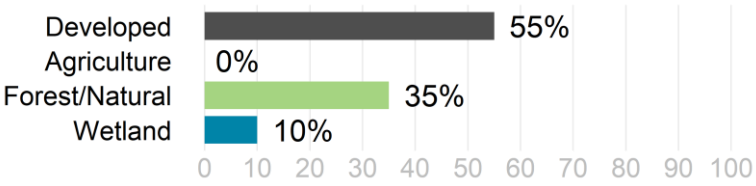
Segment Length (Miles): 2.3

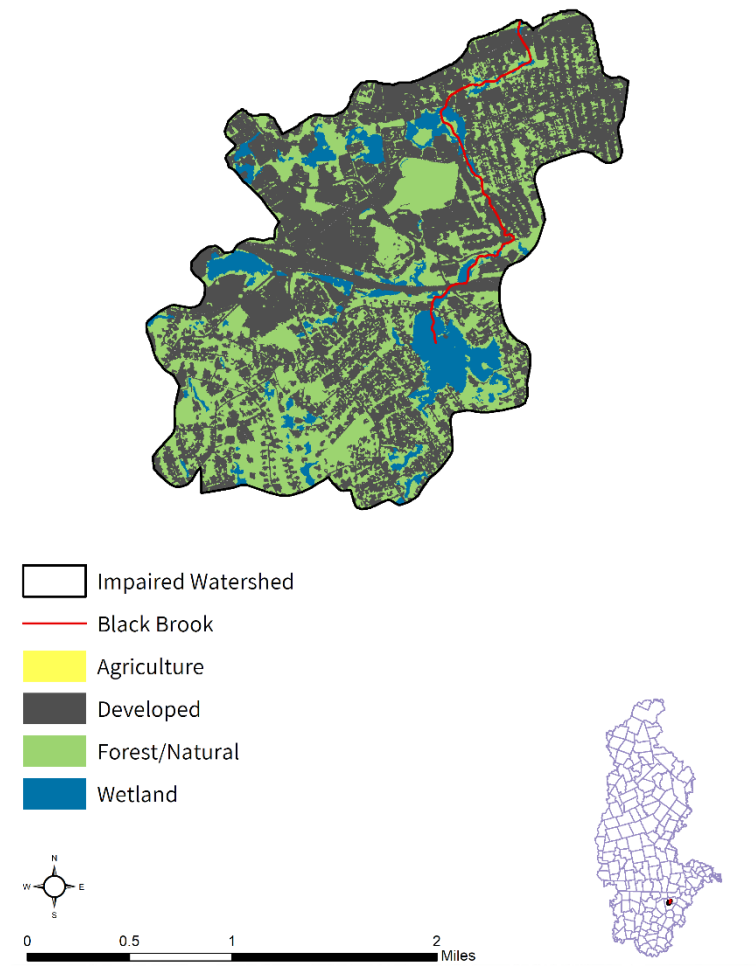
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 643 (31%)

DCIA Area (Acres, %): 460 (22%)





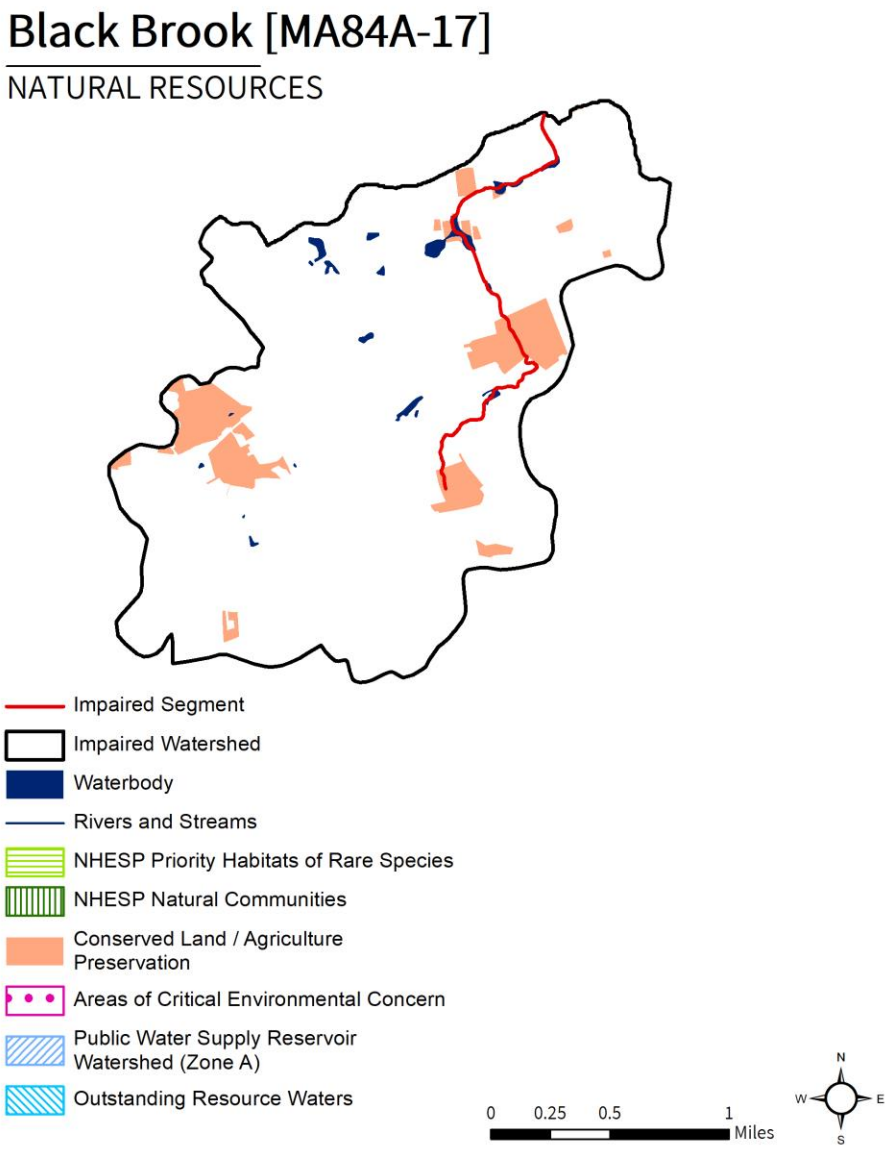
[43] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

remainder. There is no agricultural activity in the watershed. The highest density of development is located in the downstream portion of the watershed near the Merrimack River confluence.

In the Black Brook (MA84A-17) watershed, under the Natural Heritage and Endangered Species Program, there are no Priority Habitats of Rare Species or Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 49 acres (2%) of land protected in perpetuity[44], part of 166 acres (8%) of Protected and Recreational Open Space[45]. See Figure 17-1.

[44] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[45] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



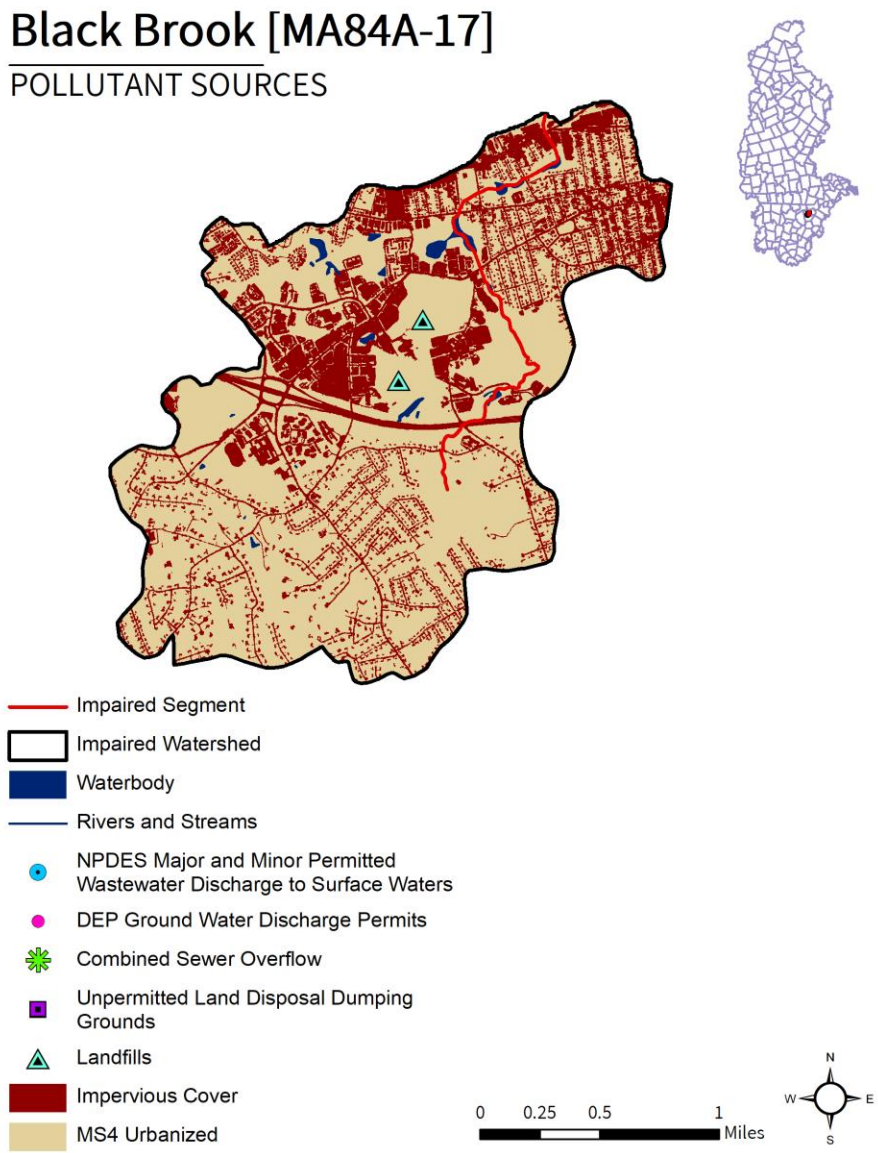


Figure 17-1. Natural resources and potential pollution sources draining to the Black Brook segment MA84A-17. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

17.2. Waterbody Impairment Characterization

Black Brook (MA84A-17) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Black Brook at one site (W1191) in 2004 (Figure 17-2). The geometric mean of *E. coli* at this site was 302 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

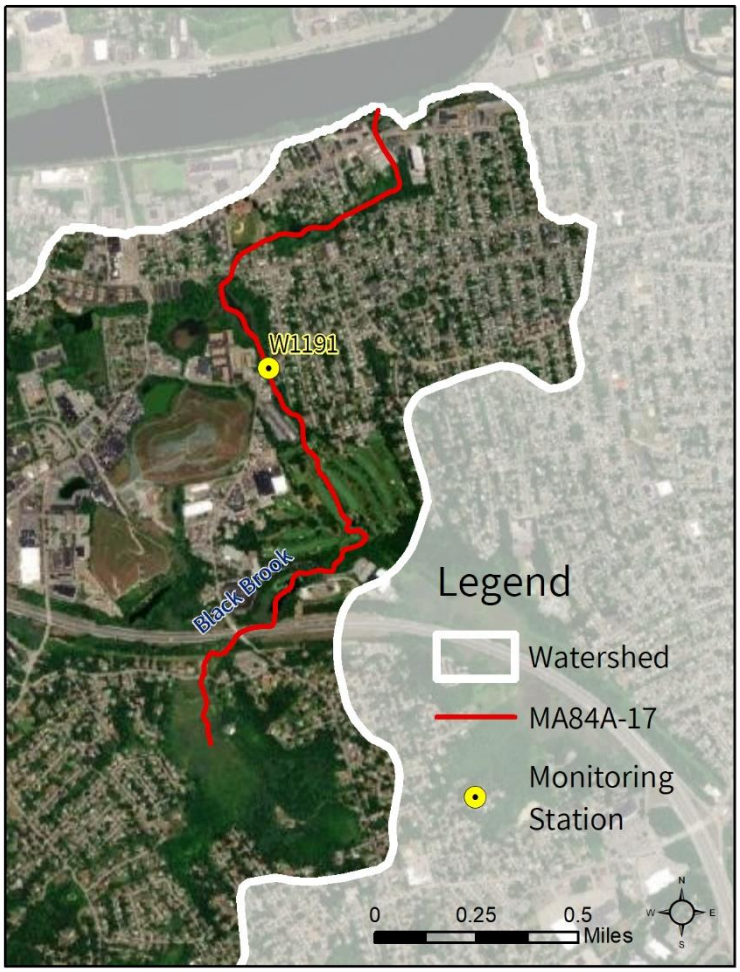


Figure 17-2. Location of monitoring station(s) along the impaired segment.

17.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: The majority of the watershed (55%) is developed, with most of this development completely surrounding the impaired segment and the wetland areas directly connected to the segment. Within the watershed, 100% of the land area is subject to MS4 permit conditions, 31% is classified as impervious area, and 22% is classified as DCIA. Stormwater runoff from urban areas is likely a substantial source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts municipalities of Chelmsford and Lowell. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: There is no agricultural activity in the watershed. As a result, stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: A few high-density residential developments, a baseball field, and a golf course are located directly adjacent to the Black Brook segment MA84A-17. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, are possible sources of pathogens.

Wildlife Waste: Large, open wetland areas and fields associated with parks and a golf course are located directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

17.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Lowell. See Section 3.4

Town of Chelmsford. See Section 3.4

18. MA84A-18 Bare Meadow Brook

18.1. Waterbody Overview

Bare Meadow Brook segment MA84A-18 is 3.0 miles long and begins at its headwaters near Baremeadow Street in Methuen, MA. The segment meanders in a northeasterly direction before ending at its confluence with the Merrimack River in Methuen, MA.

Tributaries to the Bare Meadow Brook segment MA84A-18 include a few unnamed tributaries and Hawkes Brook. There are no named lakes or ponds in the watershed, however, a few small unnamed ponds are found in forested and wetland areas in Massachusetts. Much of the river flows through wetland areas.

Key landmarks in the Massachusetts portion of the watershed include Edward S. Alekel Veterans Memorial Park and Raymond's Turkey Farm. From upstream to downstream, segment MA84A-18 is crossed by two unnamed streets, Oak Street, Chippy Lane, Albert Slack Highway/MA-213, Pleasant Valley Street/MA-113, Renfrew Street, Brookdale Avenue, Etna Avenue, and Merrimack Street/MA-110, all in Methuen.

Bare Meadow Brook (MA84A-18) drains a total area of 7.8 square miles (mi^2), of which 7.6 mi^2 (98%) are located within Massachusetts. Of these, 1.1 mi^2 (14%) are impervious and 0.6 mi^2 (8%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Methuen[46], and 100% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 18-1.

The Bare Meadow Brook segment MA84A-18 watershed is located in a moderately-developed part of Massachusetts. More than half of the

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 4,874

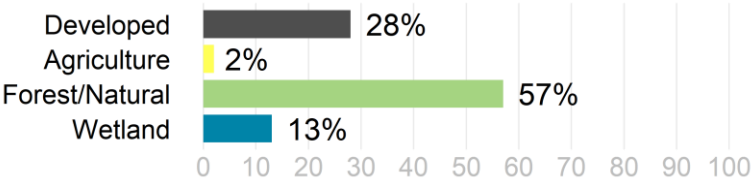
Segment Length (Miles): 3.0

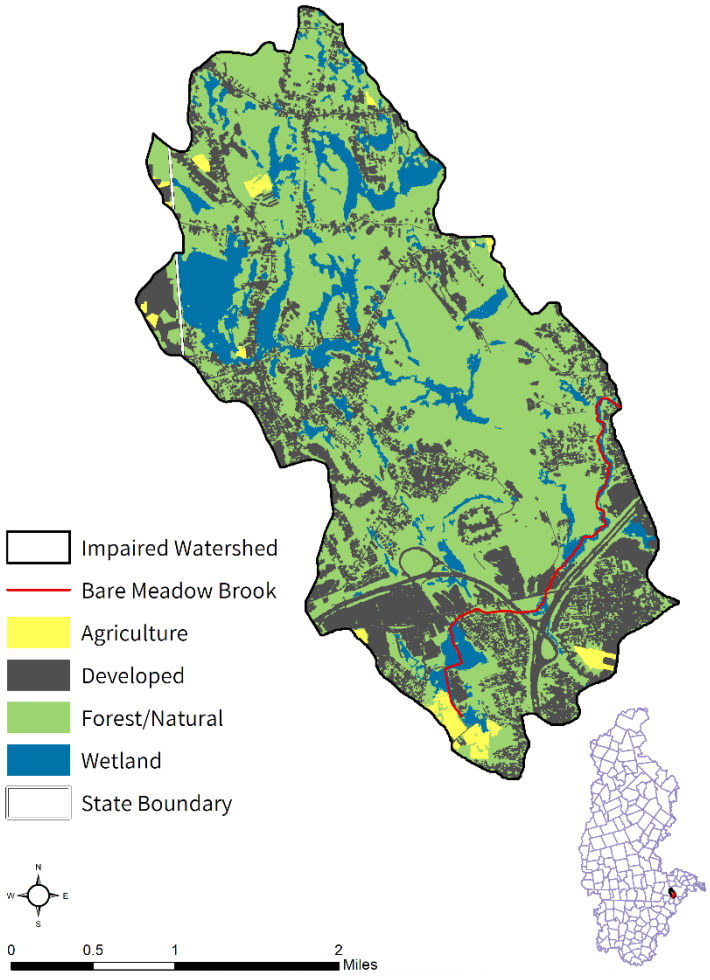
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 672 (14%)

DCIA Area (Acres, %): 392 (8%)





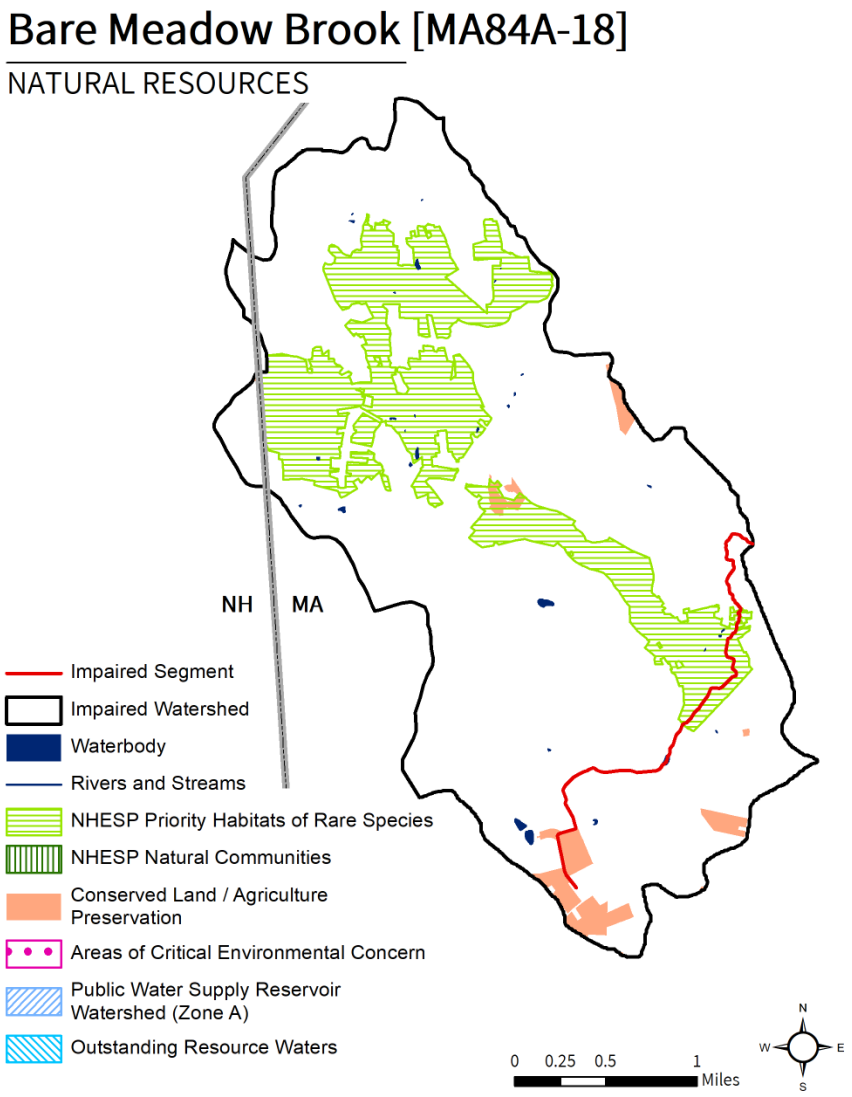
[46] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

watershed consists of forest and natural lands (57%) and 13% consists of wetland areas. Development (28%) makes up most of the remaining land area, since agricultural activities only cover a small portion of the watershed (2%). The highest density of development is located in the southern portion of the watershed near the centers of Methuen and Lawrence.

In the Massachusetts portion of the Bare Meadow Brook (MA84A-18) watershed, under the Natural Heritage and Endangered Species Program, there are 1,009 acres (21%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. There are 114 acres (2%) of land protected in perpetuity[47], constituting the 114 acres (2%) of Protected and Recreational Open Space[48]. See Figure 18-1.

[47] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[48] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



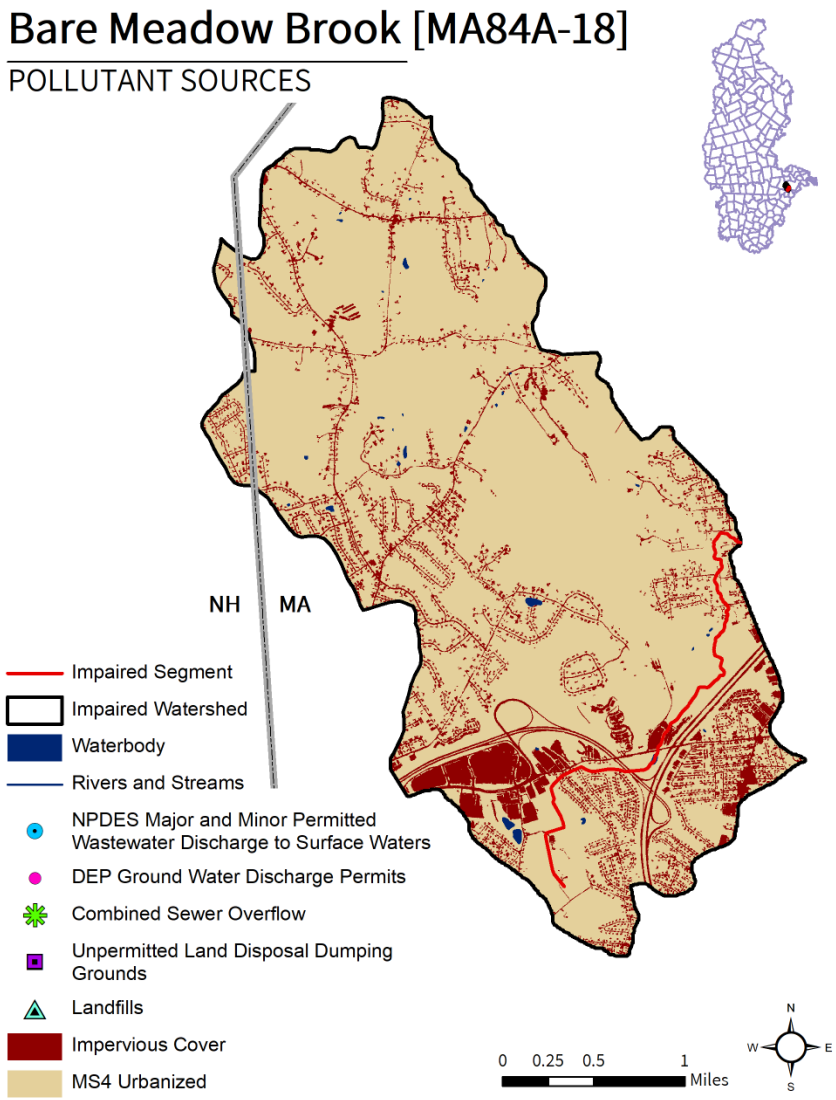


Figure 18-1. Natural resources and potential pollution sources draining to the Bare Meadow Brook segment MA84A-18. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from a high-resolution product available for Rockingham and Strafford counties in New Hampshire.

18.2. Waterbody Impairment Characterization

Bare Meadow Brook (MA84A-18) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Bare Meadow Brook at one site (W1195) in 2004 (Figure 18-2). The geometric mean of *E. coli* at this site was 323 CFU/100 mL and exceeded the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

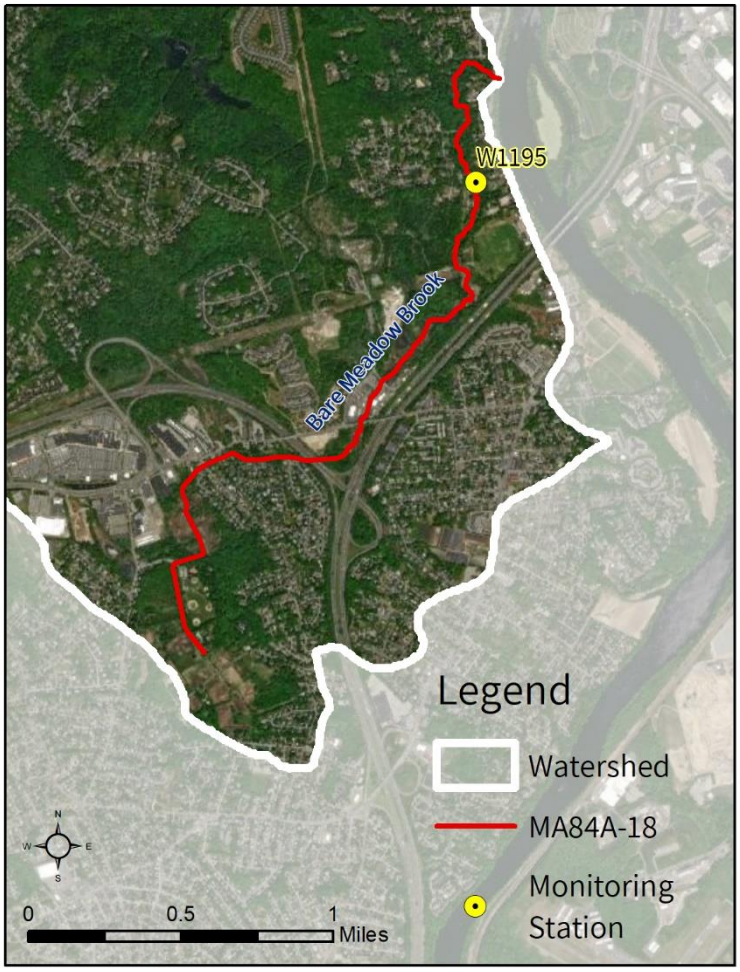


Figure 18-2. Location of monitoring station(s) along the impaired segment.

18.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (28%), located predominately in the southern region. Within the Massachusetts portion of the watershed, the entire land area is subject to MS4 permit conditions, 14% is classified as impervious area, and 8% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts city of Methuen. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for only a small portion (2%) of the total land use, however, a few fields of cultivated crops are located directly adjacent to the impaired segment near its headwaters. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few moderate-density residential neighborhoods and a park with athletic fields located directly adjacent to the Bare Meadow Brook segment MA84A-18. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: The segment flows through a few large wetland areas and there are open fields directly adjacent to the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

18.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Haverhill. See Section 6.4

City of Methuen. See Section 5.4

19. MA84A-21 Deep Brook

19.1. Waterbody Overview

Deep Brook segment MA84A-21 is 2.9 miles long and begins east of Everett Turnpike in Tyngsborough, MA. The segment flows southeast before ending at the Merrimack River in Chelmsford, MA.

Tributaries to Deep Brook segment MA84A-21 include a few unnamed tributaries. Lakes and ponds in the watershed include Swains Pond and a few other unnamed ponds. Much of the river flows through wetland and moderate-density residential areas.

Key landmarks in the watershed include the town center of North Chelmsford; the Lowell Sportsmen's Club; and the Bill Edge Deep Brook Reservation. From upstream to downstream, segment MA84A-21 is crossed by Dunstable Road (twice), Stonehill Road, Ledge Road, Dunshire Drive (twice), Tyngsborough Road/MA-3A, Butterfield Street, and Wotton Street, all in Chelmsford.

Deep Brook (MA84A-21) drains a total area of 2.6 square miles (mi^2), of which 0.3 mi^2 (13%) are impervious and 0.2 mi^2 (8%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Chelmsford[49], and the entire land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There is one landfill and no unpermitted land disposal dumping grounds within the segment watershed. See Figure 19-1.

The Deep Brook segment MA84A-21 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (62%) and 11% consists of wetland areas. The remainder of the watershed is primarily covered by development (27%) as there is very little agricultural activity (<1%). The highest density of development is

Reduction from Highest Calculated Geomean: 91%

Watershed Area (Acres): 1,678

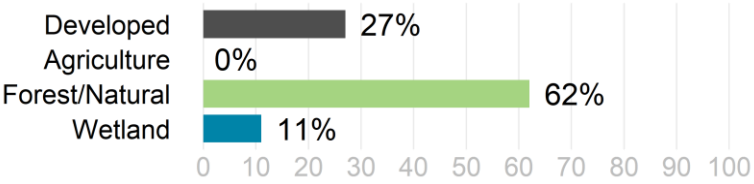
Segment Length (Miles): 2.9

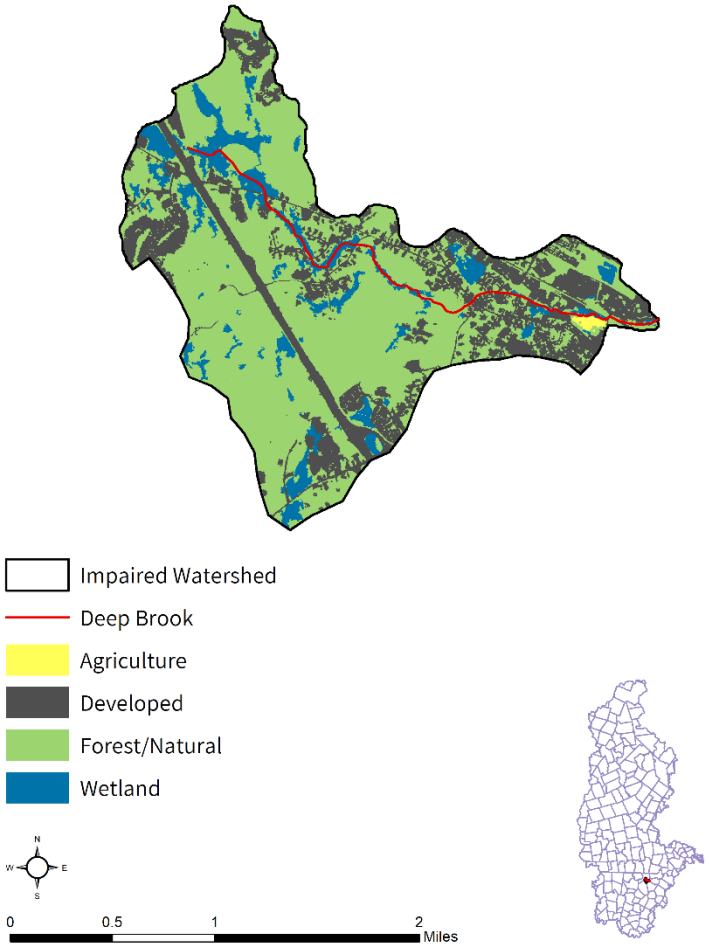
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 221 (13%)

DCIA Area (Acres, %): 133 (8%)





[49] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

located in the lower portion of the watershed, consisting primarily of single-family residential neighborhoods with some commercial and industrial buildings.

In the Deep Brook (MA84A-21) watershed, under the Natural Heritage and Endangered Species Program, there are no Priority Habitats of Rare Species or Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 113 acres (7%) of land protected in perpetuity[50], part of 193 acres (11%) of Protected and Recreational Open Space[51]. See Figure 19-1.

[50] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[51] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

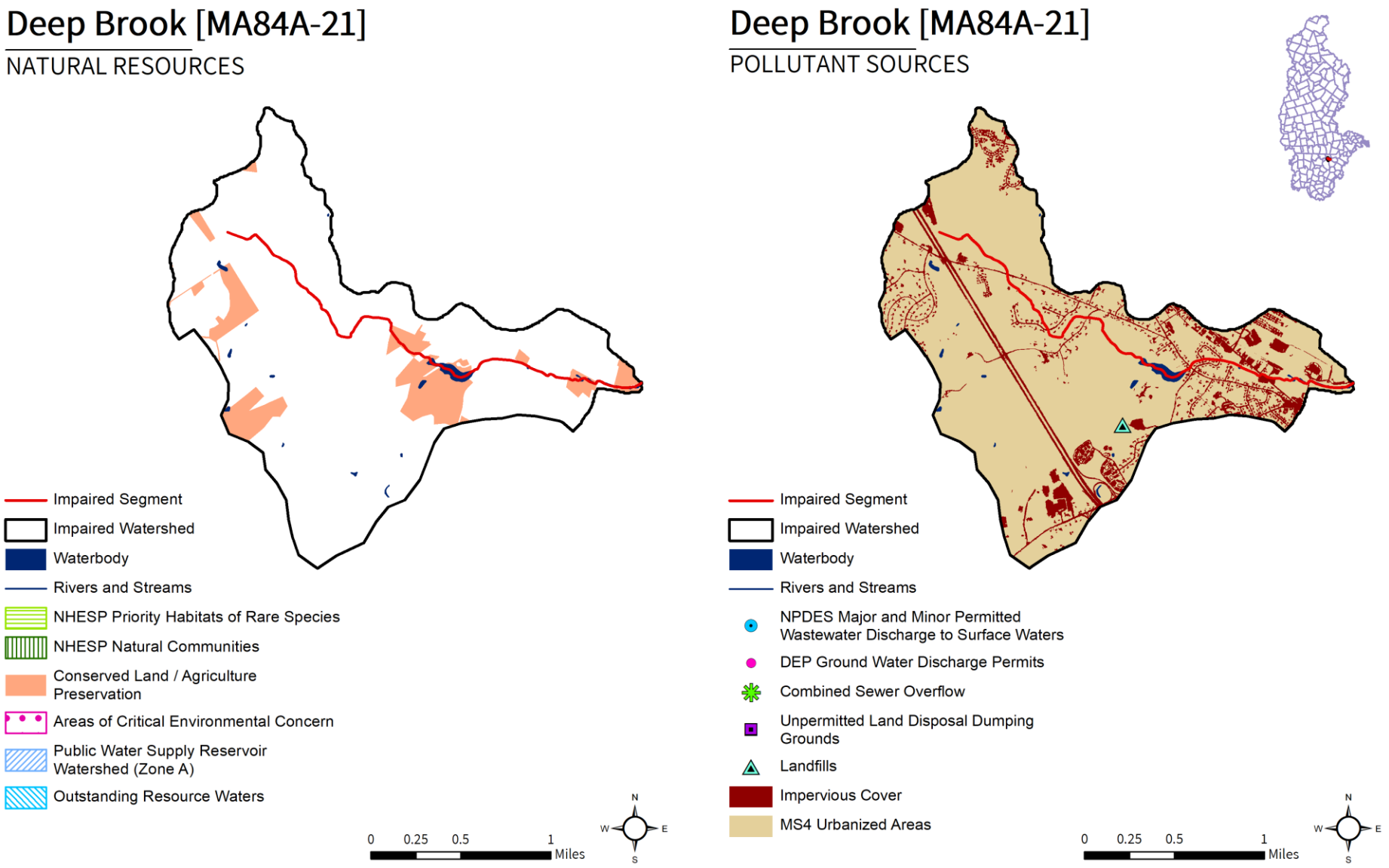


Figure 19-1. Natural resources and potential pollution sources draining to the Deep Brook segment MA84A-21. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

19.2. Waterbody Impairment Characterization

Deep Brook (MA84A-21) is a Class B Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the station identified below (refer to Tables 19-1, 19-2; Figure 19-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the Statistical Threshold Value (STV) criterion of 410 CFU/100 mL for *E. coli.* The geomean and STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2010, six samples were collected at W2159; data indicated six days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of six samples, three exceeded the STV criterion, two during wet weather and one during dry weather.

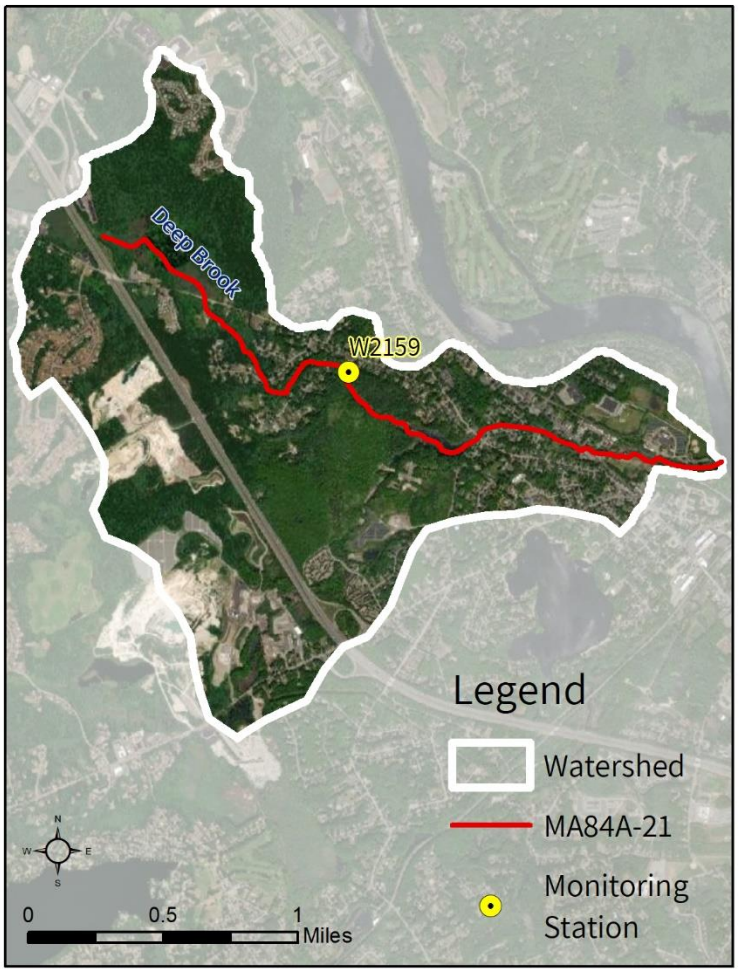


Figure 19-2. Location of monitoring station(s) along the impaired segment.

Table 19-1. Summary of indicator bacteria sampling results by station for Deep Brook (MA84A-21). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W2159	5/18/2010	9/29/2010	6	1,338	6	3

Table 19-2. Indicator bacteria data by station, indicator, and date for Deep Brook (MA84A-21). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W2159	*E. coli*	5/18/2010	DRY	390	390	
W2159	*E. coli*	6/10/2010	DRY	250	312	
W2159	*E. coli*	6/22/2010	DRY	530	372	
W2159	*E. coli*	7/27/2010	DRY	220	327	
W2159	*E. coli*	8/23/2010	WET	6,800	667	
W2159	*E. coli*	9/29/2010	WET	1,600	1,338	

19.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to the river via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and direct wildlife and domesticated animal waste (including pets).

Indicator bacteria levels for Deep Brook (MA84A-21) were elevated during both wet and dry weather. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources. Certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation, may also result in elevated levels of indicator bacteria during wet weather events . Elevated results during dry weather suggest that baseflow sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be major sources of pathogens.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (27%), most of which is located close to the impaired segment. Within the watershed, the entire land area is subject to MS4 permit conditions, 13% is classified as impervious area, and 8% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts town of Chelmsford. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Although there is very minimal agricultural activity (<1%) in the watershed, one hayfield is located directly adjacent to the impaired segment near its confluence with the Merrimack River. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: A few moderate-density residential developments, nature trails, and athletic fields are located directly adjacent to the Deep Brook segment MA84A-21. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open fields and wetland areas are located directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

19.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Chelmsford. See Section 3.4

Town of Tyngsborough. See Section 3.4

Town of Westford

Roughly 97% of Westford is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MA041232), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. In 2008, Westford completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. In 2017, the Town received a Section 319 grant to develop a Stormwater Utility to ensure stable funding to implement its Stormwater Management Master Plan (SWMMP), although no further updates on this effort were found on the Town's website. According to Westford's NOI, there are 11 stormwater outfalls to a tributary/wetland to Beaver Brook (MA84B-02) which is impaired by fecal coliform, and 14 outfalls to Tadmuck Brook (MA84B-07) which is impaired by *E. coli*.

Westford has the following ordinances and bylaws, mostly accessible online via the town website https://westfordma.gov/ (Town of Westford, 2021):

- Wetland protection bylaw
- Stormwater bylaw
- Stormwater Utility: None found, though grant funding was obtained to implement a stormwater fee
- Pet Waste: None found

Westford has a 2009 Master Plan that contains a section on Natural Resources & Open Space. This section contains extensive inventories and analysis of natural resources, including an entire subsection on water resources that has water quality data for the streams in the town. The section also contains a subsection on potential environmental hazards and sources of pollution to waterways. At the end of the section, there is a comprehensive list of goals and recommendations to protect natural resources and open space in the future. Westford's 2018 draft Open Space and Recreation Plan contains recommendations relevant to water quality, including more complete vegetative zones around waterbodies, continued monitoring, and continued enforcement and enhancement of water protection bylaws and regulations (Town of Westford, 2021).

20. MA84A-25 Powwow River

20.1. Waterbody Overview

The Powwow River segment MA84A-25 is 0.6 miles long and begins at the outlet of Lake Gardner in Amesbury, MA. The segment flows southeast before becoming tidally-influenced just downstream of Main Street in Amesbury, MA; at this point, the next Powwow River segment begins (MA84A-08).

There are no tributaries to the Powwow River segment MA84A-25. Lakes and ponds in the watershed include Lake Attitash, Lake Gardner, Tuxbury Pond, and Meadowbrook Pond in Massachusetts. Much of the river flows through developed areas.

Key landmarks in the Massachusetts portion of the watershed include the Amesbury Town Forest and Woodsom Farm and Batchelder parks. From upstream to downstream, segment MA84A-25 is crossed by High Street, Thompson Street, Pond Street, and Main Street/MA-150, all in Amesbury.

The Powwow River (MA84A-25) drains a total area of 50.3 square miles (mi^2), of which 6.4 mi^2 (13%) are located within Massachusetts. Of these, 0.5 mi^2 (7%) are impervious and 0.2 mi^2 (4%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Amesbury[52] and 88% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are two additional NPDES permits on file governing point source discharges of pollutants to surface waters. Of these two permits, neither are NPDES permits for wastewater treatment facilities. There are no MassDEP discharge-to-groundwater permits for on-site wastewater discharges or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 20-1.

The Powwow River segment MA84A-25 watershed is located in a moderately-developed part of Massachusetts. The watershed in Massachusetts is covered predominately with

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 4,119

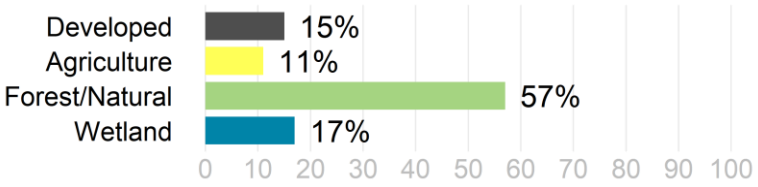
Segment Length (Miles): 0.6

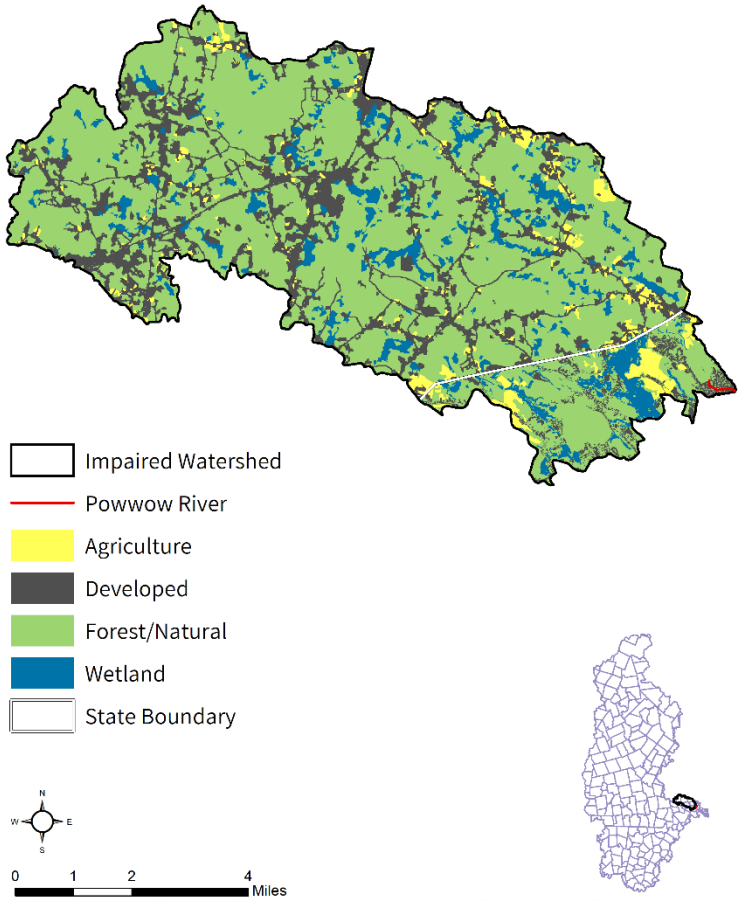
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B (Warm Water)

Impervious Area (Acres, %): 289 (7%)

DCIA Area (Acres, %): 147 (4%)





[52] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

forest and natural lands (57%) but contains a substantial amount of development (15%). There are also wetland (17%) and agricultural areas (11%). The highest density of development is located directly adjacent to the impaired segment in the City of Amesbury.

In the Massachusetts portion of the Powwow River (MA84A-25) watershed, under the Natural Heritage and Endangered Species Program, there are 223 acres (5%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also 1,095 acres (27%) under Public Water Supply protection, no Areas of Critical Environmental Concern, and 2,450 acres (59%) of Outstanding Resource Waters. There are 721 acres (18%) of land protected in perpetuity[53], part of 1,047 acres (25%) of Protected and Recreational Open Space[54]. See Figure 20-1.

[53] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[54] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

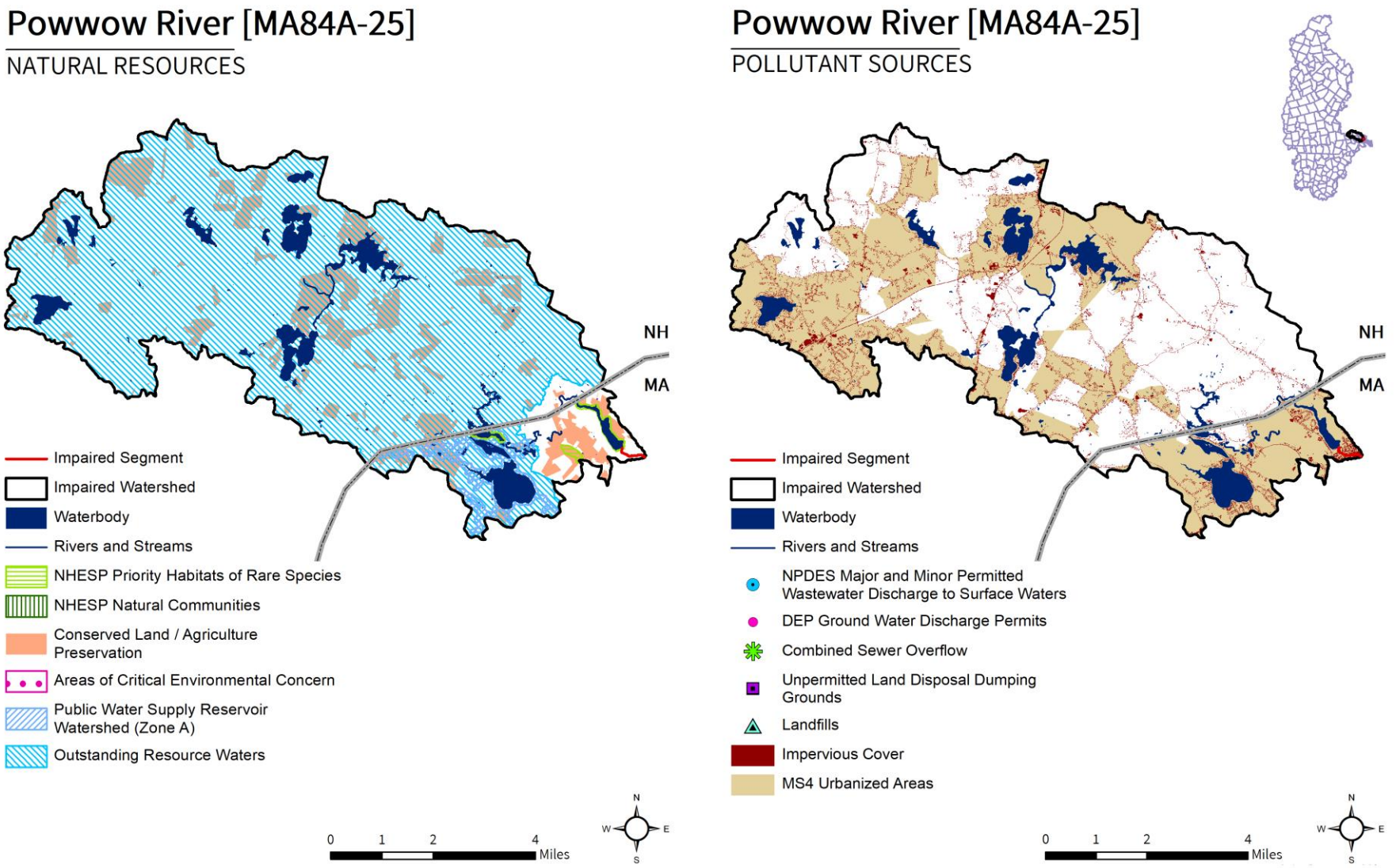


Figure 20-1. Natural resources and potential pollution sources draining to the Powwow River segment MA84A-25. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from a high-resolution product available for Rockingham and Strafford counties in New Hampshire.

20.2. Waterbody Impairment Characterization

The Powwow River (MA84A-25) is a Class B, Warm Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in the Powwow River at one site (W1198) in 2004 (Figure 20-2). The geometric mean of *E. coli* at this site was 531 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

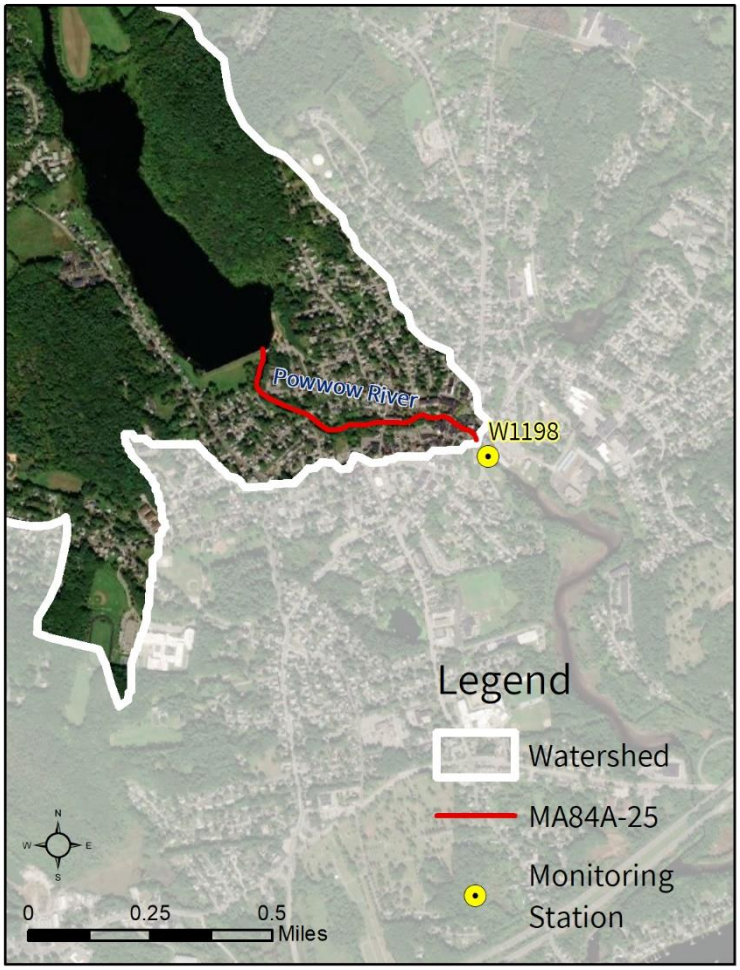


Figure 20-2. Location of monitoring station(s) along the impaired segment.

20.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (15%), with the greatest density located adjacent to the segment in the City of Amesbury. Within the Massachusetts portion of the watershed, 88% of the land area is subject to MS4 permit conditions, 7% is classified as impervious area, and 4% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts City of Amesbury. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for a sizable portion (11%) of the total land use. There are multiple large fields of hay and cultivated crops located near the impaired segment and its tributaries. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few high-density residential developments and parks surrounding the Powwow River segment MA84A-25 and its source lake. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: Lake Gardner, the segment's source, has the potential to attract waterfowl. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

20.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Amesbury. See Section 7.4

Town of Merrimac. See Section 7.4

21. MA84A-26 Merrimack River

21.1. Waterbody Overview

The Merrimack River segment MA84A-26 is 0.17 square miles (mi^2) in area and begins within the Basin in the Merrimack River Estuary in Newbury, MA. The segment is tidally influenced, but generally flows northwest before ending in the Merrimack River Estuary in Newburyport, MA.

There are no tributaries to the Merrimack River segment MA84A-26, nor named lakes or ponds in the watershed (40% of the area is covered by the impaired waterbody). Much of the segment flows through wetland and high-density residential areas.

Key landmarks are the Plum Island Light House and a small portion of Plum Island Beach. The segment is not crossed by any roads, pedestrian bridges, etc.

The Merrimack River (MA84A-26) drains a total area of 0.43 mi^2, of which 0.15 mi^2 (36%) is impervious and 0.13 mi^2 (29%) is directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Newbury and Newburyport[55], and 86% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the segment watershed. See Figure 21-1.

The Merrimack River segment MA84A-26 watershed is located in a highly-developed part of Massachusetts. Development covers just under half of the land area (45%), with forest and natural (40%) and wetland (15%) areas covering the remainder. There is no agricultural activity (identified) in the watershed. Development, composed primarily of single-family residential areas, completely surrounds the impaired segment.

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 276

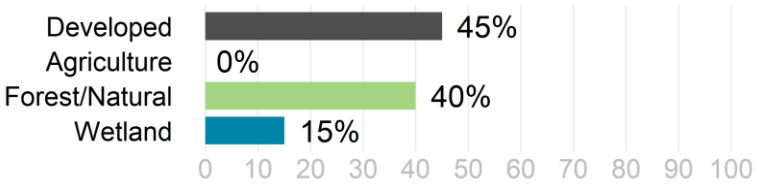
Segment Area (mi^2): 0.17

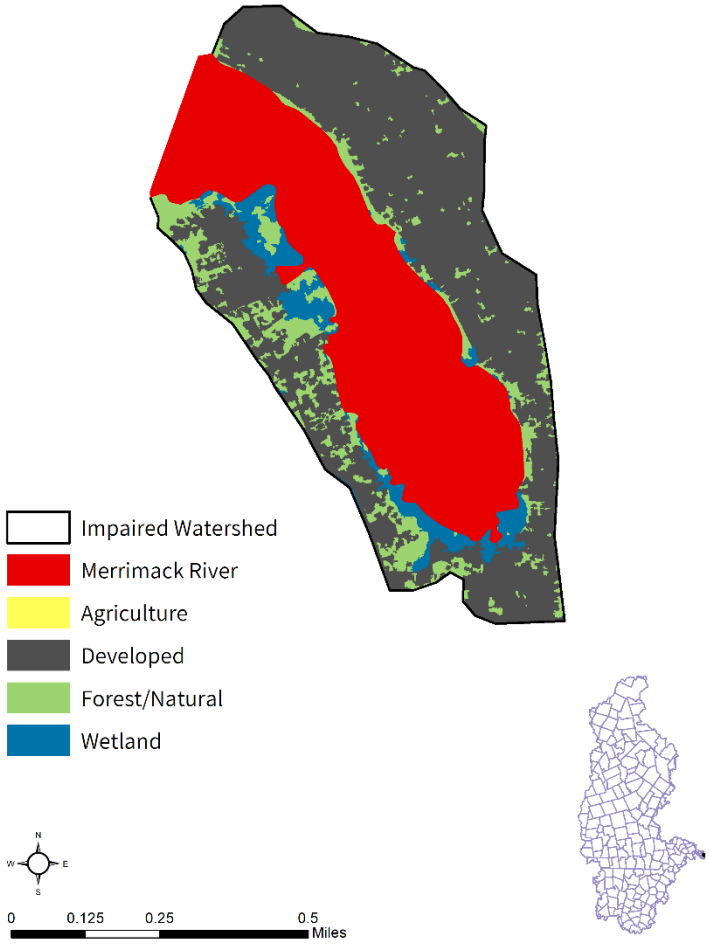
Impairment(s): Fecal Coliform (Shellfish)

Class: SA (Shellfishing)

Impervious Area (Acres, %): 98 (36%)

DCIA Area (Acres, %): 81 (29%)



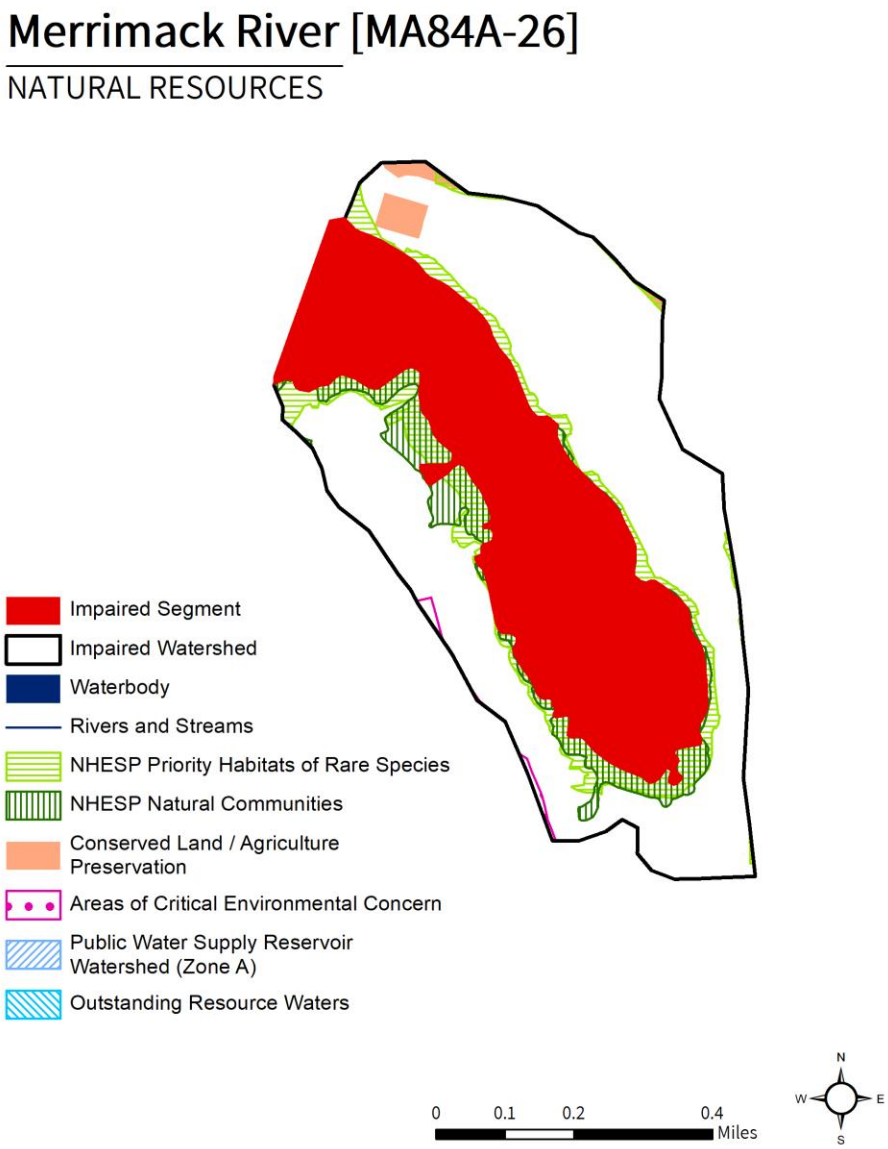


[55] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

In the Merrimack River (MA84A-26) watershed, under the Natural Heritage and Endangered Species Program, there are 132 acres (48%) of Priority Habitats of Rare Species and 110 acres (40%) of Priority Natural Vegetation Communities. There are no acres (0%) under Public Water Supply protection, one acre (<1%) within the Great Marsh Area of Critical Environmental Concern, and no Outstanding Resource Waters. Overall, there are two acres (1%) of land protected in perpetuity[56], part of four acres (1%) of Protected and Recreational Open Space[57]. See Figure 21-1.

[56] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[57] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



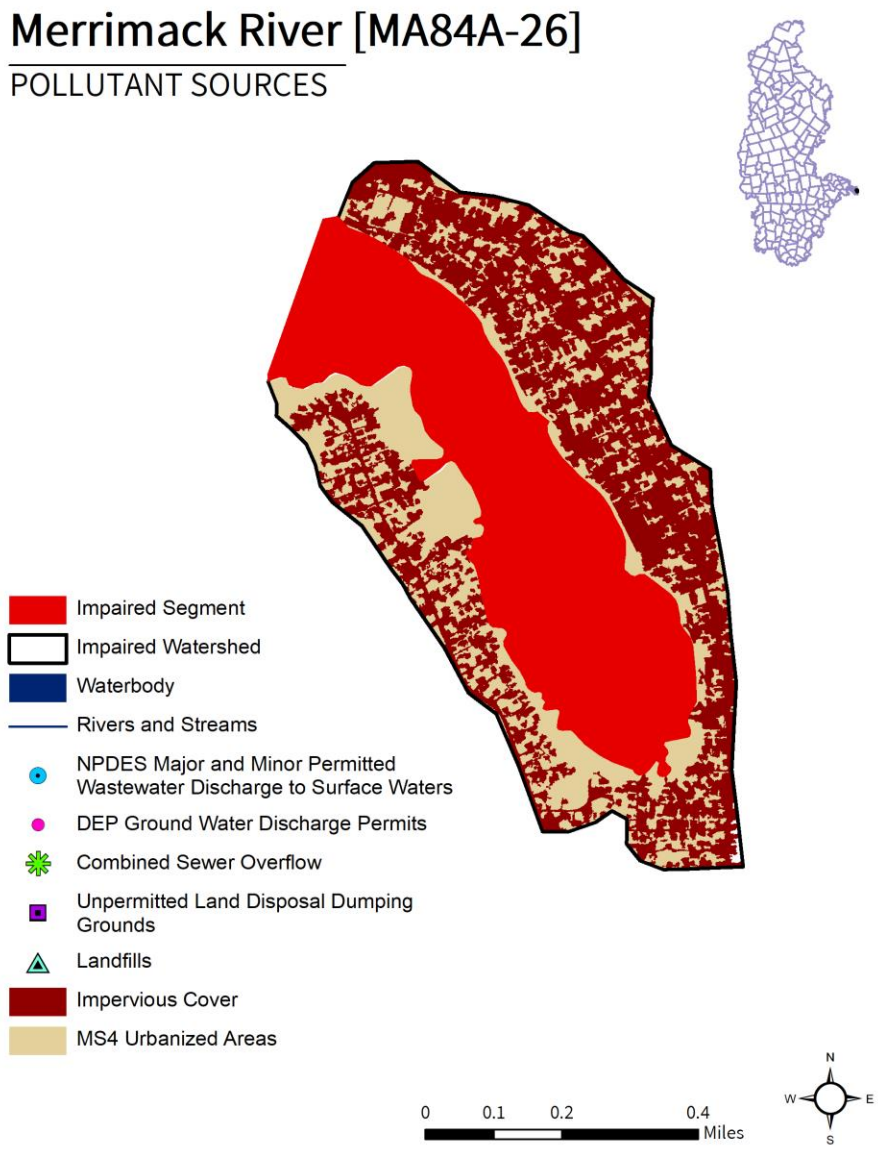


Figure 21-1. Natural resources and potential pollution sources draining to the Merrimack River segment MA84A-26. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

21.2. Waterbody Impairment Characterization

The Merrimack River (MA84A-26) is a Class SA tidal estuary, with a Shellfishing qualifier (MassDEP, 2021a).

The Shellfish Harvesting use was assessed for attainment of SWQS using fecal coliform indicator bacteria at two shellfish growing areas that cover 0.13 mi^2 (75% of the segment area; refer to Figure 21-2). MassDEP assessed the Shellfish Harvesting use as not supporting since the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries (Table 21-1).

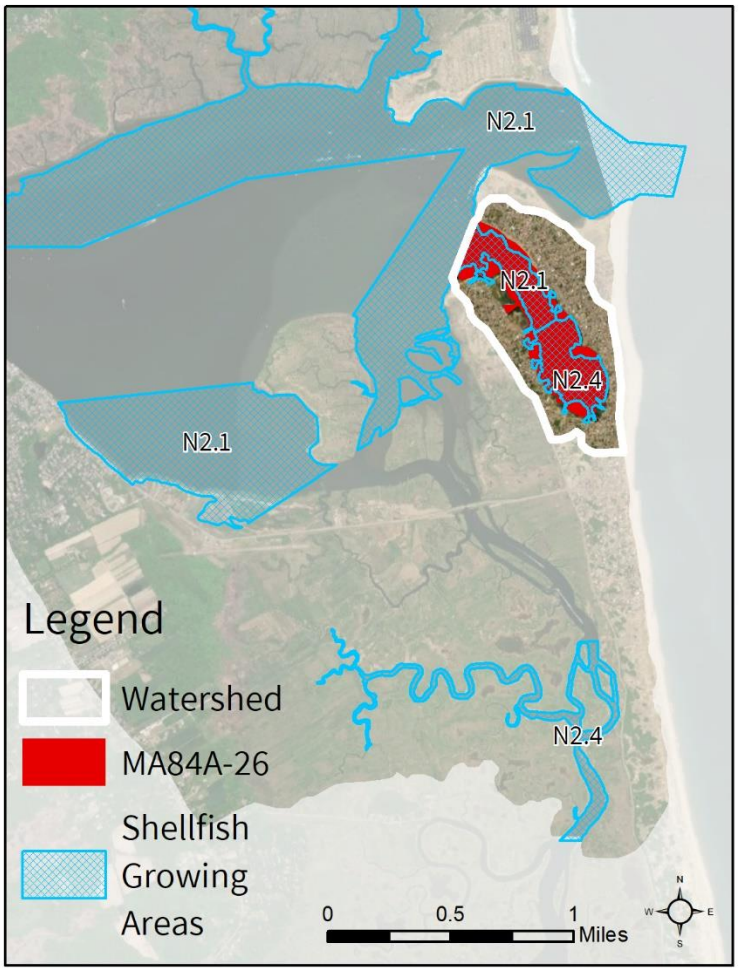


Figure 21-2. Location of shellfish growing areas associated with the impaired segment.

Table 21-1. Summary of MA DFG-Division of Marine Fisheries classification data from January 2014 for two shellfish growing areas in the Merrimack River segment MA84A-26. Percentage indicates the relative area within the segment covered by each shellfish growing area. Shellfish Harvesting is classified as not supporting if the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries.

Name	Area Description	Class	Area (mi^2)	Percentage
N2.1	Merrimack River Estuary	Conditionally Restricted	0.0601	35%
N2.4	Southern Plum Island River and Approaches	Conditionally Restricted	0.0675	40%

21.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: Development covers the largest portion of the watershed (45%), with most consisting of single-family residential areas that completely surround the impaired segment. Within the watershed, 86% of the land area is subject to MS4 permit conditions, 36% is classified as impervious area, and 29% is classified as DCIA. Stormwater runoff from urban areas is likely a substantial source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts municipalities of Newbury and Newburyport. Sewerage-related risks to water quality include leaking

infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Illicit Boat Discharges: The segment is navigable by marine vessels. Vessels with onboard toilets are required to have a marine sanitation device (MSD) to treat or store wastewater. MSDs that treat wastewater may be improperly maintained or malfunctioning and therefore could discharge untreated sewage to coastal waterbodies. For MSDs that store wastewater, this sewage can either be pumped out at shore-based pump-out facilities (CZM, 2022b) or discharged directly into the water when the vessel is more than three miles offshore, beyond the designated No Discharge Zone (NDZ). Boaters who ignore these laws and discharge untreated sewage to coastal waterbodies may be a source of pathogen pollution.

Vessel Pump-Out Facilities: There are no vessel sewage pump-out facilities directly adjacent to the Merrimack River segment MA84A-26 (CZM, 2022b). Although pump-out facilities provide boaters with a means of disposing onboard sewage without discharging it into coastal waters, these facilities are generally associated with high boating activity. Pump-out facilities which malfunction or leak also represent a potential pathogen source. As a result, waterbodies adjacent to pump-out facilities are likely at high risk of illicit boat (and facility) discharges.

Agriculture: There is no agricultural activity in the watershed. As a result, stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: A few high-density residential developments are located directly adjacent to the Merrimack River segment MA84A-26. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: The impaired segment is bordered by wetland areas. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

21.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Newbury. See Section 8.4

City of Newburyport. See Section 8.4

22. MA84A-27 Plum Island River

22.1. Waterbody Overview

The Plum Island River segment MA84A-27 is 0.13 square miles (mi^2) in area and begins at Chaces Island in the Merrimack River Estuary in Newbury, MA. The segment is tidally influenced and extends to the "high sandy" bar just north of its confluence with Pine Island Creek in Newbury, MA.

Tributaries to the Plum Island River segment MA84A-27 include Plumbush Creek, Little Pine Island Creek, and a few unnamed tributaries. Lakes and ponds in the watershed include a few small unnamed waterbodies. Much of the river flows through wetland areas.

Key landmarks in the watershed include the Plum Island Airport; Plum Island Bridge; Spencer-Peirce-Little Farm Museum; the Pink House historical landmark; and Parker River National Wildlife Refuge. Segment MA84A-27 is crossed by the Plum Island Turnpike in Newbury.

The Plum Island River (MA84A-27) drains a total area of 2.9 mi^2, of which 0.2 mi^2 (5%) are impervious and 0.1 mi^2 (3%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Newbury[58], and 11% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the segment watershed. See Figure 22-1.

The Plum Island River segment MA84A-27 watershed is located in a moderately-developed part of Massachusetts. The majority of the watershed is covered by wetland areas (62%) while only 20% is covered by forest and other natural areas. The remainder of the watershed is roughly split between developed (10%) and agricultural (8%) areas. Wetland areas completely surround the impaired segment, while

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 1,821

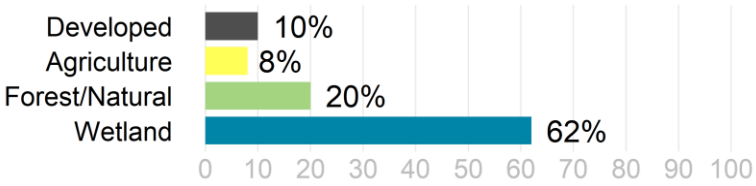
Segment Area (mi^2): 0.13

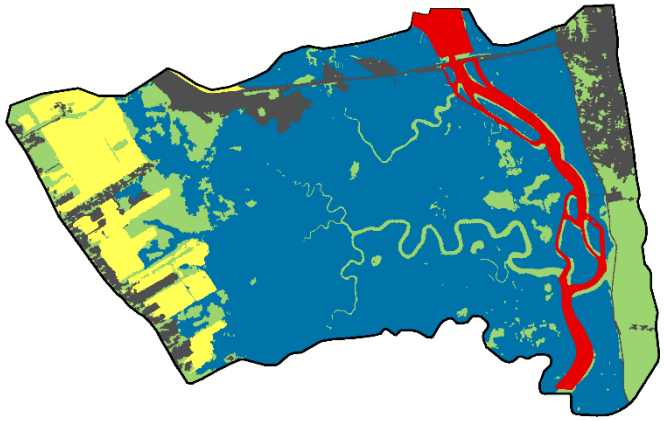
Impairment(s): Fecal Coliform (Shellfish)

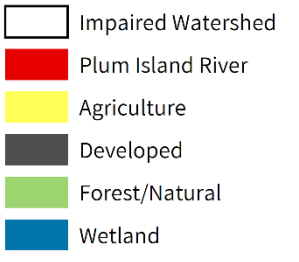
Class: SA (Shellfishing, Outstanding Resource Water)

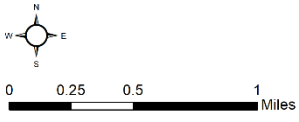
Impervious Area (Acres, %): 95 (5%)

DCIA Area (Acres, %): 50 (3%)









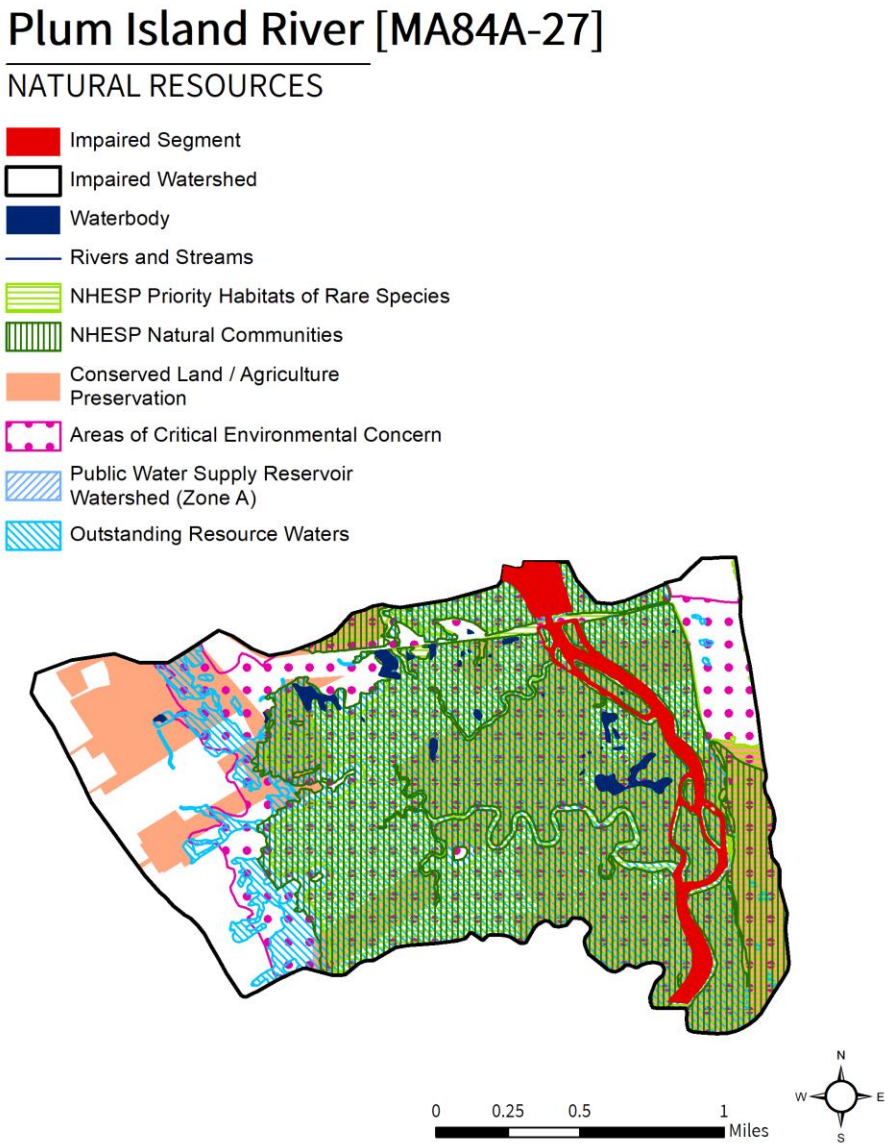
[58] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

development is isolated primarily to the northeastern portion of the watershed on Plum Island and agriculture to the western portion of the watershed.

In the Plum Island River (MA84A-27) watershed, under the Natural Heritage and Endangered Species Program, there are 1,176 acres (65%) of Priority Habitats of Rare Species and 1,130 acres (62%) of Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, 1,525 acres (84%) within the Great Marsh Area of Critical Environmental Concern, and 1,227 acres (67%) of Outstanding Resource Waters. Overall, there are 842 acres (46%) of land protected in perpetuity[59], part of 856 acres (47%) of Protected and Recreational Open Space[60]. See Figure 22-1.

[59] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[60] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



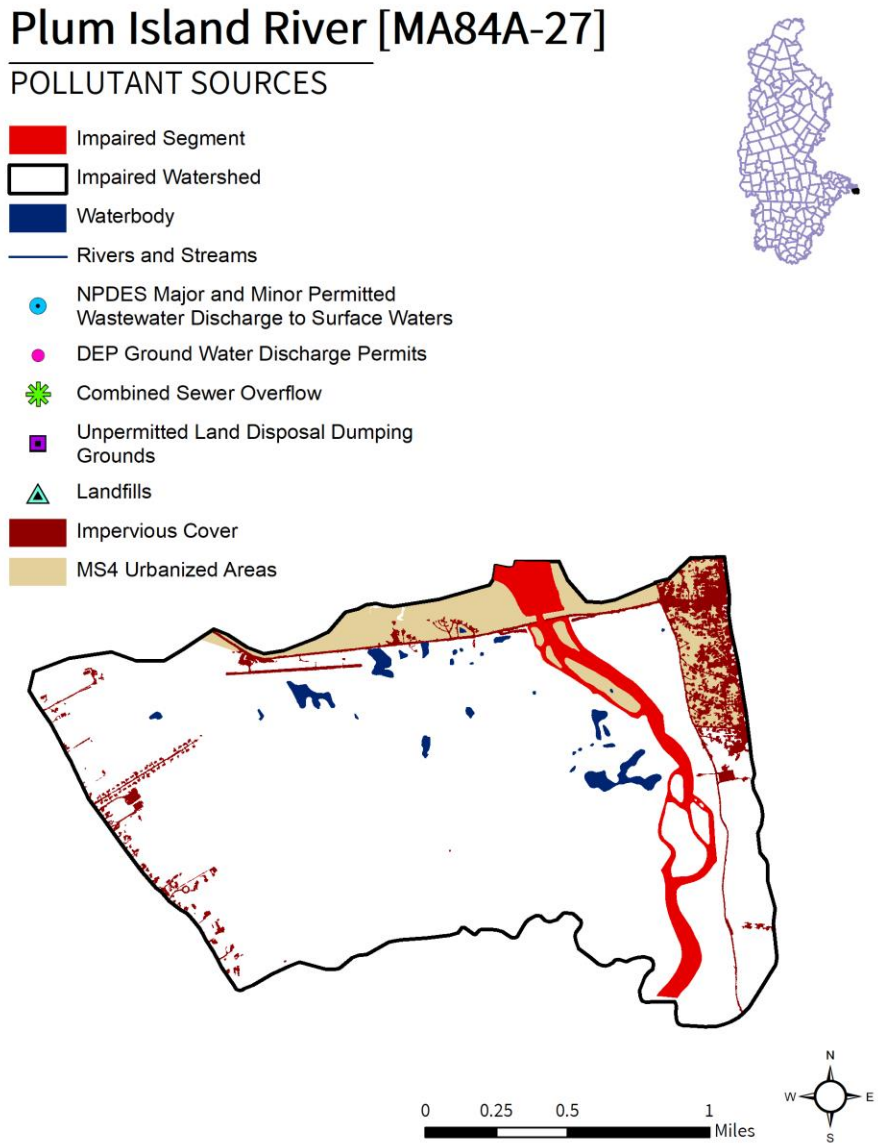


Figure 22-1. Natural resources and potential pollution sources draining to the Plum Island River segment MA84A-27. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

22.2. Waterbody Impairment Characterization

The Plum Island River (MA84A-27) is a Class SA tidal estuary, Outstanding Resource Water, with a Shellfishing qualifier (MassDEP, 2021a).

The Shellfish Harvesting use was assessed for attainment of SWQS using fecal coliform indicator bacteria at two shellfish growing areas that cover 0.10 mi^2 (75% of the segment area; refer to Figure 22-2). MassDEP assessed the Shellfish Harvesting use as not supporting since the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries (Table 22-1).

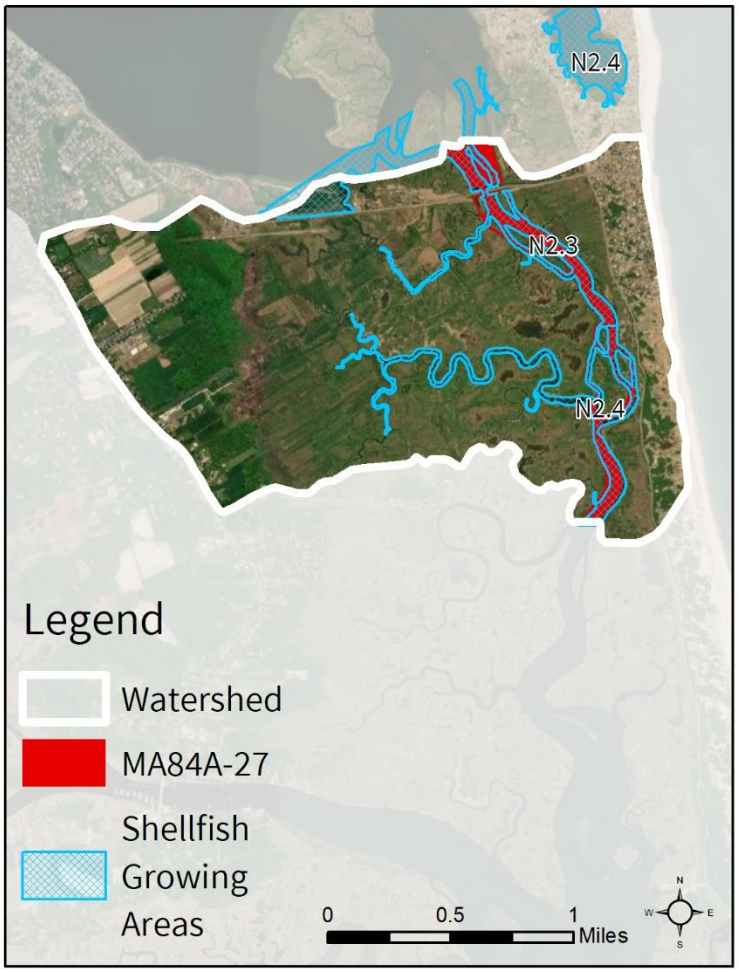


Figure 22-2. Location of shellfish growing areas associated with the impaired segment.

Table 22-1. Summary of MA DFG-Division of Marine Fisheries classification data from January 2014 for two shellfish growing areas in the Plum Island River segment MA84A-27. Percentage indicates the relative area within the segment covered by each shellfish growing area. Shellfish Harvesting is classified as not supporting if the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries.

Name	Area Description	Class	Area (mi^2)	Percentage
N2.3	Northern Plum Island River and Approaches	Conditionally Restricted	0.061	47%
N2.4	Southern Plum Island River and Approaches	Conditionally Restricted	0.0359	28%

22.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (10%), with the greatest density located in the northeast on Plum Island. 11% of the land area is subject to MS4 permit conditions, 5% is classified as impervious area, and 3% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts town of Newbury. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Illicit Boat Discharges: The segment is navigable by marine vessels. Vessels with onboard toilets are required to have a marine sanitation device (MSD) to treat or store wastewater. MSDs that treat wastewater may be improperly maintained or malfunctioning and therefore could discharge untreated sewage to coastal waterbodies. For MSDs that store wastewater, this sewage can either be pumped out at shore-based pump-out facilities (CZM, 2022b) or discharged directly into the water when the vessel is more than three miles offshore, beyond the designated No Discharge Zone (NDZ). Boaters who ignore these laws and discharge untreated sewage to coastal waterbodies may be a source of pathogen pollution.

Vessel Pump-Out Facilities: There are no vessel sewage pump-out facilities directly adjacent to the Plum Island River segment MA84A-27 (CZM, 2022b). Although pump-out facilities provide boaters with a means of disposing onboard sewage without discharging it into coastal waters, these facilities are generally associated with high boating activity. Pump-out facilities which malfunction or leak also represent a potential pathogen source. As a result, waterbodies adjacent to pump-out facilities are likely at high risk of illicit boat (and facility) discharges.

Agriculture: Agricultural activities in the watershed account for a relatively small portion (8%) of the total land use, consisting mainly of large fields of hay and cultivated land located in the western region. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are no parks or open fields adjacent to the impaired segment, though there is dense residential development in the watershed. Areas popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: The impaired segment is surrounded by expansive wetland areas. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

22.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Newbury. See Section 8.4

23. MA84A-28 Powwow River

23.1. Waterbody Overview

The Powwow River segment MA84A-28 is 2.9 miles long and begins at the outlet of Tuxbury Pond in Amesbury, MA. The segment flows southeast before meandering northeast and ending at the state line between South Hampton, NH and Amesbury, MA.

Tributaries to the Powwow River segment MA84A-28 include a few unnamed streams. Lakes and ponds in the watershed include Lake Attitash, Tuxbury Pond, and Meadowbrook Pond in Massachusetts. Much of the river flows through wetland areas.

Key landmarks in the Massachusetts portion of the watershed include the Amesbury Town Forest and Woodsom Farm Park. From upstream to downstream, segment MA84A-28 is crossed by Newton Road twice in Amesbury.

The Powwow River (MA84A-28) drains a total area of 48.9 square miles (mi^2), of which 5.5 mi^2 (11%) are located within Massachusetts. Of these, 0.3 mi^2 (6%) are impervious and 0.1 mi^2 (3%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Amesbury[61] and 86% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are two additional NPDES permits on file governing point source discharges of pollutants to surface waters; neither are NPDES permits for wastewater treatment facilities. There are no MassDEP discharge-to-groundwater permits for on-site wastewater discharges or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 23-1.

The Powwow River segment MA84A-28 watershed is located in a moderately-developed part of Massachusetts. The watershed in Massachusetts is covered predominately with forest and natural lands (57%) but contains a substantial amount of development (12%), as well

Reduction from Highest Calculated Geomean: 0%

Watershed Area (Acres): 3,492

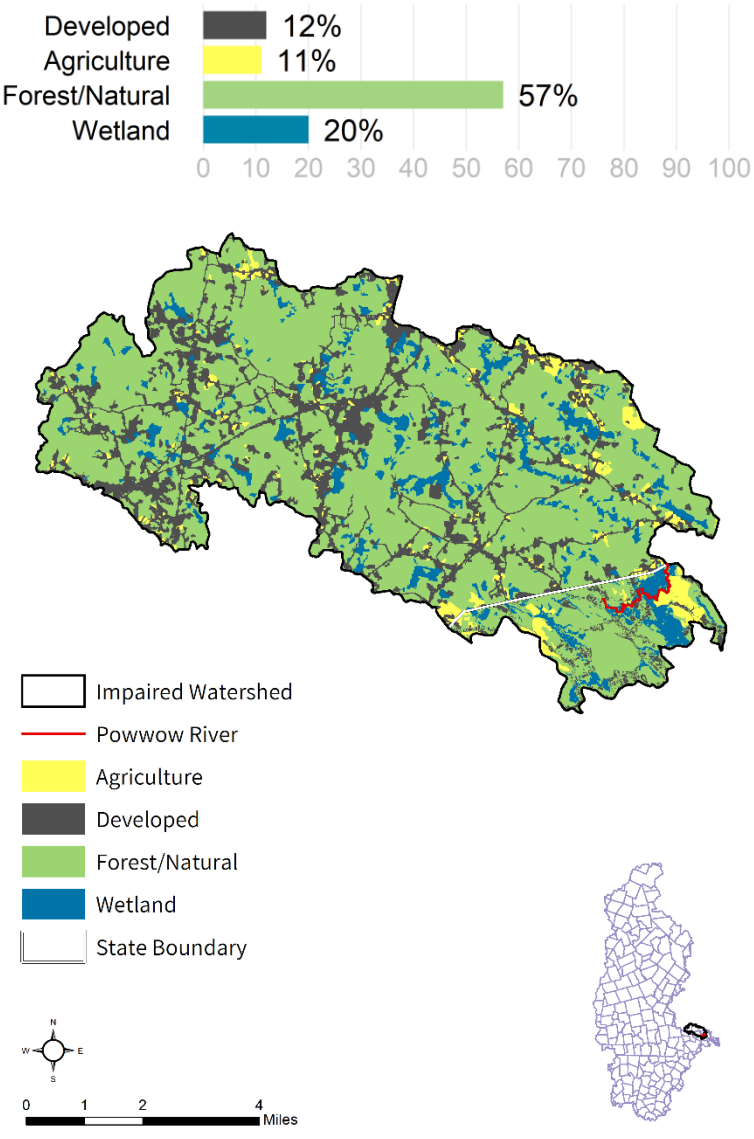
Segment Length (Miles): 2.9

Impairment(s): Fecal Coliform (Primary Contact Recreation)

Class: A (Public Water Supply, Outstanding Resource Water)

Impervious Area (Acres, %): 192 (6%)

DCIA Area (Acres, %): 88 (3%)



[61] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

as wetland (20%) and agricultural areas (11%). The segment is predominantly surrounded by wetland areas, with some hay and pasture fields bordering one side of the segment in the lower watershed.

In the Massachusetts portion of the Powwow River (MA84A-28) watershed, under the Natural Heritage and Endangered Species Program, there are 100 acres (3%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are 1,095 acres (31%) under Public Water Supply protection, no Areas of Critical Environmental Concern, and 2,450 acres (70%) of Outstanding Resource Waters. Within Massachusetts only, there are 575 acres (16%) of land protected in perpetuity[62], part of 896 acres (26%) of Protected and Recreational Open Space[63]. See Figure 23-1.

[62] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[63] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

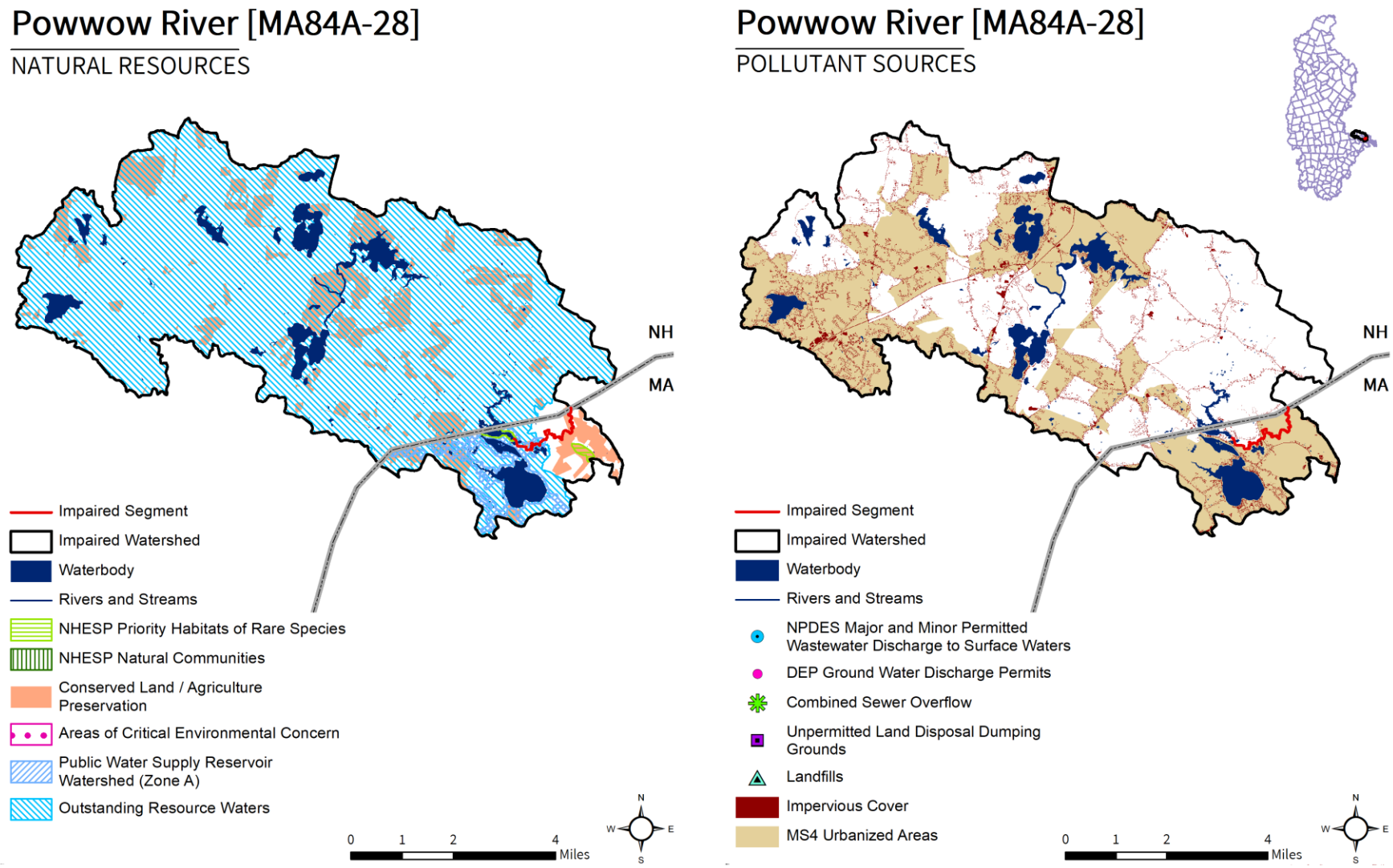


Figure 23-1. Natural resources and potential pollution sources draining to the Powwow River segment MA84A-28. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from a high-resolution product available for Rockingham and Strafford counties in New Hampshire.

23.2. Waterbody Impairment Characterization

The Powwow River (MA84A-28) is a Class A, Public Water Supply and Outstanding Resource Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the station listed below (refer to Tables 23-1, 23-2; Figure 23-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the STV criterion of 410 CFU/100 mL for *E. coli*. The geomean STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2015, five samples were collected at W2512; data indicated that the 90-day rolling geomean did not exceed the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of five samples, none exceeded the STV criterion. The segment is listed as impaired due to prior historical data, and a protective TMDL would be maintained should this waterbody be delisted in a future integrated list.

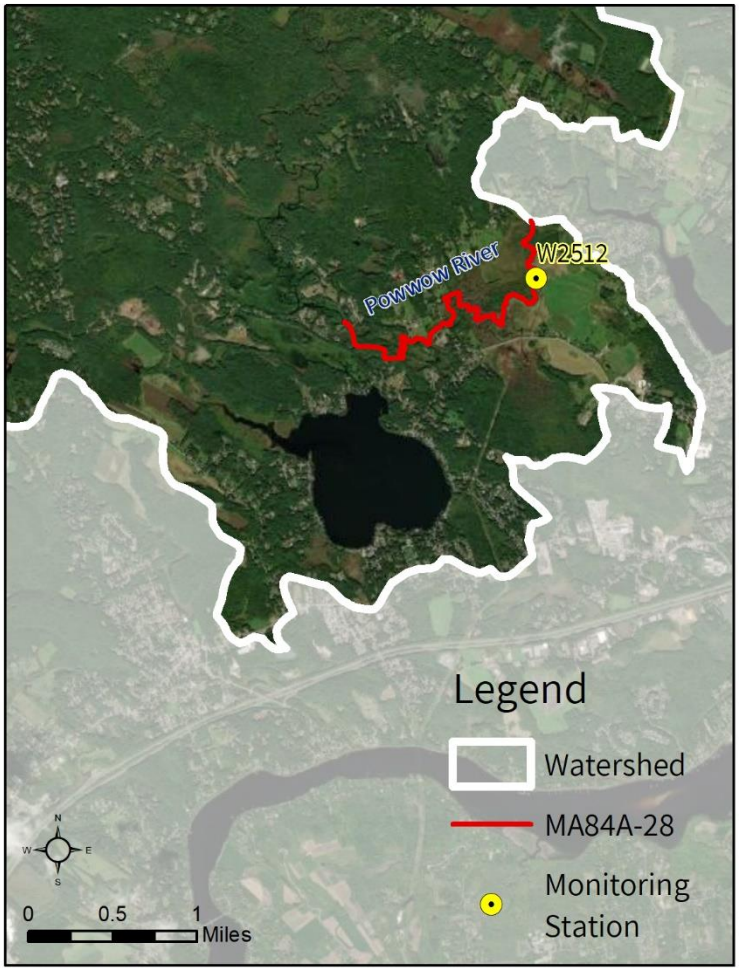


Figure 23-2. Location of monitoring station(s) along the impaired segment.

Table 23-1. Summary of indicator bacteria sampling results by station for the Powwow River (MA84A-28). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W2512	5/6/2015	9/1/2015	5	79	0	0

Table 23-2. Indicator bacteria data by station, indicator, and date for the Powwow River (MA84A-28). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W2512	*E. coli*	5/6/2015	DRY	<10*	10	
W2512	*E. coli*	6/3/2015	WET	230	48	
W2512	*E. coli*	7/9/2015	DRY	41	46	
W2512	*E. coli*	8/4/2015	DRY	52	79	
W2512	*E. coli*	9/1/2015	DRY	63	51	

* Value below the Method Detection Limit (MDL) of 10 CFU/100mL; the MDL is reported and used to calculate the geometric means for *E. coli*.

23.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to the river via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and direct wildlife and domesticated animal waste (including pets).

Indicator bacteria levels for the Powwow River (MA84A-28) were below the criterion during both wet and dry weather; however, the sole sample collected during wet weather showed the highest bacteria levels. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources. Certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation, may also result in elevated levels of indicator bacteria during wet weather events.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (12%). Within the Massachusetts portion of the watershed, 86% of the land area is subject to MS4 permit conditions, 6% is classified as impervious area, and 3% is classified as DCIA. Stormwater runoff from urban areas is a potential source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts City of Amesbury. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for a sizable portion (11%) of the total land use. There are a few large hay fields directly adjacent to the impaired segment in the

lower watershed. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few low-density residential developments and a park that is advertised as popular for dog-walking near the Powwow River segment MA84A-28. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: The segment is surrounded by large wetland areas, a pond, and a few large open agricultural fields. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

23.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Amesbury. See Section 7.4

Town of Merrimac. See Section 7.4

24. MA84A-30 Unnamed Tributary

24.1. Waterbody Overview

The unnamed tributary segment MA84A-30 (unnamed tributary to the Powwow River locally considered part of the Back River) is 0.003 square miles (mi^2) in area and begins at the outlet of Clarks Pond in Amesbury, MA. The segment flows south before ending at the Powwow River in Amesbury, MA.

There are no tributaries to the unnamed tributary segment MA84A-30. Lakes and ponds in the watershed include Clarks Pond and a few small unnamed waterbodies in Massachusetts. Much of the river flows through developed areas.

Key landmarks in the New Hampshire portion of the watershed include the Burrows-Brookside Sanctuary; the Crovetti and Riley wellfields; and the Seabrook Town Forest. Key landmarks in the Massachusetts portion of the watershed include Amesbury Elementary School; the Amesbury Golf and Country Club and Cider Hill Farm. From upstream to downstream, segment MA84A-30 is crossed by an unnamed street, Clark Street, Elm Street, and Water Street, all in Amesbury.

The unnamed tributary (MA84A-30) drains a total area of 7.2 mi^2, of which 4.0 mi^2 (56%) are located within Massachusetts. Of these, 0.4 mi^2 (11%) are impervious and 0.2 mi^2 (6%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Amesbury[64] and the entire land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 24-1.

The unnamed tributary segment MA84A-30 watershed is located in a moderately-developed part of Massachusetts. The watershed in

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 2,558

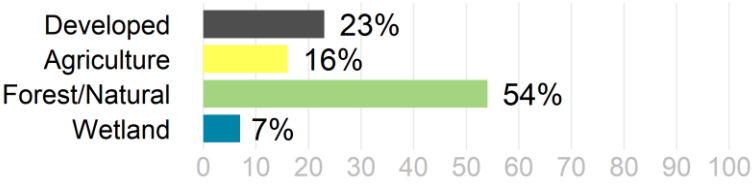
Segment Area (mi^2): 0.003

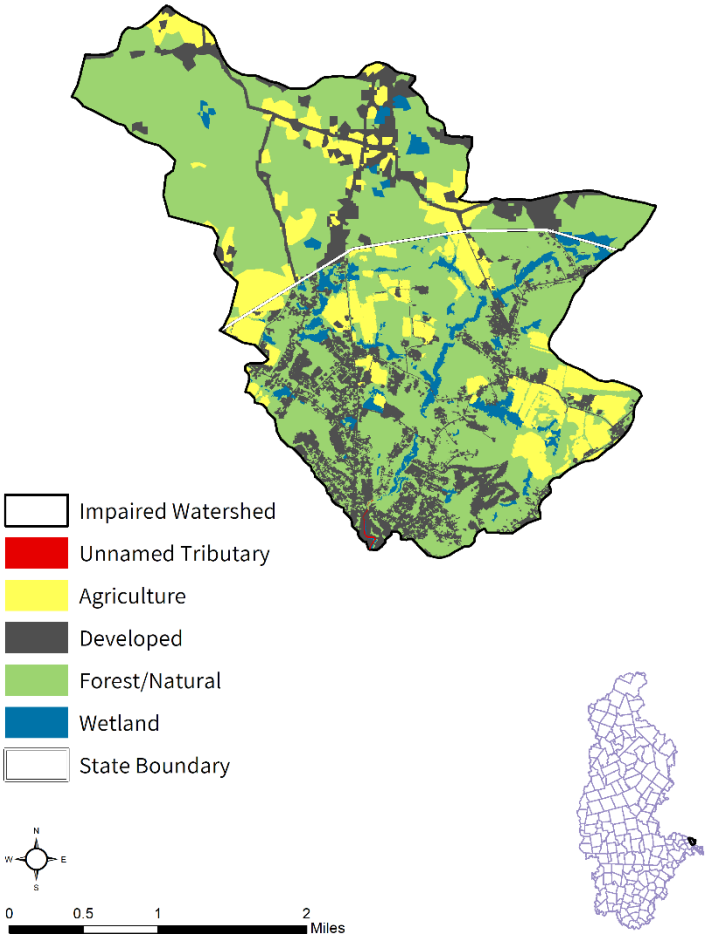
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: SA (Shellfishing)

Impervious Area (Acres, %): 274 (11%)

DCIA Area (Acres, %): 155 (6%)





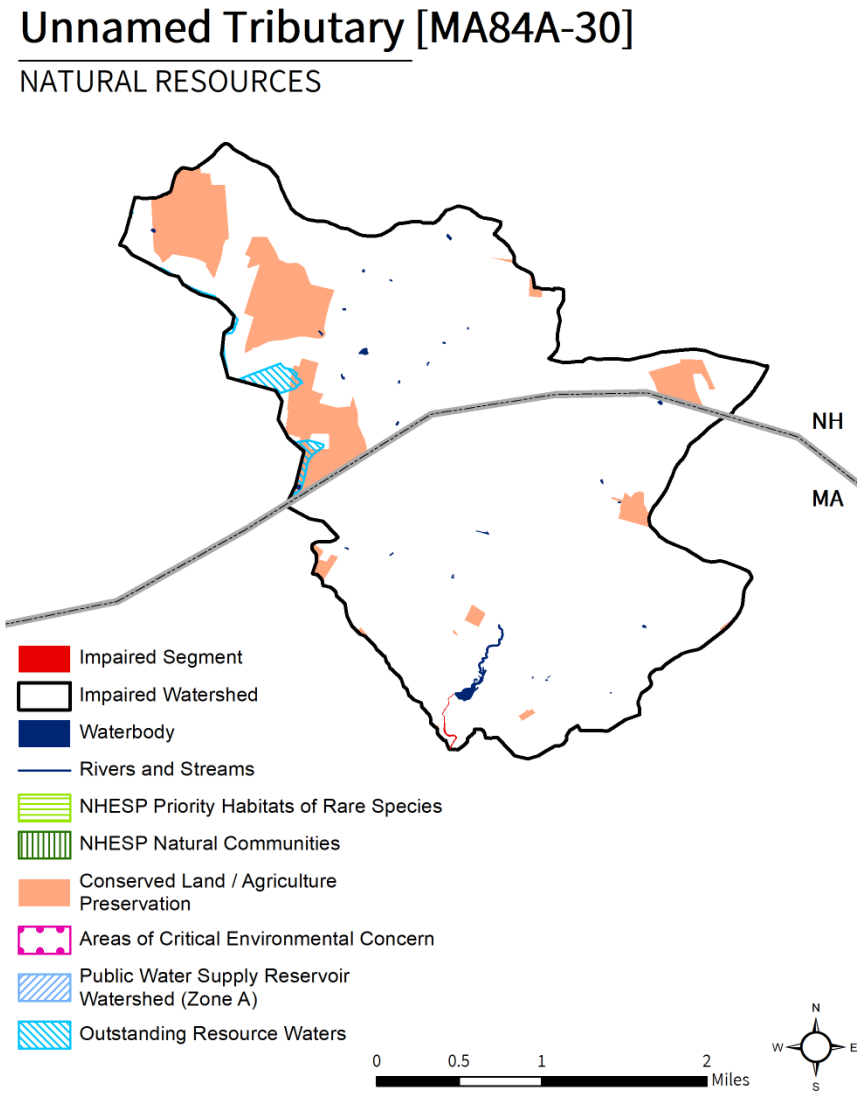
[64] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

Massachusetts is covered predominately with forest and natural lands (54%) but contains a substantial amount of development (23%); agricultural (16%) and wetland areas (7%) are also present. The segment itself is surrounded entirely by developed areas, with the agricultural land consisting of cultivated and hay fields located in the upper watershed near the Back River and its tributaries.

In the Massachusetts portion of the unnamed tributary (MA84A-30) watershed, under the Natural Heritage and Endangered Species Program, there are no Priority Habitats of Rare Species or Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection or Areas of Critical Environmental Concern, and 42 acres (1%) of Outstanding Resource Waters. There are 33 acres (1%) of land protected in perpetuity[65], part of 38 acres (2%) of Protected and Recreational Open Space[66]. See Figure 24-1.

[65] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[66] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



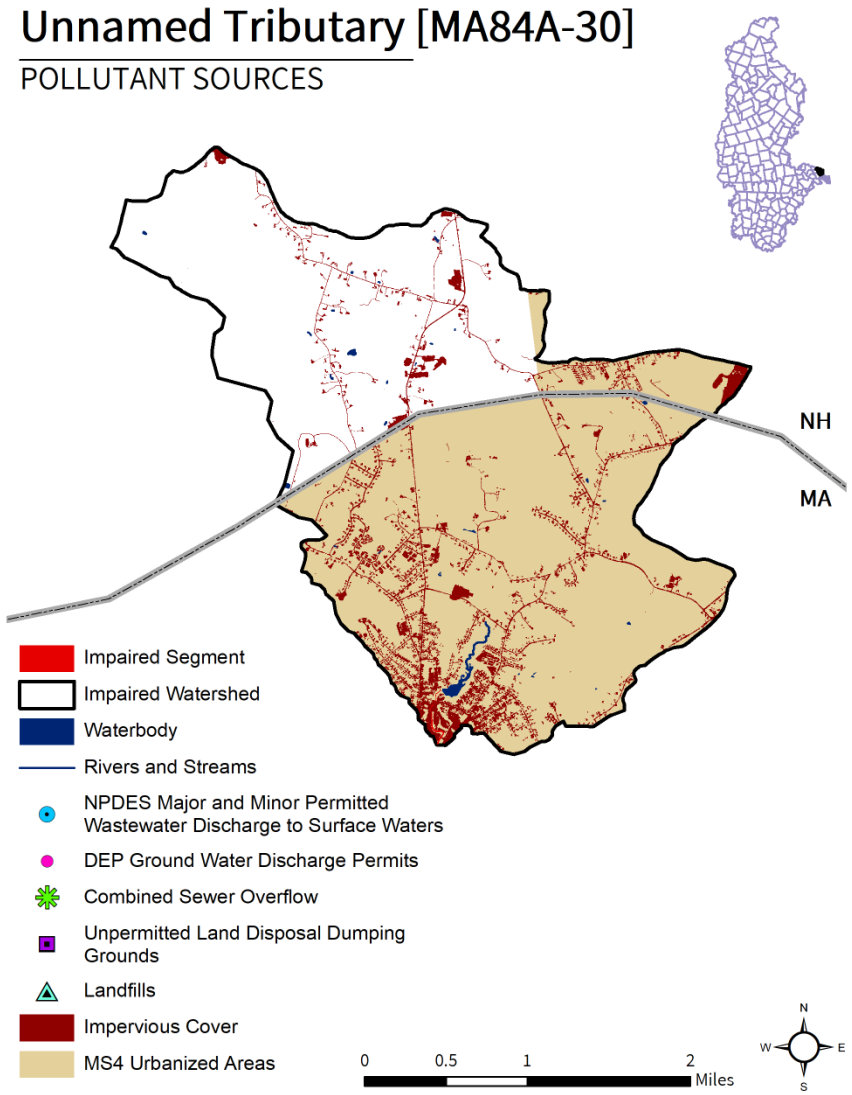


Figure 24-1. Natural resources and potential pollution sources draining to the unnamed tributary segment MA84A-30. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from a high-resolution product available for Rockingham and Strafford counties in New Hampshire.

24.2. Waterbody Impairment Characterization

The unnamed tributary (MA84A-30) is a Class SA, tidal estuary, with a Shellfishing qualifier (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in the unnamed tributary at one site (W1196) in 2004 (Figure 24-2). The geometric mean of *E. coli* at this site was 236 CFU/100 mL and exceeded the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

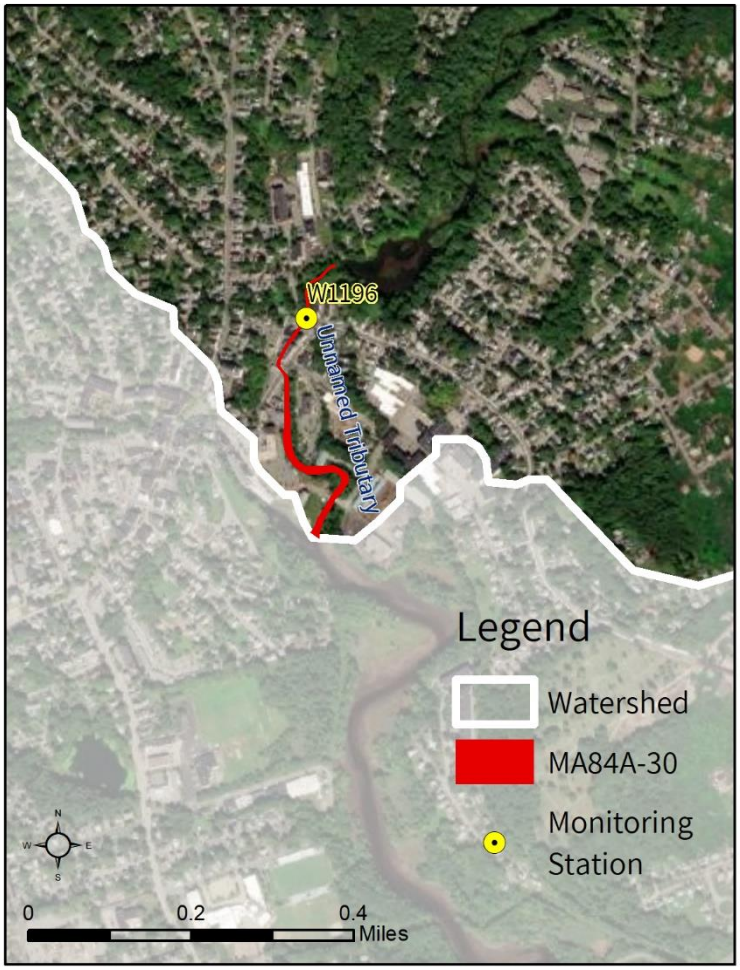


Figure 24-2. Location of monitoring station(s) along the impaired segment.

24.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (23%), with the greatest density located in the lower watershed within the City of Amesbury. In the Massachusetts portion of the watershed, the entire land area is subject to MS4 permit conditions, 11% is classified as impervious area, and 6% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts City of Amesbury. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Illicit Boat Discharges: The segment is navigable by marine vessels. Vessels with onboard toilets are required to have a marine sanitation device (MSD) to treat or store wastewater. MSDs that treat wastewater may be improperly maintained or malfunctioning and therefore could discharge untreated sewage to coastal waterbodies. For MSDs that store wastewater, this sewage can either be pumped out at shore-based pump-out facilities (CZM, 2022b) or discharged directly into the water when the vessel is more than three miles offshore, beyond the designated No Discharge Zone (NDZ). Boaters who ignore these laws and discharge untreated sewage to coastal waterbodies may be a source of pathogen pollution.

Vessel Pump-Out Facilities: There are no vessel sewage pump-out facilities directly adjacent to the unnamed tributary segment MA84A-30 (CZM, 2022b). Although pump-out facilities provide boaters with a means of disposing onboard sewage without discharging it into coastal waters, these facilities are generally associated with high boating activity. Pump-out facilities which malfunction or leak also represent a potential pathogen source. As a result, waterbodies adjacent to pump-out facilities are likely at high risk of illicit boat (and facility) discharges.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for a substantial portion (16%) of the total land use. The agricultural land is comprised predominately of pasture/hay fields, with some cultivated fields as well. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few high-density residential neighborhoods near the unnamed tributary segment MA84A-30. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: There are no open fields directly adjacent to the impaired segment; however, Clarks Pond, the segment's source, has the potential to attract waterfowl. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

24.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Amesbury. See Section 7.4

Town of Salisbury. See Section 8.4

25. MA84A-31 South Branch Souhegan River

25.1. Waterbody Overview

The South Branch Souhegan River segment MA84A-31 is 3.0 miles long and begins at the outlet of Watatic Pond in Ashburnham, MA. The segment flows northeast before turning north and ending at the state line between New Ipswich, NH and Ashby, MA.

Tributaries to the South Branch Souhegan River segment MA84A-31 include several unnamed streams. Lakes and ponds in the watershed include Marble Pond, Stodge Meadow Pond, Ward Pond, Watatic Pond, and a few small unnamed waterbodies, in Massachusetts. Much of the river flows through forest and natural or wetland areas.

Key landmarks in the Massachusetts portion of the watershed include the Watatic Mountain State Wildlife Area and the former Watatic Ski Area. From upstream to downstream, segment MA84A-31 is crossed by Old Ashby Road (Ashburnham), West State Road/MA-119 (Ashby), West Road (Ashby), and Jones Hill Road (Ashby).

The South Branch Souhegan River (MA84A-31) drains a total area of 8.6 square miles (mi^2), of which 8.6 mi^2 (99%) are located within Massachusetts. Of these, 0.3 mi^2 (3%) are impervious and 0.1 mi^2 (1%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Ashburnham[67], and none of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 25-1.

The South Branch Souhegan River segment MA84A-31 watershed is located in a slightly-

Reduction from Highest Calculated Geomean: 21%

Watershed Area (Acres): 5,495

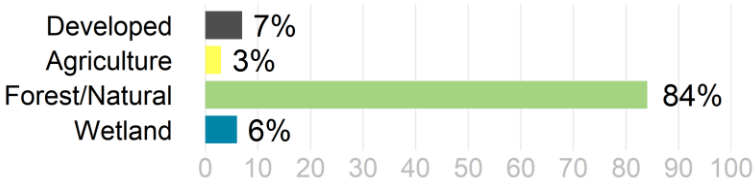
Segment Length (Miles): 3.0

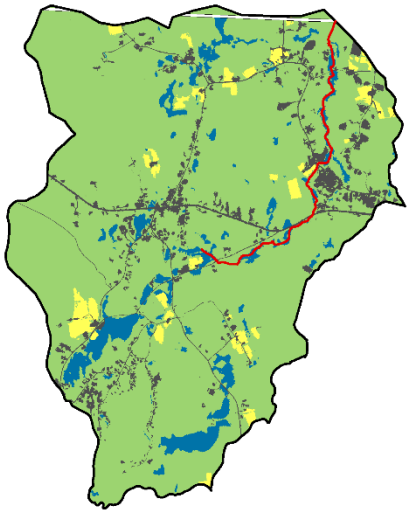
Impairment(s): *E. coli* (Primary Contact Recreation)

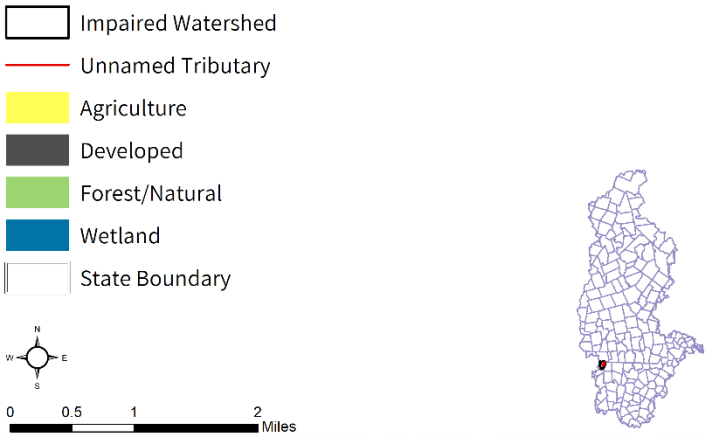
Class: B

Impervious Area (Acres, %): 166 (3%)

DCIA Area (Acres, %): 76 (1%)







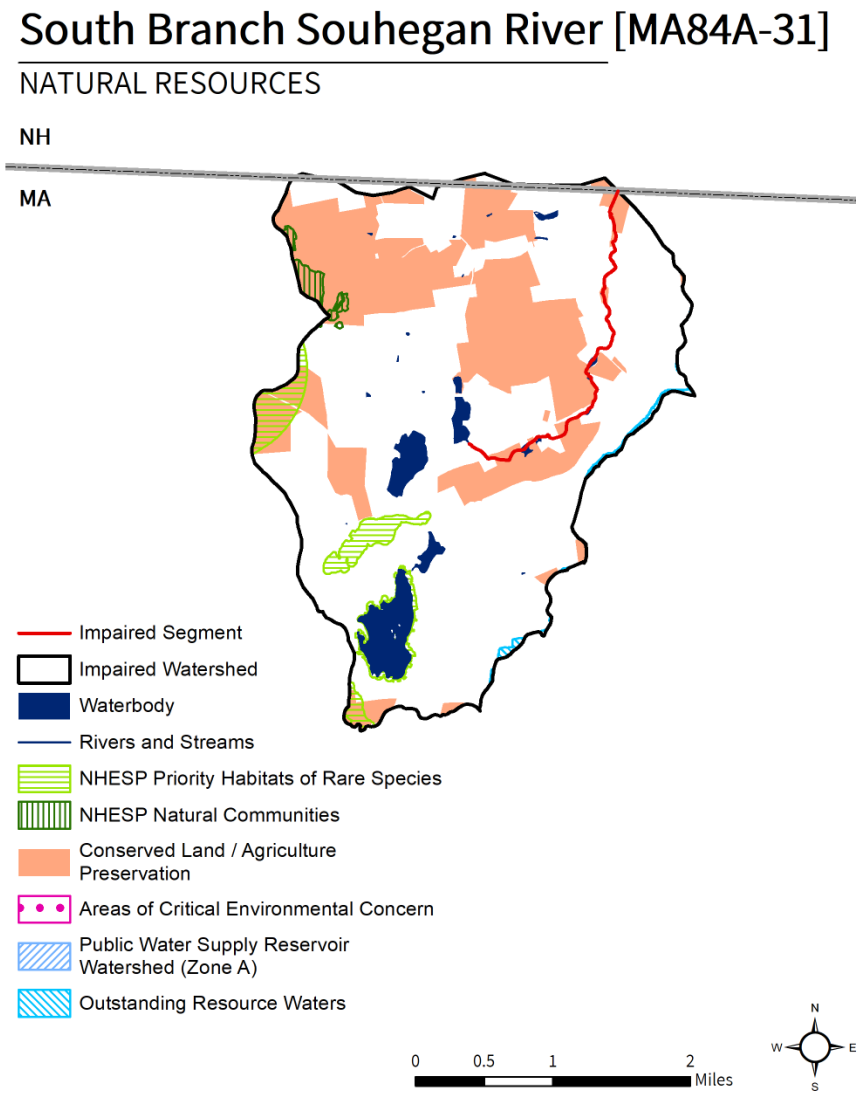
[67] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

developed part of Massachusetts. The vast majority of the watershed consists of forest and natural lands (84%); the remainder includes developed (7%), wetland (6%) and agricultural areas (3%). Most of the development consists of residential areas along MA-119, while most of the agriculture consists of pasture and hay fields scattered throughout the watershed.

In the Massachusetts portion of the South Branch Souhegan River (MA84A-31) watershed, under the Natural Heritage and Endangered Species Program, there are 320 acres (6%) of Priority Habitats of Rare Species and 41 acres (1%) of Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection or within Areas of Critical Environmental Concern, and 25 acres (<1%) of Outstanding Resource Waters. There are 1,597 acres (29%) of land protected in perpetuity[68], part of 1,604 acres (29%) of Protected and Recreational Open Space[69]. See Figure 25-1.

[68] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[69] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



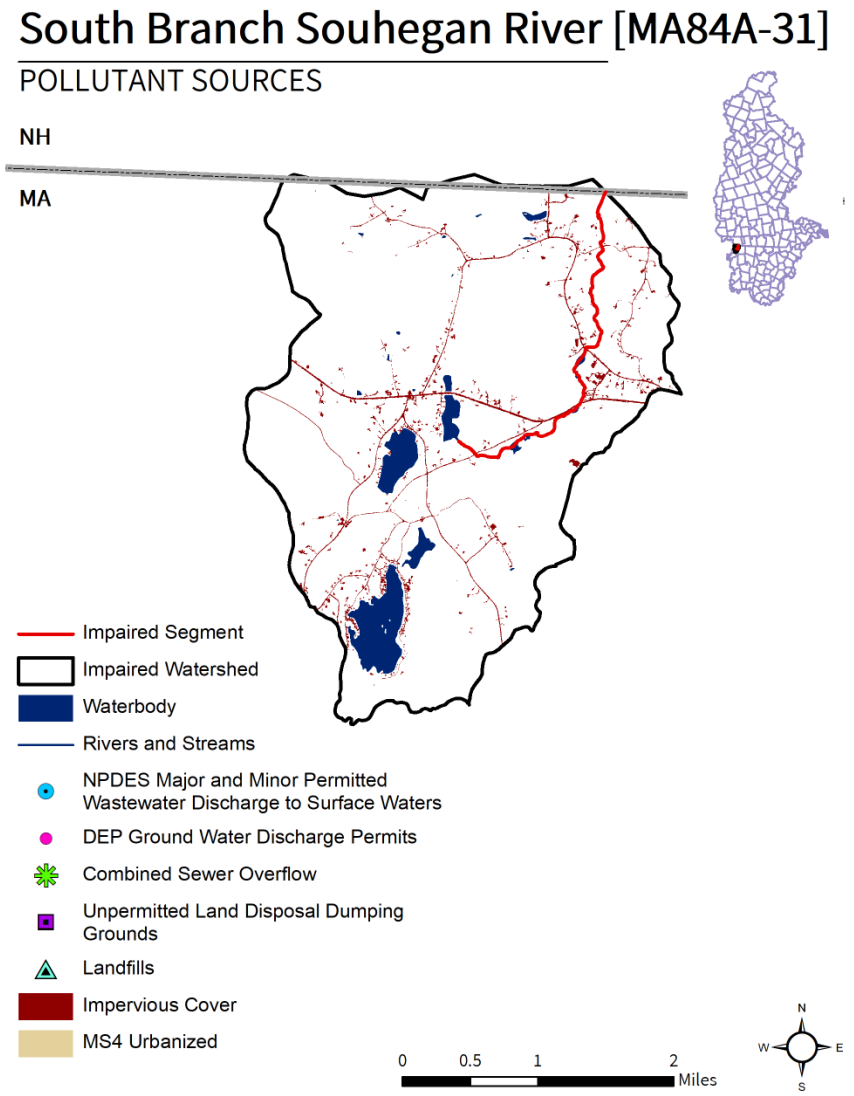


Figure 25-1. Natural resources and potential pollution sources draining to the South Branch Souhegan River segment MA84A-31. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from the 2019 National Land Cover Database.

25.2. Waterbody Impairment Characterization

The South Branch Souhegan River (MA84A-31) is a Class B Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the station listed below (refer to Tables 25-1, 25-2; Figure 25-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the STV criterion of 410 CFU/100 mL for *E. coli*. The geomean STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2010, six samples were collected at W2158; data indicated two days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of six samples, one exceeded the STV criterion during wet weather.

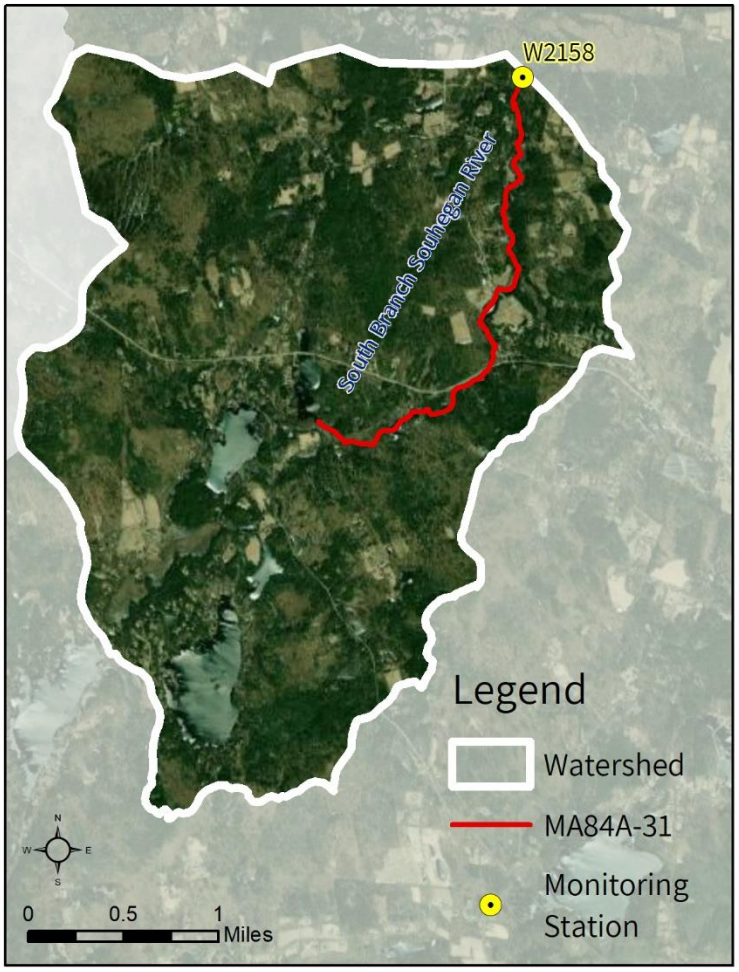


Figure 25-2. Location of monitoring station(s) along the impaired segment.

Table 25-1. Summary of indicator bacteria sampling results by station for the South Branch Souhegan River (MA84A-31). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W2158	5/18/2010	9/29/2010	6	159	2	1

Table 25-2. Indicator bacteria data by station, indicator, and date for the South Branch Souhegan River (MA84A-31). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W2158	*E. coli*	5/18/2010	DRY	100	100	
W2158	*E. coli*	6/10/2010	DRY	120	110	
W2158	*E. coli*	6/22/2010	DRY	120	113	
W2158	*E. coli*	7/27/2010	DRY	81	104	
W2158	*E. coli*	8/23/2010	WET	550	159	
W2158	*E. coli*	9/29/2010	WET	86	156	

25.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to the river via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and direct wildlife and domesticated animal waste (including pets).

Indicator bacteria levels for the South Branch Souhegan River (MA84A-31) were elevated during wet weather. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources. Certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation, may also result in elevated levels of indicator bacteria during wet weather events .

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is minimal development in the watershed (7%), with only a few residential areas located off main roads such as MA-119. In the Massachusetts portion of the watershed, none of the land area is subject to MS4 permit conditions, 3% is classified as impervious area, and 1% is classified as DCIA. Stormwater runoff from urban areas is likely a minor source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts town of Ashburnham. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Most development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for a small portion (3%) of the total land use. The agricultural land is almost entirely composed of pasture and hay fields, most of which are located near the impaired segment and its tributaries. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are only a few small residential neighborhoods near the South Branch Souhegan River segment MA84A-31. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: Only a few small agricultural fields are located directly adjacent to the impaired segment; however, Watatic Pond, just upstream of the segment, has the potential to attract waterfowl. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

25.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Ashby

Ashby has an EPA-approved waiver from MS4 requirements and is therefore not subject to stormwater regulations under the NPDES General MS4 Stormwater Permit.

Ashby has the following ordinances and bylaws, mostly accessible online via the town website https://ci.ashby.ma.us/ (Town of Ashby, 2021):

- Wetland protection bylaw: None found
- Stormwater bylaw: None found
- Stormwater Utility: None found
- Pet Waste: None found

Ashby has a 2004 Community Development Plan that contains a section on Open Space and Natural Resource Protection. This section contains an analysis of natural resources within the town, including an entire subsection on water resources. Recommendations at the end of this section include protecting future drinking water supplies and water quality in streams and ponds. In order to protect water quality in streams and ponds, one of the suggestions is to consider passing a wetlands bylaw (Town of Ashby, 2021).

Town of Ashburnham

Ashburnham has an EPA-approved waiver from MS4 requirements and is therefore not subject to stormwater regulations under the NPDES General MS4 Stormwater Permit.

Ashburnham has the following ordinances and bylaws, mostly accessible online via the town website https://www.ashburnham-ma.gov/ (Town of Ashburnham, 2021):

- Wetland protection bylaw
- Stormwater bylaw: None found
- Stormwater Utility: None found
- Pet Waste: None found

Ashburnham has a 2017 Master Plan, however, there is no section regarding natural resources or open space available online. The town does have an active Planning Board and Conservation Commission. The Conservation Commission is tasked with administering the Ashburnham Wetlands Protection Bylaw. The town has a joint Water-Sewer Commission with the Town of Winchendon (Town of Ashburnham, 2021).

26. MA84A-35 Peppermint Brook

26.1. Waterbody Overview

Peppermint Brook segment MA84A-35 is 2.7 miles long and begins at the outlet of an unnamed pond east of Bridge Street/MA-38 in Dracut, MA. The segment flows south before ending at Beaver Brook in Dracut, MA.

Tributaries to the Peppermint Brook segment MA84A-35 include a few small unnamed streams. There are no named lakes or ponds in the watershed, though the segment flows through a few small unnamed waterbodies. Much of the river flows through developed or wetland areas.

Key landmarks in the Massachusetts portion of the watershed include the Dracut Public Works Department; Dracut Conservation Land and Path; and Cross Road Trail. From upstream to downstream, segment MA84A-35 is crossed by Bridge Street/MA-38, Cross Road, Laser Road, Chuck Drive (twice), Hildreth Street, Burdette Road, Hillside Road, Pleasant Street/MA-113, Peabody Avenue, Sladen Street, and Lakeview Avenue, all in Dracut.

Peppermint Brook (MA84A-35) drains a total area of 1.8 square miles (mi^2), of which nearly the entire drainage area is located within Massachusetts. Of these 1.8 mi^2 in Massachusetts, 0.3 mi^2 (16%) are impervious and 0.2 mi^2 (11%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Dracut[70], and the entire land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There is one landfill and no unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 26-1.

The Peppermint Brook segment MA84A-35 watershed is located in a highly-developed part of Massachusetts. Over half of the watershed

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 1,153

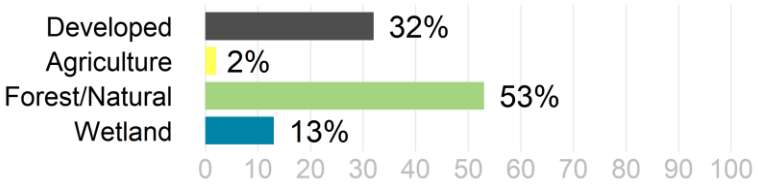
Segment Length (Miles): 2.7

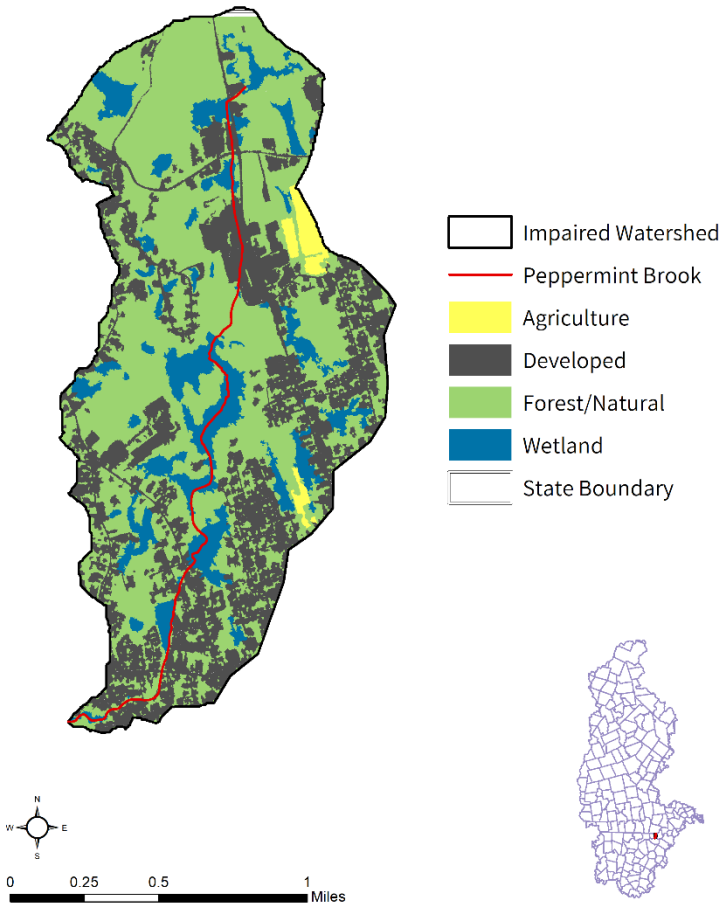
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 189 (16%)

DCIA Area (Acres, %): 121 (11%)





[70] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

consists of forest and natural lands (53%), with 13% wetland areas. The remainder of the watershed is primarily covered by development (32%), and there is little agricultural activity (2%). Most of the development consists of residential areas in the lower portion of the watershed.

In the Massachusetts portion of the Peppermint Brook (MA84A-35) watershed, under the Natural Heritage and Endangered Species Program, there are 307 acres (27%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. There are 90 acres (8%) of land protected in perpetuity[71], part of 113 acres (10%) of Protected and Recreational Open Space[72]. See Figure 26-1.

[71] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[72] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

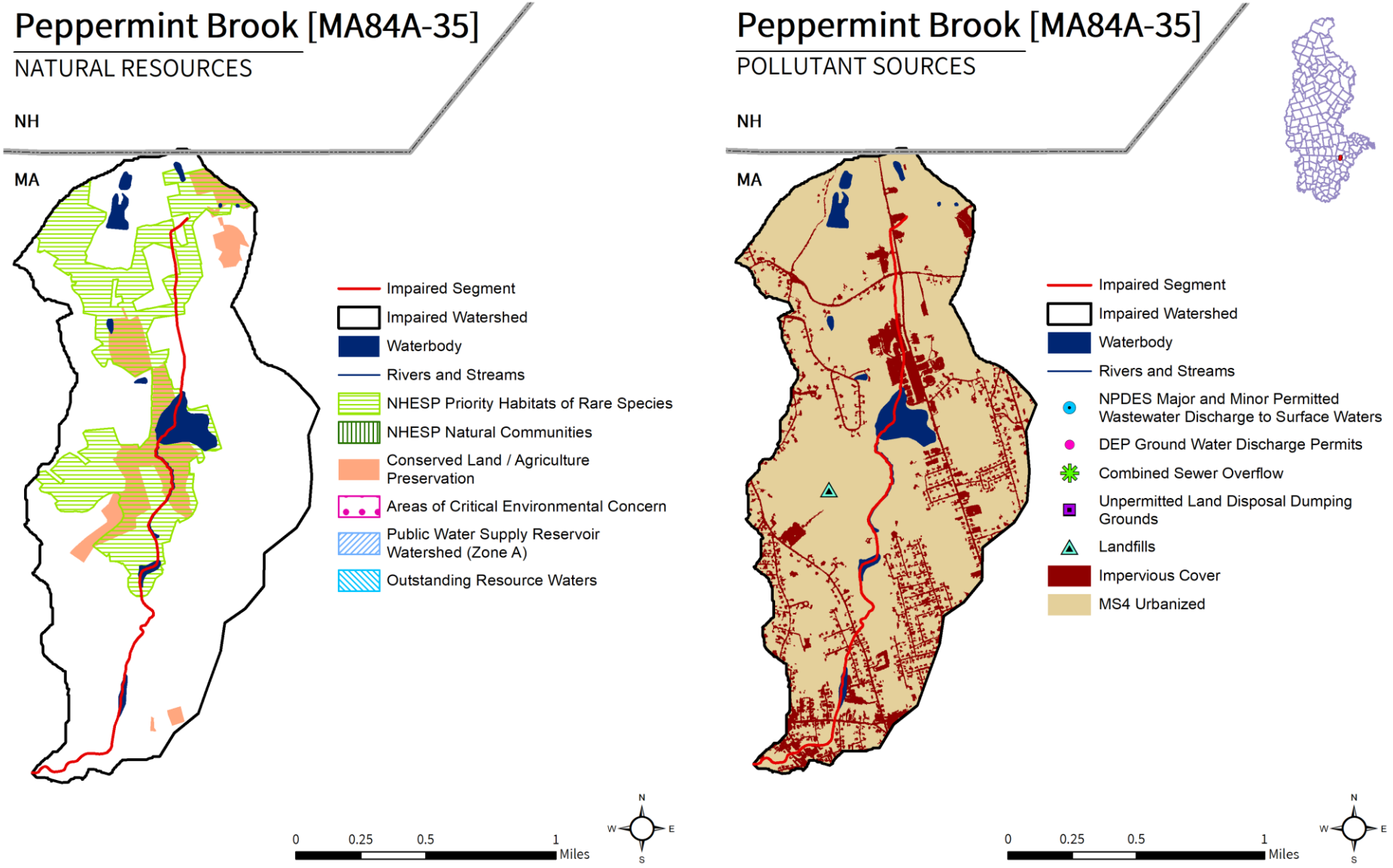


Figure 26-1. Natural resources and potential pollution sources draining to the Peppermint Brook segment MA84A-35. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

26.2. Waterbody Impairment Characterization

Peppermint Brook (MA84A-35) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Peppermint Brook at one site (W1211) in 2004 (Figure 26-2). The geometric mean of *E. coli* at this site was 644 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

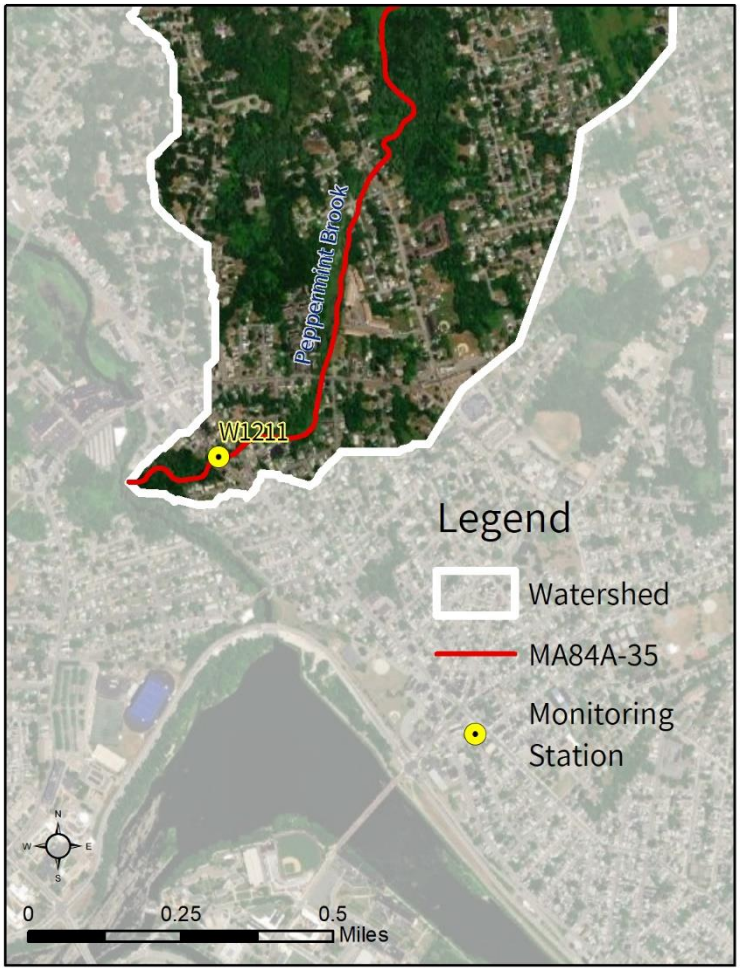


Figure 26-2. Location of monitoring station(s) along the impaired segment.

26.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (32%), with the greatest density located in the lower watershed near the city of Lowell. In the Massachusetts portion of the watershed, 100% of the land area is subject to MS4 permit conditions, 16% is classified as impervious area, and 11% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts town of Dracut. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for only a small portion (2%) of the total land use. The agricultural land consists of a few small pasture/hay and cultivated fields. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few high-density residential neighborhoods and trails near the Peppermint Brook segment MA84A-35. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: There are a few large wetland areas located directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

26.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Dracut. See Section 5.4

27. MA84A-36 Bartlett Brook

27.1. Waterbody Overview

Bartlett Brook segment MA84A-36 is 3.7 miles long and begins at the state line between Pelham, NH and Dracut, MA. The segment flows generally southeast before ending at the inlet to Mill Pond in Methuen, MA.

Tributaries to the Bartlett Brook segment MA84A-36 include two unnamed streams. Lakes and ponds in the watershed include Peters Pond and a few small unnamed waterbodies in Massachusetts. Much of the river flows through wetland areas.

Key landmarks in the Massachusetts portion of the watershed include Elmwood Cemetery and Brox Farm. From upstream to downstream, segment MA84A-36 is crossed by Sawmill Drive (twice in Dracut), Concord Road (Dracut), Salem Road (Dracut), Broadway Road/MA-113 (twice in Dracut), and North Lowell Street/MA-113 (Methuen).

Bartlett Brook (MA84A-36) drains a total area of 6.8 square miles (mi^2), of which 5.6 mi^2 (82%) are located within Massachusetts. Of these, 0.6 mi^2 (10%) are impervious and 0.3 mi^2 (6%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Dracut and Methuen[73], and 74% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 27-1.

The Bartlett Brook segment MA84A-36 watershed is located in a moderately-developed part of Massachusetts. Over half of the watershed in Massachusetts consists of forest and natural lands (55%), while a little under a quarter is developed (23%). Wetland areas (17%) cover more than

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 3,563

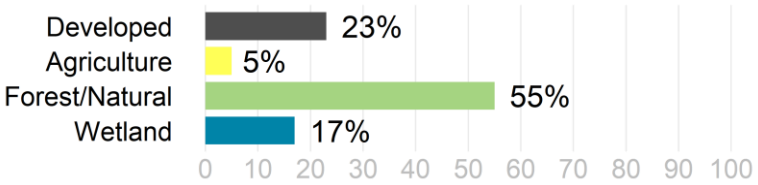
Segment Length (Miles): 3.7

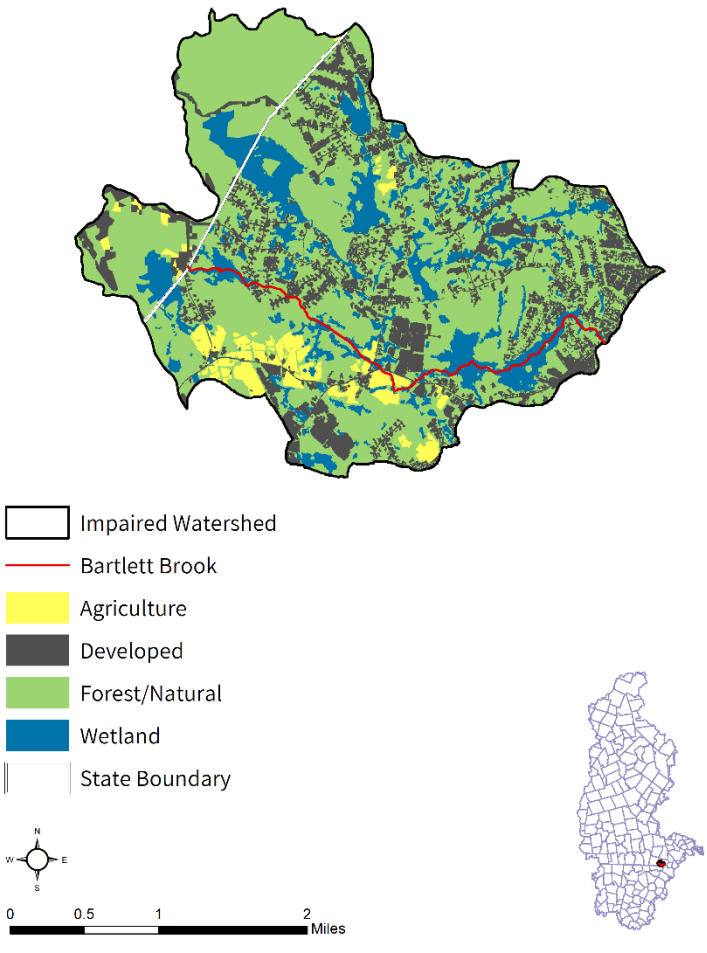
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 372 (10%)

DCIA Area (Acres, %): 217 (6%)





[73] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

three times the amount of land as agricultural areas (5%) in the watershed. Most of the development consists of residential areas scattered throughout the watershed while most of the agricultural activity consists of pasture and hay fields in the southwestern corner of the watershed.

In the Massachusetts portion of the Bartlett Brook (MA84A-36) watershed, under the Natural Heritage and Endangered Species Program, there are 269 acres (8%) of Priority Habitats of Rare Species and 60 acres (2%) of Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. There are 60 acres (2%) of land protected in perpetuity[74], part of 154 acres (4%) of Protected and Recreational Open Space[75]. See Figure 27-1.

[74] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[75] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

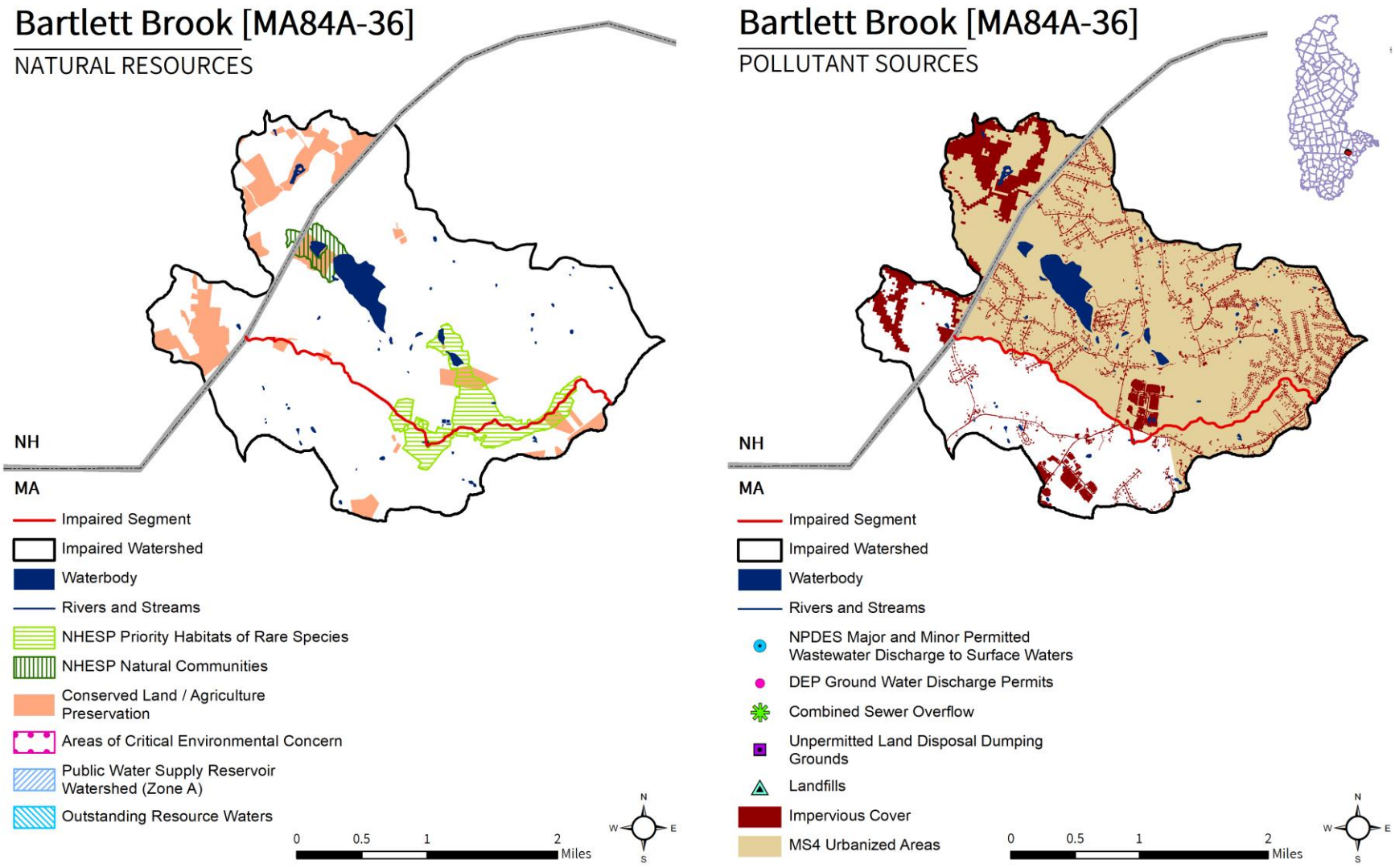


Figure 27-1. Natural resources and potential pollution sources draining to the Bartlett Brook segment MA84A-36. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from the 2019 National Land Cover Database.

27.2. Waterbody Impairment Characterization

Bartlett Brook (MA84A-36) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Bartlett Brook at one site (W1202) in 2004 (Figure 27-2). The geometric mean of *E. coli* at this site was 344 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

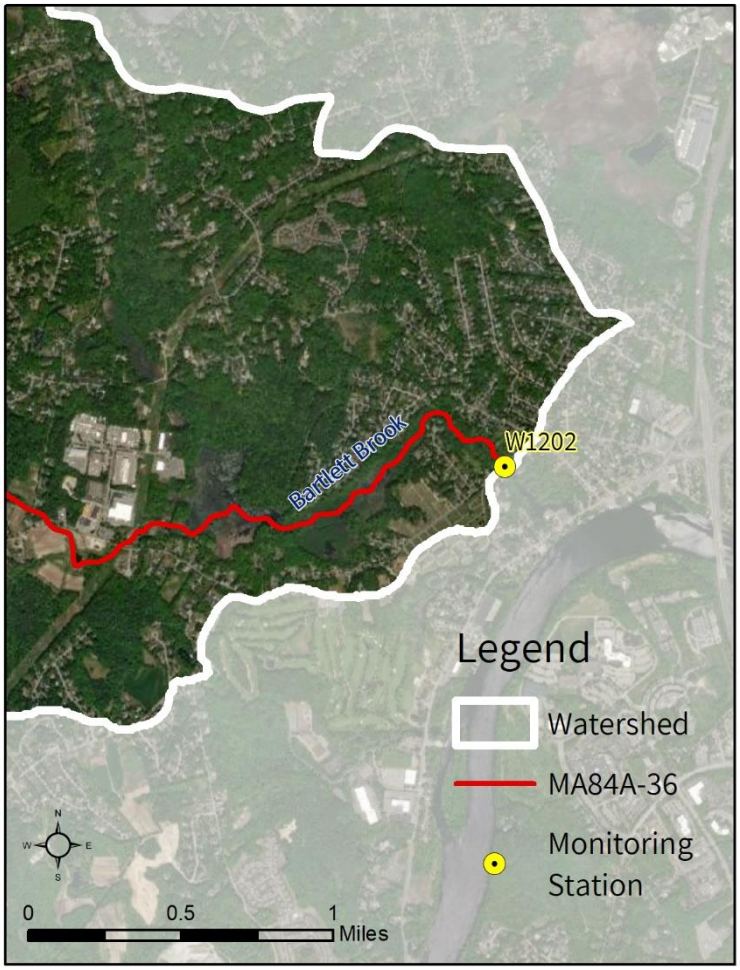


Figure 27-2. Location of monitoring station(s) along the impaired segment.

27.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (23%) that is spread out evenly. Within the Massachusetts portion of the watershed, 74% of the land area is subject to MS4 permit conditions, 10% is classified as impervious area, and 6% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts municipalities of Dracut and Methuen. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for a relatively small portion (5%) of the total land use. The agricultural land is comprised predominately of pasture/hay fields directly adjacent to the segment in the southwestern corner of the watershed, with some cultivated fields as well. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few moderate-density residential neighborhoods near the Bartlett Brook segment MA84A-36. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open fields and wetland areas are located directly adjacent to the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

27.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Methuen. See Section 5.4

Town of Dracut. See Section 5.4

28. MA84A-37 Creek Brook

28.1. Waterbody Overview

Creek Brook segment MA84A-37 is 2.3 miles long and begins at the outlet of Crystal Lake in Haverhill, MA. The segment flows southeast before meandering southwest and ending at its confluence with the Merrimack River in Haverhill, MA.

Tributaries to the Creek Brook segment MA84A-37 include an unnamed tributary and West Meadow Brook. Lakes and ponds in the watershed include Crystal Lake and a few small unnamed ponds in Massachusetts. Much of the river flows through wetland areas.

Key landmarks in the Massachusetts portion of the watershed include Crystal Lake Golf Club; St. Patrick's Cemetery; and Crystal Gorge, Crystal Point, and Crystal Shores conservations areas. From upstream to downstream, segment MA84A-37 is crossed by Lake Street, Research Drive, Broadway/MA-97, West Lowell Avenue, and River Street/MA-110, all in Haverhill.

Creek Brook (MA84A-37) drains a total area of 5.5 square miles (mi^2), of which 5.0 mi^2 (90%) are located within Massachusetts. Of these, 0.6 mi^2 (11%) are impervious and 0.3 mi^2 (6%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Haverhill[76], and the entire land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 28-1.

The Creek Brook segment MA84A-37 watershed is located in a moderately-developed part of Massachusetts. Over half of the watershed in Massachusetts consists of forest and natural lands (56%), while around a quarter is developed (25%).

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 3,179

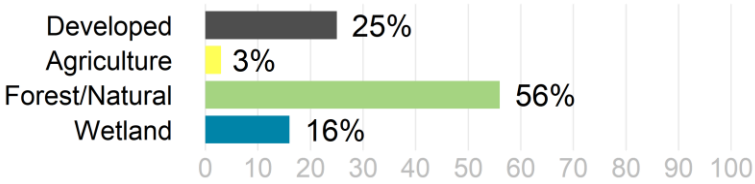
Segment Length (Miles): 2.3

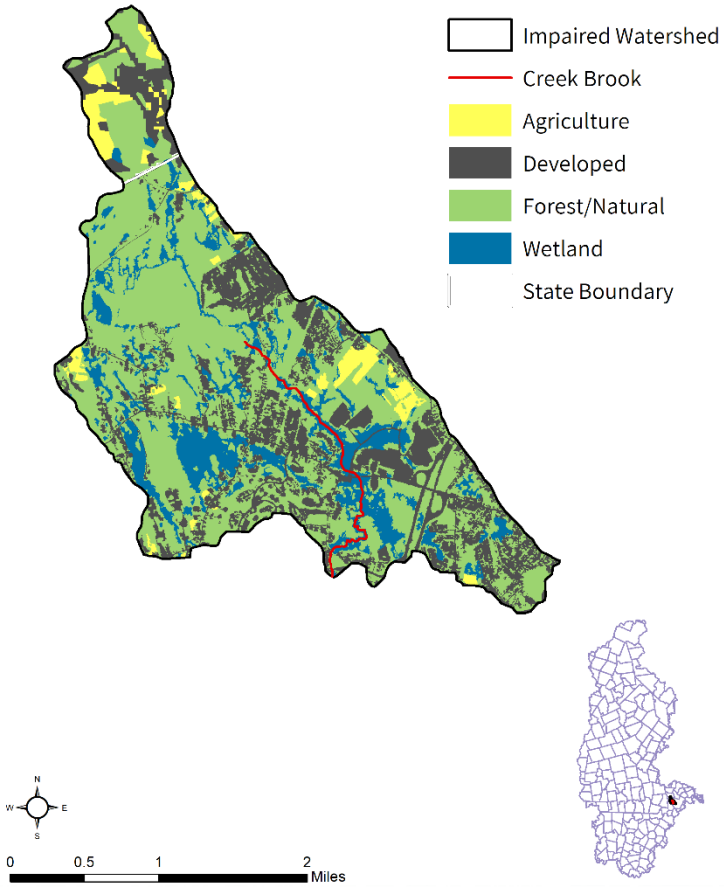
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 357 (11%)

DCIA Area (Acres, %): 202 (6%)





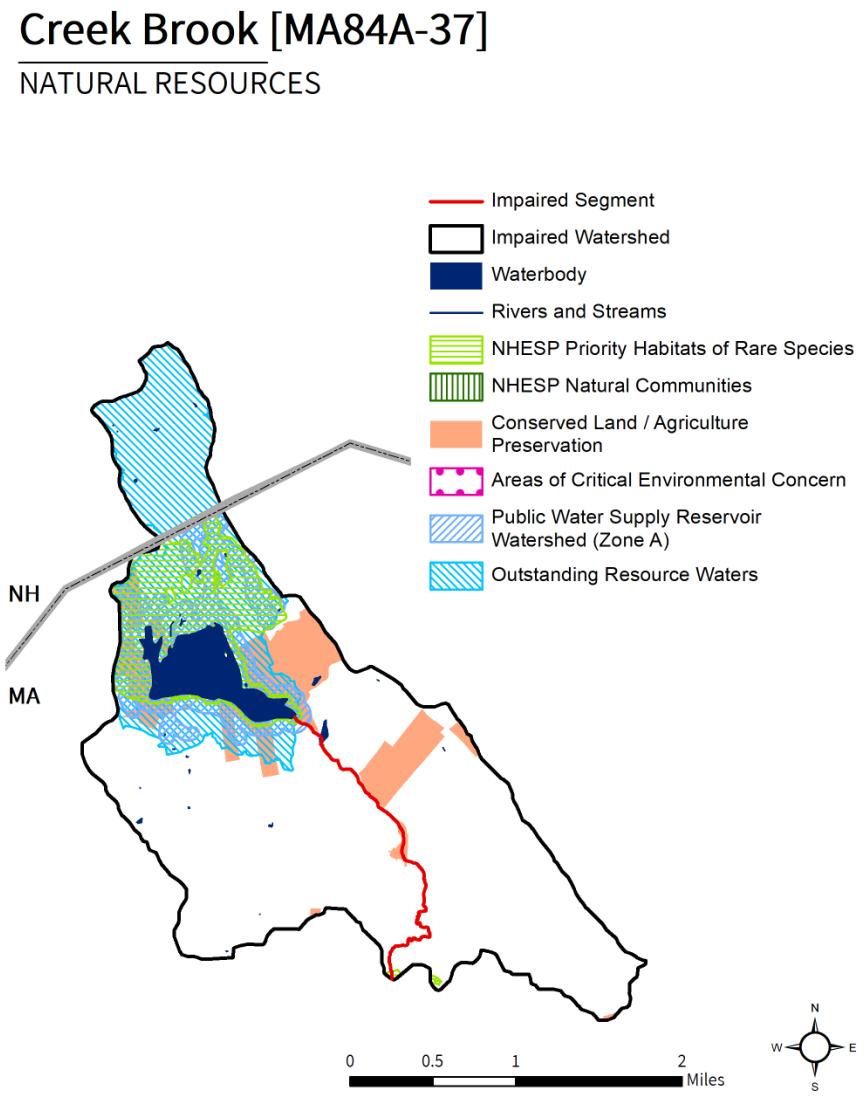
[76] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

Wetland areas (16%) cover most of the remaining watershed as there is only a small amount of agricultural activity (3%). Most of the development consists of residential areas; however, there are also large industrial and commercial buildings located near the impaired segment. Agricultural activity predominately consists of a few scattered pasture and hay fields.

In the Massachusetts portion of the Creek Brook (MA84A-37) watershed, under the Natural Heritage and Endangered Species Program, there are 521 acres (16%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also 369 acres (12%) under Public Water Supply protection, no Areas of Critical Environmental Concern, and 773 acres (24%) of Outstanding Resource Waters. There are 269 acres (8%) of land protected in perpetuity[77], part of 399 acres (13%) of Protected and Recreational Open Space[78]. See Figure 28-1.

[77] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[78] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



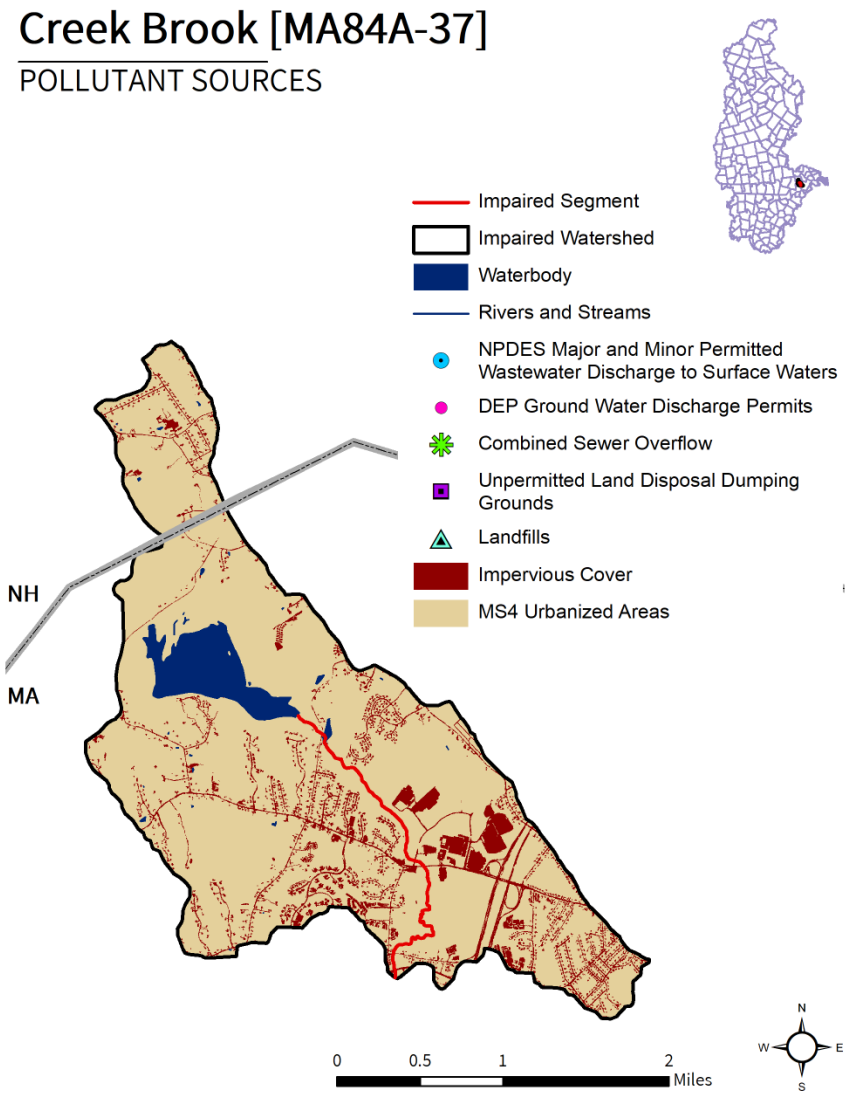


Figure 28-1. Natural resources and potential pollution sources draining to the Creek Brook segment MA84A-37. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from a high-resolution product available for Rockingham and Strafford counties in New Hampshire.

28.2. Waterbody Impairment Characterization

Creek Brook (MA84A-37) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Creek Brook at one site (W1203) in 2004 (Figure 28-2). The geometric mean of *E. coli* at this site was 331 CFU/100 mL and did not meet the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

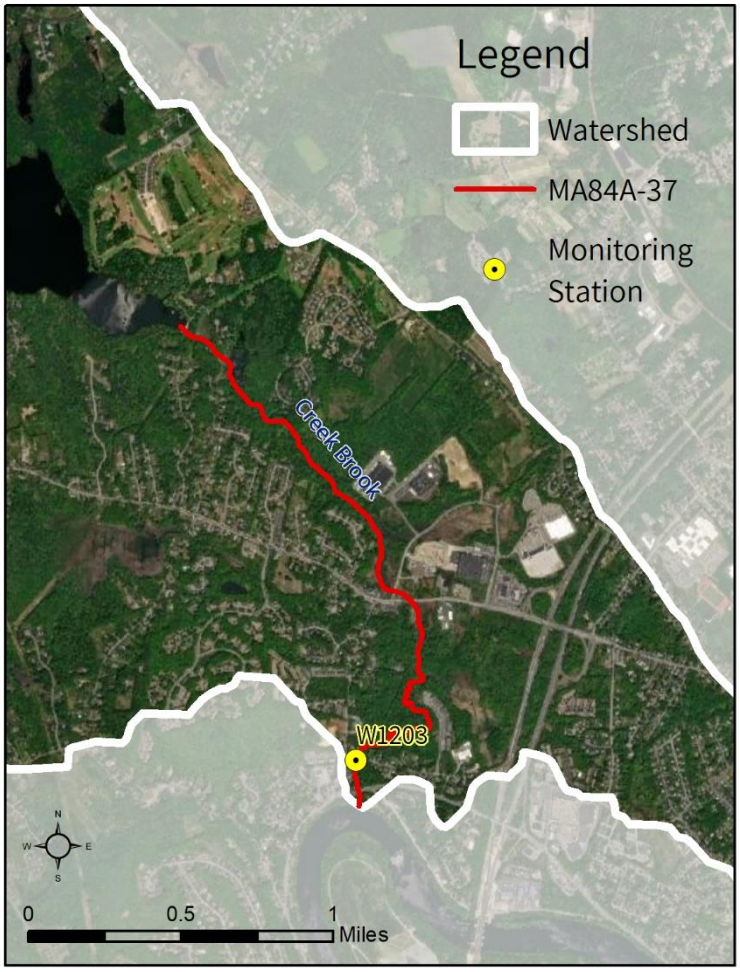


Figure 28-2. Location of monitoring station(s) along the impaired segment.

28.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (25%), consisting predominately of residential areas with some commercial and industrial development. Within the Massachusetts portion of the watershed, the entire land area is subject to MS4 permit conditions, 11% is classified as impervious area, and 6% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts city of Haverhill. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for a relatively small portion (3%) of the total land use. The agricultural land is comprised predominately of pasture/hay fields scattered throughout the watershed. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few moderate-density residential neighborhoods near the Creek Brook segment MA84A-37. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: There are a few open wetland areas directly adjacent to the impaired segment. Additionally, Crystal Lake, which is the source of the impaired segment, has the potential to attract waterfowl. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

28.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Haverhill. See Section 6.4

29. MA84A-39 East Meadow River

29.1. Waterbody Overview

The East Meadow River segment MA84A-39 is 3.0 miles long and begins at the outlet of Neal Pond in Haverhill, MA. The segment flows southwest before turning southeast and ending at the inlet of Millvale Reservoir in Haverhill, MA.

Tributaries to the East Meadow Brook segment MA84A-39 include a few unnamed streams. Lakes and ponds in the watershed include Neal Pond and a few other small unnamed waterbodies in Massachusetts. Much of the river flows through wetland areas.

Key landmarks in the Massachusetts portion of the watershed include Whittier Regional High School and Whittier Birthplace. From upstream to downstream, segment MA84A-39 is crossed by Brandy Brow Road, an unnamed street, Amesbury Road/MA-110, I-495, Country Bridge Road, and Thompson Road, all in Haverhill.

The East Meadow River (MA84A-39) drains a total area of 7.1 square miles (mi^2), of which 5.8 mi^2 (82%) are located within Massachusetts. Of these, 0.3 mi^2 (6%) are impervious and 0.2 mi^2 (3%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Haverhill[79], and 50% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). In Massachusetts, there are no NPDES permits on file governing point source discharges of pollutants to surface waters, one MassDEP discharge-to-groundwater permit for an on-site wastewater discharge (Table 29-1), and no combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the Massachusetts portion of the watershed. See Figure 29-1.

The East Meadow River segment MA84A-39 watershed is located in a moderately-developed part of Massachusetts. Over half of the watershed in Massachusetts consists of forest and natural lands (64%), with 13% also composed of wetlands; there is also development (12%) and

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 3,734

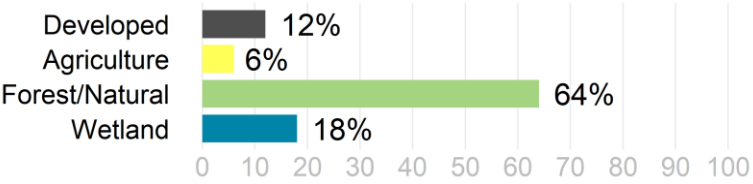
Segment Length (Miles): 3.0

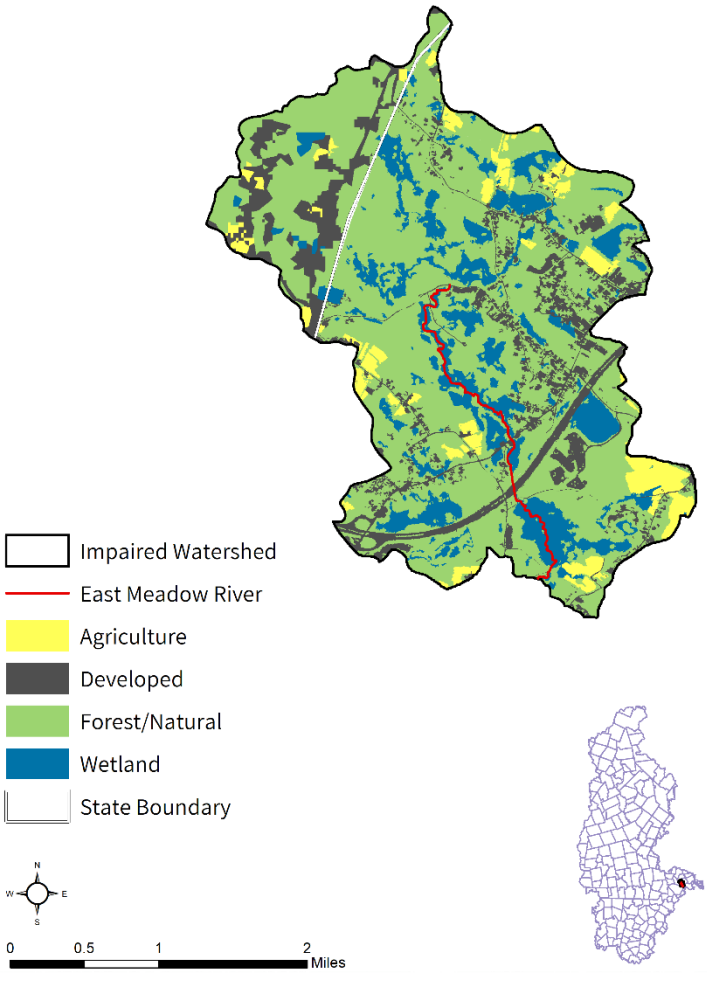
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: A (Public Water Supply, Outstanding Resource Water)

Impervious Area (Acres, %): 212 (6%)

DCIA Area (Acres, %): 95 (3%)





[79] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

agriculture (6%). Most of the development is residential with some commercial. Agricultural activity in the watershed consists of a few horse farms and other pasture/hay fields.

In the Massachusetts portion of the East Meadow River (MA84A-39) watershed, under the Natural Heritage and Endangered Species Program, there are 1,074 acres (29%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are 1,395 acres (37%) under Public Water Supply protection, no Areas of Critical Environmental Concern, and 3,690 acres (99%) of Outstanding Resource Waters. There are 433 acres (12%) of land protected in perpetuity[80], part of 604 acres (16%) of Protected and Recreational Open Space[81]. See Figure 29-1.

Table 29-1. Groundwater discharge permits in the watershed. Only permits unique to this segment watershed are shown. PERR = permit number plus renewal number. TYPE = type of groundwater discharge. FLOW = permitted effluent in gallons per day (gpd).

PERR	NAME	TOWN	TYPE	FLOW (GPD)
924-0	WHITTIER REGIONAL HIGH SCHOOL	HAVERHILL	Sanitary Discharge	22,000

[80] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[81] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

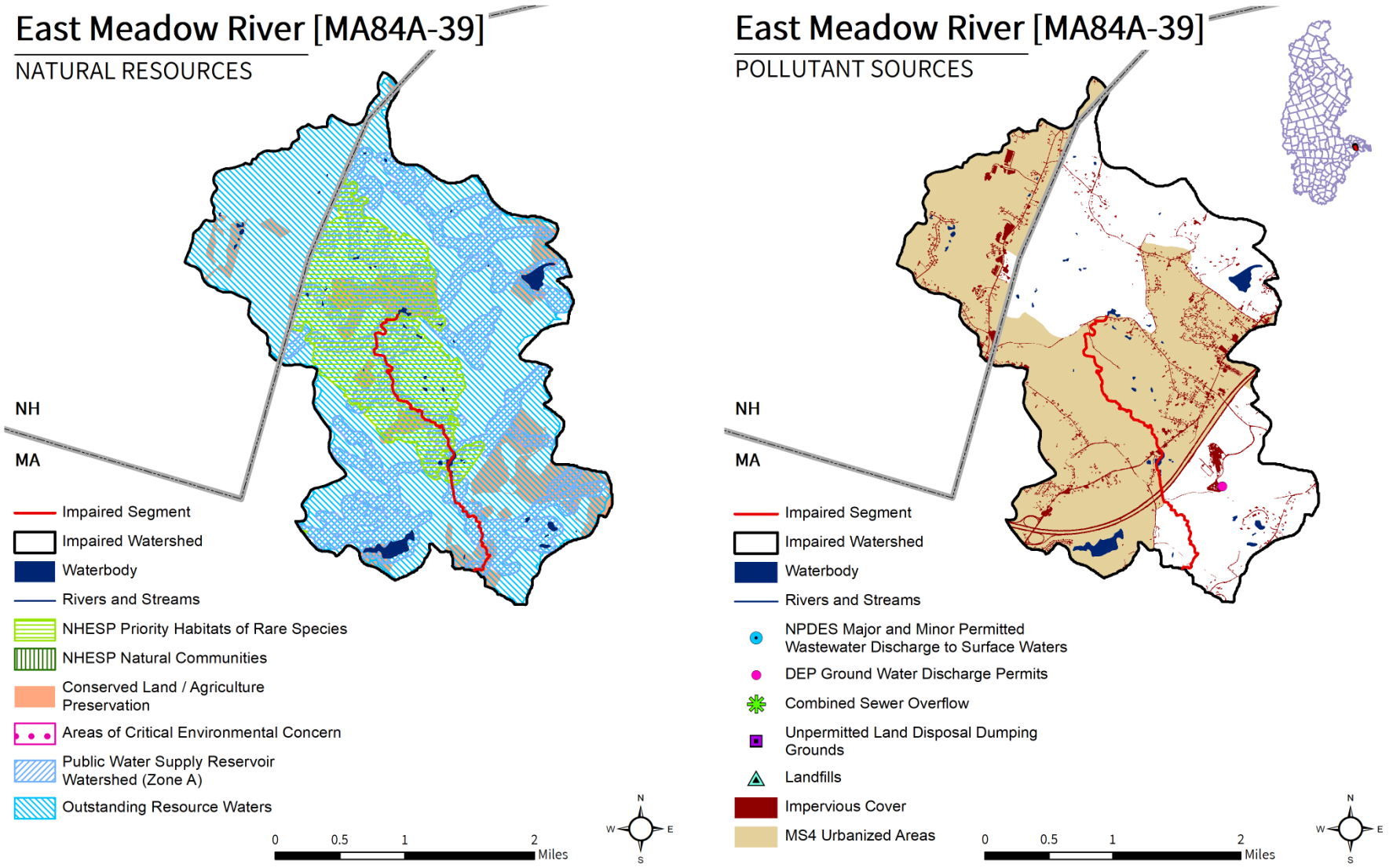


Figure 29-1. Natural resources and potential pollution sources draining to the East Meadow River segment MA84A-39. The map on the left shows critical habitat, water features, and conserved land; Massachusetts only layers include Impaired Segment, NHESP Priority Habitats of Rare Species, NHESP Natural Communities, Areas of Critical Environmental Concern, and Public Water Supply Reservoir Watershed (Zone A). The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.; Massachusetts only layers include Impaired Segment and all point features. Outside of Massachusetts, the conserved land reflects land protected in perpetuity only and the impervious cover is from a high-resolution product available for Rockingham and Strafford counties in New Hampshire.

29.2. Waterbody Impairment Characterization

The East Meadow River (MA84A-39) is a Class A, Public Water Supply, and Outstanding Resource Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in the East Meadow River at one site (W1213) in 2004 (Figure 29-2). The geometric mean of *E. coli* at this site was 128 CFU/100 mL and exceeded the criteria for Primary Contact Recreation (Meek and Kennedy, 2010).

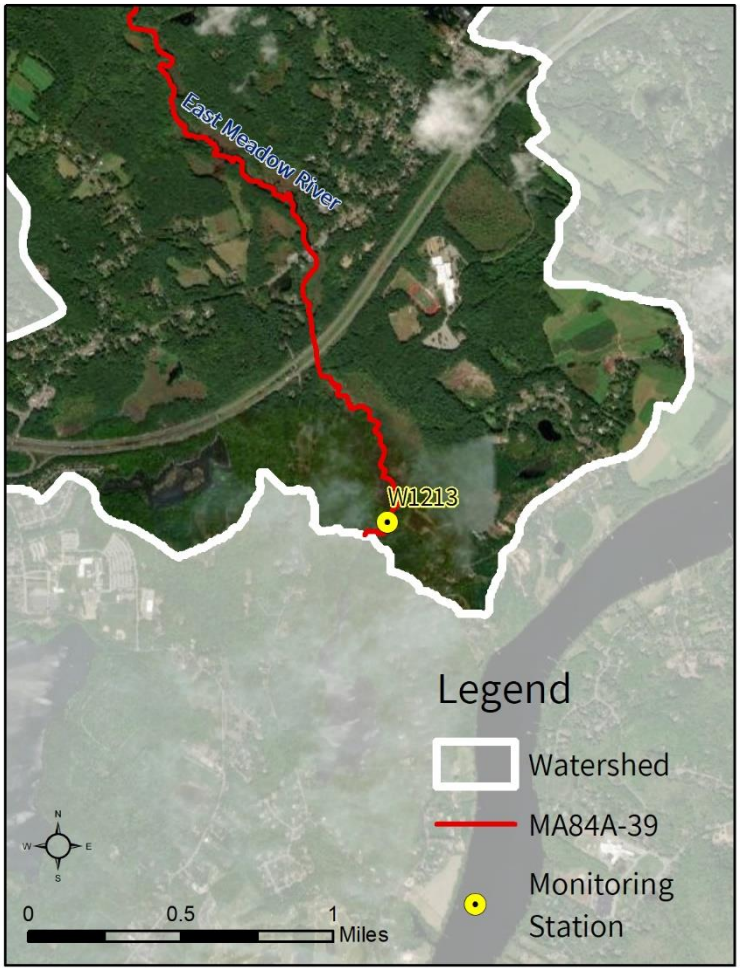


Figure 29-2. Location of monitoring station(s) along the impaired segment.

29.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (12%), predominately residential areas with some commercial development. Within the Massachusetts portion of the watershed, 50% of the land area is subject to MS4 permit conditions, 6% is classified as impervious area, and 3% is classified as DCIA. Stormwater runoff from urban areas is likely a source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts city of Haverhill. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some development in the watershed utilizes on-site septic systems for wastewater treatment. There is one MassDEP permit for an on-site wastewater discharge to groundwater. In addition to this permitted point source, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the Massachusetts portion of the watershed account for a relatively small portion (6%) of the total land use, and is mostly as horse farms and pasture/hay fields scattered throughout the watershed. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few low-density residential neighborhoods near the East Meadow River segment MA84A-39. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: There are a few open wetland areas directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

29.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

City of Haverhill. See Section 6.4

Town of Merrimac. See Section 7.4

30. MA84A-40 Fish Brook

30.1. Waterbody Overview

Fish Brook segment MA84A-40 is 4.1 miles long and begins east of Greenwood Road in Andover, MA. The segment flows northwest before ending at the Merrimack River at Fish Brook Dam (NAT ID: MA02265) in Andover, MA.

Tributaries to Fish Brook segment MA84A-40 include a few unnamed streams. Lakes and ponds in the watershed include Haggetts Pond and a few unnamed waterbodies. Much of the river flows through wetland areas.

Key landmarks in the watershed include High Plain Elementary School; the Internal Revenue Service office (Andover); the Andover Water Treatment Plant; Indian Ridge Country Club; Bald Hill Park; and High Plain, Fish Brook, and Deer Jump reservations. From upstream to downstream, segment MA84A-40 is crossed by Greenwood Road, I-93, High Plain Road, I-495, and River Road, all in Andover.

Fish Brook (MA84A-40) drains a total area of 6.1 square miles (mi^2), of which 0.6 mi^2 (10%) are impervious and 0.3 mi^2 (6%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Andover[82], and the entire land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There is one additional NPDES permit on file governing point source discharges of pollutants to surface waters (it is not for a wastewater treatment facility). There are no MassDEP discharge-to-groundwater permits for on-site wastewater discharges or combined sewer overflows (CSOs) within the watershed. There is one landfill and no unpermitted land disposal dumping grounds within the segment watershed. See Figure 30-1.

The Fish Brook segment MA84A-40 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (62%) and 17% consists of wetlands. The remainder of the watershed is primarily covered by development (20%), and little agricultural activity (1%). The

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 3,882

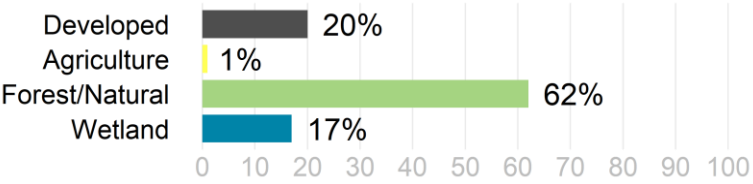
Segment Length (Miles): 4.1

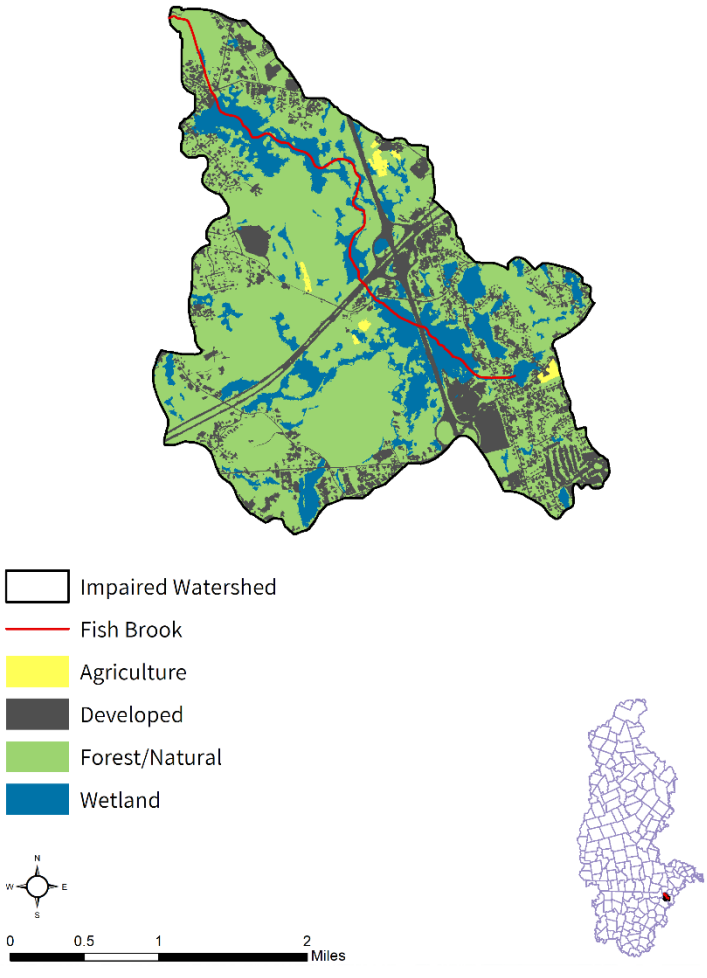
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: A (Public Water Supply, Outstanding Resource Water)

Impervious Area (Acres, %): 388 (10%)

DCIA Area (Acres, %): 215 (6%)





[82] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

highest density of development is located in the upper portion of the watershed near the headwaters, and consists primarily of single-family homes. Two major highways (I-93 and I-495) also cross the impaired segment.

In the Fish Brook (MA84A-40) watershed, under the Natural Heritage and Endangered Species Program, there are 702 acres (18%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also 1,199 acres (31%) under Public Water Supply protection, no Areas of Critical Environmental Concern, and 3,772 acres (97%) of Outstanding Resource Waters. Overall, there are 1,096 acres (28%) of land protected in perpetuity[83], part of 1,233 acres (32%) of Protected and Recreational Open Space[84]. See Figure 30-1.

[83] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[84] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

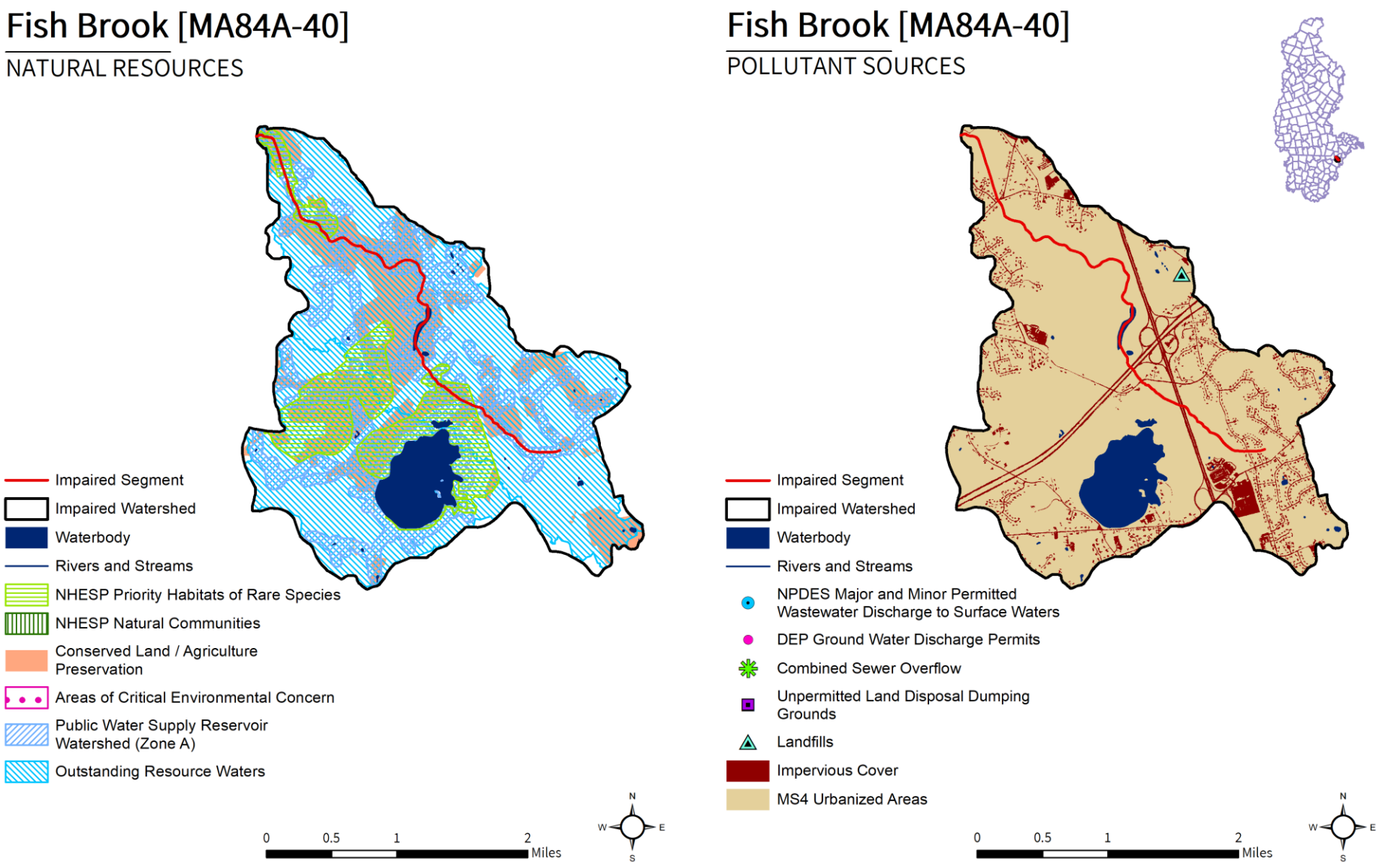


Figure 30-1. Natural resources and potential pollution sources draining to the Fish Brook segment MA84A-40. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

30.2. Waterbody Impairment Characterization

Fish Brook (MA84A-40) is a Class A, Public Water Supply, and Outstanding Resource Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Fish Brook at one site (W1206) in 2004 (Figure 30-2). The geometric mean of *E. coli* at this site was 162 CFU/100 mL and the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

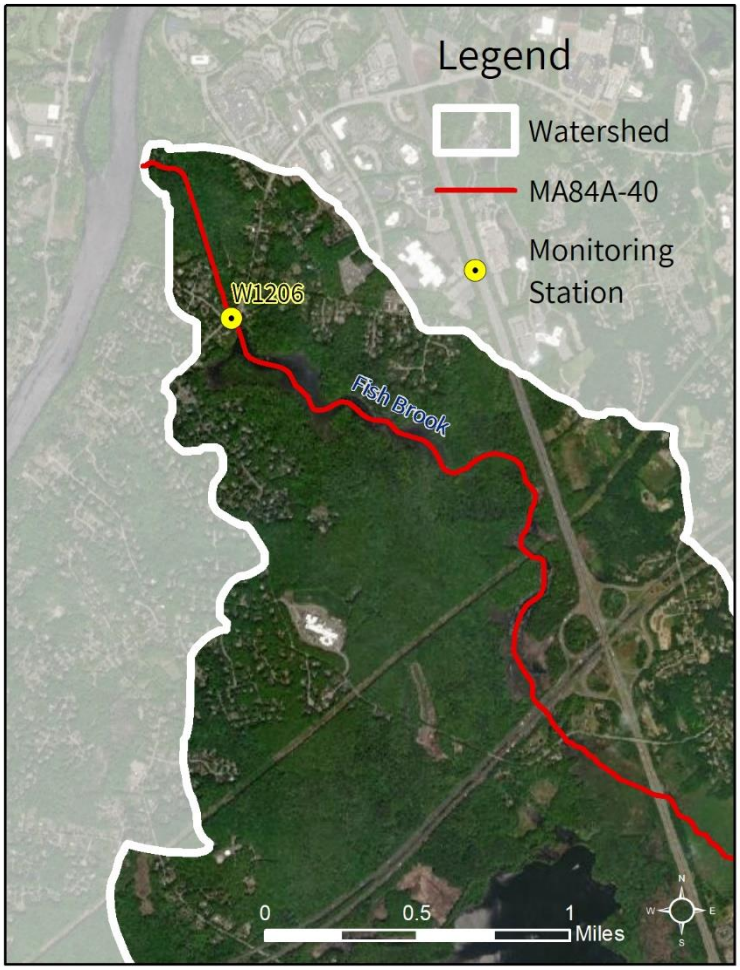


Figure 30-2. Location of monitoring station(s) along the impaired segment.

30.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (20%), most of which is located close to the impaired segment. Within the watershed, the entire land area is subject to MS4 permit conditions, 10% is classified as impervious area, and 6% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts town of Andover. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: There is minimal agricultural activity (1%) in the watershed, consisting of scattered pasture/hay fields. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: Multiple nature trails and a dog park are located near the Fish Brook segment MA84A-40. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open wetland areas are located directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

30.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Andover. See Section 5.4

31. MA84B-01 Unnamed Tributary

31.1. Waterbody Overview

The unnamed tributary segment MA84B-01 (locally known as Reedy Meadow Brook) is 1.5 miles long and begins at the outlet of a small unnamed impoundment upstream of Bruce Street in Littleton, MA. The segment flows southeast before ending at the inlet to Mill Pond in Littleton, MA.

There are no tributaries to the unnamed tributary segment MA84B-01. There are no named lakes or ponds in the watershed, though there are a few small unnamed waterbodies near wetland areas. Much of the river flows through wetland areas.

Key landmarks in the watershed include a portion of Littleton High School, Oak Hill Reservation, Lookout Rock, and Spacious Skies Campgrounds. From upstream to downstream, segment MA84B-01 is crossed by Bruce Street, King Street, and Kimball Street, all in Littleton.

The unnamed tributary (MA84B-01) drains a total area of 1.3 square miles (mi^2), of which 0.2 mi^2 (12%) are impervious and 0.1 mi^2 (8%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Littleton[85], and 66% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There is one additional NPDES permit on file governing point source discharges of pollutants to surface waters (it is not for a wastewater treatment facility). There are no MassDEP discharge-to-groundwater permits for on-site wastewater discharges or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the segment watershed. See Figure 31-1.

The unnamed tributary segment MA84B-01 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (57%) and 13% consists of wetland areas. There is roughly five times the amount of development (25%) in the watershed as agriculture (5%). Most of the development consists of industrial and

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 836

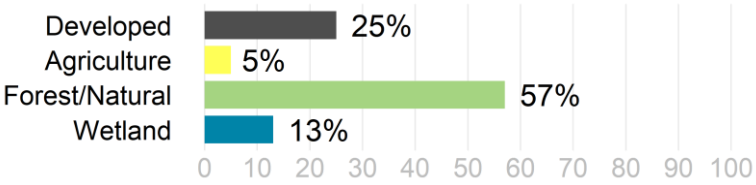
Segment Length (Miles): 1.5

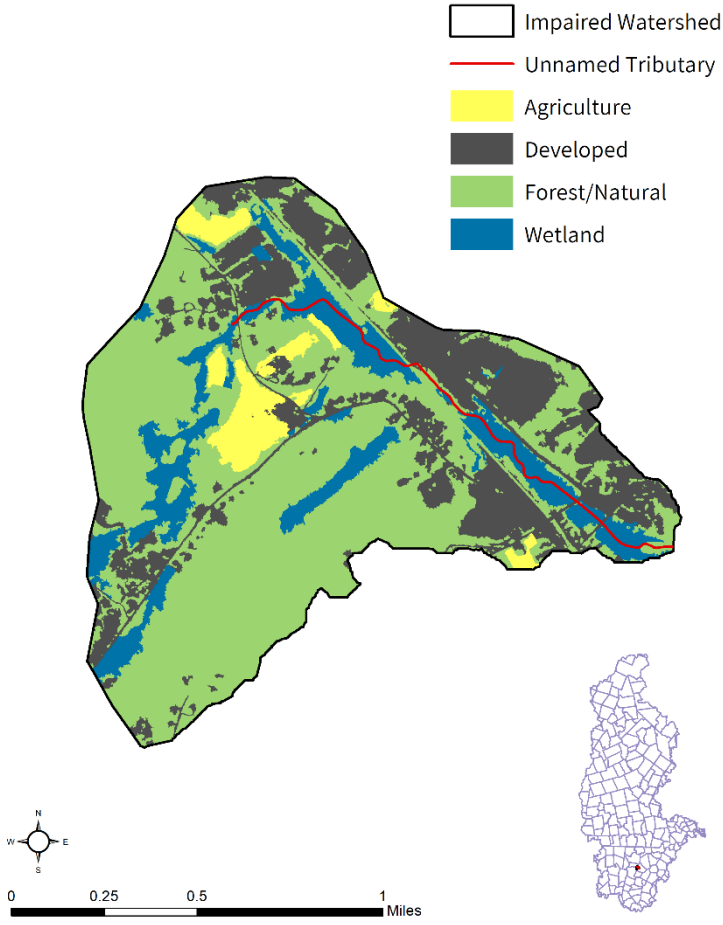
Impairment(s): Fecal Coliform (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 101 (12%)

DCIA Area (Acres, %): 67 (8%)





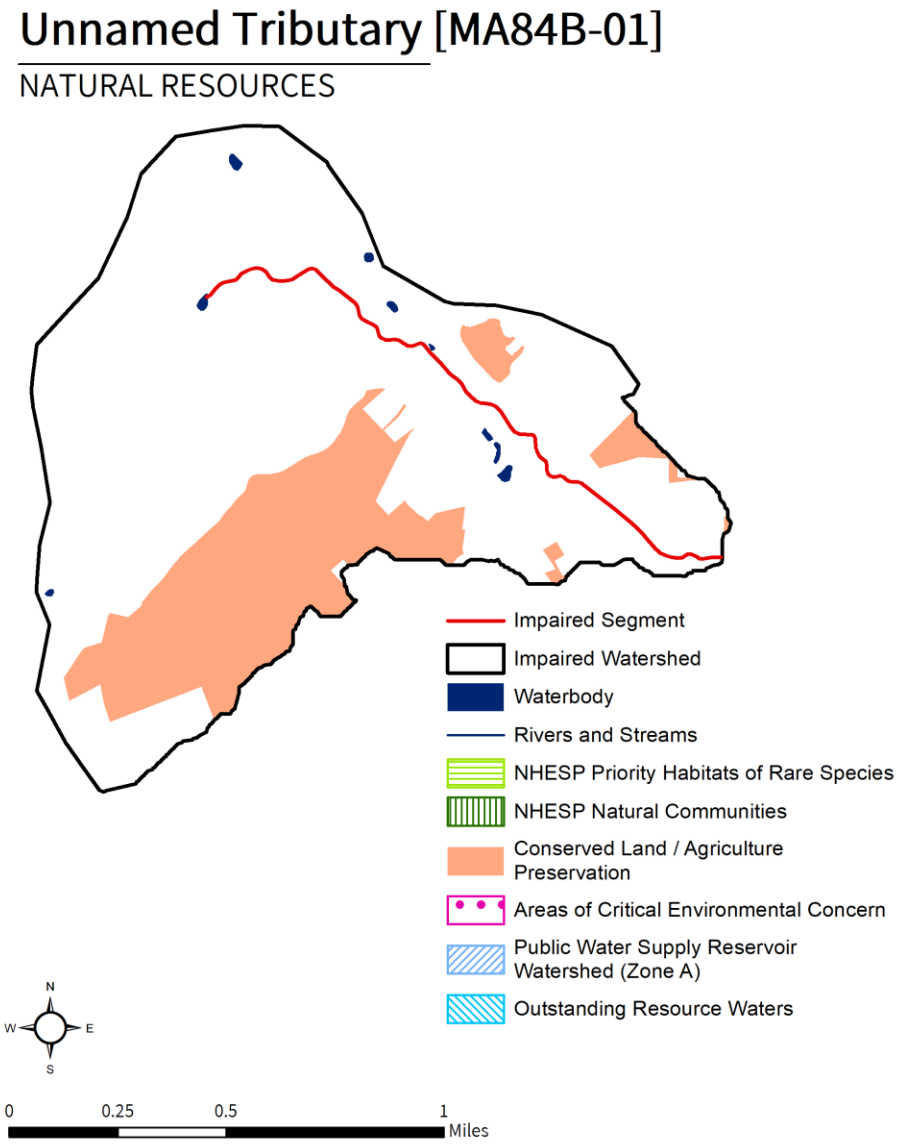
[85] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

commercial areas, with a few residential areas as well. Most of the agricultural activity consists of cultivated fields.

In the unnamed tributary (MA84B-01) watershed, under the Natural Heritage and Endangered Species Program, there are no Priority Habitats of Rare Species or Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 169 acres (20%) of land protected in perpetuity[86], part of 184 acres (22%) of Protected and Recreational Open Space[87]. See Figure 31-1.

[86] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[87] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



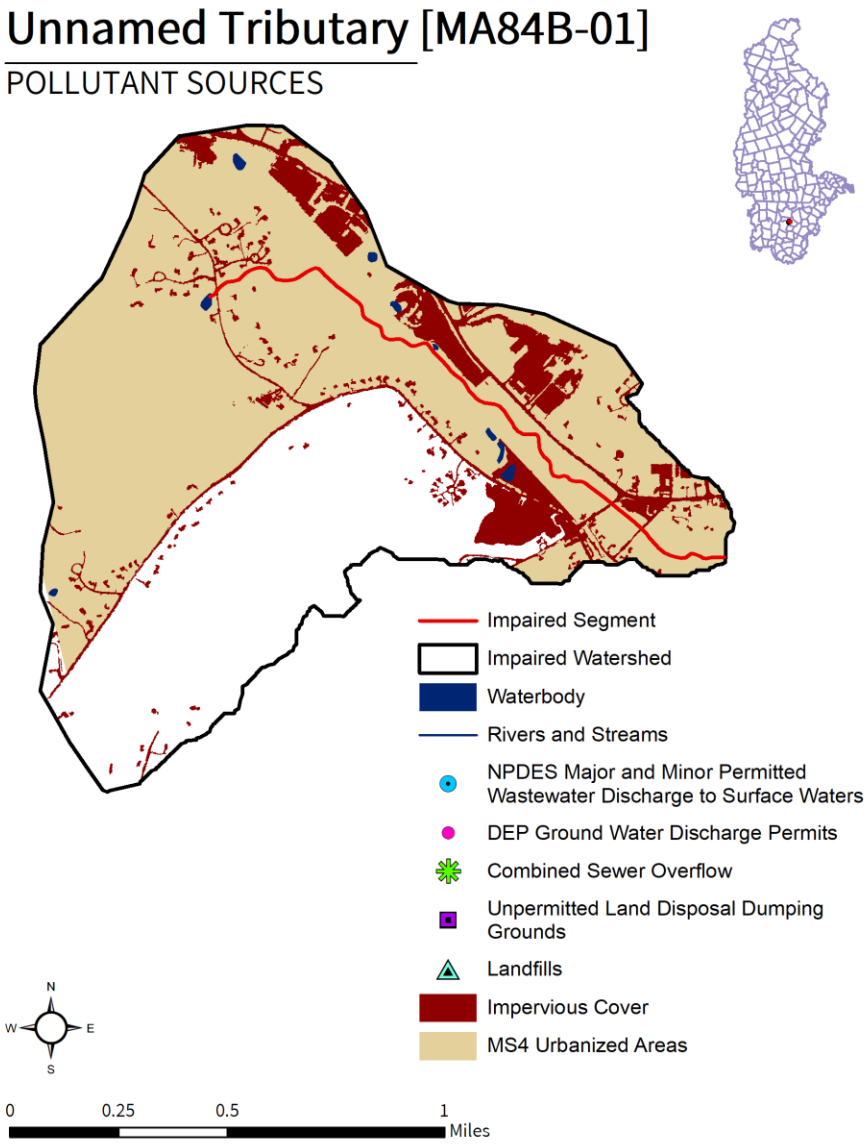


Figure 31-1. Natural resources and potential pollution sources draining to the unnamed tributary segment MA84B-01. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

31.2. Waterbody Impairment Characterization

The unnamed tributary (MA84B-01) is a Class B Water (MassDEP, 2021a).

No recent bacteria data were available to assess Primary Contact Recreation use for the unnamed tributary segment MA84B-01, and there was insufficient data in the *2004-2009 Water Quality Assessment Report* to make an assessment (Meek and Kennedy, 2010). As a result, the prior fecal coliform impairment decision was carried forward.

31.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (25%), most of which consists of industrial and commercial areas close to the impaired segment. Within the watershed, 66% of the land area is subject to MS4 permit conditions, 12% is classified as impervious area, and 8% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the town of Littleton. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the watershed account for a relatively small portion (5%) of the total land use. A few large cultivated fields are located near the impaired segment. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few residential neighborhoods and nature trails within the Oak Hill Reservation that are near the unnamed tributary segment MA84B-01. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open wetland areas are directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

31.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Littleton

About 80% of Littleton is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MA041204), and the town has an EPA approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Littleton completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations, all in 2016. According to Littleton's NOI, there are four stormwater outfalls to an unnamed tributary (MA84B-01), four outfalls to a wetland/tributary to an unnamed tributary (MA84B-01), one outfall to Beaver Brook (MA84B-02), six outfalls to a wetland/tributary to Beaver Brook (MA84B-02), all impaired by fecal coliform.

Littleton has the following ordinances and bylaws, mostly accessible online via the town website https://www.littletonma.org/ (Town of Littleton, 2021):

- Wetland protection bylaw
- Stormwater bylaw
- Stormwater Utility: None found
- Pet Waste: None found

Littleton has a 2017 Master Plan that contains a section on Natural Resources and a section on Open Space & Recreation. These sections contain comprehensive inventories and analysis of available resources and open space, followed by goals and recommendations for their protection in the future. In the Natural Resources section, there is a large subsection on water resources due to the numerous streams and ponds in the town that are of high importance to residents. Recommendations to protect water resources include acquiring more conservation land, preparing a comprehensive strategy to protect water supplies, promoting nature education in public schools, and establishing a training and education program for contractors and landscapers to teach best management practices to reduce stormwater runoff and pollution (Town of Littleton, 2021).

A major sewer upgrade and expansion project has been proposed in Littleton, MA which encompasses portions of King Street. The proposed expansion includes replacement of the existing wastewater treatment plan. Independently of the proposed expansion, a new recharge site (large leach field) is already being constructed as of early 2022 (LELWD, 2022).

32. MA84B-02 Beaver Brook

32.1. Waterbody Overview

Beaver Brook segment MA84B-02 is 4.9 miles long and begins at the outlet of Mill Pond in Littleton, MA. The segment flows northeast, ending at the inlet to Forge Pond in Westford, MA.

Tributaries to Beaver Brook segment MA84B-02 include a few unnamed streams. Lakes and ponds in the watershed include Mill Pond, Black Pond, and a few unnamed ponds. Much of the river flows through wetland areas.

Key landmarks in the watershed include the town center of Littleton; Littleton High School; Littleton Middle School; Russell Street Elementary School; Oak Hill Reservation; Lookout Rock; Smith Conservation Land; and Spacious Skies Campgrounds. From upstream to downstream, segment MA84B-02 is crossed by I-495 (twice in Littleton), Mill Road (Littleton), Warren Street (Littleton), King Street/MA-2A (Littleton), Great Road/MA-119 (Littleton), an unnamed street (Westford), and Beaver Brook Road (Westford).

Beaver Brook (MA84B-02) drains a total area of 13.3 square miles (mi^2), of which 1.5 mi^2 (11%) are impervious and 0.8 mi^2 (6%) are directly connected impervious area (DCIA). The watershed is served by a public sewer system in Littleton[88], and 72% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There is one additional NPDES permit on file governing point source discharges of pollutants to surface waters (it is not for a wastewater treatment facility). There are 10 MassDEP discharge-to-groundwater permits for on-site wastewater discharges within the watershed (all of which are within the immediate drainage area to the impaired segment, Table 32-1); there are no combined sewer overflows (CSOs). There are no landfills or unpermitted land disposal dumping grounds within the segment watershed. See Figure 32-1.

The Beaver Brook segment MA84B-02 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (55%) and 18% are wetlands; developed (23%) and

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 8,528

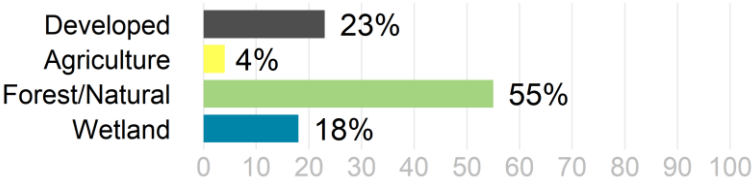
Segment Length (Miles): 4.9

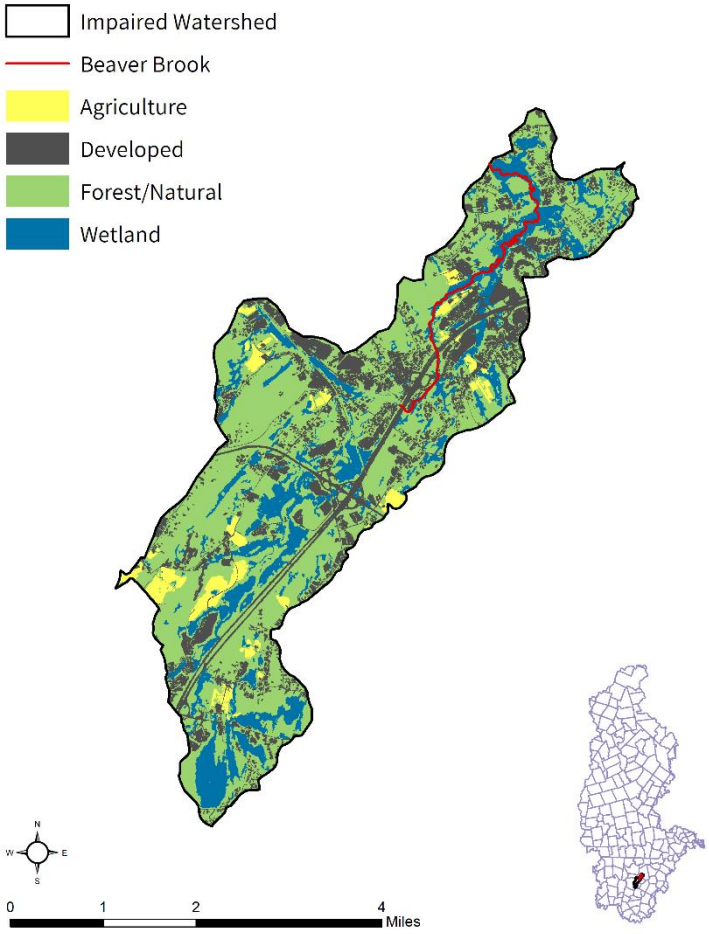
Impairment(s): Fecal Coliform (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 935 (11%)

DCIA Area (Acres, %): 533 (6%)





[88] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

agricultural (4%) areas are also present. Most of the development consists of residential areas with some industrial and commercial development. Most of the agricultural activity is pasture/hay and cultivated fields located directly adjacent to wetland areas that are connected to the impaired segment.

In the Beaver Brook (MA84B-02) watershed, under the Natural Heritage and Endangered Species Program, there are 1,964 acres (23%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 2,029 acres (24%) of land protected in perpetuity[89], part of 2,385 acres (28%) of Protected and Recreational Open Space[90]. See Figure 32-1.

Table 32-1. Groundwater discharge permits in the watershed. Only permits unique to this segment watershed are shown. PERR = permit number plus renewal number. TYPE = type of groundwater discharge. FLOW = permitted effluent in gallons per day (gpd).

PERR	NAME	TOWN	TYPE	FLOW (GPD)
79-6	LSREF4 TURTLE	LITTLETON	Sanitary Discharge	40,000
352-5M1	THE POINT TO BEAVER BROOK WWTF	LITTLETON	Sanitary Discharge	38,500
446-5	PONDSIDE APARTMENTS	LITTLETON	Sanitary Discharge	23,000
635-2	WESTFORD ACADEMY HIGH SCHOOL	WESTFORD	Sanitary Discharge	32,000
645-3M1	CISCO SYSTEMS - SITE II	BOXBOROUGH	Sanitary Discharge	80,000
654-2	BROOK VILLAGE CONDO	BOXBOROUGH	Sanitary Discharge	33,000
663-3	LITTLETON NURSING HOME	LITTLETON	Sanitary Discharge	18,000
676-3	LITTLETON PUBLIC SCHOOLS	LITTLETON	Sanitary Discharge	17,600
727-1	HARVARD RIDGE CONDO. TRUST	BOXBOROUGH	Sanitary Discharge	33,130
958-1	JEFFERSON AT BEAVER BROOK	BOXBOROUGH	Sanitary Discharge	39,820

[89] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[90] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

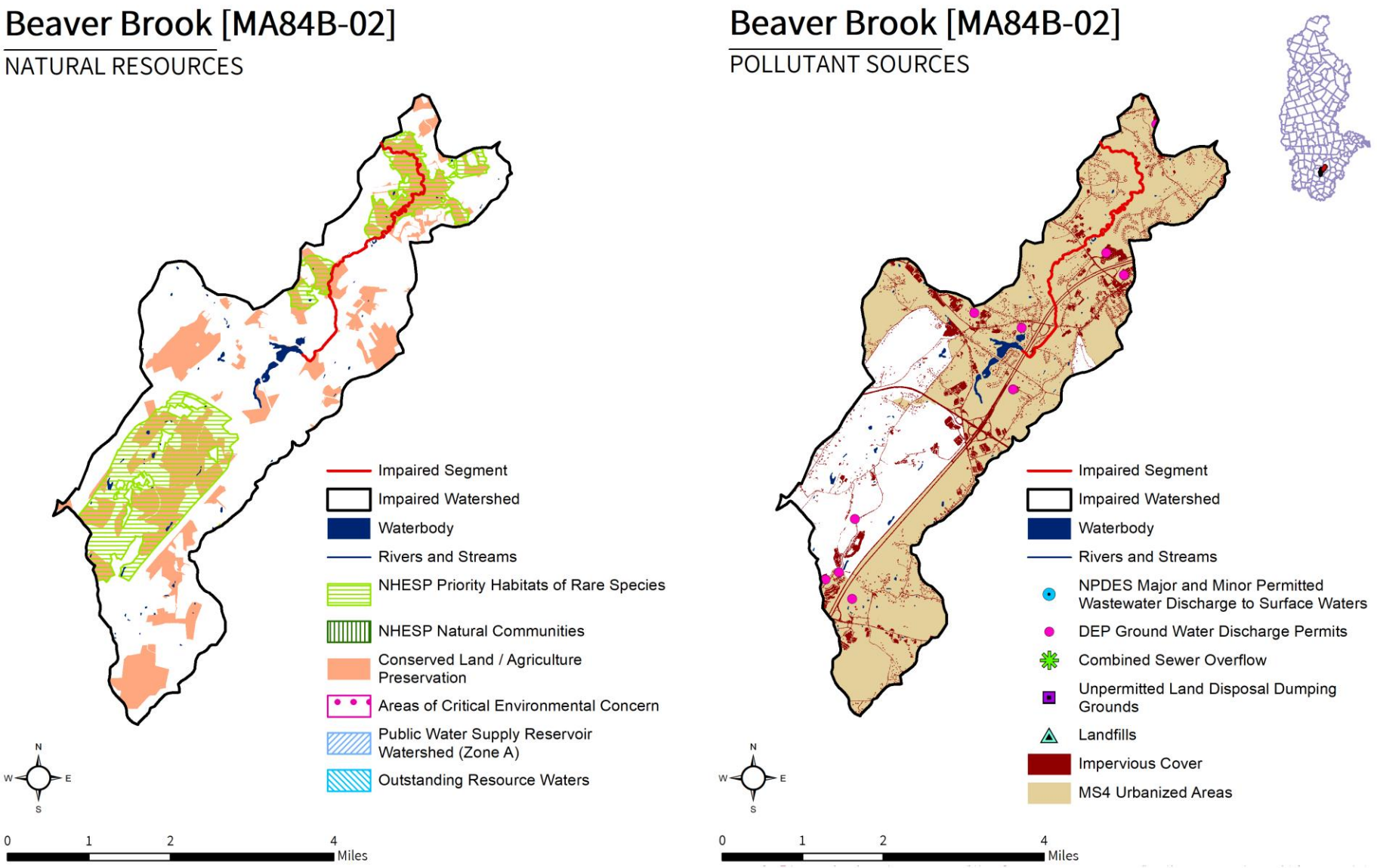


Figure 32-1. Natural resources and potential pollution sources draining to the Beaver Brook segment MA84B-02. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

32.2. Waterbody Impairment Characterization

Beaver Brook (MA84B-02) is a Class B Water (MassDEP, 2021a).

No recent bacteria data were available to assess the Primary Contact Recreation use for the Beaver Brook segment MA84B-02, and there was insufficient data in the *2004-2009 Water Quality Assessment Report* to make an assessment (Meek and Kennedy, 2010). As a result, the prior fecal coliform impairment decision was carried forward.

32.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (23%), most of which consists of residential areas with some industrial and commercial development. Within the watershed, 72% of the land area is subject to MS4 permit conditions, 11% is classified as impervious area, and 6% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the town of Littleton. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. Additionally, there are 10 MassDEP permits for on-site wastewater discharges to groundwater. In addition to these permitted point sources, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agriculture accounts for a relatively small portion (4%) of the total land use in the watershed. A few large pasture/hay and cultivated fields are directly adjacent to wetland areas that are connected to the impaired segment. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few residential neighborhoods, conservation areas, and parks located near Beaver Brook segment MA84B-02. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: Most of the segment is surrounded by large open wetland areas, with a few small open fields also located adjacent to the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

32.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Boxborough

About 90% of Boxborough is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MA941183), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 90% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Boxborough completed an illicit discharge detection and elimination (IDDE) plan in 2007, and an erosion and sedimentation control (ESC) plan and post-construction stormwater regulations in 2011. According to the NOI, there are no pathogen-impaired MS4 receiving waters in the MS4 area.

Boxborough has the following ordinances and bylaws, mostly accessible online via the town website https://boxborough-ma.gov/ (Town of Boxborough, 2021):

- Wetland protection bylaw
- Stormwater bylaw
- Stormwater Utility: None found
- Pet Waste: None found

Boxborough has a 2016 Master Plan titled “Boxborough 2030: A Rural, Engaged Community for All” that will serve as a guide for planning in the town through 2030. The town also has a 2015 Open Space & Recreation plan that contains a comprehensive Environmental Inventory and Analysis section. This section contains a water resources subsection that describes the various streams, ponds, and wetlands in the town (Town of Boxborough, 2021).

Town of Littleton. See Section 31.4

Town of Westford. See Section 19.4

33. MA84B-03 Stony Brook

33.1. Waterbody Overview

Stony Brook segment MA84B-03 is 6.5 miles long and begins at the outlet of Forge Pond in Westford, MA. The segment flows generally northeast before ending at Brookside Road in Westford, MA.

Tributaries to Stony Brook segment MA84B-03 include Reed Brook, Boutwell Brook, Coldspring Brook, Keyes Brook, Tadmuck Brook (MA84B-07), and a few unnamed streams. Lakes and ponds in the watershed include Mill Pond, Black Pond, Forge Pond, Spectacle Pond, Burges Pond, Keyes Pond, Long Sought-for Pond, Grass Pond, and a few other unnamed waterbodies. Much of the river flows through wetland areas.

Key landmarks in the watershed include the town centers of Littleton and Westford; Littleton High School; Littleton Middle School; Russell Street Elementary School; Blanchard Middle School; Crisafulli Elementary School; Norman E. Day School; Westford Academy; Stony Brook School; Shaker Hills Country Club; Oak Hill Reservation; Lookout Rock; Smith, Stony Brook, Acker, Day, Carmichael Swamp, and Groton Woods conservation lands; and Spacious Skies Campgrounds. From upstream to downstream, segment MA84B-03 is crossed by Pleasant Street/MA-225, Town Farm Road, Bridge Street, Broadway Street, River Street, Depot Street, and Stonybrook Road, all in Westford.

Stony Brook (MA84B-03) drains a total area of 38.0 square miles (mi^2), of which 3.8 mi^2 (10%) are impervious and 2.0 mi^2 (5%) are directly connected impervious area (DCIA). The watershed is partially served by public sewer systems in Ayer, Littleton, and Westford[91], and 77% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are two additional NPDES permits on file governing point source discharges of pollutants to surface waters (neither are for a wastewater treatment facility). There are 17 MassDEP discharge-to-groundwater permits for on-site wastewater discharges within the watershed (seven of which are within the immediate drainage area to the impaired segment, Table 33-1); there are no combined sewer

Reduction from Highest Calculated Geomean: 16%

Watershed Area (Acres): 24,326

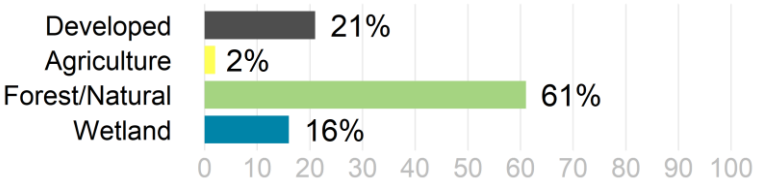
Segment Length (Miles): 6.5

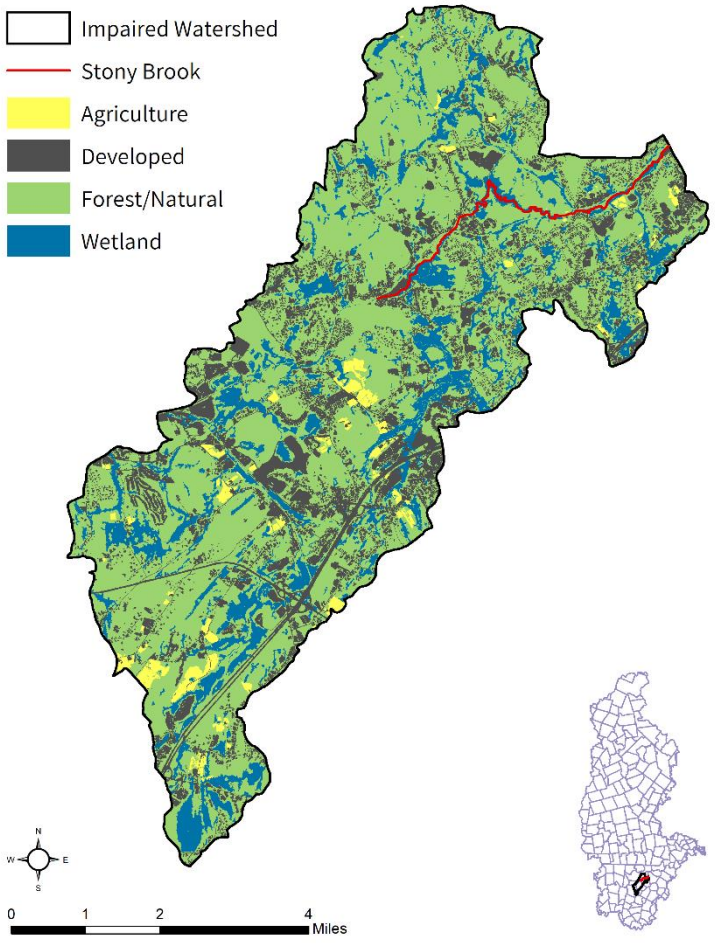
Impairment(s): Fecal Coliform (Primary Contact Recreation)

Class: B (Warm Water)

Impervious Area (Acres, %): 2,421 (10%)

DCIA Area (Acres, %): 1,308 (5%)





[91] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

overflows (CSOs). There are two landfills and no unpermitted land disposal dumping grounds within the segment watershed. See Figure 33-1.

The Stony Brook segment MA84B-03 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (61%) and 16% consists of wetland areas. The remainder of the watershed is primarily covered by development (21%) as there is very little agricultural activity (2%). Most of the development consists of residential areas with some industrial and commercial development. Most of the agricultural activity consists of pasture/hay and cultivated fields located directly adjacent to wetland areas in the watershed.

In the Stony Brook (MA84B-03) watershed, under the Natural Heritage and Endangered Species Program, there are 4,595 acres (19%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, 89 acres (<1%) within the Petapawag Area of Critical Environmental Concern, and no Outstanding Resource Waters. Overall, there are 4,468 acres (18%) of land protected in perpetuity[92], part of 5,447 acres (22%) of Protected and Recreational Open Space[93]. See Figure 33-1.

Table 33-1. Groundwater discharge permits in the segment watershed. Only permits unique to this segment watershed are shown. PERR = permit number plus renewal number. TYPE = type of groundwater discharge. FLOW = permitted effluent in gallons per day (gpd).

PERR	NAME	TOWN	TYPE	FLOW (GPD)
516-4	WESTFORD MIDDLE SCHOOL	WESTFORD	Sanitary Discharge	24,000
721-2	STONY BROOK SCHOOL	WESTFORD	Sanitary Discharge	22,000
724-2	BROOKSIDE MILL CONDOMINIUM	WESTFORD	Sanitary Discharge	7,480
729-2	ABBOTT SCHOOL	WESTFORD	Sanitary Discharge	13,120
803-1	SUMMER VILLAGE	WESTFORD	Sanitary Discharge	68,000
820-1	ABBOTT MILL	WESTFORD	Sanitary Discharge	21,560
901-1	GRANITEVILLE WOODS	WESTFORD	Sanitary Discharge	43,560

[92] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[93] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

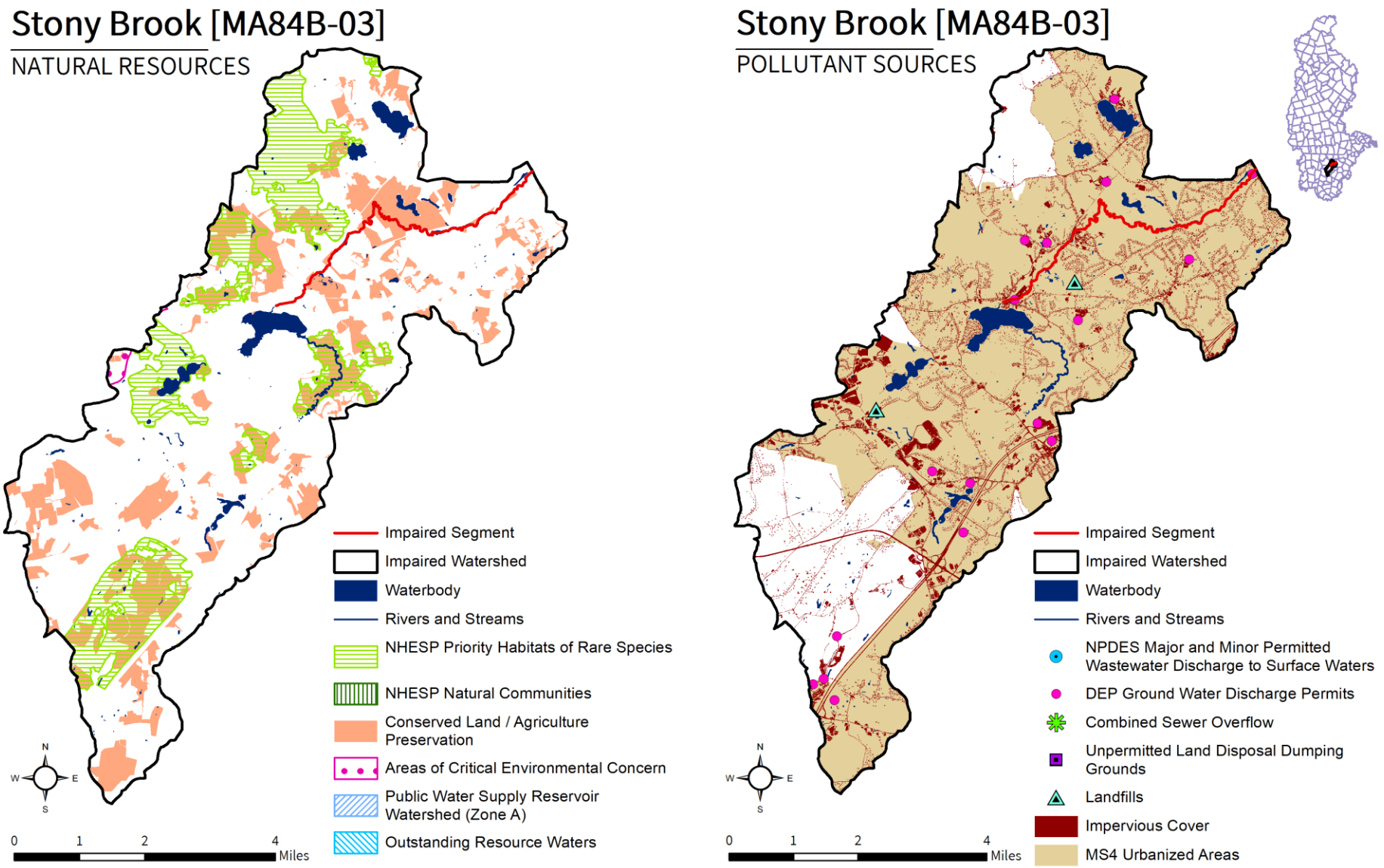


Figure 33-1. Natural resources and potential pollution sources draining to the Stony Brook segment MA84B-03. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

33.2. Waterbody Impairment Characterization

Stony Brook (MA84B-03) is a Class B, Warm Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the stations listed below (refer to Tables 33-2, 33-3; Figure 33-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the Statistical Threshold Value (STV) criterion of 410 CFU/100 mL for *E. coli.* The geomean and STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2015, five samples were collected at W2534; data indicated one day when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of five samples, none exceeded the STV criterion.
- In 2015, five samples were collected at W2539; data indicated that the 90-day rolling geomean did not exceed the criterion. Since there were no stations and years with more than 10 samples, the STV criterion was applied to single sample results. Out of five samples, none exceeded the STV criterion.

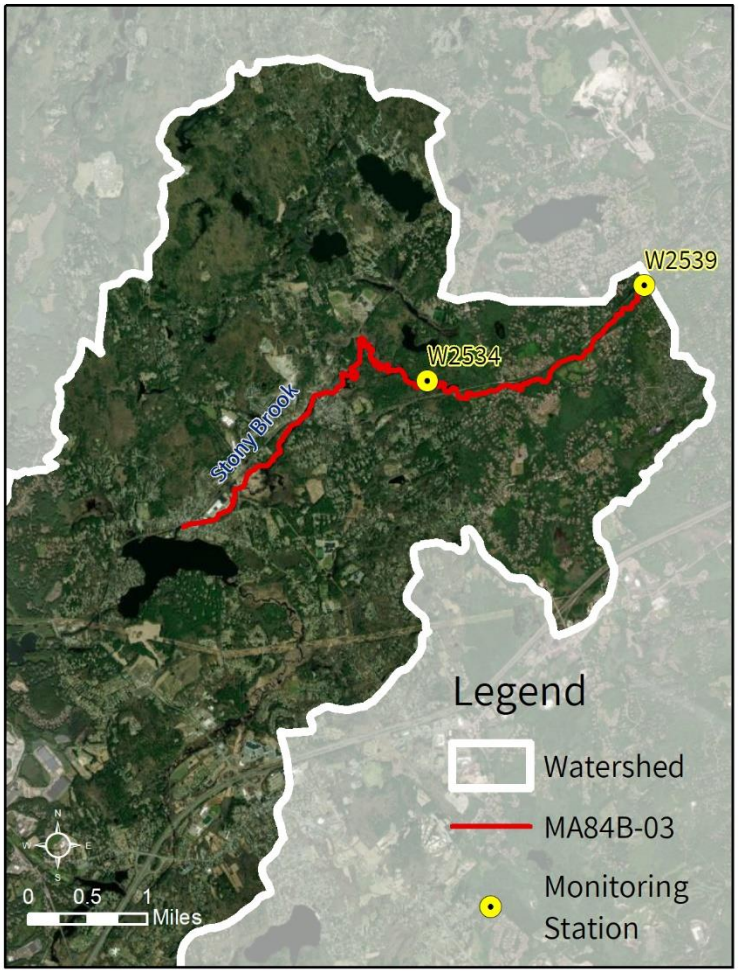


Figure 33-2. Location of monitoring station(s) along the impaired segment.

Table 33-2. Summary of indicator bacteria sampling results by station for Stony Brook (MA84B-03). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W2534	5/12/2015	9/2/2015	5	150	1	0
W2539	5/12/2015	9/2/2015	5	120	0	0

Table 33-3. Indicator bacteria data by station, indicator, and date for Stony Brook (MA84B-03). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W2534	*E. coli*	5/12/2015	DRY	150	150	
W2534	*E. coli*	6/4/2015	WET	63	97	
W2534	*E. coli*	7/14/2015	DRY	<10*	46	
W2534	*E. coli*	8/5/2015	DRY	130	59	
W2534	*E. coli*	9/2/2015	DRY	63	43	
W2539	*E. coli*	5/12/2015	DRY	120	120	
W2539	*E. coli*	6/4/2015	WET	120	120	
W2539	*E. coli*	7/14/2015	DRY	85	107	
W2539	*E. coli*	8/5/2015	DRY	120	110	
W2539	*E. coli*	9/2/2015	DRY	86	96	

*Value below the Method Detection Limit (MDL) of 10 CFU/100mL; the MDL is reported and used to calculate the geometric means for *E. coli*.

33.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to the river via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and direct wildlife and domesticated animal waste (including pets).

Indicator bacteria levels for Stony Brook (MA84B-03) were elevated during dry weather. Elevated results during dry weather suggest that baseflow sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be major sources of pathogens.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (21%), most of which consists of residential areas with some industrial and commercial development as well. Within the watershed, 77% of the land area is subject to MS4 permit conditions, 10% is classified as impervious area, and 5% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the towns of Ayer, Littleton, and Westford. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. There are 17 MassDEP permits for on-site wastewater discharges to

groundwater. In addition to these permitted point sources, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the watershed account for a relatively small portion (2%) of the total land use. A few pasture/hay and cultivated fields are located next to wetland areas within the watershed. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are many residential neighborhoods and nature trails near the Stony Brook segment MA84B-03. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open wetland areas are directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

33.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Harvard

Harvard has an EPA-approved waiver from MS4 requirements and is therefore not subject to stormwater regulations under the NPDES General MS4 Stormwater Permit.

Harvard has the following ordinances and bylaws, mostly accessible online via the town website https://www.harvard-ma.gov/ (Town of Harvard, 2021):

- Wetland protection bylaw
- Stormwater bylaw
- Stormwater Utility: None found
- Pet Waste: None found

Harvard has a 2016 Master Plan that contains a section on Natural Resources and Open Space. This section contains extensive inventories and analysis of natural resources, including an entire subsection on water resources. The water resources section outlines the various actions that have been taken to improve water quality in various waterbodies in the town. These actions include upgrading septic systems, implementing best management practices to control stormwater runoff, and instituting public education programs for property owners (Town of Harvard, 2021).

Town of Littleton. See Section 31.4

Town of Westford. See Section 19.4

34. MA84B-04 Stony Brook

34.1. Waterbody Overview

Stony Brook segment MA84B-04 is 3.4 miles long and begins at Brookside Road in Westford, MA. The segment flows northeast before ending at the Merrimack River in Chelmsford, MA.

Tributaries to Stony Brook segment MA84B-04 include Gilson Brook, Crooked Springs Brook, Cold Springs Brook, and a few unnamed tributaries. Lakes and ponds in the watershed include Mill Pond, Black Pond, Forge Pond, Spectacle Pond, Burges Pond, Keyes Pond, Long Sought-for Pond, Grass Pond, Flushing Pond, Nabnasset Pond, Freeman Lake, and a few other unnamed waterbodies. Much of the river flows through wetland areas.

Key landmarks in the watershed include the town centers of Littleton, Westford, and North Chelmsford; Littleton High School; Littleton Middle School; Russell Street Elementary School; Blanchard Middle School; Crisafulli Elementary School; Norman E. Day School; Westford Academy; Stony Brook School; Nabnasset School; Chelmsford High School; Murdoch Middle Public Charter School; Parker Middle School; Harrington Elementary School; Shaker Hills Country Club; Nabnasset Lake Country Club; Oak Hill Reservation; Lookout Rock; Smith, Stony Brook, Acker, Day, Carmichael Swamp, and Groton Woods conservation lands; and Spacious Skies Campgrounds. From upstream to downstream, segment MA84B-04 is crossed by Brookside Road (Westford), an unnamed street (Chelmsford), School Street (Chelmsford), Meadowbrook Road (Chelmsford), U.S. Route 3 (Chelmsford), Princeton Street/MA-3A (Chelmsford), and Middlesex Street (Chelmsford).

Stony Brook (MA84B-04) drains a total area of 45.5 square miles (mi^2), of which 5.0 mi^2 (11%) are impervious and 2.7 mi^2 (6%) are directly connected impervious area (DCIA). The watershed is partially served by public sewer systems in Ayer, Littleton, and Westford[94], and 81% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are five additional NPDES permits on file governing point

Reduction from Highest Calculated Geomean: 68%

Watershed Area (Acres): 29,131

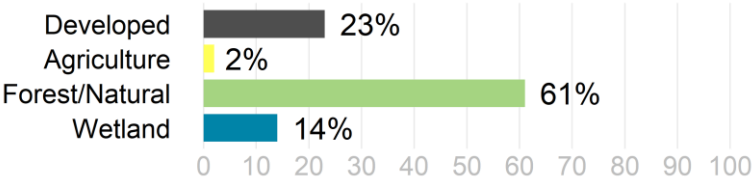
Segment Length (Miles): 3.4

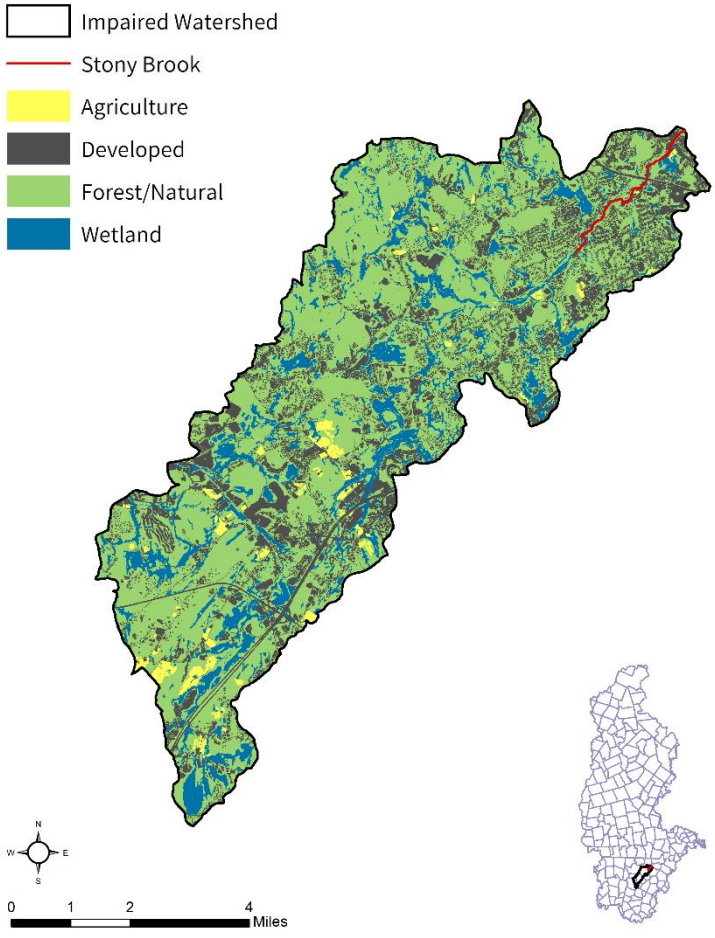
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B (Warm Water)

Impervious Area (Acres, %): 3,180 (11%)

DCIA Area (Acres, %): 1,717 (6%)





[94] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

source discharges of pollutants to surface waters (none are for a wastewater treatment facility). There are 17 MassDEP discharge-to-groundwater permits for on-site wastewater discharges within the watershed (none of which are within the immediate drainage area to the impaired segment); there are no combined sewer overflows (CSOs). There are two landfills and no unpermitted land disposal dumping grounds within the segment watershed. See Figure 34-1.

The Stony Brook segment MA84B-04 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (61%) and 14% consists of wetland areas; the remainder is primarily covered by development (23%), with little agricultural activity (2%). Most of the development consists of residential areas with some industrial and commercial development. Most agricultural activity consists of pasture/hay and cultivated fields directly adjacent to wetland areas in the watershed.

In the Stony Brook (MA84B-04) watershed, under the Natural Heritage and Endangered Species Program, there are 4,730 acres (16%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, 89 acres (<1%) within the Petapawag Area of Critical Environmental Concern, and no Outstanding Resource Waters. Overall, there are 5,126 acres (18%) of land protected in perpetuity[95], part of 6,229 acres (21%) of Protected and Recreational Open Space[96]. See Figure 34-1.

[95] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[96] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

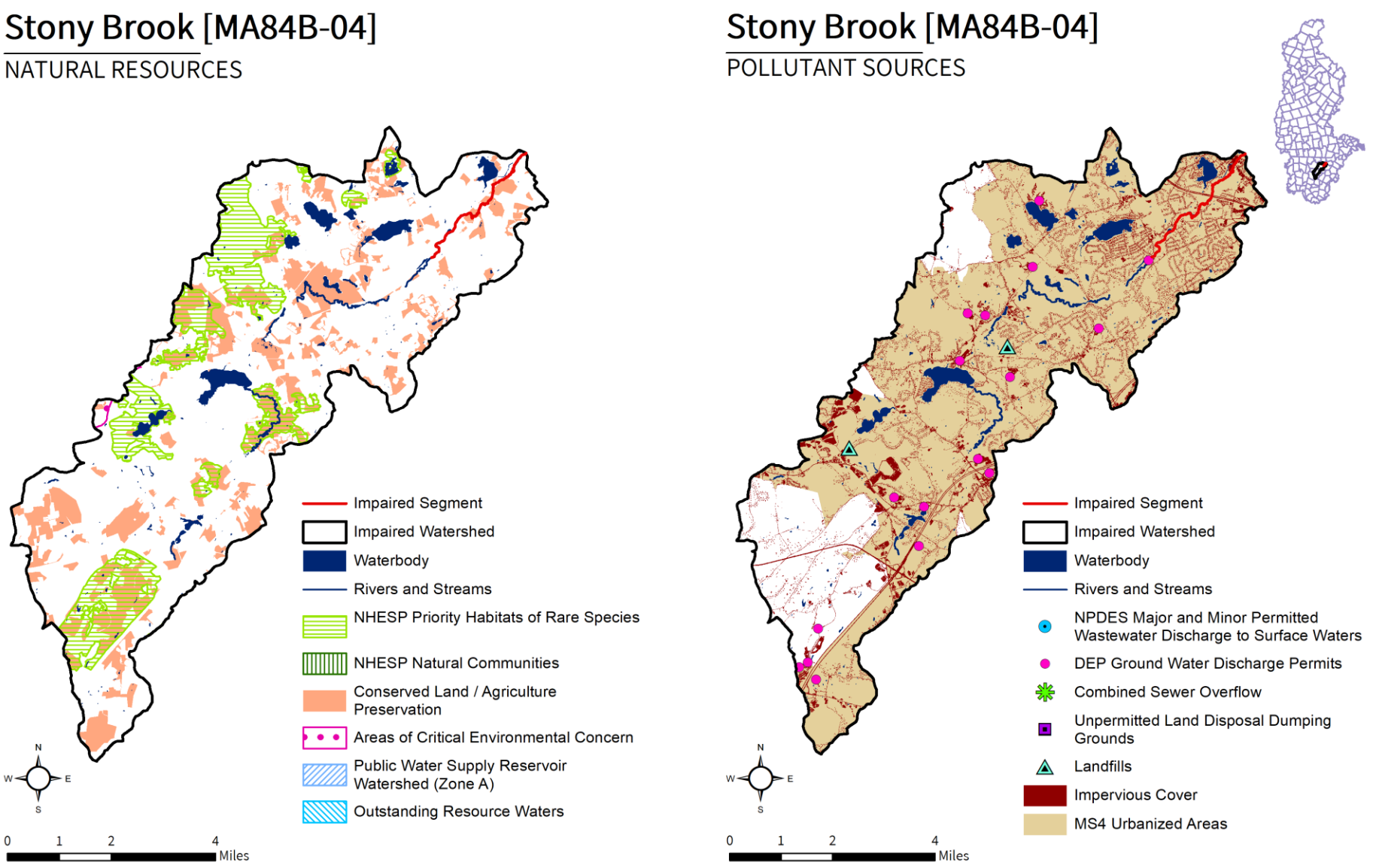


Figure 34-1. Natural resources and potential pollution sources draining to the Stony Brook segment MA84B-04. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

34.2. Waterbody Impairment Characterization

Stony Brook (MA84B-04) is a Class B, Warm water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the stations listed below (refer to Tables 34-1, 34-2; Figure 34-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the Statistical Threshold Value (STV) criterion of 410 CFU/100 mL for *E. coli.* The geomean and STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2010, three samples were collected at W2167; data indicated two days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of three samples, two exceeded the STV criterion during dry weather.
- In 2015, five samples were collected at W2516; data indicated four days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the STV criterion was applied to single sample results. Out of five samples, two exceeded the STV criterion during dry weather.

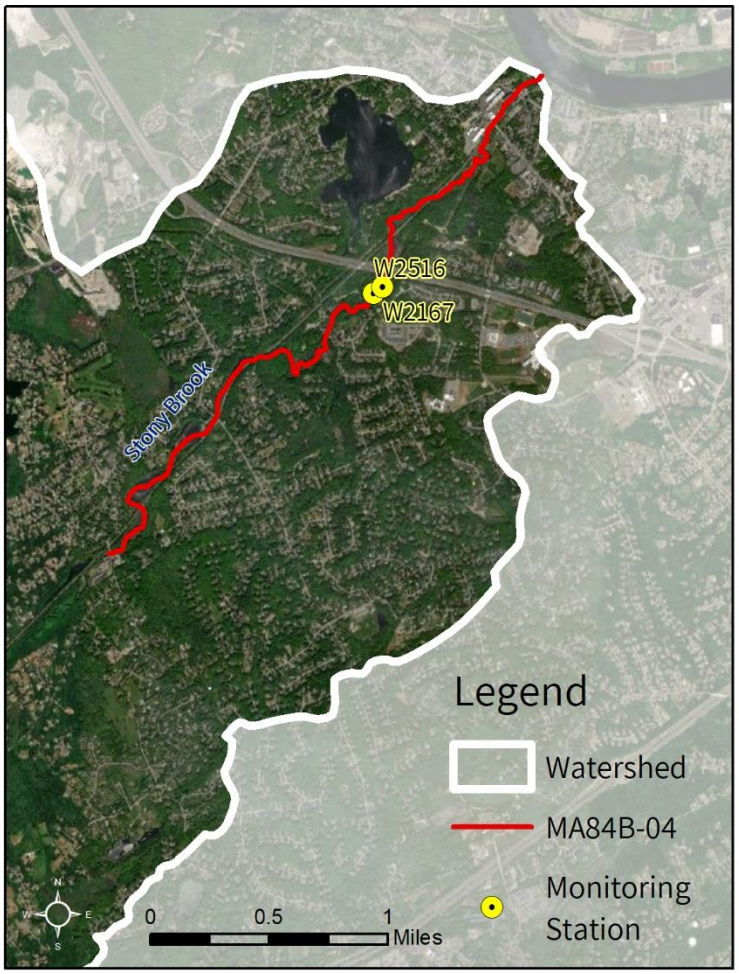


Figure 34-2. Location of monitoring station(s) along the impaired segment.

Table 34-1. Summary of indicator bacteria sampling results by station for Stony Brook (MA84B-04). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W2167	5/18/2010	6/22/2010	3	375	2	2
W2516	5/12/2015	9/2/2015	5	398	4	2

Table 34-2. Indicator bacteria data by station, indicator, and date for Stony Brook (MA84B-04). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W2167	*E. coli*	5/18/2010	DRY	90	90	
W2167	*E. coli*	6/10/2010	DRY	790	267	
W2167	*E. coli*	6/22/2010	DRY	740	375	
W2516	*E. coli*	5/12/2015	DRY	120	120	
W2516	*E. coli*	6/4/2015	WET	200	155	
W2516	*E. coli*	7/14/2015	DRY	280	189	
W2516	*E. coli*	8/5/2015	DRY	410	229	
W2516	*E. coli*	9/2/2015	DRY	550	398	

34.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to the river via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and direct wildlife and domesticated animal waste (including pets).

Indicator bacteria levels for Stony Brook (MA84B-04) were elevated during both wet and dry weather. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources. Certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation, may also result in elevated levels of indicator bacteria during wet weather events. Elevated results during dry weather suggest that baseflow sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be major sources of pathogens.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (23%), most of which consists of residential areas with some industrial and commercial development. 81% of the land area is subject to MS4 permit conditions, 11% is classified as impervious area, and 6% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts towns of Ayer, Littleton, and Westford. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. There are 17 MassDEP permits for on-site wastewater discharges to groundwater. In addition to these permitted point sources, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the watershed account for a relatively small portion (2%) of the total land use. A few pasture/hay and cultivated fields are located next to wetland areas within the watershed. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are many residential neighborhoods and parks near the Stony Brook segment MA84B-04, including a dog park. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open wetland areas are directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

34.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Chelmsford. See Section 3.4

Town of Littleton. See Section 31.4

Town of Westford. See Section 19.4

35. MA84B-06 Bennetts Brook

35.1. Waterbody Overview

Bennetts Brook segment MA84B-06 is 4.3 miles long and begins at north of Route 2 in Harvard, MA. The segment meanders generally northeast before ending at the inlet to Spectacle Pond in Ayer/Littleton, MA.

Tributaries to Bennetts Brook segment MA84B-06 include several unnamed streams. Lakes and ponds in the watershed include a few other unnamed waterbodies. Much of the river flows through wetland areas.

Key landmarks in the watershed include Harvard Shaker Village Historic District and Shaker Hills Country Club. From upstream to downstream, segment MA84B-06 is crossed by Shaker Road (twice in Harvard, once in Ayer), Sheehan Road (Harvard), and unnamed street (Harvard), Bennetts Crossing (Ayer), Littleton Road (Ayer), Willow Road (Ayer) and an unnamed street (Ayer).

Bennetts Brook (MA84B-06) drains a total area of 4.7 square miles (mi^2), of which 0.5 mi^2 (10%) are impervious and 0.3 mi^2 (6%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Ayer[97], and 38% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There is one landfill and no unpermitted land disposal dumping grounds within the segment watershed. See Figure 35-1.

The Bennetts Brook segment MA84B-06 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (62%) and 16% is wetland areas. The remainder of the watershed is primarily covered by development (21%), with little agricultural activity (1%). Most of the development consists of residential areas with some industrial and

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 2,978

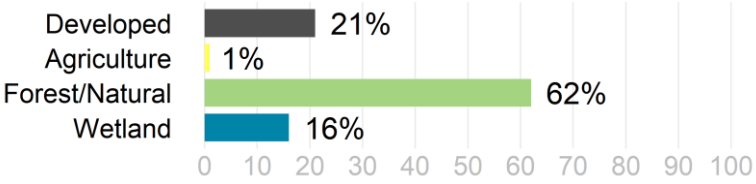
Segment Length (Miles): 4.3

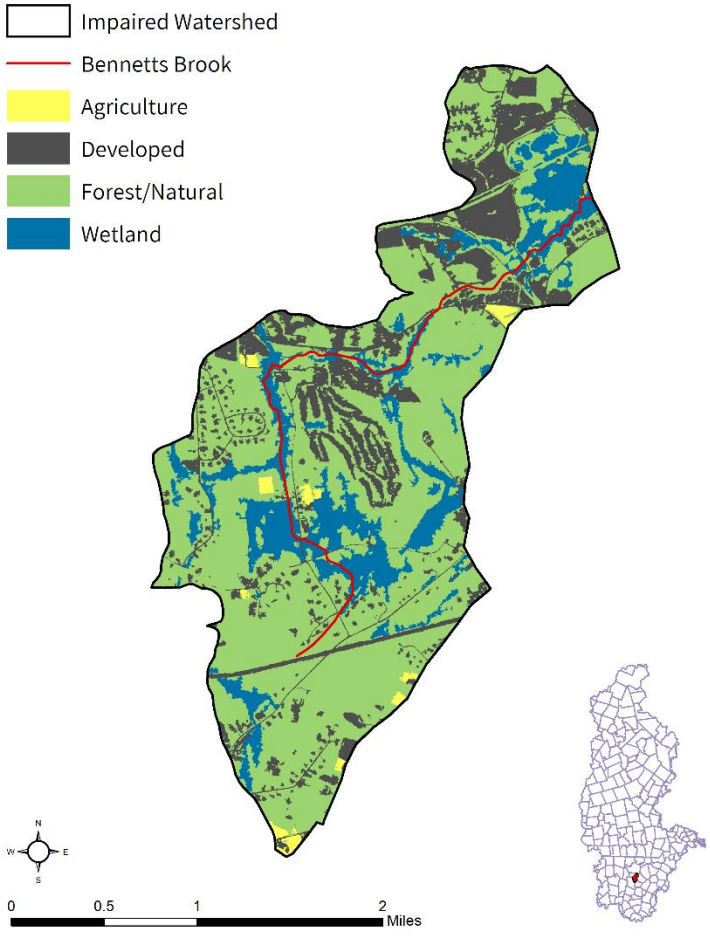
Impairment(s): *E. coli* (Primary Contact Recreation)

Class: B

Impervious Area (Acres, %): 291 (10%)

DCIA Area (Acres, %): 173 (6%)





[97] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

commercial buildings in the lower watershed. Most of the agricultural activity consists of small pasture and hay fields scattered throughout watershed.

In the Bennetts Brook (MA84B-06) watershed, under the Natural Heritage and Endangered Species Program, there are 228 acres (8%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, 87 acres (3%) within the Petapawag Area of Critical Environmental Concern, and no Outstanding Resource Waters. Overall, there are 401 acres (13%) of land protected in perpetuity[98], part of 585 acres (20%) of Protected and Recreational Open Space[99]. See Figure 35-1.

[98] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[99] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.

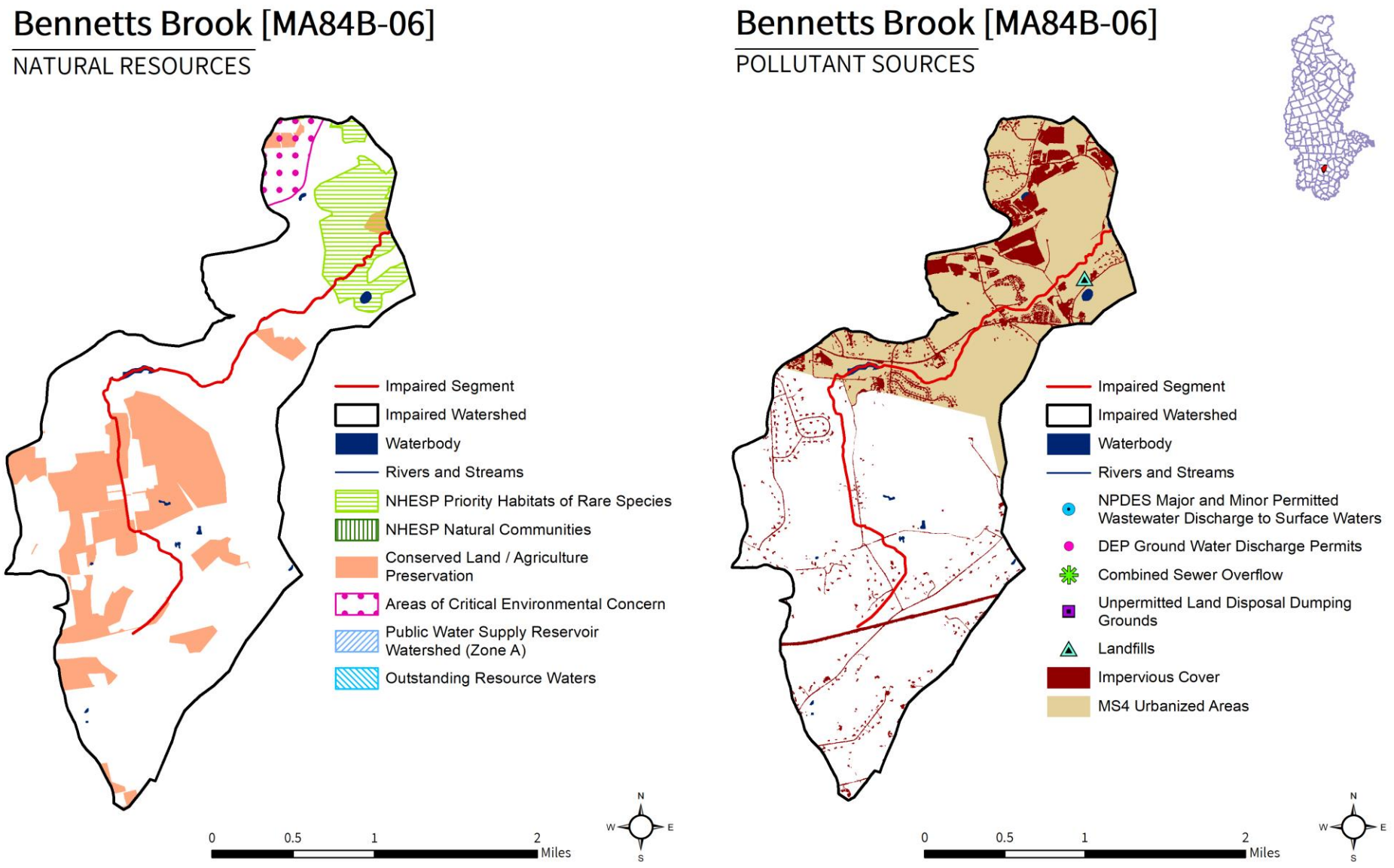


Figure 35-1. Natural resources and potential pollution sources draining to the Bennetts Brook segment MA84B-06. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

35.2. Waterbody Impairment Characterization

Bennetts Brook (MA84B-06) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Bennetts Brook at one site (W1200) in 2004 (Figure 35-2). The geometric mean of *E. coli* at this site was 397 CFU/100 mL, which exceeds the criteria for Primary Contact Recreation use (Meek and Kennedy, 2010).

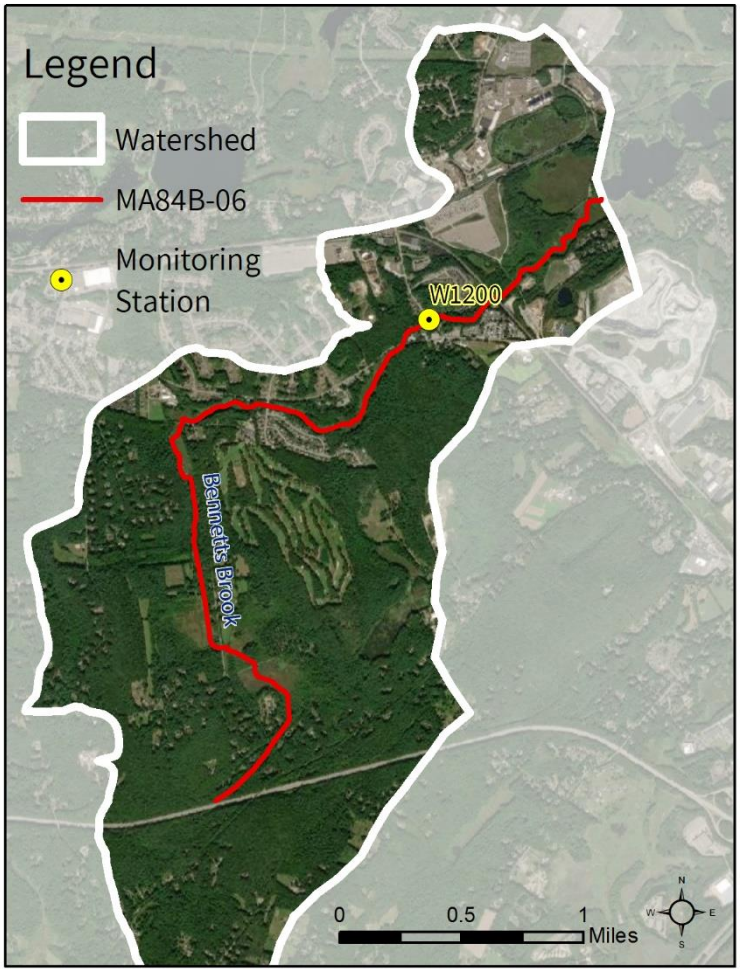


Figure 35-2. Location of monitoring station(s) along the impaired segment.

35.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (21%), most of which consists of residential areas with some industrial and commercial development in the lower watershed. Within the watershed, 38% of the land area is subject to MS4 permit conditions, 10% is classified as impervious area, and 6% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the town of Ayer. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Most of the development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the watershed account for a relatively small portion (1%) of the total land use. A few pasture and hay fields are scattered throughout the watershed. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few residential neighborhoods near the Bennetts Brook segment MA84B-06. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few open fields and wetland areas are located directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

35.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Ayer

About 80% of Ayer is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR04-1179), and the town has an EPA approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Ayer completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations, all in 2008. According to Ayer's NOI, there are six stormwater outfalls to Bennetts Brook (MA84B-06) which is impaired by *E. coli*.

Ayer has the following ordinances and bylaws, mostly accessible online via the town website https://www.ayer.ma.us/ (Town of Ayer, 2021):

- Wetland protection bylaw
- Stormwater bylaw
- Stormwater Utility: None found
- Pet Waste: None found

Ayer has a 2017 Master Plan that contains an Infrastructure section with subsections on water, wastewater, and stormwater. These subsections outline the previous work done in all of these areas to improve water quality and the future work that is needed to maintain high water quality. The town also has a 2017 Open Space and Recreation Plan that contains a section on Environmental Inventory and Analysis. Within this section, there is a subsection on Water Resources that describes the existing waterbodies in town in detail (Town of Ayer, 2021).

Town of Harvard. See Section 33.4

Town of Littleton. See Section 31.4

36. MA84B-07 Tadmuck Brook

36.1. Waterbody Overview

Tadmuck Brook segment MA84B-07 is 1.4 miles long and begins south of Main Street in Westford, MA. The segment flows generally west then north before ending at Stony Brook in Westford, MA.

Tributaries to Tadmuck Brook segment MA84B-07 include a few unnamed streams. Lakes and ponds in the watershed consist of a few unnamed waterbodies. Much of the river flows through wetlands.

Key landmarks in the watershed include a portion of the town centers of Westford, Westford Museum, and Fairview Cemetery. From upstream to downstream, segment MA84B-07 is crossed by Main Street, Lowell Road, and Grey Fox Lane, all in Westford.

Tadmuck Brook (MA84B-07) drains a total area of 2.0 square miles (mi^2), of which 0.3 mi^2 (13%) are impervious and 0.1 mi^2 (7%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Westford[100], and 100% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharges, or combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the segment watershed. See Figure 36-1.

The Tadmuck Brook segment MA84B-07 watershed is located in a moderately-developed part of Massachusetts. Half of the watershed consists of forest and natural lands (50%) and 18% consists of wetland areas; the remainder is primarily covered by development (31%), with agricultural activity (1%). Most of the development consists of residential areas with some industrial and commercial buildings in the upper watershed, away from the segment. The little agricultural activity in the watershed consists of cultivated fields.

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 1,272

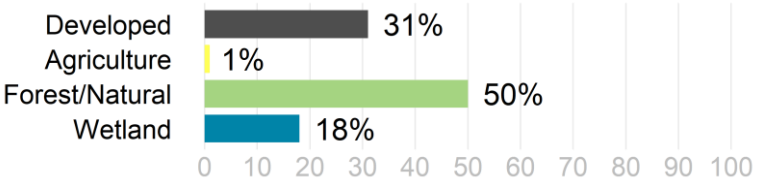
Segment Length (Miles): 1.4

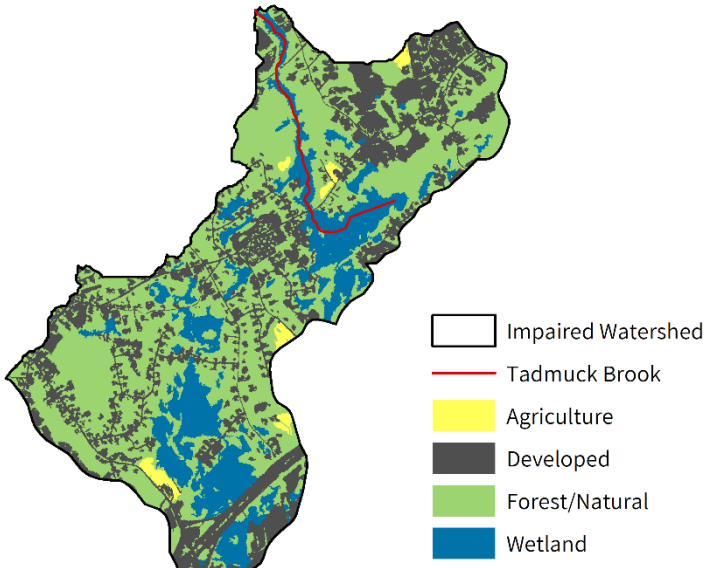
Impairment(s): *E. coli* (Primary Contact Recreation)

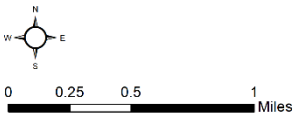
Class: B

Impervious Area (Acres, %): 165 (13%)

DCIA Area (Acres, %): 88 (7%)





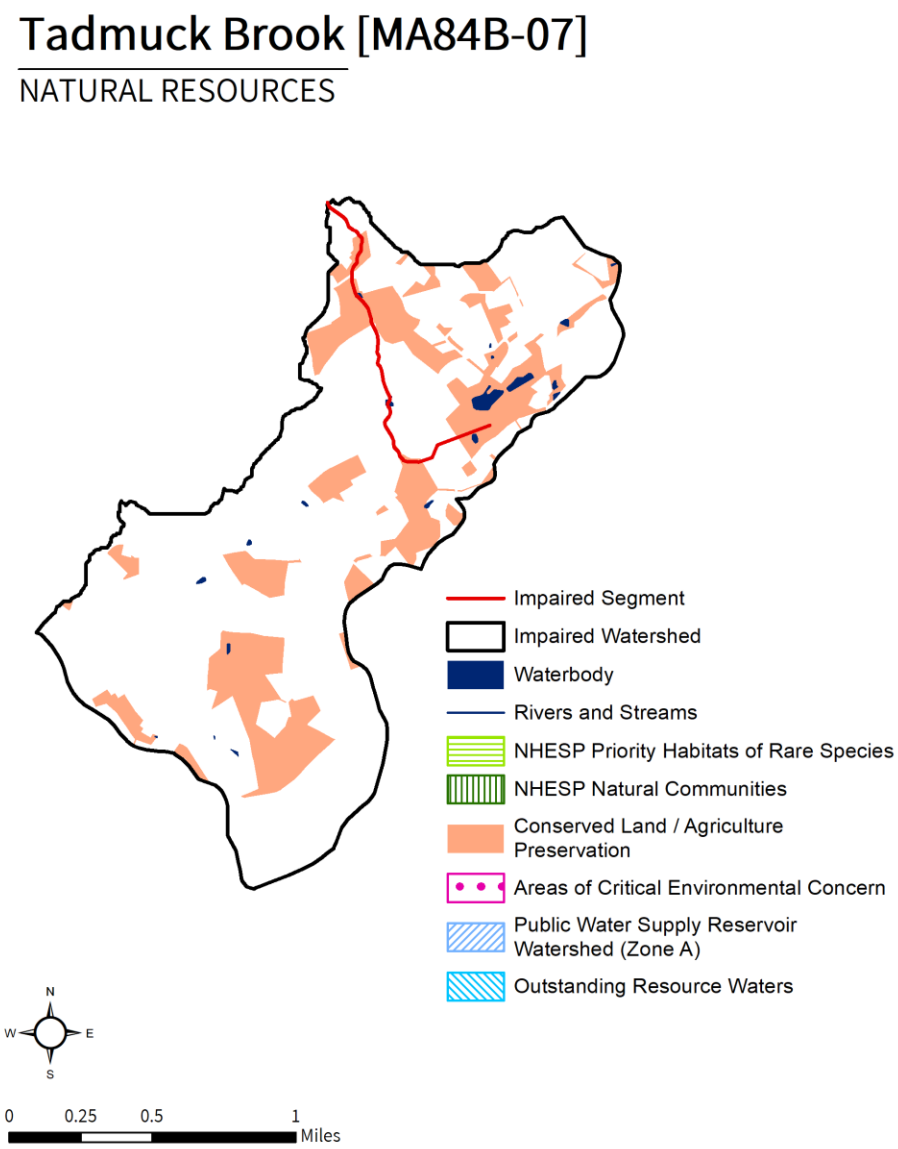


[100] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

In the Tadmuck Brook (MA84B-07) watershed, under the Natural Heritage and Endangered Species Program, there are no Priority Habitats of Rare Species or Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Environmental Concern, or Outstanding Resource Waters. Overall, there are 261 acres (20%) of land protected in perpetuity[101], part of 276 acres (22%) of Protected and Recreational Open Space[102]. See Figure 36-1.

[101] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[102] All Protected and Recreational Open Space land is shown on the natural resources map. For New Hampshire, the Protected and Recreational Open Space shown reflects only land protected in perpetuity.



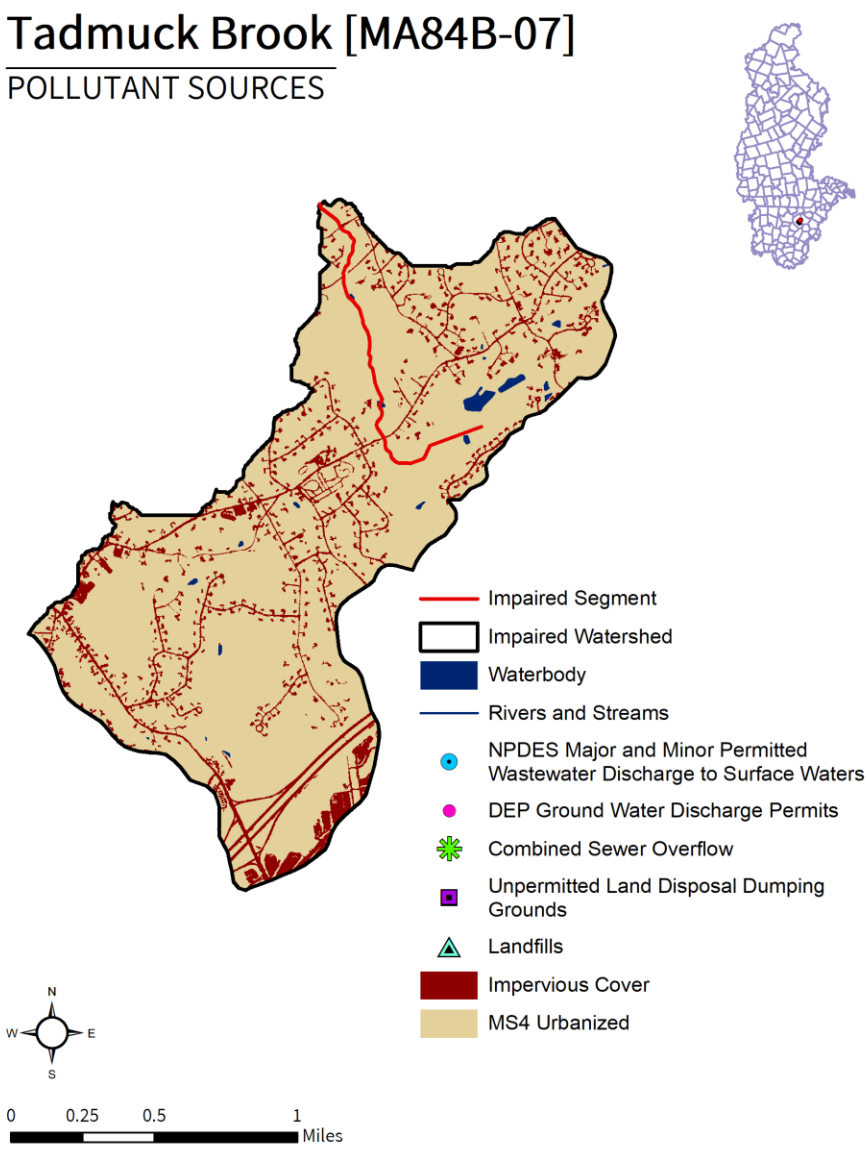


Figure 36-1. Natural resources and potential pollution sources draining to the Tadmuck Brook segment MA84B-07. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

36.2. Waterbody Impairment Characterization

Tadmuck Brook (MA84B-07) is a Class B Water (MassDEP, 2021a).

The impairment decision was carried forward from the *2004-2009 Water Quality Assessment Report* (Meek and Kennedy, 2010). MassDEP collected five *E. coli* samples in Tadmuck Brook at one site (W1201) in 2004 (Figure 36-2). The geometric mean of *E. coli* at this site was 534 CFU/100 mL which exceeds the criteria for the Primary Contact Recreation use (Meek and Kennedy, 2010).

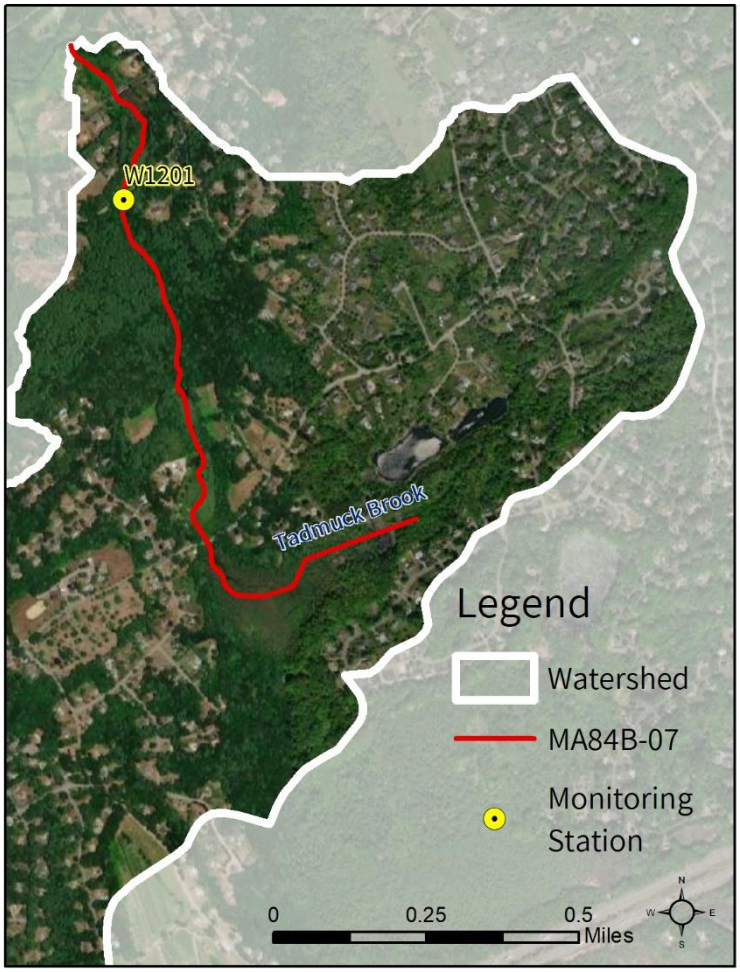


Figure 36-2. Location of monitoring station(s) along the impaired segment.

36.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (31%), most of which consists of residential areas with some industrial and commercial development in the upper watershed. Within the watershed, the entire land area is subject to MS4 permit conditions, 13% is classified as impervious area, and 7% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the Massachusetts town of Westford. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site septic systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the watershed account for a relatively small portion (1%) of the total land use, consisting of a few small cultivated fields. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few residential neighborhoods near the Tadmuck Brook segment MA84B-07. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few open wetland areas are located directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

36.4. Existing Local Managements

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Westford. See Section 19.4

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