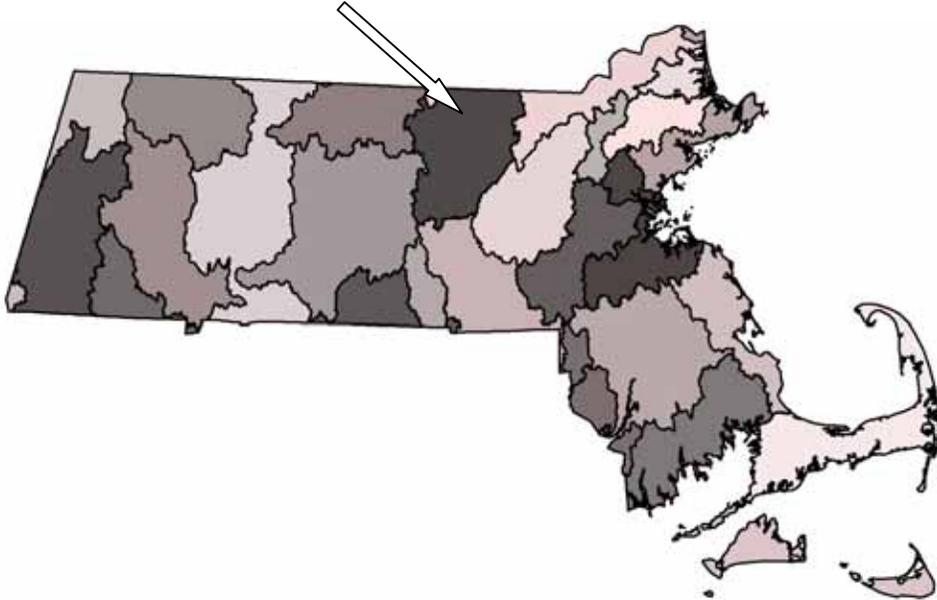


Draft Pathogen TMDL for the Nashua River Watershed

Nashua River Basin



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NOTICE OF AVAILABILITY

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

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Division of Watershed Management
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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 Nashua River Watershed



Key Features: Pathogen TMDL for the Nashua River Watershed

Location: EPA Region 1

Land Type: New England Upland

303(d) Listings: Pathogens
East Wachusett Brook (MA81-33);
Gates Brook (MA81-24);
Malagasco Brook (MA81-29);
Nashua River (MA81-05; MA81-07; MA81-08; MA81-09);
North Nashua River (MA81-01; MA81-02; MA81-03; MA81-04);
Scarletts Brook (MA81-25).

Data Sources:

- MADEP "Nashua River Basin 1998 Water Quality Assessment Report"
- NRWA Water Quality Sampling 2003

Data Mechanism: Massachusetts Surface Water Quality Standards for Fecal Coliform;
Massachusetts Department of Public Health Bathing Beaches

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; Ordinances; Septic System Maintenance/Upgrades

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) public health officials and/or municipalities that are responsible for monitoring, enforcing or otherwise mitigating fecal contamination that results in beach 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 Massachusetts portion of the Nashua 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 Nashua 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 Nashua 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 12 pathogen impaired segments of the Nashua 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 Nashua 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.

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 Nashua 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	Illicit discharges to storm drains	0	N/A
A & B	Leaking sanitary sewer lines	0	N/A
A & B	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	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	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	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	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
Fresh Water Beaches ⁵	All Sources	<p>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</p> <p>OR</p> <p><i>E. coli</i> 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</p>	<p>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</p> <p>OR</p> <p><i>E. coli</i> 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</p>

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.

³The 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 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 Nashua 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, many of the Nashua River 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 Nashua River waterbodies. These include water supply, 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. Nashua 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

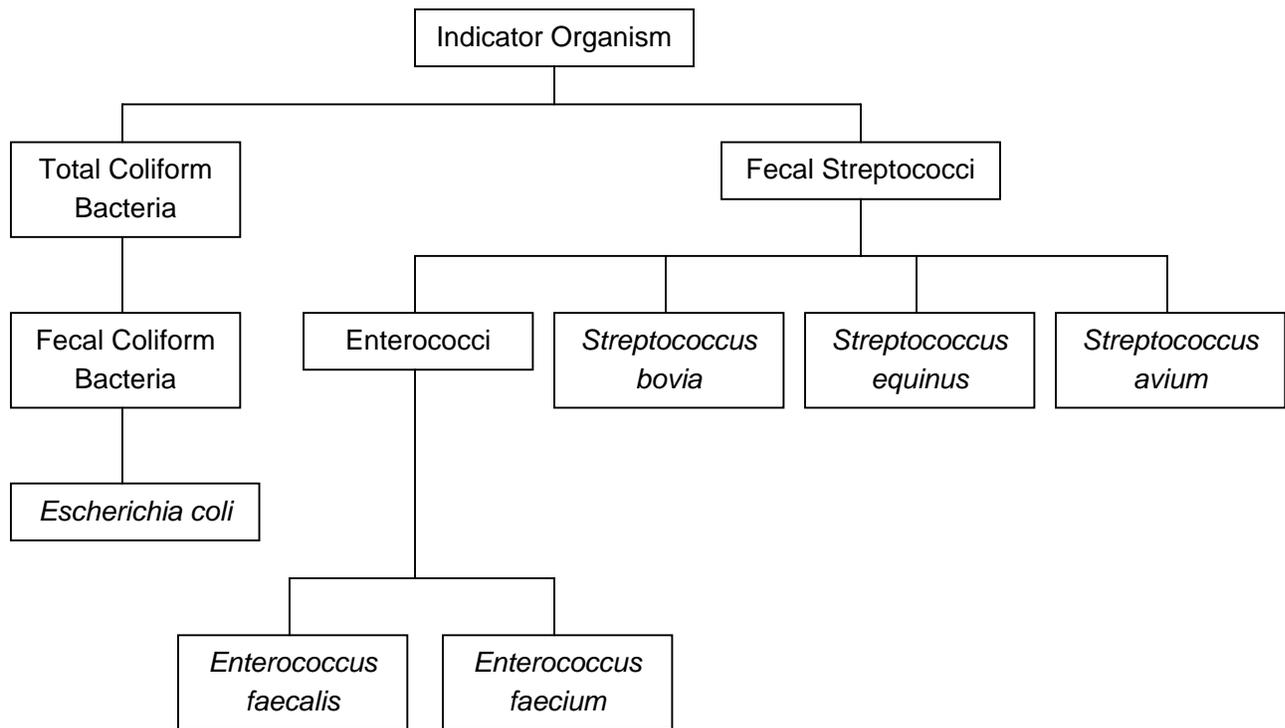
The Nashua River watershed pathogen TMDL is designed to support reduction of waterborne disease-causing organisms, known as pathogens, to reduce public health risk. Waterborne pathogens enter surface waters from a variety of sources including sewage and the feces of warm-blooded wildlife. These pathogens 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 water 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 Nashua River watershed pathogen TMDLs have been developed using fecal coliform as an indicator bacterium for fresh waters. 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 Nashua 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 Nashua 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. Pathogen impaired sections of the Nashua River watershed are a focus of this report, but this TMDL applies to all Nashua River watershed waters, including those waterbodies specified in future subsequent Massachusetts CWA Section 303(d) Integrated List of Waters.

As discussed below, this TMDL applies to the 12 pathogen impaired segments of the Nashua River watershed that are currently listed on the CWA § 303(d) list of impaired waters and determined to be pathogen impaired in the “*Nashua River Basin 1998 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 Nashua 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 108 waterbody segments assessed by the MADEP in the Nashua River watershed (MassGIS 2005). These segments consist of 35 river segments, 12 of which are pathogen impaired and appear as such on the official impaired waters list (303(d) List) (Figure 1-1). None of the 73 assessed lake segments are pathogen impaired. 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, may also be 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 Nashua 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 Nashua River watershed
- Identification of Sources (Section 5) – identifies and discusses potential sources of waterborne pathogens within the Nashua 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 Nashua River watershed lies primarily within Worcester and Middlesex counties in Massachusetts and within Hillsborough County in New Hampshire (MADEP 2001). The Nashua River drains 538 square miles, 454 square miles within Massachusetts which includes 24 cities and towns within north central Massachusetts (EOEA 2003). The “South branch” of the Nashua River originates from the outlet of Lancaster Millpond in Clinton. The “South branch” extends north to Lancaster where it meets the North Nashua River. The North Nashua River, originating in Fitchburg, flows approximately 19 miles in a southeast direction. From its confluence with the North Nashua River, the Nashua River continues another 37 miles in a northeasterly direction to its confluence with the Merrimack River in Nashua, New Hampshire (MADEP 2001). This TMDL applies only toward the Massachusetts portion of the Nashua River watershed. The Squannacook and Nissitissit Rivers are two major tributaries of the Nashua River. Land use within the watershed is primarily forest (Table 2-1). The more developed areas tend to correspond to impaired river segments (Figure 2-1).

The Nashua River hydrology is impacted by two dams along the length of the river: the dam forming the Wachusett Reservoir in the “South branch” and Pepperell Paper Company’s dam forming Pepperell Pond. The dam at the Wachusett Reservoir reduces the river’s flow to one-fifth its natural rate. The Wachusett Reservoir provides two-thirds of the drinking water in Massachusetts (EOEA 2003).

The Nashua River and tributaries are commonly used for primary and secondary contact recreation (swimming and boating), fishing, wildlife viewing, habitat for aquatic life, irrigation, agricultural uses, industrial cooling and public water supply.

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

Land Use Category	% of Total Watershed Area
Pasture	1.8
Urban Open	1.8
Open Land	2.9
Cropland	4.9
Woody Perennial	0.9
Forest	62.0
Wetland	1.9
Water Based Recreation	0.0
Water	4.0
General Undeveloped Land	80.2
Spectator Recreation	0.0
Participation Recreation	1.0
> 1/2 acre lots Residential	8.6
1/4 - 1/2 acre lots Residential	4.5
< 1/4 acre lots Residential	1.8
Multi-family Residential	0.4
Mining	0.5
Commercial	0.9
Industrial	0.8
Transportation	0.9
Waste Disposal	0.3
General Developed Land	19.8

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

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 Nashua 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>

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

The Nashua River watershed contains waterbodies classified as Class A and Class B. 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 waterbodies - 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.

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.

There are no marine bathing beaches in the Massachusetts portion of the Nashua River watershed. However, there are numerous freshwater beaches located within the watershed. A list of fresh (and marine) beaches by community with 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 Nashua 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 2002) original data provided in MDC Wachusett Storm Water Study (June 1997).

Land Use Category	Fecal Coliform Bacteria¹ 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 sewerred, on septic systems), Storm 1	30 – 29,600
High Density Residential (not sewerred, 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 river segments represent 33.7% of the total river miles assessed (53.1 miles of impairment; 157.6 total miles assessed) (MassGIS 2005). In total, 12 segments, each in need of a TMDL, contain indicator bacteria concentrations in excess of the Massachusetts WQS for Class A or B waterbodies (314 CMR 4.05)¹ and/or the MADPH standard for bathing beaches². 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 TMDLs 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 Nashua 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*, it is not necessary to provide detailed documentation of pathogen impairment herein. Data from the MADEP and the Nashua River Watershed Association (NRWA) were reviewed and are summarized by segment in the following subsection.

Data summarized in the following subsections can be found at:

- **MADEP WQA** – Nashua River Basin 1998 Water Quality Assessment Report available for download at <http://www.mass.gov/dep/brp/wm/wqassess.htm>.
- **NRWA** – downloaded from the NRWA website (<http://www.nashuariverwatershed.org/>) under water quality monitoring. The NRWA also has data from 1995-2002, which was not included in this report.

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 B: 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.

Table 4-3. Nashua River Pathogen Impaired Segments Requiring TMDLs (adapted from MADEP 2003 and MassGIS 2005).

Segment ID	Segment Name	Length (miles)	Segment Description
MA81-29	Malagasco Brook	2.4	From the headwaters southwest of Apron Hill through Pine Swamp, Boylston to the inlet of Wachusett Reservoir (South Bay), Boylston.
MA81-24	Gates Brook	3.5	Headwaters to inlet Wachusett Reservoir, West Boylston.
MA81-25	Scarletts Brook	0.5	Headwaters to confluence with Gates Brook, West Boylston.
MA81-30	East Wachusett Brook	5.4	From the headwaters (northeast of Little Wachusett Mountain), Princeton to the confluence with the Stillwater River, Sterling.
MA81-08	Nashua River "South Branch"	3.0	Outlet Lancaster Mill Pond, Clinton to Clinton WWTP, Clinton.
MA81-09	Nashua River "South Branch"	1.6	Clinton WWTP, Clinton to confluence with North Nashua River, Lancaster.
MA81-01	North Nashua River	1.2	Outlet Snows Millpond, Fitchburg to Fitchburg Paper Company Dam #1, Fitchburg.
MA81-02	North Nashua River	6.3	Fitchburg Paper Company Dam #1, Fitchburg East WWTP, Fitchburg.
MA81-03	North Nashua River	2.1	Fitchburg East WWTP Fitchburg to Leominster WWTP, Leominster.
MA81-04	North Nashua River	9.9	Leominster WWTP, Leominster to confluence with Nashua River, Lancaster.
MA81-05	Nashua River	13.5	Confluence with North Nashua River, Lancaster to confluence with Squannacook River, Shirley/Groton/Ayer.
MA81-07	Nashua River	3.7	Pepperell Dam, Pepperell to New Hampshire state line, Pepperell/Dunstable.

The following summary tables for each segment contain the data source and the calendar years data were collected (e.g., NRWA 2003). In some cases, data are broken down into two weather conditions: wet and dry. It should be noted that some reporting entities require a minimum amount of precipitation (e.g., 0.1 or 0.2 inches) before it is considered wet weather. Therefore data between reporting entities may not be directly comparable, but overall conclusions for each segment remain consistent.

Data collected by the MADEP and presented in the WQA may contain the following fields:

- Site # – indicates sampling location identifier given by the sampling entity
- Description – short narrative indicating location of sampling station
- Town – Town in which the sample was collected
- Min – the minimum value reported at that station
- Max – the maximum value reported at that station
- n – the number of samples collected at that station or within a specific time frame
- Primary or Secondary Contact Season – these column summarize data collected during primary and secondary contact recreational seasons; number and percentage of samples exceeding thresholds identified in the WQA are provided (i.e., 200, 400,1000, 2000 colony forming units (cfu)/100mL)

The purpose of this section of the report is to briefly describe the impaired segments in the Nashua River watershed. For more information on any segment, see the Nashua River Basin 1998 Water Quality Assessment Report on the DEP website: <http://www.mass.gov/dep/>.

Malagasco Brook Segment (MA81-29)

Malagasco Brook is a 2.4 mile Class A segment extending from its headwaters southwest of Apron Hill through Pine Swamp to the inlet of the Wachusett Reservoir (South Bay) in Boylston. The known source of fecal coliform along this segment is nursery agriculture. Water withdrawals and National Pollutant Discharge Elimination System (NPDES) permitted dischargers were not identified in WQA.

The Massachusetts District Commission (MDC) performed bacteria sampling between 1995 and 1999. Results of the MDC sampling, as reported in the WQA, are summarized in Table 4-4 (MADEP 2001).

Table 4-4. MDC Malagasco Brook (MA81-29) 1995-1999 Indicator Bacteria Data Summary (MADEP 2001).

Description	Town	All Samples			Primary Contact Season		
		Fecal Coliform (cfu/100mL)			Fecal Coliform (cfu/100mL)		
		Min	Max	n	# Samples >400	# Samples >2000	n
Near West Temple St.	Boylston	0	10,100	249	15 (11%)	6 (2%)	139

Note: Elevated counts were not consistently associated with storm events.

Gates Brook Segment (MA81-24)

Gates Brook is a 3.5 mile Class A segment extending from the headwaters in West Boylston to the inlet of the Wachusett Reservoir also in West Boylston. Water withdrawals and NPDES permitted dischargers were not identified in WQA.

The MDC performed bacteria sampling between 1995 and 1999. Results of the MDC sampling, as reported in the WQA, are summarized in Table 4-5 (MADEP 2001).

Table 4-5. MDC Gates Brook (MA81-24) 1995-1999 Indicator Bacteria Data Summary (MADEP 2001).

Site #	Description	Max	Primary Contact Season Fecal Coliform (cfu/100mL)			Secondary Contact Season Fecal Coliform (cfu/100mL)		
			# Samples >200	% Samples >400	n	# Samples >1000	% Samples >2000	n
9	Woodland St.	4,620	21 (15%)	7%	140	4 (2%)	<1%	246
6	Lombard St.	16,500	64 (45%)	28%	141	18 (7%)	3%	247
4	Pierce St.	13,800	47 (33%)	29%	141	14 (6%)	3%	245
3	Worcester St.	18,000	36 (26%)	13%	141	13 (5%)	3%	247
2	Route 140	8,360	41 (29%)	18%	142	15 (6%)	4%	248
1	Gate 25	11,700	21 (15%)	13%	141	8 (3%)	2%	247

Scarletts Brook Segment (MA81-25)

Scarletts Brook is a 0.5 mile Class A segment extending from the headwaters in West Boylston to the confluence with Gates Brook. The only registered water withdrawal is Wachusett Country Club in this drainage area. The Wachusett Country Club is registered to withdraw 0.04 million gallons per day (mgd). No NPDES dischargers were listed in the WQA.

The MDC performed bacteria sampling between 1995 and 1999. Results of the MDC sampling, as reported in the WQA, are summarized in Table 4-6 (MADEP 2001).

Table 4-6. MDC Scarletts Brook (MA81-25) 1995-1999 Indicator Bacteria Data Summary (MADEP 2001).

Description	Town	All Samples				Primary Contact Season	
		Fecal Coliform (cfu/100mL)				Fecal Coliform (cfu/100mL)	
		Min	Max	# Samples >2000	n	# Samples >400	n
Near West Temple St.	Boylston	0	9,000	3 (1%)	247	23 (13%)	173

East Wachusett Brook Segment (MA81-30)

East Wachusett Brook is a 5.4 mile Class A river segment extending from its headwaters northeast of Little Wachusett Mountain in Princeton to the confluence with the Stillwater River (an unimpaired segment) in Sterling. Water withdrawals and NPDES permitted dischargers were not identified in WQA.

The MDC performed bacteria sampling between 1995 and 1999. Results of the MDC sampling, as reported in the WQA, are summarized in Table 4-7 (MADEP 2001).

Table 4-7. MDC East Wachusett Brook (MA81-30) 1995-1999 Indicator Bacteria Data Summary (MADEP 2001).

Description	Town	All Samples			Primary Contact Season		
		Fecal Coliform (cfu/100mL)			Fecal Coliform (cfu/100mL)		
		Min	Max	n	# Samples >400	# Samples >2000	n
Near Route 140	Holden	0	6,000	139	15 (19%)	6 (1%)*	77

*Five of the six samples were taken in 1995.

Nashua River “South Branch” Segment (MA81-08)

This portion of the South Branch of the Nashua River segment is a 3.0 mile Class B warm water fishery. The segment originates from the outlet of Lancaster Mill Pond in Clinton and flows to the Clinton Waste Water Treatment Plant (WWTP). The MDC/Massachusetts Water Resource Authority (MWRA) is registered to withdraw surface water (registered volume 126.1 mgd) upstream of this segment from the Wachusett Reservoir system. The Weetabix Company, Inc. is authorized under a NPDES permit to discharge non-contact cooling water in this segment.

The MADEP Division of Water Management (DWM) performed bacteria sampling in 1998. Results of the DWM sampling are provided in Table 4-8. Figure 4-1, provided at the end of the segment narratives, illustrates the location of the DWM sampling stations.

Table 4-8. DWM South Branch (MA81-08) 1998 Indicator Bacteria Data Summary (MADEP 2001).

Site #	Description	Town	Dry Weather			Wet Weather		
			Fecal Coliform (cfu/100mL)			Fecal Coliform (cfu/100mL)		
			Min	Max	n	Min	Max	n
NS17	Rt. 110 (upstream)	Clinton	80	480	4	9,000	9,000	1

One sample during dry weather was analyzed for *E. coli* and enterococcus. Counts were <20 cfu/100mL for both bacteria indicators.

Nashua River “South Branch” Segment (MA81-09)

This portion of the South Branch of the Nashua River segment is a 1.6 mile segment is a Class B warm water fishery. The segment extends from the Clinton WWTP to the confluence with the North Nashua River in Lancaster. There is one NPDES permitted discharger along this segment: MWRA Clinton WWTP.

The MADEP Division of Water Management (DWM) performed bacteria sampling in 1998. Results of the DWM sampling are provided in Table 4-9. Figure 4-1, provided at the end of the segment narratives, illustrates the location of the DWM sampling stations. The NRWA has been collecting data annually since 1995. Data from the 2003 (April to October) sampling are also summarized in Table 4-9.

Table 4-9. South Branch (MA81-09) Indicator Bacteria Data Summary.

Site #	Description	Town	Dry Weather			Wet Weather		
			Fecal Coliform (cfu/100 mL)			Fecal Coliform (cfu/100 mL)		
			Min	Max	n	Min	Max	n
DWM 1998								
NS19	Bolton Rd. (upstream)	Lancaster	82	800	4	16,000	16,000	1
NWRA 2003								
SNO1	South Nashua River at Mill St.	Lancaster	20	220	6	20	20	1

One sample during dry weather was analyzed for *E. coli* and enterococcus by the DWM in 1998. Counts were 20 and 60 cfu/100mL for *E. coli* and enterococcus respectively.

North Nashua River Segment (MA81-01)

This segment of the North Nashua River is a 1.2 mile Class B warm water fishery and CSO receiving water. The segment originates at the outlet of Snows Millpond in Fitchburg and continues to Fitchburg Paper Company Dam #1. The International Recycling Corporation is registered to withdraw surface water (5.2 mgd) from Snows Millpond. The West Fitchburg Wastewater Treatment Facility (WWTF) is permitted to discharge treated wastewater into this river segment. During wet weather, the East Fitchburg WWTP is permitted to discharge storm water/wastewater from 41 combined sewer overflows into the North Nashua River, Philips Brook, Baker Brook, Punch Brook, and several streams. Options for addressing CSOs in this and other affected segments are the subject of the Long Term Control Plan now underway by the City of Fitchburg.

The MADEP Division of Water Management (DWM) performed bacteria sampling in 1998. Results of the DWM sampling are provided in Table 4-10. Figure 4-1, provided at the end of the segment narratives, illustrates the location of the DWM sampling stations.

Table 4-10. DWM North Nashua River (MA81-01) 1998 Indicator Bacteria Data Summary (MADEP 2001).

Site #	Description	Town	Dry Weather			Wet Weather		
			Fecal Coliform (cfu/100mL)			Fecal Coliform (cfu/100mL)		
			Min	Max	n	Min	Max	n
NN01	Rt. 31 bridge (downstream)	Fitchburg	<20	3,300	4	2,000	2,000	1

One sample during dry weather was analyzed for *E. coli* and enterococcus. Counts were <20 and 220 cfu/100mL for *E. coli* and enterococcus respectively.

North Nashua River Segment (MA81-02)

This segment of the North Nashua River is a 6.3 mile Class B warm water fishery. The segment flows from Fitchburg Paper Company Dam #1 to Fitchburg East WWTP. Munksjo Paper Décor, Inc. is permitted to withdraw water (1.08 mgd) from their water intake station. Simonds Cutting Tools is registered to withdraw water from eight wells (0.26 mgd). Simonds Industries, Incorporated, Fitchburg is permitted to discharge non-contact and air conditioning cooling water in this segment. During wet weather, the East Fitchburg WWTP is permitted to discharge storm water/wastewater from 41 combined sewer overflows into the North Nashua River, Philips Brook, Baker Brook, Punch Brook, and several streams. The All Natural Resources Company is licensed to operate the 50 kilowatt Fitchburg Paper Mill Dam #4 on this segment of the river.

The MADEP Division of Water Management (DWM) performed bacteria sampling in 1998. Results of the DWM sampling are provided in Table 4-11. Figure 4-1, provided at the end of the segment narratives, illustrates the location of the DWM sampling stations.

Table 4-11. DWM North Nashua River (MA81-02) 1998 Indicator Bacteria Data Summary (MADEP 2001).

Site #	Description	Town	Dry Weather			Wet Weather		
			Fecal Coliform (cfu/100mL)			Fecal Coliform (cfu/100mL)		
			Min	Max	n	Min	Max	n
NN09	Falulah Rd. bridge (upstream)	Fitchburg	280	3,100	4	3,000	3,000	1

One sample during dry weather was analyzed for *E. coli* and enterococcus. Counts were <20 and 60 cfu/100mL for *E. coli* and enterococcus respectively.

North Nashua River Segment (MA81-03)

This segment of the North Nashua River is a 2.1 mile Class B warm water fishery. This impaired segment extends from East Fitchburg WWTP to Leominster WWTP. There is one NPDES discharger along this segment, East Fitchburg WWTP. During wet weather, the WWTP is permitted

to discharge storm water/wastewater from 41 combined sewer overflows into the Nashua River upstream of this segment as well as into Philips, Baker and Punch brooks and several streams. Sampling was conducted upstream and downstream of this segment. See North Nashua River segments MA81-02 and MA81-04 for indicator bacteria data.

North Nashua River Segment (MA81-04)

This segment of the North Nashua River is a 9.9 mile Class B warm water fishery extending from the Leominster WWTP in Leominster to the confluence with the Nashua River in Lancaster. Grove Farm is registered to withdraw surface water from Farm Pond (0.04 mgd) located in this subwatershed. There are two NPDES dischargers in this segment: Leominster WWTP and River Terrace Healthcare, both discharging treated wastewater.

The MADEP Division of Water Management (DWM) performed bacteria sampling in 1998. Results of the DWM sampling are provided in Table 4-12. Figure 4-1, provided at the end of the segment narratives, illustrates the location of the DWM sampling stations. The NRWA has been collecting data annually since 1995. Data from the 2003 (April to October) sampling are also summarized in Table 4-12.

Table 4-12. North Nashua River (MA81-04) Indicator Bacteria Data Summary.

Site #	Description	Town	Dry Weather			Wet Weather		
			Fecal Coliform (cfu/100 mL)			Fecal Coliform (cfu/100 mL)		
			Min	Max	n	Min	Max	n
DWM 1998								
NN12	Rt. 190 bridge (downstream)	Lancaster	310	1,000	4	310	1,000	4
NWRA 2003								
NN01	Main St. Railroad bridge	Lancaster	40	290	6	40	290	6
NN02	Cook powerline crossing	Lancaster	88	>400 (TNTC)	8	TNTC	TNTC	1

One sample during dry weather was analyzed for *E. coli* and enterococcus by the DWM. Counts were <20 and 50 cfu/100mL for *E. coli* and enterococcus respectively.
TNTC = too numerous to count

Nashua River Segment (MA81-05)

This segment of the Nashua River is a 13.5 mile Class B warm water fishery extending from the confluence with the North Nashua River in Lancaster to the confluence with the Squannacook River in Shirley/Groton/Ayer. There are two NPDES permitted dischargers along this river segment: MCI Shirley and Ayer.

The MADEP Division of Water Management (DWM) performed bacteria sampling in 1998. Results of the DWM sampling are provided in Table 4-13. Figure 4-1, provided at the end of the segment narratives, illustrates the location of the DWM sampling stations. The NRWA has been collecting data annually since 1995. Data from the 2003 (April to October) sampling are also summarized in Table 4-13.

Table 4-13. Nashua River (MA81-05) Indicator Bacteria Data Summary.

Site #	Description	Town	Dry Weather			Wet Weather		
			Fecal Coliform (cfu/100 mL)			Fecal Coliform (cfu/100 mL)		
			Min	Max	n	Min	Max	n
DWM 1998								
NM21	Still River Rd.	Harvard	<20	210	4	1,000	1,000	1
NM21A	Jackson Rd. bridge	Harvard	40	170	4	3,250	3,250	1
NM25	Rt. 2A (downstream)	Shirley/Ayer	60	1,200	3	2,000	2,000	1
NM25A	Rt. 2A (upstream)	Shirley/Ayer	49	49	1			
NRWA 2003								
NM07	Route 2A	Shirley/Ayer	23	153	6	145	145	1
NM08	Hospital Rd.	Harvard/Devens	5	383	6	175	175	1
NM09	Tank bridge Depot Rd.	Harvard	20	250	6	TNTC	TNTC	1
NM10	Rt. 117	Lancaster	28	285	6	TNTC	TNTC	1

One sample during dry weather was analyzed for *E. coli* and enterococcus by the DWM at three of the four stations (NM21, NM21A, and NM25). Counts ranged from <20 to 20 cfu/100mL for *E. coli* <20 and 60 to 260 cfu/100mL for enterococcus.

TNTC = too numerous to count

Nashua River Segment (MA81-07)

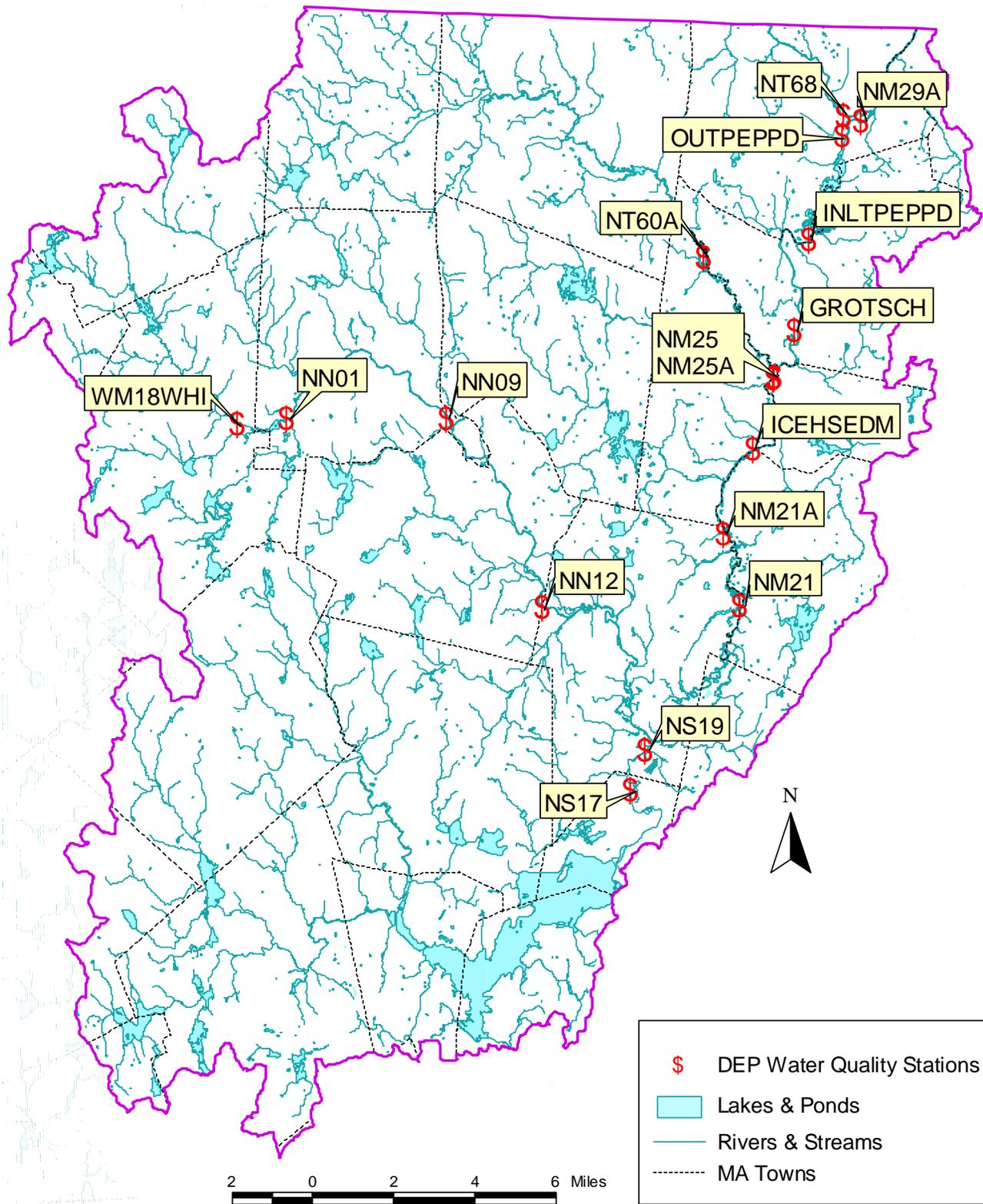
This segment of the Nashua River is a 3.7 mile Class B warm water fishery extending from the Pepperell Dam in Pepperell to the New Hampshire state line. Pepperell Paper Company is registered to withdraw surface water (1.5 mgd) from this segment. Three NPDES permits were listed in the MADEP WQA: Pepperell Paper Company, Indeck Pepperell Power, and Pepperell Publicly Owned Treatment Works (POTW). The Pepperell Paper Company is authorized to discharge process, filter backwash and storm water to the Nashua River. The paper company also operates a hydroelectric generating station immediately downstream of the Pepperell Pond Dam. Indeck Pepperell Power is authorized to discharge cooling tower blowdown, boiler blowdown, neutralization wastewater, floor drains and storm water to the Nashua River within this segment. The Pepperell POTW is authorized to discharge treated wastewater to the Nashua River.

The MADEP Division of Water Management (DWM) performed bacteria sampling in 1998. Results of the DWM sampling are provided in Table 4-14. Figure 4-1, provided at the end of the segment narratives, illustrates the location of the DWM sampling stations. The NRWA has been collecting data annually since 1995. Data from the 2003 (April to October) sampling are also summarized in Table 4-14.

Table 4-14. Nashua River (MA81-07) Indicator Bacteria Data Summary.

Site #	Description	Town	Dry Weather			Wet Weather		
			Fecal Coliform (cfu/100 mL)			Fecal Coliform (cfu/100 mL)		
			Min	Max	n	Min	Max	n
DWM 1998								
NM29A	Groton St. (downstream)	Pepperell	16	820	4	180	180	1
NRWA 2003								
NM04	Groton St. (upstream)	Pepperell	0	10	6	0	0	1

One sample during dry weather was analyzed for *E. coli* and enterococcus by the DWM. Counts were <20 and 60 cfu/100mL for *E. coli* and enterococcus respectively.



5.0 Potential Sources

The Nashua River watershed has 12 segments, located throughout the watershed, that are listed as pathogen impaired requiring a TMDL. These segments represent 33.7% of the river miles assessed. Sources of indicator bacteria in the Nashua 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 Nashua River watershed.

Largely through the efforts of the NRWA and MADEP field staff, numerous point and non-point sources of pathogens have been identified. Table 5-1 summarizes the river segments impaired due to measured fecal coliform contamination and identifies some of the suspected and known sources described in past literature.

Some dry weather sources include:

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

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 Nashua 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 5-2 and 5-3). 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 and WQA).

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

Segment	Potential Sources
MA81-29 Malagasco Brook	Overflow discharge pipe from Nursery
MA81-24 Gates Brook	Failing septic systems, storm water discharge pipes, animal populations
MA81-25 Scarletts Brook	Unknown
MA81-30 East Wachusett Brook	Unknown
MA81-08 Nashua River "South Branch"	Urban runoff/ storm sewers
MA81-09 Nashua River "South Branch"	Urban runoff
MA81-01 North Nashua River	Urban runoff, CSO
MA81-02 North Nashua River	Urban runoff, CSOs
MA81-03 North Nashua River	Urban runoff/storm sewers, CSOs
MA81-04 North Nashua River	Municipal point source, urban runoff/storm sewers
MA81-05 Nashua River	Municipal point source, urban runoff
MA81-07 Nashua River	Illicit sewer connections

Sources were identified in the MADEP WQA.

Agriculture

Land used primarily for agriculture is likely to be impacted by a number of activities that can contribute to indicator bacteria impairments of surface waters. Activities with the potential to contribute to high indicator bacteria concentrations include:

- field application of manure,
- runoff from grazing areas,
- direct deposition from livestock in streams,
- animal feeding operations,
- leaking manure storage facilities, and
- runoff from barnyards.

Indicator bacteria numbers are generally associated with sediment loading. Reducing sediment loading often results in a reduction of indicator bacteria loading as well. Brief summaries of some of these techniques are provided in the "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*".

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 10⁴ to 10⁶ 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. It is probable that numerous illicit sewer connections exist in storm drainage systems serving the older developed portions of the basin.

Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. Approximately 20.1% of the Nashua 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.

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 Nashua River and tributaries. 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 pathogen 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 is low.

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. 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 (e.g., Tables 4-1, 4-2, 5-2 and 5-3) in an attempt to characterize the quality of storm water. 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 5-2 and 5-3. 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 5-2. 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 5-3. Storm Water Event Mean Fecal Coliform Concentrations (as reported in MADEP 2002; 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 12 segments within the Nashua 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 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 surface waters (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 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 multiple municipal WWTPs, CSOs, and other NPDES-permitted discharges within the Nashua River watershed. 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 A and Class B segments within the Nashua River Basin. 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 nonpoint 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 nonpoint 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 three sets of WLAs and LAs, one for Class A waters, one for Class B, and one for freshwater 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 "*Nashua River Basin Watershed Water Quality Assessment Report*" and additional data reports from the MADEP (see Section 4.0 of this report for data resources). These data indicate that up to two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loadings will generally be necessary, especially in developed areas. 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.

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 12 pathogen impaired segments of the Nashua 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).

Table 6-1. Indicator Bacteria Waste Load Allocations (WLAs) and Load Allocations (LAs) for the Nashua 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	Illicit discharges to storm drains	0	N/A
A & B	Leaking sanitary sewer lines	0	N/A
A & B	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	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	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	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	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
Fresh Water Beaches ⁵	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 <i>E. coli</i> 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 <i>E. coli</i> 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.

³The 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 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 Nashua 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 Nashua 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 Nashua 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 Nashua 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 are taken to eliminate them. The MADEP has been successful in carrying out such monitoring, identifying sources, and in some cases mobilizing the responsible municipality and other entities to begin to take corrective actions.

Storm water runoff represents another major source of pathogens in the Nashua River watershed, 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 Nashua 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/NRWA
Development of comprehensive storm water management programs including identification and implementation of BMPs	Nashua River Basin Communities
Illicit discharge detection and elimination	Nashua River Basin Communities with NRWA
Leaking sewer pipes and sanitary sewer overflows	Nashua River Basin Communities
CSO management	Town of Fitchburg
Inspection and upgrade of on-site sewage disposal systems as needed	Homeowners, NRWA and Nashua River Basin Communities (Boards of Health)
Organize implementation; work with stakeholders and local officials to identify remedial measures and potential funding sources	MADEP, NRWA and Nashua River Basin Communities
Organize and implement education and outreach program	MADEP, NRWA and Nashua River Basin Communities
Write grant and loan funding proposals	NRWA and Nashua 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 NRWA
Provide periodic status reports on implementation of remedial activities	NRWA

The implementation strategy of this pathogen TMDL is consistent with the “Nashua River Watershed Five-Year Action Plan” (Action Plan) prepared by the NWRA and the Massachusetts Executive Office of Environmental Affairs (EOEA) Massachusetts Watershed Initiative (NWI) (NRWA and NMI 2003).

“The primary goals of recommended actions in this Five Year Action Plan are to:

- Maintain the high level of water quality in the tributaries and return degraded waters to their designated uses pursuant to State Water Quality Standards.
- Protect and manage in-stream flow and groundwater resources throughout the watershed to provide high quality drinking water supply sources and aquatic and riparian habitat.
- Support local growth planning efforts and encourage careful land use with well-planned development in order to protect priority land areas for forest, agriculture, habitat, water resources and recreational values “ (NRWA and MWI 2003).

The Action Plan provides a matrix by subbasin that outlines recommended actions responsible and potential partners, potential funding and an implementation time line. The Action Plan can be accessed on the worldwide web at <http://www.nashuariverwatershed.org>.

Data supporting this TMDL indicate that indicator bacteria enter the Nashua River 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.

7.1. Agriculture

A number of techniques have been developed to reduce the contribution of agricultural activities to pathogen contamination. There are also many methods intended to reduce sediment loads from agricultural lands. Since bacteria are often associated with sediments, these techniques are also likely to result in a reduction in bacterial loads in run off as well. Brief summaries of some of these techniques are provided in the “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*”. Techniques generally include BMPs for field application of manure, animal feeding operations, barnyards, and managing animal grazing areas.

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. According to the MADEP WQA, the East Fitchburg WWTF has 41 combined sewer overflows, which they are permitted to discharge waste water from during wet weather. In 1996, the EPA issued an Administrative Order for Fitchburg to develop a long-term CSO control plan. In 1999,

Fitchburg submitted a Draft CSO Plan and a Sewer Separation Study (MADEP 2001). The EPA issued a Consent Order to Fitchburg, which requires the town to fix the CSOs by 2020 (NRWA and MWI 2003).

Guidance for illicit discharge detection and elimination has been developed by EPA New England (USEPA 2004b). 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. Although originally prepared for the Charles River watershed it is applicable to all watersheds throughout the Commonwealth. 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,
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 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 Nashua 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>. In addition, several communities have increased their sanitary sewer service areas, thereby reducing the number of on-site septic systems in the watershed. For example, the town of Lancaster is putting in sewer lines to service homes along the river. The homes previously had septic systems, which could not function properly in the wetland soils of the river bank and consequently contributed fecal coliform to the river.

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. 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.

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 Nashua River Basin includes several components:

1. continue with the current monitoring of the Nashua River Basin (NRWA and other watershed stewards),
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