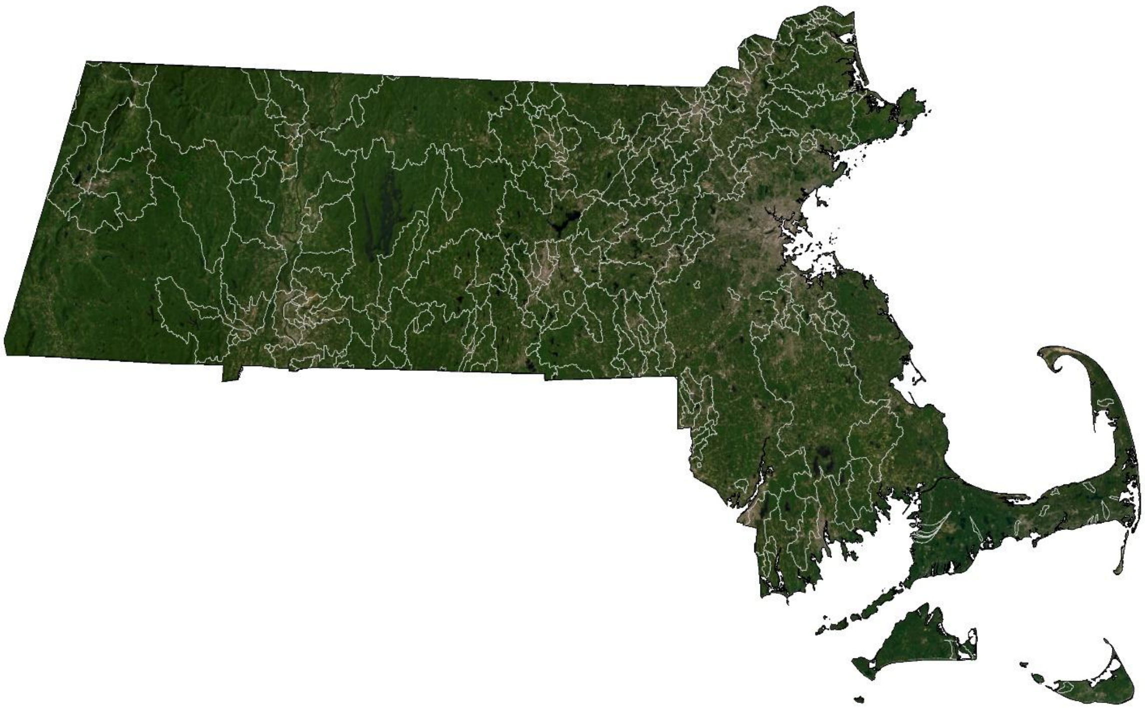
Final Massachusetts Statewide Total Maximum Daily Load for Pathogen-Impaired Waterbodies



Commonwealth of Massachusetts

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December 2024

CN 515.1

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

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Massachusetts Department of Environmental Protection

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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. The *Final Massachusetts Statewide Total Maximum Daily Load for Pathogen-Impaired Waterbodies* uses information and general guidance from the USEPA-approved *Final Pathogen TMDL for the Boston Harbor, Weymouth-Weir, and Mystic Watersheds* (MassDEP, 2018b) and *Rhode Island Statewide TMDL for Bacteria Impaired Waters* (RIDEM, 2011).

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ACRONYM LIST

∑	sum
7Q10	Lowest mean flow for seven consecutive days to be expected once in ten years
ACEC	Area of Critical Environmental Concern
AEEP	Agricultural Environmental Enhancement Program
BMP	Best Management Practice
CFU	Colony Forming Units
CMR	Code of Massachusetts Regulations
CSO	Combined Sewer Overflow
CSP	Conservation Stewardship Program
CWA	Clean Water Act
CWA § 303(d)	Section 303(d) of the federal CWA
CZM	Massachusetts Office of Coastal Zone Management
DWM	Division of Watershed Management
E. coli	Escherichia coli
EEA	Executive Office of Energy and Environmental Affairs
EMC	Event Mean Concentration
USEPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentive Program
GIS	Geographic Information System
HFRP	Healthy Forests Reserve Program
IDDE	Illicit Discharge Detection and Elimination System
LA	Load Allocation
LID	Low Impact Development
LTCP	Long-Term Control Plan
DPH	(Massachusetts) Department of Public Health
MassDEP	Massachusetts Department of Environmental Protection
DMF	(Massachusetts) Division of Marine Fisheries
MassWWP	Massachusetts Water Watch Partnership
MDAR	Massachusetts Department of Agricultural Resources
MEP	Maximum Extent Practicable
MOS	Margin of Safety
MPN	Most Probable Number
MS4	Municipal Separate Storm Sewer Systems
NOAA NCEI	National Oceanic & Atmospheric Administration National Centers for Environmental Information
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
ORW	Outstanding Resource Water
POTW	Publicly Owned Treatment Works
RCPP	Regional Conservation Partnership Program
RFR	Request for Responses
SRF	State Revolving Fund
SSO	Sanitary Sewer Overflows
SWMP	Stormwater Management Plan
STV	Statistical Threshold Value
SWQS	(Massachusetts) Surface Water Quality Standards (314 CMR 4.00)
TMDL	Total Maximum Daily Load
TOX	(Massachusetts DPH) Environmental Toxicology Program
USGS	United States Geological Survey
WLA	Waste Load Allocation
WPP	(MassDEP) Watershed Planning Program
WQC	Water Quality Criteria
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

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1. Introduction

1.1. Background

Section (§) 303(d) of the federal Clean Water Act (CWA) requires states to identify waters within their boundaries that are not meeting state water quality standards. For these impaired waterbodies, CWA §303(d) further requires the U.S. Environmental Protection Agency (USEPA) and states to develop a Total Maximum Daily Load (TMDL) for the pollutant(s) violating or causing violation of water quality standards. In Massachusetts, impaired waterbodies requiring a TMDL are listed in Category 5 of the Integrated List of Waters, such as the *Final Massachusetts Integrated List of Waters for the Clean Water Act 2018/2020 Reporting Cycle* (MassDEP, 2022).

A TMDL defines the maximum amount of a pollutant that a waterbody can assimilate while continuing to meet applicable water quality standards and allocates that maximum allowable pollutant load between point and nonpoint pollutant sources. A TMDL also provides a framework for USEPA, states, and partner organizations to establish and implement pollution control and management plans, with the ultimate management goal described in CWA §101(a)(2): to achieve "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable."

This report presents the *Massachusetts Statewide TMDL for Pathogen-Impaired Waterbodies* and provides a framework to address bacterial and other pathogenic pollutants in 210 fresh water river segments and 18 marine segments within twenty-eight watersheds in Massachusetts. **This TMDL report includes 212 TMDLs for *Escherichia coli (E. coli)*, 18 TMDLs for fecal coliform, and 228 TMDLs for enterococcus.** *E. coli* and/or enterococci are indicator organisms identified in the Massachusetts Surface Water Quality Standards (SWQS; 314 CMR 4.00) as the basis for water quality criteria established to protect the Primary Contact Recreation designated use in fresh water and coastal and marine waters, while fecal coliform criteria are the basis for assessing the Shellfishing use in coastal and marine waters. This TMDL was developed using a watershed framework. Under a watershed framework, TMDLs are provided for multiple waterbodies in a watershed. Each of the 228 pathogen-impaired river or marine segments included in this TMDL are listed are listed in Category 5 of the *Final Massachusetts Integrated List of Waters for the Clean Water Act 2018/2020 Reporting Cycle* (MassDEP, 2022), which includes the CWA §303(d) list (MassDEP, 2022). Figure 1 provides an overview map of the watersheds and the impaired waterbody segments. Table 1 summarizes the number of segments in each of the 28 watersheds. Table 2 lists each impaired waterbody name, segment ID, and impairment type.

Table 1. Summary of Major Watersheds and Number of Pathogen-Impaired Segments

Basin ID & Watershed	No. of Segs.
11 Hoosic	3
21 Housatonic	4
32 Westfield	10
33 Deerfield	7
34 Connecticut	15
35 Millers	1
36 Chicopee	17
41 Quinebaug	7
42 French	4
51 Blackstone	19
52 Ten Mile	7
81 Nashua	19
82 Concord	17
53 Narragansett Bay	3
61 Mount Hope Bay	2
62 Taunton	1
71 Mystic	3
72 Charles	7
73 Neponset	2
74 Weymouth & Weir	6
83 Shawsheen	1
84 Merrimack	34
92 Ipswich	9
93 North Coastal	4
94 South Coastal	3
95 Buzzards Bay	11
96 Cape Cod	10
97 Islands	2
TOTAL	**228**

The main body of the report includes information common to all the impaired segments, while the appendices include information specific to each impaired segment. **Appendices A through AB contain summaries of each impaired segment by watershed**, as well as GIS-based maps showing sampling locations and surrounding watershed areas, the TMDL calculations and percent reductions needed, and recommendations for management activities to achieve the necessary pollutant reduction. This report also includes recommendations for tools to help municipalities, watershed groups, and other stakeholders to implement the TMDL in a phased approach.

In addition to the recommendations provided in this report, a companion document entitled *Mitigation Measures to Address Pathogen Pollution in Surface Waters: A TMDL Implementation Guidance Manual for Massachusetts* (ENSR, 2005) provides additional guidance for the implementation of this TMDL. The Massachusetts Clean Water Toolkit (MassDEP, 2019a) also provides illustrated, interactive scenarios and fact sheets on best management practices (BMPs) for protecting water quality in a wide range of settings, such as agricultural, residential, commercial, and construction.

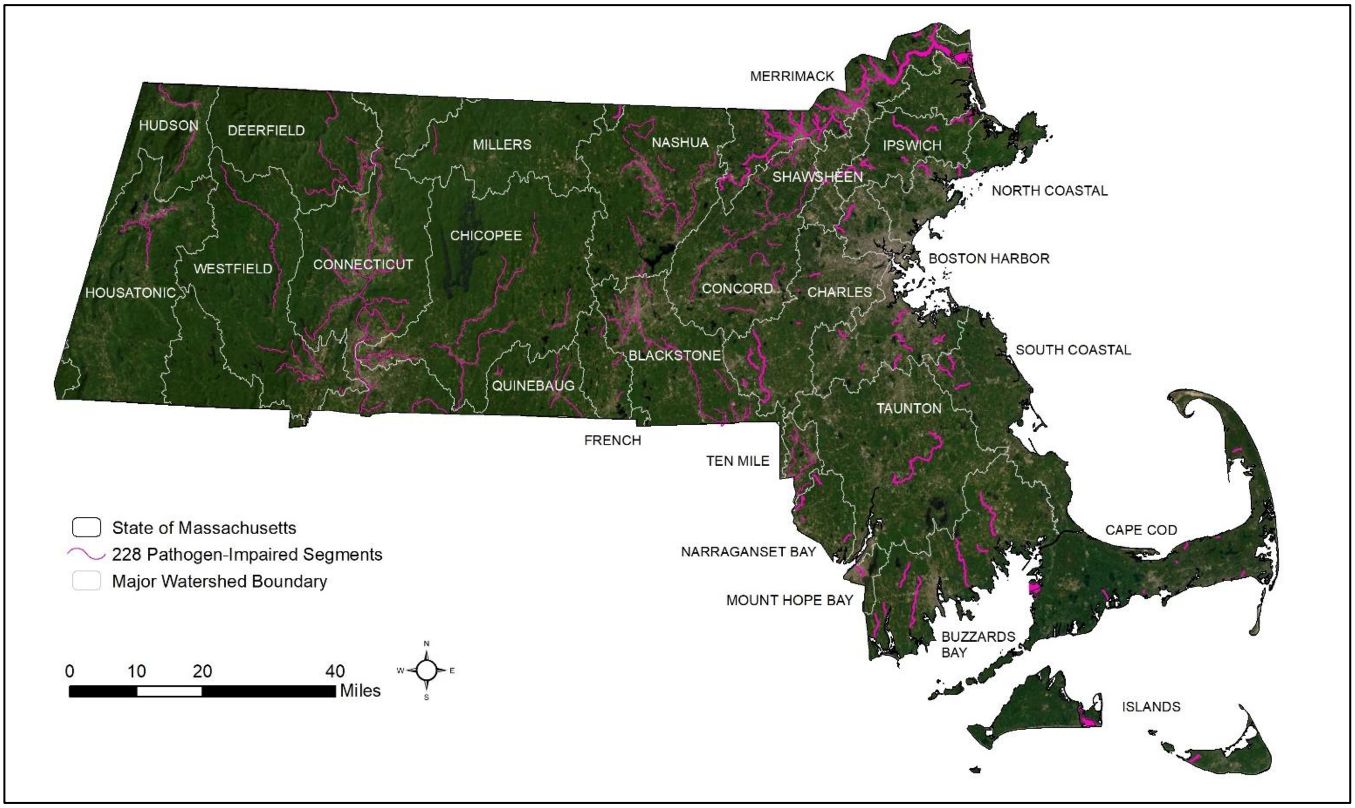

Figure 1. Map of Major Watersheds in Massachusetts and Pathogen-Impaired Segments

Table 2. Pathogen-Impaired Segments by Major Watershed addressed by this TMDL Report

Segment-specific information is detailed in each appendix by major watershed identified in the major watershed headings below. EC = *E. coli*. ENT = enterococci. FC = fecal coliform. AQL = Aquatic Life. CSO = Combined Sewer Overflow. CW = Cold Water Fishery. HQW = High Quality Water. ORW = Outstanding Resource Water. PWS = Public Water Supply (tributary). SF = Shellfishing. TWS = Treated Water Supply. WW = Warm Water Fishery.

Segment ID	Waterbody	Class (Qualifier)[1]	*E. coli* Impaired Use[2]	Enterococci Impaired Use[2]	Fecal coliform Impaired Use[2]
Hoosic River Basin [Appendix A]					
MA11-02	North Branch Hoosic River	B (CW, HQW)	Primary		Primary
MA11-03	Hoosic River	B (CW, HQW)	Primary		Primary
MA11-05	Hoosic River	B (WW)	Primary		Primary
Housatonic River Basin [Appendix B]					
MA21-02	East Branch Housatonic River	B (WW)	Primary		Primary
MA21-04	Housatonic River	B (WW)	Primary		Primary
MA21-17	Southwest Branch Housatonic River	B (CW, HQW)	Primary		Primary
MA21-18	West Branch Housatonic River	B (CW, HQW)	Primary		Primary
Westfield River Basin [Appendix C]					

Segment ID	Waterbody	Class (Qualifier)[1]	*E. coli* Impaired Use[2]	Enterococci Impaired Use[2]	Fecal coliform Impaired Use[2]
MA32-04	Westfield River	B (CW, HQW)		Primary	
MA32-08	Little River	B (CW)	Primary		Primary
MA32-09	Powdermill Brook	B	Primary		
MA32-22	Potash Brook	B (CW)	Primary		
MA32-27	Miller Brook	B (CW)	Primary		
MA32-28	White Brook	B (CW)	Primary		
MA32-36	Little River	B (CW)	Primary		
MA32-37	Ashley Brook	B (CW)	Primary		
MA32-39	Jacks Brook	B	Primary		
MA32-41	Moose Meadow Brook	B	Primary		Primary
Deerfield River Basin [Appendix D]					
MA33-03	Deerfield River	B (WW)	Primary		
MA33-04	Deerfield River	B (WW)	Primary		
MA33-19	East Branch North River	B (CW, HQW)	Primary		
MA33-21	Hinsdale Brook	B (CW)	Primary		
MA33-30	Green River	B (CW, HQW*)	Primary		Primary
MA33-101	South River	B (CW)	Primary		Primary
MA33-102	South River	B	Primary		Primary
Connecticut River Basin [Appendix E]					
MA34-03	Connecticut River	B (WW, CSO)	Primary		
MA34-04	Connecticut River	B (WW, CSO)	Primary		
MA34-05	Connecticut River	B (WW, CSO)	Primary		
MA34-07	Bachelor Brook	B (WW)	Primary		
MA34-11	Manhan River	B	Primary		
MA34-19	Stony Brook	B	Primary		
MA34-21	Longmeadow Brook	B	Primary		
MA34-25	Mill River	B	Primary		
MA34-27	Fort River	B	Primary		
MA34-28	Mill River	B	Primary		
MA34-29	Mill River	B (CSO)	Primary		
MA34-30	Scantic River	B	Primary		
MA34-36	Bloody Brook	B	Primary		
MA34-42	Buttery Brook	B	Primary		
MA34-60	Unnamed Tributary	B	Primary		
Millers River Basin [Appendix F]					
MA35-16	Keyup Brook	B (CW)	Primary		
Chicopee River Basin [Appendix G]					
MA36-05	Ware River	B (WW)	Primary		
MA36-06	Ware River	B (WW)	Primary		Primary
MA36-08	Prince River	B (CW, HQW)	Primary		
MA36-11	Sevenmile River	B (WW, HQW)	Primary		
MA36-12	Sevenmile River	B (WW)	Primary		
MA36-15	Quaboag River	B (WW)	Primary		
MA36-16	Quaboag River	B (WW)	Primary		Primary
MA36-17	Quaboag River	B (WW)	Primary		
MA36-18	Forget-Me-Not Brook	B (CW, HQW)	Primary		
MA36-21	Chicopee Brook	B (CW)	Primary		
MA36-22	Chicopee River	B (WW, CSO)	Primary		
MA36-24	Chicopee River	B (WW, CSO)	Primary		Primary
MA36-25	Chicopee River	B (WW, CSO)	Primary		
MA36-39	Unnamed Tributary	B	Primary		
MA36-40	Abbey Brook	B	Primary		
MA36-41	Fuller Brook	B	Primary		
MA36-50	Danforth Brook	B	Primary		
Quinebaug River Basin [Appendix H]					
MA41-03	Quinebaug River	B (WW)	Primary		Primary
MA41-04	Quinebaug River	B (WW)			Primary
MA41-06	Cady Brook	B (WW)	Primary		
MA41-12	Cohasse Brook	B	Primary		
MA41-13	Mckinstry Brook	B	Primary		
MA41-16	Unnamed Tributary	B	Primary		
MA41-17	West Brook	B	Primary		

Segment ID	Waterbody	Class (Qualifier)[1]	*E. coli* Impaired Use[2]	Enterococci Impaired Use[2]	Fecal coliform Impaired Use[2]
French River Basin [Appendix I]					
MA42-07	Burncoat Brook	B	Primary		
MA42-11	Wellington Brook	B	Primary		
MA42-15	Sucker Brook	B	Primary		
MA42-18	Grindstone Brook	B	Primary		
Blackstone River Basin [Appendix J]					
MA51-01	Kettle Brook	B (WW)	Primary		Primary
MA51-02	Middle River	B (WW)	Primary		
MA51-03	Blackstone River	B (WW, CSO)	Primary		
MA51-04	Blackstone River	B (WW)	Primary		
MA51-05	Blackstone River	B (WW)	Primary		
MA51-06	Blackstone River	B (WW)	Primary		
MA51-07	Beaver Brook	B (WW, HQW)	Primary		
MA51-08	Unnamed Tributary	B (WW, CSO)	Primary		Primary
MA51-15	Tatnuck Brook	B	Primary		
MA51-16	Dark Brook	B	Primary		
MA51-17	Poor Farm Brook	B	Primary		
MA51-18	Peters River	B	Primary		
MA51-27	Coal Mine Brook	B (CW)	Primary		
MA51-31	Singletary Brook	B	Primary		
MA51-32	Arnolds Brook	B	Primary		
MA51-36	Mill River	B (TWS, WW)	Primary		
MA51-39	Fox Brook	B	Primary		
MA51-40	Muddy Brook	B	Primary		
MA51-45	Cronin Brook	B	Primary		
Ten Mile River Basin [Appendix K]					
MA52-02	Ten Mile River	B (WW, HQW*)	Primary		Primary
MA52-03	Ten Mile River	B (WW)	Primary		Primary
MA52-05	Speedway Brook	B (WW)	Primary		Primary
MA52-07	Sevenmile River	A (PWS, ORW)	Primary		
MA52-08	Sevenmile River	B	Primary		Primary
MA52-09	Scotts Brook	B	Primary		
MA52-11	Coles Brook	B	Primary		
Narragansett Bay (Shore) Coastal Drainage Area [Appendix L]					
MA53-19	Bliss Brook	B	Primary		
MA53-20	Runnins River	B	Primary		
MA53-21	Unnamed Tributary	B	Primary		
Mount Hope Bay (Shore) Coastal Drainage Area [Appendix M]					
MA61-05	Quequechan River	B (WW, CSO)	Primary		
MA61-09	Lewin Brook	B	Primary		
Taunton River Basin [Appendix N]					
MA62-01	Taunton River	B (WW)	Primary		
Mystic River Basin and Coastal Drainage Area [Appendix O]					
MA71-10	Cummings Brook	B	Primary		
MA71-11	Shaker Glen Brook	B	Primary		
MA71-15	Munroe Brook	B	Primary		
Charles River Basin and Coastal Drainage Area [Appendix P]					
MA72-12	Beaver Brook	B	Primary		
MA72-14	Mine Brook	B (WW, HQW*)	Primary		
MA72-34	Chicken Brook	B	Primary		
MA72-35	Hopping Brook	B	Primary		
MA72-41	Unnamed Tributary	B	Primary		
MA72-43	Unnamed Tributary	B	Primary		
MA72-44	Seaverns Brook	B	Primary		
Neponset River Basin and Coastal Drainage Area [Appendix Q]					
MA73-18	Steep Hill Brook	B	Primary		
MA73-23	Plantingfield Brook	B	Primary		
Weymouth & Weir River Basin and Coastal Drainage Area [Appendix R]					
MA74-10	Furnace Brook	B	Primary		
MA74-20	Plymouth River	B	Primary		
MA74-22	Cranberry Brook	B (ORW)	Primary		

Segment ID	Waterbody	Class (Qualifier)[1]	*E. coli* Impaired Use[2]	Enterococci Impaired Use[2]	Fecal coliform Impaired Use[2]
MA74-23	Mary Lee Brook	B	Primary		
MA74-27	Farm River	A (PWS, ORW)	Primary		
MA74-28	Farm River	B	Primary		
Nashua River Basin [Appendix S]					
MA81-01	North Nashua River	B (WW, CSO)	Primary		
MA81-02	North Nashua River	B (WW, CSO)	Primary		
MA81-03	North Nashua River	B (WW, CSO)	Primary		
MA81-04	North Nashua River	B (WW)	Primary		
MA81-05	Nashua River	B (WW)	Primary		
MA81-09	Nashua River	B (WW)	Primary		
MA81-13	Monoosnoc Brook	B	Primary		
MA81-20	James Brook	B	Primary		
MA81-24	Gates Brook	A (PWS, ORW)	Primary		Primary
MA81-31	Stillwater River	A (PWS, ORW)	Primary		
MA81-39	Fall Brook	B	Primary		
MA81-60	Still River	B (CW)	Primary		
MA81-62	Baker Brook	B (CSO)	Primary		
MA81-72	Wekepeke Brook	B	Primary		
MA81-74	Catacoonamug Brook	B	Primary		
MA81-79	Willard Brook	B (ORW)		Primary	
MA81-80	Pearl Hill Brook	B (ORW)		Primary	
MA81-99	Falulah Brook	A (PWS, ORW)	Primary		
MA81-100	Falulah Brook	B	Primary		
Concord (SuAsCo) River Basin [Appendix T]					
MA82A-03	Sudbury River	B (AQL, HQW)	Primary		
MA82A-05	Hop Brook	B (WW)	Primary		
MA82A-07	Concord River	B (TWS, WW)	Primary		Primary
MA82A-09	Concord River	B (WW, CSO)	Primary		Primary
MA82A-10	River Meadow Brook	B	Primary		Primary
MA82A-19	Pantry Brook	B			Primary
MA82A-22	Unnamed Tributary	B	Primary		
MA82A-25	Sudbury River	B (WW, HQW)	Primary		
MA82A-34	Beaver Brook	B	Primary		
MA82B-02	Assabet River	B (WW)	Primary		Primary
MA82B-03	Assabet River	B (WW)	Primary		Primary
MA82B-04	Assabet River	B (WW)	Primary		Primary
MA82B-05	Assabet River	B (WW)	Primary		Primary
MA82B-07	Assabet River	B (WW)	Primary		Primary
MA82B-12	Elizabeth Brook	B	Primary		
MA82B-14	Nashoba Brook	B	Primary		
MA82B-22	Coles Brook	B	Primary		
Shawsheen River Basin [Appendix U]					
MA83-22	Webb Brook	B	Primary		
Merrimack River Basin and Coastal Drainage Area [Appendix V]					
MA84A-01	Merrimack River	B (TWS, WW, CSO)	Primary		Primary
MA84A-02	Merrimack River	B (TWS, WW, CSO)	Primary		
MA84A-03	Merrimack River	B (TWS, WW, CSO)	Primary		
MA84A-04	Merrimack River	B (WW, CSO)	Primary		
MA84A-05	Merrimack River	SB (SF, CSO)		Primary	
MA84A-06	Merrimack River	SB (SF, CSO)		Primary	Shellfish
MA84A-08	Powwow River	SB (SF)	Primary		
MA84A-09	Little River	B (WW)	Primary		
MA84A-10	Spicket River	B (WW, CSO)	Primary		
MA84A-11	Beaver Brook	B (CW)	Primary		
MA84A-12	Richardson Brook	B	Primary		
MA84A-13	Trout Brook	B	Primary		
MA84A-14	Trull Brook	B	Primary		
MA84A-16	Back River	B	Primary		
MA84A-17	Black Brook	B	Primary		
MA84A-18	Bare Meadow Brook	B	Primary		
MA84A-21	Deep Brook	B	Primary		
MA84A-25	Powwow River	B (WW)	Primary		

Segment ID	Waterbody	Class (Qualifier)[1]	*E. coli* Impaired Use[2]	Enterococci Impaired Use[2]	Fecal coliform Impaired Use[2]
MA84A-26	Merrimack River	SA (SF)			Shellfish
MA84A-27	Plum Island River	SA (ORW, SF)			Shellfish
MA84A-28	Powwow River	A (PWS, ORW)			Primary
MA84A-30	Unnamed Tributary	SA (SF)	Primary		
MA84A-31	South Branch Souhegan River	B	Primary		
MA84A-35	Peppermint Brook	B	Primary		
MA84A-36	Bartlett Brook	B	Primary		
MA84A-37	Creek Brook	B	Primary		
MA84A-39	East Meadow River	A (PWS, ORW)	Primary		
MA84A-40	Fish Brook	A (PWS, ORW)	Primary		
MA84B-01	Unnamed Tributary	B			Primary
MA84B-02	Beaver Brook	B			Primary
MA84B-03	Stony Brook	B (WW)			Primary
MA84B-04	Stony Brook	B (WW)	Primary		
MA84B-06	Bennetts Brook	B	Primary		
MA84B-07	Tadmuck Brook	B	Primary		
Ipswich River Basin and Coastal Drainage Area [Appendix W]					
MA92-02	Ipswich River	SA (SF)			Shellfish
MA92-05	Lubbers Brook	B	Primary		
MA92-08	Martins Brook	B	Primary		Primary
MA92-12	Unnamed Tributary	B	Primary		Primary
MA92-14	Fish Brook	B	Primary		
MA92-17	Howlett Brook	B	Primary		Primary
MA92-21	Kimball Brook	B	Primary		Primary
MA92-22	Labor in Vain Creek	SA (SF)			Shellfish
MA92-23	Unnamed Tributary	SA (SF)			Shellfish
North Shore Coastal Drainage Area [Appendix X]					
MA93-37	Beaver Brook	B	Primary		
MA93-38	Crane River	B	Primary		
MA93-58	Unnamed Tributary	B	Primary		
MA93-59	Unnamed Tributary	B	Primary		
South Shore Coastal Drainage Area [Appendix Y]					
MA94-04	Indian Head River	B (WW)	Primary		
MA94-39	Longwater Brook	B	Primary		
MA94-40	Cushing Brook	B	Primary		
Buzzards Bay Coastal Drainage Area [Appendix Z]					
MA95-04	Weweantic River	B (WW, HQW)		Primary	
MA95-06	Sippican River	B (WW, HQW)		Primary	
MA95-11	Paskamanset River	B	Primary	Primary	
MA95-12	Shingle Island River	A (PWS, ORW)		Primary	
MA95-19	Megansett Harbor	SA (SF)			Shellfish
MA95-36	Mattapoisett River	B	Primary	Primary	
MA95-68	Wild Harbor River	SA (SF)			Shellfish
MA95-78	Rands Harbor	SA (SF)			Shellfish
MA95-79	Fiddlers Cove	SA (SF)			Shellfish
MA95-82	Kirby Brook	B		Primary	
MA95-83	Angeline Brook	B		Primary	
Cape Cod Coastal Drainage Area [Appendix AA]					
MA96-75	Round Cove	SA (ORW, SF)			Shellfish
MA96-95	Allens Harbor	SA (SF)			Shellfish
MA96-96	Wychmere Harbor	SA (SF)			Shellfish
MA96-99	Little River	B	Primary		
MA96-100	Unnamed Tributary	B	Primary		
MA96-102	Whites Brook	B	Primary		
MA96-103	Chase Garden Creek	B	Primary		
MA96-104	Unnamed Tributary	B	Primary		
MA96-107	Red River	B	Primary		
MA96-108	Unnamed Tributary	B (ORW)	Primary		
Islands Coastal Drainage Area [Appendix AB]					
MA97-16	Katama Bay	SA (SF)			Shellfish
MA97-29	Long Pond	SA (SF)			Primary

1 Qualifiers are provided for informational purposes only, see the SWQS (MassDEP, 2021a). The descriptions of the current SWQS regulation included in this document are for informational purposes, only. The actual SWQS regulation shall control in the event of any discrepancy with the description provided. As a result, no person in any administrative or judicial proceeding shall rely upon the content of this document to create any rights, duties, obligations, or defenses, implied or otherwise, enforceable at law or in equity.
2 Although some of the segments impaired for the Primary Contact Recreation Use are also impaired for Secondary Contact Recreation, the criteria to protect the Primary Contact Recreation Use are more stringent, therefore these criteria form the basis for the TMDL. While Long Pond (MA97-29) is impaired for Primary Contact Recreation Use due to fecal coliform, the Shellfish criteria are more appropriate and conservative and form the basis of the TMDL

1.2. Pathogens and Indicator Bacteria

Pathogens, or disease-causing organisms, are easily carried by stormwater runoff, as well as other discharges, into surface waterbodies. Once in a surface water, these pathogens can infect humans through consumption of contaminated fish and shellfish, skin contact, or ingestion of water. Infections due to pathogen-contaminated recreational waters include gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases (USEPA, 1986). Of the designated uses listed in § 303(d) of the federal CWA, protection from pathogenic contamination is important for waters designated for recreation (primary and secondary contact), public water supplies, aquifer protection, and the protection and propagation of fish, shellfish, and wildlife (USEPA, 2001).

The most common source of pathogens in surface waters is from the fecal wastes of warm-blooded animals. Wastes from warm-blooded animals contain many types of bacteria, including the coliform group and *Streptococcus*, *Lactobacillus*, *Staphylococcus*, and *Clostridia*. Each gram of human or animal feces contains approximately 12 billion bacteria that may include pathogenic bacteria, such as *Salmonella*, associated with gastroenteritis. Feces may contain other pathogens besides bacteria, including viruses, protozoa, and parasites (MassDEP, 2007).

Pathogens can also negatively affect waters used as sources of drinking water, even though such waters undergo effective treatment. The amount of treatment required to produce potable water increases as pathogen levels increase, and high levels of treatment may result in disinfection by-products that are also harmful to humans. Information on pathogens and water quality are available at these USEPA webpages:

- Water Quality Criteria: Microbial (Pathogen) (USEPA, 2019c)
- Advisories and Technical Resources for Fish and Shellfish Consumption (USEPA, 2019a)
- Swimming Advisories (USEPA, n.d.)

The wide variety of pathogenic organisms that might be present in waters makes it expensive and sometimes difficult to identify and measure the risk of each specific disease. Therefore, scientists and public health officials usually monitor non-pathogenic bacteria that are typically associated with harmful pathogens in fecal waste but are more easily identified and measured. These associated bacteria are called indicator organisms. Indicator bacteria themselves are not necessarily a health risk but are used to indicate the likely presence of pathogenic organisms. High densities of indicator bacteria increase the likelihood of the presence of pathogenic organisms (USEPA, 2001).

Two commonly used indicators are coliform bacteria and fecal streptococci. The relationship among indicator organisms is illustrated in Figure 2, with those used in Massachusetts highlighted. Indicator criteria specific to Massachusetts are discussed in detail in Section 2. Coliform bacteria include total coliform, fecal coliform, and *E. coli*.

Fecal coliform (a subset of total coliform) and *E. coli* (a subset of fecal coliform) are present in the intestinal tracts of warm-blooded animals. The presence of coliform bacteria in water indicates fecal contamination and the possible presence of pathogens. Fecal streptococci bacteria, specifically the subgroup enterococci, are also used as indicator bacteria. All these bacteria live in the intestinal tract of animals, but because enterococci have a lower die-off rate, their presence is a better predictor of human gastrointestinal illness than fecal coliform (USEPA, 2001), particularly in brackish waters.

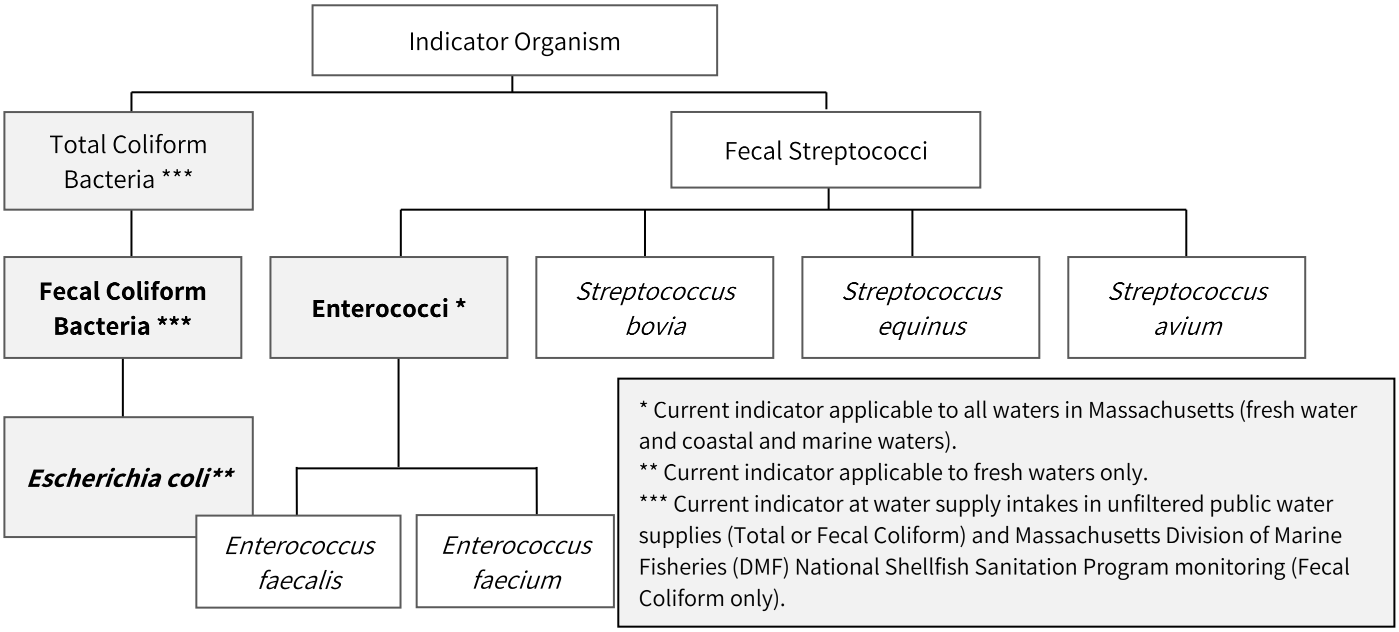

Figure 2. Relationship among indicator organisms (USEPA, 2001)

1.3. Comprehensive Watershed-Based Approach to TMDL Development

Historically, water and sediment quality studies have focused on the control of point sources of pollutants (i.e., discharges from pipes and other structural conveyances) that discharge directly into well-defined hydrologic resources, such as estuaries, lakes, ponds, or rivers. This approach has been successful in identifying and reducing a large amount of water pollutants; however, it does not fully characterize the more diffuse and chronic sources of pollutants that are widely scattered throughout a broad geographic region such as a watershed (e.g., roadway runoff, failing septic systems in high groundwater, areas of concentrated waterfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These sources are referred to as nonpoint sources of pollutants and often contribute significantly to the decline of water quality through their cumulative impacts. A watershed-based approach that uses the surface drainage area as the basic study unit enables managers to gain a more complete understanding of the potential pollutant sources impacting a waterbody and increases the precision of identifying local problem areas or “hot spots” that may detrimentally affect water and sediment quality.

Addressing many waterbodies across multiple watersheds through a watershed-based TMDL is more efficient than developing separate TMDLs for each impaired waterbody. This approach also provides a useful format for guiding both remediation and protection efforts at the municipal and regional levels by providing a coordinating framework for environmental management that supports efforts to systematically identify, evaluate, and prioritize point and nonpoint sources of pollutants using natural hydrologic boundaries to define the problem areas. Once identified, sources are required to meet applicable water quality standards for indicator bacteria or be eliminated. Water quality restoration then becomes an iterative process, where data are reviewed as they become available, especially after targeted activities, such as public education campaigns, improved infrastructure, and refined stormwater management, are implemented. Participation by local governments, watershed groups, citizens, and other stakeholders in the TMDL process is crucial to achieve intended objectives because it ensures that individuals most likely to be knowledgeable of watershed conditions will help identify problems and develop solutions. Fresh water river or coastal waterbody segments that are assessed as impaired by MassDEP after approval of this TMDL report will be added as an addendum in revised versions of the report. Future submittals will provide detailed information on the impaired waterbodies as provided in the watershed appendices. MassDEP will provide public notice for comment, then submit to the USEPA for review and approval.

2. Applicable Surface Water Quality Standards

The purpose of a TMDL is to define the maximum amount of a pollutant that a waterbody can assimilate while allowing a waterbody to meet its applicable water quality standards. This section summarizes the Massachusetts Surface Water Quality Standards (SWQS; 314 CMR 4.00) that are applicable to TMDLs presented in this report (MassDEP, 2021a).

The SWQS determine the minimum water quality criteria that all surface waters of the Commonwealth must meet to protect their designated uses. The SWQS implement provisions of the Federal Water Pollution Control Act, 33 USC §1251, et seq. (known as the CWA) and associated federal Water Quality Standards regulation, 40 CFR Part 131, as well as the Massachusetts Clean Waters Act (M.G.L. c. 21, §§ 26 through 53) (MassDEP, 2021a).

The SWQS are composed of several parts, including classification of waters by designated use and application of criteria based on designated use. Each part is described below.

2.1. Classification by Designated Uses

Under the Massachusetts SWQS at 314 CMR 4.05(3), fresh water lakes, ponds, rivers, and streams are designated as either Class A, B, or C, with corresponding designated uses. Similarly, coastal and marine waters are designated at 314 CMR 4.05(4) as either Class SA, SB, or SC, each with a set of sensitive uses. No surface waters in Massachusetts are designated Class C or SC.

All fresh waters covered by this TMDL are Class A or B and all coastal and marine waters are Class SA or SB. Based on the SWQS, these waters should be suitable for the following uses: (1) habitat for fish, other aquatic life, and wildlife, with Class A waters being excellent habitat, (2) primary and secondary contact recreation (e.g., swimming, or boating and fishing, respectively), and (3) consistently good aesthetic value, with Class A waters being of excellent aesthetic value.

In addition, Class A includes public water supplies and their tributaries, which are among the most sensitive uses and therefore receive the most stringent protections. Class B waters designated with a "Treated Water Supply" qualifier are used as a source of public water supply with appropriate treatment. Other uses assigned to Class B waters are irrigation and other agricultural uses and compatible industrial cooling and processing.

Class SA waters that are designated for shellfishing are suitable for shellfish harvesting without depuration (within Approved and Conditionally Approved Shellfish Areas). Class SB shellfishing waters are designated as suitable for shellfish harvesting with depuration (within Restricted and Conditionally Restricted Shellfish Areas). Class SA and SB waters may also serve as water intakes for desalination facilities, conditional upon compliance with the SWQS.

In addition to classification, individual waterbody segments may be assigned qualifiers, which reflect additional uses or special considerations of that waterbody that may affect the application of criteria or antidegradation provisions (see 314 CMR 4.06(1)(d)). Qualifiers are assigned to segments by category at 314 CMR 4.06(2) through (5) and to specific segments at (6)(b): *Figure A; Figures and Tables 1 through 27.* Those that relate to this TMDL are:

- **Public Water Supply (PWS):** Class A waters that may be used as a source of public drinking water for a public water system as defined in 310 CMR 22.00: *Drinking Water,* may be subject to more stringent criteria in accordance with 310 CMR 22.00, and may have restricted use; these waters are designated for protection as Outstanding Resource Waters under 314 CMR 4.04(3).
- **Outstanding Resource Water (ORW):** Waters designated for protection as ORWs under 314 CMR 4.04(3).
- **High Quality Water (HQW):** Waters designated for protection under 314 CMR 4.04(2); other waters as described in 314 CMR 4.04(2) also are high quality, although they are not necessarily denoted as high quality in the classification tables.

- **Treated Water Supply (TWS):** Class B waters used as a source of public water supply after appropriate treatment and that may be subject to more stringent site-specific criteria.
- **Cold Water (CW)**: Waters subject to the dissolved oxygen and temperature criteria needed to support cold water fisheries. Where a cold water fish population has been identified by the Division of Fisheries and Wildlife as meeting their protocol, but the water has not been documented to meet the cold water criteria in 314 CMR 4.00, the Department will protect the existing cold water fish population and its habitat as an existing use.
- **Warm Water (WW)**: Waters subject to the dissolved oxygen and temperature criteria needed to support warm water fisheries.
- **Aquatic Life (AQL):** Waters where natural background conditions prevent the attainment of a "higher use" designation, thus Class C dissolved oxygen and temperature criteria apply.
- **Combined Sewer Overflow (CSO):** Waters identified as impacted by the discharge of CSOs without a long-term control plan (LTCP) approved or fully implemented.
- **Shellfishing (SF):** Waters subject to more stringent regulation by the Massachusetts Division of Marine Fisheries (DMF) pursuant to M.G.L. c. 130, § 75, including applicable criteria of the National Shellfishing Sanitation Program. DMF issues approval for use of areas designated for shellfishing.

Except for CSO, shellfishing, and the intakes of certain PWS, these qualifiers generally do not change the fecal indicator bacteria *(E. coli* or enterococci) water quality criteria (WQC) but more often focus on other types of water quality protection measures, such as restricting discharges to the waters. For more information on the surface water classes, designated uses, and qualifiers mentioned above, see the Massachusetts SWQS (MassDEP, 2021a).

To evaluate surface water quality, surface waters in Massachusetts are divided into assessment units. Smaller streams are often a single assessment unit, while large rivers may be divided into multiple units. Each unit is potentially assessed under the full range of designated uses, including swimming, fishing, drinking, irrigation, fish and wildlife habitat, as well as any existing uses (equally or more sensitive than the designated uses, attained by the waterbody on or after November 28, 1975). Sensitive uses require more stringent water quality protection; thus, meeting the requirements of these uses will tend to protect all other uses.

2.2. Surface Water Quality Criteria for Pathogens

In 2007, fecal coliform was replaced in the SWQS with *E. coli* and enterococci as indicator bacteria, as recommended by the USEPA in the *Ambient Water Quality Criteria for Bacteria – 1986* (USEPA, 1986). (Fecal coliform and total coliform data are used to determine compliance with Massachusetts' drinking water regulations for surface water and groundwater sources.) In marine waters designated for shellfishing, fecal coliform remains in use by the DMF in accordance with the National Shellfishing Sanitation Program. Data may be presented in this TMDL that were collected prior to 2007 and therefore use the fecal coliform indicator for impairment determination; these data will be presented with no applicable WQC.

> A **geometric mean** is a way to average a set of values and is commonly used with bacterial water quality assessments which often show a great deal of variability. Unlike an arithmetic mean, a geometric mean reduces the effect of an occasional high or low value on the average.

The 2021 amendments to the SWQS adopted the USEPA's 2012 human health bacteria criteria recommendations for waters designated for Primary Contact Recreational uses such as bathing (MassDEP, 2018c; MassDEP, 2021a). The SWQS include a geometric means, or geomeans, for *E. coli* and enterococci bacteria for fresh water samples or enterococci only for coastal and marine samples collected within a 90-day period year-round. A shorter evaluation period of 30-days is used for segments containing public or semi-public beaches (during the bathing season) or have discharges from CSOs or publicly-owned treatment works (POTW) (year-round). In addition to the geometric means, the statistical threshold values (STVs) for *E. coli* and/or enterococci shall not be exceeded by more than 10% of samples in the same period. Under the SWQS, the bathing season at beaches is determined by beach operators; but for the purposes of assessment or TMDLs, is defined as April 1 to October 15 of each year. A summary of WQC for indicator bacteria is presented in Table 3.

2.3. Numeric Water Quality Targets

In a TMDL, the water quality target is a numeric endpoint that represents the level of acceptable water quality to be achieved by implementing the TMDL. For indicator bacteria, the numeric targets for the TMDLs presented in this report are equal to numeric WQC defined in the SWQS (314 CMR 4.00) and listed in Table 3.

For this TMDL report, we focus only on Class A and B fresh water river segments for the designated use of Primary Contact Recreation, and Class SA and SB coastal and marine waters for the designated uses of Shellfishing and Primary Contact Recreation. Most of the segments are listed as impaired for *E. coli*, with some segments listed as impaired for enterococci from Massachusetts Department of Public Health (DPH) data at a designated public beach along the segment, and one segment listed only for fecal coliform as a carry-over from a previous assessment (no *E. coli* data available).

For the segments with a designated beach (listed for enterococci), we apply a 30-day rolling geomean during the bathing season and a 90-day rolling geomean during the non-bathing season. For segments without a designated beach and with *E. coli* data, we identify those segments with a CSO qualifier and/or a POTW and apply a year-round, 30-day rolling geomean. For the remaining segments without a designated beach and with *E. coli* data, we apply a year-round, 90-day rolling geomean. For water quality stations and years with more than 10 samples, we also calculate the rolling 90th percentile in the relevant periods for the applicable segments, as noted for the geomean calculations. If there are no stations within a segment with more than 10 samples in a year, then the STV criteria apply to single sample results.

Table 3. Summary of water quality criteria by waterbody class, designated use, and indicator bacteria from 314 CMR 4.05(3)(a)4., (3)(b)4., (4)(a)4., (4)(b)4., and (5)(f).

CFU = Colony Forming Units. MPN = Most Probable Number

Waterbody Class, Designated Use	Indicator Bacteria	Geometric Mean Applied to Rolling 30-day or 90-day period[1]	Statistical Threshold Value (STV) Applied to Rolling 30-day or 90-day period[2]
Class A & B, Primary Contact Recreation	fecal coliform[3]	NA	NA
	E. coli	≤ 126 CFU per 100mL[2]	≤ 410 CFU per 100mL
	Enterococci	≤ 35 CFU per 100mL[2]	≤ 130 CFU per 100mL
Class SA & SB, Primary Contact Recreation	Enterococci	≤ 35 CFU per 100mL[2]	≤ 130 CFU per 100mL
Class SA, Shellfishing	fecal coliform	≤ 14 MPN per 100mL	≤ 28 MPN per 100mL
Class SB, Shellfishing	fecal coliform	≤ 88 MPN per 100mL[4]	≤ 260 MPN per 100mL

[1] *No minimum number of samples, see the Massachusetts SWQS (314 CMR 4.00) for applicable duration period*
[2] *Applicable for stations and years with more than 10 samples; otherwise, STV applied to single sample results.*
[3] *Fecal coliform criteria were replaced with* E. coli *and enterococci criteria beginning in 2007*
[4] *Median or geometric mean ≤ 88 MPN per 100mL*

3. Source Assessment

The number of potential pathogens entering waterbodies is dependent on several factors, including watershed land use characteristics and meteorological conditions. As development density and land uses that affect water quality increase (e.g., including commercial, residential, and industrial land uses), the number of pathogens (as estimated by indicator bacteria) generally increases. Increased development density and corresponding high levels of impervious cover, such as rooftops, roads, and parking lots, affect streams as follows (USEPA, 1997):

- Increased flow volume
- Increased peak flow
- Increased peak flow duration
- Increased stream temperature
- Decreased base flow
- Altered sediment loading rates

Sources of pathogen pollutants may include illicit sewer connections, failed septic systems, poorly managed pet or livestock waste, congregating waterfowl, among other factors. Many of these impacts associated with increased impervious surface area also result in changes in pathogen loading (e.g., increased sediment loading can result in increased pathogen loading). In addition to increased impervious surface impacts, increased human and pet densities in developed areas increase potential fecal contamination. Furthermore, stormwater drainage systems and associated stormwater culverts and outfall pipes often result in the channelization of streams which leads to less attenuation of pathogen pollution. Two studies in Massachusetts, summarized in Table 4 and Table 5, provide data to illustrate the relationship between land use, development intensity, and pathogen pollutants.

To reduce the amount of pathogen pollutants that impairs waterbodies, Section 402 of the CWA requires that all point sources be regulated under the National Pollutant Discharge Elimination System (NPDES) permit program to control the type and quantity of pollutants discharged. Massachusetts' discharge permits are issued under 314 CMR 3.00: *Surface Water Discharge Permit Program*. Nonpoint sources are much more difficult to identify and control as they are more diffuse. Nonpoint source pollution is typically driven by watershed runoff, or the movement of water over the land surface and through the unsaturated zone and groundwater into waterbodies. Nonpoint sources of pathogenic pollutants include failing septic systems, illicit discharges or leaky sewers, wild animal and pet waste, manure spreading, and others mentioned above and described in more detail below. The *Massachusetts Nonpoint Source Management Program Plan 2020-2024* (MassDEP, 2019c) represents Massachusetts' strategy for preventing, controlling, and reducing nonpoint source pollutants. For more information on nonpoint source pollution, see MassDEP and USEPA's webpages (MassDEP, 2019d; USEPA, 2018a).

3.1. Point Sources

The Massachusetts SWQS defines "point source" at 314 CMR 4.02:

> *Point Source. Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel or other floating craft, from which pollutants are or may be discharged. Point Source does not include return flows from irrigated agriculture.*

Under Section 402 of the CWA, all point sources must be regulated under the NPDES permit program to control the type and quantity of pollutants discharged. These include large facilities like wastewater treatment plants or facilities (WWTP, WWTF, POTW), CSOs, industrial plants, confined animal feeding operations (CAFOs), and separate storm sewer systems in municipalities.

Pathogen-related point source pollution can occur during both wet and dry weather. Usually, pathogen levels (as estimated by indicator bacteria) are higher in wet weather conditions, as CSOs, sanitary sewer overflows (SSOs), and/or stormwater runoff carry fecal matter to rivers and estuaries.

In some cases, dry weather pathogen and associated indicator bacteria concentrations can be higher than those in wet weather. The constant flow of pollutants (such as illicit wastewater connections into storm drains) becomes diluted during periods of precipitation. Although the magnitude of these relationships (indicator bacteria concentration versus precipitation) is variable in time and location, the data may provide indications of the sources of pathogen pollutants.

Examples of wet weather sources include:

- wildlife and domesticated animals (including pets),
- stormwater runoff including point sources from municipal separate storm sewer systems (MS4s),
- CSOs and SSOs.

Examples of dry weather sources include:

- leaking sewer pipes,
- stormwater drainage systems (illicit connections of sanitary sewers to storm drains),
- failing septic systems,
- recreational activities, and
- wildlife, including birds.

It is difficult to provide accurate quantitative estimates of pathogen contributions from various sources because many sources are diffuse, intermittent, and difficult to monitor. Therefore, this TMDL uses a method of providing a general level of priority according to each source category for each segment in each watershed. This approach is suitable because it identifies the severity of the sources and illustrates the need for controlling them. Precisely quantifying many sources (failing septic systems, leaking sewer pipes, SSOs, illicit wastewater connections to stormwater pipes) is difficult and unnecessary, because they are prohibited and therefore must be eliminated.

To reduce pathogen pollution from municipal sewer systems, 260 out of 351 towns in Massachusetts are regulated under the MS4 program as “urbanized areas” as defined by the US Census Bureau in 2010. The MS4 program has expanded stormwater pollution awareness through six minimum control measures: Public Education and Outreach, Public Participation, Illicit Discharge Detection and Elimination (IDDE), Management of Construction Site Runoff, Management of Post Construction Site Runoff, and Good Housekeeping in Municipal Operations. Approaches to reduce pathogen pollution in the MS4 permit include distributing fliers about pet waste, mapping outfalls and catchment areas, prioritizing repairs and improvements, and revising municipal regulatory controls. USEPA and MassDEP jointly issued the revised Phase II MS4 General Permit which became effective on July 1, 2018. Communities with approved TMDLs are required to implement enhanced BMPs for public education and designate the outfalls that discharge to pathogen-impaired waterbodies as Problem Catchments or as a high priority for investigation and improvements under the IDDE program, in addition to the requirement to reduce pollutants to the Maximum Extent Practicable or MEP, as noted in *General Permits for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems in Massachusetts* (USEPA, 2020); refer to Appendix F.

3.1.1. Illicit Discharges in Storm Sewers

An illicit discharge refers to flows to MS4-regulated storm drains during dry weather, that contain pollutants and/or pathogens typically not found in stormwater (USEPA, 2020). Illicit sanitary sewer connections to storm drains are an on-going problem in many urban drainage systems, particularly older systems that may have once combined stormwater with sanitary sewer flows (NEIWPCC, 2003). The IDDE program is a requirement of the Massachusetts General Permits for stormwater discharges from MS4s (USEPA, 2020). Permittees are required to systematically find and eliminate sources of non-stormwater discharges to MS4s. Examples of illicit discharges commonly seen in urban communities in Massachusetts include direct discharges such as sanitary wastewater pipes connected from a home to a storm drain and indirect illicit discharges such as a damaged sanitary sewer line that is leaking wastewater into a cracked storm sewer line through inflow and infiltration (NEIWPCC, 2003).

3.1.2. Sanitary Sewers and Wastewater Treatment Plants

WWTPs receive and treat wastewater from a variety of sources including institutions, hospitals, commercial, industrial, and residential users. This wastewater, which contains a variety of organic and inorganic pollutants, is transported to WWTPs via sanitary sewer networks, where it is treated to remove harmful wastes, then disinfected to inactivate, or kill, pathogens and meet effluent limitations as specified in NPDES permits. Untreated or partially treated wastewater has the potential to enter the State's surface waters due to malfunctioning WWTPs. Through municipal grants and low interest loans obtained from the State Revolving Fund (SRF), hundreds of millions of dollars have been spent over the past four decades on upgrading WWTPs to secondary and more advanced treatment processes to control pathogens and other pollutants.

3.1.3. Combined Sewer Overflows

A combined sewer system (CSS) collects rainwater runoff, domestic sewage, and industrial wastewater in one pipe. In dry conditions, the pipe transports all collected wastewater to a sewage plant for treatment; from there, effluent is discharged to a waterbody. During a heavy rainfall or snowmelt event, the volume of combined stormwater and wastewater can exceed the capacity of the CSS and/or treatment plant. When this occurs, stormwater and wastewater may be discharged, untreated, directly to streams, rivers, and other waterbodies. These events, called CSOs, contain untreated or partially treated human and industrial waste, toxic materials, and debris, as well as stormwater. CSSs are a legacy in urbanized areas and have, in many cases, been replaced or are being replaced by separate storm sewer systems and sanitary sewer systems.

According to the USEPA, CSOs are a priority water pollutant concern for the nearly 860 municipalities across the U.S. that have CSSs. Massachusetts has 19 CSO communities or sewer districts, regulated through NPDES permits. Each CSO permittee must implement system controls known as the Nine Minimum Controls to maximize efficiency of the existing facilities to limit the duration and impact of CSO discharges. Facilities must also develop and implement a Long-Term Control Plan or LTCP (MassDEP, n.d. (c)). For more information, see (USEPA, 2018b). For more information including an interactive map of CSO locations in Massachusetts see MassDEP webpage: Sanitary Sewer Systems & Combined Overflows (MassDEP, 2019b).

3.1.4. Sanitary Sewer Overflows

Sanitary Sewer Overflows (SSO) are discharges of untreated wastewater from sanitary sewer systems. These overflows can be caused by clogged or cracked sewer pipes, by excess infiltration and inflow, by undersized sewer systems (piping and/or pumps), by pumping station equipment failure, or electrical power failure. Such untreated wastewater can find its way to surface waters and cause water quality violations.

3.1.5. Illicit Discharges from Boats

Since 2014, all Massachusetts waters are designated as a No-Discharge Zone (NDZ) in which the discharge of boat sewage is prohibited. There has been extensive work by the Massachusetts Office of Coastal Zone Management (CZM), coastal communities, and other organizations to ensure that boat pump-out services are available where boating occurs (CZM, 2022). Many free boat pump-out services are available at various sites along the coast, funded by the Clean Vessel Act. The 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 discharge from boats in the waters covered by this TMDL are therefore illicit discharges.

3.2. Nonpoint Sources

3.2.1. Non-Regulated Stormwater Runoff

Stormwater runoff is the water from rain or snowmelt that flows over the land surface or through the ground (sometimes referred to as throughflow) into surface waters. Stormwater runoff may also seep through soil to infiltrate to groundwater, eventually discharging to surface waters. As the runoff moves, it transports natural and anthropogenic pollutants, such as soil, trash, and fecal waste, and eventually deposits them into surface waters. In developed areas, stormwater is typically channelized in storm drains, discharging via outfalls to wetlands and surface waters. Stormwater runoff is one of the leading sources of impairment of our nation's waters and often contains high concentrations of various pollutants, including pathogens. Urbanization and associated impervious surfaces alter the natural drainage features of a watershed, thereby significantly impacting local hydrology with increased peak discharge rates and volumes, reduced recharge to wetlands and streams, and increased discharge of pollutants to wetlands and receiving surface waters.

Extensive stormwater data have been collected and compiled in Massachusetts and on a national level to characterize the quality of stormwater. Pathogens and associated indicator bacteria are the most variable of stormwater pollutants, with concentrations often varying by factors of 10 to 100, or more, during a single storm. Considering this variability, stormwater indicator bacteria concentrations are difficult to predict accurately. Caution must be exercised when using values from single wet weather grab samples to estimate the magnitude of pathogen loading, because it is often unknown whether the sample is representative of the "true" mean of that wet weather event.

To gain an understanding of the magnitude of pathogen loading from stormwater and avoid over- or underestimating pathogen loading, event mean concentrations (EMC) are often used. An EMC is the concentration of a flow-proportioned sample collected throughout the course of a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow. Typical stormwater event mean concentrations for various indicator bacteria (fecal coliform) in Massachusetts' watersheds (and across the nation) are provided in Table 4 and Table 5. These EMCs illustrate that stormwater indicator bacteria concentrations from certain land uses (i.e., residential) are typically at levels that cause water quality problems. For additional information on EMC for pathogens including *E. coli* and enterococci see (USEPA, 2019d).

Table 4. Lower Charles River Basin Stormwater Event Mean Indicator Bacteria Concentrations*

FC EMC = Fecal Coliform Event Mean Concentration. SWQS = Massachusetts Surface Water Quality Standards. CFU = Colony Forming Units.

Land Use Category	FC EMC (CFU/100 mL)	No. Events	Pre-2007 [1] Class B SWQS	Reduction to Meet Pre-2007 SWQS (CFU/100mL, %)
Single Family Residential	2,800 – 94,000	8	10% of the samples shall not exceed 400 organisms/ 100 mL	2,400 – 93,600 (85.7 – 99.6)
Multifamily Residential	2,200 – 31,000	8		1,800 – 30,600 (81.8 – 98.8)
Commercial	680 – 28,000	8		280 – 27,600 (41.2 - 98.6)

[1] This table was developed under the previous Class B Standard (revised in 2006 and approved by USEPA in 2007): Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall more than 10% of the samples exceed 400 organisms. The number 400 was used to illustrate required reductions in the "Reduction to Meet SWQS (%)" Column.

*Note: data summarized from (USGS, Measured and Simulated Runoff to the Lower Charles River, Massachusetts, October 1999 - September 2000, 2002).

Table 5. Stormwater Event Mean Fecal Coliform Concentrations, as reported in (MassDEP, 2002); original data provided in (Metcalf and Eddy, 1991)

FC EMC = Fecal Coliform Event Mean Concentration. SWQS = Surface Water Quality Standards. CFU = Colony Forming Units.

Land Use Category	FC EMC[1] (CFU/100 mL)	Pre-2007 Class B SWQS[2]	Reduction to Meet Pre-2007 SWQS (CFU/100mL, %)
Single Family Residential	37,000	10% of the samples shall not exceed 400 organisms/ 100 mL	36,600 (98.9)
Multifamily Residential	17,000		16,600 (97.6)
Commercial	16,000		15,600 (97.5)
Industrial	14,000		13,600 (97.1)

[1] Derived from Nationwide Urban Runoff Program (NURP) study event mean concentrations and nationwide pollutant buildup data (USEPA, 1983).
[2] This table was developed under the previous Class B Standard (revised in 2006 and approved by USEPA in 2007): Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall more than 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions in the "Reduction to Meet SWQS (%)" Column.

3.2.2. Septic Systems

Septic systems designed, installed, operated, and maintained in accordance with Massachusetts 310 CMR 15.000 (Title 5) are not significant sources of pathogens. Studies demonstrate that wastewater located four feet below properly functioning septic systems contain, on average, less than one fecal coliform indicator bacteria organism per 100 mL due to effective filtration and adsorption through the leach field and underlying natural soils (Ayres Associates, 1993). However, failed or non-conforming septic systems, such as cesspools, can be a major contributor of pathogens to Massachusetts' waterbodies. Wastes from failing septic systems enter surface waters either as direct overland flow or via groundwater. Wet weather events typically increase the rate of transport of pollutant loadings from failing septic systems to surface waters because of the wash-off effect from runoff and the increased rate of groundwater recharge.

3.2.3. Pet Waste

In residential areas, household pets such as cats and dogs can be a significant source of pathogens. Depending on the size of the dog, research has found that daily fecal production was between 7.6 and 52 grams per day and from 3 million to 8.8 billion enterococci colony-forming units (CFU) per fecal event (Wright, Solo-Gabriele, Elmir, & Fleming, 2009). Based on loading estimates to a Florida beach, one dog fecal event was equivalent to fecal shedding from 7,000 adult swimmers or bird fecal events and was the largest source of enterococci to recreational waters (Wright, Solo-Gabriele, Elmir, & Fleming, 2009). If pet waste is not properly discarded, then pathogens from the waste can wash off the land under wet weather conditions and transported to surface waters. Pet waste can also enter surface waters by direct deposition of fecal matter from pets standing or swimming in surface waters (USEPA, 2001).

3.2.4. Wildlife Waste

Fecal matter from wildlife may be a significant source of pathogens in some watersheds. This is particularly true when human activities, including the feeding of wildlife and habitat modification, result in the congregation of wildlife. Geese, gulls, and ducks represent a major pathogen source, particularly at lakes and stormwater ponds where large resident populations have become established and their waste is deposited directly into surface waters (CWP, 1999). Birds were found to produce 100 million *E. coli* and enterococci colonies per day per bird in the Great Lakes area and to be one of the dominant sources of fecal indicator bacteria to those waters (Haack, Fogarty, & Wright, 2003).

Wildlife waste deposited on land can also be washed off and transported to surface waters by stormwater runoff. Roads and drainage structures that expedite the transport of natural sources of pathogens to surface waters may exacerbate the impact of these sources on water quality. Municipalities regulated under the MS4 permit are now required to establish procedures that address waterfowl congregation in problem areas by year 2 of the effective date of the permit.

Certain types of infrastructure may also attract large numbers of wildlife and result in higher pathogen loading to surface waters. For example, in Bellingham, MA, large numbers of pigeons were found congregating under a bridge over the pathogen-impaired Peters River (MA51-18). Fecal indicator bacteria concentrations upstream of the bridge were consistently lower than those downstream, suggesting that the birds may have been a significant source of indicator bacteria to this segment (MassDEP, 2010).

3.2.5. Agriculture

Agricultural activities include dairy farming, raising livestock and poultry, growing crops, and keeping horses and other animals for pleasure or profit. Activities and facilities associated with agricultural land use can be sources of pathogens to surface waters. Communities, farmers, horse owners, and others who confine animals are largely responsible for mitigating fecal pollutants. Direct deposition of fecal matter from farm animals standing or swimming in surface waters and the runoff of farm animal waste from land surfaces are considered the primary mechanisms for agricultural pollutants in surface waters. CAFOs are large agricultural facilities that are regulated as point source dischargers under the NPDES General Permit.

3.2.6. Recreation

The recreational use of waterbodies can be a source of pathogen contamination. Swimmers themselves may contribute to fecal contamination at swimming areas. When swimmers enter the water, residual fecal matter may be washed from the body and contaminate the water with pathogens. In addition, small children in diapers may contribute to contamination of the recreational waters. These sources are likely to be particularly important when the number of swimmers is high, and the flushing action of water currents is low.

4. Determination of Load Capacity

4.1. Definition of a TMDL

The Total Maximum Daily Load (TMDL) is the amount of a pollutant that a waterbody can assimilate without violating SWQS. Both point and nonpoint source pollutants are accounted for in a TMDL. USEPA regulations require that point source pollutants (i.e., discharges from discrete pipes or conveyances) subject to NPDES permits (including MassDEP's Surface Water Discharge permits) receive a waste load allocation (WLA) specifying the amount of a pollutant that can be released to the waterbody. Nonpoint source pollutants (i.e., all other diffuse sources of pollutants) receive load allocations (LA) specifying the amount of a pollutant that can be released to the waterbody. In the case of stormwater, it is often difficult to identify and distinguish between nonpoint source pollution and point source discharges that are subject to NPDES regulation.

Stormwater runoff within urbanized areas regulated by the General Stormwater Permit for MS4s is considered a point source. Stormwater is diverted, collected, and conveyed through a stormwater collection system to an outfall that discharges to a receiving water. Stormwater runoff outside of MS4 areas, or that flows directly to surface water, is considered a nonpoint source of pollutants. Permitted stormwater runoff is accounted for in the WLA of the TMDL, while non-permitted runoff is accounted for in the LA of the TMDL.

In accordance with the federal CWA, a TMDL must also account for seasonal variations and include a margin of safety (MOS) to account for uncertainty in loading capacity.

In equation form, a TMDL is expressed as follows:

$$\mathbf{TMDL = \sum WLA + \sum LA + MOS}$$

where:

∑ ***WLA*** *= sum of Waste Load Allocations, or point sources including NPDES-regulated stormwater.*

∑ ***LA*** *= sum of Load Allocations, or natural background, nonpoint sources, and stormwater not regulated by NPDES.*

MOS *= Margin of Safety.*

TMDLs can be expressed in terms of mass per unit of time (i.e., daily load), concentration, or other appropriate measures (40 CFR Part 103.2(i)). The WLA and LA both need to account for existing and future loads. This TMDL consists of two types of targets for allowable levels of indicator bacteria:

- Concentrations of indicator bacteria (expressed as bacteria counts/100mL of water), and
- Loads of indicator bacteria (expressed as numbers of bacteria/day).

The stated goal of the TMDL is to meet SWQS at the point of discharge for all the river segments in this report. Both targets are designed to meet the designated Primary Contact Recreation and Shellfishing uses by ensuring that indicator bacteria criteria in the Massachusetts SWQS will be attained. Both targets in this TMDL are considered by MassDEP to be daily targets.

4.2. Pollutant Load Allocations

This TMDL includes two types of pathogen TMDL targets: concentration and numerical load. Expressing a TMDL in terms of indicator bacteria concentrations based on criteria in the SWQS, as provided in Table 6, provides a clear and understandable expression of water quality goals. Concentration targets for indicator bacteria are also the primary guide for implementation (see Section 5). The concentration-based TMDL is a useful format for guiding both remediation and protection efforts in the watersheds. A concentration target allows interested stakeholders to readily determine (through monitoring) whether a source is exceeding its allocation.

As required under the federal CWA, the TMDL is also expressed in terms of indicator bacteria daily load or the number of organisms per day (CFU/day). The load varies with flow over the course of the day and season and can be very large (billions or trillions of indicator bacteria per day) and thus more difficult to understand and interpret and not directly comparable to WQC (expressed as concentrations). Section 4.2.2 contains the table, figure, and equations that express the TMDLs as daily loads in terms of numbers of organisms per day.

4.2.1. Concentration-Based Waste Load Allocations and Load Allocations

Table 6 presents the TMDL indicator bacteria WLAs and LAs as daily concentration targets for the various pathogen source categories applicable to surface waters in this TMDL report.

Runoff from impervious cover is likely to flow to receiving waters through a stormwater collection system. For prohibited point sources, including illicit discharges to stormwater systems and SSOs, the WLA is zero, which corresponds to complete elimination, or 100% reduction. The goal for controlling CSOs is meeting the WQC through implementation of approved LTCPs. LAs apply to all nonpoint sources of pathogens (including stormwater runoff from pervious land cover types or runoff from non-regulated impervious areas) and are equal to the WQC applicable to each segment.

These concentration targets can be used to guide implementation. The goal to attain applicable criteria established in the Massachusetts SWQS at the point of discharge is protective of designated uses and offers a practical means to identify and evaluate the effectiveness of control measures. In addition, this approach establishes clear objectives that can be easily understood by the public and others responsible for monitoring activities. Success of the control efforts and subsequent conformance with the TMDL can be determined by documenting that samples collected from the receiving waters meet the appropriate WQC for the waterbody.

Table 6. Concentration-Based Waste Load Allocations (WLAs) and Load Allocations (LAs)

Class	Indicator Bacteria Concentration-Based Load	Waste Load Allocation Pathogen Sources	Load Allocation Pathogen Sources
A, B, SA, & SB (prohibited)	0 (No load allocation)	Illicit discharges to storm drains	*Not Applicable*
		Leaking sanitary sewer lines, SSOs	*Not Applicable*
		Not Applicable	Failing septic systems
A & B for Primary Contact Recreation designated use	*E. coli* geomean[5] ≤ 126 CFU/100 mL; and no more than 10% of samples ≥ 410 CFU/100 mL (STV)[6];	Any regulated discharge, including stormwater runoff[1] subject to MS4 NPDES permits, NPDES wastewater treatment plant discharges[2,3], and combined storm sewer overflows[4].	Nonpoint source stormwater runoff[1]
	Enterococci geomean[5] ≤ 35 CFU/100 mL; no more than 10% of samples ≥ 130 CFU/100 mL (STV)[6]		
SA & SB for Primary Contact Recreation designated use	Enterococci geomean[5] ≤ 35 CFU/100 mL; no more than 10% of samples ≥ 130 CFU/100 mL (STV)[6]		
SA for Shellfishing designated use	Fecal coliform geomean[5] ≤ 14 MPN/100 mL; Statistical Threshold Value; no more than 10% of samples ≥ 28 MPN/100 mL		
SB for Shellfishing designated use	Fecal coliform median or geomean[5] ≤ 88 MPN/100 mL; and no more than 10% of samples ≥ 260 MPN/100 mL (STV)[6]		

[1] WLAs and LAs for stormwater discharges will be achieved through the implementation of structural and non-structural BMPs, source reduction, and other controls to the Maximum Extent Practicable.

[2] Or shall be consistent with the Wastewater Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

[3] Seasonal disinfection may be allowed by the MassDEP on a case-by-case basis.

[4] Or other applicable SWQS for CSOs.

[5] Geometric mean is calculated using sample results within a rolling 30-day period at bathing beaches during bathing season (April 1 to October 15). The 30-day rolling period applies year-round to CSO-discharge and POTW-impacted waters. For all other waters and at beaches during the non-bathing season, the geometric mean is calculated using samples collected within a rolling 90-day period.

[6] Statistical Threshold Value, STV. If <10 samples collected, no samples shall exceed 410 CFU/100 mL for *E.coli*, 130 CFU/100 mL for enterococci, and 260 MPN/100 mL for Fecal coliform.

Note: this table represents waste load and load allocations based on the current SWQS as of the publication date. If the pathogen criteria change in the future, MassDEP intends to revise the TMDL by addendum to reflect the revised criteria.

4.2.2. Load-Based Waste Load Allocations and Load Allocations

Although water quality criteria for pathogens are expressed as concentrations in the SWQS (and the target for restoration of the waterbody is the criterion), it is possible to evaluate pollutant loading in terms of the total number of indicator bacteria per day in a waterbody. For rivers, this means multiplying the volume of water that flows through the river per day by the concentration of observed indicator bacteria. For coastal and marine waterbodies, the numerical loading is calculated by multiplying the daily runoff volume to the waterbody by the concentration of indicator bacteria in that runoff.

Flow is highly variable depending on precipitation, season, snowmelt, and other factors. The U.S. Geological Survey (USGS) maintains a system of stream gages to measure flow, though not every river segment has a stream gage and estimates are often required. To estimate the flow for an ungaged location or segment, flows at a gage in the watershed or nearby watershed can be weighted based on drainage area. The USGS StreamStats web-based application can also be used to estimate flow statistics at ungaged sites (USGS, n.d.).

Similar to the most severe hydrologic condition at which the WQC must be applied as outlined in the Massachusetts SWQS (314 CMR 4.03(3) *Hydrologic Conditions*), the pathogen TMDL is expressed in terms of the criteria for the indicator bacteria proportional to flow for days in which flow exceeds 7Q10 conditions.

Example calculations for determining pathogen TMDLs for rivers using the load-based approach. The TMDL associated with each 1.0 cubic foot per second (cfs) of flow to meet WQC of 126 CFU/100 mL (*E. coli*, Class A or B) or 35 CFU/100 mL (enterococci, Class A or B) is derived as follows:

$$TMDL\left(\frac{10^9\,\mathrm{CFU}}{\mathrm{day}}\right) = Flow\left(\frac{ft^3}{\mathrm{sec}}\right) \times \mathrm{WQC}\left(\frac{\mathrm{CFU}}{100\mathrm{mL}}\right) \times 86{,}400\left(\frac{\mathrm{sec}}{\mathrm{day}}\right) \times 10\left(\frac{100\mathrm{mL}}{\mathrm{L}}\right) \times 28.3168\left(\frac{\mathrm{L}}{\mathrm{ft}^3}\right) \div 10^9$$

Figure 3 and Table 7 illustrate the allowable indicator bacteria daily load in CFU/day at various flows in cubic feet per second (cfs) for two WQC concentrations: the geometric mean for *E. coli* (126 CFU/100 mL) and the geometric mean for enterococci (35 CFU/100 mL). For river segments, the WLA is the daily load from allowable regulated sources and the LA is the daily load from allowable nonpoint sources. The TMDL is proportioned between the WLA and LA by multiplying the daily load by the percent impervious of the contributing watershed for the WLA, and the remaining load is assigned to the LA. The TMDLs for each pathogen impaired segment are provided in the appendices.

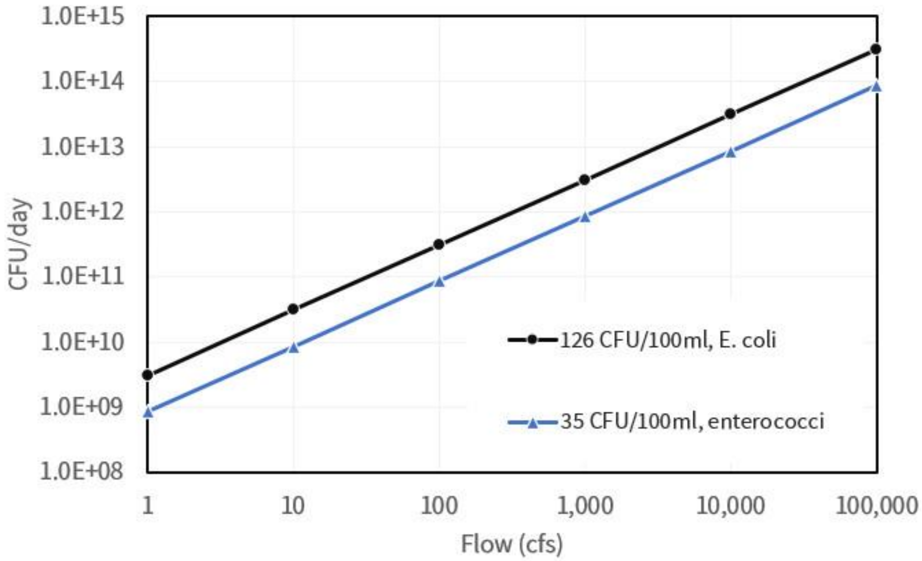

Figure 3. Total Maximum Daily Load (TMDL) by river flow for indicator bacteria

Table 7. Total Maximum Daily Load (TMDL) by river flow for *E. coli* and enterococci.

The surface water quality standard is the geometric mean of 126 CFU/100mL for E. coli and 35 CFU/100mL for enterococci. TMDL = Load Allocation (LA) + Waste Load Allocation (WLA) + Margin of Safety (MOS). MOS is implicit or zero.

Flow (cfs)	*E. coli* TMDL (10^9 CFU/100mL)	Enterococci TMDL (10^9 CFU/100mL)
1	3	1
10	31	9
100	308	86
1,000	3,083	856
10,000	30,827	8,563
100,000	308,269	85,630

mL: milliliter; cfs: cubic feet per second; CFU: colony-forming unit

Example calculations for determining pathogen TMDLs for estuaries/embayments using the load-based approach. For marine waterbodies, total maximum daily pathogen loads are typically calculated based on long-term average runoff volumes. The numerical TMDL is calculated by multiplying the average daily runoff volume to the waterbody by the concentration of indicator bacteria in that runoff. The approach differs from rivers in how the runoff volume is calculated and includes two methods depending on the location of the impaired coastal waterbody. **For segments located on Cape Cod and the Islands basins, groundwatersheds are used, and for all other segments, surface water drainage areas (i.e., watersheds) are used**. Note that some segments located on Cape Cod's western side drain to Buzzards Bay and are included in that appendix, using the groundwatershed as the basis for TMDL development.

An average daily runoff volume from the Cape Cod and Islands watersheds (including eastern Buzzards Bay) was determined according to the methodology used most recently in the *Final Pathogen TMDL for the Islands Watershed* (MassDEP, 2020a). The waterbodies in these basins are in areas of coarse and highly transmissive soils, where rain and runoff from impervious areas (IA) rapidly infiltrate into the ground, and overland surface runoff is negligible. In these waterbodies, groundwatersheds (or groundwater-controlled watersheds) determine flow to the assessment unit waterbody and have been mapped by MassDEP or USGS.

For the purposes of this TMDL, in the Cape Cod and Islands watersheds, all rainfall to impervious areas within a 200-foot buffer around the waterbody is assumed to directly enter the waterbody as runoff. In areas outside the 200-foot buffer, all precipitation is assumed to infiltrate into the ground, including precipitation to impervious areas which rapidly infiltrate into adjacent soils. Pervious areas within the 200-foot buffer are also assumed to generate zero runoff to the waterbody. Average annual rainfall to this region is 45 inches per year based on precipitation recorded from 1941 to 1995 (Walter & Whealan, 2005), and average daily rainfall is 45 inches/365 days per year (or 0.123 inches/day). Due to the assumption that there is no nonpoint source pathogen pollution, the LA is set as zero for both fresh water streams and coastal and marine waterbodies located in Cape Cod or the Islands watersheds. The margin of safety is implicit, due to conservative assumptions (see Section 4.3). **Thus, the total maximum annual load of pathogens to the Cape Cod/Island coastal and marine waterbodies is represented by the following equation:**

$$TMAL\left(\frac{10^9\mathrm{CFU}}{\mathrm{year}}\right) = IA\ in\ 200\ ft\ Buffer\ (ft^2)\ \times 144\left(\frac{in^2}{ft^2}\right) \times 45\ \left(\frac{in}{year}\right) \times\ \mathrm{WQC}\left(\frac{\mathrm{CFU}}{100\mathrm{mL}}\right) \times 10\left(\frac{100\mathrm{mL}}{\mathrm{L}}\right) \times 0.0164\left(\frac{\mathrm{L}}{in^3}\right)\ \div 10^9$$

Dividing the total maximum annual load by the number of days per year, the numerical TMDL for the Cape Cod and Islands waterbodies is therefore:

$$TMDL\left(\frac{10^9\mathrm{CFU}}{\mathrm{day}}\right) = TMAL\left(\frac{10^9\mathrm{CFU}}{\mathrm{year}}\right) \div 365$$

Flows to the waterbody from each groundwatershed are multiplied by the SWQS indicator bacteria concentration to determine the waterbody's TMDL in numeric format. For TMDL waterbodies not located on Cape Cod and not in the Islands basin, surface watersheds are used.

For all other coastal and marine impaired segments, average annual flow to the impaired segment is determined by the methodology used in the pathogen TMDLs for Buzzards Bay, South Coast, and North Coast watersheds (MassDEP, 2009; MassDEP, 2012; MassDEP, 2014) and described in detail most recently in the *Pathogen TMDL for Boston Harbor, Weymouth-Weir, and Mystic Watersheds* (MassDEP, 2018b).

Average annual precipitation in coastal watersheds in this TMDL is determined to be 45.7 inches per year. All precipitation to impervious areas (45.7 inches per year of runoff) is assumed to enter waterways and ultimately the impaired segment. In pervious areas, 24.0 inches per year of runoff is assumed to enter the impaired waterbody, based on a long term (1905-2007) 50th percentile value from USGS gages in New England. The impervious and pervious land area in each watershed is thus multiplied by 45.7 and 24.0 inches of runoff, respectively, to get the total volume of runoff to each impaired segment. The runoff volume is then multiplied by the most stringent indicator bacteria concentration to get the maximum allowable number of indicator bacteria per year for that waterbody. Daily load is determined by dividing by 365 days in a year (updated from 105 days used in the pathogen TMDLs cited above).

The margin of safety is implicit, due to conservative assumptions (see Section 4.3). Runoff from impervious areas make up the WLA, and runoff from pervious areas are the LA. **Thus, the total maximum annual load of pathogens to coastal and marine waterbodies (excluding Cape Cod/Islands) is represented by the following equation:**

$$TMAL\left(\frac{10^9\mathrm{CFU}}{\mathrm{year}}\right)$$
$$= Annual\ WLA\ [IA\ (ft^2)\ \times 144\left(\frac{in^2}{ft^2}\right)\times 45.7\ \left(\frac{in}{year}\right)\times\ \mathrm{WQC}\left(\frac{\mathrm{CFU}}{100\mathrm{mL}}\right)\times 10\left(\frac{100\mathrm{mL}}{\mathrm{L}}\right)$$
$$\times 0.0164\left(\frac{\mathrm{L}}{in^3}\right)\ \div 10^9]$$
$$+\ Annual\ LA\ [PA\ (ft^2)\ \times 144\left(\frac{in^2}{ft^2}\right)\times 24\ \left(\frac{in}{year}\right)\times\ \mathrm{WQC}\left(\frac{\mathrm{CFU}}{100\mathrm{mL}}\right)\times 10\left(\frac{100\mathrm{mL}}{\mathrm{L}}\right)$$
$$\times 0.0164\left(\frac{\mathrm{L}}{in^3}\right)\ \div 10^9]$$

Dividing the annual load by the total number of days in the year (365), the numerical TMDL for marine segments, excluding those in the Cape Cod and Islands basins, is therefore:

$$TMDL\left(\frac{10^9\mathrm{CFU}}{\mathrm{day}}\right) = TMAL\left(\frac{10^9\mathrm{CFU}}{\mathrm{year}}\right)\div 365$$

4.2.3. Application of the TMDL to Unimpaired or Currently Unassessed Segments

This TMDL report includes 212 TMDLs for *E. coli*, 18 TMDLs for fecal coliform, and 228 TMDLs for enterococcus for 228 pathogen-impaired segments on the 2018/2020 CWA § 303(d) list of impaired waters in the Commonwealth of Massachusetts. MassDEP recommends that the information contained in this TMDL report be used to guide management activities and maintain and protect existing water quality for all other waters in the Commonwealth, even if not included on the CWA § 303(d) list. The analyses conducted for the pathogen-impaired segments in this TMDL report also apply to the non-impaired segments since the potential sources and their characteristics are equivalent.

The concentration-based WLAs and/or LAs for each source and designated use are the same as specified herein. Therefore, the pollutant prevention TMDLs have identical WLAs and LAs based on the sources present and the designated uses of the waterbody segment (see Table 6). All discharges will need to be compliant with the applicable WLAs, as well as the antidegradation provisions of the SWQS (314 CMR 4.04). Any new construction that complies with State stormwater standards and permits is presumed to comply with the antidegradation requirements.

This TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and considering all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines, with USEPA approval, that this TMDL report should apply to future pathogen-impaired segments. This process will require the same type of information on the additional impaired waterbodies and their TMDLs as is contained in the appendices to this report. Newly-impaired segments will be provided to the public for review and comment and included as an addendum to the TMDL core report and appropriate appendix.

4.3. Margin of Safety

The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). The concentration-based TMDLs contain an implicit MOS by using the following conservative assumptions during the analysis: The TMDLs are set equal to the appropriate criterion for each waterbody segment and include the goal of meeting indicator bacteria criteria at the point of discharge for all sources. This means the TMDLs do not rely on dilution in the waterbody to meet the criterion. In addition, the TMDLs do not rely on in-stream processes such as bacteria die-off and settling, which are known to reduce in-stream indicator bacteria concentrations. Consequently, the concentration-based TMDLs represent conservative TMDL target-setting, so there is a high level of confidence that the TMDLs established are consistent with the criteria in the SWQS, and the entire loading capacity can be allocated among sources. For these reasons, the MOS is implicit, and the explicit MOS shown in the general TMDL formula above is equal to zero. For compliance with this TMDL, ambient water quality will be considered at the point of discharge.

Margin of Safety with regard to Climate Change: While the general vulnerabilities of inland and coastal areas to climate change can be identified, specific impacts and effects of changing conditions are not well known at this time, as described in the *Massachusetts Climate Change Adaptation Report* (EEA, 2011). Because the science is not yet available, MassDEP is unable to analyze climate change impacts on streamflow, precipitation, and pathogen loading with any degree of certainty for TMDL development. These uncertainties and informational gaps further support an implicit MOS. MassDEP does not believe that an explicit MOS approach is appropriate under the circumstances or will provide a more protective or accurate MOS than the implicit MOS approach, as the available data simply do not lend themselves to characterizing and estimating loadings to derive numeric allocations within confidence limits. Although the implicit MOS approach does not expressly set aside a specific portion of the load to account for potential impacts of climate change, MassDEP has no basis to conclude that the conservative assumptions that were used to develop the numeric model applications are insufficient to account for the lack of knowledge regarding climate change.

4.4. Estimating Indicator Bacteria Reductions to Meet SWQS

Required TMDL reductions were calculated using available indicator bacteria data (2005-2019). Methods were consistent with the Massachusetts SWQS and USEPA guidelines for statistical analysis of indicator bacteria data (USEPA, 2012b; MassDEP, 2021a). Massachusetts uses the geometric mean of enterococci and *E. coli* indicator bacteria data to assess the Primary Contact Recreation designated use, and the geometric mean of fecal coliform indicator bacteria for the Shellfishing designated use, and comparison to the applicable STV to determine compliance with SWQS (as described in Section 2).

Geometric means of indicator bacteria data from 2005-2019 were calculated using the appropriate rolling 30- or 90-day period for all sampling stations in the impaired segments, which would include the Primary Contact Recreation designated use and, where applicable, the Shellfishing designated use. For impaired segments with multiple sampling stations, the sampling station with the highest geometric mean relative to the applicable criterion was used to calculate a percent reduction needed for that segment to attain applicable criteria established in the Massachusetts SWQS. These TMDL reductions provide a rough estimation of the pollutant abatement action needed for each segment to meet SWQS. For example, if the highest geometric mean from a Class A segment impaired for *E. coli* is 500 CFU/100 mL and the geometric mean water quality criterion is 126 CFU/100 mL, the percent reduction needed to meet the geometric mean criterion is calculated as follows:

Example: Initial percent reduction = [(500 – 126) / 500] x 100 = 75% reduction

The result of this analysis for each impaired segment is provided in the appendices. The reductions necessary to achieve the TMDLs are based on estimates of current indicator bacteria concentrations. Future development activities and land use changes have the potential to increase levels of indicator bacteria or stormwater runoff associated with pollutants. These future activities will need to meet the TMDLs and be addressed in applicable watershed management plans and by state or local requirements.

4.5. Seasonal Variability

TMDLs must also account for seasonal variability. Pathogen inputs to Massachusetts' surface waters include a mix of dry- and wet-weather sources, and there may be no single critical seasonal or climatic condition that is protective for all other conditions. This TMDL has set WLAs and LAs for all known and suspected source categories equal to the Massachusetts SWQS independent of seasonal and climatic conditions. This will ensure the attainment of applicable criteria established in the Massachusetts SWQS regardless of seasonal and climatic conditions.

5. Implementation

Implementing measures to meet TMDLs require an iterative process, with realistic goals over a reasonable timeframe, and adjusted as warranted based on ongoing monitoring. A comprehensive control strategy is needed to address the numerous and diverse sources of pathogens in the impaired segments of this TMDL.

Controls on several types of pathogen sources are required as part of a comprehensive management strategy. Sources like sewer connections to drainage systems, leaking sewer pipes, SSOs, and failing septic systems are prohibited and must be eliminated. Individual sources must be first identified in the field before they can be abated. Pinpointing sources typically requires extensive monitoring of the receiving waters and upstream stormwater systems under both dry and wet weather conditions. A comprehensive program is needed to ensure illicit sources are identified and that appropriate actions will be taken to eliminate them. MassDEP, USEPA, municipalities, watershed associations, and other stakeholder groups have been successful in carrying out such monitoring, identifying sources, and, in some cases, mobilizing the responsible municipality and other entities to take corrective actions, largely through the MS4 General Permit program, which requires minimal control measures to identify and eliminate illicit discharges. Progress toward finding and eliminating illicit discharges can be followed in the annual municipal MS4 reports.

CSOs and stormwater runoff represent major sources of pathogens to the Commonwealth's rivers, and the current level of control is inadequate for applicable criteria established in the Massachusetts SWQS to be attained. Improving stormwater runoff quality is essential for restoring water quality and recreational uses. At a minimum and as required under the MS4 General Permit for applicable Phase I and Phase II communities, intensive application of non-structural BMPs is needed throughout Massachusetts to reduce pathogen loadings as well as loadings of other stormwater pollutants (e.g., nutrients and sediment) contributing to use impairment in Massachusetts' waterbodies. Depending on the degree of success of the non-structural stormwater BMP program, structural controls may become necessary.

The "*Mitigation Measures to Address Pathogen Pollution in Surface Waters: A TMDL Implementation Guidance Manual for Massachusetts*" (ENSR, 2005) was developed to support implementation of pathogen TMDLs. TMDL implementation-related tasks are shown in Table 8. MassDEP, working with USEPA and other team partners, shall make every reasonable effort to assure implementation of this TMDL. These stakeholders can provide valuable assistance in defining hotspots and sources of pathogen contamination, as well as the implementation of mitigative or preventative measures.

5.1. Segment Prioritization for Implementation Activities

In this TMDL report, each pathogen-impaired segment was assigned a priority level of High, Medium, or Low for pollutant reduction activities (Table 8). Activities to reduce pathogen sources include source tracking to identify the location of pollutants (CWP, 2004), as well as stepwise implementation of structural and non-structural BMPs that reduce or eliminate pollutant sources.

Prioritization was based on indicator bacteria concentrations, suspected illicit discharges due to dry weather exceedances (refer to Section 5.1.1) or to the presence of CSOs or POTWs, proximity to sensitive environmental areas or public bathing beaches, and high risk for concentrated stormwater runoff from MS4-regulated areas. Regardless of priority, river segments included in this TMDL are listed as impaired for indicator bacteria on the 2018/2020 Integrated List of Waters and will all require remediation.

Since limited pollutant source information and data were available for each impaired segment, a simple scheme was used to prioritize segments based on the highest indicator bacteria concentrations observed. Data for each segment are summarized in the appendices. High priority was assigned to those segments where dry or wet weather concentrations (regardless of the specific indicator bacteria, refer to Section 5.1.1) were equal to or greater than 10,000 CFU/100 mL, as such high levels generally indicate a direct sanitary source. Medium priority was assigned to segments where concentrations ranged from 1,000 to 9,999 CFU/100mL since this range of concentrations generally indicates a direct sewage source that may get diluted in the conveyance system. Low priority was assigned to segments where observed concentrations were less than 1,000 CFU/100 mL.

For segments with maximum indicator bacteria concentrations during dry weather, sources such as permitted discharges, failing septic systems, illicit sanitary sewers connected to storm drains, and/or leaking sewers may be the primary contributors. Bacteria source tracking during dry weather is usually more straightforward and successful than tracking wet weather sources, and when successful, can dramatically reduce pathogen levels in surface waters. Due to the public health risk that raw sewage in surface waters poses, plus the greater likelihood of success in tracking and eliminating these illicit connections, maximum indicator bacteria concentrations that occurred during dry weather were assigned higher priority.

When maximum indicator bacteria concentrations occurred during wet weather, potential sources may include inundated septic systems, surcharging sewers (e.g., CSOs or SSOs), and/or stormwater runoff. In urban areas, sources of elevated indicator bacteria concentrations can include runoff in areas with high populations of domestic animals or pets. Other potential sources include sanitary sewers connected to storm drains that result in flow that is delayed until the storm drain is flushed during wet weather. Segments with elevated indicator bacteria concentrations during wet weather should be evaluated for stormwater BMP implementation opportunities starting with less costly non-structural practices first (such as street sweeping, catch basin cleaning, and/or managerial approaches using local regulatory controls) and more expensive structural measures second. Additional study to identify the most cost efficient and effective technology would be required. All waterbody segments located in urbanized areas and therefore subject to the MS4 General Stormwater Permit are considered High Priority for the IDDE program and were adjusted higher in priority where the MS4 coverage area is greater than 10% in the segment watershed.

Segments were also assigned a high priority if there was a public swimming area present, regardless of the availability of indicator bacteria data. Prioritization was adjusted one level upward based on the presence of suspected illicit discharges (dry weather exceedances), and/or CSO or POTW discharge(s). Prioritization was also adjusted upward based on proximity to sensitive environmental areas (e.g., Areas of Critical Environmental Concern, Cold Water habitats, Outstanding Resource Waters, public water supplies, and shellfishing) and areas at high risk for concentrated stormwater runoff from MS4-regulated areas (i.e., the MS4 area represents 10% or greater of the contributing watershed). Segments that satisfy more than one of these criteria were adjusted upward one priority level.

In some cases, the impairment was not based on indicator bacteria data, but on administrative decisions (e.g., shellfish bed closures, beach closures, receiving water for NPDES discharges, etc.). As stated above, in segments with a public swimming area, high priority was assigned. In segments with one or more sensitive areas (as described above) located within the proximal segment watershed, the presence of POTW/CSO discharges, the suspected presence of illicit discharges, or an MS4-regulated area greater than 10% of the contributing watershed, medium priority was assigned. In segments where no sensitive environmental areas are present, then low priority was assigned. Regardless of priority, river and estuary segments included in this TMDL are listed as impaired for indicator bacteria on the 2018/2020 Integrated List of Waters and will all require remediation.

Table 8. Priority ranking for and potential pathogen sources to the pathogen impaired segments addressed in this TMDL.

The maximum single sample results for fecal indicator bacteria (*E. coli*, Enterococcus, or fecal coliform) were used to assign the priority for each segment (High ≥10,000 CFU/100mL, Medium = 1,000 to 9,999 CFU/100mL, Low <1,000 CFU/100mL). ND = no data available. Priority increased if dry weather condition on the day of maximum single sample occurrence (DRY/WET indicates a tie result under both conditions), proximal to sensitive areas such as Public Water Supplies (PWSs), Outstanding Resource Waters (ORWs), an Area of Critical Environmental Concern (ACEC) (whether the sensitive areas intersect the segment or the segment flows into a downstream watershed with more than 20% sensitive area coverage), if the waterbody has a Cold Water (CW) qualifier, and contains >10% MS4-regulated area in the segment watershed. High priority for presence of a bathing beach along the segment. These factors were used to determine the priority rank (High, Medium, or Low priority) for each segment. Potential pathogen sources include Publicly Owned Treatment Works (POTWs), Combined Sewer Overflows (CSOs), illicit discharges, urban stormwater runoff, septic systems, agriculture, pet waste, and wildlife waste.

Segment ID	Waterbody	Watershed Area (acres)	Percent MS4 Area in Watershed	Maximum Sample Parameter	Maximum Single Sample Result (CFU/100mL)	Wet/Dry	Cold Water	Proximal to Sensitive Area	Bathing Beach	Rank (H/M/L)	POTWs	CSOs	Illicit Discharges	Urban Stormwater	Septic Systems	Agriculture	Pet Waste	Wildlife Waste
Hoosic River Basin [Appendix A]																		
MA11-02	North Branch Hoosic River	27,928	5.40%	EC	380	DRY	X			M			X	X	X	X	X	X
MA11-03	Hoosic River	40,915	9.80%	EC	660	DRY	X			M			X	X	X	X	X	X
MA11-05	Hoosic River	131,152	8.00%	EC	2,200	DRY				H	X		X	X	X	X	X	X
Housatonic River Basin [Appendix B]																		
MA21-02	E. Branch Housatonic River	45,344	17.90%	EC	480	DRY		X		M			X	X	X	X	X	X
MA21-04	Housatonic River	109,022	17.50%	EC	536	WET		X		M	X		X	X	X	X	X	X
MA21-17	Southwest Branch Housatonic River	15,069	19.50%	EC	111,990	DRY	X	X		H			X	X	X	X	X	X
MA21-18	W. Branch Housatonic River	23,481	18.80%	EC	448	WET	X	X		M			X	X	X	X	X	X
Westfield River Basin [Appendix C]																		
MA32-04	Westfield River	108,159	0.00%	EC; FC	866; 120	WET; DRY	X	X	X	H			X	X	X	X	X	X
MA32-08	Little River	54,702	9.10%	EC; FC	2,420; 880	WET; WET	X			H			X	X	X	X	X	X
MA32-09	Powdermill Brook	12,542	64.50%	EC; FC	576; 290	WET; WET				M			X	X	X	X	X	X
MA32-22	Potash Brook	4,214	0.00%	EC; FC	2,420; 170	WET; WET	X			H			X	X	X	X	X	X
MA32-27	Miller Brook	320	90.90%	EC; FC	1,000; 1,340	DRY; DRY	X			H			X	X	X	X	X	X
MA32-28	White Brook	434	93.60%	EC; FC	576; 580	WET; WET	X			M			X	X	X	X	X	X
MA32-36	Little River	50,257	3.50%	EC; FC	2,420; 210	WET; WET	X	X		H			X	X	X	X	X	X
MA32-37	Ashley Brook	688	57.90%	EC	2,420	WET				H			X	X	X	X	X	X
MA32-39	Jacks Brook	1,853	32.30%	EC	2,420	WET		X		H			X	X	X	X	X	X
MA32-41	Moose Meadow Brook	5,207	0.10%	EC; FC	2,760; 6,040	WET; WET				M			X	X	X	X	X	X

Segment ID	Waterbody	Watershed Area (acres)	Percent MS4 Area in Watershed	Maximum Sample Parameter	Maximum Single Sample Result (CFU/100mL)	Wet/Dry	Cold Water	Proximal to Sensitive Area	Bathing Beach	Rank (H/M/L)	POTWs	CSOs	Illicit Discharges	Urban Stormwater	Septic Systems	Agriculture	Pet Waste	Wildlife Waste
Deerfield River Basin [Appendix D]																		
MA33-03	Deerfield River	365,497	0.10%	EC; FC	2,050; 2,800	DRY; DRY				H	X		X	X	X	X	X	X
MA33-04	Deerfield River	424,623	1.40%	EC; FC	2,910; 3,600	DRY; DRY				H	X		X	X	X	X	X	X
MA33-19	East Branch North River	34,691	0.00%	EC; FC	2,420; 630	DRY; DRY	X			H			X	X	X	X	X	X
MA33-21	Hinsdale Brook	3,426	1.60%	EC; FC	921; 1,100	DRY; DRY	X	X		M			X	X	X	X	X	X
MA33-30	Green River	57,144	8.80%	EC; FC	2,760; 3,300	DRY; DRY	X			H			X	X	X	X	X	X
MA33-101	South River	11,525	0.00%	EC; FC	921; 800	DRY; DRY	X			M			X	X	X	X	X	X
MA33-102	South River	16,832	0.00%	EC; FC	2,420; 1,600	DRY; DRY				H			X	X	X	X	X	X
Connecticut River Basin [Appendix E]																		
MA34-03	Connecticut River	4,609,991	1.40%	ND	ND	ND				M	X	X	X	X	X	X	X	X
MA34-04	Connecticut River	5,317,766	2.30%	EC	180	WET				M	X	X	X	X	X	X	X	X
MA34-05	Connecticut River	6,170,533	4.20%	EC	260	WET				M	X	X	X	X	X	X	X	X
MA34-07	Bachelor Brook	20,178	20.30%	EC	300	WET				M	X		X	X	X	X	X	X
MA34-11	Manhan River	91,611	18.10%	EC	1,200	WET		X		H	X		X	X	X	X	X	X
MA34-19	Stony Brook	14,635	54.70%	EC	970	DRY				M			X	X	X	X	X	X
MA34-21	Longmeadow Brook	3,372	100.00%	EC	4,000	WET				H			X	X	X	X	X	X
MA34-25	Mill River	19,225	19.50%	EC	440	WET				H			X	X	X	X	X	X
MA34-27	Fort River	35,055	21.70%	EC	1,500	WET				H			X	X	X	X	X	X
MA34-28	Mill River	34,814	9.10%	EC	2,900	WET				M			X	X	X	X	X	X
MA34-29	Mill River	21,581	90.00%	EC	4,000	WET				H		X	X	X	X	X	X	X
MA34-30	Scantic River	15,967	5.90%	EC	3,600	WET				M			X	X	X	X	X	X
MA34-36	Bloody Brook	3,618	33.90%	EC	960	WET				M			X	X	X	X	X	X
MA34-42	Buttery Brook	2,024	100.00%	EC	4,200	DRY				H			X	X	X	X	X	X
MA34-60	Unnamed Tributary	1,866	100.00%	EC	20,000	WET				H			X	X	X	X	X	X
Millers River Basin [Appendix F]																		
MA35-16	Keyup Brook	4,518	0.00%	EC; FC	270; 360	DRY; DRY				M			X	X	X	X	X	X
Chicopee River Basin [Appendix G]																		
MA36-05	Ware River	106,111	1.80%	EC	900	DRY		X		M	X		X	X	X	X	X	X
MA36-06	Ware River	137,373	4.10%	EC	1,050	DRY		X		H	X		X	X	X	X	X	X
MA36-08	Prince River	8,970	0.00%	EC	800	DRY	X	X		M			X	X	X	X	X	X
MA36-11	Sevenmile River	20,184	15.10%	EC	1,360	WET				H			X	X	X	X	X	X
MA36-12	Sevenmile River	26,378	15.00%	EC	1,440	WET				H	X		X	X	X	X	X	X
MA36-15	Quaboag River	93,842	11.10%	EC	2,420	DRY				H	X		X	X	X	X	X	X

Segment ID	Waterbody	Watershed Area (acres)	Percent MS4 Area in Watershed	Maximum Sample Parameter	Maximum Single Sample Result (CFU/100mL)	Wet/Dry	Cold Water	Proximal to Sensitive Area	Bathing Beach	Rank (H/M/L)	POTWs	CSOs	Illicit Discharges	Urban Stormwater	Septic Systems	Agriculture	Pet Waste	Wildlife Waste
MA36-16	Quaboag River	115,178	9.80%	EC	800	DRY				M	X		X	X	X	X	X	X
MA36-17	Quaboag River	135,813	11.80%	EC	830	WET		X		M	X		X	X	X	X	X	X
MA36-18	Forget-Me-Not Brook	798	48.80%	EC	620	DRY	X			M			X	X	X	X	X	X
MA36-21	Chicopee Brook	15,375	6.60%	EC	800	WET	X			M			X	X	X	X	X	X
MA36-22	Chicopee River	424,521	6.60%	EC	900	DRY		X		M	X	X	X	X	X	X	X	X
MA36-24	Chicopee River	457,169	10.50%	EC	510	WET		X		M	X	X	X	X	X	X	X	X
MA36-25	Chicopee River	462,582	11.50%	EC	890	WET				M	X	X	X	X	X	X	X	X
MA36-39	Unnamed Tributary	1,074	100.00%	EC	200	DRY		X		M			X	X	X	X	X	X
MA36-40	Abbey Brook	843	100.00%	-	ND	-		X		H			X	X	X		X	X
MA36-41	Fuller Brook	7,124	49.10%	-	ND	-		X		M			X	X	X	X	X	X
MA36-50	Danforth Brook	3,490	0.00%	EC	800	WET		X		L			X	X	X	X	X	X
Quinebaug River Basin [Appendix H]																		
MA41-03	Quinebaug River	93,943	11.30%	EC	980	DRY				M	X		X	X	X	X	X	X
MA41-04	Quinebaug River	96,297	11.30%	EC	2,420	WET				H	X		X	X	X	X	X	X
MA41-06	Cady Brook	7,846	28.00%	EC	1,990	WET				H	X		X	X	X	X	X	X
MA41-12	Cohasse Brook	2,609	18.00%	-	ND	-		X		L			X	X	X	X	X	X
MA41-13	Mckinstry Brook	5,129	13.60%	-	ND	-				L			X	X	X	X	X	X
MA41-16	Unnamed Tributary	3,915	0.00%	-	ND	-				L			X	X	X	X	X	X
MA41-17	West Brook	907	0.00%	EC	816	WET				L			X	X	X	X	X	X
French River Basin [Appendix I]																		
MA42-07	Burncoat Brook	2,868	96.70%	-	ND	-				M			X	X	X	X	X	X
MA42-11	Wellington Brook	2,303	49.10%	EC	866	DRY				M			X	X	X	X	X	X
MA42-15	Sucker Brook	1,644	8.50%	-	ND	-				L			X	X	X	X	X	X
MA42-18	Grindstone Brook	1,905	33.10%	-	ND	-				L			X	X	X	X	X	X
Blackstone River Basin [Appendix J]																		
MA51-01	Kettle Brook	19,433	50.50%	EC	2,420	WET		X		H			X	X	X	X	X	X
MA51-02	Middle River	32,143	59.70%	EC	1,410	DRY				H			X	X	X	X	X	X
MA51-03	Blackstone River	86,589	76.30%	EC	4,400	WET				H	X	X	X	X	X	X	X	X
MA51-04	Blackstone River	94,167	76.40%	EC	10,000	WET				H	X		X	X	X	X	X	X
MA51-05	Blackstone River	167,753	57.60%	EC	12,000	WET				H	X		X	X	X	X	X	X
MA51-06	Blackstone River	232,043	47.50%	EC	5,400	WET				H	X		X	X	X	X	X	X
MA51-07	Beaver Brook	2,799	100.00%	EC	9,800	DRY				H			X	X	X	X	X	X
MA51-08	Unnamed Tributary	8,216	100.00%	EC	10,110	DRY				H		X	X	X	X	X	X	X

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MA51-15	Tatnuck Brook	6,881	51.70%	EC	2,300	WET		X		H			X	X	X	X	X	X
MA51-16	Dark Brook	7,275	53.80%	EC	2,100	WET		X		H			X	X	X	X	X	X
MA51-17	Poor Farm Brook	2,478	92.90%	EC	2,100	WET				H			X	X	X	X	X	X
MA51-18	Peters River	7,815	80.50%	EC	1,200	WET				H			X	X	X	X	X	X
MA51-27	Coal Mine Brook	801	100.00%	EC	2,000	WET	X			H			X	X	X	X	X	X
MA51-31	Singletary Brook	3,701	42.70%	EC	500	WET				M			X	X	X	X	X	X
MA51-32	Arnolds Brook	795	100.00%	EC	490	WET				M			X	X	X	X	X	X
MA51-36	Mill River	21,193	57.20%	EC	760	DRY				M	X		X	X	X	X	X	X
MA51-39	Fox Brook	2,874	40.60%	EC	18,000	DRY				H			X	X	X	X	X	X
MA51-40	Muddy Brook	3,983	46.20%	EC	2,400	DRY				H			X	X	X	X	X	X
MA51-45	Cronin Brook	1,838	100.00%	EC	2,100	WET				H			X	X	X	X	X	X
Ten Mile River Basin [Appendix K]																		
MA52-02	Ten Mile River	7,040	85.30%	EC; ENT	3,700; 250	DRY; DRY				H			X	X	X	X	X	X
MA52-03	Ten Mile River	27,123	94.40%	EC	2,900	DRY				H	X		X	X	X	X	X	X
MA52-05	Speedway Brook	2,174	100.00%	EC; ENT; FC	24,200; 1,600; 14,000	DRY; DRY; DRY				H			X	X	X	X	X	X
MA52-07	Sevenmile River	3,192	89.10%	EC	3,500	DRY		X		H			X	X	X	X	X	X
MA52-08	Sevenmile River	8,087	95.70%	EC; ENT	1,730; 130	DRY; DRY		X		H			X	X	X	X	X	X
MA52-09	Scotts Brook	791	55.90%	EC	5,700	DRY				H			X	X	X	X	X	X
MA52-11	Coles Brook	2,092	15.00%	EC	6,300	DRY				H			X	X	X	X	X	X
Narragansett Bay (Shore) Coastal Drainage Area [Appendix L]																		
MA53-19	Bliss Brook	1,394	25.30%	EC	1,190	WET				H			X	X	X	X	X	X
MA53-20	Runnins River	2,630	55.30%	EC; ENT	7,270; 1,800	DRY; DRY				H			X	X	X	X	X	X
MA53-21	Unnamed Tributary	208	100.00%	EC	2,420	DRY				H			X	X	X		X	X
Mount Hope Bay (Shore) Coastal Drainage Area [Appendix M]																		
MA61-05	Quequechan River	19,312	55.70%	EC	90	WET				M		X	X	X	X	X	X	X
MA61-09	Lewin Brook	1,707	15.90%	EC	570	WET				M			X	X	X	X	X	X
Taunton River Basin [Appendix N]																		
MA62-01	Taunton River	193,632	56.20%	EC; FC	1,600; 1,600	DRY; DRY				M	X		X	X	X	X	X	X
Mystic River Basin and Coastal Drainage Area [Appendix O]																		
MA71-10	Cummings Brook	2,548	100.00%	EC	500	DRY				M			X	X	X	X	X	X
MA71-11	Shaker Glen Brook	1,775	100.00%	EC	1,300	DRY				H			X	X	X	X	X	X
MA71-15	Munroe Brook	952	100.00%	EC	660	WET				M			X	X	X	X	X	X

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Charles River Basin and Coastal Drainage Area [Appendix P]																		
MA72-12	Beaver Brook	1,825	56.50%	EC	510	DRY				M			X	X	X		X	X
MA72-14	Mine Brook	10,064	93.10%	EC	340	DRY		X		M			X	X	X	X	X	X
MA72-34	Chicken Brook	4,600	100.00%	EC	730	DRY				M			X	X	X	X	X	X
MA72-35	Hopping Brook	7,045	72.10%	EC	730	DRY				M			X	X	X	X	X	X
MA72-41	Unnamed Tributary	429	0.00%	EC	2,600	DRY				H			X	X	X	X	X	X
MA72-43	Unnamed Tributary	4,582	100.00%	EC	430	DRY				M			X	X	X	X	X	X
MA72-44	Seaverns Brook	1,592	100.00%	EC	9,500	DRY				H			X	X	X	X	X	X
Neponset River Basin and Coastal Drainage Area [Appendix Q]																		
MA73-18	Steep Hill Brook	3,811	100.00%	EC	1,100	DRY				H			X	X	X	X	X	X
MA73-23	Plantingfield Brook	959	100.00%	EC	8,000	WET				H			X	X	X	X	X	X
Weymouth & Weir River Basin and Coastal Drainage Area [Appendix R]																		
MA74-10	Furnace Brook	2,526	100.00%	EC	510	DRY				M			X	X	X		X	X
MA74-20	Plymouth River	2,711	100.00%	EC	980	DRY				M			X	X	X		X	X
MA74-22	Cranberry Brook	1,165	100.00%	EC	3,700	WET		X		H			X	X	X		X	X
MA74-23	Mary Lee Brook	898	100.00%	EC	3,700	WET				H			X	X	X		X	X
MA74-27	Farm River	8,139	100.00%	EC	1,500	WET		X		H			X	X	X	X	X	X
MA74-28	Farm River	8,267	100.00%	EC	43	DRY				M			X	X	X	X	X	X
Nashua River Basin [Appendix S]																		
MA81-01	North Nashua River	37,669	17.40%	EC	11,000	DRY				H		X	X	X	X	X	X	X
MA81-02	North Nashua River	55,453	27.10%	EC	3,600	DRY				H	X	X	X	X	X	X	X	X
MA81-03	North Nashua River	64,031	29.00%	EC	2,420	DRY				H	X	X	X	X	X	X	X	X
MA81-04	North Nashua River	85,951	30.00%	EC	2,420	WET		X		H	X		X	X	X	X	X	X
MA81-05	Nashua River	219,874	28.00%	EC	2,420	WET		X		H	X		X	X	X	X	X	X
MA81-09	Nashua River	83,894	22.60%	EC	2,420	WET		X		H	X		X	X	X	X	X	X
MA81-13	Monoosnoc Brook	7,148	29.90%	EC	2,420	DRY		X		H			X	X	X	X	X	X
MA81-20	James Brook	2,808	36.90%	EC	2,420	WET		X		H			X	X	X	X	X	X
MA81-24	Gates Brook	2,003	78.70%	EC	1,200	WET		X		H			X	X	X	X	X	X
MA81-31	Stillwater River	18,849	0.30%	EC	3,300	WET		X		M			X	X	X	X	X	X
MA81-39	Fall Brook	4,605	68.80%	EC	320	DRY		X		M			X	X	X	X	X	X
MA81-60	Still River	1,524	6.10%	EC	400	DRY		X		M			X	X	X	X	X	X
MA81-62	Baker Brook	11,685	29.40%	EC	470	WET				M		X	X	X	X	X	X	X
MA81-72	Wekepeke Brook	7,500	16.40%	EC	2,420	WET		X		H			X	X	X	X	X	X

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MA81-74	Catacoonamug Brook	5,470	46.30%	EC	4,400	WET		X		H			X	X	X	X	X	X
MA81-79	Willard Brook	10,984	4.30%	EC	330	DRY		X	X	H			X	X	X	X	X	X
MA81-80	Pearl Hill Brook	4,643	3.80%	EC	26	DRY		X	X	H			X	X	X	X	X	X
MA81-99	Falulah Brook	2,645	0.00%	-	ND	-				L			X	X	X	X	X	X
MA81-100	Falulah Brook	8,080	13.90%	-	ND	-		X		M			X	X	X	X	X	X
Concord (SuAsCo) River Basin [Appendix T]																		
MA82A-03	Sudbury River	74,671	81.20%	EC; FC	1,730; 650	WET; WET				H			X	X	X	X	X	X
MA82A-05	Hop Brook	9,980	95.10%	EC	430	DRY				M	X		X	X	X	X	X	X
MA82A-07	Concord River	234,601	68.40%	EC; FC	500; 590	WET; WET				M	X		X	X	X	X	X	X
MA82A-09	Concord River	256,077	69.80%	EC; FC	980; 440	DRY; WET				M	X	X	X	X	X	X	X	X
MA82A-10	River Meadow Brook	17,195	81.30%	EC; FC	8,400; 12,000	DRY; DRY				H			X	X	X	X	X	X
MA82A-19	Pantry Brook	3,853	57.30%	-	ND	-				M			X	X	X	X	X	X
MA82A-22	Unnamed Tributary	13,036	83.90%	EC	410	WET		X		M			X	X	X	X	X	X
MA82A-25	Sudbury River	27,748	61.90%	EC; FC	540; 610	WET; WET		X		M			X	X	X	X	X	X
MA82A-34	Beaver Brook	3,575	100.00%	EC	510	DRY				M			X	X	X	X	X	X
MA82B-02	Assabet River	12,771	97.20%	EC; FC	2,800; 17,000	WET; DRY				H	X		X	X	X	X	X	X
MA82B-03	Assabet River	22,608	84.70%	EC; FC	2,000; 1,600	DRY; DRY				H	X		X	X	X	X	X	X
MA82B-04	Assabet River	47,365	61.50%	EC; FC	8,000; 12,000	DRY; DRY				H	X		X	X	X	X	X	X
MA82B-05	Assabet River	61,211	61.10%	EC; FC	1,990; 340	WET; WET				H	X		X	X	X	X	X	X
MA82B-07	Assabet River	113,674	60.60%	EC; FC	1,400; 2,400	DRY; DRY				H	X		X	X	X	X	X	X
MA82B-12	Elizabeth Brook	11,314	12.30%	EC	620	WET				M			X	X	X	X	X	X
MA82B-14	Nashoba Brook	13,512	77.30%	EC	2,420	WET				H			X	X	X	X	X	X
MA82B-22	Coles Brook	1,277	100.00%	EC	3,000	WET				H			X	X	X	X	X	X
Shawsheen River Basin [Appendix U]																		
MA83-22	Webb Brook	762	100.00%	EC	6,700	DRY				H			X	X	X	X	X	X
Merrimack River Basin and Coastal Drainage Area [Appendix V]																		
MA84A-01	Merrimack River	2,643,112	11.10%	-	ND	-		X		M		X	X	X	X	X	X	X
MA84A-02	Merrimack River	2,962,287	17.60%	-	ND	-		X		M		X	X	X	X	X	X	X
MA84A-03	Merrimack River	2,984,894	18.10%	-	ND	-		X		M	X	X	X	X	X	X	X	X
MA84A-04	Merrimack River	3,105,500	20.90%	-	ND	-				M	X	X	X	X	X	X	X	X
MA84A-05	Merrimack River	3,153,135	21.70%	EC	580	WET		X		M	X	X	X	X	X	X	X	X
MA84A-06	Merrimack River	3,204,333	22.20%	-	ND	-		X	X	H	X	X	X	X	X	X	X	X
MA84A-08	Powwow River	37,876	49.00%	-	ND	-		X		M			X	X	X	X	X	X

Segment ID	Waterbody	Watershed Area (acres)	Percent MS4 Area in Watershed	Maximum Sample Parameter	Maximum Single Sample Result (CFU/100mL)	Wet/Dry	Cold Water	Proximal to Sensitive Area	Bathing Beach	Rank (H/M/L)	POTWs	CSOs	Illicit Discharges	Urban Stormwater	Septic Systems	Agriculture	Pet Waste	Wildlife Waste
MA84A-09	Little River	18,634	100.00%	EC	380	DRY				M		X	X	X	X	X	X	X
MA84A-10	Spicket River	35,199	90.80%	-	ND	-				M		X	X	X	X	X	X	X
MA84A-11	Beaver Brook	13,688	79.60%	EC	6,000	DRY	X			H		X	X	X	X	X	X	X
MA84A-12	Richardson Brook	2,733	62.10%	-	ND	-				M			X	X	X	X	X	X
MA84A-13	Trout Brook	1,545	32.90%	-	ND	-				M			X	X	X	X	X	X
MA84A-14	Trull Brook	3,113	100.00%	-	ND	-				M			X	X	X		X	X
MA84A-16	Back River	3,929	54.30%	-	ND	-				M			X	X	X	X	X	X
MA84A-17	Black Brook	2,099	100.00%	-	ND	-				M			X	X	X		X	X
MA84A-18	Bare Meadow Brook	4,969	100.00%	-	ND	-				M			X	X	X	X	X	X
MA84A-21	Deep Brook	1,678	100.00%	EC	6,800	WET				H			X	X	X	X	X	X
MA84A-25	Powwow River	32,174	45.60%	-	ND	-				M			X	X	X	X	X	X
MA84A-26	Merrimack River	276	85.80%	-	ND	-		X		M			X	X	X		X	X
MA84A-27	Plum Island River	1,821	10.90%	-	ND	-		X		M			X	X	X	X	X	X
MA84A-28	Powwow River	31,278	44.80%	EC	230	WET		X		M			X	X	X	X	X	X
MA84A-30	Unnamed Tributary	4,590	60.80%	-	ND	-				M			X	X	X	X	X	X
MA84A-31	S. Branch Souhegan River	5,530	0.00%	EC	550	WET				L			X	X	X	X	X	X
MA84A-35	Peppermint Brook	1,155	100.00%	-	ND	-				M			X	X	X	X	X	X
MA84A-36	Bartlett Brook	4,346	72.00%	-	ND	-				M			X	X	X	X	X	X
MA84A-37	Creek Brook	3,527	100.00%	-	ND	-				M			X	X	X	X	X	X
MA84A-39	East Meadow River	4,540	57.90%	-	ND	-		X		M			X	X	X	X	X	X
MA84A-40	Fish Brook	3,882	100.00%	-	ND	-		X		M			X	X	X	X	X	X
MA84B-01	Unnamed Tributary	836	65.80%	-	ND	-				M			X	X	X	X	X	X
MA84B-02	Beaver Brook	8,527	71.70%	-	ND	-				M			X	X	X	X	X	X
MA84B-03	Stony Brook	24,325	77.40%	EC	150	DRY				M			X	X	X	X	X	X
MA84B-04	Stony Brook	29,130	81.20%	EC	790	DRY				M			X	X	X	X	X	X
MA84B-06	Bennetts Brook	2,978	37.70%	-	ND	-				M			X	X	X	X	X	X
MA84B-07	Tadmuck Brook	1,271	100.00%	-	ND	-				M			X	X	X	X	X	X
Ipswich River Basin and Coastal Drainage Area [Appendix W]																		
MA92-02	Ipswich River	99,827	67.70%	-	ND	-		X		M			X	X	X	X	X	X
MA92-05	Lubbers Brook	3,772	100.00%	EC; FC	340; 210	DRY; WET				M			X	X	X		X	X
MA92-08	Martins Brook	8,460	100.00%	EC; FC	2,000; 1,200	DRY; DRY				H			X	X	X	X	X	X
MA92-12	Unnamed Tributary	2,184	100.00%	EC; FC	1,200; 3,000	WET; WET				H			X	X	X	X	X	X
MA92-14	Fish Brook	11,602	38.60%	EC; FC	960; 630	WET; DRY				M			X	X	X	X	X	X

Segment ID	Waterbody	Watershed Area (acres)	Percent MS4 Area in Watershed	Maximum Sample Parameter	Maximum Single Sample Result (CFU/100mL)	Wet/Dry	Cold Water	Proximal to Sensitive Area	Bathing Beach	Rank (H/M/L)	POTWs	CSOs	Illicit Discharges	Urban Stormwater	Septic Systems	Agriculture	Pet Waste	Wildlife Waste
MA92-17	Howlett Brook	6,686	45.20%	EC; FC	410; 1000	DRY; WET				H			X	X	X	X	X	X
MA92-21	Kimball Brook	661	87.80%	EC; FC	990; 4,000	WET; WET				H			X	X	X	X	X	X
MA92-22	Labor in Vain Creek	1,334	21.30%	-	ND	-				M			X	X	X	X	X	X
MA92-23	Unnamed Tributary	349	3.00%	-	ND	-		X		M	X		X	X	X	X	X	X
North Shore Coastal Drainage Area [Appendix X]																		
MA93-37	Beaver Brook	1,458	100.00%	EC	3,800	WET				H			X	X	X	X	X	X
MA93-38	Crane River	3,375	100.00%	EC	3,400	WET				H			X	X	X	X	X	X
MA93-58	Unnamed Tributary	990	100.00%	EC; ENT	1,600; 14,000	WET; WET				H			X	X	X		X	X
MA93-59	Unnamed Tributary	1,133	70.40%	EC; ENT	3,000; 4,600	DRY; WET				H			X	X	X	X	X	X
South Shore Coastal Drainage Area [Appendix Y]																		
MA94-04	Indian Head River	19,488	99.90%	EC; FC	250; 340	DRY; DRY				M			X	X	X	X	X	X
MA94-39	Longwater Brook	1,905	100.00%	EC	488	DRY				M			X	X	X	X	X	X
MA94-40	Cushing Brook	2,612	100.00%	EC	2,420	DRY				H			X	X	X		X	X
Buzzards Bay Coastal Drainage Area [Appendix Z]																		
MA95-04	Weweantic River	36,368	35.20%	EC; ENT; FC	1,600; 1,600; 1,600	WET; WET; WET		X		H			X	X	X	X	X	X
MA95-06	Sippican River	17,987	2.90%	EC; ENT; FC	1,600; 1,600; 1,600	WET; WET; WET		X		H			X	X	X	X	X	X
MA95-11	Paskamanset River	18,333	46.30%	EC; ENT; FC	17,330; 1,600; 1,600	WET; WET; WET				H			X	X	X	X	X	X
MA95-12	Shingle Island River	13,503	7.50%	EC; ENT; FC	440; 180; 500	DRY; DRY; DRY		X		M			X	X	X	X	X	X
MA95-19	Megansett Harbor	5,464	45.30%	ND	ND	ND		X	X	H			X	X	X	X	X	X
MA95-36	Mattapoisett River	15,568	1.50%	EC; ENT; FC	1,600; 1,600; 1,600	WET; WET; WET				M			X	X	X	X	X	X
MA95-68	Wild Harbor River	1,583	74.80%	-	ND	-				M			X	X	X	X	X	X
MA95-78	Rands Harbor	1,255	62.20%	-	ND	-				M			X	X	X		X	X
MA95-79	Fiddlers Cove	282	80.10%	-	ND	-				M			X	X	X		X	X
MA95-82	Kirby Brook	2,447	12.80%	EC; ENT; FC	1,500; 1,600; 2,600	DRY; DRY; WET				H			X	X	X	X	X	X
MA95-83	Angeline Brook	2,216	0.00%	EC; ENT; FC	1,600; 1,600; 1,600	DRY; DRY; DRY				H			X	X	X	X	X	X
Cape Cod Coastal Drainage Area [Appendix AA]																		
MA96-75	Round Cove	332	73.50%	-	ND	-		X		M			X	X	X		X	X
MA96-95	Allens Harbor	229	99.70%	-	ND	-				M			X	X	X	X	X	X
MA96-96	Wychmere Harbor	281	100.00%	-	ND	-		X	X	H			X	X	X		X	X

Segment ID	Waterbody	Watershed Area (acres)	Percent MS4 Area in Watershed	Maximum Sample Parameter	Maximum Single Sample Result (CFU/100mL)	Wet/Dry	Cold Water	Proximal to Sensitive Area	Bathing Beach	Rank (H/M/L)	POTWs	CSOs	Illicit Discharges	Urban Stormwater	Septic Systems	Agriculture	Pet Waste	Wildlife Waste
MA96-99	Little River	940	92.70%	EC	900	DRY				M			X	X	X	X	X	X
MA96-100	Unnamed Tributary	638	100.00%	EC	1,900	DRY				H			X	X	X		X	X
MA96-102	Whites Brook	734	54.10%	EC	2,200	WET				H			X	X	X	X	X	X
MA96-103	Chase Garden Creek	392	67.30%	EC	1,500	DRY				H			X	X	X	X	X	X
MA96-104	Unnamed Tributary	976	74.80%	EC	1,000	DRY				H			X	X	X	X	X	X
MA96-107	Red River	1,169	100.00%	EC	6,100	WET				H			X	X	X		X	X
MA96-108	Unnamed Tributary	1,256	0.00%	EC	800	DRY				M			X	X	X		X	X
Islands Coastal Drainage Area [Appendix AB]																		
MA97-16	Katama Bay	4,774	6.40%	-	ND	-		X	X	H			X	X	X	X	X	X
MA97-29	Long Pond	1,573	0.00%	-	ND	-		X		M			X	X	X		X	X

5.1.1. Wet-Dry Weather Analysis

The determination of weather conditions during sampling events (i.e., wet or dry weather) assists investigators in identifying likely sources of pollutants, thus supporting the prioritization of remediation efforts. To determine wet or dry weather status, daily precipitation totals were matched to each sampling data point based on the methods described below (note: hourly precipitation data were not available at sufficient spatial and temporal scales).

Rainfall data were obtained from 31 weather stations with near-complete data (>89%). Weather data were obtained from the National Oceanic & Atmospheric Administration National Centers for Environmental Information (NOAA NCEI) directly or indirectly from MassDEP. Weather conditions were defined as “wet” when precipitation was >0.50” in the prior 72 hours (including the day of sample collection) and “dry” when “wet” thresholds were not met. Since wet or dry weather status is used to target implementation measures, an assumption was made that any rainfall that fell on the sampling day occurred before collecting the sample. Therefore, if the rain that fell on that date occurred after sample collection, the sample may be misclassified as wet weather. For stations with missing information, data gaps were filled with data from the nearest weather station, provided one was within 20 miles of the watershed border or 30 miles of the segment centroid. A map and corresponding table of the sampling sites, as well as the rainfall stations, are shown in Figure 4 and Table 9.

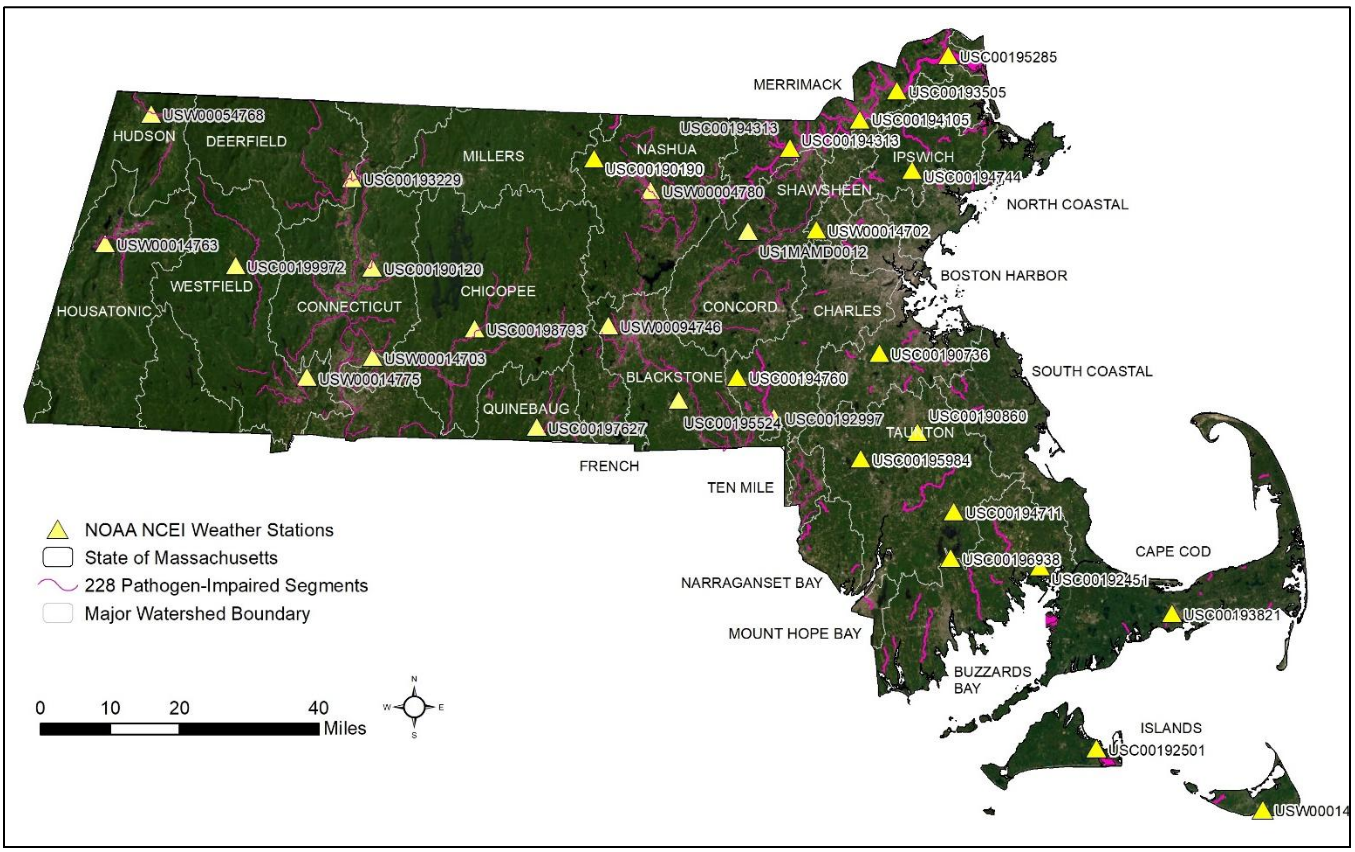

Figure 4. Weather Station Locations for Dry-Wet Weather Analysis

Table 9. List of Weather Stations Matched with Segments

Major Watershed	Weather Station	Rainfall Date Range	Segment ID
Hoosic River Basin [Appendix A]	NORTH ADAMS HARRIMAN AIRPORT MA US	2005-2015	MA11-02, MA11-03, MA11-05
Housatonic River Basin [Appendix B]	PITTSFIELD MUNICIPAL AIRPORT MA US	2005-2015	MA21-02, MA21-04, MA21-17, MA21-18
Westfield River Basin [Appendix C]	WESTFIELD BARNES MUNICIPAL AIRPORT MA US	2005-2015	MA32-08, MA32-09, MA32-22, MA32-27, MA32-28, MA32-36, MA32-37, MA32-39, MA32-41
	WORTHINGTON MA US	2005-2015	MA32-04
Deerfield River Basin [Appendix D]	GREENFIELD NUMBER 3 MA US	2005-2015	MA33-03, MA33-04, MA33-101, MA33-102, MA33-19, MA33-21, MA33-30
Connecticut River Basin [Appendix E]	AMHERST MA US	2005-2019	MA34-04, MA34-25, MA34-27, MA34-28
	CHICOPEE FALLS WESTOVER FIELD MA US	2005-2015	MA34-05, MA34-07, MA34-19, MA34-21, MA34-29, MA34-42, MA34-60
	GREENFIELD NUMBER 3 MA US	2005-2015	MA34-03, MA34-36
	WARE MA US	2005-2015	MA34-30
	WESTFIELD BARNES MUNICIPAL AIRPORT MA US	2005-2015	MA34-11
Millers River Basin [Appendix F]	GREENFIELD NUMBER 3 MA US	2005-2015	MA35-16
Chicopee River Basin [Appendix G]	CHICOPEE FALLS WESTOVER FIELD MA US	2005-2015	MA36-24, MA36-25, MA36-39, MA36-40, MA36-41
	WARE MA US	2005-2015	MA36-05, MA36-06, MA36-15, MA36-16, MA36-17, MA36-21, MA36-22, MA36-50
	WORCESTER MA US	2005-2015	MA36-08, MA36-11, MA36-12, MA36-18
Quinebaug River Basin [Appendix H]	SOUTHBRIDGE 3 SW MA US	2005-2015	MA41-03, MA41-04, MA41-06, MA41-12, MA41-13
	WARE MA US	2005-2015	MA41-16, MA41-17
French River Basin [Appendix I]	SOUTHBRIDGE 3 SW MA US	2005-2015	MA42-11, MA42-15
	WORCESTER MA US	2005-2015	MA42-07, MA42-18
Blackstone River Basin [Appendix J]	FRANKLIN MA US	2005-2015	MA51-18, MA51-32, MA51-36
	NORTHBRIDGE 2 MA US	2005-2015	MA51-04, MA51-05, MA51-06, MA51-39, MA51-40
	WORCESTER MA US	2005-2015	MA51-01, MA51-02, MA51-03, MA51-07, MA51-08, MA51-15, MA51-16, MA51-17, MA51-27, MA51-31, MA51-45
Ten Mile River Basin [Appendix K]	FRANKLIN MA US	2005-2015	MA52-02, MA52-03, MA52-05, MA52-07, MA52-08, MA52-09, MA52-11
Narragansett Bay (Shore) Coastal Drainage Area [Appendix L]	NORTON WEST, MA US	2005-2019	MA53-19, MA53-20, MA53-21
Mount Hope Bay (Shore) Coastal Drainage Area [Appendix M]	ROCHESTER, MA US	2005-2019	MA61-05, MA61-09, MA95-11, MA95-12, MA95-36, MA95-82, MA95-83

Major Watershed	Weather Station	Rainfall Date Range	Segment ID
Taunton River Basin [Appendix N]	MIDDLEBORO, MA US	2005-2019	MA62-01
Mystic River Basin and Coastal Drainage Area [Appendix O]	BEDFORD HANSCOM FIELD, MA US	2005-2019	MA71-11, MA71-10, MA71-15
Charles River Basin and Coastal Drainage Area [Appendix P]	BEDFORD HANSCOM FIELD, MA US	2005-2019	MA72-43, MA72-44
	MILFORD, MA US	2005-2019	MA72-12, MA72-14, MA72-34, MA72-35, MA72-41
Neponset River Basin and Coastal Drainage Area [Appendix Q]	BLUE HILL COOP, MA US	2005-2019	MA73-18, MA73-23, MA74-27, MA74-10, MA74-20, MA74-23, MA74-22, MA74-28
Weymouth & Weir River Basin and Coastal Drainage Area [Appendix R]	BLUE HILL COOP, MA US	2005-2019	MA74-27, MA74-10, MA74-20, MA74-23, MA74-22, MA74-28
Nashua River Basin [Appendix S]	FITCHBURG MUNICIPAL AIRPORT MA US	2005-2019	MA81-01, MA81-02, MA81-03, MA81-04, MA81-05, MA81-09, MA81-13, MA81-20, MA81-31, MA81-39, MA81-60, MA81-62, , MA81-72, MA81-74, MA81-79, MA81-80, MA81-99, MA81-100
	WORCESTER MA US	2005-2015	MA81-24
Concord (SuAsCo) River Basin [Appendix T]	ACTON 1.3 SW MA US	2005-2015	MA82A-03, MA82A-05, MA82A-07, MA82A-19, MA82A-22, MA82A-25, MA82B-02, MA82B-03, MA82B-04, MA82B-05, MA82B-07, MA82B-12, MA82B-14, MA82B-22
	LOWELL MA US	2005-2015	MA82A-09, MA82A-10, MA82A-34
Shawsheen River Basin [Appendix U]	BEDFORD HANSCOM FIELD, MA US	2005-2019	MA83-22
Merrimack River Basin and Coastal Drainage Area [Appendix V]	ASHBURNHAM, MA US	2005-2019	MA84A-31
	HAVERHILL, MA US	2005-2019	MA84A-37, MA84A-39, MA84A-04, MA84A-09, MA84A-05
	LAWRENCE, MA US	2005-2019	MA84A-36, MA84A-40, MA84A-03, MA84A-10, MA84A-18
	LOWELL, MA US	2005-2019	MA84B-06, MA84A-35, MA84B-07, MA84A-11, MA84A-12, MA84A-13, MA84A-14, MA84A-17, MA84A-21, MA84B-01, MA84B-03, MA84B-04, MA84B-02, MA84A-01, MA84A-02
	NEWBURYPORT, MA US	2005-2019	MA84A-16, MA84A-25, MA84A-28, MA84A-08, MA84A-06, MA84A-26, MA84A-27, MA84A-30

Major Watershed	Weather Station	Rainfall Date Range	Segment ID
Ipswich River Basin and Coastal Drainage Area [Appendix W]	MIDDLETON, MA US	2005-2019	MA92-05, MA92-08, MA92-12, MA92-14, MA92-17, MA92-21
	NEWBURYPORT, MA US	2005-2019	MA92-22, MA92-02, MA92-23
North Shore Coastal Drainage Area [Appendix X]	MIDDLETON, MA US	2005-2019	MA93-37, MA93-38, MA93-58, MA93-59
South Shore Coastal Drainage Area [Appendix Y]	BROCKTON, MA US	2005-2019	MA94-39, MA94-40, MA94-04
Buzzards Bay Coastal Drainage Area [Appendix Z]	EAST WAREHAM, MA US	2005-2019	MA95-06, MA95-04, MA95-19, MA95-68, MA95-79, MA95-78
Cape Cod Coastal Drainage Area [Appendix AA]	HYANNIS, MA US	2005-2019	MA96-99, MA96-100, MA96-104, MA96-108, MA96-102, MA96-103, MA96-107, MA96-75, MA96-96, MA96-95
Islands Coastal Drainage Area [Appendix AB]	EDGARTOWN, MA US	2005-2019	MA97-16
	NANTUCKET MEMORIAL AIRPORT, MA US	2005-2019	MA97-29

5.2. Stormwater Discharges

5.2.1. Regulated Stormwater Discharges

Stormwater runoff is composed of both point and nonpoint sources as discussed in Section 3. Stormwater discharges covered under the federal NPDES MS4 General Permit program are defined as point sources. The Federal Water Quality Act of 1987 recognized that runoff from urban areas and industrial sites pollutes surface waters and required the USEPA to address stormwater discharges with NPDES permits using a two-phased approach. Phase I and Phase II regulations were published in 1990 and 1999, respectively.

In Phase I, USEPA required operators of medium and large MS4 systems to obtain permit coverage which, in Massachusetts, applies to the cities of Boston and Worcester. Dischargers of "stormwater associated with industrial activity" were also required to apply for permits. The Phase I industrial sources generally include heavy and light manufacturing facilities, hazardous/solid waste processing, recycling facilities (including junkyards), mining (including sand and gravel), timber processing, power plants, vehicle maintenance, sewage/sludge treatment plants, and construction activities that disturb more than five acres.

Phase II regulates communities that fall under the definition of small MS4-designated areas. Discharges in these urbanized areas include stormwater discharges associated with small construction activity and the municipally owned industrial activities that were exempted from regulation during Phase I. In Massachusetts, this applies to 260 communities and 30 non-traditional State and federal organizations that also qualified as permittees under the designation criteria. Figure 5 shows urbanized areas (within Massachusetts) in the study area to which Phase II NPDES stormwater permit requirements apply. Of the 260 municipalities in Massachusetts regulated under the small MS4 permit, 235 are situated within the study area (Table 10; USEPA, 2016). There are 15 towns in the study area that have US Census-designated urbanized areas, but the towns requested and were granted waivers from the MS4 program by USEPA due to the small size of those areas. In addition, the City of Worcester was included in Phase I Large and Medium MS4 Permits

Many point source stormwater discharges in the TMDL study area are regulated under the NPDES Phase I and Phase II permitting programs, and the most critical stormwater point sources are described above in Section 3. The NPDES permit does not, however, establish numeric effluent limitations for stormwater discharges. Maximum Extent Practicable is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve; it is a narrative effluent limitation that is satisfied through implementation of Stormwater Management Plans (SWMPs) and achievement of measurable goals.

Nonpoint source discharges are generally characterized as sheet flow runoff and are not categorically regulated under the NPDES program, and therefore can be difficult to manage. However, some of the same principles for mitigating point source impacts may be applicable. Individual municipalities not regulated under a NPDES Stormwater Permit should implement the same six minimum control measures to minimize stormwater contamination.

Stormwater Phase II Annual Reports are submitted by regulated communities each May. Recent annual reports indicate that substantial progress is being made, particularly with certain communities, on those aspects of the six-point plan requirements that would address pathogen pollutant sources. Community-specific progress with stormwater management is presented in the appendices.

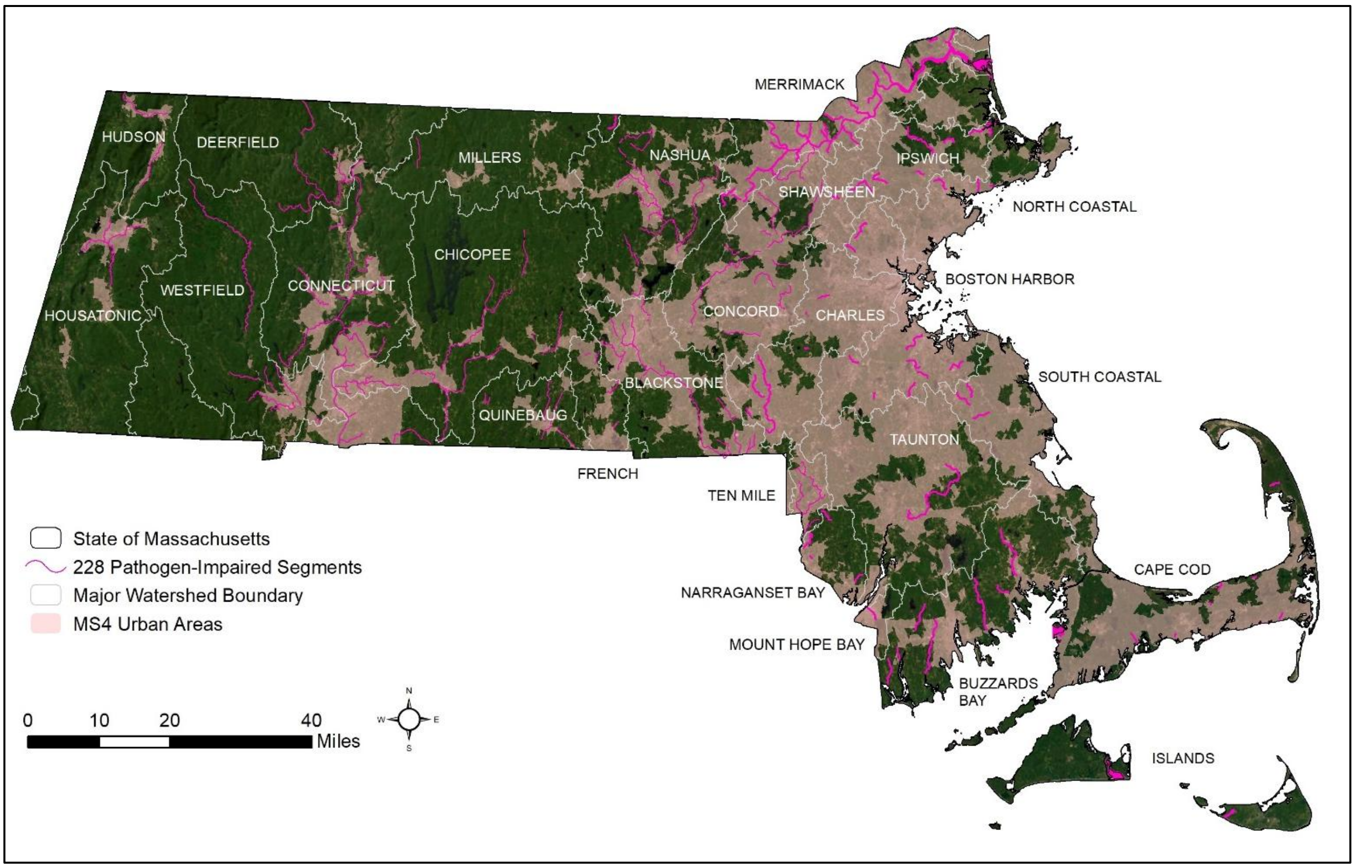

Figure 5. Massachusetts' urbanized areas within the TMDL study area subject to the MS4 General Permit

Table 10. List of Massachusetts' municipalities in the study area with portions subject to the NPDES General MS4 Stormwater Permit.

ABINGTON	EASTHAMPTON	MASHPEE	SHERBORN
ACTON	EASTON	MATTAPOISETT	SHIRLEY
ACUSHNET	ERVING	MAYNARD	SHREWSBURY
ADAMS	ESSEX	MEDWAY	SOUTH HADLEY
AGAWAM	FALL RIVER	MENDON	SOUTHAMPTON
AMESBURY	FALMOUTH	MERRIMAC	SOUTHBOROUGH
AMHERST	FITCHBURG	METHUEN	SOUTHBRIDGE
ANDOVER	FOXBOROUGH	MIDDLEBOROUGH	SOUTHWICK
ASHBURNHAM *	FRAMINGHAM	MIDDLETON	SPENCER
ASHBY *	FRANKLIN	MILFORD	SPRINGFIELD
ASHLAND	FREETOWN	MILLBURY	STERLING
ATHOL	GARDNER	MILLVILLE	STOUGHTON
ATTLEBORO	GEORGETOWN	MILTON	STOW
AUBURN	GILL	MONSON	STURBRIDGE
AVON	GRAFTON	MONTAGUE	SUDBURY
AYER	GRANBY	MONTGOMERY	SUNDERLAND
BARNSTABLE	GREENFIELD	NATICK	SUTTON
BEDFORD	GROTON	NEW BEDFORD	SWANSEA
BELCHERTOWN	GROVELAND	NEW BRAINTREE	TAUNTON
BELLINGHAM	HADLEY	NEWBURY	TEMPLETON
BERKLEY	HALIFAX	NEWBURYPORT	TEWKSBURY
BERLIN	HAMILTON	NORTH ADAMS *	TOPSFIELD
BEVERLY	HAMPDEN	NORTH ANDOVER	TOWNSEND
BILLERICA	HANOVER	NORTH ATTLEBOROUGH	TYNGSBOROUGH
BLACKSTONE	HANSON	NORTH BROOKFIELD	UPTON
BOLTON *	HARDWICK	NORTH READING	UXBRIDGE
BOURNE	HARVARD *	NORTHAMPTON	WARE *
BOXBOROUGH	HARWICH	NORTHBOROUGH	WAREHAM
BOXFORD	HAVERHILL	NORTHBRIDGE	WARREN
BOYLSTON	HINGHAM	NORTON	WAYLAND
BRAINTREE	HINSDALE *	NORWELL	WEBSTER
BREWSTER	HOLBROOK	NORWOOD	WELLESLEY
BRIDGEWATER	HOLDEN	ORANGE	WENHAM
BROCKTON	HOLLISTON	OXFORD	WEST BOYLSTON
BROOKFIELD	HOLYOKE	PALMER	WEST BRIDGEWATER
BURLINGTON	HOPEDALE	PAXTON	WEST BROOKFIELD
CANTON	HOPKINTON	PEABODY	WEST NEWBURY
CARLISLE *	HUDSON	PELHAM *	WEST SPRINGFIELD
CARVER	HUNTINGTON	PEMBROKE	WESTBOROUGH
CHARLTON	IPSWICH	PEPPERELL	WESTFIELD
CHATHAM	KINGSTON	PITTSFIELD	WESTFORD
CHELMSFRD	LAKEVILLE	PLAINVILLE	WESTHAMPTON *
CHESHIRE	LANCASTER	PLYMOUTH	WESTMINSTER
CHICOPEE	LANESBOROUGH	PLYMPTON *	WESTON
CLARKSBURG	LAWRENCE	QUINCY	WESTPORT
CLINTON	LEICESTER	RANDOLPH	WESTWOOD
CONCORD	LENOX *	RAYNHAM	WEYMOUTH
DALTON	LEOMINSTER	READING	WHATELY
DANVERS	LEXINGTON	REHOBOTH	WHITMAN
DARTMOUTH	LINCOLN	RICHMOND	WILBRAHAM
DEERFIELD	LITTLETON	ROCHESTER *	WILLIAMSBURG *
DENNIS	LONGMEADOW	ROCKLAND	WILLIAMSTOWN
DOUGLAS	LOWELL	ROWLEY	WILMINGTON
DRACUT	LUDLOW	RUSSELL *	WINCHESTER
DUDLEY	LUNENBURG	RUTLAND	WOBURN
DUNSTABLE	LYNNFIELD	SALISBURY	WORCESTER
EAST BRIDGEWATER	MANSFIELD	SANDWICH	WRENTHAM
EAST BROOKFIELD	MARION	SEEKONK	YARMOUTH
EAST LONGMEADOW	MARLBOROUGH	SHARON	

** Municipalities within the TMDL area with waivers from the MS4 program at the time this TMDL was completed.*

5.2.2. Non-Regulated Stormwater Discharges

Of the 288 towns in Massachusetts in the study area, 53 are not identified as urbanized areas and are not regulated under the MassDEP General Stormwater Permit. Fifteen more contained small urbanized areas; these towns requested and were granted waivers from regulation under the MS4 permit program. These non-MS4 municipalities are encouraged to implement both structural and non-structural BMPs as those required by the MS4 communities to address sources of pathogens.

5.2.3. Construction Stormwater Discharges

MassDEP has promulgated "Stormwater Management Regulations" that establish a statewide general permit program aimed at controlling the discharge of stormwater runoff from certain privately-owned sites containing large impervious surfaces. The regulations require private owners of land containing five or more acres of impervious surfaces to: apply for and obtain coverage under a general permit, implement nonstructural BMPs for managing stormwater, install low impact development (LID) techniques and structural BMPs at sites undergoing development or redevelopment, and submit annual compliance certifications to MassDEP. Where MassDEP has determined that stormwater runoff is causing or contributing to violations of the SWQS, the proposed regulations would allow MassDEP to impose the same requirements on certain private owners of land with less than five acres of impervious surfaces and require the owners of such land to design and implement the LID techniques and stormwater BMPs needed to address these violations.

The Massachusetts Statewide Municipal Stormwater Coalition (MSMSC), composed of about 10 stormwater-focused groups around the State, further coordinates with and assists municipalities on pathogen pollutant concerns (Think Blue Massachusetts, n.d.).

Some non-structural BMPs that manage urban stormwater runoff include street sweeping, catch basin maintenance, road salt management, spill prevention and control plans, integrated pest management, snow disposal, pollution prevention at the Departments of Public Works, and natural vegetation preservation. Public outreach and homeowner education, including landscaping education and car washing practices, are also a vital component of reducing the impact of stormwater runoff. LID techniques, such as bioretention areas and rain gardens, porous pavement, and vegetated filter strips, can also greatly reduce the impact stormwater has on local waterbodies. Communities can also consider structural stormwater controls such as sand and organic filters and constructed stormwater wetlands, among others. Find more information on the MassDEP website (MassDEP, 2019c).

5.3. CSOs, Illicit Sewer Connections, and Failing Infrastructure

Among the highest priority pathogen sources are CSOs, illicit connections of sewer pipes to storm drains, and failing wastewater infrastructure. They represent direct discharges of untreated wastewater to the environment, and thus pose serious public health risks. An integrated approach to remediating these sources is necessary to attain the goals of this TMDL. A study of the Merrimack River suggests that CSO abatement on its own would not eliminate violations of the SWQS in the river's mainstem (CDM, 2006). Most of the river from Manchester, NH to downstream of Haverhill, MA would still exceed applicable criteria established in the SWQS more than 10% of the time. Furthermore, CSO control plans with full separation of sewers in each city would only yield slight additional improvements (e.g., downstream of continuing CSO discharges following storm events). Implementing CSO discharge controls (Phase I and certain high priority Phase II), as well as non-CSO stormwater conveyance controls, fixing illicit connections and failing infrastructure, and developing septic system maintenance programs would be necessary to significantly reduce the total number of indicator bacteria violation days (CDM, 2004; CDM Smith, 2017; CDM, 2006).

USEPA's Phase II rule specifies that an MS4 community must develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants to the MEP, protect water quality, and satisfy the applicable water quality requirements of the CWA and the Massachusetts SWQS. Portions of many towns in the watersheds covered by this TMDL are classified as Urbanized Areas by the U.S. Census Bureau and are therefore subject to the regulatory authority of the Massachusetts Small MS4

General Permit (effective date July 1, 2018). Municipalities that operate regulated MS4s must develop and implement an SWMP to meet Six Minimum Control Measures within five years of the effective date of July 1, 2018, for the MS4 permit issued in 2016:

- Public education and outreach on stormwater impacts,
- Public involvement and participation,
- Illicit discharge detection and elimination (IDDE),
- Construction site stormwater runoff control,
- Post-construction stormwater management in new development and redevelopment, and
- Pollution prevention and good housekeeping for municipal operations.

Written submittal of the SWMP to USEPA was required by June 30, 2019, including the IDDE program description and procedures. This is one of the most important control measures, since it corrects prohibited sources that represent a severe health and water quality risk. In general, a comprehensive IDDE Program must contain the following four elements:

1. Develop (if not already completed) a storm sewer system map showing the location of all outfalls, and the names and locations of all waters of the United States that receive discharges from those outfalls.
2. Develop and promulgate municipal regulations/bylaws that require the municipality to comply with Phase II regulations including prohibition of illicit discharges and appropriate enforcement mechanisms.
3. Develop and implement a plan to detect and address illicit discharges, including illegal dumping, to the system. USEPA recommends that the plan include the following four components: locating priority areas; tracing the source of an illicit discharge; removing the source of an illicit discharge; and program evaluation and assessment.
4. Inform public employees, businesses, and the public of hazards associated with illegal discharges and improper disposal of waste. IDDE outreach can be integrated into the broader stormwater outreach program for the community. Fulfilling the outreach requirement for IDDE helps the MS4 community to comply with this mandatory element of the stormwater program.

The SWMP must also include municipal bylaws or ordinances that address post-construction project sediment and erosion control and pollutant removal.

Communities that are not covered under the Phase II rule (i.e., not designated as MS4 communities) are encouraged to implement a program for detecting and eliminating sewage discharges to storm sewer systems, including illicit sewer connections. Implementation of the Phase II rule, whether voluntarily or mandated, will help communities achieve TMDLs.

5.4. Wastewater Treatment Plants

WWTP discharges to surface waters are regulated under the federal NPDES and the Commonwealth's Surface Water Discharge program. Each WWTP has an effluent limit included in its NPDES or groundwater permit. Some NPDES permits are listed on the USEPA website (USEPA, 2019b) and the Commonwealth's wastewater permits are available on MassDEP's website (MassDEP, n.d. (a)). Details on the Massachusetts groundwater permit program are also available on MassDEP's website (MassDEP, n.d. (b)).

5.5. Failing Septic Systems

Pathogen pollutant inputs to surface waters in Massachusetts can be reduced through septic system inspection, maintenance, and when necessary, replacement. These activities are regulated under Massachusetts Title 5 regulation (310 CMR 15.00), which defines requirements for new construction, inspection of private sewage disposal systems before property ownership transfer, building expansions, or changes in use of properties, and aids in the discovery of poorly operating or failing systems. Additional targeted inspection programs may be warranted in watersheds where streams show high indicator bacteria levels or other evidence to suspect individual septic system failure. Regulatory and educational materials for septic system installation, maintenance, and alternative technologies are provided by MassDEP (MassDEP, n.d. (d)).

Additional information on how to prevent surface water pollution from failing septic systems is available through the Massachusetts Clean Water Toolkit (MassDEP, 2019a).

5.6. Pet Waste

Most surface water pollutants come from minor sources, especially at the household level. Pet waste is one of those small sources of pollutants, carrying untreated waste to storm sewers or directly overland into lakes, streams, and estuaries. Pet waste damages aquatic ecosystems and wildlife because it contains highly concentrated nutrients and pathogens such as parasites (e.g., campylobacteriosis, giardiasis, salmonellosis, and toxocariasis) and increases the biological oxygen demand of a waterway, depleting oxygen levels for sensitive aquatic species. Beaches may be closed if certain disease-causing bacteria and viruses are found in the water.

Stormwater Phase II requirements include an educational program to inform the public about the impact of stormwater that may carry pet waste to surface waters. To prevent pet waste from getting in the water, many towns have “pooper scooper” ordinances, with fines for violations, that require pet owners to remove fecal matter from public property. Pet waste should be disposed of away from any waterway or stormwater system. Towns should work with volunteers to map locations where waste from pets is a significant and chronic problem. This work should be incorporated into the municipalities’ Phase II plans and should result in an evaluation of strategies to reduce the impact of waste on water quality. This may include installing signage, providing pet waste receptacles or pet waste digester systems in high-use areas, enacting ordinances requiring clean-up of pet waste, and targeting educational and outreach programs in problem areas. Additional information about stormwater runoff, including preventing pathogen pollutants from abandoned pet waste, is available in the Massachusetts Clean Water Toolkit on the MassDEP website (MassDEP, 2019a).

5.7. Agriculture

Agriculture can have dramatic impacts on a range of water quality factors, including pathogens, nutrients, pesticides, salt, irrigation effects, and erosion and sedimentation. Aquatic impacts are more significant where the water table and/or infiltration rates are high.

Massachusetts has several programs to monitor and reduce agricultural impacts on water quality. For example, the Agricultural Environmental Enhancement Program (AEEP) is a voluntary statewide program that provides financial support to agricultural operators to help them implement conservation practices intended to protect natural resources by preventing pollutants that may arise from agricultural practices. Projects focus on their potential to impact the most sensitive resources, including drinking water supplies, wetlands, and MassDEP priority waterbodies. The Pesticide Program of the Massachusetts Department of Agricultural Resources (MDAR) also carries out pesticide-related activities, such as education and water monitoring.

Nutrient regulations are primarily aimed at preventing phosphorus and nitrogen water pollution, but they can also reduce pathogen pollution. In 2012, the Massachusetts Legislature passed Chapter 262, An Act Relative to the Regulation of Plant Nutrients. The Act requires MDAR to promulgate statewide regulations to ensure that plant nutrients, including manure, are applied in an effective manner to provide sufficient nutrients for plant growth while minimizing impacts on water resources to protect human health and the environment. MDAR developed regulations entitled “330 CMR 31.00: Plant Nutrient Application Requirements for Agricultural Land and Land Not Used for Agricultural Purposes.” The regulation gives MDAR authority to regulate and enforce the registration and application of plant nutrients to lawns and non-agricultural turf to prevent nonpoint source pollution to surface and groundwater. It also specifies implementation of the University of Massachusetts Amherst Extension Service’s Guidelines (UMass Guidelines), if available for the commodity grown, as the compliance standard. The regulations were first adopted in 2015 and amended on January 12, 2018.

Act regarding plant nutrients: (Commonwealth of Massachusetts, 2012)
Plant nutrient regulations: (MDAR, 2018b)
Information about UMass Extension's education and outreach materials relative to nutrient management and fertilizer: (UMass Amherst, 2020)

For more information on Nutrient Management Plan guidelines, see section 31.04 of "330 CMR 31": (MDAR, 2018a).

The USDA Natural Resource Conservation Service (NRCS) offers technical and financial assistance to farm businesses for conservation practices and other improvements to their land. This assistance offers many benefits to farmers, while also protecting rivers from pathogen pollutants. Programs most relevant to pathogens and water quality include:

- The Environmental Quality Incentives Program (EQIP) provides financial and technical assistance to agricultural producers to deliver environmental benefits such as improved water and air quality, conserved ground and surface water, increased soil health and reduced soil erosion and sedimentation, and improved or created wildlife habitat. Funds are prioritized based on the most recently available MassDEP list of impaired waters.
- The Conservation Stewardship Program (CSP) helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance—the higher the performance, the higher the payment.
- The Agricultural Conservation Easement Program helps landowners, land trusts, and other entities protect, restore, and enhance wetlands, grasslands, and working farms and ranches through conservation easements.
- The Healthy Forests Reserve Program (HFRP) helps landowners restore, enhance, and protect forestland resources on private and tribal lands through easements and financial assistance. Through HRFP, landowners promote the recovery of endangered or threatened species, improve plant and animal biodiversity, and enhance carbon sequestration.
- The Regional Conservation Partnership Program (RCPP) promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS aids producers through partnership agreements and RCPP conservation program contracts.

To assist farmers with environmentally sustainable and profitable farming, the NRCS and other stakeholders have developed an integrated farm management approach known as the CORE4 approach. The approach focuses on four fundamental components – conservation tillage, crop nutrient management, integrated pest management, and conservation buffers. Additional information on the CORE4 approach can be found in the CORE4 Conservation Practices Training Guide (NRCS, 1999).

Additional information on agricultural BMPs to protect water quality from a range of nonpoint sources of pollution, including pathogens, is available through the Massachusetts Clean Water Toolkit (MassDEP, 2019a).

5.8. Wildlife Waste

Past TMDL studies have shown that waterfowl and wildlife contribute significantly to elevated indicator bacteria concentrations in surface waters. Waste left to decay on land may be washed into storm sewers or directly into surface waters by rain or melting snow and cause water quality impairments (USEPA, 2001).

Towns and residents can take several measures to minimize waterfowl-related impacts. Shoreline homeowners can allow tall, coarse vegetation to grow in areas along the edges of impacted waterbodies frequented by waterfowl. Waterfowl, especially grazers like geese, prefer easy access to the water. Maintaining an uncut vegetated buffer along the shore will make the habitat less desirable to geese and encourage their migration. Daily cleanup of waterfowl waste on public beaches would likely reduce the number of beach closures due to bacteria exceedances of water quality standards. Educational programs should emphasize that feeding waterfowl, such as ducks, geese, and swans, may contribute to water quality impairments and can harm human health and the environment. Towns should ensure this regulation is cited in their SWMPs.

5.9. Recreational Waters Use Management

Recreational waters receive pathogen inputs from swimmers. To reduce swimmers' contributions to pathogen impairment, bathroom and shower facilities can be made available, and bathers should be encouraged to shower prior to swimming. In addition, parents should change young children's diapers as soon as they are soiled, and properly dispose of used diapers.

All Massachusetts waters are designated as a No-Discharge Zone (NDZ) in which the discharge of boat sewage is prohibited. Massachusetts Office of Coastal Zone Management (CZM), coastal communities, and other organizations continue to ensure that these boat pump-out services, including many which are free, are available and well publicized where boating occurs (CZM, 2022).

5.10. Climate Change

MassDEP recognizes that long-term (25+ years) climate change impacts to the Massachusetts environment, including in the study area covered by this TMDL, are occurring, based on the consensus in the scientific community. The Massachusetts Executive Office of Energy and Environmental Affairs (EEA) *2011 Climate Change Adaptation Report* predicts that by 2100 the sea level could be 1 to 6 feet higher than the current position, and precipitation rates in the northeast could increase by as much as 20%. However, the details of how climate change will affect sea level rise, precipitation, streamflow, and sediment-nutrient loading in specific locations are generally unknown. The ongoing debate is not about whether climate change will occur, but the rate and extent to which it will occur, as well as the adjustments needed to address its impacts. USEPA's 2012 *Climate Change Strategy* states: "Despite increasing understanding of climate change, there still remain questions about the scope and timing of climate change impacts, especially at the local scale where most water-related decisions are made" (USEPA, 2012a). This is particularly true in Massachusetts, where water quality management decisions and implementation actions generally occur at the municipal level, on a sub-watershed scale.

USEPA's *Climate Change Strategy* identifies the types of research needed to support the goals and strategic actions to respond to climate change. USEPA acknowledges that data are missing or not available for making water resource management decisions under changing climate conditions. In addition, USEPA recognizes the limitation of current modeling in predicting the pace and magnitude of localized climate change impacts and recommends further exploration of the use of tools, such as atmospheric, precipitation, and climate change models, to help states evaluate pollutant load impacts under a range of projected climatic shifts.

USEPA released *Watershed modeling to assess the sensitivity of streamflow, nutrient, and sediment loads to potential climate change and urban development in 20 U.S. watersheds* (USEPA, 2013), which studied 20 watersheds around the nation. The watershed most relevant to Massachusetts examined in the study is a New England coastal basin ranging between southern Maine and central coastal Massachusetts. This includes many watersheds in the current TMDL, covering northeast Massachusetts and the greater Boston area. The initial "first order" conclusion of this study was that in many locations, future conditions, including water quality, are likely to be different from the past. However, most significantly, this study did not demonstrate that changes to TMDLs (the water quality restoration targets) would be necessary for the region. USEPA's 2012 *Climate Change Strategy* also acknowledges that the northeast, including New England, needs to develop standardized regional assumptions regarding future climate change impacts.

MassDEP believes that impacts of climate change should be addressed through TMDL implementation with an adaptive management approach in mind. Adjustments can be made as environmental conditions, pollutant sources, or other factors change over time.

6. Monitoring Plan

The long-term plan for statewide monitoring of indicator bacteria includes the following actions:

1. Identify and prioritize Massachusetts' waterbodies for which data are lacking or absent to determine if the waterbody meets the use criteria.
2. Monitor areas where BMPs and other control strategies have been implemented or discharges have been removed to assess the effectiveness of the modification or elimination.
3. Assemble available data to formulate a concise report such as a Watershed-Based Plan (MassDEP, n.d. (f)) to assess the basin as a whole for evaluation and selection of BMPs.
4. Continue to monitor for indicator bacteria during routine monitoring via random (probabilistic) sampling or by rotating basin.

At a minimum, monitoring should be conducted with a focus on:

- Capturing water quality conditions under varied weather conditions;
- Establishing sampling locations to pinpoint sources;
- Researching new and proven technologies for distinguishing human from animal pathogen sources in water samples; and
- Assessing efficacy of BMPs.

Additional information on water quality monitoring plans in Massachusetts is found in *A Strategy for Monitoring and Assessing the Quality of Massachusetts' Waters to Support Multiple Water Resource Management Objectives 2016-2025* (MassDEP, 2018a).

The Massachusetts Department of Public Health (DPH) regulations contain fecal indicator bacteria criteria and sampling protocols to protect the health and safety of bathers. DPH regulations apply to public and semi-public marine or fresh water bathing beaches in 105 CMR 445.000, *Minimum Standards for Bathing Beaches (State Sanitary Code, Chapter VII)* (DPH, 2014).

Agencies and organizations involved in water quality monitoring include the following:

- **The Massachusetts Department of Public Health (DPH)** publishes annual reports on the testing of public and semi-public beaches for both marine and fresh waters and notes where exceedances of water quality criteria result in beach closures. These reports are available for download from the DPH website (Environmental Toxicology Program, n.d.).
    - **DPH Environmental Toxicology Program (TOX)** conducts beach monitoring and assessments of human exposure to chemical, microbial, and radiological contaminants identified in environmental and biological media. TOX provides quantitative evaluations of the human health risk of exposure to these contaminants. TOX also provides qualitative evaluations of those risks through consultations and technical assistance provided to internal and external stakeholders, including the public, as well as local, state, and federal agencies.
- **The Massachusetts Department of Marine Fisheries (DMF)** conducts monitoring of shellfishing areas in accordance with the National Shellfishing Sanitation Program. These data, along with sanitary surveys, are used to make decisions regarding classification and closure of areas for shellfish harvest. Classification and restriction information is published on the DMF website (DMF, n.d.).
- **The Strategic Monitoring and Assessment for River basin Teams (SMART)** program assessed response and exposure indicators to determine threats to waterbodies. The SMART program was specifically designed for the Massachusetts Watershed Initiative, and the monitoring program was implemented in Central Massachusetts watersheds from 1998 to 2013. The SMART program included a focus on outreach, collaboration, and technical assistance to watershed groups, as well as a long-term monitoring program to identify trends in water quality in key rivers in central Massachusetts. The SMART program was implemented in six basins in MassDEP's Central Region through the cooperative efforts of the Division of Watershed Management (DWM), the Wall

Experiment Station, the Nashua River Watershed Association, and MassDEP’s Central Regional Office. Find more information and water quality technical memorandum associated with this project see the MassDEP website (MassDEP, 2013).

- **The Water Resources Research Center** supports research, education, and outreach on water resources issues of state, regional, and national importance as part of the national system of institutes authorized under the Water Resources Research Act of 1964. Established in 1965, the Center is now part of the Center for Agriculture, Food, and the Environment at the University of Massachusetts Amherst. The Center encourages an interdisciplinary approach to resolving state and regional water problems and has involved the University system and many other Massachusetts colleges and universities in Center research. The Center supports faculty research and training of graduate students and is a national leader in the use of volunteers for high quality monitoring of surface waters. Since 1990, the Massachusetts Water Watch Partnership (MassWWP) of the Center provides training and other technical assistance to citizen scientists who conduct water quality monitoring programs on the lakes, rivers, and estuaries of Massachusetts.
- **Surface water monitoring by volunteers** (such as watershed associations, stream teams, school groups, and individuals) contributes to MassDEP's watershed management approach. MassDEP is supporting volunteer data collection in streams and lakes in the Commonwealth through its water quality monitoring grants. MassDEP has provided funding to volunteer and educational groups to initiate, or expand, bacteria monitoring in their local watersheds and to submit the data for MassDEP assessment purposes. High quality data from volunteer programs support efforts to assess surface waters, manage nonpoint sources of pollutants, and calculate TMDLs.

7. Reasonable Assurances

USEPA guidance for developing pathogen TMDLs requires that in waters "impaired by both point and nonpoint sources, where a point source is given a less stringent WLA based on an assumption that nonpoint source load reductions will occur, reasonable assurance must be provided for the TMDL to be approvable" (USEPA, 2001). This TMDL does not include less stringent WLAs for point sources based on anticipation of LA reductions from nonpoint sources, and therefore, a reasonable assurance demonstration is not required. Nonetheless, reasonable assurances that LAs will be achieved are discussed below. Successful reduction in nonpoint sources depends on the willingness and motivation of stakeholders to get involved and the availability of federal, state, and local funds.

Reasonable assurances that the TMDL will be implemented include both application and enforcement of current regulations, availability of financial incentives including low interest loans to communities through the SRF, and the various local, state, and federal programs for pollution control. Stormwater NPDES permit coverage is designed to address discharges from municipal owned stormwater drainage systems. Enforcement of regulations controlling nonpoint source discharges includes local enforcement of the state Wetlands Protection Act and Rivers Protection Act, Title 5 regulations for septic systems, and various local regulations including zoning regulations. Financial incentives may include federal funds available under CWA § 319, 604(b), and 104(b) grant programs, which are provided as part of the Performance Partnership Agreement between MassDEP and USEPA. However, CWA § 319 funds to address nonpoint source pollution cannot be used for point source remediation or to address the requirements of NPDES stormwater permits. Additional financial incentives include state income tax credits and low interest loans for Title 5 upgrades through municipalities participating in this portion of the SRF program.

A summary of many of MassDEP's tools and regulatory programs to address common pathogen sources is presented below.

7.1. Overarching Tools

Watershed-Based Plans: It is recommended that implementation be conducted on a watershed basis and that more specific watershed plans, including watershed-based plans, be developed, where appropriate, to focus and prioritize appropriate restoration measures. For a general overview of watershed-based plans, see section 2 of the *Massachusetts Nonpoint Source Pollution 319 Grant Guidebook* (MassDEP, 2021b).

Massachusetts Clean Waters Act (M.G.L. Chapter 21, sections 26-53): The Massachusetts Clean Waters Act provides MassDEP with specific and broad authority to develop regulations that address both point and nonpoint sources of pollutants. There are numerous regulatory and financial programs, including those identified in the preceding paragraph, that have been established to directly and indirectly address pathogen impairments throughout the state. Several of these programs are briefly described below.

Massachusetts' Surface Water Discharge Permit Program (314 CMR 3.00): The NPDES permit program was administered jointly by the USEPA and MassDEP until June 2020. Massachusetts and USEPA now issue separate permits. Any pollutant discharge to surface waters of the Commonwealth requires a valid permit in accordance with 314 CMR 3.03(1). This includes general permits for Phase II stormwater discharges from small MS4s.

Massachusetts SWQS (314 CMR 4.00): The SWQS assign waterbody classifications (Class A, B, and C for fresh water; SA, SB, and SC for coastal and marine waters), each with specific designated uses, and establish water quality criteria to protect those uses. Bacteria criteria are established for each classification.

Ground Water Discharge Permit Program (314 CMR 5.00): This program regulates the discharge of pollutants to the groundwaters of the Commonwealth to ensure groundwaters are protected for their actual and potential use as a source of potable water and that surface waters are protected for their existing and designated uses to ensure attainment of applicable criteria established in the Massachusetts SWQS.

Rivers Protection Act (M.G.L. Chapter 258 Acts of 1996) and the Wetlands Protection regulation (310 CMR 10.00): In 1996, Massachusetts passed the Rivers Protection Act. The purposes of the Act are to protect the private or public water supply, to protect groundwater, to provide flood control, to prevent storm damage, to prevent pollution, to protect land containing shellfish, to protect wildlife habitat, and to protect fisheries. The provisions of the Act are implemented through Massachusetts' Wetlands Protection regulation, which establish up to a 200-foot setback from rivers in the Commonwealth to control construction activity and protect the items listed above. Although this Act does not directly address pathogen discharges, it indirectly reduces many sources of pathogens close to waterbodies. More information on the Rivers Protection Act and the Wetlands Protection regulation can be found on the MassDEP website (MassDEP, n.d. (e)).

Regulation of Plant Nutrients: In 2012, MDAR developed regulations (330 CMR 31.00) to ensure that plant nutrients are applied in an effective manner to provide sufficient nutrients for maintaining healthy agricultural lands, as well as turf and lawns, while minimizing the impacts of nutrients on surface and groundwater resources to protect human health and the environment. The regulations include setbacks from surface waters, public drinking water, and wetlands and seasonal application restrictions. While not directly focused on pathogen pollutants, the setback requirements can reduce pathogen loading in cases where manure is applied.

Regulation of Shellfishing: In Massachusetts, DMF oversees both commercial and recreational shellfishing, including designating the minimum shell size for scallops, oysters, and clams; these rules are published in 322 CMR, and recreational shellfishing limits are summarized on their website, *Recreational saltwater fishing regulations* (DMF, 2023). However, shellfishing for recreation is regulated at the municipal level. Shellfishing regulations specific to a municipality can be obtained from the town clerk, as well as the required permit and the locations of open and closed beds.

No Discharge Zone: In 2014, the USEPA and the MA Office of Coastal Zone Management (CZM) designated waters adjacent to the entire Massachusetts coastline as a No Discharge Zone (NDZ), in which the discharge of sewage from vessels, whether treated or untreated, is strictly prohibited (CZM, 2021). This action was taken to ensure that the public and water quality were protected from the threats associated with such discharges, including exposure to pathogens, nutrients, and other chemicals.

7.2. Addressing CSOs

CSOs discharge stormwater with untreated or partially treated human and industrial waste, toxic materials, and debris, and as a result are a significant source of pathogen contamination. Control or reduction of CSOs will result in improvements to water quality in the receiving waters.

Massachusetts, in concert with USEPA Region 1, has established a detailed CSO abatement program and policy. CSO discharges are regulated by the Commonwealth in several ways. Like any discharge of pollutants, CSOs must have a NPDES Permit and Massachusetts' Surface Water Discharge Permit under federal and State regulations.

All permits for a CSO discharge must comply with the Massachusetts SWQS (314 CMR 4.00), which additionally provide the basis for water quality-based effluent limitations in discharge permits. Any discharge, including CSOs, is allowed only if it meets water quality criteria for the receiving segment and the antidegradation provisions. USEPA's 1994 CSO Control Policy revised some features of its 1989 version to provide greater flexibility by allowing a minimal number of overflows, which are compatible with the water quality goals of the CWA. MassDEP's 1995 regulatory revisions correspondingly decreased reliance on partial use designation as the sole regulatory vehicle to support CSO abatement plans (MassDEP, 1997).

NPDES/MA permits require the nine minimum controls necessary to meet technology-based limitations as specified in the 1994 USEPA Policy. The nine minimum controls may be summarized as: operate and maintain properly, maximize storage, minimize overflows, maximize flows to POTWs, prohibit dry weather CSOs, control solids and floatables, institute pollution prevention programs, notify the public on impacts, and observe monitoring and reporting requirements. The nine minimum controls may be supplemented with additional treatment requirements, such as screening and disinfection, on a case-by-case basis. The MassDEP's goal is to eliminate adverse CSO impacts and attain the highest water quality achievable. Separation or relocation of CSOs is required wherever it can be achieved based on an economic and technical evaluation.

As untreated CSOs cause violations of SWQS, and thus are in violation of NPDES permits, all the Commonwealth's CSO permittees are under enforcement orders to either eliminate the CSO, or plan, design, and construct CSO abatement facilities. Each LTCP must identify and achieve the highest feasible level of control. The process also requires the permittee to comply with any approved TMDL. There are 19 CSO communities in the Commonwealth (MassDEP, 2019b).

7.3. Addressing Failed Septic Systems

Septic System Regulations (Title 5) (310 CMR 15.00): MassDEP has regulations in place that require minimum standards for the design of individual septic systems. Those regulations ensure, in part, protection for nearby surface and ground waters from pathogen contamination. The regulations require minimum setbacks from surface waters and drinking water wells, standards for replacing failed and inadequate systems and include a requirement that all septic systems must be inspected and upgraded to meet Title 5 requirements at the time of sale or transfer of each property.

7.4. Addressing Stormwater

Stormwater is regulated through both federal and state programs. Those programs include, but are not limited to, the federal and state Phase I and Phase II NPDES stormwater program, and, at the state level, the Wetlands Protection Act (M.G.L. Chapter 130, Section 40), the Massachusetts SWQS (314 CMR 4.00), and the various permitting programs previously identified in Section 5.

Operators of regulated MS4s are required to design stormwater management programs to 1) reduce the discharge of pollutants to the MEP, 2) protect water quality, and 3) satisfy the appropriate water quality requirements of the CWA. Implementation of the MEP standard typically requires the development and implementation of BMPs and the achievement of measurable goals to satisfy each of the six minimum control measures mentioned in Sections 3 and 5. In addition, each permittee must determine if a TMDL has been developed and approved for any waterbody into which an MS4 discharges. If a TMDL has been approved, then the permittee must comply with the TMDL including the application of BMPs or other performance requirements. The permittee must report annually on all control measures planned or currently being implemented to control pollutants of concern identified in TMDLs. Although USEPA's Phase II MS4 regulations only require MS4 implementation in urbanized areas subject to permitting, USEPA and MassDEP nonetheless encourage permittees to update and implement their respective SWMPs jurisdiction-wide to further water quality improvements. Finally, MassDEP has the authority to issue an individual permit to achieve water quality objectives. Links to the Massachusetts Phase II permit and other stormwater control guidance can be found on the MassDEP website (MassDEP, 2020c).

The MassDEP wetlands regulations (310 CMR 10.0) direct issuing authorities to enforce the MassDEP Stormwater Management Policy, place conditions on the quantity and quality of point source discharges, and to control erosion and sedimentation. The Stormwater Management Policy was issued under the authority of 310 CMR 10.0. The policy and its accompanying Stormwater Performance Standards apply to new and redevelopment projects where there may be an alteration to a wetland resource area or within 100 feet of a wetland resource (buffer zone). The policy requires the application of structural and/or non-structural BMPs to control suspended solids, which have associated co-benefits for pathogen removal. The Massachusetts Stormwater Handbook was developed to promote consistent interpretation of the Stormwater Management Policy and Performance Standards: Volumes 1 through 3. It provides guidance on increased stormwater recharge, treatment of runoff from polluting land use, LID techniques, pollution prevention, removal of illicit discharges, and improved operation and maintenance of stormwater BMPs (MassDEP, 2008).

7.5. Financial Tools

MassDEP has developed a Nonpoint Source Management Plan that sets forth an integrated strategy and identifies important programs to prevent, control, and reduce pollutants from nonpoint sources and to protect and restore the quality of waters in the Commonwealth. Section (§) 319 of the federal CWA specifies the contents of the management plan. The plan is an implementation strategy to address nonpoint source pollution management in the Commonwealth, with attention given to funding sources and schedules. Statewide implementation of the plan is being accomplished through a wide variety of federal, state, local, and non-profit programs and partnerships.

In addition, the State is partnering with NRCS to provide implementation incentives through the national Farm Bill. As a result of this effort, NRCS now prioritizes its EQIP funds based on MassDEP's list of impaired waters. The program also provides high priority points to those projects designed to address TMDL recommendations. Over the past several years, EQIP funds have been used throughout the Commonwealth to address water quality goals through the application of structural and non-structural BMPs.

Section 604(b) of the federal CWA authorizes the awarding of funds through the USEPA to states for water quality assessment and management planning grants. The Nonpoint Source Management Section in MassDEP's Watershed Planning Program administers the 604(b) grant program in Massachusetts. Eligible applicants for 604(b) grants include municipalities, regional planning agencies, conservation districts, counties, and interstate agencies. Each year MassDEP's priority topics and basins are listed in the Request for Proposals (RFP). The 604(b) RFP is usually released in late January with proposals due approximately 8 weeks later. Recent priority topics for 604(b) grant applications have included the following:

- Development of watershed-based plans
- Identification of the nature, extent, and causes of water quality problems
- Determination of pollutant load reductions necessary to meet SWQS
- Development of municipal and regional approaches to stormwater issues including coordination of technical information sharing among communities and creation of stormwater utilities in regulated and non-regulated communities
- Development of green infrastructure projects that manage wet weather to maintain or restore natural hydrology
- Development of implementation plans that will address water quality impairments in impaired watersheds

The Nonpoint Source Management Section in MassDEP's Watershed Planning Program also administers the CWA § 319 grant program in Massachusetts to implement nonpoint source BMPs that address water quality goals. CWA § 319 funding is used to apply needed implementation measures and provide high priority points for projects that are designed to address CWA § 303(d) listed waters and to implement TMDLs. MassDEP has funded numerous projects through the § 319 grant program that were designed to address stormwater and pathogen-related impairments. Approximately 75% of all projects funded since 2002 were designed to address pathogen-related impairments. Under USEPA guidance issued in 2003, § 319 funds cannot be used to address the requirements of NPDES permits, including MS4, Residual Designation, and Phase I and Phase II permits (USEPA, 2020). Stormwater and urban implementation projects may be eligible for funding if not required as part of the stormwater permit and the communities desire credit under the permit. Applicants are advised to contact MassDEP's Watershed Planning Program regarding eligibility. For a general overview of the Section 319 grant program, see the *Massachusetts Nonpoint Source Pollution 319 Grant Guidebook* (MassDEP, 2021b). The § 319 program also provides additional assistance in the form of guidance. The Massachusetts Clean Water Toolkit (MassDEP, 2019a) provides detailed guidance in the form of BMPs by land use type to address various water quality impairments and associated pollutants.

The SRF Loan Program provides low interest loans to eligible applicants for the abatement of water pollution problems across the Commonwealth. MassDEP has issued millions of dollars in loans for the planning and construction of CSO facilities and to address stormwater pollutants. Loans have also been distributed to municipal governments statewide to upgrade and replace failed Title 5 systems. These programs all demonstrate the State's commitment to assist local governments in implementing the TMDL recommendations. More information is available on the MassDEP website (MassDEP, 2020b).

Grants also exist specifically for stormwater. The Massachusetts Stormwater MS4 Municipal Assistance Grant Program, introduced in 2017, enables groups of Massachusetts municipalities to expand their efforts to meet requirements for the 2016 Small Municipal Separate Storm Sewer System (MS4) General Permits, and to reduce stormwater pollution through coordinated partnerships that emphasize resource sharing.

MassDEP's Watershed Planning Program provided water quality monitoring grant opportunities in State Fiscal Years 2019 to 2023 for tribal nations and/or nonprofit organizations to monitor water quality including collections of indicator bacteria data for use in water quality assessments.

- SFY2019: Bacteria monitoring of surface waters ($200,000) to 17 recipients ($3,303 to $15,000)
- SFY2020: Bacteria monitoring of surface waters ($200,000) to 14 recipients ($3,222 to $15,000)
- SFY2021: Equipment and supplies grants ($100,000) to two coalitions representing 14 entities ($45,474 and $54,526)
- SFY2022: Direct monitoring of surface waters through field and laboratory work of numerous priority analytes including bacteria ($150,000) to three coalitions representing 13 entities ($51,960 to $38,306) and partial funding to one coalition representing three entities ($16,109)
- SFY2023: Direct monitoring of surface waters through field and laboratory work of numerous priority analytes including bacteria ($500,000) to six individual Eligible Entities and coalitions representing 24 entities ($26,007-$95,588), and partial funding to three individual Eligible Entities ($13,378 -$114,789).

MassDEP's goal in offering these grants is to support ongoing or new monitoring and data collection efforts to increase the amount of external data MassDEP uses for water quality assessments. MassDEP supplements its own surface water quality dataset ("internal dataset") with data collected by entities outside of the agency ("external dataset"). Internal and certain external data meeting MassDEP's acceptance criteria for data quality are used as the basis for assessing surface water quality in accordance with requirements set forth in § 305(b) and § 303(d) of the federal CWA. This includes external data for assessment of pathogen impairment. Future grant opportunities will be dependent on the availability of State funding.

The CZM Coastal Pollution Remediation grant program provides funding to municipalities located within the Massachusetts coastal watershed to address stormwater runoff pollution and boat waste from commercial vessels. Eligible projects include stormwater pollutant identification and assessment; BMP selection, design, permitting and construction; and commercial boat-waste pumpout projects. Projects must focus on waters that directly connect to the coast (i.e., inland ponds/lakes with no flow connection to coastal waters through day-lighted or culverted streams, or impacts to groundwater, are not eligible project areas). Additional funding through grant programs is also available to restore waterbodies through the Buzzards Bay National Estuary Partnership and Massachusetts Bay National Estuary Partnership.

A complete list of funding sources for implementation of nonpoint source pollutants is provided in the report, *2020-2024 Massachusetts Nonpoint Source Management Program Plan* (MassDEP, 2019c), *Nonpoint Source Pollution* (MassDEP, 2019d) and appendix A of the *Massachusetts Nonpoint Source Pollution 319 Grant Guidebook* (MassDEP, 2021b). These lists include specific programs available for nonpoint source management and resources available for communities to manage local growth and development. The SRF provides low interest loans to communities for certain capital costs associated with building or improving WWTFs. In addition, many communities in Massachusetts sponsor low-cost loans through the SRF for homeowners to repair or upgrade failing septic systems.

MassDEP's approach and existing programs provide a wide variety of tools that both MassDEP and communities can use to address pathogens based on land use and common pathogen sources (e.g., CSOs, failing septic systems, stormwater and illicit connections, pet waste, etc.). The necessary remedial actions to address pathogen sources are well established. MassDEP's authority combined with the programs identified above provide reasonable assurance that implementation of remedial actions will occur.

8. Public Participation

Public meetings to present the results of this TMDL report and answer questions were held in 2024 on May 8th, May 9th, and June 13th. The May 8th meeting was held in-person at the MassDEP Central Regional Office (CERO) in Worcester from 1 p.m. to 3 p.m. and marked the beginning of the public comment period. The May 9th meeting was held virtually via Zoom from 6 p.m. to 8 p.m. and presented the same information as the May 8th meeting. Each meeting was open to anyone throughout the Commonwealth to attend.

A notice of the public meetings was issued through a press release, a notice was placed in the Massachusetts Environmental Policy Act (MEPA) Monitor, and an email was sent to interested parties, including Environmental Justice (EJ) and Tribal communities. A copy of the draft TMDL was published on the MassDEP website.

To supplement the MEPA public notice and MassDEP press release, the Watershed Planning Program sent a notification for the Draft TMDL and information sessions on April 2, 2024, via an email distribution list to 600+ contacts. The notification was also sent to all MassDEP Environmental Justice (EJ) and Tribal contacts. This list included a contact for the Massachusetts Environmental Health Association and the Massachusetts Association of Conservation Commissions. Notice was also posted on the MassDEP Public Hearings & Comment Opportunities webpage.

An additional hybrid public information session held on June 13, 2024, at the MassDEP Southeastern Regional Office (SERO) in Lakeville from 1 p.m. to 3 p.m., was open to anyone throughout the state who wanted to attend in person or remotely via Zoom. The Watershed Planning Program sent a notification for the Draft TMDL and information sessions (and extended public comment period) on June 5th via an email distribution list previously mentioned.

MassDEP presented the same information at each public meeting. Timothy Fox and Holly Brown, TMDL Analysts in the Watershed Planning Program (WPP) at MassDEP, summarized the Statewide Pathogen TMDL Report findings. Additional MassDEP staff were present to respond to questions including Matthew Reardon (TMDL Section Chief, WPP), Richard Carey (Director, WPP) and Lealdon Langley (Director, Division of Watershed Management).

The public comment period was extended to 5 p.m., June 21, 2024. Public comments received during the public meetings and comments received in writing within an extended comment period following the public meetings were considered by the Department. This final version of the TMDL report includes a summary of the public comments, the Department's response to the comments, and attendance records from the virtual meeting and physical meeting (Appendix AC).

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10. Appendices

Appendices A through AB contain summaries of each impaired segment, GIS-based maps showing sampling locations and surrounding watershed areas, the TMDL calculations and percent reductions needed, and recommendations for management activities to achieve the necessary pollutant reduction. Each appendix represents a major watershed as follows:

Appendix A: Hoosic River Basin [3 impaired segments]
Appendix B: Housatonic River Basin [4 impaired segments]
Appendix C: Westfield River Basin [10 impaired segments]
Appendix D: Deerfield River Basin [7 impaired segments]
Appendix E: Connecticut River Basin [15 impaired segments]
Appendix F: Millers River Basin [1 impaired segments]
Appendix G: Chicopee River Basin [17 impaired segments]
Appendix H: Quinebaug River Basin [7 impaired segments]
Appendix I: French River Basin [4 impaired segments]
Appendix J: Blackstone River Basin [19 impaired segments]
Appendix K: Ten Mile River Basin [7 impaired segments]
Appendix L: Narragansett Bay (Shore) Coastal Drainage Area [3 impaired segments]
Appendix M: Mount Hope Bay (Shore) Coastal Drainage Area [2 impaired segments]
Appendix N: Taunton River Basin [1 impaired segments]
Appendix O: Mystic River Basin and Coastal Drainage Area [3 impaired segments]
Appendix P: Charles River Basin and Coastal Drainage Area [7 impaired segments]
Appendix Q: Neponset River Basin and Coastal Drainage Area [2 impaired segments]
Appendix R: Weymouth & Weir River Basin and Coastal Drainage Area [6 impaired segments]
Appendix S: Nashua River Basin [19 impaired segments]
Appendix T: Concord (SuAsCo) River Basin [17 impaired segments]
Appendix U: Shawsheen River Basin [1 impaired segments]
Appendix V: Merrimack River Basin and Coastal Drainage Area [34 impaired segments]
Appendix W: Ipswich River Basin and Coastal Drainage Area [9 impaired segments]
Appendix X: North Shore Coastal Drainage Area [4 impaired segments]
Appendix Y: South Shore Coastal Drainage Area [3 impaired segments]
Appendix Z: Buzzards Bay Coastal Drainage Area [11 impaired segments]
Appendix AA: Cape Cod Coastal Drainage Area [10 impaired segments]
Appendix AB: Islands Coastal Drainage Area [2 impaired segments]

Several segment watersheds extend outside of Massachusetts and into neighboring states and even Canada in the case of the Connecticut River watershed. Some statistics, mapping products, and/or segment descriptions cover all or a portion of the segment watersheds, depending on available data and the intended use of the data. Generally, pollutant sources and sensitive environmental areas were identified for Massachusetts only. A list of these data, including their coverage and source(s), are provided in Table 11 to better guide interpretation of information presented in the appendices.

Table 11. List of GIS layer files, including their coverage and source(s), used for mapping and segment descriptions in the appendices.

LAYER	COVERAGE	SOURCE
Watersheds	Complete watersheds	MassDEP with FBE review
Land Cover	Complete watersheds	MassGIS, VCGI, NHGRANIT, RIGIS, UCONNCLEAR, NRCAN
Impervious Cover	Complete watersheds, except the portion of the Connecticut River watershed (MA34-03, MA34-04, and MA34-05) which extends into Canada, a portion of the Connecticut River watershed in New Hampshire. Additionally, coverage is only available for Strafford and Rockingham counties and portions of Carroll and Belknap counties in NH.	MassGIS, VCGI, RIGIS, UCONNCLEAR
Directly Connected Impervious Area	Complete watersheds. Note for Connecticut River watershed segments (MA34-03, MA34-04, and MA34-05): impervious cover was not included for Canada and a portion of New Hampshire, therefore those areas were considered completely pervious.	MassDEP from available Land Cover and Impervious layers
MS4 Urban Area	Complete Watersheds (except Canada)	Data.gov
Sewer Service Area	Used as a general guide in each watershed discussion. Not represented on any map.	MassGIS, VCGI, RIGIS, UCONNCLEAR
Areas of Critical Environmental Concern	Massachusetts Only	MassGIS
NHESP Priority Habitats of Rare Species	Massachusetts Only	MassGIS
NHESP Natural Communities	Massachusetts Only	MassGIS
Public Water Supply Reservoir Watershed (Zone A)	Massachusetts Only	MassGIS
Outstanding Resource Waters	Massachusetts Only	MassGIS
Conserved Land Protected in Perpetuity	Complete watersheds, except the portion of the Connecticut River watershed in Canada.	MassGIS, VCGI, NHGRANIT, RIGIS, UCONNCLEAR
Protected and Recreational Open Space	Massachusetts Only, with other states (except Canada) representing only conserved lands protected in perpetuity and not recreational open spaces or similar.	MassGIS, VCGI, NHGRANIT, RIGIS, UCONNCLEAR
NPDES Major, Minor, Industrial Permitted Wastewater Discharge to Surface Waters	Massachusetts Only	MassDEP
DEP Ground Water Discharge Permits	Massachusetts Only	MassDEP
Combined Sewer Overflow	Massachusetts Only	MassGIS
Unpermitted Land Disposal Dumping Grounds	Massachusetts Only	MassGIS
Landfills	Complete Watersheds (except Canada)	MassGIS, VCGI, NHDES, NHGRANIT, RIGIS, UCONNCLEAR

All layers outside of MA were projected into NAD_1983_StatePlane_Massachusetts_Mainland_FIPS_2001
***MassGIS**- Massachusetts Geographic Information System*
***MassDEP**- Massachusetts Department of Environmental Protection*
***VCGI**- Vermont Center for Geographic Information*
***NHGRANIT**- New Hampshire Geographically Referenced Analysis and Information Transfer System*
***NHDES**- New Hampshire Department of Environmental Services*
***RIGIS**- Rhode Island Geographic Information System*
***UCONNCLEAR**- University of Connecticut Center for Land Use Educational and Research*
***NRCAN**- Natural Resources of Canada*