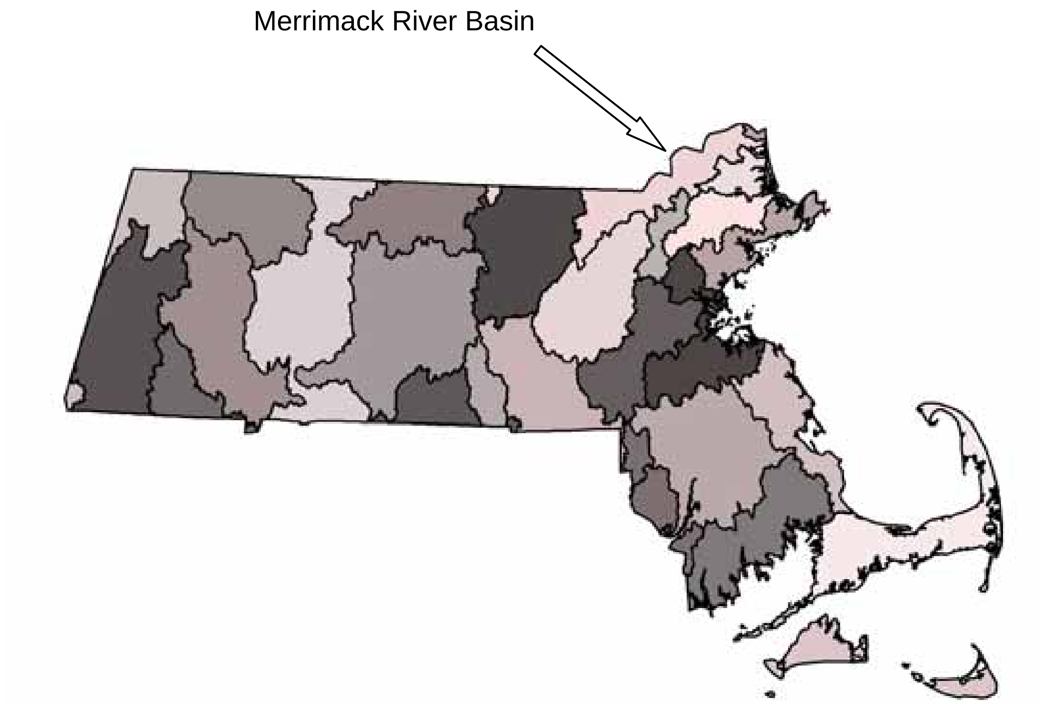
Draft Pathogen TMDL for the Merrimack River Watershed



Prepared as a cooperative effort by:

Massachusetts DEP
1 Winter Street
Boston, Massachusetts 02108

USEPA New England Region 1
1 Congress Street, Suite 1100
Boston, Massachusetts 02114

ENSR International
2 Technology Park Drive
Westford, MA 01886

NOTICE OF AVAILABILITY

Limited copies of this report are available at no cost by written request to:

Massachusetts Department of Environmental Protection (MADEP)
Division of Watershed Management
627 Main Street
Worcester, Massachusetts 01608

This report is also available from MADEP's home page on the World Wide Web.

A complete list of reports published since 1963 is updated annually and printed in July. This list, titled "Publications of the Massachusetts Division of Watershed Management (DWM) – Watershed Planning Program, 1963-(current year)", is also available by writing to the DWM in Worcester.

DISCLAIMER

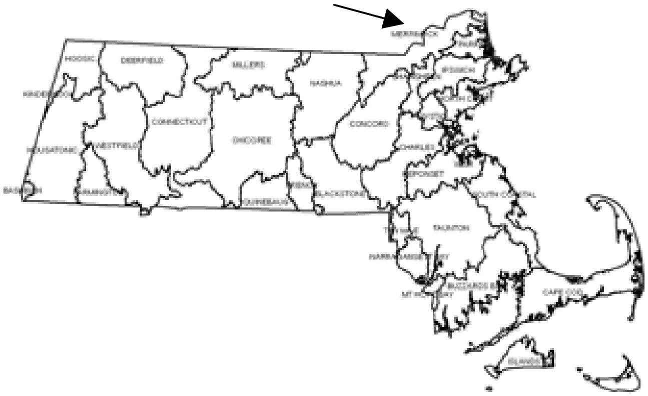
References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendations by the Division of Watershed Management for use.

Much of this document was prepared using text and general guidance from the previously approved Neponset River Basin and the Palmer River Basin Bacteria Total Maximum Daily Load documents.

Acknowledgement
This report was developed by ENSR through a partnership with Resource Triangle Institute (RTI) contracting with the United States Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection Agency under the National Watershed Protection Program.

Draft Total Maximum Daily Loads for Pathogens within the Merrimack River Watershed

Location of the Merrimack River Basin



Key Features: Pathogen TMDL for the Merrimack River Watershed
Location: EPA Region 1
Land Type: New England Upland/Coastal
303(d) Listings: Pathogens

Back River (MA84A-16);
Bare Meadow Brook (MA84A-18);
Beaver Brook (MA84A-11; MA84B-02);
Black Brook (MA84A-17);
Deep Brook (MA84A-21);
Little River (MA84A-09);
Merrimack River (MA84A-01; MA84A-02; MA84A-03; MA84A-04; MA84A-05; MA84A-06; MA84A-26);
Plum Island River (MA84A-27);
Powwow River (MA84A-08; MA84A-25; MA84A-28);
Spicket River (MA84A-10);
Stony Brook (MA84B-03; MA84B-04);
Unnamed Tributary (MA84B-01).

Data Sources:

- MADEP “Merrimack River Basin 1999 Water Quality Assessment Report”
- CDM “Merrimack River Watershed Assessment Study: Summary of Information on Pollutant Sources”

Data Mechanism: Massachusetts Surface Water Quality Standards for Fecal Coliform; The Federal BEACH Act; Massachusetts Department of Public Health Bathing Beaches; Massachusetts Division of Marine Fisheries Shellfish Sanitation and Management; Massachusetts Coastal Zone Management

Monitoring Plan: Massachusetts Watershed Five-Year Cycle

Control Measures: Watershed Management; Storm Water Management (e.g., illicit discharge removals, public education/behavior modification); CSO & SSO Abatement; BMPs; By-laws; No Discharge Areas; By-Laws; Ordinances; Septic System Maintenance/Upgrades; Waterfowl Deterrents

Executive Summary

Purpose and Intended Audience

This document provides a framework to address bacterial and other fecal-related pollution in surface waters of Massachusetts. Fecal contamination of our surface waters is most often a direct result of the improper management of human wastes, excrement from barnyard animals, pet feces and agricultural applications of manure. It can also result from large congregations of birds such as geese and gulls. Illicit discharges of boat waste are of particular concern in coastal areas. Inappropriate disposal of human and animal wastes can degrade aquatic ecosystems and negatively affect public health. Fecal contamination can also result in closures of shellfish beds, beaches, swimming holes and drinking water supplies. The closure of such important public resources can erode quality of life and diminish property values.

Who should read this document?

The following groups and individuals can benefit from the information in this report:

a) towns and municipalities, especially Phase I and Phase II storm water communities, that are required by law to address storm water and/or combined sewage overflows (CSOs) and other sources of contamination (e.g., broken sewerage pipes and illicit connections) that contribute to a waterbody's failure to meet Massachusetts Water Quality Standards for pathogens;

b) watershed groups that wish to pursue funding to identify and/or mitigate sources of pathogens in their watersheds;

c) harbormasters, public health officials and/or municipalities that are responsible for monitoring, enforcing or otherwise mitigating fecal contamination that results in beach and/or shellfish closures or results in the failure of other surface waters to meet Massachusetts standards for pathogens;

d) citizens that wish to become more aware of pollution issues and may be interested in helping build local support for funding remediation measures.

TMDL Overview

The Massachusetts Department of Environmental Protection (MADEP) is responsible for monitoring the waters of the Commonwealth, identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Water Quality Standards (WQS). The list of impaired waters, better known as the "303d list" identifies problem lakes, coastal waters and specific segments of rivers and streams and the reason for impairment.

Once a water body is identified as impaired, the MADEP is required by the Federal Clean Water Act (CWA) to develop a "pollution budget" designed to restore the health of the impaired body of water. The process of developing this budget, generally referred to as a Total Maximum Daily Load (TMDL), includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and assigning pollutant load allocations to the sources. A plan to implement the necessary pollutant reductions is essential to the ultimate achievement of meeting the water quality standards.

Pathogen TMDL: This report represents a TMDL for pathogen indicators (e.g. fecal coliform, *E. coli*, and enterococcus bacteria) in the Merrimack River watershed. Certain bacteria, such as coliform, *E. coli*, and enterococcus bacteria, are indicators of contamination from sewage and/or the feces of warm-blooded wildlife (mammals and birds). Such contamination may pose a risk to human health. Therefore, in order to prevent further degradation in water quality and to ensure that waterbodies within the watershed meet state water quality standards, the TMDL establishes indicator bacteria limits and outlines corrective actions to achieve that goal.

Sources of indicator bacteria in the Merrimack River watershed were found to be many and varied. Most of the bacteria sources are believed to be storm water related. Table ES-1 provides a general compilation of likely bacteria sources in the Merrimack River watershed including failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland storm water runoff. Note that bacteria from wildlife would be considered a natural condition unless some form of human inducement, such as feeding, is causing congregation of wild birds or animals. A discussion of pathogen related control measures and best management practices are provided in the companion document: "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*".

This TMDL applies to the 22 pathogen impaired segments of the Merrimack River watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing "pollution prevention TMDLs" consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Merrimack River watershed 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 taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations. These data indicate that in general two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loading will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of best management practices, such as those associated with the Phase II control program for storm water. This later effort will be benefiting from a study funded through the Army Corps of Engineers, and coordinated by CSO communities in New Hampshire and Massachusetts along with several state and federal agencies.

TMDL goals for each type of bacteria source are provided in Table ES-1. Municipalities are the primary responsible parties for eliminating many of these sources. TMDL implementation to achieve these goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. Certain towns in the watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. Combined sewer overflows will be addressed through the on-going long-term control plans.

In most cases, authority to regulate non-point source pollution and thus successful implementation of this TMDL is limited to local government entities and will require cooperative support from local volunteers, watershed associations, and local officials in municipal government. Those activities can take the form of expanded education, obtaining and/or providing funding, and possibly local enforcement. In some cases, such as subsurface disposal of wastewater from homes, the Commonwealth provides the framework, but the administration occurs on the local level. Among federal and state funds to help implement this TMDL are, on a competitive basis, the Non-Point Source Control (CWA Section 319) Grants, Water Quality (CWA Section 604(b)) Grants, and the State Revolving (Loan) Fund Program (SRF). Most financial aid requires some local match as well. The programs mentioned are administered through the MADEP. Additional funding and resources available to assist local officials and community groups can be referenced within the Massachusetts

Non-point Source Management Plan-Volume I Strategic Summary (2000) "Section VII Funding / Community Resources". This document is available on the MADEP's website at: www.state.ma.us/dep/brp/wm/wmpubs.htm, or by contacting the MADEP's Nonpoint Source Program at (508) 792-7470 to request a copy.

Table ES-1. Sources and Expectations for Limiting Bacterial Contamination in the Merrimack River Watershed.

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
A, B, SA, SB	Illicit discharges to storm drains	0	N/A
A, B, SA, SB	Leaking sanitary sewer lines	0	N/A
A, B, SA, SB	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[2]	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]
B & Not Designated for Shellfishing SA & SB	CSOs	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[4]	N/A
B & Not Designated for Shellfishing SA & SB	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[2]	N/A
B & Not Designated for Shellfishing SA & SB	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]	N/A
B & Not Designated for Shellfishing SA & SB	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
SA Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[2]	N/A
SA Designated Shellfishing Areas	Storm water Runoff Phase I and II	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]	N/A
SA Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]
SB Designated Shellfishing Areas	CSOs	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[4]	N/A
SB Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[2]	N/A
SB Designated Shellfishing Areas	Storm water runoff Phase I and II	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]	N/A
SB Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]
Marine Beaches[5]	All Sources	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
Fresh Water Beaches[6]	All Sources	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies

N/A means not applicable

[1] Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

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

[3]The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

[4] Or shall be consistent with an approved Long Term Control Plan (LTCP) for Combined Sewer Overflow (CSO) abatement. If the level of control specified in the LTCP is less than what is necessary to attain Class B water quality standards, then the above criteria apply unless MADEP has proposed and EPA has approved water quality standards revisions for the receiving water.

[5] Federal Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) Water Quality Criteria

[6] Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

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1.0 Introduction

Section 303(d) of the Federal Clean Water Act (CWA) and Environmental Protection Agencies (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies (commonly referred to as the "303d List") and to develop Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant(s) contributing to the impairment. In Massachusetts, impaired waterbodies are included in Category 5 of the "*Massachusetts Year 2002 Integrated List of Water: Part 2- Final Listing of Individual Categories of Waters*" (*2002 List*; MADEP 2003). Figure 1-1 provides a map of the Merrimack River watershed with pathogen impaired segments indicated. Please note that not all segments have been assessed by the Massachusetts Department of Environmental Protection (MADEP) for pathogen impairment. As shown in Figure 1-1, much of the Merrimack River watershed waterbodies are listed as a Category 5 "impaired or threatened for one or more uses and requiring a TMDL" due to excessive indicator bacteria concentrations.

TMDLs are to be developed for water bodies that are not meeting designated uses under technology-based controls only. TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating water quality standards. The TMDL process establishes the maximum allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollutant sources and instream conditions. The TMDL process is designed to assist states and watershed stakeholders in the implementation of water quality-based controls specifically targeted to identified sources of pollution in order to restore and maintain the quality of their water resources (USEPA 1999). TMDLs allow watershed stewards to establish measurable water quality goals based on the difference between site-specific instream conditions and state water quality standards.

A major goal of this TMDL is to achieve meaningful environmental results with regard to the designated uses of the Merrimack River watershed waterbodies. These include water supply, shellfish harvesting, fishing, boating, and swimming. This TMDL establishes the necessary pollutant load to achieve designated uses and water quality standard and the companion document entitled; "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" provides guidance for the implementation of this TMDL.

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 lakes, ponds, or river segments. While this localized approach may be appropriate under certain situations, it typically fails to characterize the more subtle 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 wildfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These so called nonpoint sources of pollution often contribute significantly to the decline of water quality through their cumulative impacts. A watershed-level 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

Figure 1-1. Merrimack River Watershed and Pathogen Impaired Segments

problem areas or “hot spots” which may detrimentally affect water and sediment quality. It is within this watershed-level framework that the MADEP commissioned the development of watershed based TMDLs.

1.1. Pathogens and Indicator Bacteria

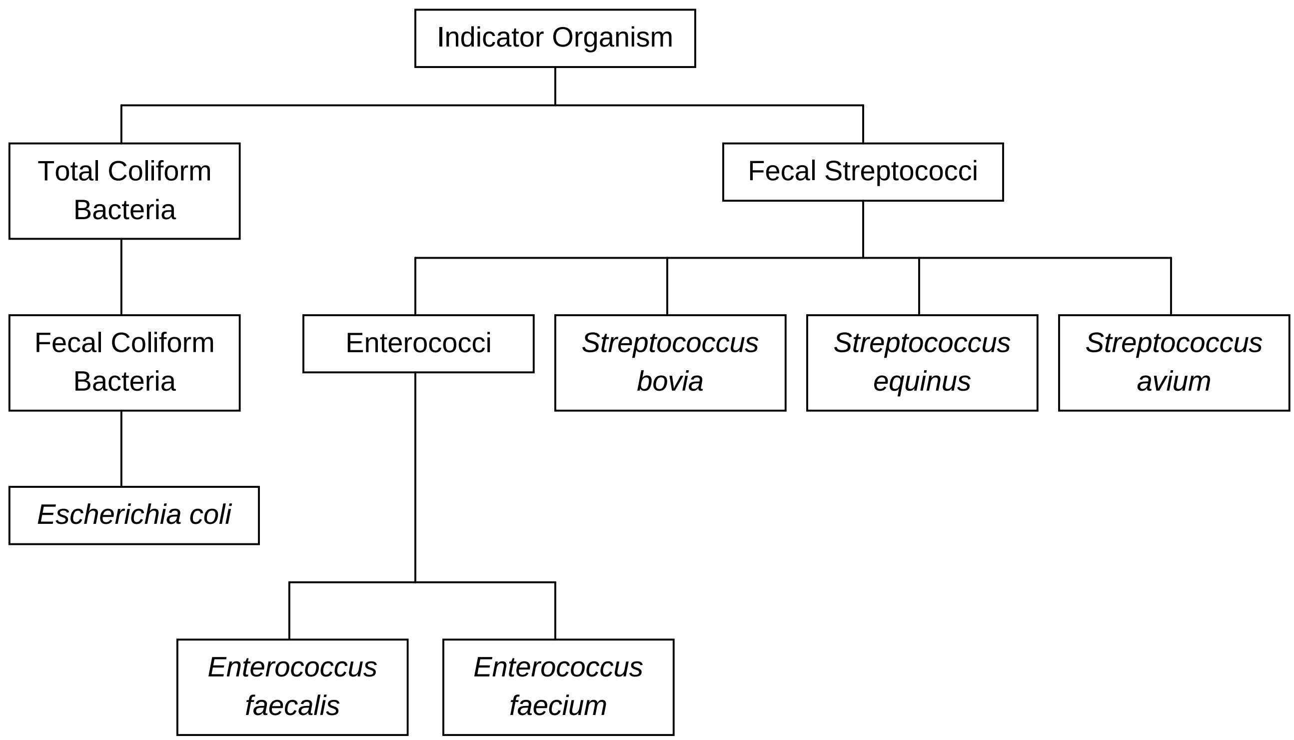
The Merrimack River watershed pathogen TMDL is designed to support reduction of waterborne disease-causing organisms, known as pathogens, to reduce public health risk. Waterborne pathogens enter surface waters from a variety of sources including sewage and the feces of warm-blooded wildlife. These pathogens can pose a risk to human health due to gastrointestinal illness through exposure via ingestion and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish.

Waterborne pathogens include a broad range of bacteria and viruses that are difficult to identify and isolate. Thus, specific nonpathogenic bacteria have been identified that are typically associated with harmful pathogens in fecal contamination. These associated nonpathogenic bacteria are used as indicator bacteria as they are easier to identify and measure in the environment. High densities of indicator bacteria increase the likelihood of the presence of pathogenic organisms.

Selection of indicator bacteria is difficult as new technologies challenge current methods of detection and the strength of correlation of indicator bacteria and human illness. Currently, coliform and fecal streptococci bacteria are commonly used as indicators of potential pathogens (i.e., indicator bacteria). Coliform bacteria include total coliforms, fecal coliform and *Escherichia coli* (*E. coli*). Fecal coliform (a subset of total coliform) and *E. coli* (a subset of fecal coliform) bacteria are present in the intestinal tracts of warm blooded animals. Presence of coliform bacteria in water indicates fecal contamination and the possible presence of pathogens. Fecal streptococci bacteria are also used as indicator bacteria, specifically enterococci a subgroup of fecal streptococci. These bacteria also live in the intestinal tract of animals, but their presence is a better predictor of human gastrointestinal illness than fecal coliform since the die-off rate of enterococci is much lower (i.e., enterococci bacteria remain in the environment longer) (USEPA 2001). The relationship of indicator organisms is provided in Figure 1-2. The EPA, in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document, recommends the use of *E. coli* or enterococci as potential pathogen indicators in fresh water and enterococci in marine waters (USEPA 1986).

Massachusetts uses fecal coliform and enterococci as indicator organisms of potential harmful pathogens. The WQS that apply to fresh waters are currently based on fecal coliform concentration but will be replaced with *E. coli.* Fecal coliform are also used by the Massachusetts Division of Marine Fisheries (DMF) in their classification of shellfish growing areas. Fecal coliform as the indicator organism for shellfish growing area status is not expected to change at this time. Enterococci are used as the indicator organism for marine beaches, as required by the Beaches Environmental Assessment and Coastal Act of 2000 (BEACH Act), an amendment to the CWA.

Figure 1-2. Relationships among Indicator Organisms (USEPA 2001).



The Merrimack River watershed pathogen TMDLs have been developed using fecal coliform as an indicator bacterium for fresh and marine waters and enterococci for marine beaches. Any changes in the Massachusetts pathogen water quality standard will apply to this TMDL at the time of the standard change. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

1.2. Comprehensive Watershed-based Approach to TMDL Development

Consistent with Section 303(d) of the CWA, the MADEP has chosen to complete pathogen TMDLs for all waterbodies in the Merrimack River watershed at this time, regardless of current impairment status (i.e., for all waterbody categories in the *2002 List*). MADEP believes a comprehensive management approach carried out by all watershed communities is needed to address the ubiquitous nature of pathogen sources present in the Merrimack River watershed. Watershed-wide implementation is needed to meet WQS and restore designated uses in impaired segments while providing protection of desirable water quality in waters that are not currently impaired or not assessed.

As discussed below, this TMDL applies to the 22 pathogen impaired segments of the Merrimack River watershed that are currently listed on the CWA § 303(d) list of impaired waters and determined to be pathogen impaired in the "*Merrimack River Basin 1999 Water Quality Assessment Report*"

(WQA; MADEP 2001) (see Figure 1-1, Table 4-3). MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Merrimack River watershed 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 taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

There are 58 waterbody segments assessed by the MADEP in the Merrimack River watershed (MassGIS 2005). These segments consist of five estuaries, all of which are pathogen impaired. Seventeen of the 25 river segments are pathogen impaired and none of the 28 lake segments are pathogen impaired and appear as such on the official impaired waters list (303(d) List) (Figure 1-1). Pathogen impairment has been documented by the MADEP in previous reports, including the MADEP WQA, resulting in the impairment determination. In this TMDL document, an overview of pathogen impairment is provided to illustrate the nature and extent of the pathogen impairment problem. Additional data, not collected by the MADEP or used to determine impairment status, are also provided in this TMDL to illustrate the pathogen problem. Since pathogen impairment has been previously established only a summary is provided herein.

The watershed based approach applied to complete the Merrimack River watershed pathogen TMDL is straightforward. The approach is focused on identification of sources, source reduction, and implementation of appropriate management plans. Once identified, sources are required to meet applicable WQS for indicator bacteria or be eliminated. This approach does not include water quality analysis or other approaches designed to link ambient concentrations with source loadings. For pathogens and indicator bacteria, water quality analyses are generally resource intensive and provide results with large degrees of uncertainty. Rather, this approach focuses on sources and required load reductions, proceeding efficiently toward water quality restoration activities.

The implementation strategy for reducing indicator bacteria is an iterative process where data are gathered on an ongoing basis, sources are identified and eliminated if possible, and control measures including Best Management Practices (BMPs) are implemented, assessed and modified as needed. Measures to abate probable sources of waterborne pathogens include everything from public education, to improved storm water management, to reducing the influence from inadequate and/or failing sanitary sewer infrastructure.

1.3. TMDL Report Format

This document contains the following sections:

- Watershed Description (Section 2) - provides watershed specific information
- Water Quality Standards (Section 3) – provides a summary of current Massachusetts WQS as they relate to indicator bacteria
- Problem Assessment (Section 4) – provides an overview of indicator bacteria measurements collected in the Merrimack River watershed
- Identification of Sources (Section 5) – identifies and discusses potential sources of waterborne pathogens within the Merrimack River watershed.
- TMDL Development (Section 6) – specifies required TMDL development components including:
  - Definitions and Equation
  - Loading Capacity
  - Load and Waste Load Allocations
  - Margin of Safety
  - Seasonal Variability
- Implementation Plan (Section 7) – describes specific implementation activities designed to remove pathogen impairment. This section and the companion "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" document should be used together to support implementing management actions.
- Monitoring Plan (Section 8) – describes recommended monitoring activities
- Reasonable Assurances (Section 9) – describes reasonable assurances the TMDL will be implemented
- Public Participation (Section 10) – describes the public participation process, and
- References (Section 11)

2.0 Watershed Description

The Merrimack River watershed drains approximately 5,014 square miles in Massachusetts and New Hampshire. One quarter (1,200 square miles) of this area is in Massachusetts (MADEP 2001). The watershed includes all or portions of 24 cities and towns within Massachusetts. In Massachusetts, the Merrimack River flows southeast for six miles before turning northeast near Lowell. The river continues to Newburyport where it enters the Atlantic Ocean. Major tributaries to the Merrimack River in Massachusetts, other than the Nashua and Sudbury-Assabet-Concord (SuAsCo) rivers addressed in separate documents, include Stony Brook, Spicket River, Little River, and Powwow River. Over its 53 mile length in Massachusetts, the Merrimack River drops 90 feet in elevation. The Merrimack travels through dams in Lawrence and Lowell, the Pawtucket Dam, and the Essex dams.

Land use within the watershed is primarily forest and residential areas (Table 2-1). The southwestern portion of the watershed has more forested area than the rest of the watershed (Figure 2-1). Residential areas tend to be concentrated along river segments. Industrial areas are concentrated in Lowell and Lawrence.

The Merrimack River watershed waters are commonly used for primary and secondary contact recreation (swimming and boating), fishing, wildlife viewing, habitat for aquatic life, industrial uses, shellfish harvesting, irrigation, agricultural uses, public water supply, and beachfront. A map of the marine beach locations is provided in Figure 2-2. Information regarding swimming beaches can be obtained from the beach quality annual reports available for download at the Massachusetts Department of Public Health website (http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm).

Table 2-1. Merrimack River Watershed Land Use as of 1999.

Land Use Category	% of Total Watershed Area
Pasture	1.7
Urban Open	1.9
Open Land	3.4
Cropland	5.6
Woody Perennial	0.5
Forest	40.2
Wetland/Salt Wetland	4.6
Water Based Recreation	0.1
Water	3.6
General Undeveloped Land	**61.6**
Spectator Recreation	<0.1
Participation Recreation	1.8
> 1/2 acre lots Residential	12.8
1/4 - 1/2 acre lots Residential	10.0
< 1/4 acre lots Residential	5.6
Multi-family Residential	1.2
Mining	0.8
Commercial	2.0
Industrial	2.2
Transportation	1.9
Waste Disposal	0.2
General Developed Land	**38.4**

Figure 2-1. Merrimack River Watershed Land Use as of 1999.

Figure 2-2. Merrimack River Marine Beach Locations and Pathogen Impaired Segments.

3.0 Water Quality Standards

The Surface Water Quality Standards (WQS) for the Commonwealth of Massachusetts establish chemical, physical, and biological standards for the restoration and maintenance of the most sensitive uses (MADEP 2000a). The WQS limit the discharge of pollutants to surface waters for the protection of existing uses and attainment of designated uses in downstream and adjacent segments.

Fecal coliform, enterococci, and *E. coli* bacteria are found in the intestinal tract of warm-blooded animals, soil, water, and certain food and wood processing wastes. "Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems" (USEPA 2004a). These bacteria are often used as indicator bacteria since it is expensive and sometimes difficult to test for the presence of individual pathogenic organisms.

Massachusetts is planning to revise its freshwater WQS by replacing fecal coliform with *E. coli* and enterococci as the regulated indicator bacteria, as recommended by the EPA in the "*Ambient Water Quality Criteria for Bacteria – 1986*" document (USEPA 1986). The state has already done so for public beaches through regulations of the Massachusetts Department of Public Health as discussed below. Currently, Massachusetts uses fecal coliform as the indicator organism for all waters except for marine bathing beaches, where the Federal BEACH Act requires the use of enterococci. Massachusetts anticipates adopting *E. coli* and enterococci for all fresh waters and enterococci for all marine waters, including non bathing marine beaches. Fecal coliform will remain the indicator organism for shellfishing areas, however. The Merrimack River watershed pathogen TMDL has been developed using fecal coliform as the pathogen indicator for fresh and marine waters and enterococci for marine beaches, but the goal of removing pathogen impairment of this TMDL will remain applicable when Massachusetts adopts new indicator bacteria criteria into its WQS. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

Pathogens can significantly impact humans through ingestion of, and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish. In addition to contact recreation, excessive pathogen numbers impact potable water supplies. The amount of treatment (i.e., disinfection) required to produce potable water increases with increased pathogen contamination. Such treatment may cause the generation of disinfection by-products that are also harmful to humans. Further detail on pathogen impacts can be accessed at the following EPA websites:

- Water Quality Criteria: Microbial (Pathogen)
  http://www.epa.gov/ost/humanhealth/microbial/microbial.html
- Human Health Advisories:
  - Fish and Wildlife Consumption Advisories
    http://www.epa.gov/ebtpages/humaadvisofishandwildlifeconsumption.html

- o Swimming Advisories
  http://www.epa.gov/ebtpages/humaadvisoswimmingadvisories.html

The Merrimack River watershed contains waterbodies classified as Class A, Class B, Class SA, and Class SB. The corresponding WQS for each class are as follows:

> Class A waterbodies - fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.
>
> Class B, and Class SA and SB not designated for shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL and no more than 10% of the samples shall exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis for waters classified as Class B, and Class SA and SB not designated for shellfishing.
>
> Class SA waters approved for open shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 mL and no more than 10% of the samples shall exceed 43 organisms per 100 mL.
>
> Class SB waters approved for open shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 88 organisms per 100 mL and no more than 10% of the samples shall exceed 260 organisms per 100 mL.

Shellfish growing areas are classified by the Massachusetts Division of Marine Fisheries (DMF). The classification system is provided below (MassGIS 2005). Figure 1-1 provides designated shellfish growing areas status as of July 1, 2000.

> **Approved** – “Open for harvest of shellfish for direct human consumption subject to local rules and state regulations” (MassGIS 2005). “The area is shown to be free of bacterial contaminants under a variety of climatological and hydrographical situations (i.e. assumed adverse pollution conditions)” (MADEP 2002a).
>
> **Conditionally Approved** - "During the time area is approved it is open for harvest of shellfish for direct human consumption subject to local rules and state regulations” (MassGIS 2005). “This classification category may be assigned for growing areas subject to intermittent and predictable microbiological contamination that may be present due to operation of a sewage treatment plant, rainfall, and/or season” (MADEP 2002a).
>
> **Conditionally Restricted** – “During the time area is restricted it is only open for the harvest of shellfish with depuration subject to local rules and state regulations” (MassGIS 2005). “A classification used to identify a growing area that meets the criteria for the restricted classification except under certain conditions described in a management plan” (MADEP 2002a).

Restricted – "Open for harvest of shellfish with depuration subject to local rules and state regulations or for the relay of shellfish" (MassGIS 2005). "A classification used to identify where harvesting shall be by special license and the shellstock, following harvest, is subject to a suitable and effective treatment process through relaying or depuration. Restricted growing areas are mildly or moderately contaminated only with bacteria" (MADEP 2002a).

Management Closure – "Closed for the harvest of shellfish. Not enough testing has been done in the area to determine whether it is fit for shellfish harvest or not" (MADEP 2002a).

Prohibited – "Closed for harvest of shellfish" (MassGIS 2005). "A classification used to identify a growing area where the harvest of shellstock is not permitted. Growing area waters are so badly contaminated that no reasonable amount of treatment will make the shellfish safe for human consumption. Growing areas must also be classified as Prohibited if there is no or insufficient information available to make a classification decision" (MADEP 2002a).

In general, shellfish harvesting use is supported (i.e., non-impaired) when shellfish harvested from approved open shellfish areas are suitable for consumption without depuration and shellfish harvested from restricted shellfish areas are suitable for consumption with depuration. For an expanded discussion on the relationship between the DMF shellfish growing areas classification and the MADEP designated use support status, please see the "*Merrimack River Basin 1999 Water Quality Assessment Report*" (MADEP 2001).

In addition to the WQS, the Commonwealth of Massachusetts Department of Public Health (MADPH) has established minimum standards for bathing beaches (105 CMR 445.000) under the State Sanitary Code, Chapter VII (www.mass.gov/dph/dcs/bb4_01.pdf). These standards will soon be adopted by the MADEP as state surface WQS for fresh water and these standards will subsequently apply to this TMDL. The MADPH bathing beach standards are generally the same as those which were recommended in the "*Ambient Water Quality Criteria for Bacteria – 1986"* document published by the EPA (USEPA 1986). In the above referenced document, the EPA recommended the use of enterococci as the indicator bacterium for marine recreational waters and enterococci or *E. coli* for fresh waters. As such, the following MADPH standards have been established for bathing beaches in Massachusetts:

Marine Waters - (1) No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Freshwaters - (1) No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or (2) No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.

The Federal BEACH Act of 2000 established a Federal standard for marine beaches. These standards are essentially the same as the MADPH marine beach standard (i.e., single sample not to exceed 104 cfu/100mL and geometric mean of a statistically sufficient number of samples not to exceed 35 cfu/100mL). The Federal BEACH Act and MADPH standards can be accessed on the worldwide web at http://www.epa.gov/waterscience/beaches/act.html and www.mass.gov/dph/dcs/bb4_01.pdf, respectively.

Figure 2-2 provides the location of marine bathing beaches, where the MADPH Marine Waters and the Federal BEACH Act standards would apply. A map of freshwater beaches is not available at this time. However, a list of beaches (fresh and marine) by community with indicator bacteria data can be found in the annual reports on the testing of public and semi-public beaches provided by the MADPH. These reports are available for download from the MADPH website located at http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm.

4.0 Problem Assessment

Pathogen impairment has been documented at numerous locations throughout the Merrimack River watershed, as shown in Figure 1-1. Excessive concentrations of indicator bacteria (e.g., fecal coliform, enterococci, *E. coli* etc.) can indicate the presence of sewage contamination and possible presence of pathogenic organisms. The amount of indicator bacteria and potential pathogens entering waterbodies is dependent on several factors including watershed characteristics and meteorological conditions. Indicator bacteria levels generally increase with increasing development activities, including increased impervious cover, illicit sewer connections, and failed septic systems.

Indicator bacteria levels also tend to increase with wet weather conditions as storm sewer systems overflow and/or storm water runoff carries fecal matter that has accumulated to the river via overland flow and storm water conduits. In some cases, dry weather bacteria concentrations can be higher when there is a constant source that becomes diluted during periods of precipitation, such as with illicit connections. The magnitude of these relationships is variable, however, and can be substantially different temporally and spatially throughout the United States or within each watershed.

Tables 4-1 and 4-2 provide ranges of fecal coliform concentrations in storm water associated with various land use types. Pristine areas are observed to have low indicator bacteria levels and residential areas are observed to have elevated indicator bacteria levels. Development activity generally leads to decreased water quality (e.g., pathogen impairment) in a watershed. Development-related watershed modification includes increased impervious surface area which can (USEPA 1997):

- Increase flow volume,
- Increase peak flow,
- Increase peak flow duration,
- Increase stream temperature,
- Decrease base flow, and
- Change sediment loading rates.

Many of the 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, storm water drainage systems and associated storm water culverts and outfall pipes often result in the channelization of streams which leads to less attenuation of pathogen pollution.

Table 4-1 Wachusett Reservoir Storm Water Sampling (as reported in MADEP 2002b) original data provided in MDC Wachusett Storm Water Study (June 1997).

Land Use Category	Fecal Coliform Bacteria[1] Organisms / 100 mL
Agriculture, Storm 1	110 - 21,200
Agriculture, Storm 2	200 - 56,400
"Pristine" (not developed, forest), Storm 1	0 - 51
"Pristine" (not developed, forest), Storm 2	8 - 766
High Density Residential (not sewered, on septic systems), Storm 1	30 - 29,600
High Density Residential (not sewered, on septic systems), Storm 2	430 - 122,000

[1] Grab samples collected for four storms between September 15, 1999 and June 7, 2000

Table 4-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002)[1].

Land Use Category	Fecal Coliform (CFU/100 mL)	Enterococcus Bacteria (CFU/100 mL)	Number of Events
Single Family Residential	2,800 – 94,000	5,500 – 87,000	8
Multifamily Residential	2,200 – 31,000	3,200 – 49,000	8
Commercial	680 – 28,000	2,100 – 35,000	8

[1] An Event Mean Concentration (EMC) is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow.

Pathogen impaired estuary segments represent 100% of the total estuary area assessed (7.3 square miles). Pathogen impaired river segments represent 72.8% of the total river miles assessed (76.1 miles of 104.5 total river miles). In total, 22 segments, each in need of a TMDL, contain indicator bacteria concentrations in excess of the Massachusetts WQS for Class A, SA, B, or SB waterbodies (314 CMR 4.05)[1], the MADPH standard for bathing beaches[2], and/or the BEACH Act[3]. The basis for impairment listings is provided in the *2002 List* (MADEP 2003). Data presented in the WQA and other data collected by the MADEP were used to generate the *2002 List*. For more information regarding the basis for listing particular segments for pathogen impairment, please see the Assessment Methodology section of the MADEP WQA for this watershed.

A list of pathogen impaired segments requiring a TMDL is provided in Table 4-3. Segments are listed and discussed in hydrologic order (upstream to downstream) in the following sections. Additional details regarding each impaired segment including water withdrawals, discharges, use assessments and recommendations to meet use criteria are provided in the MADEP WQA.

An overview of the Merrimack River watershed pathogen impairment is provided in this section to illustrate the nature and extent of the impairment. Since pathogen impairment has been previously established and documented on the *2002 List* and the *WQA Report*, it is not necessary to provide detailed documentation of pathogen impairment herein. Data from the MADEP and CDM were reviewed and are summarized by segment below for illustrative purposes.

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[1] Class A: Fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.
Class SA (Shellfishing approved): Fecal coliform bacteria shall not exceed an arithmetic mean of 14 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 43 organisms per 100 mL.
Class SB (Shellfishing approved): Fecal coliform bacteria shall not exceed an arithmetic mean of 88 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 260 organisms per 100 mL.
Class B, Class SA & Class SB (waters not designated for shellfishing): Fecal coliform bacteria shall not exceed a geometric mean of 200 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis.

[2] Freshwater bathing beaches: No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five (5) enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.
Marine bathing beaches: No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

[3] BEACH Act - Marine bathing beaches No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Table 4-3. Merrimack River Pathogen Impaired Segments Requiring TMDLs (adapted from MADEP 2001 and MassGIS 2005).

Segment ID	Segment Name	Type	Size [1]	Segment Description
MA84A-01	Merrimack River	River	9.2	State line at Hudson, NH/Tyngsborough, MA to Pawtucket Dam, Lowell.
MA84A-21	Deep Brook	River	3.05	Headwaters, East of Everett Turnpike, Tyngsborough to confluence with Merrimack river, Chelmsford.
MA84B-01	Unnamed Tributary "Reedy Meadow Brook"	River	1.5	Headwaters, outlet of small unnamed impoundment west/upstream of Bruce Road, Littleton to inlet of Mill Pond, Littleton.
MA84B-02	Beaver Brook	River	4.8	Outlet Mill Pond, Littleton to inlet Forge Pond, Westford.
MA84B-03	Stony Brook	River	7.0	Outlet Forge Pond, Westford to Chamberlin Road, Westford.
MA84B-04	Stony Brook	River	3.3	Chamberlin Road to confluence with Merrimack River, Westford/Chelmsford.
MA84A-17	Black Brook	River	3.15	Headwaters, Chelmsford to confluence with Merrimack River, Lowell.
MA84A-02	Merrimack River	River	2.8	Pawtucket Dam, Lowell to Duck Island, Lowell.
MA84A-11	Beaver Brook	River	4.2	New Hampshire state line Dracut to confluence with Merrimack River, Lowell.
MA84A-03	Merrimack River	River	8.8	Duck Island, Lowell to Essex Dam, Lawrence.
MA84A-04	Merrimack River	River	7.1	Essex Dam, Lawrence to confluence with Creek Brook, Haverhill.
MA84A-10	Spicket River	River	6.4	From the state line Salem, NH/Methuen, MA to confluence with Merrimack River, Lawrence.
MA84A-18	Bare Meadow Brook	River	3.2	Headwaters, Methuen to confluence with Merrimack River, Methuen.
MA84A-05	Merrimack River	Estuary	2.6	Confluence Creek Brook, Haverhill to confluence Indian River, West Newbury.
MA84A-09	Little River	River	4.3	State line Plaistow, NH/Haverhill, MA to confluence with Merrimack River, Haverhill.
MA84A-28	Powwow River	River	3.4	Outlet Tuxbury Pond, Amesbury to inlet Lake Gardner, Amesbury.
MA84A-25	Powwow River	River	0.59	Outlet Lake Gardner, Amesbury to tidal portion (just downstream of Main Street), Amesbury.
MA84A-16	Back River	River	3.3	New Hampshire state line to confluence with Powwow river, Amesbury.
MA84A-08	Powwow River	Estuary	0.05	Tidal portion, Amesbury to confluence with Merrimack River, Amesbury.
MA84A-06	Merrimack River	Estuary	4.37	Confluence Indian River, West Newbury to mouth at Atlantic Ocean, Newburyport/Salisbury.
MA84A-26	Merrimack River	Estuary	0.17	"The Basin" in the Merrimack River Estuary, Newburyport/Newbury.
MA84A-27	Plum Island River	Estuary	0.13	From Chaces Island in the Merrimack River Estuary, Newbury to the "High Sandy" sand bar just north of the confluence with Pine Island Creek, Newbury.

[1] Units = Miles for river segments and square miles for estuaries

This TMDL was based on the current WQS using fecal coliform as an indicator organism for fresh and marine waters and enterococci for marine beaches. Enterococci data are provided at the bottom of each table when data are available. The MADEP is in the process of developing new WQS incorporating *E. coli* and enterococci as indicator organisms for all waters other than shellfishing and potable water intake areas. Not all data presented herein were used to determine impairment listing due to a variety of reasons (including data quality assurance and quality control). The MADEP used only a subset of the available data to generate the *2002 List*. Other data presented in this section are for illustrative purposes only.

Data from the Massachusetts Division of Marine Fisheries (DMF) were used, in part, as the basis for pathogen impairment for many of the estuarine areas (Figure 1-1). Numerous samples have been collected throughout the Merrimack River watershed by the DMF. DMF has a well-established and effective shellfish monitoring program that provides quality assured data for each shellfish growing area. In addition, each growing area must have a complete sanitary survey every 12 years, a triennial evaluation every three years and an annual review in order to maintain a shellfishing harvesting classification with the exception of those areas already classified as Prohibited. The National Shellfish Sanitation Program establishes minimum requirements for sanitary surveys, triennial evaluations, annual reviews and annual fecal coliform water quality monitoring and includes identification of specific sources and assessment of effectiveness of controls and attainment of standards. “Each year water samples are collected by the DMF at 2,320 stations in 294 growing areas in Massachusetts's coastal waters at a minimum frequency of five times while open to harvesting” (DMF 2002). Due to the volume of data collected by the DMF, only a small sub-set of these data are provided herein. For the most recent indicator bacteria sampling data, please contact your local city or town shellfish constable or DMF's Shellfish Project.

Data summarized in the following subsections may be found at:

- **MADEP WQA** – Merrimack River Basin 1999 Water Quality Assessment Report available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.
- **CDM-** Merrimack River Watershed Assessment Study: Summary of Information on Pollutant Sources available online at http://www.nae.usace.army.mil under the “projects” link.

Data for each segment are summarized in a narrative or presented in tables. Depending on the information available, the tables may display different fields. The first two columns “Description” and “Town” give information on the sampling site. The following columns provide a summary of the sampling data. The “Min” and “Max” columns display the minimum and maximum values reported during sampling. The “Geometric Mean” column provides the geometric mean for the samples collected. The “n” column shows the number of samples collected. Data under “Primary Contact Season” is a summary of the samples collected during the primary contact season (April 1 through October 15). The column labeled “# Samples > 400” gives the number of samples collected, which had a fecal coliform count over 400 cfu/100 mL. The percent value provides the percentage of the samples exceeding 400 cfu/100mL.

Tables summarizing combined sewer overflow (CSO) data for a segment contain a CSO outfall number and/or description. The "Approximate Drainage Area" column provides an estimate of the drainage area for that CSO in acres. The "Average No. of Events" is the average number of times the CSO discharges into the river each year. "Annual CSO Volume" is the average water volume discharged from the CSO each year.

The MADPH publishes annual reports on the testing of public and semi-public beaches for both marine and fresh waters. These documents provide water quality data for each bathing beach by community and note if there were exceedances of water quality criteria. There is also a list of communities that did not report testing results. These reports can be downloaded from http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm. Marine and freshwater beach status is highly variable and is therefore not provided in each segment description. Please see the MADPH annual beach report for specific details regarding swimming beaches.

The purpose of this section of the report is to briefly describe the impaired segments in the Merrimack River Watershed. For more information on any of these segments, see the "*Merrimack River Basin 1999 Water Quality Assessment Report*" on the MADEP website http://www.mass.gov/dep/brp/wm/wqassess.htm.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

Merrimack River Segment MA84A-01

This segment is a 9.2 mile Class B warm water fishery extending from the state line between Hudson, NH and Tyngsborough, MA to the Patucket Dam in Lowell. There are three permitted groundwater or surface water withdrawals in the area:

1. The Dracut Water District has a wellfield in Tyngsboro;
2. The Vesper Country Club has three wells and a river intake; and
3. The Lowell Water Treatment Facility has a river intake.

According to the WQA there are no active National Pollutant Discharge Elimination System (NPDES) dischargers in this segment other than the Phase II Stormwater communities (Tyngsborough, Chelmsford, Lowell, and Dracut). Phase II communities are required to obtain permits for their municipal separate storm sewer system (MS4).

The MADEP collected four indicator bacteria samples between August 1999 and April 2001 at the Lowell Water Treatment Plant Merrimack River Intake on this segment. Results of this sampling are provided in Table 4-4.

Table 4-4. Merrimack River Segment MA84A-01 Indicator Bacteria Data Collected by the MADEP (adapted from MADEP 2001).

Site Description	Date	Fecal Coliform (cfu/100mL)	*E. coli* (cfu/100mL)
Lowell Water Treatment Plant Merrimack River Intake	8/30/99	55	36
	10/19/99	150	31
	9/12/00	5	<5
	4/10/01	100	2

CSOs discharges in New Hampshire (upstream of this segment) may contribute to elevated indicator bacteria concentrations in this segment. During dry weather, sanitary wastewater is discharged to a WWTP via the interception system. During wet weather, the capacity of the interceptor and treatment system is exceeded and waste and storm water are discharged to the Merrimack and Nashua Rivers. Table 4-5 provides a summary of the outfalls including the CSO Permit outfall number, location, interceptor, receiving water, drainage area (total area drained, area drained by combined sewers and area drained with separate storm sewers) and the average annual discharge events.

Table 4-5. CSO Discharges in Nashua, NH (from CDM 2004a)

CSO No.	Location	Interceptor	Receiving Waterbody	Approximate Drainage Area (acres)			Average Annua
				Total	*Combined*	*Separate*	*Average No. of Events*
002	Salmon Brook	Salmon Brook	Merrimack River	341	246	95	0
003	Farmington Brook	South Merrimack	Merrimack River	384	350	34	17
004	Burke Street	North Merrimack	Merrimack River	136	136	0	25
005	Hollis Street	North Merrimack	Merrimack River	935	624	311	17
006	Nashua River	North Merrimack	Nashua River	418	400	18	10
007	Tampa Street	Nashua River	Nashua River	70	70	0	2
008	Broad Street	Nashua River	Nashua River	302	199	103	23
009	Locke Street	North Merrimack	Nashua River	55	55	0	20
012	Jackson/ Beaucher	Nashua River	Nashua River	95	95	0	0
Total/ Maximum							**25**

The *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) provides a summary of representative CSO pollutant concentrations for Nashua River. CSO outfall sampling performed by Metcalf and Eddy resulted in wet weather *E. coli* densities ranging from 2,100 to 760,000 cfu/100mL. Metcalf and Eddy also sampled storm water outfalls. Storm water outfall *E. coli* values ranged from 800 to 44,000 cfu/100mL.

<u>Deep Brook Segment MA84A-21</u>

This segment is a 3.05 mile Class B waterbody extending from its headwaters east of the Everett Turnpike in Tyngsborough to its confluence with the Merrimack River in Chelmsford. There are no permitted withdrawals in the area. There are two permitted NPDES wastewater dischargers in this segment:

1. Browning-Ferris Industries, Inc. discharges treated storm water runoff via six outfalls; and
2. The Texaco Station in North Chelmsford is permitted to discharge through their recovery system discharge, but it has been terminated.

The Towns of Tyngsborough and Chelmsford are Phase II communities and are required to obtain NPDES storm water discharge permits for their MS4s.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

Unnamed Tributary "Reedy Meadow Brook" MA84B-01

This unnamed tributary, also known as "Reedy Meadow Brook," is a 1.5 mile Class B segment beginning at the outlet of a small unnamed impoundment upstream of Bruce Road in Littleton and extending to the inlet of Mill Pond in Littleton. There are two groundwater withdrawals in the area:

1. Aggregate Materials Corporation has five wells; and
2. Veryfine, Inc. has two process wells.

There is one NPDES wastewater permit listed in the MADEP WQA, Veryfine Products, Inc. Veryfine discharges treated effluent and storm water into the brook. The Town of Littleton is a Phase II community and is therefore required to obtain a NPDES storm water discharge permit for their MS4.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

Beaver Brook Segment MA84B-02

This segment is a 4.8 mile Class B waterbody extending from the outlet of Mill Pond in Littleton to the inlet of Forge Pond in Westford. There are two permitted water withdrawals in the area: the Littleton and the Westford Water Department. There is no wastewater NPDES permits listed in the MADEP WQA. The Towns of Littleton and Westford are Phase II communities and are required to obtain NPDES storm water discharge permits for their MS4s.

Stony Brook Segment MA84B-03

This segment is a 7.0 mile Class B warm water fishery in Westford. The segment begins at the outlet of Forge Pond and ends at Chamberlin Road. There are two groundwater withdrawals in the area: the Westford Water Department and the Laughton Garden Center, Inc. Two NPDES wastewater permits were listed in the MADEP WQA:

1. The Westford Anodizing Corporation is permitted to discharge treated process wastewater to this segment, and
2. Courier Westford, Inc. discharges non-contact cooling water to this segment.

The Town of Westford is a Phase II community and is required to obtain a NPDES storm water discharge permit for their MS4.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

Stony Brook Segment MA84B-04

This segment is a 3.3 mile Class B warm water fishery extending from Chamberlin Road in Westford to its confluence with the Merrimack River in Westford/Chelmsford. There are three groundwater withdrawals in the area: the Chelmsford Water District, the North Chelmsford Water District, and the Laughton Garden Center, Inc. One NPDES wastewater permit is listed in the MADEP WQA for this segment. The Fletcher Granite Company in Westford discharges overflow from the quarry supply pond and process water from cutting to a tributary of this brook. The Towns of Littleton and Westford are Phase II communities and are required to obtain NPDES storm water discharge permits for their MS4s.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

Black Brook Segment MA84A-17

This segment is a 3.15 mile Class B brook extending from Chelmsford to Lowell. The segment begins at its headwaters in Chelmsford and ends at the confluence with the Merrimack River in Lowell. The Chelmsford Water District has the only permitted water withdrawal in the area. There are no active NPDES permits listed in the MADEP WQA. The Town of Chelmsford is a Phase II community and is required to obtain NPDES storm water discharge permit for their MS4.

Merrimack River Segment MA84A-02

This segment is a 2.8 mile Class B warm water fishery utilized for water supply and receiving water for CSOs in Lowell. The segment begins at the Pawtucket Dam and ends at Duck Island. The flow over the Pawtucket Dam is controlled by Boott Hydropower, Inc. Boott Hydropower, Inc. has five powerhouses along the canal system. The Appleton Trust Project, located at the Hamilton Canal, has one powerhouse and two turbines. The Western Avenue Dyers, LP is the only permitted water withdrawal in the area. Four NPDES wastewater permits were listed in the MADEP WQA:

1. Boott Hydropower Company, Inc, discharges non-contact cooling water from three locations;
2. The Lowell Cogeneration Company discharges combined cooling tower blowdown, boiler blowdown, and demineralization wastes through one outfall and storm water runoff, building floor drains, equipment drains, and intermittent boiler blowdown through another outfall to the Pawtucket Dam;

3. The Lowell National Historic Park, Boott Cotton Mills Museum discharges non-contact cooling water into this segment; and
4. The Lowell Regional Water and Wastewater Utilities (LRWWU) is permitted to discharge via nine CSO diversion structures.

The City of Lowell is a Phase II community and is required to obtain NPDES storm water discharge permit for their MS4.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

The Lowell Heritage State Park is located just upstream of this segment. The park's public beach is frequently closed to swimming for high bacteria levels. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

Table 4-6 below summarizes indicator bacteria data collected by the MADEP between August 1999 and April 2001.

Table 4-6. Merrimack River Segment MA84A-02 Indicator Bacteria Data Collected by the MADEP (adapted from MADEP 2001).

Site Description	Date	Fecal Coliform (cfu/100mL)	*E. coli* (cfu/100mL)
Merrimack River downstream of CSO, upstream of the LRWWU POTW – Lowell, MA	8/24/99	1100	215
	10/19/99	97	56
	9/12/00	1200	580
	4/11/01	180	8

POTW – publicly owned treatment works

Thirty three percent of the City of Lowell is serviced by CSOs. These CSOs contribute to elevated indicator bacteria concentrations in this segment. During dry weather, sanitary wastewater is discharged to a WWTP via the interception system. During wet weather, the capacity of the interceptor and treatment system is exceeded and waste and storm water are discharged to the receiving waterbodies. Table 4-7 provides a summary of the outfalls including the CSO Permit outfall number, location, interceptor, receiving water, drainage area and average annual discharge statistics.

Table 4-7. CSO Discharges in Lowell, MA (from CDM 2004a).

NPDES Outfall No.	Location	Interceptor	Receiving Waterbody	Approximate Drainage Area (acres)	Average Annual CSO Statistics		
					Average No. of Events	*Annual Total Duration (hr)*	*Annual CSO Volume (MG)*
002-SDS#1	Walker Street	Southwest Bank	Merrimack River	140	0	0	0
007-SDS#2	Beaver Brook	North Bank	Beaver Brook	520	31	167	55
008-SDS#3	West Street	North Bank	Merrimack River	530	1	2	6.4
011-SDS#4	Read Street	North Bank	Merrimack River	175	11	25	2.5
012-SDS#5	First Street	North Bank	Merrimack River	90	0	0	0
020-SDS#6	Warren Street	Southeast Bank II	Concord River	2230	35	163	202
027-SDS#7	Tilden Street	Southeast Bank I	Merrimack River	350	10	22	4.8
030(1)-SDS#8	Barasford Avenue	Southeast Bank II	Merrimack River	600	14	42	26.8
030(2)-SDS#8	Merrimack River	Southeast Bank II	Merrimack River	365	37	278	54
Total/ Maximum					**37**	**278**	**351.5**

MG = million gallons

The *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) provides a summary of CSO (3 outfalls) and storm water (6 outfalls) discharges pollutant concentrations in Lowell. Fecal coliform concentrations ranged from 7,200 to 28,000 cfu/100mL. *E. coli* concentrations ranged from 3,100 to 7,900 cfu/100mL.

Beaver Brook Segment MA84A-11

This segment is a 4.2 mile Class B cold water fishery extending from the New Hampshire state line in Dracut to its confluence with the Merrimack River in Lowell. The Dracut Water District has the only water withdrawal permit on this segment. The only NPDES discharge permit in this segment is held by the Lowell Regional Water and Wastewater Utility (LRWWU) for a CSO Diversion Structure, which discharges an average of 30-37 times a year. The Town of Dracut and City of Lowell are Phase II communities and are required to obtain NPDES storm water discharge permit for their MS4s.

Lowell has one CSO that discharges to this river segment (007-SDS#2, Table 4-7). CDM conducted sampling between May and September 1999 for fecal coliform and *E. coli* concentrations in CSOs in Lowell. Information regarding the CS discharging in this segment is provided on Table 4-7 in the Merrimack River Segment MA84A-02 discussion. The exact location of the CSO sampling was not provided. Fecal coliform concentrations in three of the CSOs listed in Table 4-7 ranged from 7,200 to 28,000 cfu/100mL and *E. coli* concentrations ranged from 3,100 to 7,900 cfu/100mL.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the “Projects” link.

Merrimack River Segment MA84A-03

This segment is an 8.8 mile Class B warm water fishery utilized for water supply and receiving water for CSOs extending from Lowell to Lawrence. The segment begins at Duck Island in Lowell and extends to Essex Dam in Lawrence. As of 2001, Nickel Hill Energy, LLC was in the process of obtaining permits for a gas-fired combined-cycled power plant on this river segment. There are five permitted water withdrawals in the area: Andover Water Treatment, Methuen Water Department, Tewksbury Water Department, Lawrence Water Works, and Hickory Hill Golf Course, Inc. There is one NPDES permits listed in the MADEP WQA: The Tewksbury Water Treatment Plant is permitted to discharge to this segment. However, the LRWWU is permitted to discharge treated municipal and industrial wastewater to the Merrimack River upstream of this segment via one or more of their nine CSOs. The Cities of Lowell and Lawrence are Phase II communities and are required to obtain NPDES storm water discharge permit for their MS4s.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

Table 4-8 below summarizes indicator bacteria data collected by the MADEP between August 1999 and April 2001.

Table 4-8. Merrimack River Segment MA84A-03 Indicator Bacteria Data Collected by the MADEP (adapted from MADEP 2001).

Site Description	Date	Fecal Coliform (cfu/100mL)	*E. coli* (cfu/100mL)
Merrimack River below LRWWU POTW	8/11/99	120	69
	8/24/99	120	43
	10/19/99	52	8
	9/12/00	210	110
	4/11/01	120	15
Methuen Water Treatment Plant Merrimack River Intake	8/24/99	36	33
	10/20/99	180	58
	9/13/00	420	250
	4/10/01	23	<1
Lawrence Water Treatment Plant Merrimack River Intake	8/24/99	45	14
	10/20/99	130	87
	9/14/00	140	83
	4/10/01	32	<1

<u>Merrimack River Segment MA84A-04</u>

This segment is a 7.1 mile Class B warm water fishery, CSO receiving water extending from Lawrence to Haverhill. The segment begins at the Essex Dam in Lawrence and extends to its confluence with Creek Brook in Haverhill. Built in 1848, the dam is 39' high and 943' long. The Lawrence Hydro. Assoc. owns a run-of-river facility on the Essex Dam. The facility has one powerhouse, two generators, and two turbines. The Aquamac Corp. and the Merrimack Paper Co. each own a generating unit located on the South Canal. Both projects do not require a dam; they draw water from the reservoir created by the Essex Dam. The river occasionally floods into a few old mill buildings along the banks. There are four permitted water withdrawals in the area: Merrimack Paper Company, Inc., Newark Atlantic paperboard Corp., Lucent Technologies, Inc., and Spring Hill Farm Dairy, Inc. There are eight NPDES permits listed in the MADEP WQA:

1. AEP Industries discharges contact and non-contact cooling water and storm water into this segment;
2. The Greater Lawrence Sanitary District (GLSD) is permitted to discharge treatment plant effluent via one outfall and four CSOs;
3. Ferrous Technologies, Inc. is permitted to discharge non-contact cooling water;
4. Lucent Technologies, Inc. is permitted to discharge treated wastewater from electroplating manufacturing, treated sanitary wastewater, non-contact cooling water, ultrasonic cleaning water, well water used for backwash, deionized water, treated (remediation) ground water from wells on the property, non-contact cooling water and blowdown from the process water system, and non-contact cooling water from the chilled water system;
5. Newark Atlantic Paperboard Corp. is permitted to discharge non-contact cooling water;
6. Boott Hydropower, Lawrence Hydroelectric is permitted to discharge non-contact cooling water;
7. Vernon Plastics Corporation is permitted to discharge non-contact cooling water and storm water runoff to a tributary of this segment; and
8. Sweetheart Cup Company, Inc. is permitted to discharge non-contact cooling water to a tributary of this segment.

The Cities of Lowell and Lawrence are Phase II communities and are required to obtain NPDES storm water discharge permit for their MS4s.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the “Projects” link.

The Greater Lawrence Sanitary District has five CSOs which relieve the WWTP in North Andover, MA under wet weather events. Table 4-9 provides a summary of these outfalls including the CSO Permit outfall number, location, interceptor, receiving water, drainage area and average annual discharge statistics.

Table 4-9. GLSD CSO Discharges to the Merrimack and Spicket Rivers (from CDM 2004a).

Location	Receiving Waterbody	Average Annual Statistics		
		Average No. of Events	*Annual Total Duration (hr)*	*Annual CSO Volume (MG)*
South Bank Interceptor				
CSO002	Merrimack River	8	24	24.8
CSO003	Merrimack River	1	2	0.3
North Bank Interceptor				
CSO004	Merrimack River	14	44	76.8
CSO005	Merrimack River	3	3	1.6
Spicket River Interceptor				
CSO006	Spicket River	5	8	8.3
Total/ Maximum	**N/A**	**14**	**44**	**111.8**

Spicket River Segment MA84A-10

This segment is a 6.4 mile Class B warm water fishery extending from the state line at Salem, NH/Methuen, MA to its confluence with the Merrimack River in Lawrence. The Methuen Falls Hydro Elec Co. is located on the Spicket River. Malden Mills Industries, Inc. is the only permitted water withdrawal in the area. There are four NPDES permits listed in the MADEP WQA:

1. ITT Semiconductor applied for a permit in 1983, but discontinued their operations in 1985;
2. Odgen Martin Systems is permitted to discharge circulating condenser cooling water;
3. Greater Lawrence Sanitary District (GLSD) has a permitted combined sewer overflow; and
4. Gencorp, Inc. is permitted to discharge site water from their property, which is a hazardous waste site.

The Town of Methuen and the City of Lawrence are Phase II communities and are required to obtain NPDES storm water discharge permit for their MS4s.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

Information regarding the GLSD CSO is provided in Table 4-9, under the Merrimack River Segment MA84A-04 description.

Bare Meadow Brook Segment MA84A-18

This segment is a 3.2 mile Class B brook in Methuen. The brook extends from its headwaters in Methuen to its confluence with the Merrimack River. There are no active WMA water withdrawals or NPDES permits listed in the MADEP WQA. The Town of Methuen is a Phase II community and is required to obtain a NPDES storm water discharge permit for their MS4.

Merrimack River Segment MA84A-05

This segment is a 2.6 square mile Class SB, restricted shellfishing and CSO receiving water extending from Haverhill to West Newbury. The river segment extends from the confluence with Creek Brook to the confluence with Indian River. There are three permitted water withdrawals in the area: Haverhill Paperboard Corporation, Bradford Country Club, and Groveland Water Department. There are three NPDES permits listed in the MADEP WQA:

1. Haverhill Paperboard Corporation is permitted to discharge non-contact cooling water;
2. Haverhill Water Pollution Control Facility (WPCF) is permitted to discharge treatment plant effluent via one outfall; Haverhill WPCF is also permitted to discharge via 15 CSOs along this segment; and
3. Merrimac Waste Water Treatment Facility (WWTF) is permitted to discharge treated sanitary and industrial wastes via one outfall.

Haverhill, Merrimack and West Newbury are Phase II communities and are required to obtain NPDES storm water discharge permits for their MS4s.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

Between August 1999 and April 2001, the MADEP collected 12 samples from three sites on the Merrimack River. Table 4-10 below summarizes indicator bacteria data collected by the MADEP between August 1999 and April 2001.

Table 4-10. Merrimack River Segment MA84A-05 Indicator Bacteria Data Collected by the MADEP (adapted from MADEP 2001).

Site Description	Date	Fecal Coliform (cfu/100mL)	*E. coli* (cfu/100mL)
Merrimack River downstream of GLSD, upstream of Haverhill CSO	8/25/99	680	42
	10/20/99	83	42
	9/13/00	86	81
	4/11/01	81	4
Merrimack River downstream of CSO, upstream of the Haverhill POTW	8/25/99	380	35
	10/20/99	110	52
	9/13/00	4300	1200
	4/11/01	87	5
Near Groveland below Bates Bridge	8/25/99	97	3
	10/20/99	200	77
	9/13/00	220	140
	4/11/01	61	10

Thirty seven percent of the City of Haverhill is serviced by 21 CSO outfalls. These CSOs contribute to elevated indicator bacteria concentrations in this segment. During dry weather, sanitary wastewater is discharged to a WWTP via the interception system. During wet weather, the capacity of the interceptor and treatment system is exceeded and waste and storm water are discharged to the receiving waterbodies. Table 4-11 provides a summary of the outfalls including the CSO Permit outfall number, location, interceptor, receiving water, drainage area and average annual discharge statistics.

CSO outfall samples were collected as part of Haverhill's Phase I of their long-term CSP control plan. Representative CSO total coliform concentrations for Haverhill range from <2000 to 4,000,000 cfu/100mL. Fecal coliform concentrations ranged from <2000 to 820,000 cfu/100mL and *E. coli* concentrations ranged from <2000 to 390,000 cfu/100mL.

Table 4-11. CSO Discharges in Haverhill, MA (from CDM 2004a).

NPDES Permit No.	Overflow Location	Interceptor System	Receiving Waterbody	Average Annual CSO Statistics		
				Average No. of Events	*Annual Total Duration (hr)*	*Annual CSO Volume (MG)*
001	Bates Bridge	Riverside Interceptor	Merrimack River	0.2	0.2	0
010	Boardman Street	Lower Siphon Interceptor	Merrimack River	0.4	0.6	0
013	Lower Siphon	Lower Siphon Interceptor	Merrimack River	14.4	70	17.1
016	Fire Station	Lower Siphon Interceptor	Merrimack River	0	0	0
019	Main Street- North	Lower Siphon Interceptor	Merrimack River	0	0	0
021A	Middle Siphon- L.R.	Middle Siphon Interceptor	Merrimack River	41.6	237	18.9
021B	Emerson Street (CLOSED)	Essex Street Interceptor	Little River	--	--	--
021C	Essex Street (CLOSED)	Essex Street Interceptor	Little River	--	--	--
021D	Little River- North	Essex Street Interceptor	Little River	13	34.3	3.17
021E	Little River- South	Essex Street Interceptor	Little River	15.2	29.8	1.21
-	Orchard St. Diversional Structure	Essex Street Interceptor	Little River	0	0	0
022	R.R. Bridge	Upper Siphon Interceptor	Merrimack River	0	0	0
023	River Street	Upper Siphon Interceptor	Merrimack River	0	0	0
024	Upper Siphon	Upper Siphon Interceptor	Merrimack River	27.8	126	17.6
025	Beach Street	Upper Siphon Interceptor	Merrimack River	0	0	0
031	Front Street	Bradford Interceptor	Merrimack River	8.8	15.3	1.19
032	Bradford Avenue	Bradford Interceptor	Merrimack River	18.4	264	6.8
033	So. Prospect Street	Bradford Interceptor	Merrimack River	4.8	4.4	0.05
034	Middlesex Street	Bradford Interceptor	Merrimack River	8.2	26.6	0.35
035	Main Street- South	Bradford Interceptor	Merrimack River	14	31.3	1.47
036	Ferry Street	Bradford Interceptor	Merrimack River	18.6	82	2.17
-	Mill Street (CLOSED)	Mill Street Interceptor	Merrimack River	--	--	--
-	Duncan St. Diversional Structure	30-inch sewer in Winter St.	Little River	0	0	0
-	Hale St. Regulator	39x50-inch sewer in Hale St.	Little River	3.4	4.3	0.66
-	Lafayette Square Regulator (CLOSED)	42-inch sewer in Essex St.	Lake Staltonstall	--	--	--
-	Broadway Diversional Structure	24-inch sewer in Broadway	Little River	0	0	0
-	High Street Diversional Structure	24-inch sewer in High St.	Little River	0.2	0	0
Total/ Maximum			**N/A**	**41.6**	**264**	**70.67**

Although this segment has been classified as SB – shellfishing, the Division of Marine Fisheries does not list this segment on their October 2000 List of Shellfishing Growing Area and therefore, shellfishing status is not available for this segment (MADEP 2001).

Little River Segment MA84A-09

This segment is a 4.3 mile Class B warm water fishery in Haverhill segment extends from the state line at Plaistow, NH/Haverhill, MA to the confluence with the Merrimack River in Haverhill. There are no permitted water withdrawals listed in the WQA for this area. There is one NPDES permit listed in the MADEP WQA; the Haverhill WPCF is permitted to discharge via four CSOs. See Table 4-11 above for information regarding these CSOs. The Town of Haverhill is a Phase II community and is required to obtain a NPDES storm water discharge permit for their MS4.

Powwow River Segment MA84A-28

This segment is a 3.4 mile Class A waterway in Amesbury. The river segment extends from the outlet of Tuxbury Pond to the inlet of Lake Gardner. There is one permitted water withdrawal listed in the MADEP WQA for this area: the Amesbury Water Treatment Facility. The Amesbury WWTP is permitted to discharge wastewater via two outfalls. The Town of Amesbury is a Phase II community and is required to obtain a NPDES storm water discharge permit for their MS4.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

Note: this segment is designated as segment number MA84A-24 in the MADEP WQA. The segment is designated as MA84A-28 in this TMDL to correspond to the designation number used for this segment in MassGIS 2005 and the *Massachusetts Year 2002 Integrated List of Waters.*

Powwow River Segment MA84A-25

This segment is a 0.59 mile Class B warm water fishery in Amesbury. The river segment extends from the outlet of Lake Gardner to the tidal portion of the river (just downstream of Main Street in Amesbury). There are no permitted water withdrawals or NPDES permits listed in the MADEP WQA for this area. The Town of Amesbury is a Phase II community and is required to obtain a NPDES storm water discharge permit for their MS4.

A list of municipal and private WWTP discharges and industrial NPDES discharges is provided in the *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources* (CDM 2004a) document. Effluent limits and concentration data are also provided. The document can be accessed on-line at http://www.nae.usace.army.mil under the "Projects" link.

Back River Segment MA84A-16

This segment is a Class B river in Amesbury. The river segment extends from the New Hampshire state line to its confluence with the Powwow River. There is one permitted water withdrawal permit listed in the MADEP WQA for this area: the Salisbury Water Supply Company. There are no NPDES permits listed in the MADEP WQA for this segment. The Town of Amesbury is a Phase II community and is required to obtain a NPDES storm water discharge permit for their MS4.

Powwow River Segment MA84A-08

This segment is a 0.05 square mile Class SB shellfishing restricted waterbody in Amesbury. The segment extends from the tidal portion of the river to its confluence with the Merrimack River. There are no permitted water withdrawals or NPDES permits listed in the MADEP WQA for this area. The Town of Amesbury is a Phase II community and is required to obtain a NPDES storm water discharge permit for their MS4.

Although this segment has been classified as SB – shellfishing, the Division of Marine Fisheries (DMF) does not list this segment on their October 2000 List of Shellfishing Growing Area and therefore, shellfishing status is not available for this segment (MADEP 2001).

Merrimack River Segment MA84A-06

This segment is a 4.37 square mile Class SB waterway extending from West Newbury to Newburyport/Salisbury. The segment extends from the confluence with Indian River to the mouth at the Atlantic Ocean. There are two Marine Pumpout Stations along this segment. There are two permitted water withdrawals in the area: Newburyport Water Department and West Newbury Water Department. There are five NPDES permits listed in the MADEP WQA:

1. The Amesbury WWTP is permitted to discharge treated sanitary and industrial wastewater via one outfall;
2. The Salisbury Sewer Commission is permitted to discharge treated effluent via one outfall to a tributary of this segment;
3. Ferraz Shawmut Inc. is permitted to discharge treated process wastewater and non-contact cooling water through one outfall;
4. Newburyport WPCF is permitted to discharge treated effluent through one outfall to a tributary of this segment; and
5. Newburyport WTP is permitted to discharge water treatment plant effluent.

Amesbury, Salisbury, and Newburyport are Phase II communities and are required to obtain NPDES storm water discharge permits for their MS4s.

Shellfishing is prohibited for 3.51 square miles of this segment. The remaining area (0.86 square miles) of this segment (upstream of Route 95 bridge) is not designated as a shellfish growing area by the DMF.

The DMF conducted fecal coliform sampling at eleven stations in this segment between February 1996 and July 2000. The results are summarized in Table 4-12.

Table 4-12. Merrimack River Segment MA84A-06 DMF Wet and Dry Weather Fecal Coliform Data Summary (adapted from MADEP 2001).

		All Samples				Primary Contact Season	
		Fecal Coliform (cfu/100mL)				Fecal Coliform (cfu/100mL)	
Description	**Town**	**Min**	**Max**	**Geometric Mean**	**n**	**# Samples >400**	**n**
Eleven DMF Stations	Newbury/ Newburyport	2.9	>2,400	<68*	717	16 (4%)	438

*Geometric mean for any individual station did not exceed 68 cfu/100 mL.

The DMF also sampled four tributaries to this segment. The highest counts for fecal coliform were found in Black Rock Creek following heavy rain (>2,400 cfu/100mL). Only one of 72 samples for this site exceeded 2,000 cfu/100mL. The geometric mean for this station was 59 cfu/100mL.

Merrimack River Segment MA84A-26

This segment is a 0.17 square mile Class SA waterbody in Newburyport/Newbury. There are no permitted water withdrawals or NPDES permits listed in the MADEP WQA for this area. Newburyport and Newbury are Phase II communities and are required to obtain NPDES storm water discharge permits for their MS4s. Local septic system failures contaminating drinking water wells with bacteria have been documented in this area. The Towns of Newbury and Newburyport are planning to expand water and sewer to Plum Island.

The DMF conducted fecal coliform sampling at three stations in this segment between February 1996 and July 2000. The results are summarized in Table 4-13. Shellfishing is Prohibited in this segment.

Table 4-13. Merrimack River Segment MA84A-26 DMF Wet and Dry Weather Fecal Coliform Data Summary (adapted from MADEP 2001).

		All Samples				Primary Contact Season	
		Fecal Coliform (cfu/100mL)				Fecal Coliform (cfu/100mL)	
Description	**Town**	**Min**	**Max**	**Geometric Mean**	**n**	**# Samples >400**	**n**
Three DMF Stations	Newbury/ Newburyport	2.9	1,547	<36	146	3 (3%)	88

Plum Island River Segment MA84A-27

This segment is a 0.13 square mile Class SA waterbody in Newbury. The segment extends from Chaces Island in the Merrimack River Estuary to the "High Sandy" sand bar just north of the confluence with Pine Island Creek. There are no permitted water withdrawals or NPDES permits listed in the MADEP WQA for this area. The Town of Newbury is a Phase II community and is required to obtain a NPDES storm water discharge permit for their MS4.

The DMF conducted fecal coliform sampling at three stations in this segment between February 1996 and July 2000. The results are summarized in Table 4-14. Shellfishing is Prohibited in this segment.

Table 4-14. Plum Island River Segment MA84A-27 DMF Wet and Dry Weather Fecal Coliform Data Summary (adapted from MADEP 2001).

		All Samples Fecal Coliform (cfu/100mL)				Primary Contact Season Fecal Coliform (cfu/100mL)	
Description	**Town**	**Min**	**Max**	**Geometric Mean**	**n**	**# Samples >400**	**n**
Four DMF Stations	Newbury	2.9	1,587	<29	257	2 (1%)	152

5.0 Potential Sources

The Merrimack River watershed has 22 segments, located throughout the watershed, that are listed as pathogen impaired requiring a TMDL. These segments represent 100% of the estuary area and 72.8% of the river miles assessed. Sources of indicator bacteria in the Merrimack River watershed are many and varied. A significant amount of work has been done in the last decade to improve the water quality in the Merrimack River watershed.

Recently, the Merrimack River Basin Community Coalition (MRBCC) has been working with communities in Massachusetts and New Hampshire and the United States Army Corps of Engineers (USACE) to document potential point and non-point sources as part of a watershed study. In addition, the DMF, MACZM, and MADEP field staff have identified potential point and non-point sources of pathogen. Table 5-1 summarizes the river segments impaired due to measured indicator bacteria densities and identifies some of the suspected and known sources identified in the MADEP WQA.

Some dry weather sources include:

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

Some wet weather sources include:

- wildlife and domesticated animals (including pets),
- storm water runoff including municipal separate storm sewer systems (MS4),
- combined sewer overflows (CSOs), and
- sanitary sewer overflows (SSOs).

It is difficult to provide accurate quantitative estimates of indicator bacteria contributions from the various sources in the Merrimack River watershed because many of the sources are diffuse and intermittent, and extremely difficult to monitor or accurately model. Therefore, a general level of quantification according to source category is provided (e.g., see Tables 5-3 and 5-4). This approach is suitable for the TMDL analysis because it indicates the magnitude of the sources and illustrates the need for controlling them. Additionally, many of the sources (failing septic systems, leaking sewer pipes, sanitary sewer overflows, and illicit sanitary sewer connections) are prohibited because they indicate a potential health risk and, therefore, must be eliminated. However, estimating the magnitude of overall indicator bacteria loading (the sum of all contributing sources) is achieved for wet and dry conditions using the extensive ambient data available that define baseline conditions (see segment summary tables, MADEP 2001, and CDM 2004a&b).

Table 5-1. Some of the Potential Sources of Bacteria in Pathogen Impaired Segments in the Merrimack River Watershed.

Segment	Segment Name	Potential Sources (adapted from MADEP 2001)
MA84A-01	Merrimack River	CSO, urban runoff/storm sewers, dense waterfowl populations
MA84A-21	Deep Brook	Unknown
MA84B-01	Unnamed Tributary “Reedy Meadow Brook”	Unknown
MA84B-02	Beaver Brook	Unknown
MA84B-03	Stony Brook	Unknown
MA84B-04	Stony Brook	Unknown
MA84A-17	Black Brook	Unknown
MA84A-02	Merrimack River	CSO, urban runoff
MA84A-11	Beaver Brook	CSO
MA84A-03	Merrimack River	Unknown
MA84A-04	Merrimack River	Unknown
MA84A-10	Spicket River	Urban runoff
MA84A-18	Bare Meadow Brook	Unknown
MA84A-05	Merrimack River	Unknown
MA84A-09	Little River	CSO
MA84A-28	Powwow River	Unknown
MA84A-25	Powwow River	Unknown
MA84A-16	Back River	Unknown
MA84A-08	Powwow River	Unknown
MA84A-06	Merrimack River	Unknown
MA84A-26	Merrimack River	Septic systems, unknown
MA84A-27	Plum Island River	Unknown

MS4 = Municipal Separate Storm Water Sewer System – community storm water drainage system

Sanitary Waste

Leaking sewer pipes, illicit sewer connections, sanitary sewer overflows (SSOs), combined sewer overflows (CSOs) and failing septic systems represent a direct threat to public health since they result in discharge of partially treated or untreated human wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source because the magnitude is directly proportional to the volume of the source and its proximity to the surface water. Typical values of fecal coliform in untreated domestic wastewater range from 10^4 to 10^6 MPN/100mL (Metcalf and Eddy 1991).

Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. The existence of illicit sewer connections to storm drains is well documented in many urban drainage systems, particularly older systems that may have once been combined. The EPA, MWRA, the Boston Water and Sewer Commission (BWSC) and many communities throughout the Commonwealth have been active in the identification and mitigation of these sources. It is estimated by EPA New England that over one million gallons per day (gpd) of illicit discharges were removed in the last decade in the Charles River Watershed, for example. It is probable that numerous other illicit sewer connections exist in storm drainage systems serving the older developed portions of the Merrimack River watershed.

Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. Approximately 65% of the Merrimack River watershed is classified as Urban Areas by the United States Census Bureau and is therefore subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. See Section 7.0 of this TMDL for information regarding illicit discharge detection guidance.

The Merrimack River watershed receives CSO inputs from five communities. Two of these communities are located in New Hampshire (Nashua and Manchester). Massachusetts communities are Lowell, Lawrence, and Haverhill. Table 5-2 below provides a summary of CSO discharges in these communities.

Table 5-2. Merrimack River Watershed CSO Discharge Statistics Summary (modified from CDM 2004a).

Community	Maximum Number of Discharge Events per Year	Average Annual Discharge Volume (MG)	Range of Fecal Coliform Concentrations (cfu/100 mL)[1]	Range of *E. coli* Concentrations (cfu/100 mL)[1]
Manchester, NH	49	220		800-80,000
Nashua, NH	25	26		2,100-760,000
Lowell, MA	37	352	7,200-28,000	3,100-7,900
Lawrence, MA (GLSD)	14	112	165,000	
Haverhill, MA	41	71	<2,000-820,000	<2,000-390,000

[1] The range of indicator bacteria concentrations are representative CSO quality concentrations adopted for modeling purposes and do not necessarily represent sample quality of all CSO discharges. See Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources for details (CDM 2004a).

SSO contributions are not considered a major source of pollution in the Merrimack River watershed (CDM 2004a). However, "…no studies have been conducted in the Merrimack River watershed to identify and quantify the impact of SSO discharges in the Merrimack River watershed." (CDM 2004a).

Septic systems designed, installed, operated and maintained in accordance with 310 CMR 15.000: Title 5, are not significant sources of fecal coliform bacteria. Studies demonstrate that wastewater located four feet below properly functioning septic systems contain on average less than one fecal coliform bacteria organism per 100 mL (Ayres Associates 1993). Failed or non-conforming septic systems, however, can be a major contributor of fecal coliform to the Merrimack River and tributaries. CDM estimates that 1.0 to 51.5 percent of the Merrimack River watershed basin. CDM's

Merrimack River watershed is much larger than the watershed described in this TMDL (Figure 1-1) and includes other major watershed drainage basins and sub-basins within Massachusetts (e.g., Nashua River, Assabet River, etc.) and New Hampshire (CDM 2004b). The 1.0-51.5% value represents only the areas within the drainage area illustrated in Figure 1-1. 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.

Recreational use of waterbodies is a source of pathogen contamination. Swimmers themselves may contribute to bacterial impairment 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 waves or tides is low.

Another potential source of pathogens is the discharge of sewage from vessels with onboard toilets. These vessels are required to have a marine sanitation device (MSD) to either store or treat sewage. When MSDs are operated or maintained incorrectly they have the potential to discharge untreated or inadequately treated sewage. For example, some MSDs are simply tanks designed to hold sewage until it can be pumped out at a shore-based pump-out facility or discharged into the water more than 3 miles from shore. Uneducated boaters may discharge untreated sewage from these devices into near-shore waters. In addition, when MSDs designed to treat sewage are improperly maintained or operated they may malfunction and discharge inadequately treated sewage. Finally, even properly operating MSDs may discharge sewage in concentrations higher than allowed in ambient water for fishing or shellfishing. Vessels are most likely to contribute to bacterial impairment in situations where large numbers of vessels congregate in enclosed environments with low tidal flushing. Many marinas and popular anchorages are located in such environments.

Wildlife and Pet Waste

Animals that are not pets can be a potential source of pathogens. Geese, gulls, and ducks are speculated to be a major pathogen source, particularly at lakes and storm water ponds where large resident populations have become established (Center for Watershed Protection 1999).

Household pets such as cats and dogs can be a substantial source of bacteria – as much as 23,000,000 colonies/gram, according to the Center for Watershed Protection (1999). A rule of thumb estimate for the number of dogs is ~1 dog per 10 people producing an estimated 0.5 pound of feces per dog per day. In Lowell alone there were 105,167 residents in 2000, according to the US Census Bureau (US Census Bureau 2005). Assuming 10,516 dogs, 5,258 pounds of feces would be produced per day in Lowell alone. Uncollected pet waste is then flushed from the parks, beaches and yards where pets are walked and transported into nearby waterways during wet-weather.

Storm Water

Storm water runoff is another significant contributor to pathogen pollution. As discussed above, during rain events fecal matter from domestic animals and wildlife are readily transported to surface waters via the storm water drainage systems and/or overland flow. The natural filtering capacity provided by vegetative cover and soils is dramatically reduced as urbanization occurs because of the increase in impervious areas (i.e., streets, parking lots, etc.) and stream channelization in the watershed.

Extensive storm water data have been collected and compiled both locally and nationally in an attempt to characterize the quality of storm water (e.g., Tables 4-1, 4-2, 5-3 and 5-4). Bacteria are easily the most variable of storm water pollutants, with concentrations often varying by factors of 10 to 100 during a single storm. Considering this variability, storm water bacteria concentrations are difficult to accurately predict. Caution must be exercised when using values from single wet weather grab samples to estimate the magnitude of bacteria loading because it is often unknown whether the sample is representative of the "true" mean. To gain an understanding of the magnitude of bacterial loading from storm water and avoid overestimating or underestimating bacteria loading, event mean concentrations (EMC) are often used. An EMC is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow. Typical storm water event mean densities for various indicator bacteria in Massachusetts watersheds and nationwide are provided in Tables 5-3 and 5-4. These EMCs illustrate that storm water indicator bacteria concentrations from certain land uses (i.e., residential) are typically at levels sufficient to cause water quality problems.

Table 5-3. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform EMC (CFU/100 mL)	Number of Events	Class B WQS[1]	Reduction to Meet WQS (%)
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] Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

Table 5-4. Storm Water Event Mean Fecal Coliform Concentrations (as reported in MADEP 2002b; original data provided in Metcalf & Eddy, 1992) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform[1] Organisms / 100 mL	Class B WQS[2]	Reduction to Meet WQS (%)
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 NURP study event mean concentrations and nationwide pollutant buildup data (USEPA 1983).

[2] Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

6.0 Pathogen TMDL Development

Section 303 (d) of the Federal Clean Water Act (CWA) requires states to place water bodies that do not meet the water quality standards on a list of impaired waterbodies. The most recent impairment list, *2002 List*, identifies 22 segments within the Merrimack River watershed for use impairment caused by excessive indicator bacteria concentrations.

The CWA requires each state to establish Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant contributing to the impairment(s). TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating the water quality standards. Both point and non-point pollution sources are accounted for in a TMDL analysis. Point sources of pollution (those discharges from discrete pipes or conveyances) subject to NPDES permits receive a waste load allocation (WLA) specifying the amount of pollutant each point source can release to the waterbody. Non-point sources of pollution (all sources of pollution other than point) receive a load allocation (LA) specifying the amount of a pollutant that can be released to the waterbody by this source. In accordance with the CWA, a TMDL must account for seasonal variations and a margin of safety, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Thus:

$$\text{TMDL} = \text{WLAs} + \text{LAs} + \text{Margin of Safety}$$

Where:

WLA = Waste Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future point source of pollution.

LA = Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future non-point source of pollution.

This TMDL uses an alternative standards-based approach which is based on indicator bacteria concentrations, but considers the terms of the above equation. This approach is more in line with the way bacterial pollution is regulated (i.e., according to concentration standards) and achieves essentially the same result as if the equation were to be used.

6.1. Indicator Bacteria TMDL

Loading Capacity

The pollutant loading that a waterbody can safely assimilate is expressed as either mass-per-time, toxicity or some other appropriate measure (40 CFR § 130.2). Typically, TMDLs are expressed as total maximum daily loads. Expressing the TMDL in terms of daily loads is difficult to interpret given the very high numbers of indicator bacteria and the magnitude of the allowable load is dependent on flow conditions and, therefore, will vary as flow rates change. For example, a very high load of indicator bacteria are allowable if the volume of water that transports indicator bacteria is also high. Conversely, a relatively low load of indicator bacteria may exceed water quality standard if flow rates are low. Therefore, the MADEP believes it is appropriate to express indicator bacteria TMDLs in terms of a concentration because the water quality standard is also expressed in terms of the concentration of organisms per 100 mL. Since source concentrations may not be directly added due to varying flow conditions, the TMDL equation is modified and reflects a margin of safety in the case of this pathogen concentration based TMDL. To ensure attainment with Massachusetts' WQS for indicator bacteria, all sources (at their point of discharge to the receiving water) must be equal to or less than the WQS for indicator organisms. For all the above reasons the TMDL is simply set equal to the concentration-based standard and may be expressed as follows:

$$\text{TMDL} = \text{State Standard} = \text{WLA}_{(p1)} = \text{LA}_{(n1)} = \text{WLA}_{(p2)} = \text{etc.}$$

Where:

$\text{WLA}_{(p1)}$ = allowable concentration for point source category (1)
$\text{LA}_{(n1)}$ = allowable concentration for nonpoint source category (1)
$\text{WLA}_{(p2)}$ = allowable concentration for point source category (2) etc.

For Class A surface waters (1) *the arithmetic mean of a representative set of fecal coliform samples shall not exceed 20 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 100 organisms per 100 mL.*

For Class B and Class SB and SA areas not designated for shellfishing (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 400 organisms per 100 mL*.

For Class SA open shellfish area surface waters (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 43 organisms per 100 mL.*

For Class SB open shellfish surface waters (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 88 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 260 organisms per 100 mL.*

For marine bathing beaches (BEACH Act standard) (1) *the geometric mean of a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period) shall not exceed 35 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 104 colonies per 100 mL*.

For freshwater bathing beaches (MADPH standard, not yet adopted by the MADEP) (1) *the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 33 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 61 colonies per 100 mL*. – OR – (1) *the geometric mean of the most recent five E. coli levels within the same bathing season shall not exceed 126 colonies per 100 mL* and (2) *no single E. coli sample shall exceed 235 colonies per 100 mL.*

Waste Load Allocations (WLAs) and Load Allocations (LAs).

There are several WWTPs and other NPDES-permitted wastewater discharges within the Merrimack River watershed (listing is available in the CDM 2004a document: *Merrimack River Watershed Assessment Study Summary of Information on Pollutant Sources*). NPDES wastewater discharge WLAs are set at the WQS. In addition there are numerous storm water discharges from storm drainage systems throughout the watershed. All piped discharges are, by definition, point sources regardless of whether they are currently subject to the requirements of NPDES permits. Therefore, a WLA set equal to the WQS will be assigned to the portion of the storm water that discharges to surface waters via storm drains.

WLAs and LAs are identified for all known source categories including both dry and wet weather sources for Class SA, Class SB, Class A and B segments within the Merrimack River watershed. Establishing WLAs and LAs that only address dry weather indicator bacteria sources would not ensure attainment of standards because of the significant contribution of wet weather indicator bacteria sources to WQS exceedances. Illicit sewer connections and deteriorating sewers leaking to storm drainage systems represent the primary dry weather point sources of indicator bacteria, while failing septic systems and possibly leaking sewer lines represent the non-point sources. Wet weather point sources include discharges from storm water drainage systems (including MS4s), sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). Wet weather non-point sources primarily include diffuse storm water runoff.

Table 6-1 presents the indicator bacteria WLAs and LAs for the various source categories. WLAs and LAs will change to reflect the revised indicator organisms (*E. coli* and enterococci) when the updated WQS have been finalized (See Section 3.0 of this report). Source categories representing discharges of untreated sanitary sewage to receiving waters are prohibited, and therefore, assigned WLAs and LAs equal to zero. There are several sets of WLAs and LAs, one for Class SA shellfish open waters, one for Class SB shellfish open waters, one for Class A waters, one for Class B and shellfish restricted Class SA and SB waters, one for no discharge areas, one for freshwater beaches, and one for marine beaches.

The TMDL should provide a discussion of the magnitudes of the pollutant reductions needed to attain the goals of the TMDL. Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources including failing septic systems, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations, as presented in the "*Merrimack River Basin 1999 Water Quality Assessment Report*". These data indicate that up to two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loadings generally will be necessary, especially in developed areas.

Table 6-1. Indicator Bacteria Waste Load Allocations (WLAs) and Load Allocations (LAs) for the Merrimack River Basin.

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
A, B, SA, SB	Illicit discharges to storm drains	0	N/A
A, B, SA, SB	Leaking sanitary sewer lines	0	N/A
A, B, SA, SB	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[2]	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]
B & Not Designated for Shellfishing SA & SB	CSOs	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[4]	N/A
B & Not Designated for Shellfishing SA & SB	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[2]	N/A
B & Not Designated for Shellfishing SA & SB	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]	N/A
B & Not Designated for Shellfishing SA & SB	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
SA Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[2]	N/A
SA Designated Shellfishing Areas	Storm water Runoff Phase I and II	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]	N/A
SA Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]
SB Designated Shellfishing Areas	CSOs	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[4]	N/A
SB Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[2]	N/A
SB Designated Shellfishing Areas	Storm water runoff Phase I and II	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]	N/A
SB Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]
Marine Beaches[5]	All Sources	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
Fresh Water Beaches[6]	All Sources	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies

N/A means not applicable

[1] Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

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

[3] The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

[4] Or shall be consistent with an approved Long Term Control Plan (LTCP) for Combined Sewer Overflow (CSO) abatement. If the level of control specified in the LTCP is less than what is necessary to attain Class B water quality standards, then the above criteria apply unless MADEP has proposed and EPA has approved water quality standards revisions for the receiving water.

[5] Federal Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) Water Quality Criteria

[6] Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

This goal is expected to be accomplished through implementation of the best management practices (BMPs) associated with the Phase II control program in designated Urban Areas. The specific goal for controlling discharges from combined sewer overflows (CSOs) will be based on the site specific studies embodied in the Long Term Control Plan being developed by each community with combined sewers. This later effort will be benefiting from a study funded through the Army Corps of Engineers, and coordinated by CSO communities in New Hampshire and Massachusetts along with several state and federal agencies.

The expectation to attain WQS at the point of discharge is environmentally protective, 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 individuals responsible for monitoring activities.

This TMDL applies to the 22 pathogen impaired segments of the Merrimack River watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Merrimack River watershed 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 taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

6.2. Margin of Safety

This section addresses the incorporation of a Margin of Safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either 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). This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted below the water quality standard, provided that the receiving water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

6.3. Seasonal Variability

In addition to a Margin of Safety, TMDLs must also account for seasonal variability. Pathogen sources to Merrimack River waters arise from a mixture of continuous and wet-weather driven sources, and there may be no single critical 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 WQS independent of seasonal and climatic conditions. This will ensure the attainment of water quality standards regardless of seasonal and climatic conditions. Controls that are necessary will be in place throughout the year, protecting water quality at all times. However, for discharges that do not affect shellfish beds, intakes for water supplies and primary contact recreation is not taking place (i.e., during the winter months) seasonal disinfection is permitted for NPDES point source discharges.

7.0 Implementation Plan

Setting and achieving TMDLs should be an iterative process, with realistic goals over a reasonable timeframe and adjusted as warranted based on ongoing monitoring. The concentrations set out in the TMDL represent reductions that will require substantial time and financial commitment to be attained. A comprehensive control strategy is needed to address the numerous and diverse sources of pathogens in the Merrimack River watershed.

Controls on several types of pathogen sources will be required as part of the comprehensive control strategy. Many of the sources in the Merrimack River watershed including sewer connections to drainage systems, leaking sewer pipes, sanitary sewer overflows, 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 tributary storm water drainage systems during 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. Few studies have been conducted to identify and eliminate illicit connections (CDM 2004a).

CSOs and storm water runoff represent major sources of pathogens to the Merrimack River and tributaries, and the current level of control is inadequate for standards to be attained. Improving storm water runoff quality is essential for restoring water quality and recreational uses. At a minimum, intensive application of non-structural BMPs is needed throughout the watershed to reduce pathogen loadings as well as loadings of other storm water pollutants (e.g., nutrients and sediments) contributing to use impairment in the Merrimack River watershed. Depending on the degree of success of the non-structural storm water BMP program, structural controls may become necessary.

For these reasons, a basin-wide implementation strategy is recommended. The strategy includes a mandatory program for implementing storm water BMPs and eliminating illicit sources. The "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" was developed to support implementation of pathogen TMDLs. TMDL implementation-related tasks are shown in Table 7-1. The MADEP working with EPA and other team partners shall make every reasonable effort to assure implementation of this TMDL. These stakeholders can provide valuable assistance in defining hot spots and sources of pathogen contamination as well as the implementation of mitigation or preventative measures.

Table 7-1. Tasks

Task	Organization
Writing TMDL	MADEP
TMDL public meeting	MADEP
Response to public comment	MADEP
Organization, contacts with volunteer groups	MADEP/Merrimack River Watershed Council (MRWC)
Development of comprehensive storm water management programs including identification and implementation of BMPs	Merrimack River Basin Communities
Illicit discharge detection and elimination	Merrimack River Basin Communities
Leaking sewer pipes and sanitary sewer overflows	Merrimack River Basin Communities
CSO management	Merrimack River Basin Communities, CSO Coalition aided by a study funded through the Army Corps of Engineers
Inspection and upgrade of on-site sewage disposal systems as needed	Homeowners and Merrimack River Basin Communities (Boards of Health)
Organize implementation; work with stakeholders and local officials to identify remedial measures and potential funding sources	MADEP, MRWC, and Merrimack River Basin Communities
Organize and implement education and outreach program	MADEP, MRWC, and Merrimack River Basin Communities
Write grant and loan funding proposals	MRWC and Merrimack River Basin Communities and Planning Agencies with guidance from MADEP
Inclusion of TMDL recommendations in Executive Office of Environmental Affairs (EOEA) Watershed Action Plan	EOEA
Surface Water Monitoring	MADEP and MRWC
Provide periodic status reports on implementation of remedial activities	MRWC and Merrimack River Basin Communities

CSO Coalition - The communities of Lowell, Lawrence, Haverhill, Nashua, and Manchester and the MRWC

7.1. Summary of Activities within the Merrimack River Watershed

There are several not-for-profit organizations in the Merrimack River watershed. The Merrimack River Watershed Council (MRWC) is an advocate for the wise use of the Merrimack River watershed land and waters. The MRWC focuses on watershed education, working with communities to make land use decisions, and environmental monitoring. As part of the Council's efforts, it has formed the Volunteer Environmental Monitoring Network (VEMN). The network is made up of more than 30 monitoring groups and 1,000 volunteers. The MRWC coordinates the efforts of the groups (MRWC 2001). For more information about the MRWC, please see their website on the worldwide web (http://www.merrimack.org).

The Stony Brook Watershed Association (SBWA) focuses on protecting greenways and promoting communication and cooperation between towns. SBWA also works with students to conduct water quality monitoring and is working to make an adult program. SBWA is currently making efforts to protect land abutting Beaver Brook (Mass Riverways 1997).

Many other organizations have conducted monitoring in the watershed. These organizations can be instrumental in the identification of future and existing sources of pathogens in the Merrimack River watershed. Past programs included:

- The Powwow River Stream Team - shoreline survey and action plan (Mass Riverways 1997).
- The Bare Meadow Brook Stream Team - shoreline survey in 1999.
- The Merrimack Valley Planning Council, Merrimack River Watershed Council, and the DMF – fecal coliform sampling program between Haverhill and Newburyport to identify sources and reopen the shellfish beds (Mass Riverways 1997).

The Massachusetts Executive Office of Environmental Affairs (EOEA) has developed a *Merrimack River 5-Year Watershed Action Plan 2002-2007* (Action Plan; EOEA 2002). This five year plan mission statement is to "Develop and implement a watershed management plan that will restore and maintain the physical, chemical, and biological integrity of the river and its watershed to meet existing and future multiple uses and protect its natural resources" (EOEA 2002). Specific goals of the Action Plan, objectives, strategies, key players and measures of success are provided in this document. The Action Plan is accessible on the worldwide web at http://www.mass.gov/envir/water/publications.htm. Many of the goals outlined in the Action Plan are commensurate with goals of this TMDL. The Action Plan goals are to:

- Improve water quality in the mainstem and tributaries,
- Provide sustainable water supply to support predicted future population increases,
- Decrease flooding in the affected tributaries and prevention of future,
- Manage growth that reduces sprawl and protects critical open space, habitats, and water resources, and
- Improve river recreational access and regional open space protection for all watershed residents.

Additional information regarding on-going projects and assessment in the Merrimack River watershed can be obtained through the United States Army Corps of Engineers website at http://www.nae.usace.army.mil/projects/ma/merrimack/merrimack.htm

Data supporting this TMDL indicate that indicator bacteria enter the Merrimack River watershed from a number of contributing sources, under a variety of conditions. Activities that are currently ongoing and/or planned to ensure that the TMDL can be implemented include and are summarized in the following subsections. The "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" provides additional details on the implementation of pathogen control measures summarized below as well as additional measures not provided herein, such as by-law, ordinances and public outreach and education.

7.2. Illicit Sewer Connections, Failing Infrastructure and CSOs.

Elimination of illicit sewer connections, repairing failing infrastructure and controlling impacts associated with CSOs are of extreme importance. Several steps are currently underway in this regard. Several sewer and drainage projects are on-going in the City of Nashua, NH. A list of these projects is available on the worldwide web at http://www.gonashua.com/defaulto.asp?url=/dpwengineering/ProjectSchedules.asp. Two of the projects directly involve CSOs. The City of Nashua has completed a CSO Long Term Control Plan (LTCP) which includes separation of its combined sewers in 1997. A revised plan was submitted in 2003 which includes "…infrastructure improvements on aging combined sewer lines, implementation of stormwater controls, increased storage at select CSO locations, and improvements to the Nashua wastewater treatment facility" (CDM 2004a).

The City of Lowell, MA submitted a draft LTCP in 2001. Lowell has been installing new drainage pipe in central Lowell as part of the urban renewal and street reconstruction projects (CDM 2004a). Storm water flow was separated from the sanitary sewer lines where possible.

> In January of 2001, Lowell received a $5.85 million zero-interest loan to increase the capacity of its wastewater system from the federally subsidized Clean Water Act State Revolving Loan Fund. Also last year Congress passed the fiscal year 2002 Energy and Water Appropriations Conference Report, which contained $500,000 for the U.S. Army Corps of Engineers to conduct a multi-state study of water pollution and potential pollution control measures for the Merrimack River Basin. Lowell also received $350,000 in EPA State and Tribal Assistance Grants to help solve combined sewer overflow (CSO) infrastructure problems. (Lowell 2002).

Haverhill submitted a final LTCP in 2002. Originally there were 25 CSO outfalls, four of which have been sealed and no longer discharge.

> The city of Haverhill is committed to moving forward with programs that will clearly have a positive impact on water quality and use of the Merrimack and Little Rivers. Programs that will have an impact and those that the city is committed to:

1. Construction of primary clarifier modifications at the treatment plant to ensure that process equipment is reliable and capable of treating existing and future flows as effectively as possible. This is the first step towards increasing wet-weather capacity at the treatment plant and thus reducing CSOs. $2 Million

2. Design and construction of a new grit removal facility to provide more reliable operation of the primary clarifiers and associated sludge removal equipment during wet-weather conditions. $6 Million

3. Design and construction of upgrades to the plant influent pumping station, control gate, and/or force main to allow for an increased plant wet-weather flow of approximately 60-mgd. $8 Million

4. Design and construction of miscellaneous plant improvements to accommodate an increase to approximately 60-mgd of wet-weather capacity including a new secondary bypass conduit and associated control gates, instrumentation, and separate disinfection diffuser in the bypass conduit. $3.5 Million

5. Design and construction of miscellaneous improvements at the Bradford-side CSO regulators to reduce CSO discharges. These improvements include modifications to the Front Street, Middlesex Street, South Main Street, Ferry Street, and South Prospect Street CSO structures. $0.5 Million

6. Continue implementation of the nine minimum controls as outlined in the CDM report "City of Haverhill, Massachusetts Wastewater Division Draft Report on Nine Minimum Control Measures for CSOs" dated September 1996.

7. Implementation of a CSO monitoring plan to further characterize CSO activation and to evaluate the effectiveness of the recommended improvements. The monitoring plan was submitted to EPA under a separate cover, dated August 1, 2002.

8. Acting to control storm water pollution most effectively by investigating and correcting identified problems in the city's storm drainage system that contributes to water quality problems in the rivers.

9. Continuing as an active participant in the Merrimack River Initiative and sharing in the costs necessary to ensure that a comprehensive, scientifically accurate study is completed. $0.1 Million (Haverhill 2005).

The Greater Lawrence Sanitary District (GLSD) submitted a draft LTCP in 2002. The GLSD is "currently working on a 'Phase 1' control program that will reduce the volume of combined sewer overflows by more than half. The program focuses on upgrading the District wastewater treatment plant to increase its ability to accept wet weather flow" (GLSD 2005). This project is scheduled to be completed in late 2007.

The communities of Lowell, Lawrence, Haverhill, Nashua, and Manchester and the Merrimack River Watershed Council (MRWC) have joined together to form the "CSO coalition." The coalition has worked to raise money for a study to be conducted by the United States Army Corps of Engineers. The study's purpose is to provide more information on pollution sources and water quality issues, to inform the communities and regulatory agencies, and to provide insight on CSO and storm water pollution projects.

Guidance for illicit discharge detection and elimination has been developed by EPA New England (USEPA 2004b) for the Lower Charles River. The guidance document provides a plan, available to all Commonwealth communities, to identify and eliminate illicit discharges (both dry and wet weather) to their separate storm sewer systems. Implementation of the protocol outlined in the guidance document satisfies the Illicit Discharge Detection and Elimination requirement of the NPDES program. A copy of the guidance document is provided in Appendix A.

7.3. Storm Water Runoff

Storm water runoff can be categorized in two forms; 1) point source discharges and 2) non-point source discharges (includes sheet flow or direct runoff). Many point source storm water discharges are regulated under the NPDES Phase I and Phase II permitting programs when discharged to a Waters of the United States. Municipalities that operate regulated municipal separate storm sewer systems (MS4s) must develop and implement a storm water management plan (SWMP) which must employ, and set measurable goals for the following six minimum control measures:

1. public education and outreach particularly on the proper disposal of pet waste,
2. public participation/involvement,
3. illicit discharge detection and elimination,
4. construction site runoff control,
5. post construction runoff control, and
6. pollution prevention/good housekeeping.

Portions of towns in this watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule. This rule requires the development and implementation of an illicit discharge detection and elimination plan.

The BBAC created a web page to help municipalities with obtaining their Phase II permits. Partly due to their efforts, 95% of the municipalities submitted their permit applications within the required time limit (all municipalities have submitted their permit application at this point).

The NPDES permit does not, however, establish numeric effluent limitations for storm water discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals.

Non-point source discharges are generally characterized as sheetflow runoff and are not categorically regulated under the NPDES program and can be difficult to manage. However, some of the same principles for mitigating point source impacts may be applicable. Individual municipalities not regulated under the Phase I or II should implement the exact same six minimum control measures minimizing storm water contamination.

7.4. Failing Septic Systems

Septic system bacteria contributions to the Merrimack River and its tributaries may be reduced in the future through septic system maintenance and/or replacement. Additionally, the implementation of Title 5, which requires inspection of private sewage disposal systems before property ownership may be transferred, building expansions, or changes in use of properties, will aid in the discovery of poorly operating or failing systems. Because systems which fail must be repaired or upgraded, it is expected that the bacteria load from septic systems will be significantly reduced in the future. Regulatory and educational materials for septic system installation, maintenance and alternative technologies are provided by the MADEP on the worldwide web at http://www.mass.gov/dep/brp/wwm/t5pubs.htm.

7.5. Wastewater Treatment Plants

WWTP discharges are regulated under the NPDES program when the effluent is released to surface waters. Each WWTP has an effluent limit included in its NPDES or groundwater permit. Some NPDES permits are listed on the following website: www.epa.gov/region1/npdes/permits_listing_ma.html. Groundwater permits are available at http://www.mass.gov/dep/brp/gw/gwhome.htm.

7.6. Recreational Waters Use Management

Recreational waters receive pathogen inputs from swimmers and boats. To reduce swimmers' contribution to pathogen impairment, shower facilities can be made available, and bathers should be encouraged to shower prior to swimming. In addition, parents should check and change young children's diapers when they are dirty. Options for controlling pathogen contamination from boats include:

- petitioning the State for the designation of a No Discharge Area (NDA),
- supporting installation of pump-out facilities for boat sewage,
- educating boat owners on the proper operation and maintenance of marine sanitation devices (MSDs), and
- encouraging marina owners to provide clean and safe onshore restrooms and pump-out facilities.

Currently, a no discharge area (NDA) has not been established in the Merrimack River watershed. The designation of a NDA by the Commonwealth of Massachusetts and approved by the EPA would provided protection of the designated area by a Federal Law, which prohibits the release of raw or treated sewage from vessels into navigable waters of the U.S. The law is enforced by the Massachusetts Environmental Police. The MACZM and Massachusetts Environmental Law Enforcement are actively pursuing an amendment to State regulations allowing for the institution of fines up to $2000 for violations within a NDA (USEPA 2004c).

7.7. Funding/Community Resources

A complete list of funding sources for implementation of nonpoint source pollution is provided in Section VII of the Massachusetts Nonpoint Source Management Plan Volume I (MADEP 2000b) available on line at http://www.mass.gov/dep/brp/wm/nonpoint.htm. This list includes specific programs available for non-point source management and resources available for communities to manage local growth and development. The State Revolving Fund (SRF) provides low interest loans to communities for certain capital costs associated with building or improving wastewater treatment facilities. In addition, many communities in Massachusetts sponsor low cost loans through the SRF for homeowners to repair or upgrade failing septic systems.

7.8. Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts

For a more complete discussion on ways to mitigate pathogen water pollution, see the "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" accompanying this document.

8.0 Monitoring Plan

The long term monitoring plan for the Merrimack Watershed includes several components:

1. continue with the current monitoring of the Merrimack River Drainage Basin (MADEP, MRWC, and other stakeholders),
2. continue with MADEP watershed five-year cycle monitoring,
3. monitor areas within the watershed where data are lacking or absent to determine if the waterbody meets the use criteria,
4. 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,
5. assemble data collected by each monitoring entity to formulate a concise report where the basin is assessed as a whole and an evaluation of BMPs can be made, and
6. add/remove/modify BMPs as needed based on monitoring results.

The monitoring plan is an ever changing document that requires flexibility to add, change or delete sampling locations, sampling frequency, methods and analysis. At the minimum, all monitoring should be conducted with a focus on:

- capturing water quality conditions under varied weather conditions,
- establishing sampling locations in an effort to pin-point sources,
- researching new and proven technologies for separating human from animal bacteria sources, and
- assessing efficacy of BMPs.

9.0 Reasonable Assurances

Reasonable assurances that the TMDL will be implemented include both enforcement of current regulations, availability of financial incentives including low or no-interest loans to communities for wastewater treatment facilities through the State Revolving Fund (SRF), and the various local, state and federal programs for pollution control. Storm water NPDES permit coverage will address discharges from municipal owned storm water drainage systems. Enforcement of regulations controlling non-point discharges includes local enforcement of the states Wetlands Protection Act and Rivers Protection Act; Title 5 regulations for septic systems and various local regulations including zoning regulations. Financial incentives include Federal monies available under the CWA Section 319 NPS program and the CWA Section 604 and 104b programs, which are provided as part of the Performance Partnership Agreement between MADEP and the EPA. Additional financial incentives include state income tax credits for Title 5 upgrades, and low interest loans for Title 5 septic system upgrades through municipalities participating in this portion of the state revolving fund program.

10.0 Public Participation

To be added later….

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Appendix A

Lower Charles River Illicit Discharge Detection & Elimination (IDDE) Protocol
Guidance for Consideration - November 2004