MERRIMACK RIVER WATERSHED
2004 WATER QUALITY ASSESSMENT REPORT

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
IAN BOWLES, SECRETARY
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
LAURIE BURT, COMMISSIONER
BUREAU OF RESOURCE PROTECTION
ARLEEN O'DONNELL, ASSISTANT COMMISSIONER
DIVISION OF WATERSHED MANAGEMENT
GLENN HAAS, DIRECTOR

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MERRIMACK RIVER WATERSHED

2004-2009 WATER QUALITY ASSESSMENT REPORT

Prepared by:

James Meek and Laurie Kennedy
Massachusetts Department of Environmental Protection
Division of Watershed Management

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Division of Watershed Management
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ATTACHED DATA CD – COMPENDIUM OF MASSDEP DWM MERRIMACK RIVER TECHNICAL MEMORANDUMS AND REPORTS

Merrimack River Watershed 2004 Water Quality Assessment Report
Technical Memorandum TM-84-5 Merrimack River Watershed 2004 Water Quality
Technical Memorandum TM-84-6 Merrimack River Watershed 2004 Benthic Macroinvertebrate Assessment
Technical Memorandum 84-7 2004 Merrimack River Watershed Fish Population Assessment
Technical Memorandum 84-7 2004 Merrimack and French & Quinebaug Periphyton Study - Stream Velocity and Canopy Cover Considerations
Technical Memorandum TM S-16 Baseline Lake Survey 2003 Technical Memorandum (Excerpt)

***Segments not included in the report due to insufficient data to assess any of the uses.**
Beaver Brook (MA84B-05)
Beaver Brook (MA84B-02)
Stony Brook (MA84B-03)
Powwow River (MA84A-28)
Bailey Pond (MA84003)
Mill Pond (MA84038)
Mill Pond (MA84081)
Mill Pond (MA84039)
Uptons Pond (MA84075)
Ward Pond (MA84096)

List of Acronyms and Abbreviations

surface water quality standards	SWQS	Safe Drinking Water Act	SDWA
Waterbody System	WBS	New England Interstate Water Pollution Control Commission	NEIWPCC
Assessment Database	ADB	Massachusetts Department of Public Health	MA DPH
National Hydrography Dataset	NHD	rapid bioassessment protocol	RBP
Clean Water Act	CWA	Massachusetts Department of Fish and Game	MA DFG
U.S. Environmental Protection Agency	EPA	milligrams per liter	mg/L
Massachusetts Department of Environmental Protection	MassDEP	micrograms per liter	ug/L
total maximum daily load	TMDL	milliliter	ml
Division of Watershed Management	DWM	Massachusetts Division of Marine Fisheries	MA DMF
combined sewer overflows	CSO	sanitary sewer overflow	SSO
dissolved oxygen	DO	National Pollutant Discharge Elimination System	NPDES
colony forming units	CFU	water pollution control facility	WPCF
MassDEP Drinking Water Program	DWP	Merrimack River Watershed Assoc.	MRWA

EXECUTIVE SUMMARY

MERRIMACK RIVER WATERSHED 2003 WATER QUALITY ASSESSMENT REPORT

The Massachusetts Surface Water Quality Standards (SWQS) designate the most sensitive uses for which surface waters in the state shall be protected. The assessment of current water quality conditions is a key step in the successful implementation of the Watershed Approach. This critical phase provides an assessment of whether or not the designated uses are supported or impaired, or not assessed, as well as basic information needed to focus resource protection and remediation activities later in the watershed management planning process.

This report presents a summary of current water quality data/information in the Merrimack River watershed used to assess the status of the designated uses as defined in the SWQS. The designated uses, where applicable, include: *Aquatic Life, Fish Consumption, Drinking Water, Primary and Secondary Contact Recreation and Aesthetics*. Each use, within a given assessment segment, is individually assessed as ***support*** or ***impaired***. When too little current data/information exists or no reliable data are available for an assessment segment the use is ***not assessed***. However, if there is some indication of water quality impairment, which is not "naturally-occurring", the use is identified with an "Alert Status". Some rivers and lakes do not have an assigned assessment segment identification number and the status of their designated uses has never been assessed, investigated, and/or reported to the EPA in the Commonwealth's Summary of Water Quality Report (305(b) Report) nor is information on these waters maintained in the Assessment Database (ADB). In the interest of reporting on all river miles and lake acres in the Merrimack River watershed, any waters not currently assigned an assessment segment identification number are classified as ***not assessed other waters***.

The summary of the assessments for the *Aquatic Life, Fish Consumption, Shellfishing, Primary and Secondary Contact Recreation and Aesthetics* uses in the Merrimack River watershed segments are illustrated in Figures 1 through 6, respectively. The percentage of total river miles, lake acreage and estuarine area classified as impaired, support, and not assessed for each designated use are provided in Table 1.

Table 1. Percentage of total river miles (391 miles), lake acreage (5734 acres) and estuarine area (6.7 square miles) in the Merrimack River basin assessed as support, impaired, or not assessed for each use. (National Hydrography Dataset (NHD) 1:24,000 is the source for the total river miles and lake acreage calculations)

	River			Lakes			Estuaries		
Use	**Support**	**Impaired**	**Not Assessed[1]**	**Support**	**Impaired**	**Not Assessed[1]**	**Support**	**Impaired**	**Not Assessed**
Aquatic Life	15.5%	3.3%	81.2%	0.0%	21.1%	78.9%	94.0%	0.0%	6.0%
Fish Consumption	0.0%	6.6%	93.4%	0.0%	53.9%	46.1%	0.0%	0.0%	100%
Shellfishing	Not Applicable						0.0%	72.0%	28.0%
Drinking Water	Not Assessed in this Report[2]						Not Applicable		
Primary Contact	6.3%	20.8%	72.9%	0.0%	0.0%	100%	0.0%	95.5%	4.5%
Secondary Contact	17.1%	10.0%	72.9%	0.0%	0.0%	100%	68.6%	26.9%	4.5%
Aesthetics	19.3%	2.5%	78.4%	0.0%	0.0%	100%	0.04%	0.0%	99.96%

1 - Not Assessed includes river or lakes not assigned assessment segments or not assessed other waters.
2 - While this use is not assessed in this report, information on drinking water source protection and finish water quality is available at http://www.mass.gov/dep/water/drinking.htm and from local public water suppliers.

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Figure 1. *Aquatic Life Use* assessment summary for rivers, estuarine, and lake segments in the Merrimack River watershed

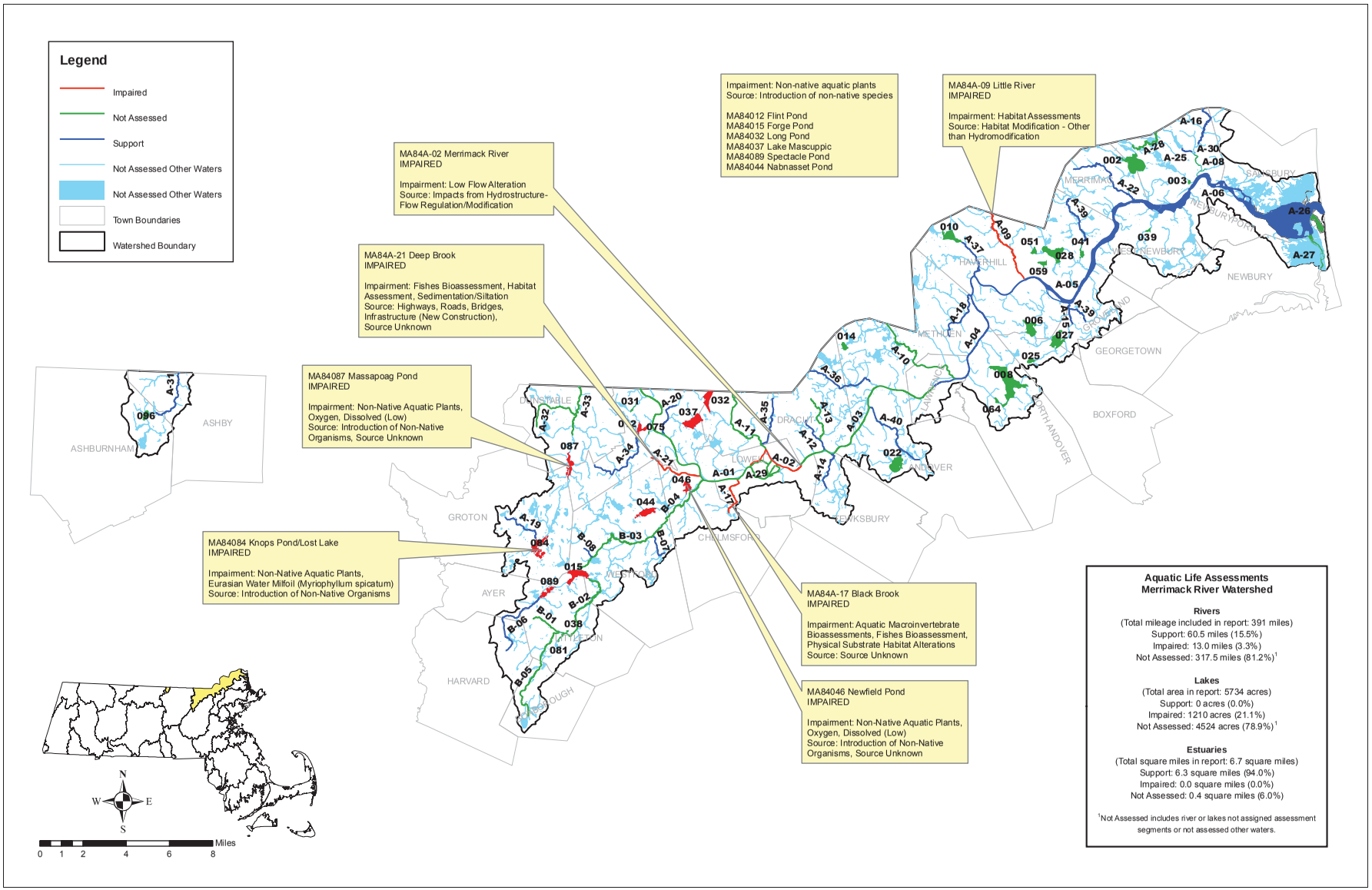

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Figure 2. *Fish Consumption Use* assessment summary for rivers, estuarine, and lake segments in the Merrimack River watershed

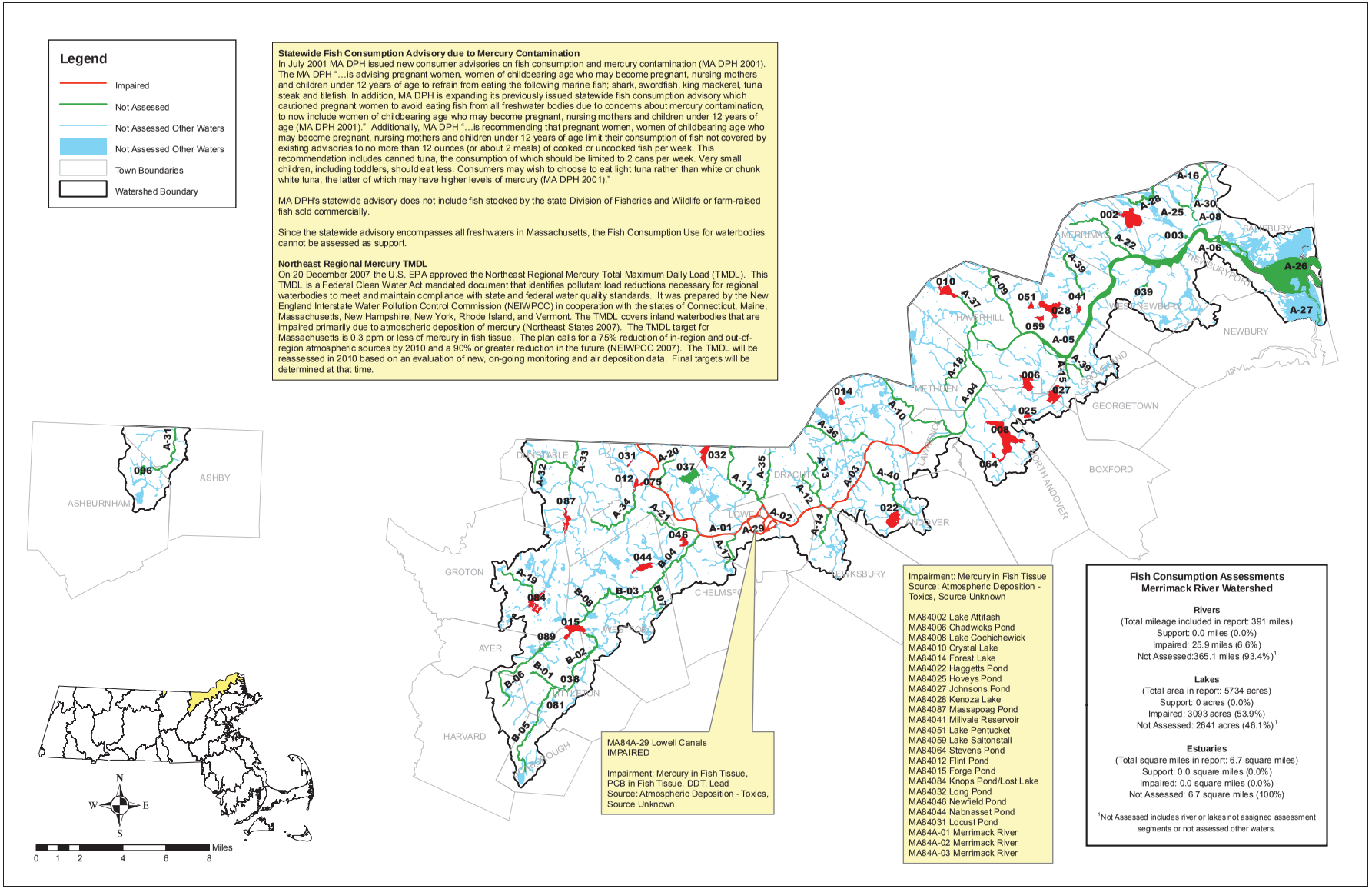

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Figure 3. *Shellfishing Use* assessment summary for estuarine segments in the Merrimack River watershed

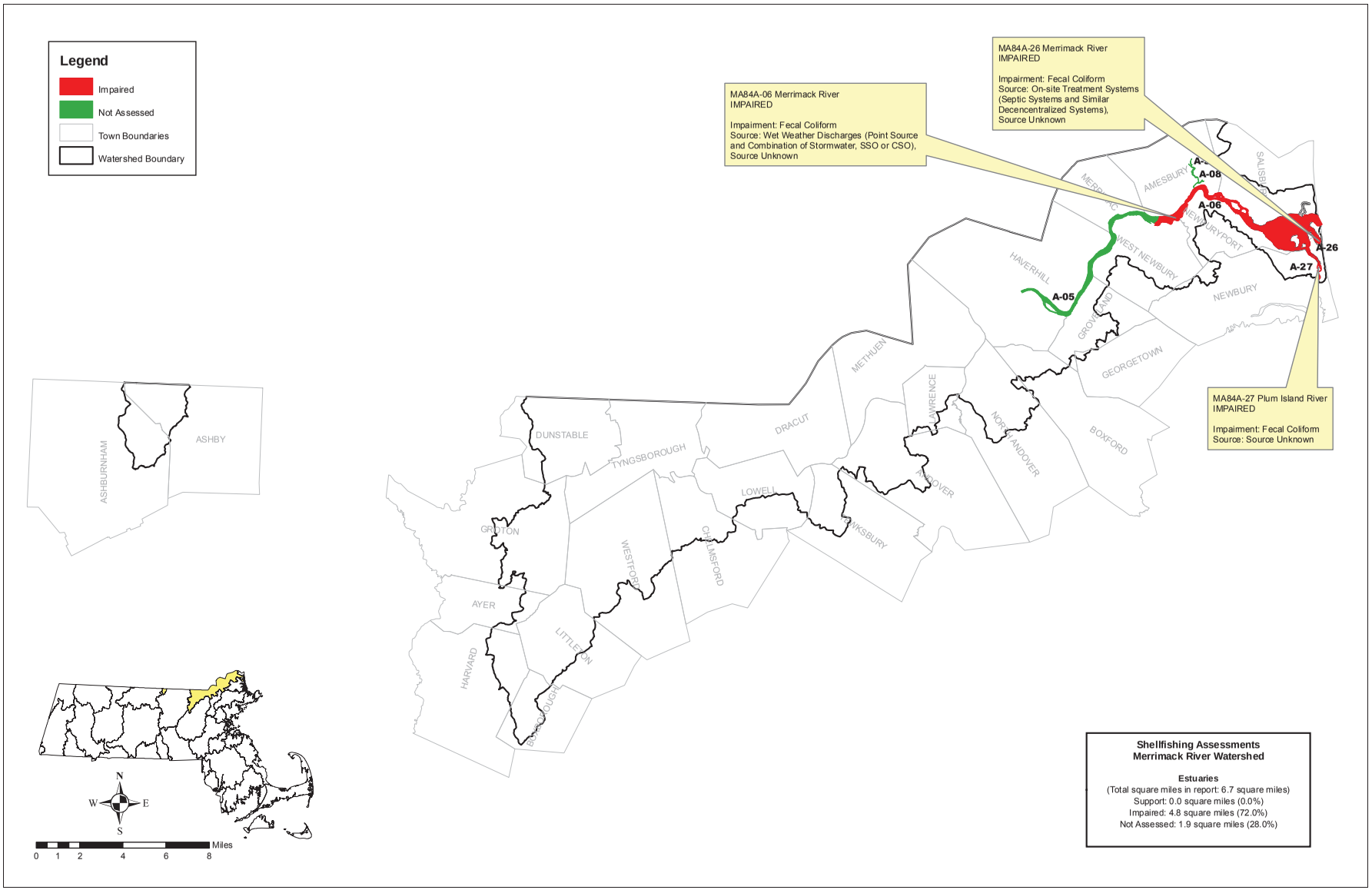

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Figure 4. *Primary Contact Recreational Use* assessment summary for rivers, estuarine, and lake segments in the Merrimack River watershed

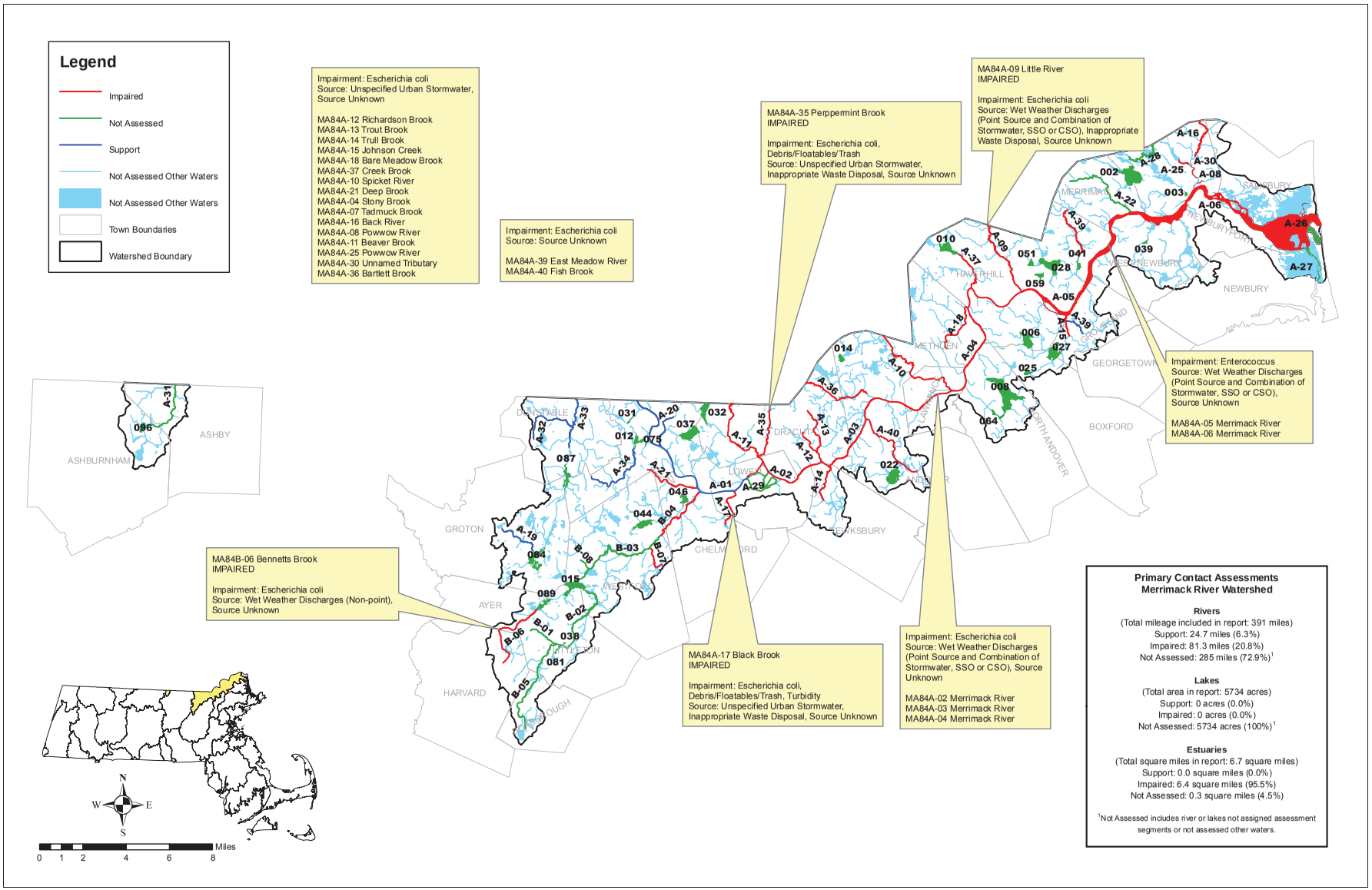

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Figure 5. *Secondary Contact Recreational Use* assessment summary for rivers, estuarine, and lake segments in the Merrimack River watershed

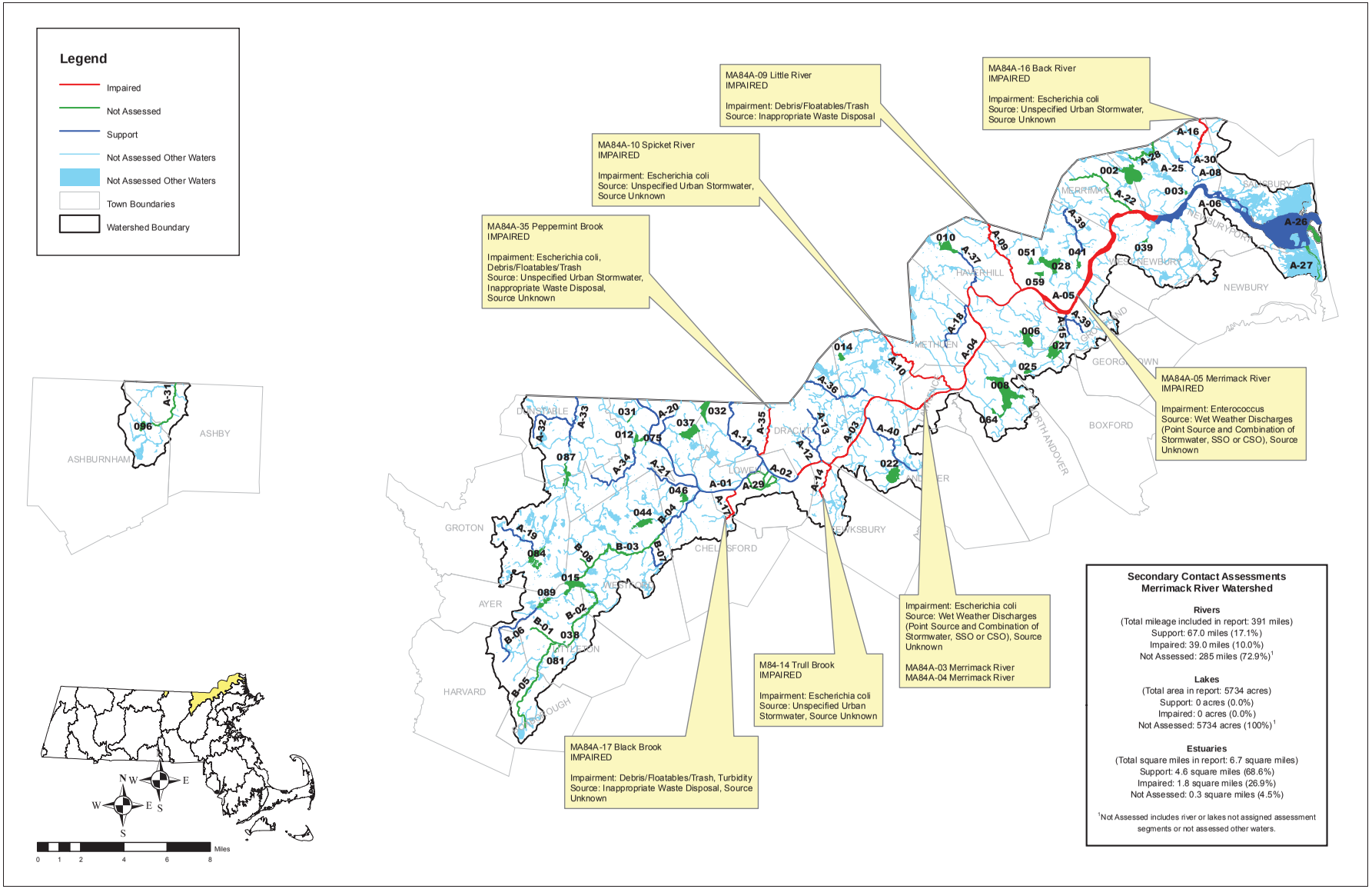

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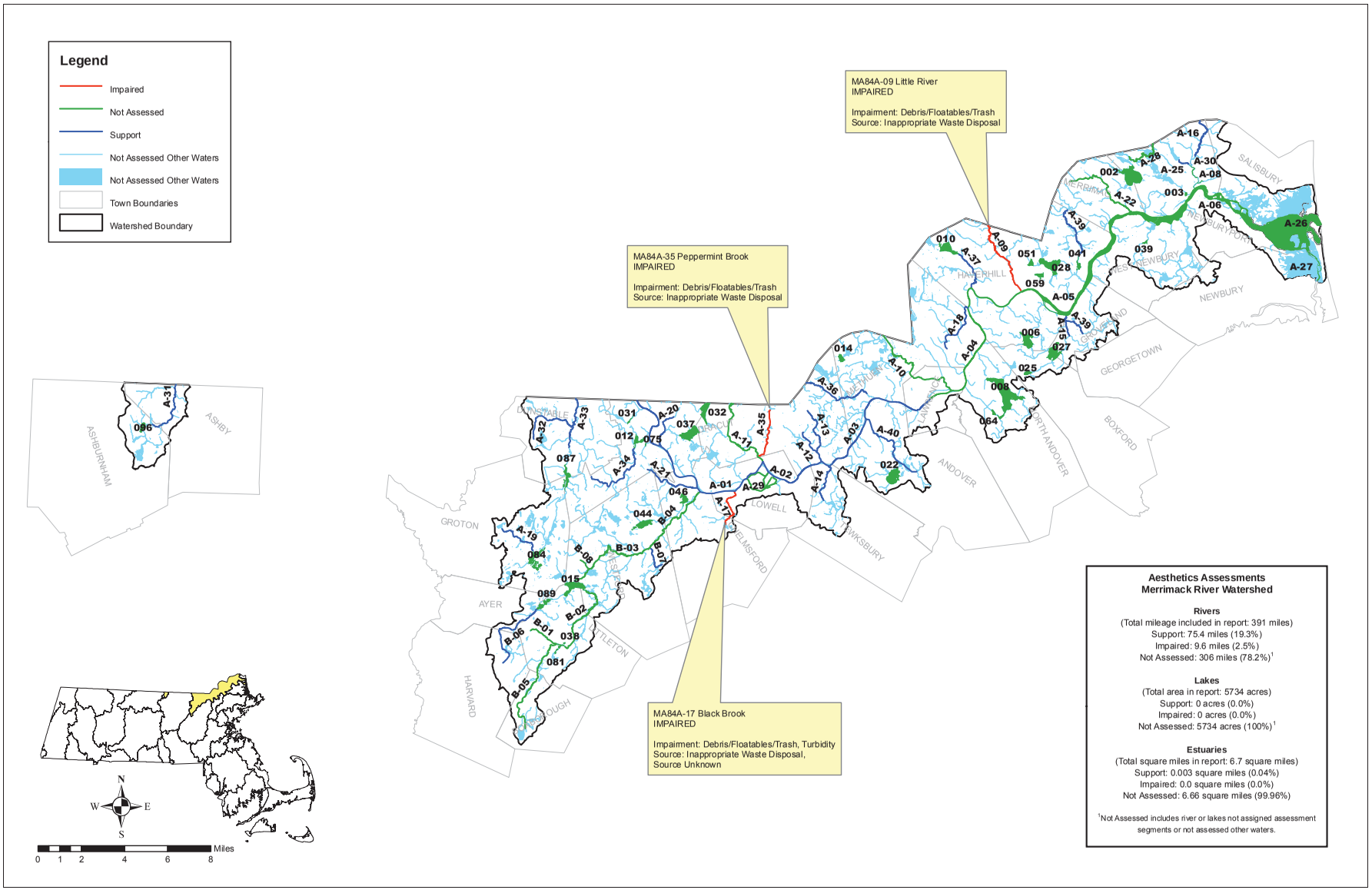
Figure 6. *Aesthetics Use* assessment summary for rivers, estuarine, and lake segments in the Merrimack River watershed



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INTRODUCTION

The goal of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. To meet this objective, the CWA requires states to develop information on the quality of the Nation's water resources and report this information to the U.S. Environmental Protection Agency (EPA), the U.S. Congress, and the public. Together, these agencies are responsible for implementation of the CWA mandates. Under Section 305(b) of the Federal Clean Water Act, every two years, the Massachusetts Department of Environmental Protection (MassDEP) must submit to EPA a statewide report that describes the status of water quality in the Commonwealth. Until 2002 this was accomplished as a statewide summary of water quality (the 305(b) Report). States are also required to submit, under Section 303(d) of the CWA, a list of impaired waters requiring a total maximum daily load (TMDL) calculation. In 2002, however, EPA gave states the option to combine elements of the statewide 305(b) Report and the Section 303(d) List of Impaired Waters into one "Integrated List of Waters" (Integrated List). This statewide list is based on the compilation of information for the Commonwealth's 27 watersheds. Massachusetts has opted to write individual watershed surface water quality assessment reports and use them as the supporting documentation for the Integrated List. The assessment reports utilize data compiled from a variety of sources and provide an evaluation of water quality, progress made towards maintaining and restoring water quality, and the extent to which problems remain at the watershed level. Quality-assured in-stream biological, habitat, physical/chemical, toxicity data and other information are evaluated to assess the status of water quality conditions. This analysis follows a standardized process described in the Assessment Methodology Appendix.

This report presents the current assessment of water quality conditions in the Merrimack River watershed. The assessments are based on information that has been researched and developed by the MassDEP through the first three years (information gathering, monitoring, and assessment) of the five-year basin cycle in partial fulfillment of MassDEP federal mandate to report on the status of the Commonwealth's waters under the CWA. Specifically, water quality monitoring data collected by the MassDEP, Division of Watershed Management (DWM) staff in 2004 were utilized to make assessment decisions. All data collected by MassDEP DWM in 2004 are available on the attached data CD in the form of technical memorandums. Water quality data from other sources (see Acknowledgements) used to make use assessment decisions is available from those agencies and organizations.

MASSACHUSETTS INTEGRATED LIST OF WATERS

Section 305(b) of the CWA defines the process whereby states monitor and assess the quality of their surface and groundwater and report on the status of those waters every two years. Section 303(d) of the CWA requires states to periodically identify and list those waterbodies for which existing controls on point and nonpoint sources of pollutants are not stringent enough to attain or maintain compliance with applicable surface water quality standards. Through the year 2000 the MassDEP fulfilled the 305(b) and 303(d) reporting requirements in two completely separate documents. In 2001 the EPA released guidance that provided states with the option of preparing a single Integrated List of Waters to be submitted that would meet the reporting requirements of both sections 305(b) and 303(d) of the CWA.

The EPA approved the Massachusetts Year 2008 Integrated List of Waters in May 2009. In that report each waterbody segment was placed in one of five major categories. Category 1 included those waters that were meeting all designated uses. No Massachusetts waters were listed in Category 1 because a statewide health advisory pertaining to the consumption of fish precludes any waters from being in full support of the fish consumption use. Waters listed in Category 2 were found to support some of the uses for which they were assessed but other uses were not assessed. Category 3 contained those waters for which insufficient or no information was available to assess any uses.

Waters exhibiting impairment for one or more uses were placed in either Category 4 (impaired but not requiring a TMDL report) or Category 5 (impaired and requiring one or more TMDLs) according to the EPA guidance. Category 4 was further divided into three sub-categories – 4A, 4B and 4C – depending upon the reason that TMDLs were not needed. Category 4A included waters for which the required TMDL(s) had

already been completed and approved by the EPA. However, since segments could only appear in one-category waters that had an approved TMDL for some pollutants, but not others, remained in Category 5. Category 4B was to include waters for which other pollution control requirements were reasonably expected to result in the attainment of the designated use before the next listing cycle. Because of the uncertainty related to making predictions about conditions in the future the MassDEP made a decision not to utilize Category 4B in the 2008 Integrated List. Finally, waters impaired by factors, such as flow modification or habitat alteration, that are not subjected to TMDL calculations because the impairment is not related to one or more pollutants were included in Category 4C. See individual segment assessments for information pertaining to the 2008 Integrated List category and causes of impairment.

MERRIMACK RIVER WATERSHED DESCRIPTION

The Merrimack River drainage area is the fifth largest in New England encompassing a total of 5,014 square miles in New Hampshire and Massachusetts. As a New England interstate basin, it is surpassed only by the Connecticut River. The mainstem Merrimack River is formed in central New Hampshire by the confluence of the Pemigewasset and Winnipesaukee rivers. The mainstem flows southward through central New Hampshire (approximately 78 miles) and enters Massachusetts. Nearly one quarter of the Merrimack's drainage area (1,200 square miles) lies within northeastern Massachusetts. In Massachusetts, the Merrimack River Basin is bordered by the Parker River Basin to the east, the Ipswich River Basin to the southeast, the Shawsheen River Basin to the south, the Concord River Basin to the southwest and the Nashua River Basin to the west while the northern portion of the basin is bordered by the state of New Hampshire.

Once in Massachusetts, the Merrimack River flows generally southeast for about six miles then turns northeast near the city of Lowell, Massachusetts. The Merrimack River continues to flow northeast towards the city of Newburyport where it then empties into the Atlantic Ocean. The Merrimack River drops 90 feet in elevation along its 53-mile course through Massachusetts to the Atlantic Ocean. This elevation change includes the two major dams in Lawrence and Lowell, the Pawtucket and Essex dams. The river is tidal downstream from its confluence with Creek Brook in Haverhill (the lower 25 mile linear reach with an area of approximately 6.97 square miles). Excluding the Nashua, Concord and Shawsheen rivers (treated as separate major watersheds in Massachusetts), large tributaries to the Merrimack River in Massachusetts include: Stony Brook and the Spicket, Little and Powwow rivers. In Massachusetts, the Merrimack River watershed contains approximately 391 miles of river and 5734 acres of lakes, ponds, and reservoirs.

In Massachusetts, 24 communities lie wholly or in part within the basin boundaries: Amesbury, Andover, Ayer, Boxford, Boxborough, Chelmsford, Dracut, Dunstable, Groton, Groveland, Harvard, Haverhill, Lawrence, Littleton, Lowell, Merrimac, Methuen, Newburyport, North Andover, Salisbury, Tewksbury, Tyngsborough, Westford, and West Newburyport. The three major cities along the Merrimack River in Massachusetts are Lowell, Lawrence, and Haverhill. As historic industrial centers, these cities were once sources of severe pollution from untreated municipal and industrial wastewater discharges. Water quality problems are still evident today in the watershed due in part to combined sewer overflows (CSO) in Lowell, Lawrence, and Haverhill; various nonpoint sources of pollution; and smaller industrial discharges.

OBJECTIVES

This report summarizes information generated in the Merrimack River watershed since the last water quality assessment report that was published in November 2001. The methodology used to assess the status of water quality conditions of rivers and lakes in accordance with EPA and MassDEP use assessment methods is provided in Appendix A. Data collected by DWM in 2004 are available on the attached DataCD.

The objectives of this water quality assessment report are to:

1. evaluate whether or not surface waters in the Merrimack River watershed, defined as segments in the MassDEP/EPA databases, currently support their designated uses and

2. identify the stressors impairing designated uses and any confirmed sources of those stressors

ASSESSMENT REPORT FORMAT

In this report the assessment information for waters that are assessed for any one or more designated use(s) is summarized in a table format. The tables summarize the assessment decisions for the *Aquatic Life, Fish Consumption, Shellfishing Primary* and *Secondary Contact Recreation* and *Aesthetics* uses, the data that informed those decisions, the cause(s) of any impairment, the confirmed source(s) for the impairment and monitoring recommendations (Table 2).

Table 2. An example of the table format used to present assessment information in the 2004 Merrimack River Watershed Assessment Report.

EXAMPLE BROOK (SEGMENT MA81-99)
Location: Fake Pond, Groton, to confluence with Cat Brook, Shirley.
Segment Length: 4.4 Miles
Classification: Class B
2006 Integrated List of Waters: Category 5 - Waters requiring a TMDL - Cause Unknown, Nutrients-Pathogens

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
MassDEP DWM measured dissolved oxygen, temperature, and pH six times at one site in 2003 and found no violations of the temperature or pH criterion and five violations of the dissolved oxygen criterion. The dissolved oxygen violations ranged from 2.9 mg/L to 3.6 mg/L. **Cause(s) of Impairment:** Dissolved oxygen **Source(s) of Impairment:** Unknown *Data Sources: 24*		
Fish Consumption	**Not Assessed**	**No**
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Support**	**No**
MassDEP DWM collected five Escherichia coli samples at one site in 2003. The geometric mean of the samples collected during the primary contact season was 102 CFU/100ml. This result does not violate the geometric mean criterion (126 CFU/100ml) for Escherichia coli. *Data Sources: 24*		
Secondary Contact	**Support**	**No**
MassDEP DWM collected five Escherichia coli samples at one site in 2003. The geometric mean was 102 CFU/100ml. This result does not violate the geometric mean criterion (630 CFU/100ml) for Escherichia coli. *Data Sources: 24*		
Aesthetics	**Not Assessed**	**No**
MassDEP DWM recorded aesthetic field observations at one site in 2003. There were no field observations indicating prolonged or frequent occurrences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. *Data Sources: 24*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

The *Drinking Water* use is not assessed in this report. MassDEP Drinking Water Program (DWP) has primacy for implementing the provisions of the federal Safe Drinking Water Act (SDWA) and maintains current drinking supply monitoring data. More information is available on the MassDEP website at http://www.mass.gov/dep/water/drinking.htm.

The table is divided into several sections (i.e., one section for each use and one for monitoring recommendations) and the "Designated Use" column in the table indicates which use is being summarized in that section. The "Use Assessment" column states the assessment decision (support, impaired, not assessed) for the use. The "Alert" column is used when an issue was identified that is of concern (i.e., an "Alert Status" was noted for the use but the use was not assessed as impaired). In the space below each use in the table is a summary of the data that directed or influenced the assessment decision and their sources. The numbers identified as the data sources correspond to the numbered citations in the Data Sources section. The "Cause(s) of Impairment" and "Source(s) of Impairment" identify the stressors leading to the impairment decision and the any confirmed source(s) of the stressor(s). The causes and sources come from the list in the EPA Assessment Database Version 2 (ADB). The "Monitoring Recommendations" section lists some recommendations for future monitoring by MassDEP DWM. The recommendations listed are not inclusive and indicate a priority for targeted monitoring.

SPECIAL NOTES

In the data summary of some segments, there is a reference to a special note. Special notes refer to unique assessment situations that apply to several segments and are best described in a separate section rather than repeated for each segment. The special notes for this assessment report are:

1. **USACOE *E. coli* data** - As part of the Merrimack River Watershed Assessment Study, CDM (under contract to USACOE) collected *E. coli* samples during three dry weather and two wet weather events. Only one *E. coli* sample was collected during each dry weather event while multiple samples were collected during the wet weather events. The maximum *E. coli* concentration for each wet weather event was used in calculating the geometric mean to avoid biasing the statistic towards the wet weather events.
2. **USACOE Water Chemistry data** - As part of the Merrimack River Watershed Assessment Study, CDM (under contract to USACOE) measured dissolved oxygen, temperature, and pH and collected total phosphorus and chlorophyll- a samples during three dry weather and two wet weather events. Only one set of measurements were collected during each dry weather event while five measurements were made on regular intervals during the wet weather events. Any site that did not have measurements from all five sampling events was not considered in any assessment decision.
3. **Northeast Regional Mercury TMDL** - On 20 December 2007 the U.S. EPA approved the Northeast Regional Mercury Total Maximum Daily Load (TMDL). This TMDL is a Federal Clean Water Act mandated document that identifies pollutant load reductions necessary for regional waterbodies to meet and maintain compliance with state and federal water quality standards. It was prepared by the New England Interstate Water Pollution Control Commission (NEIWPCC) in cooperation with the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. The TMDL covers inland waterbodies that are impaired primarily due to atmospheric deposition of mercury (Northeast States 2007). The TMDL target for Massachusetts is 0.3 ppm or less of mercury in fish tissue. The plan calls for a 75% reduction of in-region and out-of-region atmospheric sources by 2010 and a 90% or greater reduction in the future (NEIWPCC 2007). The TMDL will be reassessed in 2010 based on an evaluation of new, on-going monitoring and air deposition data. Final targets will be determined at that time.
4. **Statewide Fish Consumption Advisory due to Mercury Contamination** - In July 2001 MA DPH issued new consumer advisories on fish consumption and mercury contamination (MA DPH 2001). The MA DPH "…is advising pregnant women, women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age to refrain from eating the following marine fish; shark, swordfish, king mackerel, tuna steak and tilefish. In addition, MA DPH is expanding its previously issued statewide fish consumption advisory which cautioned

pregnant women to avoid eating fish from all freshwater bodies due to concerns about mercury contamination, to now include women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age (MA DPH 2001)." Additionally, MA DPH "…is recommending that pregnant women, women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age limit their consumption of fish not covered by existing advisories to no more than 12 ounces (or about 2 meals) of cooked or uncooked fish per week. This recommendation includes canned tuna, the consumption of which should be limited to 2 cans per week. Very small children, including toddlers, should eat less. Consumers may wish to choose to eat light tuna rather than white or chunk white tuna, the latter of which may have higher levels of mercury (MA DPH 2001)."

LITERATURE CITED

MA DPH. 2001. *MA DPH Issues New Consumer Advisories on Fish Consumption and Mercury Contamination.* Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA.

NEIWPCC. 2007. *Northeast Regional Mercury TMDL Fact Sheet October 2007.* [Online]. New England Interstate Water Pollution Control Commission, Lowell, MA. Retrieved 23 January 2008 from http://www.neiwpcc.org/mercury/mercury-docs/FINAL%20Northeast%20Regional%20Mercury%20TMDL%20Fact%20Sheet.pdf.

Northeast States. 2007. *Northeast Regional Mercury Total Maximum Daily Load.* Connecticut Department of Environmental Protection, Maine Department of Environmental Protection, Massachusetts Department of Environmental Protection, New Hampshire Department of Environmental Services, New York State Department of Environmental Conservation, Rhode Island Department of Environmental Management, Vermont Department of Environmental Conservation, New England Interstate Water Pollution Control Commission. October 24, 2007.

MA DPH. 2001. *MA DPH Issues New Consumer Advisories on Fish Consumption and Mercury Contamination.* Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA.

SOUTH BRANCH SOUHEGAN (SEGMENT MA84A-31)

Segment Description: Headwaters, outlet Watatic Pond, Ashburnham to New Hampshire state line, Ashby.
Segment Length: 3.0 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	
In 2004, MassDEP DWM collected benthic macroinvertebrates and periphyton at one site (B0524). This site was used as the "reference" or "least disturbed" site for the 2004 Merrimack River basin survey and displayed the diverse and well-balanced aquatic community expected. The *Aquatic Life Use* is assessed as support. *Data Sources: 1, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Support**	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (B0524). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 17*		
Monitoring Recommendations		
None		

MARTINS POND BROOK (SEGMENT MA84A-19)

Segment Description: Outlet Martins Pond, Groton to inlet Lost Lake, Groton.
Segment Length: 2.3 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Siltation, Organic enrichment/Low DO, Turbidity).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	
In July 2004, MassDEP DWM collected benthic macroinvertebrates and periphyton at one site (B0319). The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "slightly impacted". DWM conducted monthly in-situ water quality monitoring at one site (W1188) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 1:43 and 2:23 am, n=3) and other water quality physico-chemical monitoring data were indicative of good water quality conditions. The maximum water temperature was 21.9℃. None of the dissolved oxyg en, temperature, or pH measurements violated water quality criteria. The *Aquatic Life Use* is assessed as support based on the "slightly impacted" benthic macroinvertebrate community. *Data Sources: 1, 2, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Support**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1188) during the primary contact season. The geometric mean of the five samples was 77 CFU/100ml. Based on this result meeting the geometric mean criterion (126 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Primary Contact Recreational Use* is assessed as support. *Data Sources: 2, 9, 17*		
Secondary Contact	**Support**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1188). The geometric mean of the five samples was 77 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. *Data Sources: 2, 9, 17*		
Aesthetics	**Support**	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at two sites (W1188, B0319). There were no field observations by DWM field sampling crews or biologists indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9, 17*		
Monitoring Recommendations		
None		

JOINT GRASS BROOK (SEGMENT MA84A-32)

Segment Description: Headwaters, between Hollis Street and Hawk Swamp, Dunstable to the confluence with Salmon Brook, Dunstable.
Segment Length: 3.2 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	**Yes**
MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1208) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 2:20 and 3:03am, n=3) and other water quality physico-chemical monitoring data were indicative of good water quality conditions. The maximum water temperature was 21.2℃. MA DFG conducted backpack electrofishing in July 2006 at one site (1609) along this segment. All fish collected (n=136), representing four species, were macrohabitat generalists and pollution tolerant. Insufficient data were available to assess the Aquatic Life use. This use is identified with Alert Status due to the lack of any fluvial fish species. *Data Sources: 2, 15*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli samples at one site (W1208) during the primary contact season. The geometric mean of the five samples was 74 CFU/100ml. Based on this result meeting the geometric mean criterion (126 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Primary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to one elevated E. coli count during a wet weather sampling event. *Data Sources: 2, 9*		
Secondary Contact	**Support**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1208). The geometric mean of the five samples was 74 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. *Data Sources: 2, 9*		
Aesthetics	**Support**	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1208). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The The *Aesthetics Use* is assessed as support. *Data Sources: 9*		
Monitoring Recommendations		
None		

SALMON BROOK (SEGMENT MA84A-33)

Segment Description: Headwaters, outlet Lower Massapoag Pond, Dunstable to New Hampshire state line, Dunstable.
Segment Length: 2.9 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
MassDEP DWM conducted monthly in-situ water quality monitoring in Salmon Brook (W1199) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 2:45 and 3:35am, n=3) and other water quality physico-chemical monitoring data were indicative of good water quality conditions with the exception of one DO measurement of 4.6 mg/L. The maximum water temperature was 21.7℃. I nsufficient data were available to assess the Aquatic Life use. *Data Sources: 2*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli samples at one site (W1199) during the primary contact season. The geometric mean of the five samples was 82 CFU/100ml. Based on this result meeting the geometric mean criterion (126 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Primary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to one elevated E. coli count during a wet weather sampling event. *Data Sources: 2, 9*		
Secondary Contact	**Support**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1199). The geometric mean of the five samples was 82 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. *Data Sources: 2, 9*		
Aesthetics	**Support**	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1199). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9*		
Monitoring Recommendations		
Conduct dissolved oxygen monitoring to evaluate diurnal variation by deploying multiprobes overnight.		

MERRIMACK RIVER (SEGMENT MA84A-01)

Segment Description: State line at Hudson, NH/Tyngsborough, MA to Pawtucket Dam, Lowell.
Segment Length: 9.0 Miles
Segment Classification: B\TWS, WWF, CSO
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals, Pathogens).
NPDES Permits: Lowell Regional Wastewater Utilities (MA0100633), Lowell Regional Water Utility (MAG640055)

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	**Yes**
In 2003, CDM collected five total phosphorus samples and three chlorophyll-a samples from two sites (M011, M012) (See Special Note 2). The total phosphorus concentrations ranged from 0.037 to 0.110 mg/L and the chlorophyll-a concentrations ranged from 1.9 to 11.8 ug/L at these sites. Insufficient data were available to assess the *Aquatic Life Use*. An Alert Status is identified for this use due to elevated total phosphorus concentrations. *Data Sources: 3*		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for this portion of the Merrimack River. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat White Sucker or Largemouth Bass fish from this water body. The general public should limit consumption of White Sucker and Largemouth Bass to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Support**	**Yes**
In 2008, MRWA collected E.coli samples at eight sites (49.6, 48.9, 47.3, 43.6, 43.4, 42.4, 41.1). The geometric means of the samples collected during the primary contact season at each site ranged from 16.2 CFU/100ml to 63.8 CFU/100ml. In 2003, CDM collected E. coli samples at two sites (M011, M012) (See Special Note 1). The geometric means of the samples collected during the primary contact season at each site were 93 and 72 CFU/100ml. Based on these results meeting the geometric mean criterion (126 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Primary Contact Recreational Use* is assessed as support. CSO discharges in New Hampshire communities upstream from this segment influence water quality in this segment of the river. One Lowell Regional Wastewater Utilities CSO (Outfall 002 Walker Street) also discharges near the downstream end of this segment. This use is identified with an Alert Status due to these CSO discharges and spikes in E. coli concentrations during wet weather conditions. *Data Sources: 3, 25*		

Secondary Contact	Support	Yes
In 2008, MRWA collected E.coli samples at eight sites (49.6, 48.9, 47.3, 43.6, 43.4, 42.4, 41.1). The geometric means of the samples collected at each site ranged from 16.2 CFU/100ml to 63.8 CFU/100ml. In 2003, CDM collected E. coli samples at two sites (M011, M012) (See Special Note 1). The geometric means of the samples at each site were 93 and 72 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. CSO discharges in New Hampshire communities upstream from this segment influence water quality in this segment of the river. One Lowell Regional Wastewater Utilities CSO (Outfall 002 Walker Street) also discharges near the downstream end of this segment. This use is identified with an Alert Status due to these CSO discharges and spikes in E. coli concentrations during wet weather conditions. *Data Sources: 3,25*		
Aesthetics	**Support**	**Yes**
MassDEP DWM field staff did not note any objectionable conditions (e.g., odors, oils, growths, scums, deposits or turbidity) in the Merrimack River at the Tyngsboro Bridge in the four sampling events conducted in June and August 2004 or June and September 2005. It should be noted however that the USACOE study included surveys by Normandeau Associates in November and December 2002 to identify areas of erosion along the Merrimack River greater than approximately 50-feet in length. Several problem areas were identified during this field reconnaissance effort in this segment of the river although many more locations were identified in the river upstream from the MA/NH state line. *Aesthetics Use* is assessed as support but is identified with an Alert Status based on identified erosional areas and turbidity. *Data Sources: 9, 23, 24*		
Monitoring Recommendations		
Conduct fish tissue toxics monitoring to evaluate the current fish consumption advisory. Conduct dissolved oxygen monitoring to evaluate diurnal variation by deploying multiprobes overnight.		

BRIDGE MEADOW BROOK (SEGMENT MA84A-34)

Segment Description: Headwaters, north of Chestnut Road, Tyngsborough to inlet Flint Pond, Tyngsborough.
Segment Length: 4.0 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM collected benthic macroinvertebrates at one site (B0522). The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "slightly impacted". Habitat quality was limited mostly by low flow conditions, likely influenced by beaver dams and other small impoundments. Recent development (medium density residential housing) in the subwatershed area was also noted. MassDEP DWM biologists also estimated canopy cover (10 - 25% open) as well as micro and macroalgal cover at this site (0%, respectively) in the both the riffle and pool habitat. In 2004, MassDEP DWM collected fish at one site (BR01). All fish collected in the sample are classified as pollution tolerant or moderately pollution tolerant macrohabitat generalists although sampling efficiency was noted as 50% due to water color in the pool area where most fish were collected. MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1207) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Two of the three early morning DO measurements (between 3:40 and 4:36am, n=3) were low (3.1 and 3.9 mg/L) violating the water quality criterion of 5 mg/L and pH was also slightly low. Given the influence of wetlands and beaver activity in this subwatershed, however, these conditions are likely naturally occuring. The maximum water temperature was 21.8℃. The *Aquatic Life Use* is assessed as support based on the "slightly impacted" benthic macroinvertebrate community. An Alert Status is identified for this use due to low dissolved oxygen and the absence of fluvial fish. *Data Sources: 1, 2, 4, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli samples at one site (W1207) during the primary contact season. The geometric mean of the five samples was 51 CFU/100ml. Based on this result meeting the geometric mean criterion (126 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Primary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to one elevated E. coli count during a wet weather sampling event. *Data Sources: 2, 9, 17*		
Secondary Contact	**Support**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1207). The geometric mean of the five samples was 51 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. *Data Sources: 2 9, 17*		

Aesthetics	Support	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1207). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9, 17*		
Monitoring Recommendations		
None		

LAWRENCE BROOK (SEGMENT MA84A-20)

Segment Description: Headwaters, Tyngsborough (excluding intermittent portion) to confluence with Merrimack River, Tyngsborough.
Segment Length: 2.0 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 3 - No Uses Assessed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	
MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1189) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 3:16 and 4:07am, n=3) and other water quality physico-chemical monitoring data were indicative of good water quality conditions. The maximum water temperature was 24.7℃. The *Aquatic Life Use* is assessed as support based on the available water quality data. *Data Sources: 2*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Support**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1189) during the primary contact season. The geometric mean of the five samples was 100 CFU/100ml. Based on this result meeting the geometric mean criterion (126 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Primary Contact Recreational Use* is assessed as support. *Data Sources: 2, 9*		
Secondary Contact	**Support**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1189). The geometric mean of the five samples was 100 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. *Data Sources: 2, 9*		

Aesthetics	Support	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1189). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The The *Aesthetics Use* is assessed as support. *Data Sources: 9*		
Monitoring Recommendations		
None		

DEEP BROOK (SEGMENT MA84A-21)

Segment Description: Headwaters east of Everett Turnpike, Tyngsborough to confluence with Merrimack River, Chelmsford.
Segment Length: 2.9 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Unknown toxicity, Siltation, Organic enrichment/Low DO, Pathogens).
NPDES Permits: Allied Waste Services of Massachusetts, LLC (MA0030066)

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
In August 2004, MassDEP DWM collected fish at one site (DRB05). Habitat quality was most noticeably limited by sediment deposition and substrate embeddedness resulting in marginal epifaunal substrate as well as low flow conditions. All fish collected in the sample are classified as macrohabitat generalists and either pollution tolerant or moderately pollution tolerant. MassDEP DWM biologists last sampled this same reach in Deep Brook in 1990 and collected 17 native eastern brook trout. The absence of eastern brook trout in the 2004 sample may indicate that the water and habitat quality has worsened over the last 15 years. DWM conducted monthly in-situ water quality monitoring at one site (W1190) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 4:34 and 5:33am, n=3) and other water quality physico-chemical monitoring data were indicative of good water quality conditions. The maximum water temperature was 19.0℃. Highway construction runoff was identified as one source of the problem. The *Aquatic Life Use* is assessed as impaired based on the poor fish community. **Cause(s) of Impairment:** Fishes Bioassessment, Habitat Assessment, Sedimentation/Siltation **Source(s) of Impairment:** Highways, Roads, Bridges, Infrastructure (New Construction), Source Unknown *Data Sources: 2, 4*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1190) during the primary contact season. The geometric mean of the five samples was 365 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified Urban Stormwater, Source Unknown *Data Sources: 2, 9*		

Secondary Contact	Support	Yes
In 2004, MassDEP DWM collected five E. coli samples at one site (W1190). The geometric mean of the five samples was 365 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to one elevated E. coli count during a wet weather sampling event. *Data Sources: 2, 9*		
Aesthetics	**Support**	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1190). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources. Conduct reconniasance fish surveys to determine if brook trout are present in the segment.		

UNNAMED TRIBUTARY "REEDY MEADOW BROOK" (SEGMENT MA84B-01)

Segment Description: (Locally known as Reedy Meadow Brook) Headwaters, outlet of small unnamed impoundment upstream of Bruce Street, Littleton to inlet Mill Pond, Littleton.
Segment Length: 1.5 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Nutrients, pH, Organic enrichment/Low DO, Pathogens, Suspended solids).
NPDES Permits: Veryfine Products (Sunny Delight Beverages Co.) (MA0004936)

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	**Alert**
Water from Reedy Meadow Brook is collected upstream from the Veryfine Products Inc. outfall for use as a site control sample in the facility's whole effluent toxicity tests. Between January 2001 and April 2009 survival of P. promelas exposed (7days) to the brook ranged from 0 to 100% (n=34) and was less than 75% in 5 of the 34 test events (April 05, April 06, April 08, and January and April 2009 with survivals of 28, 58, 33, 58, and 0%, respectively) representing 15% of the test events. An Alert Status is identified for this use due to evidence of ambient toxicity. *Data Sources: 7*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		

Monitoring Recommendations
Conduct additional bacteria monitoring to confirm the 303(d) listing for pathogens.
Conduct dissolved oxygen monitoring to evaluate diurnal variation by deploying multiprobes overnight.
Conduct additional biological and water quality monitoring to evaluate designated uses.

TADMUCK BROOK (SEGMENT MA84B-07)

Segment Description: Headwaters south of Main Street, Westford to confluence with Stony Brook, Westford.
Segment Length: 1.4 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM collected benthic macroinvertebrates and periphyton at one site (B0523). The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community is "non-impacted". Backpack electrofishing by DWM biologists in August 2004 only resulted in the capture of 6 fish at one site (TA01). Habitat quality was only limited by the low flow conditions encountered. MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1201) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 4:06 and 5:05am, n=3) and other water quality physico-chemical monitoring data were indicative of good water quality conditions. The maximum water temperature was 21.0℃. The *Aquatic Life Use* is assessed as support based on the "non-impacted" benthic macroinvertebrate community. An Alert Status is identified for this use due to the low number of fish. *Data Sources: 1, 2, 4, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1201) during the primary contact season. The geometric mean of the five samples was 534 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified Urban Stormwater, Source Unknown *Data Sources: 2, 9, 17*		
Secondary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli samples at one site (W1201). The geometric mean of the five samples was 534 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to elevated bacteria during a wet weather sampling event. *Data Sources: 2, 9, 17*		

Aesthetics	Support	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1201). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9, 17*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

BENNETTS BROOK (SEGMENT MA84B-06)

Segment Description: Headwaters, north of Route 2, Harvard to the inlet of Spectacle Pond, Ayer/Littleton.
Segment Length: 4.3 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM collected benthic macroinvertebrates at one site (B0525). The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "non-impacted". MassDEP DWM biologists also estimated canopy cover (30% open) as well as micro and macroalgal cover at this site (30 and 0% for both). In 2006, MA DFG biologists conducted backpack electrofishing at two sites (1605, 1643). All fish collected in the sample are macrohabitat generalists and moderately pollution tolerant. MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1200) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 1:14 and 1:48am, n=3) and other water quality physico-chemical monitoring data were indicative of good water quality conditions. The maximum water temperature was 21.2℃. None of the dissolved oxygen, temperature, or pH measurements violated water quality criteria. The *Aquatic Life Use* is assessed as support based on the "non-impacted" benthic macroinvertebrate community. An Alert Status is identified for this use due to the lack of any fluvial fish species. *Data Sources: 1, 2, 15, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1200) during the primary contact season. The geometric mean of the five samples was 397 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Wet Weather Discharges (Non-point), Source Unknown *Data Sources: 2, 9, 17*		

Secondary Contact	Support	Yes
In 2004, MassDEP DWM collected five E. coli samples at one site (W1200). The geometric mean of the five samples was 397 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to elevated bacteria during a wet weather sampling event. *Data Sources: 2, 9, 17*		
Aesthetics	**Support**	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1200). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9, 17*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

STONY BROOK (SEGMENT MA84B-04)

Segment Description: Brookside Road, Westford to confluence with Merrimack River, Chelmsford.
Segment Length: 3.4 Miles
Segment Classification: B, WWF
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Cause Unknown, Nutrients, pH, Organic enrichment/Low DO, Pathogens).
NPDES Permits: Fletcher Granite Company (MA0020231)

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
USGS from 1999 through 2004 measured dissolved oxygen, temperature, and pH 12 times and collected 11 total phosphorus, 14 chlorophyll-a (periphyton) and 11 ammonia samples from Stony Brook at School Street bridge in Chelmsford. None of the dissolved oxygen, temperature, or pH measurements violated water quality criteria. The total phosphorus concentrations ranged from 0.014 mg/L to 0.049 mg/L and the chlorophyll-a concentrations ranged from 2.2 mg/m2 to 84.2 mg/m2. In 2003, CDM measured dissolved oxygen, temperature, and pH 13 times and collected five total phosphorus and three chlorophyll-a (phytoplankton) samples at one site (T006) (See Special Note 2). None of the dissolved oxygen, temperature, or pH measurements violated water quality criteria. The total phosphorus concentrations ranged from 0.023 mg/L to 0.045 mg/L and the chlorophyll-a concentrations ranged from 0.4 ug/L to 3.7 ug/L. While water quality data are indicative of generally good conditions, due to a lack of pre-dawn (worse-case) dissolved oxygen data, the *Aquatic Life Use* is not assessed. *Data Sources: 3, 5*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		

Primary Contact	Impaired	
In 2003, CDM collected E. coli samples at one site (T006) (See Special Note 1). The geometric mean of the samples collected during the primary contact season was 535 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified Urban Stormwater, Source Unknown *Data Sources: 3*		
Secondary Contact	**Support**	**Yes**
In 2003, CDM collected E. coli samples at one site (T006) (See Special Note 1). The geometric mean of the samples was 535 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli., the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to occasional spikes in E. coli concentrations particularly during wet weather conditions. *Data Sources: 3*		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources. Conduct dissolved oxygen monitoring to evaluate diurnal variation by deploying multiprobes overnight. Conduct additional biological and water quality monitoring to evaluate designated uses.		

REED BROOK (SEGMENT MA84B-08)

Segment Description: Headwaters, south of the West Street Cowdry Hill Road intersection, Westford to the confluence with Stony Brook, Westford.
Segment Length: 0.6 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	
In 2006, MA DFG collected fish at one site (1644). The sample was dominated by eastern brook trout (Salvelinus fontinalis), a fluvial specialist, pollution intolerant species. Of the 42 individual fish collected 39 were identified as eastern brook trout of varying size classes. The dominance of a reproducing eastern brook trout population indicates excellent water quality. The fisheries data indicate that cold water fishery is an existing use for this segment. The *Aquatic Life Use* is assessed as support based on the good fish community. *Data Sources: 15*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		

Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

BLACK BROOK (SEGMENT MA84A-17)

Segment Description: Headwaters, Chelmsford to confluence with Merrimack River, Lowell.
Segment Length: 2.3 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Unknown toxicity, Siltation, Pathogens, Turbidity).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
In 2004, MassDEP DWM collected benthic macroinvertebrates at one site (B0521). Habitat quality degradation was observed (marginal instream cover and velocity/depth combinations, as well as sediment deposition and substrate embeddedness resulting in suboptimal epifaunal substrate). The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "moderately impacted". MassDEP DWM in 2004 and MA DFG in 2001 collected fish at the same site (511, BB05). Both samples contained low total fish abundance. MassDEP DWM collected 24 fish and MA DFG collected just four fish and fluvial species were almost absent. MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1191) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 5:01 and 5:59am, n=3) and other water quality physico-chemical monitoring data were indicative of good water quality conditions although conductivity was higher than most sites. The maximum water temperature was 19.7℃. The *Aquatic Life Use* is assessed as impaired based on the "moderately impacted" benthic macroinvertebrate community, the low fish abundance and absence of fluvial species, and the degraded habitat quality conditions. Sources are unknown but habitat modification, unspecified urban stormwater runoff, and loss of riparian habitat are suspected. **Cause(s) of Impairment:** Aquatic Macroinvertebrate Bioassessments, Fishes Bioassessment, Physical Substrate Habitat Alterations **Source(s) of Impairment:** Source Unknown *Data Sources: 1, 2, 4, 15*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		

Primary Contact	Impaired	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1191) during the primary contact season. The geometric mean of the five samples was 302 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli and the frequent aesthetically objectionable conditions observed, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli, Debris/Floatables/Trash, Turbidity **Source(s) of Impairment:** Unspecified Urban Stormwater, Inappropriate Waste Disposal, Source Unknown *Data Sources: 2, 9, 17*		
Secondary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1191). The geometric mean of the five samples was 302 CFU/100ml. This result does not violate the geometric mean criterion (630 CFU/100ml) for E. coli however frequent aesthetically objectionable conditions (e.g., trash, turbidity, occasional sheens) were observed so the *Secondary Contact Recreational Use* is assessed as impaired. It should be noted that elevated bacteria during storm events is also a concern. **Cause(s) of Impairment:** Debris/Floatables/Trash, Turbidity **Source(s) of Impairment:** Inappropriate Waste Disposal, Source Unknown *Data Sources: 2, 9, 17*		
Aesthetics	**Impaired**	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1191). There were frequent observations of aesthetically objectionable conditions (primarily trash, turbidity and occasional sheens) throughout the summer. The *Aesthetics Use* is assessed as impaired. **Cause(s) of Impairment:** Debris/Floatables/Trash, Turbidity **Source(s) of Impairment:** Inappropriate Waste Disposal, Source Unknown *Data Sources: 9, 17*		
Monitoring Recommendations		
Conduct additional biological and water quality monitoring to characterize any impairments and identify unknown sources.		

MERRIMACK RIVER (SEGMENT MA84A-02)

Segment Description: Pawtucket Dam, Lowell to Lowell Regional Wastewater Utilities outfall at Duck Island, Lowell.
Segment Length: 3.2 Miles
Segment Classification: B\TWS, WWF, CSO
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals, Nutrients, (Flow alteration*), Pathogens). * denotes a non-pollutant.
NPDES Permits: Boott Hydropower, Inc. (MAG250950), Boott Hydropower, Inc. (MAG250163), Lowell Regional Wastewater Utilities (MA0100633)

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
In 2003, CDM collected five total phosphorus samples and three chlorophyll-a samples from two sites (MO14, M015) (See Special Note 2). The total phosphorus concentrations ranged from 0.044 to 0.140 mg/L and the chlorophyll-a concentrations ranged from 0.5 to 42 ug/L at these sites. Water from the river is collected at the Hunts Falls Bridge for use as a site control for the Lowell Regional Wastewater Utilities modified acute and chronic whole effluent toxicity tests. Survival of C. dubia exposed (7-days) to river water was >90% for the tests conducted between April 2008 and April 2009 (n=5). The bypass reach of the Merrimack River downstream from the Pawtucket Dam through Pawtucket Falls to the confluence with the Lowell Project tailrace (0.7 miles) is periodically dry (during low flow conditions). The riverbed along the Pawtucket Falls reach is exposed when the flow is diverted solely through the Northern canal system. The *Aquatic Life Use* is assessed as impaired because of the flow alterations associated with the hydropower project in the upper 0.7 mile reach of the segment results in a dry channel. **Cause(s) of Impairment:** Low Flow Alteration **Source(s) of Impairment:** Impacts from Hydrostructure Flow Regulation/Modification *Data Sources: 3, 6, 7,*		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for this portion of the Merrimack River. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat White Sucker or Largemouth Bass fish from this water body. The general public should limit consumption of White Sucker and Largemouth Bass to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Impaired**	
In 2003, CDM collected E. coli samples at two sites (MO14, M015) (See Special Note 1). The geometric means of the samples collected during the primary recreation season at each site were 141 and 351 CFU/100ml. Based on these results violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. Six Lowell Regional Wastewater Utilities CSOs (Outfall 027 Tilden Street, Outfall 008 West Street, Outfall 011 Read Street, Outfall 030 (1 & 2) Merrimack River and Barasford Ave, and Outfall 012 First Street) also discharge to this segment. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Source Unknown *Data Sources: 3*		

Secondary Contact	Support	Yes
In 2003, CDM collected E. coli samples at two sites (MO14, M015) (See Special Note 1). The geometric means of the samples collected at each site were 141 and 351 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to occasional spikes in E. coli concentrations and the presence of six Lowell Regional Wastewater Utilities CSOs (Outfall 027 Tilden Street, Outfall 008 West Street, Outfall 011 Read Street, Outfall 030 (1 & 2) Merrimack River and Barasford Ave, and Outfall 012 First Street) that also discharge to this segment. *Data Sources: 3*		
Aesthetics	**Support**	
MassDEP DWM field staff did not note any frequent or prolonged objectionable conditions (e.g., odors, oils, growths, scums, deposits or turbidity) at two sampling locations (Oulette Bridge and Hunts Falls Bridge in Lowell) in this segment of the Merrimack River during sampling events conducted between June 2004 and September 2005. A slight oil sheen and some trash/debris were noted at the Hunts Falls Bridge sampling location on one occasion. The The *Aesthetics Use* is assessed as support. *Data Sources: 9, 24*		
Monitoring Recommendations		
Conduct additional biological monitoring to evaluate the impact of the flow alteration on the lower reaches of the segment. Conduct fish tissue toxics monitoring to evaluate the current fish consumption advisory. Conduct dissolved oxygen monitoring to evaluate diurnal variation by deploying multiprobes overnight.		

PEPPERMINT BROOK (SEGMENT MA84A-35)

Segment Description: Headwaters, outlet of unnamed pond east of Route 38, Dracut to confluence with Beaver Brook, Dracut.
Segment Length: 2.7 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM collected benthic macroinvertebrates at one site (B0520). The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "slightly-impacted". Habitat quality was limited primarily by low flow conditions and limited velocity/depth combinations as well as some sediment deposition and poor bank stability/riparian zone particularly on one bank. In 2004, MassDEP DWM collected fish at one site (PE01A). Backpack electrofishing resulted in capture of 8 species although sampling efficiency was poor due to poor visibility (fine sediment in pools got stirred up during sampling). Three fluvial species were collected although yellow bullhead, a tolerant macrohabitat generalist, dominated the sample. MassDEP DWM biologists also estimated canopy cover (100% open) as well as micro and macroalgal cover in cobble/riffle at this site (80 and 0%, respectively). MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1211) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 1:45 and 2:28am, n=3) ranged from 4.1 to 6.5 mg/L and was <5.0 mg/L on one occasion. The other limited physico-chemical monitoring data were indicative of good conditions. The maximum water temperature was 21.2℃. The *Aquatic Life Use* is assessed as support based on the "slightly impacted" benthic macroinvertebrate community. An Alert Status is identified for this use due to low dissolved oxygen and habitat quality conditions. *Data Sources: 1, 2, 4, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1211) during the primary contact season. The geometric mean of the five samples was 644 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli and the frequent aesthetically objectionable conditions observed, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli, Debris/Floatables/Trash **Source(s) of Impairment:** Unspecified Urban Stormwater Inappropriate Waste Disposal, Source Unknown *Data Sources: 2, 9, 17, 4*		
Secondary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1211). The geometric mean of the five samples was 644 CFU/100ml. Based on this result violating the geometric mean criterion (630 CFU/100ml) for E. coli and the frequent aesthetically objectionable conditions observed, the *Secondary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli, Debris/Floatables/Trash **Source(s) of Impairment:** Unspecified Urban Stormwater, Inappropriate Waste Disposal, Source Unknown *Data Sources: 2, 9, 17, 4*		

Aesthetics	Impaired	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1211). There were no field observations indicating prolonged or frequent occurences of objectionable odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. There were observations of extensive objectionable deposits in the form of trash. The *Aesthetics Use* is assessed as impaired. **Cause(s) of Impairment:** Debris/Floatables/Trash **Source(s) of Impairment:** Inappropriate Waste Disposal *Data Sources: 9, 17, 4*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

BEAVER BROOK (SEGMENT MA84A-11)

Segment Description: New Hampshire state line, Dracut to confluence with Merrimack River, Lowell.
Segment Length: 4.8 Miles
Segment Classification: B, CWF
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Cause Unknown, (Other habitat alterations*), Pathogens, Oil and grease, Turbidity, (Objectionable deposits*)). * denotes a non-pollutant.
NPDES Permits: Lowell Regional Wastewater Utilities (MA0100633)

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	**Yes**
In 2004, MA DMF evaluated fish passage in the Merrimack basin. Substantial potential riverine anadromous fish habitat was identified in Beaver Brook but the Beaver Brook Dam as well as other obstructions on the lower brook prevent fish passage into available habitats. In 2003, CDM measured dissolved oxygen, temperature, and pH a total of 13 times and collected five total phosphorus and three chlorophyll-a (phytoplankton) samples at one site (T007). Limited water quality data indicate generally good conditions although one slightly low DO (4.9 mg/L) and seven of 13 temperature measurements exceeded the cold water criterion (20°C). The total phosphorus concentrations ranged from 0.022 to 0.210 mg/L and chlorophyll-a concentrations ranged from 0.1 ug/L to 13.2 ug/L. An Alert Status is identified for this use due to fish migration barriers, elevated temperature, and elevated total phosphorus concentrations. *Data Sources: 3, 8*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2003, CDM collected E. coli samples at one site (T007) during the primary contact season (See Special Note 1). The geometric mean of the samples was 317 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. Elevated counts were only documented during wet weather conditions. One Lowell Regional Wastewater Utilities CSO (Outfall 007 Beaver Brook) also discharges near the downstream end of this segment. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified Urban Stormwater, Source Unknown *Data Sources: 3*		

Secondary Contact	Support	Yes
In 2003, CDM collected E. coli samples at one site (T007) (See Special Note 1). The geometric mean of the samples was 317 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli., the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to occasional spikes in E. coli concentrations. One Lowell Regional Wastewater Utilities CSO (Outfall 007 Beaver Brook) also discharges near the downstream end of this segment. *Data Sources: 3*		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources. Conduct biological (macroinvertebrates) monitoring to evaluate the *Aquatic Life Use*. Conduct dissolved oxygen monitoring to evaluate diurnal variation by deploying multiprobes overnight.		

MERRIMACK RIVER (SEGMENT MA84A-03)

Segment Description: Lowell Regional Wastewater Utilities outfall at Duck Island, Lowell to Essex Dam, Lawrence.
Segment Length: 8.8 Miles
Segment Classification: B\TWS, WWF, CSO
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Priority organics, Metals, Nutrients, Pathogens).
NPDES Permits: Lowell Regional Wastewater Utilities (MA0100633), Brox Industries, Inc. (MA0040177)

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	**Yes**
In 2003, CDM collected five total phosphorus samples and three chlorophyll-a samples from three sites (M016, M017, M018) (See Special Note 2). The total phosphorus concentrations ranged from 0.056 to 0.180 mg/L and chlorophyll-a concentrations ranged from 2.6 to 23.2 µg/L at these sites. MassDEP DWM staff deployed a multiprobe meter in the river upstream from the Essex Dam for two days in August 2004. The DO and temperature measurements all met standards (DO ranged from 6.2 to 7.6 mg/L and the maximum temperature 24.5℃). Insuffic ient data were available to assess the Aquatic Life use. An Alert Status is identified for this use due to elevated total phosphorus and occasional elevated chlorohpyll-a concentrations. *Data Sources: 3*		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for this portion of the Merrimack River. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat White Sucker or Largemouth Bass fish from this water body. The general public should limit consumption of White Sucker and Largemouth Bass to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		

Primary Contact	Impaired	
In 2008, MRWA collected E.coli samples at seven sites (37.9, 36.3, 35.1, 33.4, 32.2, 31.4, 29.6). The geometric means of the samples collected during the primary contact season at each site ranged from 20.2 CFU/100ml to 41.0 CFU/100ml. In 2003, CDM collected E. coli samples at three sites (M016, M017, M018) (See Special Note 1). Only one site (M017) had the minimum number of samples (5) required to determine compliance with the water quality criteria. The geometric mean of the samples collected during the primary contact season at this site was 721 CFU/100ml. Based on the CDM result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational* Use is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Source Unknown *Data Sources: 3, 25*		
Secondary Contact	**Impaired**	
In 2008, MRWA collected E.coli samples at seven sites (37.9, 36.3, 35.1, 33.4, 32.2, 31.4, 29.6). The geometric means of the samples collected at each site ranged from 20.2 CFU/100ml to 41.0 CFU/100ml. In 2003, CDM collected E. coli samples at three sites (M016, M017, M018) (See Special Note 1). Only one site (M017) had the minimum number of samples (5) required to determine compliance with the water quality criteria. The geometric mean of the samples at this site was 721 CFU/100ml. Based on the CDM result violating the geometric mean criterion (630 CFU/100ml) for E. coli, the *Secondary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Source Unknown *Data Sources: 3, 25*		
Aesthetics	**Support**	**Yes**
MassDEP DWM field staff did not note any frequent or prolonged objectionable conditions (e.g., odors, oils, growths, scums, deposits or turbidity) in this segment of the Merrimack River (sites sampled more than once included River Road in Lowell, Haverhill Street in Dracut, above Pine Island in Methuen, between Route 93 and Methuen intake in Methuen, and between Lawrence and Methuen intake in Lawrence) during sampling events conducted between October 2004 and September 2005. Odors, slight oil sheens and some trash/debris were noted at the River Road in Lowell, Haverhill Street in Dracut sampling sites on occasion but none of these conditions were noted downstream. It should be noted however that the USACOE study included surveys by Normandeau Associates in November and December 2002 to identify areas of erosion along the Merrimack River greater than approximately 50-feet in length. Several problem areas were identified during this field reconnaissance effort in this segment of the river. The *Aesthetics Use* is assessed as support but is identified with an Alert Status based on the areas identified and concern regarding erosion/turbidity. *Data Sources: 9, 23, 24*		
Monitoring Recommendations		
Conduct fish tissue toxics monitoring to evaluate the current fish consumption advisory. Conduct dissolved oxygen monitoring to evaluate diurnal variation by deploying multiprobes overnight.		

RICHARDSON BROOK (SEGMENT MA84A-12)

Segment Description: Headwaters, Dracut (excluding intermittent portion) to confluence with Merrimack River, Dracut.
Segment Length: 1.9 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 4c - Impairment Not Caused by a Pollutant ((Other habitat alterations*)). * denotes a non-pollutant.
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM collected benthic macroinvertebrates at one site (B0306). The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "slightly-impacted". Habitat quality was limited primarily by limited velocity/depth combinations and the poor riparian vegetative zone width along one bank near the sampling location. In 2004, MassDEP DWM collected fish at one site (RBR01A). During this sampling the channel flow status was limited. Only two species were collected in the sample . MassDEP DWM biologists also sampled both closed and open canopy cover sites (0 and 70% open, respectively) with microalgal cover estimated at 20 and 30% and macroalgal cover estimated at 0 and 10% in the closed and open cobble/riffle habitats, respectively. MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1192) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 2:31 and 3:36am, n=3) ranged from 5.6 to 7.6 mg/L and the other limited physico-chemical monitoring data were indicative of good conditions. The maximum water temperature was 22.6℃. The *Aquatic Life Use* is assessed as support based on the "slightly impacted" benthic macroinvertebrate community. An Alert Status is identified for this use due to the lack of fluvial fish other than redfin pickerel as well as the low number of fish. *Data Sources: 1, 2, 4, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1192) during the primary contact season. The geometric mean of the five samples was 162 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. The high counts were collected during wet weather conditions. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified Urban Stormwater, Source Unknown *Data Sources: 2, 9, 17*		
Secondary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli samples at one site (W1192). The geometric mean of the five samples was 162 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to elevated bacteria during a wet weather sampling event. *Data Sources: 2, 9, 17*		

Aesthetics	Support	
In 2004, MassDEP DWM staff recorded field observations regarding aesthetics at one site (W1192). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9, 17*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

TROUT BROOK (SEGMENT MA84A-13)

Segment Description: Headwaters, Dracut to confluence with Richardson Brook, Dracut.
Segment Length: 2.6 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 3 - No Uses Assessed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	**Yes**
In 2004, MassDEP DWM collected fish at one site (TRB02). Habitat quality was noted to be limited most by sediment deposition, the marginal channel flow status which also limited velocity/depth combinations and the limited riparian vegetative zone width. The fish sample contained only 21 individuals and one species, redfin pickerel. In 2006 MA DFG collected fish at two sites (1607, 1608). Both samples had less than ten individuals and were dominated by macrohabitat generalists. It should be noted that during a survey conducted in the summer of 1990, MassDEP DWM collected multiple age classes of native brook trout from the brook near Kenwood Street. MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1193) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 02:12 and 03:04am, n=3) ranged from 7.7 to 7.9 mg/L and the other limited physico-chemical monitoring data were indicative of excellent conditions. The maximum water temperature was 17.2℃. An Alert Status is identified for this use due to the low numbers and diversity of fish and the concerns related to habitat quality conditions (e.g., sediment deposition and limited flow regimes) and the absence of brook trout. *Data Sources: 2, 4, 15*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1193) during the primary contact season. The geometric mean of the five samples was 353 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9*		

Secondary Contact	Support	Yes
In 2004, MassDEP DWM collected five E. coli samples at one site (W1193). The geometric mean of the five samples was 353 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to elevated bacteria during a wet weather sampling event. *Data Sources: 2, 9*		
Aesthetics	**Support**	
In 2004, MassDEP DWM field crews recorded field observations regarding aesthetics at one site (W1193). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

TRULL BROOK (SEGMENT MA84A-14)

Segment Description: Source, Tewksbury (excluding intermittent portion) to confluence with Merrimack River, Tewksbury.
Segment Length: 2.1 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 3 - No Uses Assessed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM collected benthic macroinvertebrates at one site (B0308) and fish at one site (TB02). The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "slightly impacted". Habitat quality was generally good but was limited primarily by the marginal channel flow as well as some sediment deposition and marginal bank stability/riparian zone particularly on one bank. An erosion channel originating at a storm drain at River Road was noted as a concern. Backpack electrofishing resulted in the capture of four species and only 13 individuals but was dominated by fluvial dependants. DWM biologists also estimated canopy cover (35% open) as well as micro and macroalgal cover in cobble/riffle at this site (80 and 0%, respectively). In-situ water quality monitoring at one site (W1194) was conducted by MassDEP DWM in July, August, and September 2004. Multiprobe samplers deployed in the brook recorded temperature and DO. The minimum DO measurement was 6.6 mg/L (23 hours of deployment on 6/7 July and 43 hours 30 minutes of deployment 16 to 18 August) and the maximum temperature was 21.9℃ (23 hours of deployment on 6/7 July, 43 hours 30 minutes from 16 to 18 August, and 43 hours 15 minutes of deployment from 7 to 9 September). The *Aquatic Life Use* is assessed as support based on the "slightly impacted" benthic macroinvertebrate community. An Alert Status is identified for this use due to the low number of fish. *Data Sources: 1, 2, 4, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		

Primary Contact	Impaired	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1194) during the primary contact season. The geometric mean of the samples was 740 cfu/100 mL. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. Although source(s) of bacteria are unknown, geese/droppings were identified in the vicinity of the sampling location. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9, 17*		
Secondary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1194). The geometric mean of the sample was 740 cfu/100 mL. Based on this result violating the geometric mean criterion (630 CFU/100ml) for E. coli, the *Secondary Contact Recreational Use* is assessed as impaired. It should also be noted that the extremely high count was associated with a storm event. Although source(s) of bacteria are unknown, geese/droppings were identified in the vicinity of the sampling location. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9, 17*		
Aesthetics	**Support**	
In 2004, MassDEP DWM recorded field observations in Trull Brook (W1194) downstream from River Road in Tewskbury. There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9, 17*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

BARTLETT BROOK (SEGMENT MA84A-36)

Segment Description: New Hampshire state line, Dracut to inlet Mill Pond, Methuen.
Segment Length: 3.7 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM collected benthic macroinvertebrates at one site (B0519) and fish at one site (BA01A). Habitat quality was limited by the marginal channel flow status and lack of velocity/depth combinations, evidence of erosion and deposition, as well as a limited riparian vegetative zone width along one bank in the sampling reach. The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "slightly/non-impacted". Six species of fish (28 individuals) were collected in the sample. Yellow bullhead, a pollution tolerant macrohabitat generalist, dominated the sample. MassDEP DWM biologists also estimated canopy cover (0% open) as well as micro and macroalgal cover in cobble/riffle at this site (~10 and 0%, respectively). MassDEP DWM conducted monthly in-situ water quality at one site (W1202) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 03:01 and 03:55am, n=3) ranged from 6.8 to 7.9 mg/L and the other limited physico-chemical monitoring data were indicative of good conditions. The maximum water temperature was 20.9℃. The *Aquatic Life Use* is assessed as support based on the "slightly/non-impacted" benthic macroinvertebrate community. An Alert Status is identified for this use due the relatively low number of fluvial fish and habitat quality concerns related to flow and erosion/deposition problems. *Data Sources: 1, 2, 4, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1202) during the primary contact season. The geometric mean of the five samples was 344 CFU/100ml . Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9, 17*		
Secondary Contact	**Support**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1202). The geometric mean of the five samples was 344 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. *Data Sources: 2, 9, 17*		
Aesthetics	**Support**	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1202). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9, 17*		

Monitoring Recommendations
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.

FISH BROOK (SEGMENT MA84A-40)

Segment Description: Headwaters, east of Greenwood Road, Andover to confluence with Merrimack River at Fish Brook Dam, Andover.
Segment Length: 4.1 Miles
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM collected benthic macroinvertebrates at one site (B0517) and fish at two sites (FI01, FI01A). Habitat quality appeared to be most limited by the marginal channel flow status. The RBP III analysis in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "non- impacted". The total number of fish collected was very low although high flows decreased sampling efficiency. Both fish samples were dominated by fluvial specialists. MassDEP DWM biologists also estimated canopy cover (0% open) as well as micro and macroalgal cover in a pool habitat at this site (90 and 0%, respectively). MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1206) on three occasions in July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 1:13 and 1:43am, n=3) were extremely low ranging from 1.2 to 1.9 mg/L although upstream wetlands likely contribute to these conditions. It should also be noted that conductivity was fairly high and is of concern particularly given the major highways/interchange and salt storage activities in this public water supply watershed area . The maximum water temperature was 22.7℃. and condu ctivity was fairly high. The *Aquatic Life Use* is assessed as support based on the "non-impacted" benthic macroinvertebrate community. An Alert Status is identified for this use due to low dissolved oxygen, elevated conductivity and the low number of fish despite excellent habitat quality. *Data Sources: 1, 2, 4, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1206) during the primary contact season. The geometric mean of the five samples was 162 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Source Unknown *Data Sources: 2, 9, 17*		
Secondary Contact	**Support**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1206). The geometric mean of the five samples was 162 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. *Data Sources: 2, 9, 17*		

Aesthetics	Support	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1206). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9, 17*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

MERRIMACK RIVER (SEGMENT MA84A-04)

Segment Description: Essex Dam, Lawrence to confluence with Little River, Haverhill.
Segment Length: 10.0 Miles
Segment Classification: B, CSO
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Priority organics, Nutrients, Pathogens).
NPDES Permits: Boott Hydropower, Inc. (MAG250948), Greater Lawrence Sanitary District (MA0100447), City of Haverhill Wastewater Division (MA0101621), Lucent Technologies, Inc. (MA0001261)

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2003, CDM measured dissolved oxygen, temperature, and pH a total of 26 times and collected ten total phosphorus and six chlorophyll-a (phytoplankton) samples at three sites in (M019, M021, M022) (See Special Note 2). None of the dissolved oxygen, temperature, or pH measurements violated water quality criteria. The total phosphorus concentrations ranged from 0.071 to 0.150 mg/L and the chlorophyll-a concentrations ranged from 2.3 to 23.0 ug/L. Water from the Merrimack River was collected at the Route 495 (O'Reilly Bridge) in Lawrence for use as dilution water in the Greater Lawrence Sanitary District's whole effluent toxicity tests. Survival of C. dubia exposed (7-day) to the river water was > 80% with the exception of the August 2002 test event when survival was 60% (n=37). The *Aquatic Life Use* is assessed as support for this segment of the river based primarily on the good survival of test organisms. An Alert Status is identified for this use due to elevated total phosphorus and occasionally chlorophyll-a concentrations. *Data Sources: 3, 7*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4). *Data Sources: 10*		

Primary Contact	Impaired	
In 2008, MRWA collected E.coli samples at five sites (29.1, 28.2, 26.9, 25.6, 22.3). The geometric means of the samples collected during the primary contact season at each site ranged from 93.3 CFU/100ml to 151.9 CFU/100ml. In 2003, CDM collected E. coli samples at three sites (M019, M021, M022) (See Special Note 1). Only two of the sites (M019 and M022) had the minimum number of samples (5) required to determine compliance with the water quality criteria. The geometric means of the samples collected during the primary contact season at these sites were 666 CFU/100ml (M019) and 215 CFU/100ml (M022). Based on the CDM and MRWA results violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. Highest counts were representative of wet weather sampling conditions. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Source Unknown *Data Sources: 3, 25*		
Secondary Contact	**Impaired**	
In 2008, MRWA collected E.coli samples at five sites (29.1, 28.2, 26.9, 25.6, 22.3). The geometric means of the samples collected during at each site ranged from 93.3 CFU/100ml to 151.9 CFU/100ml. In 2003, CDM collected E. coli samples at three sites (M019, M021, M022) (See Special Note 1). Only two of the sites (M019 and M022) had the minimum number of samples (5) required to determine compliance with the water quality criteria. The geometric means of the samples collected during the primary contact season at these sites were 666 CFU/100ml (M019) and 215 CFU/100ml (M022). Based on the CDM results violating the geometric mean criterion (630 CFU/100ml) for E. coli, the *Secondary Contact Recreational Use* is assessed as impaired. Highest counts were representative of wet weather sampling conditions. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Source Unknown *Data Sources: 3, 25*		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

SPICKET RIVER (SEGMENT MA84A-10)

Segment Description: New Hampshire state line, Methuen to confluence with Merrimack River, Lawrence.
Segment Length: 5.8 Miles
Segment Classification: B, WWF
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Cause Unknown, Metals, Nutrients, (Other habitat alterations*), Pathogens, (Objectionable deposits*)). * denotes a non-pollutant.
NPDES Permits: GenCorp, Inc. (MAG910424), Greater Lawrence Sanitary District (MA0100447)

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	**Yes**
In 2004, MA DMF evaluted fish passage in the Merrimack River basin. American Shad has been observed at the mouth of the Spicket River but the Spicket River Dam obstructs the passage of anadromous fish upstream. In 2003, CDM measured dissolved oxygen, temperature, and pH a total of 12 times and collected five total phosphorus and three chlorophyll-a (phytoplankton) samples at one site (T009) (See Special Note 2). Dissolved oxygen and pH measurements were slightly low on one occasion each. The total phosphorus concentrations ranged from 0.049 to 0.360 mg/L and the chlorophyll-a concentrations ranged from 0.7 to 7.4 ug/L. The *Aquatic Life Use* is not assessed (too limited data). An Alert Status is identified for this use due to elevated total phosphorus concentrations and the barrier to fish migration. *Data Sources: 3, 8*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2003, CDM collected E. coli samples at one site (T009) (See Special Note 1). The geometric mean of the samples collected during the primary contact season was 9404 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 3*		
Secondary Contact	**Impaired**	
In 2003, CDM collected E. coli samples at one site (T009) (See Special Note 1). The geometric mean of the samples was 9404 CFU/100ml. Based on this result violating the geometric mean criterion (630 CFU/100ml) for E. coli, the *Secondary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 3*		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources. Conduct biological (macroinvertebrates) monitoring to evaluate the *Aquatic Life Use*. Conduct dissolved oxygen monitoring to evaluate diurnal variation by deploying multiprobes overnight.		

BARE MEADOW BROOK (SEGMENT MA84A-18)

Segment Description: Headwaters, Methuen to confluence with Merrimack River, Methuen.
Segment Length: 3.0 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Siltation, Organic enrichment/Low DO, Pathogens, Turbidity).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	
In 2004, MassDEP DWM collected fish at one site (BMB01A). The sample was dominated by moderately pollution tolerant fluvial species. DWM conducted monthly in-situ water quality monitoring at one site (W1195) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity . Early morning DO measurements (between 3:36 and 4:33am, n=3) and other water quality physico-chemical monitoring data were indicative of good water quality conditions. The maximum water temperature was 23.5℃ . The *Aquatic Life Use* is assessed as support based on the available water quality data. *Data Sources: 2, 4*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1195) during the primary contact season. The geometric mean of the five samples was 323 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9*		
Secondary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli samples at one site (W1195). The geometric mean of the five samples was 323 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to an elevated E. coli count during a wet weather sampling event. *Data Sources: 2, 9*		
Aesthetics	**Support**	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1195). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

CREEK BROOK (SEGMENT MA84A-37)

Segment Description: Headwaters, outlet Crystal Lake, Haverhill to confluence with Merrimack River, Haverhill.
Segment Length: 2.3 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	
In 2004, MassDEP DWM collected benthic macroinvertebrates at one site (B0518) and fish at one site (CR01). The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "slightly-impacted". Habitat quality during the benthic survey was limited primarily by low flow conditions which affected instream cover, velocity-depth combinations, and channel flow status. Flow conditions were not low during the fish population survey (14 August). Backpack electrofishing resulted in capture of 7 species (44 individuals); and three most dominant species are considered to be tolerant to moderately tolerant "fluvial" species. MassDEP DWM biologists also estimated canopy cover (0% open) as well as micro and macroalgal cover in cobble/riffle at this site (25 and 0%, respectively). MassDEP DWM conducted monthly in-situ water quality at one site (W1203) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 3:57 and 4:52am, n=3) ranged from 7.8 to 8.7 mg/L . The other limited physico-chemical monitoring data were indicative of good conditions. The maximum water temperature was 19.6℃. The *Aquatic Life Use* is assessed as support based on the "slightly impacted" benthic macroinvertebrate community. *Data Sources: 1, 2, 4, 19*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1203) during the primary contact season. The geometric mean of the five samples was 331 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9, 17*		
Secondary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli samples at one site (W1203). The geometric mean of the five samples was 331 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to elevated bacteria during a wet weather sampling event. *Data Sources: 2, 9, 17*		

Aesthetics	Support	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1203). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9, 17*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

MERRIMACK RIVER (SEGMENT MA84A-05)

Segment Description: Confluence Little River, Haverhill to confluence Indian River, West Newbury/Amesbury.
Segment Length: 1.8 Square Miles
Segment Classification: SB, CSO, Shellfishing
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Priority organics, Pathogens).
NPDES Permits: City of Haverhill Wastewater Division (MA0101621), Haverhill Paperboard Corp. (MAG250961), Town of Merrimac (MA0101150)

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2003, CDM collected eight total phosphorus and six chlorophyll-a (phytoplankton) samples at two sites (M024, M025) (See Special Note 2). The total phosphorus concentrations ranged from 0.062 to 0.095 mg/L and the chlorophyll-a concentrations ranged from 2.2 to 28.6 µg/L. Water from the Merrimack River was collected from the Route 125 bridge (Basiliere Bridge) in Haverhill for use as dilution water in the Haverhill WPAF whole effluent toxicity tests. Between June 2001 and April 2009 survival of P. promelas exposed (48 hours) to the river was > 95% (n=31 test events). Water from the Merrimack River just upstream from its confluence with Cobbler Brook in Merrimac was also collected for use as dilution water in the Merrimac WWTP's whole effluent toxicity tests. Between November 2001 and July 2008 survival of M. bahia and M. beryllina exposed (48-hours) to the river water was > 93% (n= 14 and 12 test events, respectively). The *Aquatic Life Use* is assessed as support based primarily on the good survival of test organisms exposed to river water samples in this segment of the river. An Alert Status is identified for this use due to occasionally elevated chlorophyll-a concentrations. *Data Sources: 3, 7*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Shellfishing	**Not Assessed**	
DMF does not classify any shellfishing areas in this segment so the Shellfishing Use is not assessed.		

Primary Contact	Impaired	
In 2008, MRWA collected E.coli samples at three sites (19.1, 17.8, 16.8) and Enterococcus at two sites (14.1, 10.6). The geometric means of the samples collected at each site during the primary contact season ranged from 107.2 CFU/100ml to 124.3 CFU/100ml for the E. coli sites and 31.8CFU/100ml to 39.2 CFU/100ml for the Enterococcus sites. In 2003, CDM collected Enterococcus samples at two sites (M024, M025) (See Special Note 1). Neither site had the minimum number of samples (5) required to determine compliance with the Enterococcus geometric mean criterion, however five out of eight counts at the two sites exceeded 104 colonies/100ml. Based on the CDM and MRWA results violating the Enterococcus geometric mean criterion (35 CFU/100ml), the *Primary Contact Recreational Use* is assessed as impaired. Bacteria was elevated during both dry and wet weather conditions and the highest counts represented wet weather sampling. NOTE: Between June 2000 and July 2006 $20.1 Million has been invested to increase capacity at the Haverhill WWTP to capture over 97% of all combined flows including modifications at the WWTP and design and construction of miscellaneous improvements at CSO structures. **Cause(s) of Impairment:** Enterococcus **Source(s) of Impairment:** Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Source Unknown *Data Sources: 3, 25*		
Secondary Contact	**Impaired**	
In 2008, MRWA collected E.coli samples at three sites (19.1, 17.8, 16.8) and Enterococcus at two sites (14.1, 10.6). The geometric means of the samples collected at each site ranged from 107.2 CFU/100ml to 124.3 CFU/100ml for the E. coli sites and 31.8CFU/100ml to 39.2 CFU/100ml for the Enterococcus sites. In 2003, CDM collected Enterococcus samples at two sites (M024, M025) (See Special Note 1). Neither CDM site had the minimum number of samples (5) required to determine compliance with the Enterococcus geometric mean criterion 175 colonies/100ml), however four out of eight counts at the two sites exceeded 350 colonies/100ml so the *Secondary Contact Recreational Use* is assessed as impaired. Bacteria was elevated during both dry and wet weather conditions and the highest counts represented wet weather sampling and were more frequently detected at the upstream sampling location. NOTE: Between June 2000 and July 2006 $20.1 Million has been invested to increase capacity at the Haverhill WWTP to capture over 97% of all combined flows including modifications at the WWTP and design and construction of miscellaneous improvements at CSO structures. **Cause(s) of Impairment:** Enterococcus **Source(s) of Impairment:** Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Source Unknown *Data Sources: 3, 25*		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct bacteria monitoring to evaluate if recent upgrades to the Haverhill WWTP and CSO structures have improved water quality.		

LITTLE RIVER (SEGMENT MA84A-09)

Segment Description: New Hampshire state line, Haverhill to confluence with Merrimack River, Haverhill.
Segment Length: 4.6 Miles
Segment Classification: B, WWF
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL ((Other habitat alterations*), Pathogens). * denotes a non-pollutant.
NPDES Permits: City of Haverhill Wastewater Division (MA0101621)

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
In 2006, MA DFG collected fish at one site (1651). The sample was comprised of a total of 31 fish representing 7 species. Fluvial specialists/dependants comprised 35% of the sample. DWM conducted monthly in-situ water quality monitoring at one site (W1210) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 4:21 and 5:13 am, n=3) and other water quality physico-chemical monitoring data were indicative of good water quality conditions. The maximum water temperature was 21.3℃. The lower 0.4 miles of this segement is culverted underground impairing *Aquatic Life Use* due to habitat modification. The limited water quality and fish population information indicates that conditions in the upper 4.2 miles of the segment may support *Aquatic Life Use*. **Cause(s) of Impairment:** Habitat Assessments **Source(s) of Impairment:** Habitat Modification - other than Hydromodification *Data Sources: 2*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1210) during the primary contact season. The geometric mean of the five samples was 429 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli and the frequent aesthetically objectionable conditions observed, the *Primary Contact Recreational Use* is assessed as impaired. The lower reach of the Little River also receives flow from 4 of Haverhill WPCF CSOs. **Cause(s) of Impairment:** Escherichia coli, Debris/Floatables/Trash **Source(s) of Impairment:** Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Inappropriate Waste Disposal, Source Unknown *Data Sources: 2, 9*		
Secondary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1210). The geometric mean of the E. coli counts was 429 CFU/100ml. This result does not violate the geometric mean criterion (630 CFU/100ml) for E. coli however frequent aesthetically objectionable conditions (e.g., trash, turbidity, occasional sheens) were observed so the *Secondary Contact Recreational Use* is assessed as impaired. Elevated bacteria during storm events is also a concern as well as flow from 4 of Haverhill WPCF CSOs. **Cause(s) of Impairment:** Debris/Floatables/Trash **Source(s) of Impairment:** Inappropriate Waste Disposal *Data Sources: 2, 9*		

Aesthetics	Impaired	
In 2004, MassDEP DWM staff recorded field observations regarding aesthetics at one site (W1210). Objectionable deposits of trash and debris blanketed the streambed. The *Aesthetics Use* is assessed as impaired. Occasionally objectionable odors (e.g., sewage, chlorine, chemical) were noted although not consistently so this is identified as a concern. This lower reach of the Little River also receives flow from 4 of Haverhill WPCF CSOs. **Cause(s) of Impairment:** Debris/Floatables/Trash **Source(s) of Impairment:** Inappropriate Waste Disposal *Data Sources: 9*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

JOHNSON CREEK (SEGMENT MA84A-15)

Segment Description: Headwaters, Groveland (excluding intermittent portion) to confluence with Merrimack River, Groveland/Haverhill.
Segment Length: 1.1 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 3 - No Uses Assessed
NPDES Permits: Town of Groveland (MA0102661)

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	
In 2004, MassDEP DWM collected fish at one site (JC03). Habitat quality at this sampling location was limited by sediment deposition and embeddedness. Bank stability was also marginal. The fish sample was comprised of three species, and while containing low numbers of fish (n=11), was dominated by eastern brook trout (n=9) of varying size classes. Eastern brook trout are a cold water species classified as a fluvial specialist and pollution intolerant and the presence of a reproducing eastern brook trout population is indicative of excellent water quality. In 2002, MA DFG also collected fish in Johnson Creek further downstream near Main Street (736). A total of 12 species (118 fish) were collected. The sample was dominated by a pollution tolerant, fluvial dependant species (white sucker). Approximately half of the individuals collected are classified as fluvial specialists or dependents. MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1197) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 4:25 and 5:18am, n=3) and other water quality physico-chemical monitoring data were indicative of excellent water quality conditions. The maximum water temperature was 17.3℃. The *Aquatic Life Use* is assessed as support based on the fish community and available water quality data. *Data Sources: 2, 4, 15*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		

Primary Contact	Impaired	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1197) during the primary contact season. The geometric mean of the five samples was 310 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. The elevated counts represented wet weather conditions. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9*		
Secondary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli samples at one site (W1197). The geometric mean of the five samples was 309 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to elevated bacteria during wet weather sampling events. *Data Sources: 2, 9*		
Aesthetics	**Support**	
Between June and September 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1197). There were no field observations indicating prolonged or frequent occurences of any objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

UNNAMED TRIBUTARY (AKA ARGILLA BROOK) (SEGMENT MA84A-38)

Segment Description: (Locally known as Argilla Brook) Unnamed tributary to Johnson Creek (excluding intermittent portion) from Center Street, Groveland to confluence with Johnson Creek, Groveland.
Segment Length: 1.3 Miles
Segment Classification: B
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM collected fish at one site (AR01A). They noted habitat quality was limited most by sediment deposition/embeddedness and channel alteration as well as some bank instability and limited bank vegetative protection. A total of 11 species (86 individuals) were collected in the sample. Although the fish population included a number of golden shiner, a macrohabitat generalist, the majority of fish collected are classified as fluvial specialists/dependants. It should also be noted that in 2000, MA DFG biologists collected 21 eastern brook trout of varying size classes from a site (1456) downstream of the MassDEP DWM sample. Eastern brook trout are a cold water species classified as a fluvial specialist and are pollution intolerant. The presence of a reproducing eastern brook trout population was indicative of excellent water quality. In 2004, MassDEP DWM measured dissolved oxygen, temperature, and pH at one site (W1209) on three occasions during July, August and September 2004. Early morning DO measurements (between 4:03 and 4:49am, n=3) ranged from 6.9 to 8.1 mg/L. The other limited physico-chemical monitoring data were also indicative of good conditions. The maximum water temperature was 21.8℃. he *Aquatic Life Use* is assessed as support based on the fish community and available water quality data. This use is identified with an Alert Status because no trout were collected by MassDEP DWM during the most recent survey in this stream. *Data Sources: 2, 4, 15, 16*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli at one site (W1209) during the primary contact season. The geometric mean of the five samples was 119 CFU/100ml. Based on this result meeting the geometric mean criterion (126 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Primary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to elevated bacteria during a wet weather sampling event. *Data Sources: 2, 9*		
Secondary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli samples at one site (W1209). The geometric mean of the five samples was 119 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to elevated bacteria during a wet weather sampling event. *Data Sources: 2, 9*		

Aesthetics	Support	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1209). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9*		
Monitoring Recommendations		
None		

EAST MEADOW RIVER (SEGMENT MA84A-39)

Segment Description: Headwaters, outlet Neal Pond, Haverhill to inlet Millvale Reservoir, Haverhill.
Segment Length: 3.0 Miles
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM collected fish at one site (EA01). Habitat quality scored well. Backpack electrofishing resulted in the capture of five species (n=73 fish including young-of-year). The fish sample was comprised of both fluvial (American eel and redfin pickerel) and macrohabitat generalist species and all species are classified as tolerant or moderately tolerant of pollution. MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1213) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 3:30 and 3:59am, n=3) were extremely low (maximum of 1.8 mg/L). The maximum water temperature was 20.7℃. The *Aquatic Life Use* is assessed as support primarily based on best professional judgement of MassDEP DWM fishery biologists but is identified with an Alert Status because of the extremely low DO although these conditions are considered to be naturally occuring given the influence of the wetlands and beaver activity. *Data Sources: 2, 4*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1213) during the primary contact season. The geometric mean of the five samples was 128 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Source Unknown *Data Sources: 2, 9*		

Secondary Contact	Support	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1213). The geometric mean of the five samples was 128 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. *Data Sources: 2, 9*		
Aesthetics	**Support**	
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1213). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support. *Data Sources: 9*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

COBBLER BROOK (SEGMENT MA84A-22)

Segment Description: Headwaters, Merrimac to confluence with Merrimack River, Merrimac.
Segment Length: 4.4 Miles
Segment Classification: B, CWF
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Cause Unknown, Unknown toxicity).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2006, MA DFG biologists collected fish at two sites (1649, 1650). At the upstream sampling location the majority of the streambed was exposed due to very low flows while the downstream sampling reach was noted to have shallow pools and undercut banks that provided fish habitat. Both sampling sites were dominated by fluvial specialists and the downstream reach was dominated by multiple age classes of eastern brook trout. Of the 40 individual fish collected 31 (69%) in this reach were identified as eastern brook trout of varying size classes. Eastern brook trout are a cold water species classified as fluvial specialist and pollution intolerant. The second sample did not include any species classified as cold water. The *Aquatic Life Use* is assessed as support based on the good fish community. An Alert Status is identified for this use due to the absence of cold water fish species at the second site. *Data Sources: 15, 16*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		

Monitoring Recommendations
Conduct biological (macroinvertebrates) monitoring to evaluate the *Aquatic Life Use*.

POWWOW RIVER (SEGMENT MA84A-25)

Segment Description: Outlet of Lake Gardner, Amesbury to tidal portion, just downstream of Main Street, Amesbury.
Segment Length: 0.6 Miles
Segment Classification: B, WWF
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Pathogens, Suspended solids, Noxious aquatic plants, Turbidity).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2004, MassDEP DWM biologists collected benthic macroinvertebrates at one site (B0516). Habitat quality was degraded by channel alteration, poor bank stability and little to no riparian vegetative zone. The channel flow status was marginal and instream cover was also limited. The RBP III score in comparison to the "reference" site indicated that the benthic macroinvertebrate community was "slightly-impacted". MassDEP DWM biologists also estimated canopy cover (100% open) as well as micro and macroalgal cover in cobble/riffle at this site (0 and 100%, respectively) and in cobble/run (0 and 0%, respectively). MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1198) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 1:49 and 1:57am, n=3) ranged from 8.3 to 8.5 mg/L and the other limited physico-chemical monitoring data were indicative of good conditions. The maximum water temperature was 22.9℃. MA DMF evaluted fish passage in the Merrimack River basin. Bluebacks are known to enter the Powwow River in small numbers but the Mill Street Dam near the downstream end of this segment presently obstructs the passage of anadromous fish upstream. Because this particular dam presents a very difficult passage problem and, when combined with the cost of providing passage at the large dam at Lake Gardner, eliminates any development potential here. The *Aquatic Life Use* is assessed as support based on the "slightly impacted" benthic macroinvertebrate community. This use is identified with an Alert Status because of the habitat quality issues, barriers to fish migration, and concerns regarding enriched conditions (i.e., algal biomoass).		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1198) during the primary contact season. The geometric mean of the five samples was 531 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. Field crews also sampled a pipe discharging to the river just downstream from the water quality sampling location. Elevated bacteria counts were documented during both dry and wet weather sampling events and sewage odors were noted on occasion eminating from the pipe. Elevated counts were representative of both dry and wet weather sampling events. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9, 17, 19*		

Secondary Contact	Support	Yes
In 2004, MassDEP DWM collected five E. coli samples at one site (W1198). The geometric mean of the five samples was 531 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. Field crews also sampled the pipe discharging to the river just downstream from the water quality sampling location and noted sewage odors eminating from the pipe on occasion. Elevated bacteria counts were documented during both dry and wet weather sampling events. Some green filamentous algae was observed in the open riffle areas at the lower end of the sampling reach which is of concern. An Alert Status is identified for this use due to elevated bacteria during both dry and wet weather sampling events, the pipe discharge and occasional sewage odors, and the growth of filamentous green algae in the open riffle habitat. *Data Sources: 2, 9, 17, 19*		
Aesthetics	**Support**	**Yes**
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1198). There were no field observations of prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae but there was an observation of sewage odors eminating from a pipe just downstream from the sampling. The MassDEP DWM biologists did observe some green filamentous algae in the open riffle areas at the lower end of the sampling reach (% of macroalgal cover estimated at 80%) which is of concern. The *Aesthetics Use* is assessed as support but is identified with an Alert Status due to the pipe discharge and occasional sewage odors and the growth of filamentous green algae in the open riffle habitat. *Data Sources: 9, 17, 19*		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

UNNAMED TRIBUTARY (SEGMENT MA84A-30)

Segment Description: Unnamed tributary to Powwow River locally considered portion of Back River from outlet of Clarks Pond, Amesbury to confluence with Powwow River, Amesbury (formerly portion of segment MA84A-16).
Segment Length: 0.003 Square Miles
Segment Classification: SA
2008 Integrated List of Waters: Not Listed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	
MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1106) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity . Early morning DO measurements (between 2:13 and 2:27am, n=3) ranged from 6.9 to 7.9 mg/L and the other limited physico-chemical monitoring data were indicative of good conditions. The maximum water temperature was 22.8℃ . Small numbers of river herring have b een observed in the stream and a fishway could be installed at a reasonable cost. The *Aquatic Life Use* is assessed as support based on available water quality data. *Data Sources: 2, 8*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		

Shellfishing	**Not Assessed**	
DMF does not classify shellfishing beds in this segment area so the Shellfishing Use is not assessed.		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1106) during the primary contact season. The geometric mean of the five samples was 236 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. Elevated bacteria counts were documented during both dry and wet weather sampling conditions but the extremely high count represented wet weather. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9*		
Secondary Contact	**Support**	**Yes**
In 2004, MassDEP DWM collected five E. coli samples at one site (W1106). The geometric mean of the five samples was 236 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli and the absence of frequent aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to presence of trash/debris in the stream. *Data Sources: 2, 9*		
Aesthetics	**Support**	**Yes**
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1106). There were no field observations indicating prolonged or frequent occurences of objectionable odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae but trash/debris were noted at this sampling location. The Aestheticsl Use is assessed as support but is identified with an Alert Status because of the trash/debris at the sampling location. *Data Sources: 9*		
Monitoring Recommendations		
None		

BACK RIVER (SEGMENT MA84A-16)

Segment Description: New Hampshire state line, Amesbury to inlet Clarks Pond, Amesbury.
Segment Length: 2.7 Miles
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Siltation, Pathogens, Turbidity).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2002 MA DFG biologists collected fish at one site (738). The fish sample contained 46 individuals representing eight species. Although white sucker, a fluvial dependant species, co-dominated the sample, the other species were all macrohabitat generalists. MassDEP DWM conducted monthly in-situ water quality monitoring at one site (W1212) on three occasions during July, August and September 2004. Parameters measured include dissolved oxygen, percent saturation, temperature, pH, total dissolved solids and conductivity. Early morning DO measurements (between 02:35 and 02:56am, n=3) ranged from 6.2 to 7.6 mg/L and the other limited physico-chemical monitoring data were indicative of excellent conditions. The maximum water temperature was 20.2℃. In 2004, MA DMF evaluted anadromous fish passage in the Merrimack River Basin. There is a relatively low head dam at the outlet of Clarks Pond that obstructs the passage of anadromous fish upstream. The *Aquatic Life Use* is assessed as support based on available water quality data. An Alert Status is identified for this use due to fish migration barriers.		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1212) during the primary contact season. The geometric mean of the five samples was 862 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. The elevated counts represent both dry and wet weather conditions although the highest counts represented wet weather sampling conditions. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9*		
Secondary Contact	**Impaired**	
In 2004, MassDEP DWM collected five E. coli samples at one site (W1212). The geometric mean of the five samples was 862 CFU/100ml. Based on this result violating the geometric mean criterion (630 CFU/100ml) for E. coli, the *Secondary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 2, 9*		
Aesthetics	**Support**	**Yes**
In 2004, MassDEP DWM recorded field observations regarding aesthetics at one site (W1212). There were no field observations indicating prolonged or frequent occurences of objectionable deposits, odors, turbidity or color, floating scum, or overabundant growths of aquatic plants or algae. The *Aesthetics Use* is assessed as support but an Alert Status is identified for this use due to consistent observations of moderate turbidity. *Data Sources: 9*		

Monitoring Recommendations
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.

POWWOW RIVER (SEGMENT MA84A-08)

Segment Description: Tidal portion, just downstream of Main Street, Amesbury to confluence with Merrimack River, Amesbury.
Segment Length: 0.1 Square Miles
Segment Classification: SB, Shellfishing
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Pathogens).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	**Yes**
In 2003, CDM collected five total phosphorus and chloropyll-a samples at one site (T011) (See Special Note 2). The total phosphorus concentrations at this sampling site ranged from 0.076 mg/L to 0.110 mg/L and the chlorophyll-a concentrations ranged from 3.8 ug/L to 29.9 ug/L. Insufficient quality assured data were available to assess the Aquatic Life use. An Alert Status is identified for this use due to elevated total phosphorus and chlorophyll-a concentrations. *Data Sources: 3*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Shellfishing	**Not Assessed**	
DMF does not classify shellfishing beds in this segment area so the Shellfishing Use is not assessed.		
Primary Contact	**Impaired**	
In 2003, CDM collected E. coli samples at one site (T011) (See Special Note 1). The geometric mean of the samples collected at this site during the primary contact season was 566 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the *Primary Contact Recreational Use* is assessed as impaired. **Cause(s) of Impairment:** Escherichia coli **Source(s) of Impairment:** Unspecified urban stormwater, Source Unknown *Data Sources: 3*		
Secondary Contact	**Support**	**Yes**
In 2003, CDM collected E. coli samples at one site (T011) (See Special Note 1). The geometric mean of the samples was 566 CFU/100ml. Based on this result meeting the geometric mean criterion (630 CFU/100ml) for E. coli., the *Secondary Contact Recreational Use* is assessed as support. An Alert Status is identified for this use due to occasional spikes in E. coli concentrations. *Data Sources: 3*		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources.		

MERRIMACK RIVER (SEGMENT MA84A-06)

Segment Description: Confluence Indian River, West Newbury/Amesbury to mouth at Atlantic Ocean, Newburyport/Salisbury (includes Back River, Salisbury).
Segment Length: 4.5 Square Miles
Segment Classification: SB, CSO, Shellfishing
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Priority organics, Pathogens).
NPDES Permits: Town of Amesbury (MA0101745), Ferraz Shawmut, Inc. (MA0000281), Newburyport Water Department (MAG640018), City of Newburyport (MA0101427), Salisbury Sewer Commission (MA0102873)

Designated Use	Use Assessment	Alert
Aquatic Life	**Support**	**Yes**
In 2003, CDM measured dissolved oxygen, temperature, and pH a total of 42 times and collected 26 total phosphorus and 15 chlorophyll-a (phytoplankton) samples at five sites (M26, M28, M29, M27, M30) (See Special Note 2). None of the dissolved oxygen and temperature measurements and only two of the pH measurements violated water quality standards. The total phosphorus concentrations ranged from 0.023 to 0.130 mg/L and the chlorophyll-a concentrations ranged from 1.1 to 35.2 ug/L. Water from the Merrimack River was collected from the shore at the Amesbury WPAF for use as dilution water in the facility's whole effluent toxicity tests. Between April 2002 and October 2008 (n=15) survival of M. bahia exposed to river water (48 hours) was > 80%. Between April 2002 and August 2003 survival of M. beryllina exposed (48 hours) to river water >90% (n=5). Water from the Merrimack River was collected at Deer Island in Amesbury, usually on an outgoing tide, for use as dilution water in the Salisbury WWTPs whole effluent toxicity tests. Between May 2001 and March 2009 survival of M. beryllina (48 hour to 7-day exposure) was >88% (n=32). Survival of M. bahia (48 hour exposure) was > 98% (n=4 test events). Water from the Merrimack River was collected off of the southern shoreline opposite Carr Island in Newburyport for use as dilution water in the Ferraz Shawmut, Inc. whole effluent toxicity tests. Between May 2001 and April 2005 (n=12) survival of M. bahia and M. beryllina exposed (48-hours) to the river water was > 88% in all tests conducted. Water from the Merrimack River was collected slightly east of the Route 1 bridge in Newburyport for use in the Newburyport WPCF acute whole effluent toxicity tests. Between June 2001 and May 2009 (n=34 test events) survival of M. bahia was > 90% with the exception of the May 2006 test event (survival =40%) and survival of M. beryllina was > 75% with the exception of the May 2003 test event (survival =65%). The *Aquatic Life Use* is assessed as support based primarily on the good survival of test organisms exposed to river water samples in this segment of the river. An Alert Status is identified for this use due to occasionally elevated chlorophyll-a concentrations. *Data Sources: 3, 7*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Shellfishing	**Impaired**	
A large portion of this segment (east of Route 95 bridge) was part of the MA DMF's Designated Shellfish Growing Area referred to as Merrimack River N2.0 which was classified as Prohibited prior to 2006. This area has recently been further partitioned by DMF into smaller areas. The large area N2.0 is still classified as Prohibited. This segment also contains portions of Growing Areas N2.1 and N2.3 both of which are classified as Conditionally Restricted). **Cause(s) of Impairment:** Fecal Coliform **Source(s) of Impairment:** Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Source Unknown *Data Sources: 11*		

Primary Contact	Impaired	
In 2008, MRWA collected Enterococcus samples at six sites (9.4, 8.3, 6.8, 4.4, 3.8, 2.7). The geometric means of the samples collected during the primary contact season at each site ranged from 16.9 CFU/100ml to 42.1 CFU/100ml. In 2003, CDM collected Enterococcus and E. coli samples at five sites (M26, M28, M29, M27, M30) (See Special Note 1). Only one CDM site (M27) had the minimum number of samples (5) required to determine compliance with the Enterococcus geometric mean criterion (35 colonies/100ml) and the geometric mean at this site was 43 CFU/100ml. Three of the other four sampling sites also had more than one Enterococcus bacteria count greater than 104 CFU/100ml. Bacteria was elevated during both dry and wet weather conditions and the highest counts almost always represented wet weather sampling. Plum Island Beach in Newburyport lines the shoreline along the southeastern edge of this segment. Between 2002 and 2007 the beach was only closed in the 2006 season for a total of eight days (8% of the season) and was not closed at all during any other year. The *Primary Contact Recreational Use* is assessed as impaired based on elevated Enterococci bacteria. **Cause(s) of Impairment:** Enterococcus **Source(s) of Impairment:** Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Source Unknown *Data Sources: 3, 12, 25*		
Secondary Contact	**Support**	
In 2008, MRWA collected Enterococcus samples at six sites (9.4, 8.3, 6.8, 4.4, 3.8, 2.7). The geometric means of the samples collected at each site ranged from 16.9 CFU/100ml to 42.1 CFU/100ml. In 2003, CDM collected Enterococcus and E. coli samples at five sites (M26, M28, M29, M27, M30) (See Special Note 1). Only one site (M27) had the minimum number of samples (5) required to determine compliance with the Enterococcus geometric mean criterion for secondary contact recreation (175 CFU/100ml). The geometric mean of the samples collected at M27 was 43 CFU/100ml. Based these results meeting the criterion for Enterococcus and the absence of aesthetically objectionable conditions, the *Secondary Contact Recreational Use* is assessed as support. *Data Sources: 3, 25*		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

MERRIMACK RIVER (SEGMENT MA84A-26)

Segment Description: The Basin in the Merrimack River Estuary, Newbury/Newburyport.
Segment Length: 0.2 Square Miles
Segment Classification: SA, Shellfishing
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Pathogens).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		

Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Shellfishing	**Impaired**	
This segment was formerly part of the MA DMF's Designated Shellfish Growing Area referred to as Merrimack River N2.0 which was classified as Prohibited prior to 2006. Growing Area N2.0 has recently been further partitioned by DMF into smaller areas. This segment now contains portions of Growing Areas N2.1 and N2.4 which are both classified by DMF as Conditionally Restricted. **Cause(s) of Impairment:** Fecal Coliform **Source(s) of Impairment:** On-site Treatment Systems (Septic Systems and Similar Decencentralized Systems), Source Unknown *Data Sources: 11*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the Primary Contact.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the Secondary Contact.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct bacteria monitoring to evaluate/document improvements in water quality conditions as a result of improvements a the Newburyport WPCF and the sewering of Plum Island.		

PLUM ISLAND RIVER (SEGMENT MA84A-27)

Segment Description: From Chaces Island, Merimack River Estuary, to the "high sandy" sand bar just north of the confluence with Pine Island Creek, Newbury (formerly encompassed in MA84A-23).
Segment Length: 0.1 Square Miles
Segment Classification: SA
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Pathogens).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		

Shellfishing	Impaired	
This segment was formerly part of the MA DMF's Designated Shellfish Growing Area referred to as Merrimack River N2.0 which was classified as Prohibited prior to 2006. Growing Area N2.0 has recently been further partitioned by DMF into smaller areas. This segment now contains portions of Growing Areas N2.3 and N2.4 which are both classified by DMF as Conditionally Restricted. **Cause(s) of Impairment:** Fecal Coliform **Source(s) of Impairment:** Source Unknown *Data Sources: 11*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct bacteria monitoring to evaluate/document improvements in water quality conditions as a result of improvements a the Newburyport WPCF and the sewering of Plum Island.		

LOWELL CANALS (SEGMENT MA84A-29)

Segment Description: Canal system near Pawtucket Falls, Lowell.
Segment Length: 4.9 Miles
Segment Classification: B\TWS
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Pesticides, Priority organics, Metals).
NPDES Permits: Boott Hydropower, Inc. (MAG250949), Lowell Cogeneration Company (MA0031071), Lowell National Historical Park (MAG250732)

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
Fish toxics monitoring was conducted by MassDEP DWM biologists and/or Menzie-Cura Inc. in the Lowell Canal system in June 2004. MA DPH has issued a fish consumption advisory due to mercury, lead, PCBs, and DDT contamination for Lowell Canals. Children younger than 12 years or age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any fish from this water body. The general public should not consume any of the affected fish species (American Eel) from this water body. The general public should limit consumption of non-affected fish from this water body to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue, PCB in Fish Tissue, DDT, Lead **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10, 21*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		

Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

LAKE ATTITASH (SEGMENT MA84002)

Segment Description: Amesbury/Merrimac
Segment Area: 369 Acres
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: Merrimack Water Department (MAG640030)

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Lake Attitash. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any fish from this water body. The general public should not consume Largemouth Bass from this water body. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct monitoring to confirm the presence of non-native aquatic plants.		

CHADWICKS POND (SEGMENT MA84006)

Segment Description: Haverhill/Boxford
Segment Area: 173 Acres
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Chadwicks Pond. The general public should not consume any fish from this water body. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

LAKE COCHICHEWICK (SEGMENT MA84008)

Segment Description: North Andover
Segment Area: 575 Acres
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Lake Cochichewick. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any Largemouth Bass fish from this water body. The general public should limit consumption of Largemouth Bass fish to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		

Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

CRYSTAL LAKE (SEGMENT MA84010)

Segment Description: Haverhill
Segment Area: 161 Acres
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Crystal Lake. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any fish from this water body. The general public should not consume Largemouth Bass from this water body. The general public should limit consumption of non-affected fish from this waterbody to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

FLINT POND (SEGMENT MA84012)

Segment Description: Tyngsborough
Segment Area: 72 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals [12/20/2007NEHgTMDL], Noxious aquatic plants, (Exotic species*)).
* denotes a non-pollutant.
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
Two non-native aquatic plant species (*Myriophyllum heterophyllum, Najas minor*) were documented in Flint Pond. The *Aquatic Life Use* is assessed as impaired based on the presence of non-native aquatic plants. **Cause(s) of Impairment:** Non-Native Aquatic Plants **Source(s) of Impairment:** Introduction of Non-Native Organisms *Data Sources: 13*		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Flint Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any fish from this water body. The general public should not consume Largemouth Bass from this water body. The general public should limit consumption of non-affected fish from this waterbody to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

FOREST LAKE (SEGMENT MA84014)

Segment Description: Methuen
Segment Area: 48 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals, Noxious aquatic plants).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		

Fish Consumption	Impaired	
MA DPH has issued a fish consumption advisory due to mercury contamination for Forest Lake. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any Largemouth Bass fish from this water body. The general public should limit consumption of Largemouth Bass fish to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

FORGE POND (SEGMENT MA84015)

Segment Description: Westford/Littleton
Segment Area: 203 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 4a-TMDL is Completed (Metals [12/20/2007NEHgTMDL]).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
Non-native aquatic plant species (recent documentation of *Trapa natans*, and historical observations of *Cabomba caroliniana, Potamogeton crispus*) infest Forge Pond. The *Aquatic Life Use* is assessed as impaired based on the presence of non-native aquatic plants. **Cause(s) of Impairment:** Non-Native Aquatic Plants **Source(s) of Impairment:** Introduction of Non-Native Organisms *Data Sources: 13, 18*		
Fish Consumption	**Impaired**	
MassDEP DWM biologists collected fish from the pond in May 2004 and composite samples of edible fillets were analyzed for As, Cd, Hg, Pb, Se, PCBs and organochlorine pesticides. MA DPH has issued a fish consumption advisory due to mercury contamination for Forge Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any Largemouth Bass fish from this water body. The general public should limit consumption of Largemouth Bass fish to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10, 21*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		

Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct monitoring to confirm the presence of non-native aquatic plants.		

HAGGETTS POND (SEGMENT MA84022)

Segment Description: Andover
Segment Area: 211 Acres
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: Town of Andover (MAG640058)

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Haggetts Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any fish from this water body. The general public should not consume any of the affected fish species (Largemouth Bass) from this water body. The general public should limit consumption of non-affected fish from this water body to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

HOVEYS POND (SEGMENT MA84025)

Segment Description: Boxford
Segment Area: 36 Acres
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Hoveys Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any fish from this water body. The general public should limit consumption of all fish from this water body to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

JOHNSONS POND (SEGMENT MA84027)

Segment Description: Groveland/Boxford
Segment Area: 194 Acres
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals, Organic enrichment/Low DO).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		

Fish Consumption	Impaired	
MA DPH has issued a fish consumption advisory due to mercury contamination for Johnsons Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat Largemouth Bass fish from this water body. The general public should limit consumption of Largemouth Bass fish to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

KENOZA LAKE (SEGMENT MA84028)

Segment Description: Haverhill
Segment Area: 240 Acres
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Kenoza Lake. The general public should not consume any fish from this water body. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		

None

KNOPS POND/LOST LAKE (SEGMENT MA84084)

Segment Description: Groton
Segment Area: 187 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 4c - Impairment Not Caused by a Pollutant (Metals [12/20/2007NEHgTMDL], (Exotic species*)). * denotes a non-pollutant.
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
Four non-native aquatic plant species (*Trapa natans, Myriophyllum spicatum, Cabomba caroliniana, Potamogeton crispus*) have been reported in Knops Pond/Lost Lake. The *Aquatic Life Use* is assessed as impaired based on the presence of non-native aquatic plants. **Cause(s) of Impairment:** Non-Native Aquatic Plants, Eurasian Water Milfoil (*Myriophyllum spicatum*) **Source(s) of Impairment:** Introduction of Non-Native Organisms *Data Sources: 13, 14, 18*		
Fish Consumption	**Impaired**	
MassDEP DWM biologists collected fish from the pond in May 2004 and composite samples of edible fillets were analyzed for As, Cd, Hg, Pb, Se, PCBs and organochlorine pesticides. MA DPH has issued a fish consumption advisory due to mercury contamination for Knops Pond/Lost Lake. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any Largemouth Bass fish from this water body. The general public should limit consumption of Largemouth Bass fish to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10, 21*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct monitoring to confirm the presence of non-native aquatic plants.		

LONG POND (SEGMENT MA84032)

Segment Description: Dracut/Tyngsborough (size indicates portion in Massachusetts)
Segment Area: 137 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals [12/20/2007NEHgTMDL], Noxious aquatic plants).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
One non-native aquatic macrophyte (*Potamogeton crispus*) has been documented in Long Pond. The *Aquatic Life Use* is assessed as impaired based on the presence of non-native aquatic plants. **Cause(s) of Impairment:** Non-Native Aquatic Plants **Source(s) of Impairment:** Introduction of Non-Native Organisms *Data Sources: 13, 14*		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Long Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any fish from this water body. The general public should limit consumption of all fish from this water body to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct monitoring to confirm the presence of non-native aquatic plants.		

LAKE MASCUPPIC (SEGMENT MA84037)

Segment Description: Tyngsborough/Dracut
Segment Area: 210 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 3 - No Uses Assessed
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
Two non-native aquatic macrophytes (*Potamogeton crispus and Cabomba caroliniana*) have been documented in Lake Mascuppic. The *Aquatic Life Use* is assessed as impaired based on the presence of non-native aquatic plants. **Cause(s) of Impairment:** Non-Native Aquatic Plants **Source(s) of Impairment:** Introduction of Non-Native Organisms *Data Sources: 13, 14*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct monitoring to confirm the presence of non-native aquatic plants.		

MASSAPOAG POND (SEGMENT MA84087)

Segment Description: Dunstable/Groton/Tyngsborough
Segment Area: 111 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals [12/20/2007NEHgTMDL], Organic enrichment/Low DO, Noxious aquatic plants, (Exotic species*)). * denotes a non-pollutant.
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
Two non-native aquatic plant species (*Myriophyllum heterophyllum, Potamogeton crispus*) have been observed in Massapoag Pond. In 2003, MassDEP measured dissolved oxygen, temperature, and pH profiles on one occassion near the maximum lake depth (11.2 meters). Oxygen depletion occured at depths of approximately 3.5 m (approximately 25% of the lake surface area). The *Aquatic Life Use* is assessed as impaired based on the presence of non-native aquatic plants and low dissolved oxygen. **Cause(s) of Impairment:** Non-Native Aquatic Plants, Oxygen, Dissolved (Low) **Source(s) of Impairment:** Introduction of Non-Native Organisms, Source Unknown *Data Sources: 13, 22*		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Massapoag Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any fish from this water body. The general public should limit consumption of all fish from this water body to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct monitoring to confirm the presence of non-native aquatic plants.		

MILLVALE RESERVOIR (SEGMENT MA84041)

Segment Description: Haverhill
Segment Area: 44 Acres
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Millvale Reservoir. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any fish from this water body. The general public should not consume Largemouth Bass from this water body. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

NEWFIELD POND (SEGMENT MA84046)

Segment Description: Chelmsford
Segment Area: 77 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals [12/20/2007NEHgTMDL], Organic enrichment/Low DO, Noxious aquatic plants, (Exotic species*)). * denotes a non-pollutant.
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
Three non-native aquatic plant species (*Cabomba caroliniana, Potamogeton crispus, Myriophyllum spicatum*) have been observed in Newfield Pond. In 2003, MassDEP measured dissolved oxygen, temperature, and pH (depth profile) on one occassion at the deep hole (5.0 meters). Oxygen depletion occured at depths greater than 4m representing approximately 10% of the area of the waterbody. The *Aquatic Life Use* is assessed as impaired based on the presence of non-native aquatic plants and low dissolved oxygen. **Cause(s) of Impairment:** Non-Native Aquatic Plants, Oxygen, Dissolved (Low) **Source(s) of Impairment:** Introduction of Non-Native Organisms, Source Unknown *Data Sources: 13, 22*		
Fish Consumption	**Impaired**	
Fish toxics monitoring in Newfield Pond was conducted in 1999 as part of the DEP ORS mercury study. MA DPH has issued a fish consumption advisory due to mercury contamination for Newfield Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat Largemouth Bass fish from this water body. The general public should limit consumption of Largemouth Bass fish to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10, 13*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
While no aesthetically objectionable conditions were noted during the DWM survey of the pond in August 2003, insufficient data were available to assess the *Aesthetics Use*. *Data Sources: 9*		
Monitoring Recommendations		
Conduct monitoring to confirm the presence of non-native aquatic plants.		

LAKE PENTUCKET (SEGMENT MA84051)

Segment Description: Haverhill
Segment Area: 38 Acres
Segment Classification: A\PWS\ORW
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Lake Pentucket. The general public should not consume any fish from this water body. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

LAKE SALTONSTALL (SEGMENT MA84059)

Segment Description: Haverhill
Segment Area: 44 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Lake Saltonstall. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any Largemouth Bass fish from this water body. The general public should limit consumption of Largemouth Bass fish to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		

Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

SPECTACLE POND (SEGMENT MA84089)

Segment Description: Littleton/Ayer
Segment Area: 79 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Organic enrichment/Low DO, Noxious aquatic plants, (Exotic species*)). * denotes a non-pollutant.
NPDES Permits: Littleton Water Department (MAG640002)

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
Three non-native aquatic plant species (*Cabomba caroliniana, Potamogeton crispus, Myriophyllum heterophyllum*) were documented in Spectacle Pond. The *Aquatic Life Use* is assessed as impaired based on the presence of non-native aquatic plants. **Cause(s) of Impairment:** Non-Native Aquatic Plants **Source(s) of Impairment:** Introduction of Non-Native Organisms *Data Sources: 13, 14*		
Fish Consumption	**Not Assessed**	
This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 4).		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct monitoring to confirm the presence of non-native aquatic plants.		

STEVENS POND (SEGMENT MA84064)

Segment Description: North Andover
Segment Area: 23 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 5 - Waters Requiring a TMDL (Metals).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Stevens Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any Largemouth Bass fish from this water body. The general public should limit consumption of Largemouth Bass fish to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

NABNASSET POND (SEGMENT MA84044)

Segment Description: Westford
Segment Area: 134 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 4a-TMDL is Completed (Metals [12/20/2007NEHgTMDL]).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Impaired**	
Two non-native aquatic plant species (*Myriophyllum heterophyllum, Potamogeton crispus*) in Nabnasset Pond were documented by ACT as part of herbicide treatment applications. The *Aquatic Life Use* is assessed as impaired based on the presence of non-native aquatic plants. **Cause(s) of Impairment:** Non-Native Aquatic Plants **Source(s) of Impairment:** Introduction of Non-Native Organisms *Data Sources: 14, 18*		

Fish Consumption	Impaired	
MassDEP DWM biologists collected fish from the pond in May 2004 and composite samples of edible fillets were analyzed for As, Cd, Hg, Pb, Se, PCBs and organochlorine pesticides. MA DPH reviewed the data and issued a fish consumption advisory due to mercury contamination for Nebnasset Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any Largemouth Bass fish from this water body. The general public should limit consumption of Largemouth Bass fish to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10, 21*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		
Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
Conduct monitoring to confirm the presence of non-native aquatic plants.		

LOCUST POND (SEGMENT MA84031)

Segment Description: Tyngsborough
Segment Area: 16 Acres
Segment Classification: B
2008 Integrated List of Waters: This segment is on the 2008 Integrated List of Waters in Category 4a-TMDL is Completed (Metals [12/20/2007NEHgTMDL]).
NPDES Permits: None

Designated Use	Use Assessment	Alert
Aquatic Life	**Not Assessed**	
Insufficient data were available to assess the *Aquatic Life Use*.		
Fish Consumption	**Impaired**	
MA DPH has issued a fish consumption advisory due to mercury contamination for Locust Pond. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any fish from this water body. The general public should limit consumption of all fish from this water body to two meals per month. **Cause(s) of Impairment:** Mercury in Fish Tissue **Source(s) of Impairment:** Atmospheric Deposition - Toxics, Source Unknown *Data Sources: 10*		
Primary Contact	**Not Assessed**	
Insufficient data were available to assess the *Primary Contact Recreational Use*.		
Secondary Contact	**Not Assessed**	
Insufficient data were available to assess the *Secondary Contact Recreational Use*.		

Aesthetics	**Not Assessed**	
Insufficient data were available to assess the *Aesthetics Use*.		
Monitoring Recommendations		
None		

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APPENDIX A - ASSESSMENT METHODOLOGY
GUIDELINES FOR EVALUATING DESIGNATED USE STATUS OF MASSACHUSETTS SURFACE WATERS - 2009

WATER QUALITY CLASSIFICATION

The Massachusetts Surface Water Quality Standards (SWQS) designate the most sensitive uses for which the surface waters of the Commonwealth shall be enhanced, maintained and protected; prescribe minimum water quality criteria required to sustain the designated uses; and include provisions for the prohibition of discharges (MassDEP 2006). These regulations should undergo public review every three years. The surface waters are segmented and each segment is assigned to one of the six classes described below. Each class is identified by the most sensitive and, therefore, governing water uses to be achieved and protected. Surface waters may be suitable for other beneficial uses, but shall be regulated by the Department of Environmental Protection to protect and enhance the designated uses.

Inland Water Classes

- *CLASS A* - These waters include waters designated as a source of public water supply and their tributaries. They are designated as excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation, even if not allowed. These waters shall have excellent aesthetic value. These waters are protected as Outstanding Resource Waters.
- *CLASS B* - These waters are designated as a habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. Where designated in 314 CMR 4.06, they shall be suitable as a source of public water supply with appropriate treatment ("Treated Water Supply"). Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.
- *CLASS C* - These waters are designated as a habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for secondary contact recreation. These waters shall be suitable for the irrigation of crops used for consumption after cooking and for compatible industrial cooling and process uses. These waters shall have good aesthetic value.

Coastal And Marine Classes

- *CLASS SA* - These waters are designated as an excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. In certain waters, excellent habitat for fish, other aquatic life and wildlife may include, but is not limited to, sea grass. Where designated in the tables to 314 CMR 4.00 for shellfishing, these waters shall be suitable for shellfish harvesting without depuration (Approved and Conditionally Approved Shellfish Areas). These waters shall have excellent aesthetic value.
- *CLASS SB* - These waters are designated as a habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. In certain waters, habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass. Where designated in the tables to 314 CMR 4.00 for shellfishing, these waters shall be suitable for shellfish harvesting with depuration (Restricted and Conditionally Restricted Shellfish Areas). These waters shall have consistently good aesthetic value.
- *CLASS SC* - These waters are designated as a habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for secondary contact recreation. They shall also be suitable for certain industrial cooling and process uses. These waters shall have good aesthetic value.

The Clean Water Act (CWA), Section 305(b), water quality reporting process is an essential aspect of the Nation's water pollution control effort. It is the principal means by which EPA, Congress, and the public evaluate existing water quality, assess progress made in maintaining and restoring water quality, and determine the extent of remaining problems. By this process, states report on waterbodies within the context of meeting their designated uses. These uses include: *Aquatic Life, Fish Consumption, Drinking Water, Primary Contact Recreation, Secondary Contact Recreation, Shellfish Harvesting* and *Aesthetics*. Two subclasses of Aquatic Life are also designated in the Massachusetts Surface Water Quality Standards (SWQS): Cold Water Fishery – waters capable of sustaining a year-round population of cold water aquatic life, such as trout – and Warm Water Fishery – waters that are not capable of sustaining a year-round population of cold water aquatic life (MassDEP 2006).

The SWQS, summarized in Table A1, prescribe minimum water quality criteria to sustain the designated uses. Furthermore, these standards describe the hydrological conditions at which water quality criteria must be applied (MassDEP 2006). In rivers the lowest flow conditions at and above which aquatic life criteria must be applied are the lowest mean flow for seven consecutive days to be expected once in ten years (7Q10). In waters where flows are regulated by dams or similar structures the lowest flow conditions at which aquatic life criteria must be applied are the flows equal to or exceeded 99% of the time on a yearly basis or another equivalent flow that has been agreed upon (see Mass DEP 2006 for more detail). In coastal and marine waters and for lakes the Massachusetts Department of Environmental Protection (MassDEP) will determine on a case-by-case basis the most severe hydrological condition for which the aquatic life criteria must be applied.

The availability of appropriate and reliable scientific data and technical information is fundamental to the 305(b) reporting process. It is EPA policy (EPA Order 5360.1 CHG 1) that any individual or group performing work for or on behalf of EPA establish a quality system to support the development, review, approval, implementation, and assessment of data collection operations. To this end MassDEP describes its Quality System in an EPA-approved Quality Management Plan to ensure that environmental data collected or compiled by the MassDEP are of known and documented quality and are suitable for their intended use. For external sources of information, MassDEP requires the following: 1) an appropriate Quality Assurance Project Plan (QAPP) including a laboratory Quality Assurance /Quality Control (QA/QC) plan; 2) use of a state certified lab (or as otherwise approved by DEP for a particular analysis); and 3) sample data, QA/QC and other pertinent sample handling information documented in a citable report. This information will be reviewed by MassDEP to determine its validity and usability to assess water use support. Data use could be modified or rejected due to poor or undocumented QAPP implementation, lack of project documentation, incomplete reporting of data or information, and/or project monitoring objectives unsuitable for MassDEP assessment purposes.

EPA provides guidelines to states for making their use support determinations (EPA 1997 and 2002, Grubbs and Wayland III 2000 and Wayland III 2001). The determination of whether or not a waterbody supports each of its designated uses is a function of the type(s), quality and quantity of available current information. Although data/information older than five years are usually considered "historical" and used for descriptive purposes they can be utilized in the use support determination provided they are known to reflect the current conditions. While the water quality standards (Table A1) prescribe minimum water quality criteria to sustain the designated uses, numerical criteria are not available for every indicator of pollution. Best available guidance from available literature may be applied in lieu of actual numerical criteria (e.g., freshwater sediment data may be compared to *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario* 1993 by D. Persaud, R. Jaagumagi and A. Hayton). Excursions from criteria due solely to "naturally occurring" conditions (e.g., low pH in some areas) do not constitute violations of the SWQS.

Each designated use within a given segment is individually assessed as ***support*** or ***impaired***. When too little current data/information exist or no reliable data are available, the use is ***not assessed***. In this report, however, if there is some indication that water quality impairment may exist, and it is not "naturally occurring", the use is identified with an "Alert Status". It is important to note that not all waters are assessed. Some ponds, rivers, and estuaries have never been assessed; the status of their designated uses has never been reported to EPA in the Commonwealth's 305(b) Report or the Integrated List of Waters nor is information on these waters maintained in the waterbody system database (WBS) or the new assessment database (ADB). These waterbodies are considered ***not assessed other waters.***

Table A1. Summary of Massachusetts Surface Water Quality Standards (MassDEP 2006, MA DPH 2002, FDA 2003).

Dissolved Oxygen	Class A and Class B Cold Water Fishery (BCWF) and Class SA: ≥6.0 mg/L Class A and Class B Warm Water Fishery (BWWF) and Class SB: ≥5.0 mg/L Class C: Not <5.0 mg/L at least 16 hours of any 24-hour period and not <3.0 mg/L at any time. Class SC: Not <5.0 mg/L at least 16 hours of any 24-hour period and not <4.0 mg/L anytime. For all classes, where natural background conditions are lower than the criteria stated for each class, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall also be maintained.
Temperature	Class A CWF: ≤68℉ (20℃) based on the mean of the daily maximum temperature over a seven day period in cold water fisheries, unless naturally occurring and ΔT due to a discharge ≤1.5℉ (0.8℃). Class A WWF: ≤83℉ (28.3℃) and ΔT due to a discharge ≤1.5℉ (0.8℃). Class BCWF: ≤68℉ (20℃) based on the mean of the daily maximum temperature over a seven day period in all cold water fisheries, unless naturally occurring, and ΔT due to a discharge ≤Δ3℉ (1.7℃)

Table A1. Summary of Massachusetts Surface Water Quality Standards (MassDEP 2006, MA DPH 2002, FDA 2003).

	Class BWWF: ≤83℉ (28.3℃) and ΔT due to a discharge ≤5℉ (2.8℃) in rivers (based on the minimum expected flow for the month) and ΔT due to a discharge ≤3℉ (1.7℃) in the epilimnion (based on the monthly average of maximum daily temperatures) in lakes, Class C and Class SC: ≤85℉ (29.4℃) and ΔT due to a discharge ≤5℉ (2.8℃) Class SA: ≤85℉ (29.4℃) nor a maximum daily mean of 80℉ (26. 7℃) and ΔT due to a discharge ≤1.5℉ (0.8℃) Class SB: ≤85℉ (29.4℃) nor a maximum daily mean of 80℉ (26. 7℃) and Δ T due to a discharge ≤1.5℉ (0.8℃) between July and September and ≤4.0℉ (2.2℃) between October and June. *For all classes, natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. There shall be no changes from natural background conditions that would impair any uses assigned to each class, including those conditions necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.* For CWF waters, where a reproducing cold water aquatic community exists at a naturally higher temperature, the temperature necessary to protect the community shall not be exceeded and natural daily and seasonal temperature fluctuations necessary to protect the community shall be maintained. Class B, C, SA, SB, and SC: See MassDEP 2006 for language specific to alternative effluent limitations relating to thermal discharges and cooling water intake structures.
pH	Class A, Class BCWF and Class BWWF: 6.5 - 8.3 SU and Δ0.5 outside the natural background range. Class C: 6.5 - 9.0 SU and Δ1.0 outside the natural background range. Class SA and Class SB: 6.5 - 8.5 SU and Δ0.2 SU outside the natural background range. Class SC: 6.5 - 9.0 SU and Δ0.5 SU outside the natural background range. There shall be no change from natural background conditions that would impair any use assigned to each class.
Solids	All Classes: *These waters shall be free from floating, suspended, and settleable solids in concentrations or combinations that would impair any use assigned to each class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.*
Color and Turbidity	All Classes: *These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use.*
Oil and Grease	Class A and Class SA: *Waters shall be free from oil and grease, petrochemicals and other volatile or synthetic organic pollutants.* Class SA: *Waters shall be free from oil and grease and petrochemicals.* Class B, Class C, Class SB and Class SC: *Waters shall be free from oil, grease, and petrochemicals that produce a visible film on the surface of the water, impart an oily taste to the water or an oily or other undesirable taste to the edible portions of aquatic life, coat the banks or bottom of the water course, or are deleterious or become toxic to aquatic life.*
Taste and Odor	Class A and Class SA: *None other than of natural origin.* Class B, Class C, Class SB and Class SC: *None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to each class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life.*
Aesthetics	All Classes: *All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.*
Toxic Pollutants	All Classes: *All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife. For pollutants not otherwise listed in 314 CMR 4.00, the National Recommended Water Quality Criteria: 2002, EPA 822-R-02-047, November 2002 published by EPA pursuant to Section 304(a) of the Federal Water Pollution Control Act, are the allowable receiving water concentrations for the affected waters, unless the Department either establishes a site specific criterion or determines that naturally occurring background concentrations are higher. The Department shall use the water quality criteria for the protection of aquatic life expressed in terms of the dissolved fraction of metals when EPA's 304(a) recommended criteria provide for use of the dissolved fraction* (see Mass DEP 2006 for more detail regarding permit limits, conversion factors, site specific criteria).
Nutrients	*Unless naturally occurring, all surface waters shall be free from nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed the site specific criteria developed in a TMDL or as otherwise established by the Department pursuant to these Standards.*
Bacteria (MassDEP 2006	Class A: *At water supply intakes in unfiltered public water supplies:* either fecal coliform shall not exceed 20

Table A1. Summary of Massachusetts Surface Water Quality Standards (MassDEP 2006, MA DPH 2002, FDA 2003).

and MA DPH 2002) Class A criteria apply to the *Drinking Water Use*. Class B and SB criteria apply to *Primary Contact Recreation Use* while Class C and SC criteria apply to *Secondary Contact Recreation Use*.	organisms/100 ml in all samples taken in any six month period, or total coliform shall not exceed 100 organisms/ 100 ml in 90% of the samples taken in any six month period. If both total and fecal coliform are measured, then only the fecal coliform criterion must be met. Class A other waters, Class B: Where *E.* coli is the chosen indicator at public bathing beaches as defined by MA DPH: The geometric mean of the five most recent *E. coli* samples taken within during the same bathing season shall not exceed 126 colonies/ 100 ml and no single sample taken during the bathing season shall exceed 235 colonies/ 100 ml (these criteria may be applied on a seasonal basis at the Department's discretion). Where Enterococci are the chosen indicators at public bathing beaches*:* The geometric mean of the five most recent samples taken during the same bathing season shall not exceed 33 colonies /100 ml and no single *Enterococci* sample taken during the bathing season shall exceed 61 colonies /100 ml. For other waters and, during the non bathing season, for waters at public bathing beaches: The geometric mean of all *E. coli* samples taken within the most recent six months shall not exceed 126 colonies/ 100 ml typically based on a minimum of five samples and no single sample shall exceed 235 colonies/ 100 ml. These criteria may be applied on a seasonal basis at the Department's discretion. The geometric mean of all *Enterococci* samples taken within the most recent six months shall not exceed 33 colonies/ 100 ml typically based on a minimum of five samples and no single sample shall exceed 61 colonies/ 100 ml. These criteria may be applied on a seasonal basis at the Department's discretion. Class C: *The geometric mean of all E. coli samples taken within the most recent six months shall not exceed 630 E. coli/ 100 ml, typically based on a minimum of five samples and 10% of such samples shall not exceed 1260 E. coli/ 100 ml.* This criterion may be applied on a seasonal basis at the discretion of the Department. Class SA: Waters designated for shellfishing: *Fecal coliform bacteria shall not exceed a geometric mean (Most Probable Number (MPN) method) of 14 organisms/100 ml, nor shall more than 10% of the samples exceed an MPN of 28 organisms/100 ml, or other values of equivalent protection based on sampling and analytical methods used by the Massachusetts Division of Marine Fisheries and approved by the National Shellfish Sanitation Program in the latest revision of the Guide for the Control of Molluscan Shellfish Areas (more stringent regulations may apply, see 314 CMR 4.06(1)(d)(5)).* Class SB: Waters designated for shellfishing: *Fecal coliform median or geometric mean MPN shall not exceed 88 organisms/100 ml, nor shall more than 10% of the samples exceed an MPN of 260 organisms/100 ml or other values of equivalent protection based on sampling and analytical methods used by the Massachusetts Division of Marine Fisheries and approved by the National Shellfish Sanitation Program in the latest revision of the Guide for the Control of Molluscan Shellfish Areas (more stringent regulations may apply, see 314 CMR 4.06(1)(d)(5)).* Class SA and Class SB: At public bathing beaches, as defined by MA DPH: No single *Enterococci* sample taken during the bathing season shall exceed 104 colonies /100 ml and the geometric mean of the five most recent *Enterococci* samples taken within the same bathing season shall not exceed 35 colonies /100 ml. At public bathing beaches during the non-bathing season and in non bathing beach waters: No single *Enterococci* sample shall exceed 104 colonies/ 100 ml and the geometric mean of all samples taken within the most recent six months, typically a minimum of five samples, shall not exceed 35 colonies/ 100 ml. These criteria may be applied on a seasonal basis at the discretion of the Department). Class SC: *The geometric mean of all Enterococci samples taken within the most recent six months shall not exceed 175 colonies/ 100 ml, typically based on the five most recent samples, and 10% of such samples shall not exceed 350 colonies/ 100 ml. This criterion may be applied on a seasonal basis at the discretion of the Department.*

Note: *Italics are direct quotations.* Δ criterion (referring to a change from natural background conditions) is applied to the effects of a permitted discharge.

DESIGNATED USES

The Massachusetts Surface Water Quality Standards designate the most sensitive uses for which the surface waters of the Commonwealth shall be enhanced, maintained and protected. Each of these uses is briefly described below (MassDEP 2006):

- *AQUATIC LIFE* - suitable habitat for sustaining a native, naturally diverse, community of aquatic flora and fauna, including, but not limited to, wildlife and threatened and endangered species and for their reproduction, migration, growth and other critical functions. Two subclasses of aquatic life are also designated in the standards for freshwater bodies: *Cold Water Fishery* - capable of sustaining a year-round population of cold water aquatic life, such as trout; *Warm Water Fishery* - waters that are not capable of sustaining a year-round population of cold water aquatic life. In certain waters, excellent habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass.
- *FISH CONSUMPTION* - pollutants shall not result in unacceptable concentrations in edible portions of marketable fish or for the recreational use of fish, other aquatic life or wildlife for human consumption.
- *DRINKING WATER* - used to denote those waters used as a source of public drinking water. They may be subject to more stringent regulation in accordance with the Massachusetts Drinking Water Regulations (310 CMR 22.00). These waters are designated for protection as Outstanding Resource Waters under 314 CMR 4.04(3).
- *SHELLFISH HARVESTING* (in SA and SB segments) – Class SA waters where designated shall be suitable for shellfish harvesting without depuration (Approved and Conditionally Approved Shellfish Areas); Class SB waters where designated shall be suitable for shellfish harvesting with depuration (Restricted and Conditionally Restricted Shellfish Areas).
- *PRIMARY CONTACT RECREATION* - suitable for any recreation or other water use in which there is prolonged and intimate contact with the water with a significant risk of ingestion of water. These include, but are not limited to, wading, swimming, diving, surfing and water skiing.
- *SECONDARY CONTACT RECREATION* - suitable for any recreation or other water use in which contact with the water is either incidental or accidental. These include, but are not limited to, fishing, including human consumption of fish, boating and limited contact incident to shoreline activities. Where designated, secondary contact recreation also includes shellfishing, including human consumption of shellfish. Human consumption of fish and shellfish are assessed as the *Fish Consumption* and *Shellfish Harvesting* uses, respectively.
- *AESTHETICS* - all surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.
- *AGRICULTURAL AND INDUSTRIAL* - suitable for irrigation or other agricultural process water and for compatible industrial cooling and process water.

The guidance used to assess the *Aquatic Life, Fish Consumption, Drinking Water, Shellfish Harvesting, Primary* and *Secondary Contact Recreation* and *Aesthetics* uses follows.

Note: Waterbodies affected by Combined Sewer Overflow (CSO) discharges are qualified in the standards, however, unless a variance has been granted and states otherwise, excursions from criteria are not allowed during storm events (designated uses are still applicable).

AQUATIC LIFE USE

This use is suitable for sustaining a native, naturally diverse, community of aquatic flora and fauna, including, but not limited to, wildlife and threatened and endangered species and for their reproduction, migration, growth and other critical functions. The results of biological (and habitat), toxicological, and chemical data are integrated to assess this use. The nature, frequency, and precision of the MassDEP's data collection techniques dictate that a weight of evidence be used to make the assessment, with biosurvey results used as the final arbiter of borderline cases. The following chart provides an overview of the guidance used to assess the status (support or impaired) of the *Aquatic Life Use.*

Variable	***Support*** Data available clearly indicates support or minor modification of the biological community. Excursions from chemical criteria (Table A1) not frequent or prolonged and may be tolerated if the biosurvey results demonstrate support.	***Impaired*** There are frequent or severe violations of chemical criteria, presence of acute toxicity, or a moderate or severe modification of the biological community.
BIOLOGY		
Rapid Bioassessment Protocol (RBP) III*	Non/Slightly impacted	Moderately or Severely Impacted
Fish Community	Best Professional Judgment (BPJ)	BPJ
Habitat and Flow	BPJ	Dewatered streambed due to artificial regulation or channel alteration, BPJ
Eelgrass Bed Habitat (Howes *et al.* 2003, Costello 2003)	Stable (No/minimal loss), BPJ	Loss/decline, BPJ
Non-native species	BPJ	Non-native species present, BPJ
Plankton/Periphyton	No/infrequent algal blooms	Frequent and/or prolonged algal blooms
TOXICITY TESTS**		
Water Column/Ambient	≥75% survival either 48 hr or 7-day exposure	<75% survival either 48 hr or 7-day exposure
Sediment	≥75% survival	<75% survival
CHEMISTRY-WATER**		
Dissolved oxygen (DO) (MassDEP 2006, EPA 1997)	Infrequent excursion from criteria (Table A1), BPJ (minimum of three samples representing critical period)	Frequent and/or prolonged or severe excursion from criteria [river and shallow lakes - exceedances >10% of representative measurements; deep lakes (with hypolimnion) - exceedances in the hypolimnetic area >10% of the surface area during maximum oxygen depletion].
pH (MassDEP 2006, EPA 1999a)	Infrequent excursion from criteria (Table A1)	Criteria exceeded >10% of measurements.
Temperature **(**MassDEP 2006,EPA 1997) [Note: typically the analysis of this variable is applicable to a summer index period ranging anywhere from mid-June through early September.]	Infrequent excursion from criteria (Table A1)	Small datasets: Criteria exceeded >10% of measurements. Deployed probe (long term) datasets: CWF: excursion based on mean of the daily maximum temperatures over a 7-day period. WWF: BPJ (e.g., >10% days in a 30 day period or three consecutive days in a 30 day period exceed 28.3℃, or 7-day average of daily maximum temperatures exceeds 28.3℃)
Toxic Pollutants (MassDEP 2006, EPA 1999a) Ammonia-N (MassDEP 2006, EPA 1999b) Chlorine (MassDEP 2006, EPA 1999a)	Infrequent excursion from criteria (Table A1) Ammonia is pH and temperature dependent[1] 0.011 mg/L (freshwater) or 0.0075 mg/L (saltwater) total residual chlorine (TRC)[2]	Frequent and/or prolonged excursion from criteria (exceeded >10% of measurements).

AQUATIC LIFE USE (CONTINUED)

CHEMISTRY-SEDIMENT**		
Toxic Pollutants (Persaud *et al.* 1993)	Concentrations ≤ Low Effect Level (L-EL), BPJ	Concentrations ≥ Severe Effect Level (S-EL)[3], BPJ
CHEMISTRY-TISSUE		
PCB – whole fish (Coles 1998)	≤500 µg/kg wet weight	BPJ
DDT (Environment Canada 1999)	≤14.0 µg/kg wet weight	BPJ
PCB in aquatic tissue (Environment Canada 1999)	≤0.79 ng TEQ/kg wet weight	BPJ

*RBP II analysis may be considered for assessment decision on a case-by-case basis, **For identification of impairment, one or more of the following variables may be used to identify possible causes/sources of impairment: NPDES facility compliance with whole effluent toxicity test and other limits, turbidity and suspended solids data, nutrient (nitrogen and phosphorus) data for water column/sediments. [1] Saltwater is temperature dependent only. [2] The minimum quantification level for TRC is 0.05 mg/L. [3]For the purpose of this report, the S-EL for total polychlorinated biphenyl compounds (PCB) in sediment (which varies with total organic carbon (TOC) content) with 1% TOC is 5.3 ppm while a sediment sample with 10% TOC is 53 ppm.

Note: National Academy of Sciences/National Academy of Engineering (NAS/NAE) guideline for maximum organochlorine concentrations (i.e., total PCB) in fish tissue for the protection of fish-eating wildlife is 500µg/kg wet weight (ppb, not lipid-normalized). PCB data (tissue) in this report are presented in µg/kg wet weight (ppb) and are not lipid-normalized to allow for direct comparison to the NAS/NAE guideline.

FISH CONSUMPTION USE

Pollutants shall not result in unacceptable concentrations in edible portions of marketable fish or for the recreational use of fish, other aquatic life or wildlife for human consumption. The assessment of this use is made using the most recent list of Fish Consumption Advisories issued by the Massachusetts Executive Office of Health and Human Services, Department of Public Health (MA DPH), Bureau of Environmental Health Assessment (MA DPH 2008). The MA DPH list identifies waterbodies where elevated levels of a specified contaminant in edible portions of freshwater species pose a health risk for human consumption. Hence, the *Fish Consumption Use* is assessed as impaired in these waters.

In July 2001 MA DPH issued new consumer advisories on fish consumption and mercury contamination (MA DPH 2001).

1. The MA DPH "…is advising pregnant women, women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age to refrain from eating the following marine fish; shark, swordfish, king mackerel, tuna steak and tilefish. In addition, MA DPH is expanding its previously issued statewide fish consumption advisory which cautioned pregnant women to avoid eating fish from all freshwater bodies due to concerns about mercury contamination, to now include women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age (MA DPH 2001)."
2. Additionally, MA DPH "…is recommending that pregnant women, women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age limit their consumption of fish not covered by existing advisories to no more than 12 ounces (or about 2 meals) of cooked or uncooked fish per week. This recommendation includes canned tuna, the consumption of which should be limited to 2 cans per week. Very small children, including toddlers, should eat less. Consumers may wish to choose to eat light tuna rather than white or chunk white tuna, the latter of which may have higher levels of mercury (MA DPH 2001)."

Other statewide advisories that MA DPH has previously issued and are still in effect are as follows (MA DPH 2001):

1. Due to concerns about chemical contamination, primarily from polychlorinated biphenyl compounds (PCB) and other contaminants, no individual should consume lobster tomalley from any source. Lobster tomalley is the soft green substance found in the tail and body section of the lobster.
2. Pregnant and breastfeeding women and those who are considering becoming pregnant should not eat bluefish due to concerns about PCB contamination in this species.

The following is an overview of EPA's guidance used to assess the status (support or impaired) of the *Fish Consumption Use*. Because of the statewide advisory no waters can be assessed as support for the *Fish Consumption Use*. Therefore, if no site-specific advisory is in place, the *Fish Consumption Use* is not assessed.

Variable	***Support*** No restrictions or bans in effect	***Impaired*** There is a "no consumption" advisory or ban in effect for the general population or a sub-population for one or more fish species or there is a commercial fishing ban in effect.
MA DPH Fish Consumption Advisory List	Not applicable, precluded by statewide advisory (Hg)	Waterbody on MA DPH Fish Consumption Advisory List

Note: MA DPH's statewide advisory does not include fish stocked by the state Division of Fisheries and Wildlife or farm-raised fish sold commercially.

Northeast Regional Mercury TMDL: On 20 December 2007 the U.S. EPA approved the Northeast Regional Mercury Total Maximum Daily Load (TMDL). This TMDL is a Federal Clean Water Act mandated document that identifies pollutant load reductions necessary for regional waterbodies to meet and maintain compliance with state and federal water quality standards. It was prepared by the New England Interstate Water Pollution Control Commission (NEIWPCC) in cooperation with the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. The TMDL covers inland waterbodies that are impaired primarily due to atmospheric deposition of mercury (Northeast States 2007). The TMDL target for Massachusetts is 0.3 ppm or less of mercury in fish tissue. The plan calls for a 75% reduction of in-region and out of region atmospheric sources by 2010 and a 90% or greater reduction in the future (NEIWPCC 2007). The TMDL will be reassessed in

2010 based on an evaluation of new on-going monitoring and air deposition data. Final targets will be determined at that time.

DRINKING WATER USE

The term *Drinking Water Use* denotes those waters used as a source of public drinking water. These waters may be subject to more stringent regulation in accordance with the Massachusetts Drinking Water Regulations (310 CMR 22.00). They are designated for protection as Outstanding Resource Waters in 314 CMR 4.04(3). MassDEP's Drinking Water Program (DWP) has primacy for implementing the provisions of the federal Safe Drinking Water Act (SDWA). Except for suppliers with surface water sources for which a waiver from filtration has been granted (these systems also monitor surface water quality) all public drinking water supplies are monitored as finished water (tap water). Monitoring includes the major categories of contaminants established in the SDWA: bacteria, volatile and synthetic organic compounds, inorganic compounds and radionuclides. The DWP maintains current drinking supply monitoring data. The suppliers currently report to MassDEP and EPA the status of the supplies on an annual basis in the form of a consumer confidence report (http://yosemite.epa.gov/ogwdw/ccr.nsf/Massachusetts). Below is EPA's guidance to assess the status (support or impaired) of the drinking water use.

Variable	***Support*** No closures or advisories (no contaminants with confirmed exceedances of maximum contaminant levels, conventional treatment is adequate to maintain the supply).	***Impaired*** Has one or more advisories or more than conventional treatment is required or has a contamination-based closure of the water supply.
Drinking Water Program (DWP) Evaluation	See note below	See note below

Note: While this use is not assessed in this report, information on drinking water source protection and finish water quality is available at http://www.mass.gov/dep/water/drinking.htm and from local public water suppliers.

SHELLFISHING USE

This use is assessed using information from the Department of Fish and Game's Division of Marine Fisheries (DMF). A designated shellfish growing area is an area of potential shellfish habitat. Growing areas are managed with respect to shellfish harvest for direct human consumption, and comprise at least one or more classification areas. The classification areas are the management units, and range from being approved to prohibited (described below) with respect to shellfish harvest. Shellfish areas under management closures are *not assessed.* Not enough testing has been done in these areas to determine whether or not they are fit for shellfish harvest, therefore, they are closed for the harvest of shellfish.

Variable	***Support*** SA Waters: Approved[1] SB Waters: Approved[1], Conditionally Approved[2], or Restricted[3]	***Impaired*** SA Waters: Conditionally Approved[2], Restricted[3], Conditionally Restricted[4], or Prohibited[5] SB Waters: Conditionally Restricted[4] or Prohibited[5]
DMF Shellfish Project Classification Area Information (MA DFG 2000)	Reported by DMF	Reported by DMF

NOTE: Designated shellfish growing areas may be viewed using the MassGIS datalayer available from MassGIS at http://www.mass.gov/mgis/dsga.htm. This coverage currently reflects classification areas as of July 1, 2000.

[1] **Approved** - "...open for harvest of shellfish for direct human consumption subject to local rules and regulations..." An approved area is open all the time and closes only due to hurricanes or other major coastwide events.

[2] **Conditionally Approved** - "...subject to intermittent microbiological pollution..." During the time the area is open, it is "...for harvest of shellfish for direct human consumption subject to local rules and regulations…" A conditionally approved area is closed some of the time due to runoff from rainfall or seasonally poor water quality. When open, shellfish harvested are treated as from an approved area.

[3] **Restricted** - area contains a "limited degree of pollution." It is open for "harvest of shellfish with depuration subject to local rules and state regulations" or for the relay of shellfish. A restricted area is used by DMF for the relay of shellfish to a less contaminated area.

[4] **Conditionally Restricted** - "...subject to intermittent microbiological pollution..." During the time area is restricted, it is only open for "the harvest of shellfish with depuration subject to local rules and state regulations." A conditionally restricted area is closed some of the time due to runoff from rainfall or seasonally poor water quality. When open, only soft-shell clams may be harvested by specially licensed diggers (Master/Subordinate Diggers) and transported to the DMF Shellfish Purification Plant for depuration (purification).

[5] **Prohibited -** Closed for harvest of shellfish.

PRIMARY CONTACT RECREATION USE

This use is suitable for any recreational or other water use in which there is prolonged and intimate contact with the water with a significant risk of ingestion of water during the primary contact recreation season (1 April to 15 October). These include, but are not limited to, wading, swimming, diving, surfing and water skiing. The chart below provides an overview of the guidance used to assess the status (support or impaired) of the *Primary Contact Recreation Use*. Excursions from criteria due to natural conditions are not considered impairment of use.

Variable	***Support*** Criteria are met, no aesthetic conditions that preclude the use	***Impaired*** Frequent or prolonged violations of criteria and/or formal bathing area closures, or severe aesthetic conditions that preclude the use
Bacteria (105 CMR 445.000) Minimum Standards for Bathing Beaches State Sanitary Code) (MassDEP 2006)	At "public bathing beach" areas: Formal beach postings/advisories neither frequent nor prolonged during the swimming season (the number of days posted or closed cannot exceed 10% during the locally operated swimming season). Collected samples* meet the geometric mean criteria (Table A1). Shellfish Growing Area classified as "Approved by DMF.	At "public bathing beach" areas: Formal beach closures/postings >10% of time during swimming season (the number of days posted or closed exceeds 10% during the locally operated swimming season). Collected samples* do not meet the geometric mean criteria (Table A1).
Aesthetics (MassDEP 1996) - *All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance* [growth or amount] *species of aquatic life*		
Odor, oil and grease, color and turbidity, floating matter	Narrative "free from" criteria met or excursions neither frequent nor prolonged, BPJ.	Narrative "free from" criteria not met - objectionable conditions either frequent and/or prolonged, BPJ.
Transparency (MA DPH 1969)	Public bathing beach and lakes – Secchi disk depth ≥1.2 meters (≥ 4') (minimum of three samples representing critical period).	Public bathing beach and lakes - Secchi disk depth <1.2 meters (< 4') (minimum of three samples representing critical period).
Nuisance organisms	No overabundant growths (i.e., blooms) that render the water aesthetically objectionable or unusable, BPJ.	Overabundant growths (i.e., blooms and/or non-native macrophyte growth dominating the biovolume) rendering the water aesthetically objectionable and/or unusable, BPJ.

* Data sets to be evaluated for assessment purposes must be representative of a sampling location (at least five samples per station recommended) and the season being analyzed, as described in the SWQS (see Table 1). Samples collected on one date from multiple stations on a river are not considered adequate to assess this designated use. Because of low sample frequency (i.e., less than ten samples per station) an impairment decision will not be based on a single sample exceedance (i.e., the geometric mean of five samples is < 126 *E. coli* colonies/100 ml but one of the five sample exceeds 235 *E. coli* colonies/100 ml). The method detection limit (MDL) will be used in the calculation of the geometric mean when data are reported as less than the MDL (e.g., use 20 cfu/100 ml if the result is reported as <20 cfu/100 ml). Those data reported as too numerous to count (TNTC) will not be used in the geometric mean calculation; however frequency of TNTC sample results should be presented.

SECONDARY CONTACT RECREATION USE

This use is suitable for any recreation or other water use in which contact with the water is either incidental or accidental. These include, but are not limited to, fishing, boating and limited contact incident to shoreline activities. Following is an overview of the guidance used to assess the status (support or impaired) of the *Secondary Contact Use*. Excursions from criteria due to natural conditions are not considered impairment of use.

Variable	***Support*** Criteria are met, no aesthetic conditions that preclude the use	***Impaired*** Frequent or prolonged violations of criteria, or severe aesthetic conditions that preclude the use
Bacteria (MassDEP 2006)	Collected samples* meet the Class C or SC geometric mean criteria (see Table A1). Shellfish Growing Area classified as "Approved" by DMF.	Collected samples* do not meet the Class C or SC geometric mean criteria (see Table A1).
Aesthetics (MassDEP 2006) - *All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance* [growth or amount] *species of aquatic life*		
Odor, oil and grease, color and turbidity, floating matter	Narrative "free from" criteria met or excursions neither frequent nor prolonged, BPJ.	Narrative "free from" criteria not met - objectionable conditions either frequent and/or prolonged, BPJ.
Transparency (MA DPH 1969)	Public bathing beach and lakes – Secchi disk depth ≥1.2 meters (≥ 4') (minimum of three samples representing critical period).	Public bathing beach and lakes - Secchi disk depth <1.2 meters (< 4') (minimum of three samples representing critical period).
Nuisance organisms	No overabundant growths (i.e., blooms) that render the water aesthetically objectionable or unusable, BPJ.	Overabundant growths (i.e., blooms and/or non-native macrophyte growth dominating the biovolume) rendering the water aesthetically objectionable and/or unusable, BPJ.

*Data sets to be evaluated for assessment purposes must be representative of a sampling location (at least five samples per station recommended) over time. Because of low sample frequency (i.e., less than ten samples per station) an impairment decision will not be based on a single sample exceedance. Samples collected on one date from multiple stations on a river are not considered adequate to assess this designated use.

AESTHETICS USE

All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life. The aesthetic use is closely tied to the public health aspects of the recreational uses (swimming and boating). Below is an overview of the guidance used to assess the status (support or impaired) of the *Aesthetics Use*.

Variable	***Support*** Narrative "free from" criteria met	***Impaired*** Objectionable conditions frequent and/or prolonged
Odor, oil and grease, color and turbidity, floating matter	Narrative "free from" criteria met or excursions neither frequent nor prolonged, BPJ.	Narrative "free from" criteria not met - objectionable conditions either frequent and/or prolonged, BPJ.
Transparency (MA DPH 1969)	Public bathing beach and lakes – Secchi disk depth ≥1.2 meters (≥ 4') (minimum of three samples representing critical period).	Public bathing beach and lakes - Secchi disk depth <1.2 meters (< 4') (minimum of three samples representing critical period).
Nuisance organisms	No overabundant growths (i.e., blooms) that render the water aesthetically objectionable or unusable, BPJ.	Overabundant growths (i.e., blooms and/or non-native macrophyte growth dominating the biovolume) rendering the water aesthetically objectionable and/or unusable, BPJ.

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APPENDIX B – SUMMARY OF NPDES PERMITTING INFORMATION
MERRIMACK RIVER WATERSHED

Table 1. NPDES discharges in the Merrimack River Watershed (excluding permits for construction/dewatering) including a summary of whole effluent toxicity results if available.

Permittee	NPDES #	Segment	Description
Allied Waste Services of Massachusetts, LLC	MA0030066	MA84A-21	Allied Waste Services of Massachusetts, LLC is authorized (MA0030066 issued March 2003) (transfer of ownership from Browning-Ferris Industries, Inc.) to discharge treated stormwater runoff through four outfalls from a truck refueling, washing and maintenance facility on Dunstable Road in Tyngsborough, MA. The outfalls 001, 003, 004, and 007 discharge into "Bridge Meadows" which flows into Deep Brook (MA84A-21).
Town of Amesbury	MAG640065	MA84A-28	The Town of Amesbury is authorized (MAG640065 issued May 2004) to discharge a maximum daily flow of 0.485 MGD from the Amesbury Water Treatment Plan on Newton Rd. into the Powwow River via outfalls #001 and #002.
Town of Amesbury	MA0101745	MA84A-06	The Town of Amesbury is authorized (MA0101745 issued February 2004 and modified in May 2007) to discharge 2.4 MGD of treated sanitary and industrial wastewater from the Amesbury Water Pollution Abatement Facility via outfall #001 to the Merrimack River. The maximum daily TRC limit is 1.0 mg/L. Acute whole effluent toxicity test are required twice a year using M. bahia with an LC50 limit ≥50% effluent. (Note: the permit required testing with M. beryllina as well but EPA approved request to reduce to M. bahia only in May 2004 letter to town). Between April 2002 and October 2008, no acute whole effluent toxicity was detected in the Amesbury WPAF discharge during the test events (i.e., all LC50s were >100% effluent in the valid tests conducted).
Town of Andover	MAG640058	MA84022	The Town of Andover is authorized (MAG640058 issued August 2001) to discharge a maximum daily flow of 0.97 MGD of backwash water processing wastewater from the Andover Water Treatment Plant into Haggetts Pond via 1 outfall.
Boott Hydropower, Inc.	MAG250949	MA84A-29	Boott Hydropower, Inc. is authorized (MAG250949 issued September 2000) to discharge 0.00144 MGD of non-contact cooling water from the Hamilton Power Station on Jackson St. in Lowell into the Merrimack River via the Hamilton Canal.
Boott Hydropower, Inc.	MAG250950	MA84A-02	Boott Hydropower, Inc. is authorized (MAG250950 issued September 2000) to discharge 0.006 MGD of non-contact cooling water from the John Street Power Station to the Merrimack River.
Boott Hydropower, Inc.	MAG250163	MA84A-02	Boott Hydropower, Inc. is authorized (MAG250163 issued September 2000) to discharge 0.6 MGD of non-contact cooling water from Eldred L. Field Hydroelectric Project on Pawtucket St. in Lowell to the Merrimack River.
Boott Hydropower, Inc.	MAG250948	MA84A-04	Boott Hydropower, Inc. is authorized (MAG250948 issued September 2000) to discharge 0.9 MGD of non-contact cooling water from the Lawrence Hydroelectric Project on South Broadway St. to the Merrimack River.
Brox Industries, Inc.	MA0040177	Not a Segment (MA84A-03 subwatershed)	Brox Industries, Inc. is authorized (MA0040177 issued in March 2007) to discharge a maximum daily flow of 1.58 MGD treated storm water and process generated wastewater from the quarry and crushing/washing operations at its facility on Methuen St. in Dracut into the receiving wetland system adjacent to the Merrimack River via outfall #003. The facility conducted one modified acute and chronic whole effluent toxicity test in October 2003. No acute or chronic toxicity was detected by either C. dubia or P. promelas.

Permittee	NPDES #	Segment	Description
Ferraz Shawmut, Inc.	MA0000281	MA84A-06	Ferraz Shawmut, Inc. (formerly Gould, Inc.) was authorized (MA0000281 issued in September 2002) to discharge an average monthly flow of 0.04 MGD of treated process wastewater from its facility on Merrimac St. in Newburyport, into the receiving waters of the Merrimack River via outfall #001. Whole effluent toxicity testing in May and November each year was required using both Mysidopsis bahia and Menidia beryllina. The LC50 limit was ≥50% effluent. Whole effluent toxicity tests from May 2001 to April 2005 (n=12) showed the effluent was acutely toxic to M. bahia (consistently the more sensitive test organism) in all 12 test events with LC50s ranging from 21.1 to 82.6% effluent. The LC50 permit limit of 50% was not met in half of the tests conducted. The facility tied into the Newburyport WPCF in August 2005 and the NPDES permit was terminated by EPA in November 2005.
Fletcher Granite Company	MA0020231	Not a Segment (MA84B-04 subwatershed)	Fletcher Granite Company is authorized (MA0020231 issued April 2003) to discharge via outfall 001 and process water discharge from the cutting mill via outfall #003 to Gilson Brook, a tributary to Stony Brook.
GenCorp, Inc.	MAG910424	MA84A-10	GenCorp, Inc. was authorized (MA0003824 issued July 1992) to discharge from its facility on General St. in Lawrence to the Spicket River. The company applied for coverage under a Remedial General Permit (RGP) MAG910424 for ongoing remedial activities at the site (removal of contaminated sediment and residue from subsurface interior raceways and an exterior, at grade, raceway) and plugging of interior raceways to permanently isolate them from surface water except during a 100 year frequency flood event. Installation of a permanent groundwater treatment system, using the plugged raceways as the groundwater collection system will be applied for as a separate RGP. The RGP was issued to the facility in July 2009.
Greater Lawrence Sanitary District	MA0100447	MA84A-04 MA84A-10	Greater Lawrence Sanitary District is authorized (MA0100447 issued in August 2005) to discharge (via outfall #001) treated effluent to the Merrimack River from the facility on Charles St. in North Andover. The monthly average flow is 52MGD. The TRC limit is 0.15 mg/L average monthly with a daily maximum concentration of 0.26 mg/L. The facility is also required to monitor and report quarterly total ammonia nitrogen, Kjeldahl nitrogen, nitrite and nitrate concentrations as well as monthly total phosphorus concentrations. The facility is also required to conduct quarterly chronic and modified acute whole effluent toxicity tests using Ceriodaphnia dubia. The LC50 limit is ≥100% and the C-NOEC must be reported. February 2001 and April 2009 modified acute and chronic whole effluent toxicity tests were conducted on Greater Lawrence Sanitary District's treated effluent using C. dubia (n=39). The facility met the LC50 limit of ≥100% effluent with three exceptions (February, May, and August 2002 when LC50s were 71, 71, and 65.98% effluent, respectively). CNOEC test results ranged from <6.25 to 100% effluent (n=33 valid tests). CSO Discharges (upstream to downstream): Outfall 003 South Bank secondary overflow just downstream O'Leary Bridge to Merrimack River, Outfall 005 North Bank secondary overflow just downstream Casey Bridge to Merrimack River, Outfall 002 South Bank main overflow to Merrimack River, Outfall 006 Spicket River secondary overflow to Spicket River, Outfall 004 North Bank main overflow at mouth of Spicket River

Permittee	NPDES #	Segment	Description
Town of Groveland	MA0102661	MA84A-15	The Town of Groveland (Mill Pond GW Intercept System) was authorized (MA0102661 issued April 1983) to discharge from test well site #4 and test well site #14 to Johnson Creek and Brindle Brook via outfall #001 and #002 respectively. The average flow was 0.5 MGD and 0.35 respectively. In November 2001 EPA terminated the permit because the site was determined to be a Superfund Site. *EPA Status of Site: Completion of construction for the 150 gallons per minute groundwater extraction, treatment and discharge facility was achieved in Spring 2000. The groundwater treatment plant began treating contaminated groundwater in April of 2000. Treatment will continue until such time that the groundwater clean up goals have been met throughout the site. The first year of operation and maintenance (O&M) is being provided by the current construction contractor. Funding is provided through a Superfund State Contract with the MassDEP. Under the contract, EPA is funding the O & M for the groundwater treatment system until the end of June 2011. Beginning July 2011, MassDEP will be responsible for funding the continued operation and maintenance of the treatment system until the residual site risk(s) are within an acceptable (protective) range. EPA completed the first five-year review of the remedy in 2005 and determined that the clean up actions at the site are still currently protective of human health and the environment.. In September of 2007, EPA in consultation with MassDEP issued an Explanation of Significant Differences (ESD) to document the clean-up levels and also document that Electrical Resistive Heating (ERH) will be the treatment method used to clean-up TCE contaminated soils on the southern portion of the property. In September of 2008, EPA authorized funding for our oversight contractor implement the ERH remedy. EPA, expects to complete procurement and implement the ERH design in the summer of 2009. See above section entitled "source control". As of October 2006, the treatment system has extracted and treated over 388 million gallons of contaminated groundwater and has removed approximately 1,093 pounds of contamination (Total VOCs). URL: http://www.epa.gov/region1/superfund/sites/groveland Last updated on Thursday, June 18th, 2009*
City of Haverhill Wastewater Division	MA0101621	MA84A-04 MA84A-05 MA84A-09	The City of Haverhill is authorized (MA0101621) issued in December 2007to discharge an average monthly flow of 18.1 MGD treated of treated industrial and sanitary wastewater and storm water from the Haverhill Wastewater Treatment Facility via outfall #046 to the Merrimack River. The average monthly and daily maximum TRC limits are 0.40 and 0.70 mg/L, respectively. The facility is also required to conduct quarterly acute whole effluent toxicity tests with Pimephales promelas with an LC50 limit ≥100% effluent. Monitoring and reporting of monthly total ammonia nitrogen, Kjeldahl nitrogen, nitrite and nitrate concentrations is required. Between June 2001 and April 2009, no acute whole effluent toxicity was detected in the Haverhill WPAF discharge during the test events (i.e., all LC50s were >100% effluent). The facility's 20 CSOs discharge as follows: Merrimack River (MA84A-04) - Outfall #025 (Beach St.), Outfall #031 (Front St.), Outfall #024 (Upper Siphon), Outfall #023 (266 River St.), Outfall #022 (Railroad Bridge), Outfall #032 (Bradford Ave) Outfall #033 (South Prospect St.), Outfall #021A (Middle Siphon) Merrimack River (MA84A-05) - Outfall #034 (Middlesex St.), Outfall #019 (Main St. North), Outfall #035 (South Main St.), Outfall #016 (Fire Station), Outfall #036 (Ferry St.), Outfall #013 (Lower Siphon), Outfall #010 (Boardman St.), Outfall #001 (Bates Bridge) Little River (MA84A-09) - Outfall #021H (Winter and Hale (near Lafayette Square)), Outfall #038 (High St. Diversion), Outfall #021D (Locke St. North), Outfall #021E (Locke St. South)
Haverhill Paperboard Corp.	MAG250961	MA84A-05	The Haverhill Paperboard Corp. is authorized (MAG250961 issued April 2009) to discharge 0.02 MGD of non-contact cooling water via Outfall 003 to the Merrimack River. This facility, which began operation in 1902, ceased operation in August 2008 and is in the process of complete closure. The source of water for cooling was the Merrimack River. Little information is available for the cooling water intake structure except that it is gravity fed.

Permittee	NPDES #	Segment	Description
Littleton Water Department	MAG640002	MA84089	The Littleton Water Department is authorized (MAG6400002 issued March 2002) to discharge an average monthly flow of 0.02 MGD (0.03 MGD maximum daily) from Spectacle Pond Water Production Facility near Rt. 119 to Spectacle Pond.
Lowell Cogeneration Company	MA0031071	MA84A-29	The Lowell Cogeneration Company, L.P. is authorized (MA0031071 issued December 2008) to discharge a monthly average flow of 0.0865 MGD (0.115 MGD maximum daily) of cooling tower blowdown, boiler blowdown, demineralizer wastewater and water softener regeneration wastewater from its facility on Western Ave. via outfall #001 to the Pawtucket Canal to the Merrimack River. The Total Residual Chlorine limit is 0.1 mg/l. Acute whole effluent toxicity testing with both Ceriodaphnia dubia and Pimephales promelas is required once during the first year of the permit (sometime between July and September) and then once every other year thereafter with an LC50 limit of ≥50%effluent. The daily maximum temperature limit is 105℉.
Lowell National Historical Park	MAG250732	MA84A-29	The Lowell National Historical Park is authorized (MAG250732 issued November 2000) to discharge an average monthly flow of 0.360 MGD (0.4 MGD daily maximum) of non-contact cooling water from the Boott Cotton Mills Museum to the Eastern Canal of the Merrimack River.
Lowell Regional Wastewater Utilities	MA0100633	MA84A-01 MA84A-02 MA84A-03 MA84A-11	Lowell Regional Wastewater Utilities is authorized (MA0100633 issued September 2005) to discharge an average monthly flow of 32 MGD of treated effluent from its facility on Rt.110 via Outfall #035) to the Merrimack River (MA84A-03). Total Residual Chlorine limit is 0.21 mg/L average monthly (0.37mg/l daily maximum). Quarterly modified acute and chronic whole effluent toxicity testing is required using Ceriodaphnia dubia with an LC50 limit of ≥ 100% and C-NOEC report only. Two additional acute tests are required each year when secondary treatment is bypassed. Between February 2001 and April 2009 acute and/or modified acute and chronic whole effluent toxicity tests using C. dubia were conducted on Lowell Regional Wastewater Utilities treated effluent using C. dubia (n=38). No acute whole effluent toxicity was detected in any of the test events (LC50s were all >100% effluent). The CNOEC test results ranged from <6.25 to 100% effluent (n=14) and although two tests (July 2006 and July 2007 had CNOECs of <6.25 and 6.25% effluent, respectively) were of concern, no chronic whole effluent toxicity at levels of concern has been detected since October 2007. The permit also authorizes the discharge from 9 CSOs (see below) to the receiving waters of the Merrimack River, Concord River and Beaver Brook. Chelmsford Sewer Commission, Dracut Sewer Commission, Tewksbury DPW and Tynsborough Town Hall are all co- permittees for specific activities required in Part I.C. Unauthorized Discharges, Part I.D. Operation Maintenance of the Sewer System and, Part I.E. Alternate Power Source. The locations of the CSOs are: Merrimack River - Outfall #002 (Walker St.), Outfall #008 (West St.), Outfall #011 (Read St.), Outfall #012 (First St.), Outfall #027 (Tilden St.), Outfall #030(1) (Barasford St.), Outfall #030(2) (Merrimack River) Beaver Brook - Outfall #007 (Beaver Brook) Concord River - Outfall #020 (Warren St. Parking Lot)
Lowell Regional Water Utility	MAG640055	MA84A-01	The Lowell Regional Water Utility is authorized (MAG640055 issued June 2001) to discharge effluent from the water treatment facilities on Pawtucket Blvd to the Merrimack River. The permit application indicates maximum daily discharge is 0.5 MGD.

Permittee	NPDES #	Segment	Description
Lucent Technologies, Inc.	MA0001261	MA84A-04	Lucent Technologies Inc., was authorized (MA0001261) issued in July 2002 to discharge 0.2 MGD of treated sanitary effluent from its facility on Osgood St. in N. Andover into the Merrimack River via outfall #001B, 0.518 MGD maximum daily of treated effluent from a groundwater remediation system via outfalls #001E and 0.072 MGD via outfall #002C, and 0.075 MGD daily maximum flow of non-contact cooling water blowdown and chiller water blowdown and condensate via outfall #002A. Both discharges for outfalls 001B and 002A were tied into the Greater Lawrence Sanitary District at the time the permit was issued. Acute whole effluent toxicity testing was required using both C. dubia and P. promelas twice per year with an LC50 limit of 50% effluent. The facility has since closed down and EPA terminated the permit in September 2006. The two groundwater remediation outfalls are covered under MAG91045 and MAG91046. Between July 2001 and July 2002 acute whole effluent toxicity tests were conducted on Lucent Technologies Inc. (#001) treated effluent using both C. dubia and P. promelas (n=3). The LC50s ranged from 96 to 100% effluent (C. dubia more sensitive test species) and all tests met the LC50 limit of 50% effluent.
Merrimack Water Department	MAG640030	MA84002	The Merrimack Water Department is authorized (MAG640030 issued October 2001) to discharge effluent from the Merrimack Water Treatment Plant on Wallace Way to an unnamed swamp bordering Lake Attittash.
Town of Merrimac	MA0101150	MA84A-05	The Town of Merrimac is authorized (MA0101150 issued October 2006) to discharge an average monthly flow of 0.45 MGD of treated effluent from the Merrimac Wastewater Treatment Plant to the Merrimack River via outfall #001. Effluent is discharged to the Merrimack River through a 12 inch diameter pipe which travels approximately 3,700 feet from the WTF to the Merrimack River. The pipe extends approximately 100 feet into the river. The top of the pipe is submerged approximately four feet below the surface during low tide. Annual acute whole effluent toxicity testing with M. bahia is required each July. The LC50 limit is ≥50% effluent. During summer of 2005 the permittee installed a new ultraviolet disinfection system, replacing chlorine for effluent disinfection.
Newburyport Water Department	MAG640018	MA84A-06	The Newburyport Water Department is authorized (MAG640018 issued August 2001) to discharge an average monthly flow of 0.171 MGD (0.226 MGD maximum daily) of effluent from the Newburyport Water Treatment Plant located on Spring Lane to the Merrimack River.
City of Newburyport	MA0101427	MA84A-06	The City of Newburyport is authorized (MA0101427 issued in May 2004 and modified in October 2006) to discharge an average monthly flow of 3.4 MGD of treated effluent from the Newburyport Wastewater Treatment Plant via Outfall #001 to the Merrimack River Estuary. The TRC limits are 0.23 and 0.39 mg/L average monthly and maximum daily, respectively. Quarterly acute whole effluent toxicity tests using Mysidopsis bahia and Menidia beryllina.are required with an LC50 limit ≥100% effluent. Between June 2001 and May 2009, acute whole effluent toxicity was generally not detected in the Newburyport WPCF discharge (i.e., most LC50s were > 100% effluent), however it was detected by M. bahia in two of 33 valid tests events (32% in September 2001 and 95% in November 2003) and by M. beryllina in three of 31 valid tests (89% in June 2001, 70.7% in October 2005, and 74.8% in February 2008). Neither test species is consistently more sensitive.
Salisbury Sewer Commission	MA0102873	MA84A-06	The Salisbury Sewer Commission is authorized (MA0102873 issued in February 2002) to discharge 1.3 MGD of treated sanitary wastewater effluent via outfall #001 from the Salisbury Wastewater Treatment Plant to a tidal creek that drains into the Merrimack River. The facility is required to conduct modified acute and chronic whole effluent toxicity tests on a quarterly basis using M. beryllina as a test organism. The LC50 and CNOEC permit limits are >100% effluent. The facility uses UV for disinfection. Between May 2001 and March 2009, no acute whole effluent toxicity was detected in the Salisbury WWTP effluent (all LC50s were >100% effluent). Some chronic whole effluent toxicity (CNOECs = 25 or 50% effluent) was detected in four of the 28 chronic tests (September 2002 and 2003, June 2007 and 2008) and somewhat anomalous results occurred during the December 2002 test event.
Salisbury Water Supply Co.	MA0025038	Not a Segment (MA84A-06 subwatershed)	The Salisbury Water Supply Co. was authorized (MA0025038 issued July 1975) to discharge a monthly average flow of 0.685 MGD from their sewers into Black Rock Creek. The permit was terminated by EPA (no longer a surface water discharge) in January 2001.

Permittee	NPDES #	Segment	Description
Veryfine Products (Sunny Delight Beverages Co.)	MA0004936	MA84B-01	Veryfine Products, Inc. (now owned by Sunny Delight Beverages Co. as of November 2007) is authorized (MA0004936 issued September 2006) to discharge an average monthly flow of 0.55 MGD (max daily 0.75 MGD) of treated beverage product effluent, reverse osmosis reject water, and contact and non-contact cooling water from the bottling facility located on Harvard Rd. in Littleton, into the receiving waters of Reedy Meadow Brook via outfall #001. Whole effluent toxicity testing must be conducted 4 times annually (January, April, July, and October) using the species Pimephales promelas. The limits are LC50 ≥100% and C-NOEC ≥91% effluent. Between January 2001 and April 2009 modified acute and chronic whole effluent toxicity tests were conducted on Veryfine Products, Inc's. treated effluent using P. promelas. No acute whole effluent toxicity was detected (LC50's were all > 100% effluent, n=34). Chronic whole effluent toxicity was not usually detected (all CNOECs were 100% effluent) with the exception of 3 of the 32 valid test events. The CNOECs were ≤ 6.25% effluent in the July 2006, January 2007, and July 2008 test events.
Westford Anodizing	MA0024414	MA84B-03	Westford Anodizing was authorized (MA002414 issued August 2002) to discharge an average daily design flow of 0.0014 MGD (max daily 0.002 MGD) of treated process wastewater to Stony Brook via outfall #001. Whole effluent toxicity tests using C. dubia and Pimephales promelas was required quarterly. The limit was LC50 ≥50% effluent. Occasional acute whole effluent toxicity was detected in the Westford Anodizing effluent (LC50's ranged from 26.5 to 100%). The facility ceased discharging in December 2002. EPA terminated the permit in February 2004.

STORMWATER

The NPDES Phase II General Permit program requires NPDES permit coverage for stormwater discharges from small municipal separate storm sewer systems (MS4s), and construction activity disturbing one acre or more of land in a mapped "urbanized area" defined and delineated by the US Bureau of Census in 2000 http://www.epa.gov/npdes/pubs/fact2-2.pdf. Large and medium MS4s (populations over 100,000) were permitted during Phase I of the NPDES stormwater program. Under EPA's Phase II program, the definition of "municipal" includes Massachusetts communities, U.S. military installations, state or federal owned facilities such as hospitals, prison complexes, state colleges or universities and state highways. An MS4 is a system that: discharges at one or more a point sources; is a separate storm sewer system (not designed to carry combined stormwater and sanitary waste water); is operated by a public body; discharges to the Waters of the United States or to another MS4; and, is located in an "Urbanized Area". The NPDES Phase II General Permit requires operators of regulated MS4s to develop and implement a stormwater management program that prevents harmful pollutants from being washed or dumped directly into the storm sewer system which is subsequently discharged into local waterbodies. Certain Massachusetts communities were automatically designated (either in full or part) by the Phase II rule based on the urbanized area delineations from the 2000 U.S. Census.

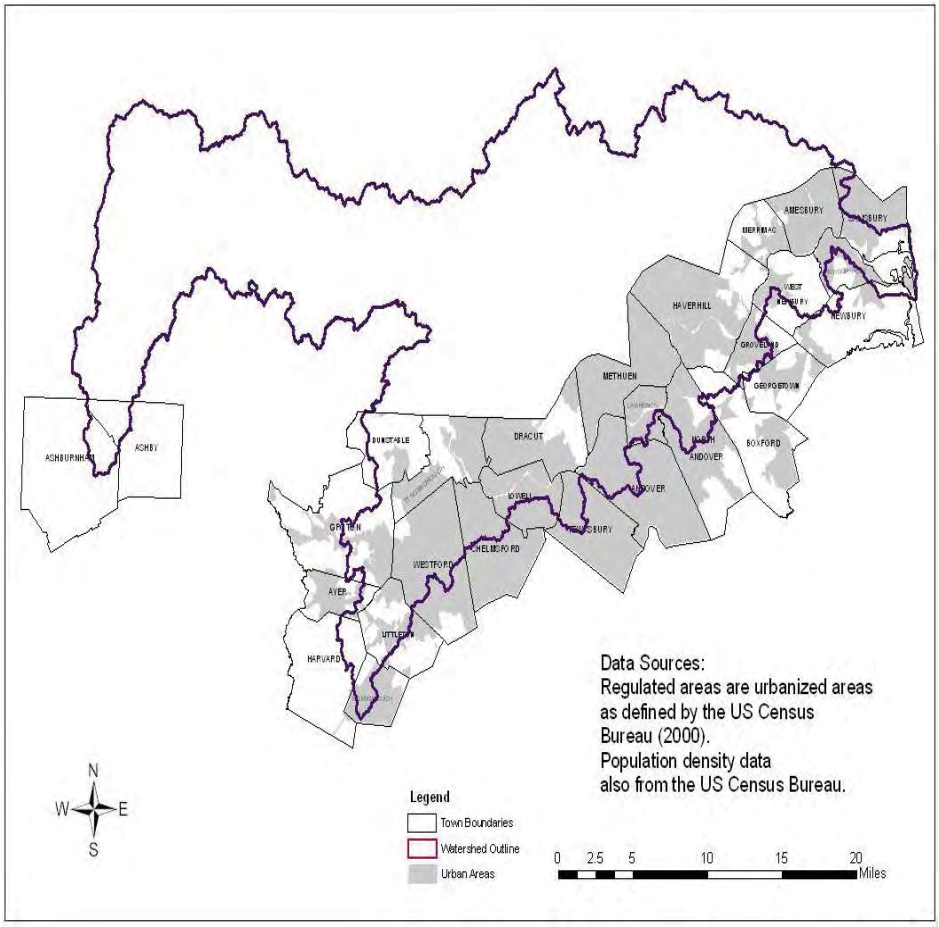

Figure 1. Merrimack Watershed and Associated Communities

As a result of the census mapping, 26 of the 28 communities in the Merrimack Watershed were located either totally or partially in the regulated Urbanized Area. Municipalities that are totally regulated must implement the requirements of the Phase II permit in the entire town, while communities that are partially regulated need to comply with the Phase II permit only in the mapped Urbanized Areas. Merrimack drainage area communities applied to EPA and MassDEP for coverage under the Phase II stormwater general permit, issued on 1 May 2003. EPA issued stormwater general permits to 24 Merrimack municipalities. After administrative review and, in coordination with MassDEP, a thorough review of the communities' stormwater management program was to be conducted during the five-year permit term. Phase II stormwater general permits expire on 1 May 2008 but remain in effect until a new permit is issued. All communities must reapply for coverage under the update general permit. The updated general permit will likely

require some monitoring within the MS4 Phase II area including outfalls and receiving waters and the general permit will require a more detailed and better defined Illicit Discharge Detection and Elimination Program (IDDEP). For detailed community maps see http://www.epa.gov/region01/npdes/stormwater/ma.html.

Table 2. NPDES Phase II stormwater permit information for Merrimack Watershed Communities

Community	Permit #	Permit Issued	Mapped Regulatory area in community
Amesbury	MAR041177	1/8/2004	Total
Andover	MAR041178	9/24/2003	Partial
Ashburnham	Not listed		Partial
Ashby	Not listed		Partial
Ayer	MAR041179	1/8/2004	Partial
Boxford	MAR041184	12/4/2003	Partial
Boxborough	MAR041183	1/20/2004	Partial
Chelmsford	MAR041185	8/28/2003	Partial
Dracut	MAR041194	9/26/2003	Total
Dunstable	Waiver4		Partial
Georgetown	MAR041191	9/26/2003	Partial
Groton	MAR041193	10/28/2003	Partial
Groveland	MAR041195	12/10/2003	Partial
Harvard	Waiver5		Partial
Haverhill	MAR041197	9/26/2003	Total
Lawrence	MAR041201	3/1/2004	Partial
Littleton	MAR041204	9/25/2003	Partial
Lowell	MAR041205	9/12/2003	Partial
Merrimac	MAR041209	1/26/2004	Total
Methuen	MAR041210	10/2/2003	Total
Newbury	MAR041212	9/26/2003	Partial
Newburyport	MAR041213	12/4/2003	Partial
North Andover	MAR041214	10/7/2003	Partial
Salisbury	MAR041220	10/30/2003	Partial
Tewksbury	MAR041226	9/12/2003	Partial
Tyngsborough	MAR041229	8/26/2003	Total
West Newbury	MAR041231	1/8/2004	Partial
Westford	MAR041232	10/7/2003	Partial

APPENDIX C – SUMMARY OF MONITORING SITE LOCATIONS

Table 1. Summary of all monitoring site locations cited in the assessment report and the source of the monitoring site.

Station ID	Location Description	Source
B0524	South Branch Souhegan River, downstream from Jones Hill Road, 275 m downstream from unnamed tributary, Ashby, MA	MassDEP
B0306	Richardson Brook, 200 m upstream from Methuen Street, Dracut, MA	MassDEP
B0308	Trull Brook, 100 m downstream from River Road, Tewksbury, MA	MassDEP
B0319	Martins Pond Brook, 25 m upstream from footpath extending from Loomis Lane, Groton, MA	MassDEP
B0516	Powwow River, 125 m downstream from Rt. 150 (Main Street), off Mill Street, Amesbury, MA	MassDEP
B0517	Fish Brook, ~300 m upstream from the dam at mouth of stream, south of Brundrett Ave., Andover, MA	MassDEP
B0518	Creek Brook, 25 m upstream from West Lowell Ave., Haverhill, MA	MassDEP
B0519	Bartlett Brook, 5 m upstream from Rt. 113 (North Lowell Street), Methuen, MA	MassDEP
B0520	Peppermint Brook, ~100 m downstream from Lakeview Ave., Dracut, MA	MassDEP
B0521	Black Brook, ~250 m upstream from Westford Street, below the golf course (Mt. Pleasant), Lowell, MA	MassDEP
B0522	Bridge Meadow Brook, 80m downstream from road to Tyngsborough Elementary School (205 Westford Road), Tyngsborough, MA	MassDEP
B0523	Tadmuck Brook, ~200 m upstream from Lowell Road, Westford, MA	MassDEP
B0525	Bennets Brook, ~100 m downstream from Willow Road, Ayer, MA	MassDEP
W1209	Unnamed Tributary, unnamed tributary to Johnson Creek, locally known as Argilla Brook, west off Baldwin Terrace approximately 1400 feet upstream/east of Main Street crossing, Groveland ,MA	MassDEP
W1106	Unnamed Tributary, unnamed tributary to Powwow River, approximately 50 feet upstream/northeast of R Street, Amesbury ,MA	MassDEP
W1198	Powwow River, approximately 550 feet downstream/east of Route 150 (approximately 225 feet downstream of Amesbury electrical substation but upstream of discharge pipe directly across from 35 Mill Street), Amesbury ,MA	MassDEP
W1212	Back River, Clinton Street crossing, Amesbury ,MA	MassDEP
W1213	East Meadow River, Thompson Road crossing, Haverhill ,MA	MassDEP
W1197	Johnson Creek, Center Street crossing, Groveland ,MA	MassDEP
W1210	Little River, Downstream/south at Winter Street crossing, Haverhill ,MA	MassDEP
W1203	Creek Brook, West Lowell Avenue crossing, Haverhill ,MA	MassDEP
W1195	Bare Meadow Brook, Renfrew Street crossing, Methuen ,MA	MassDEP
W1202	Bartlett Brook, Route 113 (North Lowell Street) crossing, Methuen ,MA	MassDEP
W1206	Fish Brook, River Road crossing, Andover ,MA	MassDEP
W1194	Trull Brook, Approximately 230 feet downstream/north of River Road, Tewksbury ,MA	MassDEP
W1192	Richardson Brook, Methuen Street crossing, Dracut ,MA	MassDEP
W1193	Trout Brook, Kenwood Road crossing, Dracut ,MA	MassDEP
W1211	Peppermint Brook, Lakeview Avenue crossing, Dracut ,MA	MassDEP
W1191	Black Brook, Westford Street crossing, Lowell ,MA	MassDEP
W1201	Tadmuck Brook, Lowell Road crossing, Westford ,MA	MassDEP

Station ID	Location Description	Source
W1200	Bennetts Brook, Willow Road crossing, Ayer ,MA	MassDEP
W1190	Deep Brook, Ledge Road crossing, Chelmsford ,MA	MassDEP
W1189	Lawrence Brook, Approximately 130 feet downstream/south of Sherburne Avenue, Tyngsborough ,MA	MassDEP
W1207	Bridge Meadow Brook, Downstream/northeast of the unnamed school access road crossing north off Westford Avenue between the localities of Hayward Corner and Swan Corner, Tyngsborough ,MA	MassDEP
W1199	Salmon Brook, Ridge Road crossing, Nashua, New Hampshire ,MA	MassDEP
W1208	Joint Grass Brook, Downstream/east of Main Street crossing (below confluence of unnamed tributary), Dunstable ,MA	MassDEP
W1188	Martins Pond Brook, Approximately 180 feet downstream from washed out culvert crossing of Loomis Lane, Groton ,MA	MassDEP
M011	Merrimack River, Upstream of Lowell, 500 feet downstream of Tyngs Island, Chelmsford, MA	CDM
T006	Stony Brook, Middlesex Road bridge (downstream side), Chelmsford, MA	CDM
M012	Merrimack River, Lowell Public Beach Adjacent to beach area, Lowell, MA	CDM
M013	Merrimack River, Upstream of Pawtucket Dam, 200 feet upstream of Float line, Lowell, MA	CDM
M014	Merrimack River, Downstream Pawtucket Dam, Ouelette Bridge- Aiken Street, Lowell, MA	CDM
T007	Beaver Brook Parker Ave bridge (upstream side), Dracut, MA	CDM
M015	Merrimack River, Downstream of Lowell USGS Gaging Station at Lowell, Lowell, MA	CDM
M016	Merrimack River, Lowell WWTP, 300 feet downstream of Lowell WWTP outfall, Lowell, MA	CDM
M017	Merrimack River, Upstream of Lawrence County Line, Methuen, MA	CDM
M018	Merrimack River, Upstream of Essex Dam Float line, Lawrence, MA	CDM
M019	Merrimack River, Downstream Essex Dam Casey Bridge, Lawrence, MA	CDM
T009	Spicket River Haverhill St bridge (downstream side), Lawrence, MA	CDM
M021	Merrimack River, GLSD WWTP 300 feet downstream of GLSD WWTP outfall, Lawrence, MA	CDM
M022	Merrimack River, Upstream of Haverhill Haverhill/N. Andover Town Line, Methuen, MA	CDM
M024	Merrimack River, Haverhill WWTP 300 feet downstream of Haverhill WWTP outfall, Haverhill, MA	CDM
M025	Merrimack River, Merrimac WWTP 300 feet downstream of Merrimac WWTP outfall, Merrimac, MA	CDM
M026	Merrimack River, Amesbury WWTP 300 feet downstream of Amesbury WWTP outfall, Amesbury, MA	CDM
T011	Powwow River 200-300 feet upstream of confluence, Amesbury, MA	CDM
M027	Merrimack River, Shellfish Bed Newburyport Boat Ramp in Joppa Flats, Newburyport, MA	CDM
M028	Merrimack River, Salisbury WWTP 300 feet downstream of Salisbury WWTP, Salisbury, MA	CDM
M029	Merrimack River, Newburyport WWTP 300 feet downstream of Newburyport WWTP, Newburyport, MA	CDM
M030	Shellfish Bed North side of bay, Salisbury, MA	CDM

Station ID	Location Description	Source
TA01	Tadmuck Brook, upstream from Lowell Road reach beginning at breached dam and continuing 150 m upstream., Westford, MA	MassDEP
BR01	Bridge Meadow Brook, downstream from elementary school entrance road off Chestnut Road., Tyngsborough, MA	MassDEP
DBR05	Deep Brook, downstream of Ledge Road, Behind houses off Dunstable Road. Upstream of un-named tributary., Chelmsford, MA	MassDEP
BB05	Black Brook, off of and adjacent to Montgomery Ave just downstream from golf course., Lowell, MA	MassDEP
PE01A	Peppermint Brook, 200 meters downstream from Lakeview Ave. Reach extended to riffle located approx 100 m downstream of bridge., Dracut, MA	MassDEP
TRB02	Trout Brook, upstream and downstream of Kenwood Sreet., Dracut, MA	MassDEP
RBR01A	Richardson Brook, reach beginning upstream of a new road off of Methuen Street, Dracut, MA	MassDEP
TB02	Trull Brook, downstream of River Road reach beginning just upstream from golf course, Tewksbury, MA	MassDEP
BA01A	Bartlett Brook, downstream and upstream of Rte 113 , Methuen, MA	MassDEP
FI01A	Fish Brook, near confluence with Merrimack River upstream of footpath at sewer line crossing., Andover, MA	MassDEP
FI02	Fish Brook, near confluence with Merrimack River downstream of footpath at sewer line crossing., Andover, MA	MassDEP
BMB01A	Bare Meadow Brook, downstream from Renfrew Street., Methuen, MA	MassDEP
CR01	Creek Brook, upstream from Lowell Avenue., Haverhill, MA	MassDEP
JC03	Johnson Creek, downstream of Center Street bridge., Groveland, MA	MassDEP
AR01A	Argilla Brook, west of circle at end of Baldwin Terrace downstream of footpath and bridge., Groveland, MA	MassDEP
EA01	East Meadow River, beginning 150 m downstream of cart road at end of Thompson Road, Haverhill, MA	MassDEP
511	Black Brook, Westford St (upstream), Lowell, MA	MA DFG
736	Johnson Brook, Main Street downstream, Groveland, MA	MA DFG
737	Powwow River, Newton Road bridge downstream, Amesbury, MA	MA DFG
738	Back River (2), Fern Ave upstream, Amesbury, MA	MA DFG
1456	UNT(Argella Brook), 75' upstream of Main St, Groveland, MA	MA DFG
1605	Bennetts Brook, Willow Rd downstream, 500' N of Littleton Rd, Ayer, MA	MA DFG
1607	Trout Brook, Pelczar Rd xing upstream, just E of Sesame St, Dracut, MA	MA DFG
1608	Trout Brook, Kenwood Rd xing 300' E of Sesame St, Dracut, MA	MA DFG
1609	Joint Grass Brook, Main St downstream, 400' S of Mill St, Dunstable, MA	MA DFG
1643	Bennetts Brook, Rt 2A xing downstream ~0.2mi W of Willow Rd, Ayer/Littleton, MA	MA DFG
1644	Reed Brook, N. Main St upstream. Next to Norman Day School, Westford, MA	MA DFG
1645	Stony Brook, Stony Brook Rd downstream, next to RR tracks, Westford, MA	MA DFG
1646	Stony Brook, Brookside Rd upstream, Westford, MA	MA DFG
1649	Cobbler Brook, Harriman Rd downstream 0.3mi N of Highland St, Merrimac, MA	MA DFG
1650	Cobbler Brook, Highland St xing upstream 0.3mi N of Harriman Rd, Merrimac, MA	MA DFG

Station ID	Location Description	Source
1651	Little River, Rosemont St xing upstream E of RR tracks, Haverhill, MA	MA DFG
2.7	Merrimack River, Newburyport WWTP	MRWA
3.6	Merrimack River, Cashman Park	MRWA
3.8	Merrimack River, North Boat	MRWA
4.4	Merrimack River, Yankee	MRWA
6.8	Merrimack River, PowWow	MRWA
8.3	Merrimack River, Artichoke	MRWA
9.4	Merrimack River, Indian RIver	MRWA
10.6	Merrimack River, Cobbler's Brook	MRWA
14.1	Merrimack River, North Canal	MRWA
16.8	Merrimack River, Johnson	MRWA
17.8	Merrimack River, Haverhill WWTP	MRWA
19.1	Merrimack River, Little River	MRWA
22.3	Merrimack River, Creek Brook	MRWA
25.6	Merrimack River, Lucent	MRWA
26.9	Merrimack River, Lawrence WWTP	MRWA
28.2	Merrimack River, Spickett River	MRWA
29.1	Merrimack River, Below Essex Dam	MRWA
29.6	Merrimack River, Above Essex	MRWA
31.4	Merrimack River, Methuen Intake	MRWA
32.2	Merrimack River, Bartlett	MRWA
33.4	Merrimack River, Fish Brook	MRWA
35.1	Merrimack River, Gravel Pt	MRWA
36.3	Merrimack River, Trull Brook	MRWA
37.9	Merrimack River, Duck Island	MRWA
41.1	Merrimack River, Falls	MRWA
42.4	Merrimack River, Rourke	MRWA
43.4	Merrimack River, Stoney	MRWA
43.6	Merrimack River, Intake	MRWA
46.4	Merrimack River, Lawrence	MRWA
47.3	Merrimack River, Rte. 113	MRWA
48.9	Merrimack River, Limon Brook	MRWA
49.6	Merrimack River, NH Border	MRWA

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2004 Merrimack River Watershed Fish Population Assessment

Robert J. Maietta
Jane Ryder
Watershed Planning Program
Worcester, MA

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Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Ian Bowles, Secretary
Department of Environmental Protection
Laurie Burt, Commissioner
Bureau of Resource Protection
Glenn Haas, Acting Assistant Commissioner
Division of Watershed Management
Glenn Haas, Director

Introduction

Fish population surveys were conducted at sixteen stations in the Merrimack River Watershed in Massachusetts using techniques similar to Rapid Bioassessment Protocol V as described originally by Plafkin et al. (1989) and later by Barbour et al. (1999) (See Figure 1). Standard Operating Procedures are described in *Fish Collection Procedures for Evaluation of Resident Fish Populations* (MassDEP 2006 CN 75.1). Surveys also included a habitat assessment component modified from that described in Barbour et al (1999).

Methods

Fish populations in the Merrimack River watershed were sampled during August and September of 2004 by electrofishing using a Smith Root Model 12 battery powered backpack electrofisher. A reach of between 80m and 100m was sampled by passing a pole-mounted anode ring, side to side through the stream channel and in and around likely fish holding cover. All fish shocked were netted and held in buckets. Sampling proceeded from an obstruction or constriction, upstream to an endpoint at another obstruction or constriction such as a waterfall or shallow riffle. Following completion of a sampling run, all fish were identified to species, measured, and released. Results of the fish population surveys can be found in Table 1. It should be noted that young-of-the-year (yoy) fish from most species (with the exception of salmonids) are not targeted for collection. Young-of-the-year fishes that are collected are noted in Table 1.

Habitat Assessment

An evaluation of physical habitat quality is critical to any assessment of ecological integrity (Karr et al. 1986; Barbour et al. 1999). Habitat assessment supports understanding of the relationship between physical habitat quality and biological conditions, identifies obvious constraints on the attainable potential of a site, assists in the selection of appropriate sampling stations, and provides basic information for interpreting biosurvey results (US EPA 1995). Before leaving the sample reach habitat qualities were scored using a modification of the evaluation procedure in Barbour et al. (1999). The matrix used to assess habitat quality is based on key physical characteristics of the water body and riparian area. Most parameters evaluated are instream physical attributes often related to overall land use and are potential sources of limitation to the aquatic biota (Barbour et al. 1999). The ten habitat parameters are as follow: instream cover for fish, epifaunal substrate, embeddedness, sediment deposition, channel alteration, velocity/depth combinations, channel flow status, right and left (when facing downstream) bank vegetative protection, right and left bank stability, right and left bank riparian vegetative zone width. Habitat parameters are scored, totaled, and, when appropriate, compared to a reference station to provide relative habitat ranking (See Table 2).

Data Analysis

The RBP V protocol (Plafkin et al. 1989 and Barbour et al. 1999) calls for the analysis of the data generated from fish collections using an established Index of Biotic Integrity (IBI) similar to that described by Karr et al. (1986). Since no formal IBI for Massachusetts currently exists, the data provided by this sampling effort were used to qualitatively assess the general condition of the resident fish population as a function of the overall abundance (number of species and individuals) and species composition classifications listed below (See Tables 1 and 2).

1. Tolerance Classification - Classification of tolerance to environmental stressors similar to that provided in Plafkin et al. (1989), Barbour et al. (1999), and Halliwell et al. (1999). Final tolerance classes are those provided by Halliwell et al. (1999).

2. Macrohabitat Classification – Classification by common macrohabitat use as presented by Bain and Meixler (2000) modified regionally following discussions between MassDEP and MA Division of Fish and Game (DFG) fishery biologists.

3. Trophic Classes - Classification which utilizes both dominant food items as well as feeding habitat type as presented in Halliwell et al.(1999).

Station Habitat Descriptions and Results

Tadmuck Brook (TA01) upstream from Lowell Road in Westford

Tadmuck Brook is a small second order stream with a drainage area of approximately 4.7 km^2. It was sampled on the south side of Lowell Road just upstream of a breached dam. Eight of ten habitat parameters scored in the "optimal" category. Velocity-depth combinations and channel flow status scored "marginal" and "poor" respectively. This appeared to be due to very low flows on the date of the sampling. The final habitat score was 161 (See Table 2). The watershed upstream of the sampling station is a mix of forest, forested wetland, and medium density residential.

Fish species captured in order of abundance included brown bullhead *Ameiurus nebulosus*, fallfish *Semotilus corporalis*, and redfin pickerel *Esox americanus*. Although fish habitat was rated as "optimal" only six fish were collected. All fish present are classified as being either tolerant or moderately tolerant of pollution, however, water quality data (temperature, dissolved oxygen, and pH) collected by DWM during 2004 appeared normal and met Class B standards (MassDEP 2006).

It should be noted that benthic macroinvertebrate assessment revealed an invertebrate community described as being "quite healthy" (Mitchell 2007). It is unclear why there are so few fish present in Tadmuck Brook, however, flow conditions on the date of the sampling suggest that periodic low flows may be an issue. Future monitoring should include re-sampling TA01 and sampling an additional station upstream.

Bridge Meadow Brook (BR01) downstream from Tyngsborough Elementary School access road in Tyngsborough

The sampled reach of this second order stream was of low gradient and contained a mix of riffles, pools, and shallow runs. The terminal end of the reach was located just downstream of a beaver pond. Three of the seven primary habitat parameters scored low in the "optimal" category. Instream cover for fish and channel alteration, scored "sub-optimal". Velocity depth combinations and channel flow status scored in the "marginal" category. All secondary parameters scored "optimal" except for riparian vegetative zone width in the left zone, which scored "sub-optimal". The final habitat score was 150 (See Table 2). The watershed upstream of the sampled reach is mostly newer medium density residential developments. The southern third of the watershed is a large forested wetland and there are also a number of small ponds and beaver ponds located a short distance upstream from the sampled location. The upstream drainage area is approximately 8.2 km^2.

Fish species captured in order of abundance included yellow bullhead *Ameiurus natalis*, pumpkinseed *Lepomis gibbosus*, golden shiner *Notemigonus crysoleucas*, redfin pickerel *Esox americanus*, largemouth bass *Micropterus salmoides*, chain pickerel *Esox niger*, bluegill *Lepomis macrochirus*, and yellow perch *Perca flavescens*. All fish collected are classified as tolerant or moderately tolerant macrohabitat generalists. Flow was extremely low on the date of the sampling, and most fish were captured in the one large pool located just downstream of the road at the terminal end of the sampled reach. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) was collected by DWM on three dates during 2004. Dissolved oxygen concentrations were below Class B criteria on two of the sampling dates. (MassDEP 2006).

The overall low numbers of fish and the absence of fluvial fishes is troubling. It is possible that periodic low flow events related to the beaver activity may have resulted in the loss of fluvial fishes with re-population being hindered due to the upstream impoundments. Low dissolved oxygen concentrations and fish migrating downstream from the ponds may preclude a balanced fish community at this location. In light of the large amounts of recent development within the watershed, and the recent beaver activity, it is unlikely that Bridge Meadow Brook will rebound any time soon. Future monitoring should include re-sampling BR01 and sampling additional stations especially if there is a reduction in beaver activity.

Deep Brook (DBR05) downstream of Ledge Road in Chelmsford

The sampled reach of this first order stream was a moderate to high gradient reach and contained a mix of riffles, runs, and pools. It should be noted that flows were very low on the date of the sampling. In addition to this reach, an additional reach located upstream was qualitatively sampled specifically to look for wild brook trout.

Only two of the seven primary habitat parameters scored in the "optimal" category. Embeddedness and velocity-depth combinations scored "sub-optimal". Epifaunal substrate, channel flow status, and sediment deposition scored "marginal". All secondary parameters scored "optimal" except for riparian vegetative zone width in the left zone, which scored "sub-optimal". This sub-optimal score was due to residences. The lower-most section of the sampled reach was heavily sedimented. The final habitat score was 140 (See Table 2). The watershed upstream of the sampled reach is mostly medium density residential (newer construction), forested, and mining land uses. The drainage area upstream of the sampled location was approximately 1.4 km^2.

Fish species captured in order of abundance included banded sunfish *Enneacanthus obesus*, pumpkinseed, redfin pickerel, golden shiner, yellow bullhead, chain pickerel, and bluegill. All fish collected are classified as tolerant or moderately tolerant macrohabitat generalists. Flow was extremely low on the date of the sampling. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) were collected by DWM on three dates during 2004. Although classified as a Class B, water quality easily met Class B coldwater fishery standards (MassDEP 2006). It should be noted that Deep Brook is classified as a Coldwater Fishery Resource (CFR) by MassWildlife (MassWildlife 2007).

Mass DEP DWM last sampled Deep Brook in 1990. At that time the fish population survey resulted in the collection of seventeen native brook trout. The absence of trout in 2004 is alarming, particularly in light of the cold well-oxygenated water available in Deep Brook. There has been a large amount of residential and road construction in the watershed in recent years and heavy sediments in pools and very low flows may be responsible for what seems to be the loss of brook trout. Additional fish population monitoring should be conducted to document the possible presence of naturally reproducing brook trout in other sections of Deep Brook.

Black Brook (BB05) upstream from Westford Street in Lowell

The sampled reach of this second order stream was a low to moderate gradient reach and contained a mostly shallow riffle and run habitat. Only one of seven primary habitat parameters (channel alteration) scored in the "optimal" category. Embeddedness , sediment deposition, and channel flow status scored "sub-optimal". Instream cover for fish, epifaunal substrate, and velocity-depth combinations scored "marginal". For secondary parameters, bank vegetative protection scored "sub-optimal" and "marginal" on the left and right banks respectively. Bank stability scored "sub-optimal", and riparian vegetative zone width scored "sub-optimal" and "poor" in the left and right zones respectively. The sub-optimal scoring in the secondary parameters are mostly the result of residential development on the right side of the brook and commercial development on the left. The final habitat score was 116 (the lowest of the 2004 Merrimack River Watershed sites).

Fish species captured in order of abundance included chain pickerel, yellow bullhead, and white sucker. All fish present are classified as being either tolerant or moderately tolerant of pollution; however, water quality data (temperature, dissolved oxygen, and pH) collected by DWM during 2004 appeared normal and met Class B standards (MassDEP 2006). Fish were also collected at BB05 and one other station on Black Brook in 1990.

Although equipment problems were noted during the 1990 fish survey, again very few fish were collected or observed. The low total fish abundance and relative absence of fluvial fish species despite what appears to be good water quality is most likely the result of the poor habitat noted at this station.

Peppermint Brook (PE01A) downstream of Lakeview Ave in Dracut

Peppermint Brook is a large first order stream of moderate gradient containing mostly shallow riffles, runs and pools. Flow was extremely low on the date of the survey and most water was contained in stagnant pools. The drainage area upstream from the sampling station is approximately 4.5 km^2. Three of seven primary habitat parameters scored in the "optimal" category. Epifaunal substrate, sediment deposition, and velocity-depth combinations scored "sub-optimal". Channel flow status scored "marginal". For secondary parameters, bank vegetative protection scored "optimal" and "sub-optimal" on the right and left banks respectively. Bank stability scored "marginal", and riparian vegetative zone width scored "optimal" and "sub-optimal" in the left and right zones respectively. The sub-optimal scoring in the secondary parameters are mostly the result of steep eroded banks on the left-hand side of the stream and banks with very little vegetation on both sides. The stream is noted as being "totally trashed". The final habitat score was 134, which is the third lowest score of the 2004 Merrimack Fish Population sites. The upper part of the watershed is forested with a little commercial landuse. The brook flows through a large wetland and then into a medium to high density residential neighborhood.

Although instream cover for fish was rated low in the "optimal" category (17), flows were very low on the day of the survey and silt in pools got stirred up during sampling, which caused visibility problems. Fish collection efficiency was estimated at around 50%. Fish species captured in order of abundance included yellow bullhead, fallfish *Semotilus corporalis*, pumpkinseed, white sucker, bluegill, largemouth bass, golden shiner and common shiner *Luxilus cornutus*. There were thousands of young-of-the-year fallfish also noted. Three fluvial species were collected, although yellow bullhead, a tolerant macrohabitat generalist, dominated the sample. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) were collected by MassDEP on three dates during 2004. Dissolved oxygen concentrations were below Class B criteria on one of the sampling dates. (MassDEP 2005 and 2006).

While the presence of three fluvial species is usually indicative of a stable flow regime, streamflow was extremely low on the date of the sampling and two of the three fluvial species were represented by just eleven individual fish. Sampling inefficiencies with regard to turbid conditions make it very hard to predict impacts but it seems that the deeper pools located within the sampled reach were definitely serving as refugia for fishes displaced from the dry stream. Future sampling should include stations located further upstream.

Trout Brook (TRB02) either side of Kenwood Street in Dracut

The sampled reach of this small second order stream was of moderate gradient and contained a mix of riffles, runs, and pools. Three of seven primary habitat parameters scored in the "optimal" category. Instream cover for fish scored "sub-optimal". Sediment deposition, velocity-depth combinations, and channel flow status scored "marginal". For secondary parameters, bank vegetative protection scored "sub-optimal". Bank stability scored "optimal" and "sub-optimal" on the left and right banks respectively and riparian vegetative zone width scored "marginal". The less-than-optimal scoring of secondary parameters is mostly due to the presence of residences on both sides of the brook. The pools downstream of Kenwood Street contained heavy deposits of fine silt. The final habitat score was 133 which was the second lowest of the 2004 Merrimack River watershed sites. (See Table 2). The Trout Brook watershed upstream from the sampled reach is approximately 3.2 km^2 and is a mix of forested, agricultural, medium density residential and commercial land-uses. Agricultural and residential land-uses predominate.

The fish community included only redfin pickerel. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) were collected by DWM on three dates during 2004. Although classified as Class B, water quality easily met Class B coldwater fishery standards (MassDEP 2006).

In light of the amount of sediment found in pools downstream of the road, erosion from the agricultural fields may be impacting the fish community at this site. Any future fish population monitoring should be concentrated further upstream and should include an expanded reconnaissance survey to search for trout.

Richardson Brook (RBR01A) upstream of Methuen Street in Dracut

The sampled reach of this third order stream was of moderate gradient and contained mostly riffle and run habitat. Four of seven primary habitat parameters scored in the "optimal" category. Channel alteration and channel flow status scored "sub-optimal", and velocity depth combinations scored "marginal". For secondary parameters, bank vegetative protection and bank stability scored "optimal". Riparian vegetative zone width scored "sub-optimal" and "poor on the right and left banks respectively. The poor scoring was due to the presence of a residential driveway that parallels the brook in the left riparian zone. The final habitat score was 155 (See Table 2). Just upstream from the sampled reach, Richardson Brook picks up flow from both an un-named tributary (which drains a wetland area) and from Trout Brook.
The watershed upstream from the sampling station is approximately 10.87 km^2 , includes Trout Brook, and is a mix of forested, agricultural, medium density residential and commercial land-uses.

Despite stable instream cover for fish in the form or boulders and rocks, only nine redfin pickerel and seven yellow bullhead were collected at RBR01A. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) collected by DWM during 2004 appeared normal and met Class B standards (MassDEP 2006).

Although riparian vegetative zone width scored poor on the left bank, instream cover for fish was rated low in the optimal category. The absence of fluvial fishes is surprising in light of the riffle run habitat that was present. The pond and wetland located just upstream may be influencing the fish population of Richardson Brook. Any future fish population monitoring should be concentrated further upstream and should included an expanded reconnaissance survey to search for trout or other fluvial fishes.

Trull Brook (TB02) downstream of River Road in Tewksbury

Trull Brook, a large second order stream, drains an area of approximately 11.2 km^2 . The brook drains a large wetland and it's watershed contains a mix of high and medium density residential, forested and open wetland, and recreational (golf courses) land uses. Trull Brook was sampled approximately one kilometer from it's confluence with the Merrimack River, just upstream from the golf course, between the golf course and River Road. The reach was of moderate gradient and contained a good mix of riffle run and pool habitat. All ten habitat parameters scored in the "optimal" category and the total habitat score of 185 was the highest of the 2004 Merrimack survey (See Table 2). It should be noted that there was a large dry erosion channel which joined the stream on the left bank which appeared to have originated as the result of the discharge of a storm drain off River Road. This channel has the potential of causing significant sedimentation in Trull Brook.

Despite excellent habitat and stable instream cover for fish in the form or boulders and rocks, only thirteen fish were collected at TB02. Fallfish (n=7) and American eel, both fluvial dependant species, dominated the fish sample. Other species collected included largemouth bass and golden shiner which are both considered macrohabitat generalists more common in lakes and ponds or slow moving stretches and backwaters of rivers and streams. Water quality data (temperature, dissolved oxygen, and pH) collected by DWM one occasion during 2004 appeared normal and met Class B standards (MassDEP 2006). It should be noted that the data were "qualified" for the following reason: "one or more methods….not followed" (MassDEP 2005).

Although the presence and dominance by fallfish, a fluvial species, suggests adequate flows, the relatively low number of fish collected is alarming. The potential impacts of the storm drain off River Road should be addressed in an effort to prevent excessive sedimentation of Trull Brook during heavy rain events. Future fish population monitoring should include re-sampling the aforementioned location and possibly an expanded reconnaissance survey as well.

Bartlett Brook (BA01A) upstream and downstream of Route 113 in Methuen

Bartlett Brook is a third order stream which has a number of ponds and a large wetland in the upper and middle part of its watershed respectively. The sampled reach is near the lower end of the watershed just upstream of Mill Pond. The watershed contains a mix of medium density residential, forested and agricultural land uses.

Four of seven primary habitat parameters scored in the "optimal" category. Channel alteration scored sub-optimal due to the presence of old and current bridge abutments in the middle of the reach. Velocity-depth combinations and channel flow status scored marginal due to a relative absence of deep water habitats and a large amount of exposed substrates. For secondary parameters, bank vegetative protection and bank stability scored "sub-optimal". Riparian vegetative zone width scored "sub-optimal" on the right bank and "poor" on the left bank due to the presence of residenential properties on both sides of the brook. It was noted that there was an eroding drainage ditch located on the upstream (north) side of Route 113 running into the brook from the east. The final habitat score was 141 which was in the lower 25 percent of scores for 2004 Merrimack River watershed sites. (See Table 2).

Although instream cover for fish scored low in the optimal category and electrofishing collection efficiency was estimated at 85%, only twenty-eight fish were collected at BA01. Yellow bullhead, a tolerant macrohabitat generalist, heavily dominated the sample (n=18). Although three fluvial species (American eel, tessellated darter, and redfin pickerel) were collected, they totaled only 5 fish. Other macrohabitat generalists included largemouth bass and pumpkinseed. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) collected by DWM during 2004 appeared normal and easily met Class B standards (MassDEP 2006).

The absence of deep water habitat and marginal channel flow status at BA01 suggest flow problems. The relatively low number of fluvial fish present support this assertion. The potential impacts of the drainage ditch include increased sedimentation of this reach and Mill Pond. Future fish population monitoring should investigate potential locations further upstream.

Fish Brook (FI01A and FI02) near confluence with Merrimack River upstream and downstream of footpath at sewer line crossing in Andover

The two sampled reaches of this large second order stream were of medium to high gradient and contained a mix of riffles, pools, and shallow runs. Both reaches were located just upstream from Fish Brooks' confluence with the Merrimack River. The watershed upstream of the sampled reaches is mostly forested with some medium density residential, commercial and transportation land uses. The southern (upper) third of the watershed drains Haggets Pond and a large wetland. The drainage areas upstream of FI01A and FI02 are 15.85 and 15.92 km^2 respectively.

Five of the six primary habitat parameters (epifaunal substrate not scored) scored in the "optimal" category at FI01A where sediment deposition scored high in the "sub-optimal" category. All six of the primary habitat parameters (epifaunal substrate not scored) scored in the "optimal" category at FI02. At FI01A all secondary parameters scored "optimal" on the left bank and "suboptimal" on the right due to the presence of recent pipeline or sewer line construction. At FI02 bank vegetative protection was "optimal" on both banks, bank stability scored high in the "suboptimal" category, and riparian vegetative zone width scored "optimal" and "marginal" in the left and right zones, respectively. This was due mostly to the presence of an access road on the right bank of Fish Brook at this location. The final habitat scores were 149 and 157 (out of a possible 180) at FI01A and FI02, respectively (See Table 2).

Despite excellent habitat and stable instream cover for fish, only thirteen fish were collected at FI01A and FI02 combined. American eel and redfin pickerel were collected at both station locations. In addition, three yellow bullhead and one young-of-the-year alosid *Alosa* sp. were also collected at FI02. Although American eel and redfin pickerel are both "fluvial" species, the paucity of fish was surprising. Although not collected at the same station as fish population assessment, pre-dawn water quality data (temperature, dissolved oxygen, and pH) collected by DWM on three occasions during 2004 revealed violations of the Class B warmwater standard for dissolved oxygen on all three sampling dates. It should be noted that two of the dissolved oxygen data points were "qualified" for the following reason: "one or more methods…not followed" (MassDEP 2006). Athough two of the three dissolved oxygen data points were qualified, they were very similar to the unqualified data point (MassDEP 2005).

The relatively low numbers of fish in Fish Brook may be the result of poor water quality. Low dissolved oxygen is most likely due to the large wetlands located upstream of FI01A and FI02. Future fish population monitoring should include re-sampling the aforementioned locations and possibly an expanded reconnaissance survey as well.

Bare Meadow Brook (BMB01A) downstream from Renfrew Street in Methuen

Bare Meadow Brook is a third order stream which flows north out of Methuen and then picks up considerable flow from Hawkes Brook before emptying into the Merrimack River near the Haverhill border and Kimball Island. Hawkes Brook drains wetlands in it's headwaters (and the westernmost part of the watershed) and land use in it's watershed is primarily forest and medium density residential. The Broad Meadow Brook watershed is a mix of forested, medium density residential, commercial, and industrial land uses. The drainage area upsteam of BMB01A was equal to that of EA01 at 18.3 km^2. these were the largest drainage areas of all sites surveyed. Five of seven primary habitat parameters scored in the "optimal" category. Epifaunal substrate and sediment deposition scored "sub-optimal". For secondary parameters, "bank vegetative protection" was optimal on both banks, "bank stability" scored "suboptimal" on both sides and "riparian vegative zone width" scored "optimal" and "sub-optimal" in the left and right riparian zones, respectively.

Although instream cover for fish was rated as being "optimal" the total number of fish collected was low (n=21). Fish collection efficiency was not estimated, however, it was noted that the water was highly colored and there were some deep pools. Fish species captured in order of abundance included blacknose dace, white sucker, American eel, common shiner, tessellated darter, and pumpkinseed. All species with the exception of pumpkinseed are considered to be tolerant to moderately tolerant "fluvial" species. This is indicative of a stable flow regime and a relative absence of ponds or impoundments within this sub-watershed. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) collected by DWM on three dates during 2004 appeared normal and met Class B standards (MassDEP 2005 and 2006).

The relatively low numbers of fish may be the result of poor sampling efficiencies. Future fish population monitoring should include re-sampling of BMB01 and possibly an expanded reconnaissance survey as well.

Creek Brook (CR01) upstream from Lowell Avenue in Haverhill

Creek Brook is a large second order stream which flows south as the outflow from Crystal Lake and then picks up considerable flow from West Meadow Brook before emptying into the Merrimack River upstream from Stanley Island in Haverhill. West Meadow Brook drains some wetlands in it's headwaters (and the westernmost part of the watershed) and land use in it's watershed is primarily forest and medium to high density residential. The Creek Brook watershed is mostly the same with some industrial and open space recreational (golf course) land uses as well. The drainage area upstream from the sampling station is approximately 14.4 km^2. Six of seven primary habitat parameters scored in the "optimal" category. Sediment deposition scored "sub-optimal". For secondary parameters, bank vegetative protection was optimal on both banks, bank stability scored "suboptimal" on both sides and riparian vegative zone width scored "optimal" and "sub-optimal" in the left and right riparian zones, respectively.

Instream cover for fish was rated as being “optimal” and the total number of fish collected about average for the survey (n=44). Fish collection efficiency was not estimated. The fish sample was heavily dominated by blacknose dace (n=23). Nine American eel and six white suckers were also collected. Redfin pickerel, pumpkinseed, brown bullhead and bluegill were present but were represented by only one or two fish each. The three most dominant species are considered to be tolerant to moderately tolerant “fluvial” species. This is indicative of a stable flow regime. A heavy dominance by blacknose dace can sometimes be indicative of nutrient enrichment but usually numbers of dace (and other fish) are much higher in those instances. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) were collected by DWM on three dates during 2004. Although classified as Class B, water quality easily met Class B coldwater fishery standards (MassDEP 2005 and MassDEP 2006).

Although water quality in Creek Brook met Class B coldwater fishery standards in 2004, there is no evidence to suggest that this brook contains trout or any other coldwater fishes, nor is it classified as a Coldwater Fishery Resource (CFR) by MassWildlife. Future fish population monitoring should include an expanded reconnaissance survey.

Johnson Creek (JC03A) downstream from Central Street Bridge in Groveland

The sampled reach of this large second order stream was of moderate gradient and contained a mix of mostly riffles and runs. Three of seven primary habitat parameters scored in the “optimal” category. Epifaunal substrate, embeddedness and velocity-depth combinations scored “sub-optimal”. Sediment deposition scored only “marginal”. For secondary parameters, bank vegetative protection and riparian zone width was “optimal” on both sides of the creek. Bank stability scored “marginal” on both sides due to steep banks. The final habitat score was 146 (See Table 2).

The watershed upstream of the sampled reach is mostly forested with some medium density residential and mining land use. There are two ponds upstream and one pond just downstream of the sampling station. Drainage area upstream from the sampling station is approximately 16.16 km^2.

Instream cover for fish was rated as being “optimal” but the total number of fish collected or observed was low (n=11). Fish collection efficiency was not estimated. The fish sample was heavily dominated by wild brook trout (n=9). One American eel and one yellow bullhead were observed and/or collected. Brook trout are an intolerant fluvial fish species that requires cold clean waters and are usually indicative of a stable flow regime. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) were collected by DWM on three dates during 2004. Although classified as a Class B, water quality easily met Class B coldwater fishery standards (MassDEP 2005 and MassDEP 2006).

Although multiple age classes of wild brook trout were present and water quality in Johnson Creek met Class B coldwater fishery standards in 2004, it is not currently listed as a Coldwater Fishery Resource (CFR) by MassWildlife or classified as a coldwater fishery by MassDEP. Future fish population monitoring should include an expanded reconnaissance survey for the presence of brook trout.

Argilla Brook (AR01) west of Baldwin Terrace in Groveland

The sampled reach of this second order stream was of moderate gradient and contained a diverse mix of riffles, runs, and pools. Four of seven primary habitat parameters scored in the “optimal” category. Embeddedness and channel alteration scored “sub-optimal”. Sediment deposition scored only marginal. For secondary parameters, bank vegetative protection scored “sub-optimal” and “marginal” on the left and right bank respectively. Bank stability scored “sub-optimal” and “marginal” on the right and left banks respectively. Riparian zone width was “sub-optimal” on both sides of the brook. The final habitat score was 147 (See Table 4). Heavily used trails and steep eroded banks contributed to the less than optimal conditions.

The watershed upstream of the sampled reach is a mix of forested, medium density residential, and mining land use. There is a large forested wetland in the headwaters and a ponded area located just

upstream from the sampling location. Drainage area upstream from the sampling station is approximately 5 km^2.

Instream cover for fish was rated as being "optimal" and the total of eighty-six fish were collected. Fish collection efficiency was not estimated. Fish species captured in order of abundance included fallfish golden shiner, blacknose dace, American eel, white sucker, pumpkinseed, common shiner, bluegill, sea lamprey *Petromyzon marinus*, and one each of redfin pickerel and yellow bullhead. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) were collected by MassDEP on three dates during 2004. Water quality met Class B warmwater fishery standards (MassDEP 2005 and MassDEP 2006).

Although the fish population included a number of golden shiner, a macrohabitat generalist, the majority of fish collected are classified as fluvial specialists/dependants. The dominance by fluvial species is indicative of a stable flow regime, however, the presence of five different macrohabitat generalists reflects the presence of the small pond and forested wetland located upstream. Bank stability and erosion appear to be of concern within this reach and management practices to minimize erosion should be investigated.

East Meadow River (EA01) downstream of cart road (Thompson Road) in Haverhill

The sampled reach of this third order stream was of moderate gradient and contained a mix of riffles, runs, and one deep pool. Three of six primary habitat parameters scored in the "optimal" category. Embeddedness, velocity-depth combinations, and channel flow status scored "sub-optimal". Epifaunal substrate was not scored. For secondary parameters, bank vegetative protection scored "optimal" and "sub-optimal" on the left and right bank, respectively. Bank stability and riparian vegetative zone width scored "optimal" on both banks/zones. The final habitat score was 153 of a possible 180 (See Table 4).

The watershed upstream of the sampled reach includes mostly forested and non-forested wetlands. There is also a small pond or impoundment located upstream from the sampling location. The drainage area is approximately 18.3 km^2.

Instream cover for fish was rated as being low within the "optimal" category and a total of sixty-one fish were collected. Fish species captured in order of abundance included bluegill, American eel, pumpkinseed, redfin pickerel, and one largemouth bass. Pre-dawn water quality data (temperature, dissolved oxygen, and pH) collected by DWM on three occasions during 2004 revealed violations of the Class B warmwater dissolved oxygen standard on all three sampling dates (MassDEP 2005 and MassDEP 2006). It should be noted that one of the dissolved oxygen data points was "qualified" for the following reason: "one or more methods….not followed". Athough one of the three dissolved oxygen data points was qualified, the data point was similar to the unqualified data point (MassDEP 2005).

The fish population was heavily dominated by macrohabitat generalists. The dominance by macrohabitat generalists reflects the presence of the small pond and non-forested wetlands located upstream. Future monitoring should be conducted at other stations in order to document the presence (if any) of fluvial species.

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Table 1. List of fish population biomonitoring station locations and fish population data for the 2004 Merrimack River Watershed survey.

Station Description	Date	Species Code[1]																	Comments
		BND	CS	FF	GS	AE	RFP	WS	BB	YB	CP	BS	SL	EBT	B	LMB	P	YP	TD	
TA01, Tadmuck Brook, Westford, upstream from Lowell Road reach beginning at breached dam and continueing 150 m upstream.	11 Aug 2004	-	-	2	-	-	1	-	3	-	-	-	-	-	-	-	-	-	-	
BR01, Bridge Meadow Brook, Tyngsborough, downstream from elementary school entrance road off Chestnut Road.	11 Aug 2004	-	-	-	7	-	7	-	-	14	1	-	-	-	1	3	12	1	-	Very little flow. Most fish collected from pool just downstream of road crossing. Sampling efficiencies estimated at 50% due to water color in pool..
DBR05, Deep Brook, Chelmsford, downstream of Ledge Road.behind houses off Dunstable Road. Upstream of un-named tributary.	11 Aug. 2004	-	-	-	3	-	4	-	-	3	1	24	-	-	1	-	14	-	-	Deep very fine silt noted in lower part of sampled reach.
BB05, Black Brook, Lowell, off of and adjacent to Montgomery Ave just downstream from golf course.	11 Aug. 2004	-	-	-	-	-	-	2	-	11	11	-	-	-	-	-	-	-	-	
PE01A, Peppermint Brook, Dracut, 200 meters downstream from Lakeview Ave. Reach extended to riffle located approx 100 m downstream of bridge.	12 Aug 2004	-	1	18*	1	-	-	9(1)	-	27	-	-	-	-	3(1)	2	16	-	-	Very little flow and fine sediment made water very turbid when sampling. Sampling efficiencies rated as poor (<50%). B less than 50 mm and WS less than 60 mm considered YOY
TRB02, Trout Brook, Dracut, upstream and downstream of Kenwood Sreet.	12 Aug 2004	-	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-	Shocking efficiency excellent, estimated pick-up 90%.

Table 1 (continued). List of fish population biomonitoring station locations and fish population data for the 2004 Merrimack River Watershed survey.

Station Description	Date	Species Code[1]																	Comments
		BND	CS	FF	GS	AE	RFP	WS	BB	YB	CP	BS	SL	EBT	B	LMB	P	YP	TD	
RBR01A, Richardson Brook, Dracut, reach beginning upstream of a new road off of Methuen Street	12 Aug. 2004	-	-	-	-	-	9	-	-	7(5)	-	-	-	-	-	-	-	-	-	Shocking efficiency very good, estimated pick-up 85%.. Bullhead less than 53 mm considered young of the year (YOY)
TB02, Trull Brook, Tewksbury, downstream of River Road reach beginning just upstream from golf course	19 Aug 2004	-	-	7	1	3	-	-	-	-	-	-	-	-	-	2	-	-	-	
BA01A, Bartlett Brook, Methuen, downstream and upstream of Rte 113	12 Aug. 2004	-	-	-	-	1	3	-	-	18	-	-	-	-	-	4	1	-	1	Shocking efficiency very good, estimated pick-up 85%.. One unidentified sunfish collected possibly a hybrid
FI01A, Fish Brook, Andover, near confluence with Merrimack River upstream of footpath at sewer line crossing.	19 Aug 2004	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	
FI02, Fish Brook, Andover, near confluence with Merrimack River downstream of footpath at sewer line crossing.	23 Sept 2004	-	-	-	-	2	3	-	-	3	-	-	-	-	-	-	-	-	-	One young of the year alosid also collected. High flows and dark colored water made collection difficult.
BMB01A, Bare Meadow Brook, Methuen, downstream from Renfrew Street.	17 Aug. 2004	6	-	-	-	5	-	5	-	-	-	-	-	-	-	-	1	-	(1)	Tesselated darter less than 40 mm considered young of the year
CR01, Creek Brook, Haverhill, up[stream from Lowell Avenue.	14 Aug 2004	23	-	-	-	9	2	6	1	-	-	-	-	-	1	-	2	-	-	
JC03, Johnson Creek, Groveland, downstream of Center Street bridge.	17 Aug. 2004	-	-	-	-	1	-	-	-	1	-	-	-	9	-	-	-	-	-	Multiple age classes of EBT appeared to be representative of a reproducing population
AR01A,Argilla Brook, Groveland, west of circle at end of Baldwin Terrace downstream of footpath and bridge.	17 Aug. 2004	13	5	17	15	12	1	8	-	1	-	-	3	-	5	-	6	-	-	

Table 1 (continued). List of fish population biomonitoring station locations and fish population data for the 2004 Merrimack River Watershed survey.

Station Description	Date	Species Code[1]																	Comments
		BND	CS	FF	GS	AE	RFP	WS	BB	YB	CP	BS	SL	EBT	B	LMB	P	YP	TD	
EA01, East Meadow River Haverhill beginning 150 m downstream of cartroad at end of Thompson Road	19 Aug 2004	-	-	-	-	20(5)	10	-	-	-	-	-	-	-	20(6)	(1)	11	-	-	AE, RFP, bluegill, and largemouth bass less than 100, 33, 40, and 65 mm respectively, considered young of the year

[1] SPECIES CODE | COMMON NAME | SCIENTIFIC NAME | TOLERANCE/ MACROHABITAT CLASSIFICATION

SPECIES CODE	COMMON NAME	SCIENTIFIC NAME	TOLERANCE/ MACROHABITAT CLASSIFICATION
AE	American eel	*Anguilla rostrata*	Tolerant / Fluvial dependant (Catadromous)
SL	sea lamorey	*Petromyzon marinus*	Moderately tolerant / Fluvial dependant (Anadromous)
BND	Eastern blacknose dace	*Rhinichthys atratulus*	Tolerant / Fluvial specialist
CS	common shiner	*Luxilus cornutus*	Moderately tolerant / Fluvial dependant
FF	fallfish	*Semotilus corporalis*	Moderately tolerant / Fluvial specialist
GS	golden shiner	*Notemigonus crysoleucas*	Tolerant / Macrohabitat generalist
WS	white sucker	*Catostomus commersonii*	Tolerant / Fluvial dependant
RFP	redfin pickerel	*Esox americana*	Moderately tolerant / Macrohabitat generalist
CP	chain pickerel	*Esox niger*	Moderately tolerant / Macrohabitat generalist
BB	brown bullhead	*Ameiurus nebulosus*	Tolerant / Macrohabitat generalist
YB	yellow bullhead	*Ameiurus natalis*	Tolerant / Macrohabitat generalist
EBT	brook trout	*Salvelinus fontinalis*	Intolerant / Fluvial Dependant
BS	banded sunfish	*Enneacanthus obesus*	Intolerant/ Macrohabitat generalist
B	bluegill	*Lepomis macrochirus*	Tolerant / Macrohabitat generalist
LMB	largemouth bass	*Micropterus salmoides*	Moderately tolerant / Macrohabitat generalist
P	pumpkinseed	*Lepomis gibbosus*	Tolerant / Macrohabitat generalist
YP	yellow perch	*Perca flavescens*	Moderately tolerant / Macrohabitat generalist
TD	tessellated darter	*Etheostoma olmstedi*	Moderately tolerant / Fluvial specialist

[2] number in parentheses indicate young-of-the-year (not included in count totals)

Table 2. . . Habitat assessment summary for fish population stations sampled during the 2004 Merrimack River Watershed fish population survey. For primary parameters, scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For secondary parameters, scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor. Refer to Table 1 for a listing and description of sampling stations.

Stations	Tadmuck Brook	Bridge Meadow Brook	Deep Brook	Black Brook	Peppermint Brook	Trout Brook	Richardson Brook	Trull Brook	Bartlett Brook	Fish Brook	Fish Brook	Bare Meadow Brook	Creek Brook	Johnson Creek	Argilla Brook	East Meadow Brook
Primary Habitat Parameters	**Score (0-20)**															
INSTREAM COVER (for Fish)	17	15	17	10	17	15	16	19	16	18	19	18	16	17	18	16
EPIFAUNAL SUBSTRATE	17*	16	6	10	11	16	20	16*	16*	N/A	N/A	15	19	13	17	N/A
EMBEDDEDNESS	18	16	12	13	17*	18	18	17	16	17	18	17	17	11	12	14
CHANNEL ALTERATION	18	15	20	16	19	17	15	19	15	18	18	19	19	20	13	19
SEDIMENT DEPOSITION	18	16	10	13	12	10	19	18	16	15	18	13	12	6	10	18
VELOCITY-DEPTH COMBINATIONS	10	10	15	8	11	10	10	19	10	17	18	20	16	15	19	15
CHANNEL FLOW STATUS	3	6	8	11	6	10	11	18	10	16	17	20	20	17	19	14
Secondary Habitat Parameters	**Score (0-10)**															
BANK VEGETATIVE PROTECTION left	10	9	9	7	7	8	9	10	8	9	9	9	10	9	7	10
BANK VEGETATIVE PROTECTION right	10	9	9	4	9	7	10	10	8	6	9	9	9	9	5	8
BANK STABILITY left	10	10	9	8	3	9	9	10	8	10	8	6	7	5	5	10
BANK STABILITY right	10	10	9	7	5	7	9	10	8	6	8	6	8	5	8	9
RIPARIAN VEGETATIVE ZONE WIDTH left	10	8	7	7	10	3	1	10	2	10	10	10	9	10	7	10
RIPARIAN VEGETATIVE ZONE WIDTH right	10	10	9	2	7	3	8	9	8	7	5	8	8	9	7	10
Total Score	**161**	**150**	**140**	**116**	**134**	**133**	**155**	**185**	**141**	**149****	**157****	**170**	**170**	**146**	**147**	**153****

N/A not assessed
* scores taken from benthic macroinvertebrate field sheets
** of a possible 180

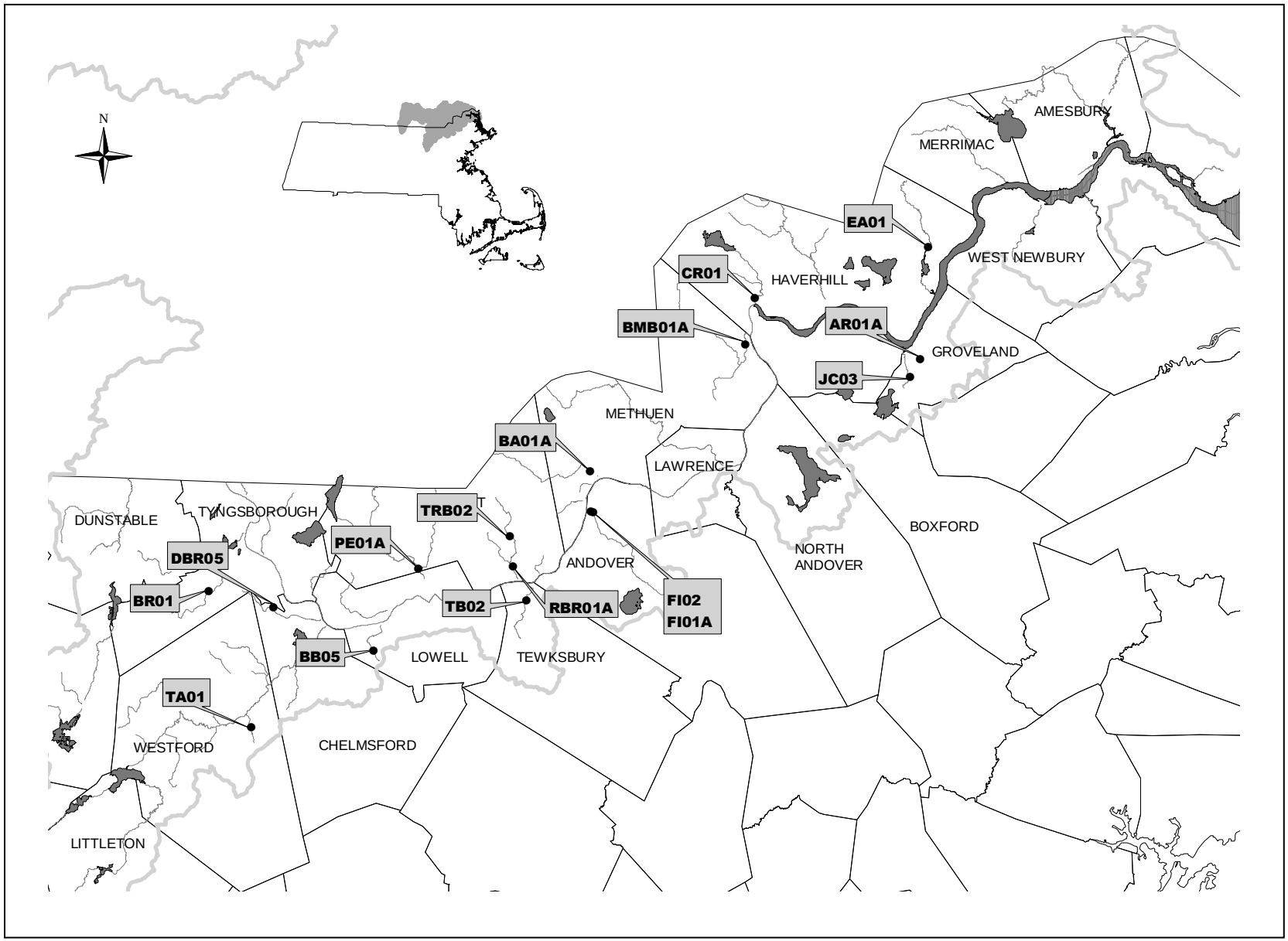

Figure 1. 2004 Merrimack River Watershed Fish Population Survey Station locations.

Technical Memorandum TM-84-6

Merrimack River Watershed
2004 Benthic Macroinvertebrate Assessment

Prepared by:

Peter Mitchell
Watershed Planning Program
Worcester, MA

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Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
Ian Bowles, Secretary
Department of Environmental Protection
Laurie Burt, Commissioner
Bureau of Resource Protection
Glenn Haas, Acting Assistant Commissioner
Division of Watershed Management
Glenn Haas, Director

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Tables and Figures

INTRODUCTION

Biological monitoring is a useful, cost-effective method of detecting anthropogenic impacts to the aquatic community. Resident biota (e.g., benthic macroinvertebrates, fish, periphyton) in a water body are natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration (Barbour et al. 1999, Barbour et al. 1995). Surveying and assessing these sentinel species and their habitats are the principle tools of biomonitoring.

As part of the Massachusetts Department of Environmental Protection/Division of Watershed Management's (MassDEP/DWM) 2004 Merrimack River watershed assessments, aquatic benthic macroinvertebrate biomonitoring and habitat assessment were conducted to evaluate the biological health of selected portions of the watershed. A total of 13 benthic stations were sampled to obtain evidence of potential stressor effects on resident biological communities. Biomonitoring station locations, along with station identification numbers and sampling dates, are noted in Table 1. Selected stations also appear in Figure 1.

Collection and analysis of macroinvertebrate data provide information necessary for making basin-wide aquatic life use-support determinations required by Section 305(b) of the Clean Water Act. All Merrimack River watershed biomonitoring stations were compared to a reference station (South Branch Souhegan River - station B0524) most representative of the "best attainable" (i.e., least-impacted) conditions in the watershed. The selection of the reference station to use for comparisons with study sites was based on comparability of stream morphology, flow regimes, and drainage area. Use of a watershed reference station is particularly useful in assessing nonpoint source pollution originating from multiple and/or unknown sources in a watershed (Hughes 1989). Both the quality and quantity of available habitat affect the structure and composition of resident biological communities. Effects of habitat features can be minimized by comparing collected data to reference stations with similar habitats (Barbour et al. 1999). Sampling highly similar habitats also reduces metric variability attributable to factors such as current speed and substrate type.

The main objectives of biomonitoring in the Merrimack River watershed were:

(a) To determine the biological health of unassessed rivers/streams within the watershed by conducting assessments based on biological (aquatic macroinvertebrates, fish, periphyton) communities; and

(b) To identify problem stream segments so that efforts can be focused on developing or modifying NPDES and Water Management Act permits, stormwater management, and control of nonpoint source (NPS) pollution.

During winter 2003-2004, problem areas, potential problem areas, and areas lacking historical data within the Merrimack River watershed were better defined through such processes as coordination with appropriate groups (MA DEP, USGS, EPA, and Watershed Associations), examining historical data (greater than five years old), identifying "unassessed" waters, conducting site visits, examining GIS datalayers, and reviewing NPDES and water withdrawal permits. Following these activities, the 2004 biological sampling and habitat assessment program was more closely focused and the study objectives better defined. Table 2 includes a summary of the perceived problems identified prior to the 2004 biomonitoring surveys of waters in the Merrimack River watershed (MassDEP, 2004).

Table 1. List of benthic biomonitoring stations sampled during the 2004 Merrimack River watershed survey, including station identification number, mile point (distance from mouth), upstream drainage area, station description, and sampling date.

Station ID	Km Point	Upstream Drainage Area (Km^2)	Merrimack River Watershed Benthic Station Description	Sampling Date
B0524*	1.63	22.35	South Branch Souhegan River, downstream from Jones Hill Road, 275 m downstream from unnamed tributary, Ashby, MA	27 July 2004
B0306	0.71	10.88	Richardson Brook, 200 m upstream from Methuen Street, Dracut, MA	30 July 2004
B0308	1.14	11.29	Trull Brook, 100 m downstream from River Road, Tewksbury, MA	30 July 2004
B0319	0.61	5.15	Martins Pond Brook, 25 m upstream from footpath extending from Loomis Lane, Groton, MA	29 July 2004
B0516	2.67	130.00	Powwow River, 125 m downstream from Rt. 150 (Main Street), off Mill Street, Amesbury, MA	23 August 2004
B0517	0.42	15.77	Fish Brook, ~300 m upstream from the dam at mouth of stream, south of Brundrett Ave., Andover, MA	2 August 2004
B0518	0.52	14.40	Creek Brook, 25 m upstream from West Lowell Ave., Haverhill, MA	2 August 2004
B0519	0.80	17.43	Bartlett Brook, 5 m upstream from Rt. 113 (North Lowell Street), Methuen, MA	2 August 2004
B0520	0.18	4.48	Peppermint Brook, ~100 m downstream from Lakeview Ave., Dracut, MA	30 July 2004
B0521	1.95	4.27	Black Brook, ~250 m upstream from Westford Street, below the golf course (Mt. Pleasant), Lowell, MA	29 July 2004
B0522	2.37	8.29	Bridge Meadow Brook, 80m downstream from road to Tyngsborough Elementary School (205 Westford Road), Tyngsborough, MA	29 July 2004
B0523	0.74	4.66	Tadmuck Brook, ~200 m upstream from Lowell Road, Westford, MA	29 July 2004
B0525	1.54	8.52	Bennets Brook, ~100 m downstream from Willow Road, Ayer, MA	27 July 2004

* Reference Station

Table 2. List of perceived problems identified prior to the 2004 Merrimack River watershed biomonitoring survey.

Waterbody	Known and Suspected Conditions/Problems
Martins Pond Brook	303d-siltation, organic enrichment (confirmation needed); misc. NPS*
Black Brook	303d-pathogens, turbidity, siltation, unknown toxicity (confirmation needed); Lowell landfill
Richardson Brook	303d-habitat alterations, noxious aquatic plants (confirmation needed); misc. NPS*
Trull Brook	303d-unknown toxicity (confirmation needed); golf course and misc. NPS*
Powwow River	303d-pathogens, suspended solids, turbidity, noxious aquatic plants; NPDES
Bennets Brook	Sand/gravel; misc. NPS*; Coldwater Fishery Resource
Tadmuck Brook	Highway runoff; misc. NPS*
Bartlett Brook	Miscellaneous NPS*
Creek Brook	Golf course; sand/gravel; misc. NPS*
Fish Brook	Flow modification; highway runoff; salt supply shed runoff; misc. NPS*
Bridge Meadow Brook	Impoundment effects; sand/gravel; highway runoff; misc. NPS*
Peppermint Brook	Urban runoff
South Branch Souhegan River	Coldwater Fishery Resource

(MassDEP, 2004)

*NPS = Nonpoint source(s) of pollution

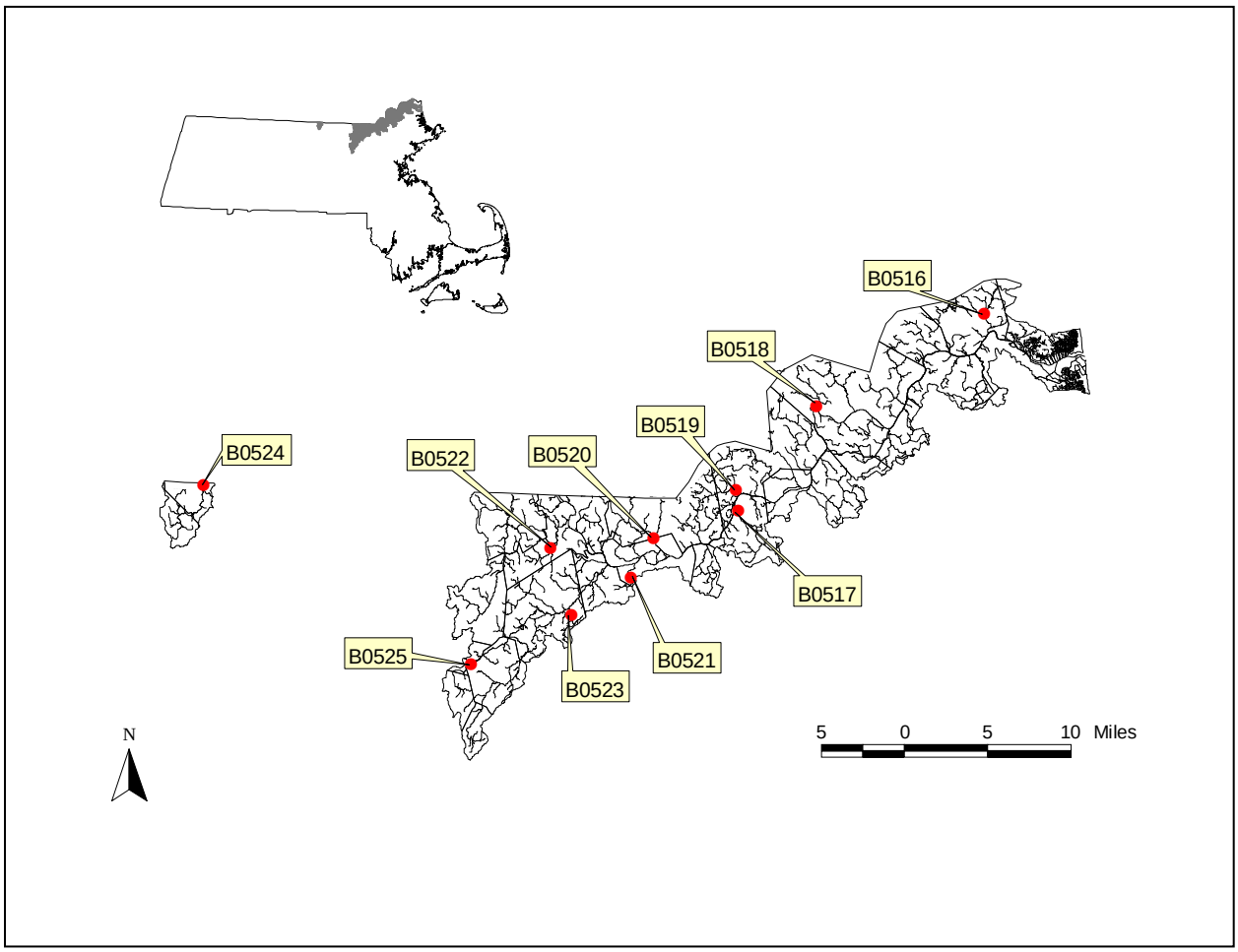

Figure 1. Location map of selected 2004 Merrimack watershed benthic sampling locations.

METHODS

MACROINVERTEBRATE SAMPLING

The macroinvertebrate sampling procedures employed during the 2004 Merrimack River watershed biomonitoring survey are described in Nuzzo (2002), and are based on US EPA Rapid Bioassessment Protocols (RBPs) for wadeable streams and rivers (Barbour et al. 1999). The macroinvertebrate collection procedure utilized kick-sampling, a method of sampling benthic organisms by kicking or disturbing bottom sediments and catching the dislodged organisms in a net as the current carries them downstream. Sampling activities were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (MassDEP 2004). Sampling was conducted by MassDEP/DWM biologists throughout a 100 m reach, in riffle/run areas with fast currents and rocky (boulder, cobble, pebble, and gravel) substrates—generally the most productive habitats, supporting the most diverse communities in the stream system. Ten kicks in squares approximately 0.46 m x 0.46 m were composited for a total sample area of about 2 m^2. Samples were labeled and preserved in the field with denatured 95% ethanol, then brought to the MassDEP/DWM lab for further processing.

MACROINVERTEBRATE SAMPLE PROCESSING AND ANALYSIS

The macroinvertebrate sample processing and analysis procedures employed for the 2004 Merrimack River watershed biomonitoring samples are described in the standard operating procedures (Nuzzo 2002) and were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (MassDEP 2004). Macroinvertebrate sample processing entailed random selection of specimens from the other materials in the sample until approximately 100 organisms (±10%) were extracted. Specimens were identified to genus or species as allowed by available keys, specimen condition, and specimen maturity. Taxonomic data were analyzed using a modification of Rapid Bioassessment Protocol III (RBP III) metrics and scores (Plafkin et al. 1989). Metric values for each station were scored based on comparability to the reference station, and scores were totaled. The percent comparability of total metric scores for each study site to those for a selected "least-impacted" reference station yields an impairment score for each site. The analysis separates sites into four categories: non-impacted, slightly impacted, moderately impacted, and severely impacted. Each impact category corresponds to a specific aquatic life use-support determination used in the Clean Water Act (CWA) Section 305(b) water quality reporting process—non-impacted and slightly impacted communities are assessed as "support" in the 305(b) report; moderately impacted and severely impacted communities are assessed as "Impacted." A description of the *Aquatic Life* use designation is outlined in the *Massachusetts Surface Water Quality Standards* (SWQS) (MassDEP 1996). Impacts to the benthic community may be indicated by the absence of generally pollution-sensitive macroinvertebrate taxa such as Ephemeroptera, Plecoptera, and Trichoptera (EPT); dominance of a particular taxon, especially the pollution-tolerant Chironomidae and Oligochaeta taxa; low taxa richness; or shifts in community composition relative to the reference station (Barbour et al. 1999). Those biological metrics calculated and used in the analysis of 2004 Merrimack River watershed macroinvertebrate data are listed and defined below (For a more detailed description of metrics used to evaluate benthos data, and the predicted response of these metrics to increasing perturbation, see Barbour et al. 1999):

1) Taxa Richness—a measure based on the number of taxa present. Generally increases with increasing water quality, habitat diversity, and habitat suitability. The lowest possible taxonomic level is assumed to be genus or species.

2) EPT Index—a count of the number of genera/species from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). As a group these are considered three of the more pollution sensitive aquatic insect orders. Therefore, the greater the contribution to total richness from these three orders, the healthier the community.

3) Hilsenhoff Biotic Index (HBI)—an index designed to produce a numerical value to indicate the level of organic pollution (Hilsenhoff 1987). Organisms have been assigned a value ranging from zero to ten based on their tolerance to organic pollution. Tolerance values (TV) currently used by MassDEP/DWM biologists were originally developed by Hilsenhoff and have since been supplemented by Bode et al. (1991) and Lenat (1993). A value of zero indicates the taxon is highly intolerant of pollution and is likely to be found only in pollution-free waters. A value of ten indicates the taxon is tolerant of pollution and may be found in highly polluted waters. The number of organisms and the individually assigned values are used in a mathematical formula that describes the degree of organic pollution at the study site. The formula for calculating HBI is:

$$HBI = \sum \frac{x_i t_i}{n}$$

where:

x_i = number of individuals within a taxon
t_i = tolerance value of a taxon
n = total number of organisms in the sample

4) Ratio of EPT and Chironomidae Abundance—a ratio using relative abundance of these indicator groups as a measure of community balance. Skewed populations having a disproportionate number

of the generally tolerant Chironomidae ("midges") relative to the more sensitive insect groups may indicate environmental stress.

5) Percent Dominant Taxon—the percent contribution of the numerically dominant taxon (genus or species) to the total numbers of organisms. A community dominated by few species indicates environmental stress. Conversely, more balance among species indicates a healthier community.

6) Ratio of Scraper and Filtering Collector Functional Feeding Groups—a ratio reflecting the community food base. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source (Barbour et al. 1999). Scrapers predominate when diatoms are the dominant food resource, and decrease in abundance when filamentous algae and mosses prevail. Filtering collectors thrive where filamentous algae and mosses are prevalent and where fine particulate organic matter (FPOM) levels are high.

7) Community Similarity—a comparison of a study site community to a reference site community. Similarity is often based on indices that compare community composition. Most Community Similarity indices stress richness and/or richness and abundance. Generally speaking, communities with comparable habitat will become more dissimilar as stress increases. In the case of the Merrimack River watershed bioassessment, an index of macroinvertebrate community composition was calculated based on similarity (i.e., affinity) to the reference community, expressed as percent composition of the following organism groups: Oligochaeta, Ephemeroptera, Plecoptera, Coleoptera, Trichoptera, Chironomidae, and Other. This approach is based on a modification of the Percent Model Affinity (Novak and Bode 1992). The reference site affinity (RSA) metric is calculated as:

   $100 - (\Sigma\ \delta \times 0.5)$

   where δ is the difference between the reference percentage and the sample percentage for each taxonomic grouping. RSA percentages convert to RBPIII scores as follows: <35% receives 0 points; 2 points in the range from 35 to 49%; 4 points for 50 to 64%; and 6 points for ≥65%.

HABITAT ASSESSMENT

An evaluation of physical habitat quality is critical to any assessment of ecological integrity (Karr et al. 1986; Barbour et al. 1999). Habitat assessment supports understanding of the relationship between physical habitat quality and biological conditions, identifies obvious constraints on the attainable potential of a site, assists in the selection of appropriate sampling stations, and provides basic information for interpreting biosurvey results (US EPA 1995). Before leaving the sampling reach during the 2004 Merrimack River watershed macroinvertebrate biosurveys, habitat qualities were assessed using a modification of the evaluation procedure in Barbour et al. (1999). The matrix used to assess habitat quality is based on key physical characteristics of the water body and related streamside features. Most of the parameters related to instream physical attributes are influenced by overall land-use and are potential sources of limitation to the aquatic biota (Barbour et al. 1999). The ten habitat parameters are as follow: instream cover, epifaunal substrate, embeddedness, sediment deposition, channel alteration, velocity/depth combinations, channel flow status, right and left (when facing downstream) bank vegetative protection, right and left bank stability, right and left bank riparian vegetative zone width. Habitat parameters are scored, totaled, and compared to a reference station to judge the probable magnitude of the influence of any detected habitat differences on the RBP outcome.

QUALITY CONTROL

Field and laboratory Quality Control (QC) activities were conducted in accordance with the Quality Assurance Project Plan (QAPP) for biomonitoring and habitat assessment (MassDEP 2004). Quality Control procedures are further detailed in the standard operating procedures (Nuzzo 2002).

RESULTS AND DISCUSSION

Based on USGS surface-water runoff data (USGS 2005), streamflow conditions appeared "normal" (neither drought, nor flood conditions) during the month of benthic sample collection (July, 2004). As a result, the resident benthic communities were not under stress from either drought conditions or flood conditions during the sampling period.

B0524 – SOUTH BRANCH SOUHEGAN RIVER

Downstream from Jones Hill Road, 275m downstream from unnamed tributary, Ashby, MA

Habitat

The South Branch of the Souhegan River is classified as a Class B water as defined in the Massachusetts Surface Water Quality Standards (MassDEP 1996). The watershed contributing to B0524 is 22.35 km^2. The waters that make up the South Branch of the Souhegan River begin in Stodge Meadow Pond, Marble Pond, and Ward Pond (Ashburnham, MA). These wetland-fed ponds flow into Watatic Pond. It is at the outfall of Watatic Pond where the South Branch of the Souhegan River begins its course as a named stream. The river flows in a northerly direction into New Hampshire. The Massachusetts portion of the watershed is heavily forested (and sparsely populated) and mostly lies within Ashby, MA. Three gravel pits abut the river upstream of the benthic monitoring station (one of which is along an unnamed tributary in Ashby, MA). There are also several wetlands that either contribute to the flow of the South Branch of the Souhegan River, or through which the river flows. The river is of low to medium gradient; falling approximately 1.88 meters in the last kilometer upstream of the benthic monitoring station. The immediate area upstream of B0524 is heavily forested, and provides 100% canopy cover to the sampled reach.

The within-reach habitat conditions at B0524 were the fourth best of the 13 stations examined within the Merrimack River watershed in 2004 (163/200) (Table A3). Naturally occurring sand deposits increased the Sediment Deposition and embedded much of the existing cobble and boulder. This reduced the Instream Cover and Epifaunal Substrate to "suboptimal" conditions. Also, there were no deep pools and a reduction in instream flow further reduced the instream habitat conditions.

Riparian and bank conditions were all optimal. The native vegetation along the banks, and within the riparian zone included, Hemlock (*Tsuga canadensis*), Red Maple (*Acer rubrum*), Hobble Bush (*Viburnum alnifolium*), Mountain Laurel (*Kalmia latifolia*), Wintergreen (*Gaultheria procumbens*), Partridgeberry (*Mitchella repens*), and ferns (Pteridophyta). Hemlock was the dominant tree species within the riparian zone. These trees greatly reduced the development of an understory.

The stream width (within the 100 meter sampled area) was estimated at seven meters. The depths at the riffles were estimated as 0.2 meters. The depths at the "run" habitats were estimated as 0.3 meters, and the depths at the pools were estimated as 0.5 meters. There was no evidence of NPS (NonPoint Source) pollution to the reach. The water was clear, but had a tea-stained color to it. This coloration points towards the influence of the contributing wetlands upstream of B0524. The inorganic substrate components were 50% cobble, 30% gravel and sand, and 20% boulder. The organic substrate components were 98% Coarse Particulate Organic Matter (CPOM, particles >1mm) and 2% Fine Particulate Organic Matter (FPOM, particles <1mm). Brown, thin-film algae coverage (within the reach) was estimated at 60%.

Benthos

The sample collected from the South Branch of the Souhegan River represents the reference condition in the Merrimack watershed to which all other Merrimack benthic samples are compared. It was decided to use this station as a reference because the watershed contributing to this station appears to have the least amount of human impact. The community observed within the collected sample was dominated by Filtering-Collectors (63%). The dominant taxon was *Hydropsyche betteni* (16.5% - a Filtering-Collector). While this is a relatively low percent contribution of a single taxon, the dominance of Filter – Collectors

alludes to ample suspended particulates (FPOM) to support the Filtering-Collector FFG. Although CPOM was the dominant organic substrate component observed within this reach, it is possible that, due to the stream velocities, FPOM was not being deposited within this reach. It is also possible that there is an increase in nutrient inputs from the upstream wetlands (DeBusk 1999) and the two small impoundments.

In comparison to all other stations, B0524 had the lowest Hilsenhoff Biotic Index (HBI = 4.51). This indicates that the resident benthic community was populated with the most sensitive fauna of all stations examined. The EPT Index (number of EPT taxa) was eight, second only to Tadmuck Brook which had nine EPT taxa. EPT taxa are among the most sensitive to lower dissolved oxygen levels associated with organic pollution. The relatively low HBI and high EPT Index metrics supports B0524's designation as a reference station. Other metrics that performed well relative to the other stations were Taxa Richness (23) and Percent Dominant Taxon (16%).

B0306 – RICHARDSON BROOK

200 meters upstream from Methuen Street, Dracut, MA

Habitat

Richardson Brook begins its course at the outlet of an unnamed pond south of Marsh Hill Road, Dracut and flows through many wetlands, forested areas, pastures and residential areas where it receives flow from Trout Brook and three unnamed streams. Examination of aerial photographs of the Richardson Brook watershed (10.88 km^2) reveals that the riparian areas appear to contain most of the Forest cover. This condition should protect the water quality of Richardson Brook by providing a buffer to potential human perturbations, such as those associated with residential development within the watershed. Also, the photographs reveal that most of the tributary ponds are shallow, with abundant aquatic plant growth. It is possible that these ponds and wetlands are sources of nutrients and the observed tannins within the water column at B0306. Richardson Brook is of moderate gradient, dropping 1 meter over the one-kilometer reach upstream from B0306. The sampled reach is forested and provides 85% canopy cover. A shallow pond exists approximately 50 meters upstream of the sampling reach.

The within-reach habitat conditions at B0306 resulted in the second highest habitat score of the 13 Merrimack stations examined in 2004 (166/200). Channel Alteration was observed to be "suboptimal", due in part to the presence of an historic retaining wall along the left bank. The lack of depth reduced the Velocity-Depth Combinations score to "marginal", and the proximity of a driveway along the left bank reduced the left-bank Riparian Vegetative Zone Width score to "poor". All other habitat parameters scored within the optimal range. Riparian vegetation included: maple (*Acer* sp.), birch (*Betula* sp.), oak (*Quercus* sp.), white pine (*Pinus strobus*), elderberry (*Sambucus canadensis*), grape (*Vitis* sp.), fern (Pteridophyta), joe-pye weed (*Eupatorium* sp.), jewel weed (*Impatiens capensis*), skunk cabbage (*Symplocarpus foetidus*), and purple loosestrife (*Lythrum salicaria*). Maple was the dominant tree within the riparian zone.

The stream width within the sampled reach was estimated at three meters. The depth was 0.2 meters in the riffles as well as in the runs and pools. The adjacent driveway was the only observed potential source of NPS pollution. The water was clear, but exhibited a tan ("tea-stained") color resulting from upstream shallow ponds and wetlands. The inorganic substrates within the sampled reach were comprised of Boulder (40%), Cobble (40%), Pebble (10%), and Gravel (10%). The organic portion of the substrates was comprised of both CPOM (80%), and FPOM (20%). Filamentous green algae covered less than 5% of the substrates within the reach, yet other aquatic vegetation (mosses) covered 60% of the instream habitat.

MassDEP sampled Richardson Brook in 1990 (MassDEP 1990). At that time, concerns were raised regarding potential NPS problems, such as abbreviated riparian buffers. Some of these conditions (such as the nearby driveway along the left bank) still existed in 2004. However, the other potential impacts were not observed.

Benthos

The benthic macroinvertebrate community in Richardson Brook received a total metric score of 30, representing 71% comparability to the reference site and resulting in an assessment of "slightly impacted" (Table A2). The dominant Functional Feeding Group (FFG) that made up the benthic sample from B0306 was the Filtering-Collector (61%) and the subdominant FFG was the Gathering-Collector (16%). The numerically dominant taxon was *Chimarra* sp. (28%). The dominance of the Filtering-Collectors is evidence of the effect that upstream wetlands may be having upon the food resources available at the sampled location. As noted above, the "tea-stained" water is further evidence of the presence of upstream wetlands.

The sample collected from Richardson Brook had a HBI value of 4.84, which indicates a slight increase in the number of pollution tolerant taxa when compared with the reference station B0524 (South Branch Souhegan River). The Taxa Richness at Richardson Brook was 18 which, along with Bartlett Brook and the powwow River, is the third highest of the 13 stations sampled. The EPT richness (5) was fourth highest of all stations; however, no Ephemeroptera or Plecoptera taxa were represented. By contrast, eight different EPT taxa (two Ephemeroptera, two Plecoptera, four Trichoptera) were represented in the reference station sample. The EPT / Chironomidae Ratio at B0306 was 3.11 (more than three times as many EPT as Chironomidae).

A benthic invertebrate sample was collected from this station as part of the 1990 biomonitoring survey (MassDEP 1990). Organisms were identified to the family level, only. Whereas the 1990 sample contained 16 different families, only nine families comprised the 2004 sample. Despite the decline in family-level richness at this station, HBI values were comparable. The family-level HBI values were 4.27 and 4.21 in 1990 and 2004, respectively. Six families from the EPT orders were represented in the 1990 sample, whereas only three EPT families were present in the 2004 sample. Among the taxa common to both samples, the family Elmidae showed the most dramatic shift in density. One Elmidae was collected in 1990, and 19 Elmidae were collected in 2004.

B0308 – TRULL BROOK
100 meters downstream from River Road, Tewksbury, MA

Habitat

Trull Brook is classified as a Class B waterbody (MassDEP 2001). From its headwaters east of Kennedy Road in Tewksbury to station B0308 Trull Brook flows a distance of 5.23 kilometers and drains 11.29 km^2 of watershed. From its origin the brook flows generally north into Great Swamp, crosses under Route 495 and enters another wetland area. From there Trull Brook flows under River Road where the gradient increases as the stream enters a golf course. Over all, Trull Brook may be considered of low gradient. The stream drops 1.9 meters in the first kilometer upstream from B0308. The 1999 Merrimack River Watershed Water Quality Assessment Report (MassDEP 2001) states that the top three landuse categories within the Trull Brook watershed are Residential (35%), Forest (30%), and Open land (12%).

The within-reach habitat conditions at B0308 received a habitat score of 149/200. Sand, gravel, and fine sediment deposits were noted within the reach. This condition reduced the available epifaunal habitat and resulted in a suboptimal rating of the Sediment Deposition parameter. The Channel Flow Status was rated as "marginal" with little more than half of the available channel containing water. The Right Bank Vegetative Protection score was 5/10. This marginal score was due to a lack of vegetation and frequent areas of bare soil along that bank. The Right Bank Stability score was only marginal (4/10). There was much erosion observed along the right bank. However, the Left Bank conditions were optimal. The Velocity–Depth Combinations were suboptimal, as there were no fast/deep habitats.

The vegetation within the riparian zones included: maple (*Acer* sp.), ash (*Fraxinus* sp.), sumac (*Rhus* sp.), grape (*Vitis* sp.), Japanese knotweed (*Polygonum cuspidatum*), elderberry (*Sambucus* sp.), jewelweed (*Impatiens capensis*), fern (Pteridophyta), poison ivy (*Rhus radicans*), and skunk cabbage (*Symplocarpus foetidus*). The riparian zone (adjacent to the sampled reach) provided 50% canopy cover. Much of the shading provided to the stream was due to shrubs, and not the trees. Aquatic plants covered 5% of the

sampled reach, and consisted entirely of mosses. Algae coverage was estimated at 40%, and consisted of thin-film algae.

The stream width was estimated at two meters. The stream depth was estimated at 0.25 meters in the riffles and 0.4 meters in the pools. There were some potential sources of non-point source pollution (road crossings, adjacent houses, golf courses), and some obvious sources of NPS pollution (trash). The water was colorless, with no odor, but slightly turbid. The inorganic substrate components were 5% boulder, 30% cobble, 40% pebble, 10% gravel, and 15% sand. The organic substrate components consisted of 60% CPOM and 40% FPOM.

Benthos

The benthic macroinvertebrate community in Trull Brook received a total metric score of 26, representing 62% comparability to the reference site and resulting in an assessment of "slightly impacted" (Table A2). The benthic invertebrate assemblage at B0308 was dominated by Filtering-Collectors (60%); *Hydropsyche* sp. was the dominant taxon collected (49%). It is likely that the upstream wetlands have significant influence over the benthos at this station. Seventeen different taxa were collected and the EPT Index at station B0308 was four. The EPT/Chironomidae metric was 4.67. At first glance, this condition appears very good (the EPT/Chironomidae metric was 1.11 at the reference site). However, the hyperdominance of *Hydropsyche* sp. leads to an inflated EPT/Chironomidae metric value. The HBI metric at B0308 was 4.80, third best HBI value of the 13 stations examined.

Biomonitoring was conducted at this same site on Trull Brook in 1990 (MassDEP 1990). The taxonomy for the 1990 survey was performed at the family level. Ten families were collected, and the family level biotic index was 4.19. The 2004 survey results exhibited 11 families, with only four taxa in common with the 1990 survey. The 2004 family-level biotic index score was 4.68. One of the most noteworthy differences between the two surveys was the loss of stoneflies (Perlidae – a pollution-sensitive family) from the 2004 sample.

B0319 – MARTINS POND BROOK

25 meters upstream of footpath extending from Loomis Lane, Groton, MA

Habitat

Martins Pond Brook drains approximately 5.15 km^2. Martins Pond Brook begins at the outfall of Martin's Pond in Groton. It flows past a series of hills, and as it passes north of Brown Loaf, it loses much of its gradient. The brook then enters an area of wetlands just upstream from the sampled station (B0319). The stream drops 8.6 meters through the one-kilometer reach immediately upstream of B0319, but the majority of that drop occurs near Brown Loaf, and not within the upstream wetland. The within-reach landuse was 95% forest and 5% residential. Trees provided 95% canopy cover to the sampled reach. However, vegetation within the wetland immediately upstream from B0319 provided little to no shading to that segment of Martins Pond Brook.

The total habitat score at B0319 was 143/200, placing it eighth of the 13 streams examined. The water quantity was greatly reduced during the sampling event, thus decreasing the Channel Flow Status metric to the marginal range. There were no deep habitats (either fast or slow), which reduced the Velocity – Depth Combinations to the marginal range, as well. The lack of deep habitats, reduced flows, and lack of refugia combined to reduce the Instream Cover to the marginal range. The above habitat constraints accounted for most of the reduction in the overall habitat score.

Riparian and bank vegetative conditions were all optimal, but Bank Stability was suboptimal. The vegetation within the riparian zone included: white pine (*Pinus strobus*), red maple (*Acer rubrum*), ash (*Fraxinus* sp.), willow (*Salix* sp.), jewelweed (*Impatiens capensis*), fern (Pteridophyta), cardinal flower (*Lobelia cardinalis*), and moss (Bryophyta). Aquatic vegetation covered approximately 5% of the available habitat and was made up of 50% rooted emergent plants [Arrow arum (*Peltandra virginiana*)], and 50% free-floating plants [watermeal (*Wolfia* sp.) and duckweed (*Lemna* sp.)]. Algae also covered

approximately 5% of the available habitat and included filamentous and thin-film growth forms. Both forms of algae were attached to the rock substrates within the pools.

The stream width at B0319 was estimated to be two meters. The depths ranged from 0.1 meters in the riffle zones, to 0.2 meters in the run zones, to 0.4 meters in the pools. The inorganic substrate components within the sampled reach consisted of 20% cobble, 40% pebble, 30% sand, and 10% silt. The organic substrates were observed to be 60% CPOM and 40% FPOM. The water was clear, with a slight tan color. This coloration is most likely due to the upstream wetlands. There were no odors from within either the riffles or the runs, but there was an odor associated with anaerobic processes within the pools. There were some obvious sources of NPS pollution - most significantly, a dirt-bike (or ATV) trail cutting through the streambed.

Biological sampling and habitat evaluations were performed at this same location in 1990 (MassDEP 1990). Comparable habitat observations were made during that survey. However, it appears that there was more water in the stream during the 1990 survey.

Benthos

The benthic macroinvertebrate community in Martins Pond Brook received a total metric score of 26, representing 62% comparability to the reference site and resulting in an assessment of "slightly impacted" (Table A2). The dominant functional feeding group at B0319 was the Gathering-Collectors, which accounted for 55% of the collected benthos. The numerically dominant taxon was the isopod *Caecidotea racovitzai racovitzai* (29%). The dominance by this feeding group (along with the tan water color and free-floating plants) is indicative of organic enrichment, possibly related to the presence of upstream wetlands.

Taxonomic Richness (number of different taxa) in the sample from B0319 was 14 and the Hilsenhoff Biotic Index was 6.61. The HBI value was the worst score of all 13 stations examined, indicating that the benthic community at this station was represented by relatively pollution-tolerant taxa. The EPT Index (three) was second lowest of the survey and consisted only of caddisflies (Trichoptera).

Nine macroinvertebrate families were collected during the 1990 biological survey performed at this same location (MassDEP 1990) compared with ten families in 2004. Only three families were common to both (Asellidae, Hydropsychidae, and Chironomidae). The family-level Hilsenhoff biotic index values were 5.28 and 6.33 in 1990 and 2004, respectively, indicating a marked increase in the number of pollution tolerant taxa represented in the sample from the more recent survey. No stoneflies or mayflies were collected during either survey.

B0516 – POWWOW RIVER

Powwow River, 125 meters downstream from Route 150 (Main Street), off Mill Street, Amesbury, MA

Habitat

This segment of the Powwow River is a Class B waterbody (MassDEP 2001), and has a 130 km^2 contributing watershed. The Powwow River flows out of Lake Gardner and through the center of Amesbury. It passes through an area of dense residential, commercial and historic industrial landuse. Along its course the river passes through two additional impoundments. Finally, the Powwow River flows under Main Street (Amesbury) where it enters the sampling reach. The river is considered to be high-gradient within this reach, and the sampling site is upstream from any tidal influence. This site is channelized, with large boulders stabilizing part of the right bank, and a brick and concrete wall along the left bank. The single line of trees on the right bank (and the industrial building on the left bank) provided only 35% canopy cover to the reach.

The within-reach habitat score (124/200) at B0516 was among the worst observed during the 2004 survey. Key reductions in the habitat score were the result of Channel Alteration. More than 80% of the stream reach had been channelized and disrupted, resulting in an assessment of "poor" for this feature. Although the Bank Vegetative Protection parameter scored in the optimal range for the right bank (more

than 90% of the bank was covered with naturally occurring vegetation), the left bank scored in the marginal range. The left bank was a brick and concrete wall (part of an old mill building), which provided no opportunity for natural plant growth but did provide stability to the left bank. However, the wall forces excessive flows towards the right bank. Some of the boulders along the right bank had shifted, and areas of erosion were observed along the right bank.

The Riparian Vegetative Zone Width was poor for both sides of the river. The vegetation observed along the right bank included: elm (*Ulmus* sp.), Norway maple (*Acer platanoides*), black locust (*Robinia pseudoacacia*), silver maple (*Acer saccharinum*), ash (*Fraxinus* sp.), poison ivy (*Rhus radicans*), bittersweet (*Celastrus* sp.), mountain ash (*Sorbus americana*), dogwood (*Cornus* sp.), Virginia creeper (*Parthenocissus quinquefolia*), jewelweed (*Impatiens capensis*), goldenrod (*Solidago* sp.), and grasses. There was very little understory, and all vegetation (except mown grasses) appeared only along the bank. There was no observed aquatic vegetation. Algae coverage was estimated at 80%. All algae were noted in the riffle zones, and were dominated by green filamentous forms.

Stream width was estimated at four meters. The water depths in riffles, runs and pools measured 0.2. 0.4 and 0.5 meters, respectively. Potential sources of NPS pollution included urban runoff, and much trash in the stream. The inorganic substrate components included 40% boulder, 40% cobble, 15% pebble, and 5% gravel and sand. The organic substrate consisted entirely of CPOM.

Benthos

The benthos assemblage in the powwow River at B0516 received a total metric score of 26, representing 62% comparability to the reference community and resulting in a bioassessment of “slightly impacted” (Table A2). While the total Taxa Richness was 18, the EPT Index was only four and the HBI was 5.55 indicating the presence of several pollution-tolerant taxa. No Plecoptera were collected. The Filtering-Collector functional feeding group (63%) dominated the sample collected from B0516, and *Hydropsyche betteni* was the most dominant taxon collected (34%). It is likely that the upstream impoundments, as well as urban runoff, are sources of nutrient additions to the river at this location (Mackay and Waters 1986, Whiles and Dodds 2002).

B0517 – FISH BROOK

Fish Brook, ~300 meters upstream from the dam at the mouth of the stream, south of Brundrett Avenue, Andover, MA

Habitat

Fish Brook begins it course to the Merrimack River within a wetland, south of Route 133 (Lowell Street) in Andover. The brook flows generally northwest through wetlands and under both interstate routes 93 and 495. MassHighways maintains a salt storage area within the cloverleaf of the route 495/93 intersection, and there is concern about the potential effects on surface waters from salt runoff (Fiorentino 2004). After crossing under Brundett Avenue, the stream increases velocity as the gradient increases near the mouth. It was in this area of higher gradient that the 2004 benthic sample collection occurred. A 15.8 km^2 watershed supplies the sampled reach.

The within-reach habitat conditions at B0517 were the second best of the 13 stations examined in 2004. The only measure that scored in the marginal range was the left bank Riparian Vegetative Zone Width. The low score for this measure was due to the recent “road” cut along the left bank. This “road” was covered with wood chips. The Channel Flow Status metric was rated as suboptimal. While this score indicates a reduction in instream flow, this station fared better than many others. It may be the case that the extensive upstream wetlands are acting as reservoirs, and slowly releasing their water to the stream over time.

The native vegetation within the riparian zone, included: hemlock (*Tsuga canadensis*), red oak (*Quercus rubra*), elm (*Ulmus* sp.), ash (*Fraxinus* sp.), witch hazel (*Hamamelis virginiana*), honeysuckle (*Lonicera* sp.), skunk cabbage (*Symplocarpus foetidus*), jewelweed (*Impatiens capensis*), and ferns (Pteridophyta). Hemlock dominated the left riparian zone. This greatly reduced the understory along the left side of the

brook. The vegetation provided 100% canopy cover. Aquatic plants covered 10% of the available habitat. The majority of the aquatic plants were mosses. However, pickerelweed (*Pontederia* sp.) was also observed within the stream. Algae coverage was estimated at 10%, mostly observed within the riffle zones.

The stream width was seven meters. The depths were 0.3 meters in both the riffles and runs, and 0.5 meters in the pools. The only observed potential source of NPS pollution within the sampled reach was the newly cleared road. The water was clear, but with a slight tea-stained color, most likely due to the upstream wetlands. The inorganic substrate components included 10% boulder, 80% cobble, 5% pebble, and 5% gravel and sand. The organic substrate was made up of 95% CPOM and 5% FPOM.

Benthos

The benthic macroinvertebrate community in Fish Brook received a total metric score of 36, representing 86% comparability to the reference site and resulting in an assessment of "non-impacted" (Table A2). The Taxa Richness (28) was the same as that of the reference condition. Four EPT taxa were present in the sample, in contrast with eight EPT taxa in the reference sample. The sample collected from B0517 was dominated by the Gathering-Collector feeding group (36%) and the dominant taxon collected was *Hydropsyche betteni* (16%, a Filtering-Collector). This low Percent Dominant Taxon metric is the second best of all 13 stations examined and indicates good community balance. The net-spinning caddisfly *Hydropsyche betteni* utilizes FPOM as a food resource, which may be entering the stream from the upstream wetlands and/or impoundments.

B0518 – CREEK BROOK

Creek Brook, 25 meters upstream from West Lowell Avenue, Haverhill, MA

Habitat

Creek Brook begins as a named stream at the outlet of Crystal Lake (Haverhill, MA). It flows southeastward through a small pond and wetland areas before flowing under Route 97 (700 meters west of the intersection with Route 495) where it receives the flow from West Meadow Brook. Upstream from this confluence, Meadow Brook flows through, and is influenced by, several wetlands. Downstream from its confluence with West Meadow Brook, Creek Brook meanders through a forested and wetland area prior to reaching the benthic monitoring station. The watershed area at station B0518 is 14.5 km^2.

Low flow conditions were the underlying cause of habitat problems encountered at this station. The reduced volume of water decreased the Instream Cover habitat metric to poor. The lack of water also reduced the Velocity–Depth Combinations and the Channel Flow Status parameters to marginal. Epifaunal Substrate was rated as suboptimal, with the lack of water resulting in much exposed and unavailable substrate. The overall habitat score was 137/200.

The canopy cover was estimated to provide 95% shade to the sampled reach. Vegetation within the riparian zone included: black locust (*Robina pseudoacacia*), elm (*Ulmus* sp.), ash (*Fraxinus* sp.), paper birch (*Betula papyrifera*), red maple (*Acer rubrum*), Norway maple (*Acer platanoides*), hickory (*Carya* sp.), barberry (*Berberis* sp.), honeysuckle (*Lonicera* sp.), rose (*Rosa* sp.), ferns (Pteridophyta), jewelweed (*Impatiens capensis*), and grasses. The understory was well developed and well populated with shrubs, vines, and herbaceous plants. No aquatic plants were observed within the sampled reach. Algae coverage was estimated at 75%. The majority of the algae was in the riffle zones, and occurred as a brown, thin film.

The stream width was estimated at two meters. The depth in the riffles, runs, and pools was consistent at 0.2 meters. The water was slightly turbid and exhibited a very slight "tea-stained" color. This is likely evidence of the upstream wetlands. The inorganic substrate components included: 25% boulder, 50% cobble, 15% pebble, 5% gravel, and 5% sand. The organic substrate components included 90% CPOM and 10% FPOM.

Benthos

The benthic community in Creek Brook received an assessment of "slightly impacted" based on a total metric score (30) that was 71% comparable to the reference community. Taxa Richness was 16 and the EPT Index was six, however, no stoneflies were collected. The HBI score at B0518 was 4.92. This HBI score ranks fifth of all the stations examined. Although it may be the case that the richness is reduced at B0518, the remaining taxa are relatively intolerant of pollution, and are only slightly more tolerant than those collected at the reference station where the HBI was 4.51. The EPT/Chironomidae ratio metric was 7.88 at B0518. This is the highest (and "best") of all stations examined. The dominant functional feeding group represented in the sample from Creek Brook was the Filtering–Collectors (63%). The dominant taxon was *Hydropsyche betteni* (34%).

B0519 – BARTLETT BROOK

Bartlett Brook, 5 meters upstream from Route 113 (North Lowell Street), Methuen, MA.

Habitat

Bartlett Brook begins its course to the Merrimack River at the outlet of a small, unnamed pond in Pelham, NH. The brook flows across the MA/NH border and into the town of Dracut, MA. From there, the stream flows in a southeasterly direction into the town of Methuen where it receives the flow from an unnamed stream that drains a watershed that includes Center Pond, Peters Pond, and several wetlands. After flowing through an extensive wetland, Bartlett Brook enters the sampled reach. The stream drops four meters in the immediate upstream 1.6 km. The land use within the sampled reach was estimated as 50% forest and 50% residential. The total watershed area contributing to B0519 is 17.43 km^2.

The overall habitat score at B0519 was 124/200. Along with B0516, this is the second worst habitat score in the entire survey. Habitat score reduction was due to human activities. Present within the reach were the remains of a breached dam, the remains of a brick retaining wall, and a lawn within six meters of the stream. The Instream Cover was poor. Less than 10% of the sampled reach had a mix of stable habitat. The Riparian Vegetative Zone Width (along the left bank) was also rated poor due to the proximal lawn and house.

The observed vegetation within the riparian vegetative zone included: red maple (*Acer rubrum*), grey birch (*Betula populifolia*), Norway maple (*Acer platanoides*), ash (*Fraxinus* sp.), roses (*Rosa* sp.), honeysuckle (*Lonicera* sp.), bittersweet (*Ceastrus* sp.), dogwood (*Cornus* sp.), grape (*Vitis* sp.), ferns (Pteridophyta), Joe-Pye weed (*Eupatorium* sp.), Arrow arum (*Peltandra virginica*), deadly nightshade (*Atropa belladonna*), jewelweed (*Impatiens capensis*), grasses, and several members of the Asteraceae (daisy) family. These plants (primarily the trees) provided 45% canopy cover to the stream. Aquatic plants covered 25% of the available habitat and consisted of 25% *Sparganium* sp. and 75% mosses. Algae coverage was estimated at <1%.

The stream width was estimated at three meters. The riffle and run zones were 0.2 meters deep, and the depth of the pools was estimated at 0.4 meters. The water was clear, but slightly "tea-stained". The inorganic substrate components included: 5% boulder, 15% cobble, 40% pebble, 20% gravel, and 20% sand. The organic substrate components included 75% CPOM and 25% FPOM.

Benthos

The benthic macroinvertebrate community in Bartlett Brook received a total metric score of 34, representing 81% comparability to the reference site and resulting in an assessment of "slightly/non-impacted" (Table A2). Eighteen different taxa were collected at B0519. Five EPT taxa were collected from B0519; however, the order Plecoptera was not represented in the sample. The HBI metric score was 5.13 and the EPT/Chironomidae Ratio was 1.16. Chironomidae made up almost half of the collected sample, which, along with the increased HBI score, indicates a community that contains several pollution-tolerant taxa. Filtering–Collectors were the dominant functional feeding group represented in the sample from Bartlett Brook (41%). The dominant taxon was *Hydropsyche betteni* (17%). The Percent Dominant Taxon

metric was equivalent to that found at the reference station. A reduced percentage of the most frequently collected taxon implies an increase in diversity among the benthic macroinvertebrates.

B0520 – PEPPERMINT BROOK

Peppermint Brook, ~100 meters downstream from Lakeview Avenue, Dracut, MA

Habitat

Peppermint Brook, a tributary to Beaver Brook. Originates at the outlet of an unnamed pond, just south of the New Hampshire border in Dracut, MA. The stream flows generally south and enters a shallow unnamed pond and extensive area of wetlands just west of Route 38, and north of the urbanized area of Dracut. After entering the more densely developed portion of Dracut, the brook crosses Hildreth and Pleasant streets and Lakeview Avenue before flowing into the sampling reach. The streambed is heavily incised within this reach, as the stream has cut its way into the relatively sandy soils. The stream drops 11 meters in the last upstream river kilometer. The Peppermint Brook watershed upstream from B0520 is 4.5 km^2.

The overall habitat score for B0520 was 121/200, reflecting the worst habitat condition of all streams examined in the Merrimack River Watershed in 2004. Significant reductions in habitat scores occurred for the following habitat parameters: The Velocity–Depth Combinations parameter score was reduced to the marginal range, due to the lack of any deep habitats. The Channel Flow Status was also reduced to the marginal range due to the lack of water. The Bank Vegetative Protection was reduced to marginal along the left bank, and suboptimal along the right bank. The Bank Stability parameter was reduced to marginal for both banks, as there were extensive areas of erosion. The Riparian Vegetative Zone Width, while optimal along the right zone, was poor along the left zone – due to dwellings within six meters of the stream. Extensive amounts of trash were observed in the stream.

The vegetation within the reach included maple (*Acer* sp.), Norway spruce (*Picea abies*), elderberry (*Sambucus canadensis*), jewelweed (*Impatiens capensis*), skunk cabbage (*Symplocarpus foetidus*), and grape (*Vitis* sp.). This vegetation (along with the high banks) provided 90% canopy cover to the stream. There was no aquatic vegetation observed within the reach. Algae coverage was estimated as covering 5% of the available habitat, and consisted of green, thin-film algae attached to the rocks and debris.

The stream width was estimated at two meters. The depth in the riffles, runs and pools was 0.1, 0.2 and 0.3 m, respectively. There were obvious signs of NPS pollution (a great deal of trash in the stream), and many potential sources of NPS pollution. These included many road crossings, yards and residential development. The water was turbid, but had no odor. The inorganic substrates consisted of 10% Bedrock, 30% Boulder, 30% Cobble, 10% Sand, and 20% Silt. The organic substrate components included 60% CPOM and 40% FPOM.

Benthos

The macroinvertebrate community at B0520 received a total metric score of 28, which was 67% comparable to the reference site. This resulted in a “slightly impacted” bioassessment of Peppermint Brook. The total number of taxa collected at B0520 was 14, which was third lowest in terms of richness. Only two EPT taxa were represented in the sample, which is the lowest EPT Index of all stations examined. Both representatives of the EPT taxa were net-spinning caddisflies (*Cheumatopsyche* sp. and *Hydropsyche betteni*). The reduction in EPT taxa, and the lack of either mayflies (Ephemeroptera) or stoneflies (Plecoptera) indicate a decrease in pollution-sensitive taxa, and unsuitable conditions for taxa requiring high levels of dissolved oxygen. The HBI value (5.94) was second highest of the stations examined. This poor score for the HBI metric indicates that the benthic community is influenced by organic enrichment. The EPT/Chironomidae Ratio was 1. The equal number of EPT and Chironomidae specimens further indicates that the benthic community is under stress. The dominant functional feeding group at B0520 was the Gathering-Collector FFG (51%), and the dominant taxon was the amphipod, *Gammarus* sp. (38%). *Gammarus* sp. feeds on deposited FPOM, and its high density within the sampled reach is indicative of an abundant food supply. It is possible that the watershed contains areas of highly

productive habitats influenced by natural or anthropogenic conditions (or a combination of the two). *Gammarus* sp. can be quite successful in colonizing disturbance-prone habitats (MacNeil et al. 1997).

B0521 – BLACK BROOK

Approximately 250 meters upstream from Westford Street, below Mt. Pleasant golf course, Lowell, MA

Habitat

The watershed upstream from the Black Brook sampling station (B0521) is 4.27 km^2. Black Brook begins and ends its course within highly developed areas of mixed residential, municipal, commercial and industrial landuse. Also within this relatively small watershed is a major highway (Route 3), a capped landfill, a golf course, the remains of the Middlesex Canal, and a gravel pit. Of these, only the capped landfill is downstream from the sampling reach. Black Brook drops three meters in the last kilometer upstream from station B0521.

The overall habitat score at B0521 was 130/200. This is the fourth lowest habitat score of all 13 stations examined. B0521 scored in the marginal range for the following habitat parameters: Instream Cover, Embeddedness, Sediment Deposition, and Velocity–Depth Combinations. These reductions were the primary reasons for the decreased overall habitat score.

The observed riparian vegetation included: oak (*Quercus* sp.), maple (*Acer* sp.), grapes (*Vitis* sp.), ferns (Pteridophyta), jewelweed (*Impatiens capensis*), skunk cabbage (*Symplocarpus foetidus*) and mosses. This vegetation provided the sampled reach with 90% canopy cover. However, the sampling reach was immediately downstream from a golf course that provided very little shading to the upstream portion of the brook. Aquatic vegetation was estimated to occupy 5% of the available habitat and was composed of mosses. Algae coverage was estimated to cover less than 5% of the available habitat. Observed algae included brown-colored, thin-film forms attached to rocks in the riffle zones.

The stream width was estimated at three meters. The stream depths were 0.15 meters in the riffles and 0.2 meters in the runs and pools. There were many potential sources of NPS pollution, including adjacent yards, trash, road runoff, the golf course, and sand and gravel operations. The inorganic substrates included bedrock (10%), boulder (10%), cobble (20%), pebble (10%), gravel (10%) and sand (40%). The organic substrate components were all CPOM (100%). The water was slightly turbid and “tea-stained”.

Benthos

The benthic community in Black Brook received an assessment of “moderately impacted” based on a total metric score (20) that was only 48% comparable to the reference community. Only 12 different taxa were collected from Black Brook, representing the lowest total taxa richness of all water bodies examined. Three caddisfly taxa – *Cheumatopsyche* sp., *Hydropsyche betteni*, and *Chimarra* sp. – comprised the EPT Index value, second lowest of the survey. The HBI Index (5.72) was the third highest (worst) value of the other stations examined, and reflected a community populated with pollution-tolerant taxa. The dominant functional feeding group at B0521 was the Gathering–Collector FFG (61%), and the dominant taxon was *Gammarus* sp. (53%). The dominance of a single taxon to this extent (>40%) suggests an unbalanced community with relatively low diversity. The EPT/Chironomidae Ratio was 6.33. This was the second highest score for this metric. Usually an elevated EPT/Chironomidae Ratio is a sign of good water quality conditions. However, the EPT/Chironomidae Ratio from Black Brook was not driven by an increased number of EPT but, rather, by a decreased number of Chironomidae. Only three individual midges were collected from Black Brook – *Micropsectra polita* gr., *Parametriocnemus* sp., and *Tvetenia paucunca*. It is unclear why there were so few Chironomidae present in the sample from Black Brook.

B0522 – BRIDGE MEADOW BROOK

60 meters downstream from access road to Tyngsborough Elementary School (205 Westford Road), Tyngsborough, MA

Habitat

An 8.3 km^2 watershed provides streamflow to the sampling station (B0522) on Bridge Meadow Brook. The headwaters of this brook are in a mixed forested and residential area of Tyngsborough, MA. The brook runs eastward, enhanced by flow from two large wetlands. Further downstream, very near B0522, the USGS topographical map indicates the presence of two large sand and gravel operations on either side of the brook. Aerial photographs from 2001-2004, however, indicate that both of these sand and gravel operations were discontinued and replaced by a residential area to the south of Bridge Meadow Brook and the Tyngsborough Elementary School to the north of the brook in close proximity to the sampling reach. A large beaver pond is situated immediately upstream of the sampling reach. Below the pond the brook passes under the access road that leads to the elementary school. The top of the reach is approximately 60 meters below the road crossing. Bridge Meadow Brook drops six meters in the last kilometer upstream from B0522.

The overall habitat score for B0522 was 156/200. Reductions in the habitat score were primarily due to the marginal Velocity–Depth Combinations metric. There were no deep habitats within the sampled reach. Instream Cover, Epifaunal Substrate and Bank Stability were rated suboptimal.

Riparian vegetative conditions were optimal. The vegetation along the banks included: white pine (*Pinus strobus*), red maple (*Acer rubrum*), oak (*Quercus* sp.), elderberry (*Sambucus* sp.), skunk cabbage (*Symplocarpus foetidus*), moss (Bryophyta), and ferns (Pteridophyta). Canopy cover was estimated at 100%. Algae coverage within the reach was estimated at 20%. The observed algae were filamentous and green, and were attached to rocks in the pools. A gray fungal flock was observed in both the pools and the riffles.

The stream width was estimated at three meters. The stream depth of the riffles and runs was 0.1 meters, whereas the depth in the pools was 0.2 meters. There was some evidence of NPS pollution from the upstream road crossing. The water was slightly turbid. The inorganic substrate included 40% cobble, 40% pebble, 10% gravel, and 10% sand. The inorganic substrate included 70% CPOM and 30% FPOM.

Benthos

The benthic macroinvertebrate community in Bridge Meadow Brook received a total metric score of 26, representing 62% comparability to the reference site and resulting in an assessment of “slightly impacted” (Table A2). When viewed in concert with the habitat observations, the macroinvertebrate community at B0522 appeared to be structured in response to organic enrichment. The Taxa Richness was 13, second lowest richness value of any sample obtained during the entire survey. By contrast, the HBI value was 4.56, which was the second lowest (“best”) of the 13 stations examined. This relatively low index value is indicative of a benthic community populated by pollution-sensitive taxa. Four EPT Taxa were collected – one Plecopteran and three Trichopteran taxa. No mayflies (Ephemeroptera) were represented. The EPT/Chironomidae metric at B0522 was 3.05. The dominant functional feeding group in the sample from B0522 was Filtering–Collectors (65%), and the dominant taxon was *Hydropsyche* sp. (38%). This elevated Percent Dominant Taxon score (38%) and the reduced richness metric indicate an unbalanced community, despite the presence of pollution-sensitive forms.

B0523 – TADMUCK BROOK

Approximately 200 meters upstream from Lowell Road, Westford, MA

Habitat

Tadmuck Brook drains 4.7 km^2 of watershed at the sampling site (B0523). The brook rises in an unnamed wetland near Route 495 interchange 32 in Westford. The stream flows generally in a northerly direction through additional wetland; then turns east and runs through a residential neighborhood and adjacent to Fairview Cemetery. Below the cemetery, Tadmuck Brook turns north once again, passes under Main Street, and flows down to the sampling reach, located 200 meters upstream from Lowell Road. The area surrounding B0523 is conservation land, and there are a few stone remnants of a colonial-era mill site.

The area adjacent to the sampling reach has been reclaimed by forest, and the trees provided 95% canopy cover to the stream.

The habitat score for B0523 (171/200) was the highest of all the stations examined within the Merrimack River Watershed in 2004. Only one habitat measure (i.e., Velocity–Depth Combinations) scored within the marginal range, due to the lack of deep habitats within the sampled reach. All other habitat measures were optimal. The observed vegetation included hemlock (*Tsuga canadensis*), pine (*Pinus* sp.), maple (*Acer* sp.), dogwood (*Cornus* sp.), barberry (*Berberis* sp.), alder (*Alnus* sp.), *Viburnum* sp., grapes (*Vitis* sp.), poison ivy (*Rhus radicans*), skunk cabbage (*Symplocarpus foetidus*), ferns (Pteridophyta), moss (Bryophyta) and jewelweed (*Impatiens capensis*).

The stream width was estimated at two meters. The depth in the riffle zones, runs and pools was 0.2, 0.3 and 0.4 meters, respectively. The inorganic substrates included 60% boulder, 20% cobble, and 20% sand. The organic substrates were entirely made up of CPOM. The water was slightly turbid and tan colored. Aquatic vegetation, consisting entirely of mosses, covered 30% of the available habitat. Algae covered less than 5% of the available habitat and comprised green filamentous and brown-colored thin-film forms.

Benthos

The benthic macroinvertebrate community in Tadmuck Brook received a total metric score of 40, representing 95% comparability to the reference site and resulting in an assessment of “non-impacted” (Table A2). Four of the seven metrics outperformed the reference condition. Total Taxa Richness was 25, and nine EPT taxa were collected, the most of any stream assessed during the 2004 Merrimack survey. However, the HBI was 5.05, which was only the sixth best HBI value of the stations examined. The dominant functional feeding group was the Filtering-Collectors (40%), and the dominant taxon was *Stenelmis* sp. (24%), a Scraper. The predominance of *Stenelmis* sp. in the invertebrate community may have been a response to the availability of periphyton as a food resource.

B0525 – BENNETS BROOK

Approximately 100 meters downstream from Willow Road, Ayer, MA

Habitat

There are 8.5 km^2 of watershed area upstream from station B0525. Bennets Brook begins in the town of Harvard at an unnamed wetland north of Route 2 and south of Shaker Village. The brook flows north, adjacent to Shaker Village, and then into Shaker Millpond in the town of Ayer. From the outlet of the pond Bennets Brook runs in an easterly direction, augmented by flow from an unnamed wetland-fed stream, and subjected to runoff from a nearby golf course. Turning more northward, the stream flows under Route 2A, through a small pond, and under Willow Road. B0525 was located approximately 100 meters downstream from the Willow Road crossing. Bennets Brook drops three meters in the kilometer-long segment immediately upstream from the sampling station. However, the majority of this drop occurs within the sampling reach. The majority of the land within this watershed is divided between forest and residential uses. The canopy cover within the sampled reach was estimated at 45%.

The Total Habitat Score for Bennets Brook (162/200) was just one point lower than that of the reference station. Reductions in the score were primarily due to low flow conditions and lack of deep habitats. Also, a nearby parking lot reduced the right bank Riparian Vegetative Zone Width to marginal. The riparian vegetation included: elm (*Ulmus* sp.), red maple (*Acer rubrum*), Norway Maple (*Acer platanoides*), alder (*Alnus* sp.), *Rosa* sp., sumac (*Rhus typhina*), barberry (*Berberis* sp.), Virginia creeper (*Parthenocissus quinquefolia*), ferns (Pteridophyta), goldenrod (*Solidago* sp.), grasses, skunk cabbage (*Symplocarpus foetidus*), and jewelweed (*Impatiens capensis*). Aquatic vegetation covered less than 1% of the available substrate and consisted entirely of mosses. Thin-film algae were observed on rock substrates and occupied approximately 15 percent of the available habitat.

Benthos

The benthos in Bennets Brook received a total metric score of 36, representing 86% comparability to the reference site and resulting in an assessment of "non-impacted" (Table A2). There were 25 different taxa collected at B0525, the same richness value as reported for Tadmuck Brook, and representing the highest number of taxa encountered during the 2004 Merrimack survey. The dominant functional feeding group at B0525 was the Filtering-Collector (50%), and the Percent Dominant Taxon was 15% (*Hydropsyche betteni*). The lack of hyperdominance by a single taxon indicates a well-balanced community. While the above measures indicate good diversity when compared with the other streams assessed, only four EPT taxa were represented in the sample from Bennets Brook. The HBI (5.32), while slightly elevated, received the maximum metric score of six suggesting that the community was not overly represented by pollution-tolerant taxa.

SUMMARY AND RECOMMENDATIONS

Benthic macroinvertebrate biomonitoring stations within the Merrimack River Watershed included wadeable streams that were monitored employing DWM kick-net methodologies (Nuzzo 2002). The reference station (B0524 – South Branch Souhegan River) was chosen based on the lack of development within the contributing watershed, the lack of significant water withdrawals, high scoring metric values for instream benthics, and good riparian and instream habitats.

Habitat scores ranged from 121/200 at Peppermint Brook to 171/200 at Tadmuck Brook. The 50-point spread was affected by a variety of habitat conditions ranging from extensive anthropogenic impacts, to the presence of protected conservation areas.

The South Branch Souhegan River supports the diverse and well-balanced aquatic community expected for a "Least-Impacted" stream system. Aside from the reference station, only three other streams – Fish Brook, Tadmuck Brook and Bennets Brook – were found to be "non-impacted". Black Brook received an assessment of "moderately impacted". Impacts to resident biota in this watershed were generally a result of habitat degradation and/or nonpoint source-related water quality impairment. All other stations were "slightly impacted".

The schematic presented in Figure 2 is based on a proposed conceptual model that predicts the response of aquatic communities to increasing human disturbance. It incorporates both the biological condition impact categories outlined in the RBPIII biological assessment methodology currently used by MassDEP and the Tiered Aquatic Life Use (TALU) conceptual model developed by the US EPA and refined by various state environmental agencies (USEPA 2003). The model summarizes the main attributes of an aquatic community (in this case the benthic macroinvertebrate community only) that can be expected at each level of the biological condition gradient, and how these metric-based bioassessments can then be used to make aquatic life use determinations as part of the 305(b) reporting process. Slightly or non-impacted benthic communities *support* the Massachusetts SWQS designated *Aquatic Life* use in addition to meeting the objective of the Clean Water Act (CWA), to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Environmental Law Reporter 1988). Only the benthic community from B0521 (Black Brook) failed to support the *Aquatic Life* use goal of the CWA with its designation of "moderately impacted". This is not to say that stations achieving a designation of "non-impacted" should be considered pristine. There may be stressors affecting water quality, aesthetics, and other biota that have minimal impact upon the benthic community.

While the RBP analysis of benthic macroinvertebrate communities is an effective means of determining the severity of water quality impacts, it is less effective in determining what kinds of pollution are causing the impact (i.e., ascertaining cause and effect relationships between potential stressors and affected biota). Nevertheless, in some situations a close examination of individual metric performance, taxon absence or presence, habitat evaluations, or other supporting field data can lead to inferences of potential anthropogenic causes of perturbation. Table 3 lists the potential causes of benthic community impairment, where applicable, observed at each biomonitoring station. The table also includes recommendations addressing the various types of impairment and general conditions observed. The list is by no means exhaustive, but rather a summary of suggestions for additional monitoring efforts, BMP

implementation, and other recommendations for follow-up activities while still working within the framework of the "5-Year Basin Cycle" and using the resources routinely available to DWM personnel.

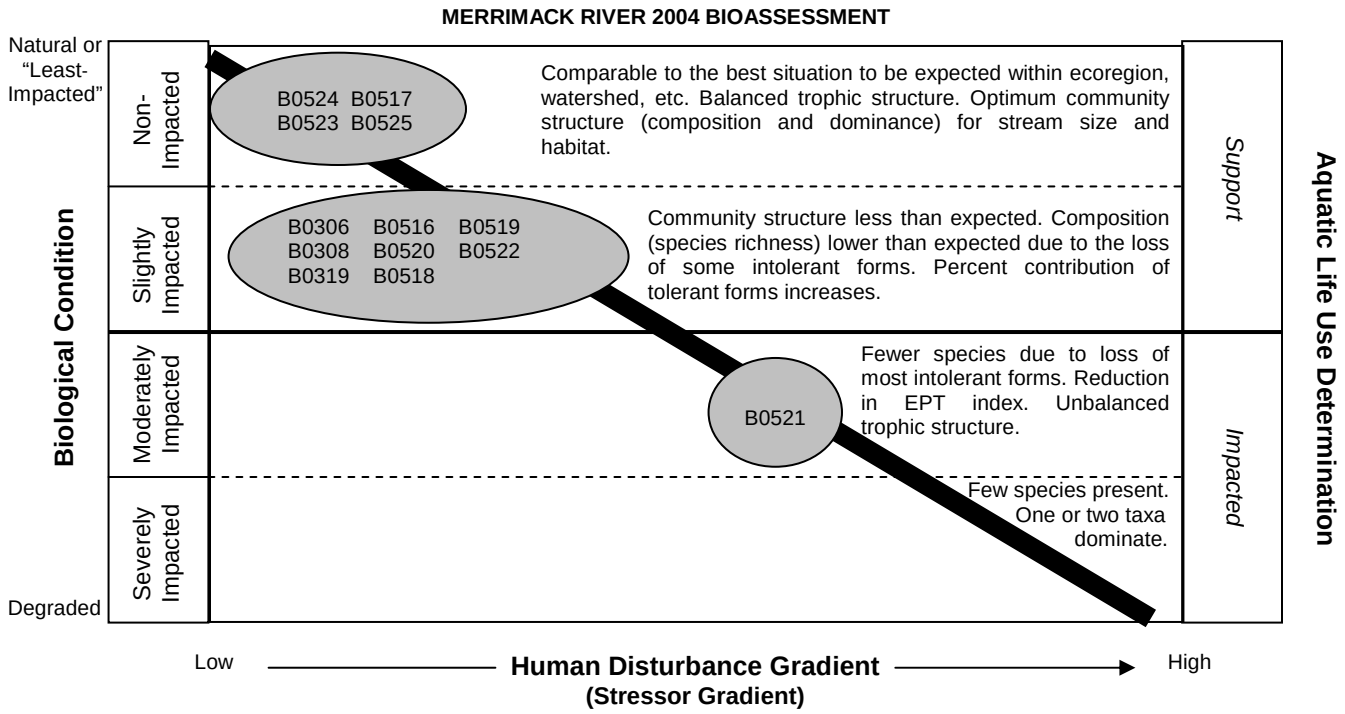

Figure 2. Schematic of the predictive response of aquatic communities to increasing human disturbance. Included is the performance (Biological Condition and Aquatic Life Use determinations) of the Merrimack River watershed 2004 biomonitoring stations along the Human Disturbance Gradient. NOTE: reference station (B0524) is considered to represent the "best attainable" conditions and to be supportive of the *Aquatic Life* use.

Table 3. A summary of potential causes of benthos and habitat impairment observed at each biomonitoring station during the 2004 Merrimack River watershed survey. Where applicable, recommendations have been made.

Site	Possible Causes of Impairment	Recommendations
B0524	No biological impacts observed	Preservation of existing conditions within the watershed is the most obvious and cost-effective way to maintain the biological integrity in the South Branch of the Souhegan River.
B0306	Riparian and instream habitat degradation, NPS from residential landuse, upstream impoundments	Properly guided ("Smart") growth and proper management of existing structures and infrastructure will serve to enhance or maintain the health of instream fauna.
B0308	Riparian and instream habitat degradation, Trash and NPS from residential landuse and golf course	Increased awareness of abutting landowners to the impacts of potential NPS pollution may have a significant positive impact to this reach.
B0319	Low flow, riparian and instream habitat degradation, NPS from ATV stream crossing and upstream impoundments.	Public outreach (perhaps in the form of signage) to educate recreational users about the potential impacts of ATVs and dirt bikes to stream health.
B0516	Channelization, riparian and instream habitat degradation, urbanization, historical industrial use	Measures should be taken to reduce storm water run-off impacts. An assessment of the old mills should be conducted to assure that there are no direct feeds of drains and wastewater to the river
B0517	No biological impacts observed	--
B0518	Low flow, instream habitat degradation	Development is encroaching upon the upstream wetlands and ponds that provide water to Creek Brook. Education of home (and business) owners on ways to reduce NPS pollution is recommended.
B0519	Riparian and instream habitat degradation, NPS from residential landuse	Habitat restoration, through the enhancement of the riparian vegetative zone, may improve the aquatic life condition at this site. Public outreach to abutting landowners may be the best way to increase local stewardship of this resource.
B0520	Riparian habitat degradation, erosion, instream trash and debris, NPS from residential landuse	Education of riparian landowners may be the most cost-effective measure to rehabilitate this stream. By reducing NPS inputs (through Best Management Practices at road crossings), and, perhaps, a stream clean-up, the habitat and aquatic community may show signs of improvement.
B0521	Instream habitat degradation, trash and debris, NPS from urbanization	Continued monitoring and nutrient load reductions are recommended for this stream.
B0522	Water quality of the upstream beaver pond, NPS from development/road crossings	--
B0523	No biological impacts observed	It is likely that habitat protection (especially the designation of conservation land) will have positive effects upon the resident biotic community.
B0525	No biological impacts observed	It is suggested that a riparian buffer strip be created to address potential impacts from the adjacent parking lot.

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APPENDIX

Macroinvertebrate taxa list, RBPIII benthos analyses, and Habitat evaluations

Table A1. Taxa list and counts, functional feeding groups (FFG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2004 Merrimack River watershed survey July/August 2004.

Station ID and Stream Names: B0524/South Branch Souhegan River, B0306/Richardson Brook, B0308/Trull Brook, B0319/Martins Pond Brook, B0516/Powwow River, B0517/Fish Brook, B0518/Creek Brook, B0519/Bartlett Brook, B0520/Peppermint Brook, B0521/Black Brook, B0522/Bridge Meadow Brook, B0523/Tadmuck Brook, B0525/Bennets Brook.

Taxon	FFG[1]	TV[2]	BO524*	BO306	BO308	BO319	B0516	BO517	BO518	BO519	BO520	BO521	BO522	BO523	BO525
Laevapex fuscus	SC	7					4								
Pseudosuccinea columella	GC	6												1	
Planorbula armigera	SC	6						1							
Pisidiidae	FC	6			1		2	1				1	1	1	5
Enchytraeidae	GC	10					1								
Nais behningi	GC	6													5
Nais communis	GC	8						11							
Pristinella osborni	GC	10						1							
Limnodrilus hoffmeisteri	GC	10				1									
Tubificidae lWB	GC	10					1				3				
Tubificidae lWH	GC	10				1									
Lumbriculidae	GC	7			2		1	4	2		1				6
Erpobdella sp.	PR	8				1									
Caecidotea sp.	GC	8			4					1					
Caecidotea communis	GC	8				15					2			4	
Caecidotea racovitzai racovitzai	CG	8				30						5			
Crangonyx sp.	GC	6		3	1	3		3		2					
Gammarus sp.	GC	6			7	1	5		2	5	38	56			
Hydrachnidia	PR	6		1										1	
Baetidae	GC	4							3	1					
Baetis (subeq. term.) sp.	GC	6	1				3								
Leptophlebiidae	GC	2													3
Boyeria vinosa	PR	2												1	
Plecoptera	GC	3												5	
Acroneuria sp.	PR	0	2					5					1		
Nigronia serricornis	PR	0	2					2		2		1	1		1
Adicrophleps hitchcocki	SH	2												1	
Glossosoma sp.	SC	0			1										
Cheumatopsyche sp.	FC	5	3	9	7	24	5	1	4	6	15	9	8	2	7
Diplectrona sp.	FC	0							3					1	
Hydropsyche sp.	FC	4			47								40		

Taxon	FFG[1]	TV[2]	BO524*	BO306	BO308	BO319	B0516	BO517	BO518	BO519	BO520	BO521	BO522	BO523	BO525
Hydropsyche betteni	FC	6	16	19		4	37	16	32	17	10	8		17	16
Hydropsyche morosa gr.	FC	6												5	
Ceraclea sp.	GC	3		1											
Oecetis sp.	PR	5		2											
Limnephilidae	SH	4												1	
Pycnopsyche sp.	SH	4								2					
Psilotreta sp.	SC	0				1		2							
Chimarra sp.	FC	4	10	28			10		20	10		2	18		12
Wormaldia sp.	FC	0												1	
Lype diversa	GC	2			1										
Rhyacophila sp.	PR	1												1	
Neophylax sp.	SC	3							1						
Microcylloepus pusillus	GC	3		8			8	1							
Oulimnius latiusculus	SC	4	1	2				1	2						
Promoresia sp.	SC	2		2					1						
Stenelmis sp.	SC	5		4		3	11	10	8	13	4		12	24	7
Stenelmis crenata	SC	5			10							19			
Ectopria nervosa	SC	5												1	
Psephenus herricki	SC	4		2				3	5	7					
Bezzia sp.	PR	6													1
Probezzia sp.	PR	6													2
Microtendipes pedellus gr.	FC	6					1								
Microtendipes rydalensis gr.	FC	6		5				1		3					
Paratendipes sp.	GC	6		1											
Polypedilum flavum	SH	6		10	7	16	4	6	4	13	16		18		4
Polypedilum illinoense	SH	6			1										
Polypedilum scalaenum gr.	SH	6												1	
Xenochironomus sp.	PR	0				1									
Micropsectra sp.	GC	7				3									
Micropsectra polita gr.	GC	7						4			4	1			
Paratanytarsus sp.	FC	6													1
Rheotanytarsus exiguus gr.	FC	6	13				11				2		1		
Rheotanytarsus pellucidus	FC	5	5								1			2	1
Tanytarsus sp.	FC	6	12											2	1
Diamesinae	GC	2								1					
Diamesa sp.	GC	5							1						
Orthocladiinae	GC	5											1		
Brillia sp.	SH	5			1										
Cardiocladius sp.	PR	5													1

Taxon	FFG[1]	TV[2]	BO524*	BO306	BO308	BO319	B0516	BO517	BO518	BO519	BO520	BO521	BO522	BO523	BO525
Eukiefferiella claripennis gr.	GC	8			1										
Orthocladius sp.	GC	6					1								2
Parametriocnemus sp.	GC	5	1	2	1			4			1	1		1	11
Rheocricotopus sp.	GC	6		1											
Tvetenia paucunca	GC	5	4		1			8	3	11		1	1	12	1
Tanypodinae	PR	7													1
Conchapelopia sp.	PR	6					1	1		2				1	3
Nilotanypus sp.	PR	6											1		
Thienemannimyia sp.	PR	6	1							1	1			1	2
Clinocera sp.	PR	6													4
Hemerodromia sp.	PR	6	1			1		2					1		
Simulium sp.	FC	5	2	1	3		2	11	4	6				8	12
Antocha sp.	GC	3									2				
Dicranota sp.	PR	3	7											3	
Tipula sp.	SH	6										1			1
Total number of organisms			**97**	**101**	**96**	**105**	**108**	**99**	**95**	**103**	**100**	**105**	**104**	**98**	**110**

[1]Functional Feeding Group (FFG). The feeding habit of each taxon. SH-Shredder; GC-Gathering Collector; FC-Filtering Collector; SC-Scraper; PR-Predator.
[2]Tolerance Value (TV). An assigned value used to calculate the biotic index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for organisms very tolerant.
*Reference station

Table A2. Summary of RBP III data analysis for macroinvertebrate communities sampled during the Merrmimack River watershed survey – July / August 2004. Shown are the calculated metric values, metric scores (underlined) based on comparability to the South Branch Souhegan River (B0524) reference station, and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a complete listing and description of sampling stations.

STATION	B0524		B0306		B0308		B0319		B0516		B0517		B0518		B0519		B0520		B0521		B0522		B0523		B0525	
STREAM	South Branch Souhegan River		Richardson Brook		Trull Brook		Martins Pond Brook		Powwow River		Fish Brook		Creek Brook		Bartlett Brook		Peppermint Brook		Black Brook		Bridge Meadow Brook		Tadmuck Brook		Bennets Brook	
HABITAT SCORE	163		166		149		143		124		166		137		124		121		130		156		171		162	
TAXA RICHNESS	23	6	18	4	17	4	14	4	18	4	23	6	16	4	18	4	14	4	12	2	13	2	25	6	25	6
BIOTIC INDEX	4.51	6	4.84	6	4.80	6	6.61	2	5.55	4	5.34	6	4.92	6	5.13	6	5.94	4	5.72	4	4.56	6	5.05	6	5.32	6
EPT INDEX	8	6	5	0	4	0	3	0	4	0	4	0	6	2	5	0	2	0	3	0	4	0	9	6	4	0
EPT/CHIRONOMIDAE	1.11	6	3.11	6	4.67	6	1.45	6	3.06	6	1	6	7.88	6	1.16	6	1	6	6.33	6	3.05	6	4.7	6	1.36	6
SCRAPER/FILTERER	0.07	6	0.16	6	0.19	6	0.14	6	0.22	6	0.57	6	0.27	6	0.48	6	0.14	6	0.95	6	0.18	6	0.64	6	0.13	6
% DOMINANT TAXON	16%	6	28%	4	49%	0	29%	4	34%	2	16%	6	34%	2	17%	6	38%	2	53%	0	38%	2	24%	4	15%	6
REFERENCE AFFINITY	100	6	57	4	62	4	64	4	65	4	66	6	51	4	80	6	68	6	39	2	58	4	73	6	78	6
TOTAL METRIC SCORE	*42*		*30*		*26*		*26*		*26*		*36*		*30*		*34*		*28*		*20*		*26*		*40*		*36*	
% COMPARABILITY TO REFERENCE	100%		71%		62%		62%		62%		86%		71%		81%		67%		48%		62%		95%		86%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	Reference		Slightly Impacted		Slightly Impacted		Slightly Impacted		Slightly Impacted		Non Impacted		Slightly Impacted		Slightly / Non - Impacted		Slightly Impacted		Moderately Impacted		Slightly Impacted		Non-Impacted		Non - Impacted	

Table A3. Habitat assessment summary for biomonitoring stations sampled during the Merrimack River watershed survey – July / August 2004. For instream parameters, scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For bank and riparian zone parameters parameters, scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor. Refer to Table 1 for a complete listing and description of sampling stations.

Habitat Parameter	**BO524***		**B0306**		**B0308**		**B0319**		**B0516**		**B0517**		**B0518**		**B0519**		**B0520**		**B0521**		**B0522**		**B0523**		**B0525**	
STREAM	South Branch Souhegan River		Richardson Brook		Trull Brook		Martins Pond Brook		Powwow River		Fish Brook		Creek Brook		Bartlett Brook		Peppermint Brook		Black Brook		Bridge Meadow Brook		Tadmuck Brook		Bennets Brook	
Instream Cover	14		16		18		10		13		18		3		4		11		7		11		16		15	
Epifaunal Substrate	15		19		16		15		20		19		14		11		16		13		15		17		18	
Embeddedness	15		20		19		19		19		19		17		16		17		10		17		18		18	
Channel Alteration	20		15		16		20		1		17		20		15		19		15		20		17		16	
Sediment Deposition	14		19		13		10		19		16		19		12		11		10		16		17		18	
Velocity-Depth Combinations	12		10		15		10		16		15		7		12		9		10		7		10		11	
Channel Flow Status	15		16		9		9		8		11		6		11		7		16		14		16		13	
Bank Vegetative Protection	10^{L}	10^{R}	10	10	8	5	9	9	10	3	9	9	10	9	7	10	5	7	10	9	10	10	10	10	10	10
Bank Stability	10	10	10	10	10	4	7	7	10	3	8	10	10	7	7	8	3	5	8	7	8	8	10	10	8	10
Riparian Vegetative Zone Width	9	9	2	9	10	6	8	10	0	2	5	10	7	8	1	10	2	9	9	6	10	10	10	10	10	5
TOTAL SCORE	**163**		**166**		**149**		**143**		**124**		**166**		**137**		**124**		**121**		**130**		**156**		**171**		**162**	

^{L} = Left Bank
^{R} = Right Bank
* = Reference Station

Merrimack River Watershed
2004 Water Quality Technical Memorandum

TM-84-5

Prepared by:
Katie O'Brien-Clayton
With final edits by Arthur S. Johnson

Watershed Planning Program
Worcester, MA

March, 2007

DWM Control Number: 179.2

Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Ian Bowles, Secretary
Department of Environmental Protection
Arleen O'Donnell, Acting Commissioner
Bureau of Resource Protection
Glenn Haas, Acting Assistant Commissioner
Division of Watershed Management
Glenn Haas, Director

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Introduction

The watershed assessment process in Massachusetts is carried out on a 5-year cycle. In Year One, the Massachusetts Department of Environmental Protection Division of Watershed Management (DWM) coordinates with watershed groups, gathers background information and begins to compile sampling needs for streams, rivers, ponds and lakes in pre-determined watersheds. During Year Two of the cycle, sampling sites and parameters are finalized and sampling is conducted. In Year Three, the finalized data are used for assessment reporting to comply with Section 305b of the Clean Water Act (CWA). Implementation of specific projects or programs to address water quality problems, and post-project evaluation are conducted in Year Four and Year Five, respectively.

As part of the DWM Year Two monitoring in 2004, the Division of Watershed Management's Assessment Monitoring Program was charged with increasing, both temporally and spatially, the percent coverage of assessed surface waters in the Commonwealth. Specifically, emphasis was placed on monitoring waters currently "unassessed" (i.e., there are no data) or "not assessed" (i.e., historical data exist but are greater than five years old). As part of the 2004 watershed assessments, biological monitoring, bacteria sampling, and habitat assessments were conducted to evaluate the biological health and recreational use status of various portions of the Merrimack River Watershed. Water quality surveys were performed at 24 sites in the Merrimack River Watershed and included measuring *in situ* parameters (e.g., dissolved oxygen, temperature, pH, specific conductance) and collecting grab samples for bacteria analysis. This technical memorandum is designed to present final DWM-generated water quality monitoring data for use in watershed assessment reports and for reporting data to outside groups. The biological and habitat assessment data will be presented in a separate technical memorandum.

Project Objectives

The main objectives of monitoring in the Merrimack River Watershed were: (a) to determine the biological health and recreational status of "unassessed" and "not assessed" rivers/streams within the watershed by conducting assessments based on biological (aquatic macroinvertebrates, fish, periphyton, bacteria) communities; and (b) to identify problem stream segments so that efforts can be focused on developing or modifying NPDES and Water Management Act permits, stormwater management, and control of other nonpoint source (NPS) pollution (MassDEP 2004a). Biological assessments were supplemented with a habitat assessment and *in situ* water quality measurements (including dissolved oxygen, percent saturation, temperature, pH, depth, and specific conductivity) to evaluate water quality and habitat quality at each study site. The 2004 DWM monitoring efforts also included fecal coliform and *E. coli* bacteria sampling at all biomonitoring stations. Bacteria data will provide information used in making assessments of the *Primary and Secondary Contact Recreation* uses.

Methods

Twenty-four stations (Figure 1) in the Merrimack River Watershed were selected for monitoring in 2004. Sampling station descriptions are provided in Table 1. Additional information pertaining to station location (including detailed station maps), rationale, objectives, and sampling methods is available in *Quality Assurance Project Plan 2004 Surface Water Quality Monitoring and Assessment CN 177.0 (*MassDEP 2004a) and *2004 Biological Monitoring and Habitat Assessment QAPP* (MassDEP 2004b). During the summer, low-flow months of July, August and September dissolved oxygen (DO), percent DO saturation, pH, conductivity, temperature, and total dissolved solids were measured *in situ* during pre-dawn hours using multi-probe units.

Between May and September wade-in grab samples were also collected monthly (n=5) from the 24 stations and sent to the Senator William X. Wall Experiment Station (WES) in Lawrence, MA where they were analyzed for *E. coli* and fecal coliform bacteria. The analytical methods, associated detection limits and project data quality objectives for water sample analyses at WES and DWM are provided in Table 2.

QA/QC decisions were imposed on the data following the guidelines of the DWM working SOP *Data Validation and Usability Standard Operating Procedure* (MassDEP 2005). Details pertaining to data validation are available in the *2004 Data Validation Report* (MassDEP 2006). It should be noted that when the multi-probe depths are reported as less than 0.1 m, they are automatically qualified as potentially in error (e.g., depth not calibrated by field crews). Additionally, if zero and/or negative depth readings occur more than once per survey date, then all negative/zero depth data are censored, and all other depth data for that survey are qualified [indicating that erroneous depth readings were not recognized in the field and that corrective action (field calibration of the depth sensor) was not taken, i.e., that all positive readings may be in error.]

Field sheets, raw data files, chain-of-custody forms, lab reports, and other metadata used in this report are stored and maintained by DWM in project files and the Water Quality Database in Worcester, MA.

Table 1. Massachusetts Department of Environmental Protection Division of Watershed Management 2004 Merrimack River Watershed Water Quality Sampling Station Descriptions.

Waterbody	Station ID#	Site Description
Unnamed Tributary	AR01	unnamed tributary to Johnson Creek, locally known as Argilla Brook, west off Baldwin Terrace approximately 1400 feet upstream/east of Main Street crossing, Groveland
Unnamed Tributary	ABR01	unnamed tributary to Powwow River, approximately 50 feet upstream/northeast of R Street, Amesbury
Powwow River	PO01	approximately 550 feet downstream/east of Route 150 (approximately 225 feet downstream of Amesbury electrical substation but upstream of discharge pipe directly across from 35 Mill Street), Amesbury
Back River	ABR02	Clinton Street crossing, Amesbury
East Meadow River	EA01	Thompson Road crossing, Haverhill
Johnson Creek	JC03	Center Street crossing, Groveland
Little River	LR01	Downstream/south at Winter Street crossing, Haverhill
Creek Brook	CR01	West Lowell Avenue crossing, Haverhill
Bare Meadow Brook	BMB01A	Renfrew Street crossing, Methuen
Bartlett Brook	BA01	Route 113 (North Lowell Street) crossing, Methuen
Fish Brook	FI01	River Road crossing, Andover
Trull Brook	TB02	Approximately 230 feet downstream/north of River Road, Tewskbury
Richardson Brook	RBR01	Methuen Street crossing, Dracut
Trout Brook	TRB02	Kenwood Road crossing, Dracut
Peppermint Brook	PE01	Lakeview Avenue crossing, Dracut
Black Brook	BB05	Westford Street crossing, Lowell
Tadmuck Brook	TA01	Lowell Road crossing, Westford
Bennetts Brook	BE01	Willow Road crossing, Ayer
Deep Brook	DBR05	Ledge Road crossing, Chelmsford
Lawrence Brook	LWB02	Approximately 130 feet downstream/south of Sherburne Avenue, Tyngsborough
Bridge Meadow Brook	BR01	Downstream/northeast of the unnamed school access road crossing north off Westford Avenue between the localities of Hayward Corner and Swan Corner, Tyngsborough
Salmon Brook	SA01	Ridge Road crossing, Nashua, New Hampshire
Joint Grass Brook	JG01	Downstream/east of Main Street crossing (below confluence of unnamed tributary), Dunstable
Martins Pond Brook	MRB01	Approximately 180 feet downstream from washed out culvert crossing of Loomis Lane, Groton

Figure 1. Massachusetts Department of Environmental Protection Division of Watershed Management 2004 Water Quality Monitoring Station Locations in the Merrimack River Watershed.

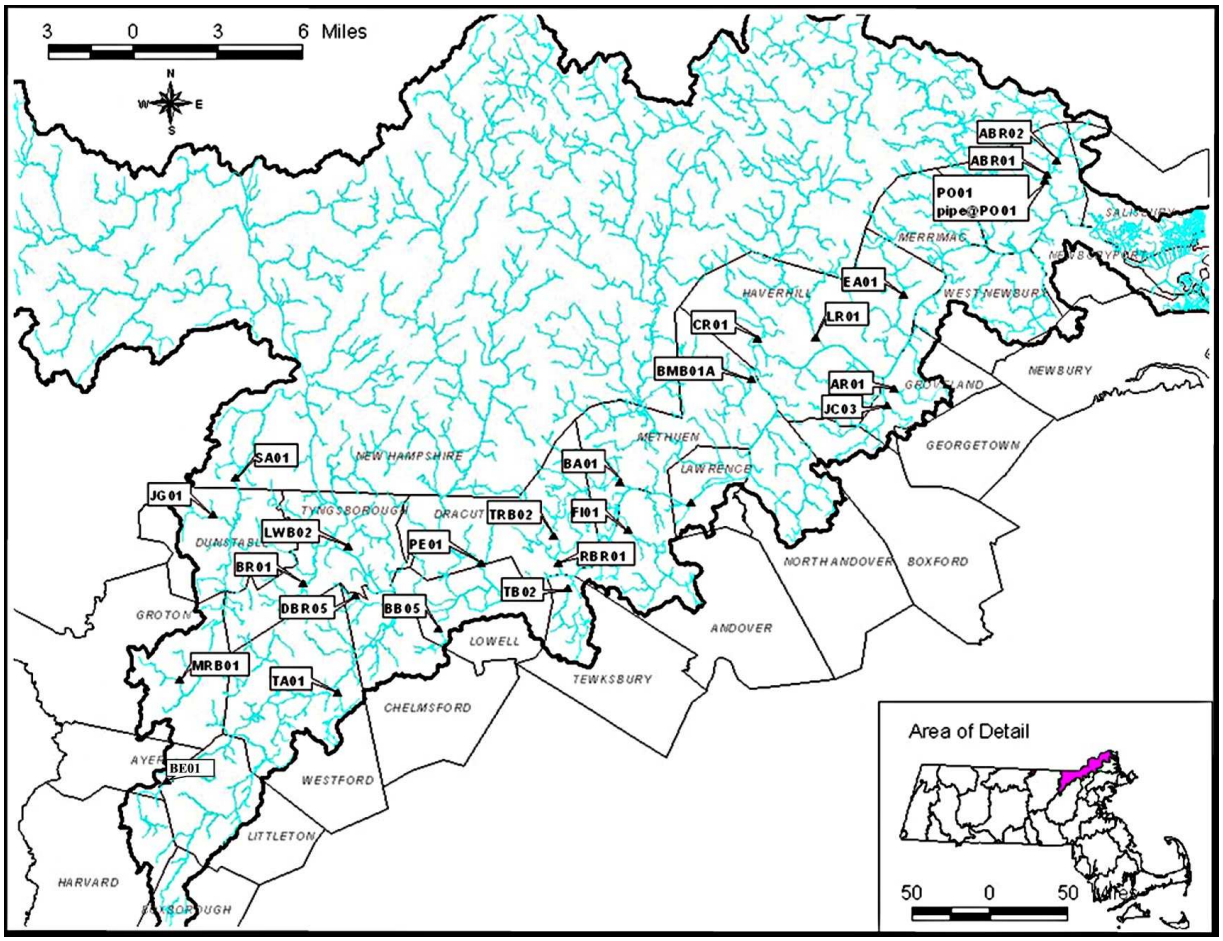


Table 2. Analytical Methods & MDLs for 2004 Merrimack River Watershed Water Quality Analytes

Water Quality Analyte	Method *	MDL **	RDL **
Hydrolab® Multiprobe Series 3 & 4	DWM SOP (CN 4.2)	NA	NA
YSI 600 XLM	DWM SOP (CN 4.2)	NA	NA
Fecal Coliform ***	SM 9222D	6 CFU/100mls	6 CFU/100mls
E. coli ***	EPA 1603 (also modified 1103.1)	6 CFU/100mls	6 CFU/100mls

***** = "Methods for Chemical Analysis of Water and Wastes", Environmental Protection Agency, Environmental Monitoring Systems Laboratory – Cincinnati (EMSL-CI), EPA-600/4-79-020, Revised March 1983 and 1979 where applicable; Standard Methods, Examination of Water and Wastewater, 20th edition

** = WES typically reports results down to the MDL with a qualifier.

*** = 6 CFUs/100 ml was the practical RDL for WES, as no results were reported below 6 (these were reported as "<6")

NA = Not Applicable

Survey Conditions

To fulfill 305(b) assessment guidance, precipitation (NOAA undated) and stream discharge (Socolow et al. 2005) data were analyzed to estimate hydrological conditions during the 2004 water quality sampling events in the Merrimack River Watershed. This review was conducted to estimate streamflow conditions in relation to the 7-day, 10-year (7Q10) low flow. Additionally, this review was used to determine whether fecal coliform bacteria data were representative of "wet" or "dry weather" sampling conditions. A sample is considered to be collected during dry weather when there has been no precipitation (<0.1 inch) on the sampling day and three days prior. Wet weather is defined as a precipitation event, generally greater than 0.25 inches of rain, on the sampling date that results in a subsequent increase in streamflow. Given limited resources, sampling the first flush (first 1 hour of a rain event forecast to produce 0.25 inches of precipitation) was not possible.

There is one United States Geological Survey (USGS) stream gauge (#01100000) on the main stem Merrimack River. It is situated on the right bank of the river, 1,100 ft. downstream from the Concord River at Lowell. The daily discharge includes water released from 210 mi^2 in basins of the Sudbury and Nashua Rivers and Lake Cochituate. Flows are regulated by power plants, by Franklin Falls Reservoir since 1942, and by Squam, Newfound, Winnipesaukee, Winnisquam, and other lakes and reservoirs upstream (in New Hampshire). The total drainage area above this gauge is 4,635 mi^2. Because the DWM 2004 Merrimack surveys entailed sampling only tributaries in Massachusetts, discharge data from the Lowell gauge was not deemed representative of flow conditions in the much smaller watersheds of the tributary streams. A real-time gauge on the Spicket River near Methuen (#01100561) is operated for flood forecasting and warning purposes. The USGS states that low-flow discharges below 200 cubic feet per second are not generally available due to variable backwater effects from downstream dam operation (USGS 2005a). Therefore, data from this gauge were also considered unacceptable for assessing survey conditions.

Although managed separately from the main stem Merrimack by the MassDEP's Watershed Planning Program, the Shawsheen Watershed is tributary to the Merrimack River and lies entirely within the boundaries of Massachusetts. Furthermore, its 78 mi^2 watershed, while still larger than most, more closely approximates the drainage areas of those tributary streams monitored in 2004. Therefore, discharge data from the Shawsheen River gauge in Wilmington was considered more representative of the local flow conditions in neighboring watersheds.

Survey conditions are described below for each sampling event. Precipitation (Table 3) and stream discharge (Table 4) data were reviewed for a minimum of five days leading up to each sampling date in an effort to determine whether survey conditions were more representative of dry or wet-weather conditions (Figure 2). No drought advisories were issued in 2004; USGS reports that streamflows were normal to above normal during July, August, and September 2004 (USGS 2005b).

2 June 2004: Sampling crews reported overcast skies with temperatures between 50 and 60°F. On the day of sampling 0.02 inches of rain fell at the Lawrence Airport. One day prior to sampling (1 June) 0.22 inches of rain was recorded at the airport. Streamflows in the Shawsheen River near Wilmington (Gauge #01100600) decreased from a high of 88 cfs on 29 May to 40 cfs on the day of sampling. Flows were near the May monthly average streamflow of 59.7 cfs (Socolow et al. 2005). Since streamflows did not respond to the rain event (i.e., increase), samples collected during this survey will be interpreted as being representative of **dry weather conditions**.

23 June 2004: The sun was shining on field crews during this bacteria survey in mid-June; air temperatures were estimated to be between 70-80°F. At the Lawrence Airport the rain gauge was generally dry with rain fall totaling 0.08 inches five days prior to sampling and 0.03 inches falling the day before sampling (Table 3). Streamflows at the USGS gauge continued to generally decrease from the 2 June survey. The daily mean flow value five days prior to sampling was 33 cfs. Stream flow increased to 42 cfs the next day but then steadily decreased to 13 cfs on 23 June. Flow on the sampling date was six times greater than 7Q10 and four times lower than the period-of-record mean discharge for June (Table 4). Bacteria samples collected on 23 June were considered representative of **dry weather**.

8 July 2004: A total of 1.52 inches of rain were reported for 8 July. Pre-dawn crews reported clear to mostly cloudy skies during the multi-probe survey. Later sampling crews reported that their day began with overcast skies and occasional drizzle. The Spicket River gauge is equipped with a rain gauge. Hourly precipitation data from the gauge **showed that precipitation began around 2200 hours, long after sampling** was completed (USGS 2005c). The Shawsheen River exhibited steadily declining daily mean flow values from 3 July (11 cfs) to 8 July (5.9 cfs) despite a minimal amount (0.05 inches) of precipitation on 5 July. Since the rain event on the 8th occurred after crews were finished sampling, samples collected on this date will be interpreted as being representative **of dry-weather conditions**.

18 August 2004: Field crews during the pre-dawn survey reported drizzle while samplers reported mostly cloudy skies during the bacteria survey. Precipitation was recorded at Lawrence on each of the five days preceding the survey (Table 3) totaling 1.44 inches. It is also important to note that on 12 August, 2.44 inches of rain was recorded at Lawrence as well. The mean daily discharge at the Shawsheen River Gauge on 12 August was 4.9 cfs, a value that was nearing the provisional 7Q10 statistic (i.e., 2.3 cfs). Due to the rain, however, daily mean flow increased dramatically to 52 cfs on 13 August, and increased again to 168 cfs on the day after that. While flows gradually declined from 14 August to 18 August, the mean flow on the 18th was still approximately 14 times higher than the week before and three times higher than the mean monthly value for the period of record (i.e., 23.3 cfs). Data from samples collected on the 18th will be interpreted as being indicative of **wet-weather conditions**.

9 September 2004: Field crews reported rain at the beginning of the final Merrimack survey in September. However, by the end of the survey, crews reported only overcast skies. No precipitation fell at Lawrence between 4 September and 7 September. On 8 September, 0.20 inches were measured in the gauge and 1.17 inches of rain was reported for the sampling date (9 September). Streamflows decreased slightly each day between 4 September and 7 September (19-14 cfs) but doubled on the 9th (28 cfs) in response to the rain event. Daily mean flow values continued to increase to a maximum of 66 cfs on 11 September. Since field crews reported collecting in rainy weather, and stream discharge was twice that of the previous day, bacteria samples collected on 9 September 2004 are considered representative of **wet-weather conditions.**

Table 3. Provisional precipitation data summaries for MassDEP DWM bacteria surveys obtained from the NOAA website http://www.erh.noaa.gov/box/dailystns.shtml for Lawrence, MA (NOAA undated).

Merrimack River Bacteria Survey
Precipitation Data Summary (reported in inches of rain)

Survey Dates	5 Days Prior	4 Days Prior	3 Days Prior	2 Days Prior	1 Day Prior	Sample Date
Lawrence						
6/2/2004	0.4	0.00	0.00	T*	0.22	0.02
6/23/2004	0.08	T	0.00	0.00	0.03	0.00
7/8/2004	0.00	0.00	0.05	0.00	0.00	1.52
8/18/2004	0.48	T	0.66	0.29	0.01	0.00
9/9/2004	0.00	0.00	0.00	0.00	0.20	1.17

* trace amount of precipitation noted

Table 4. USGS gauge data summary for the 2004 MassDEP DWM Merrimack River Watershed surveys (Socolow et al. 2005).

Merrimack River Watershed Surveys
USGS Discharge Data Summary (reported in cfs)

Survey Dates	5 Days Prior	4 Days Prior	3 Days Prior	2 Days Prior	1 Day Prior	Sample Date	Monthly Mean	POR* Monthly Mean
Shawsheen River near Wilmington, MA. (Provisional 7Q10 = 2.306 cfs, USGS 1998) Gauge #01100600								
6/2/2004	79	88	80	61	46	40	59.7**	63.7**
6/23/2004	33	42	36	26	16	13	25.9	49.8
7/8/2004	11	10	8.0	7.8	6.8	5.9	32.3	24.8
8/18/2004	52	168	135	101	88	68	52.5	23.3
9/9/2004	19	17	15	14	14	28	52.3	21.8

* Period of Record
** Statistics for May, 2004 discharge data

Figure 2. Streamflow versus precipitation in the Merrimack River Watershed. Streamflow from USGS Gauge #01100600 (Shawsheen River) and precipitation data from Lawrence, MA.

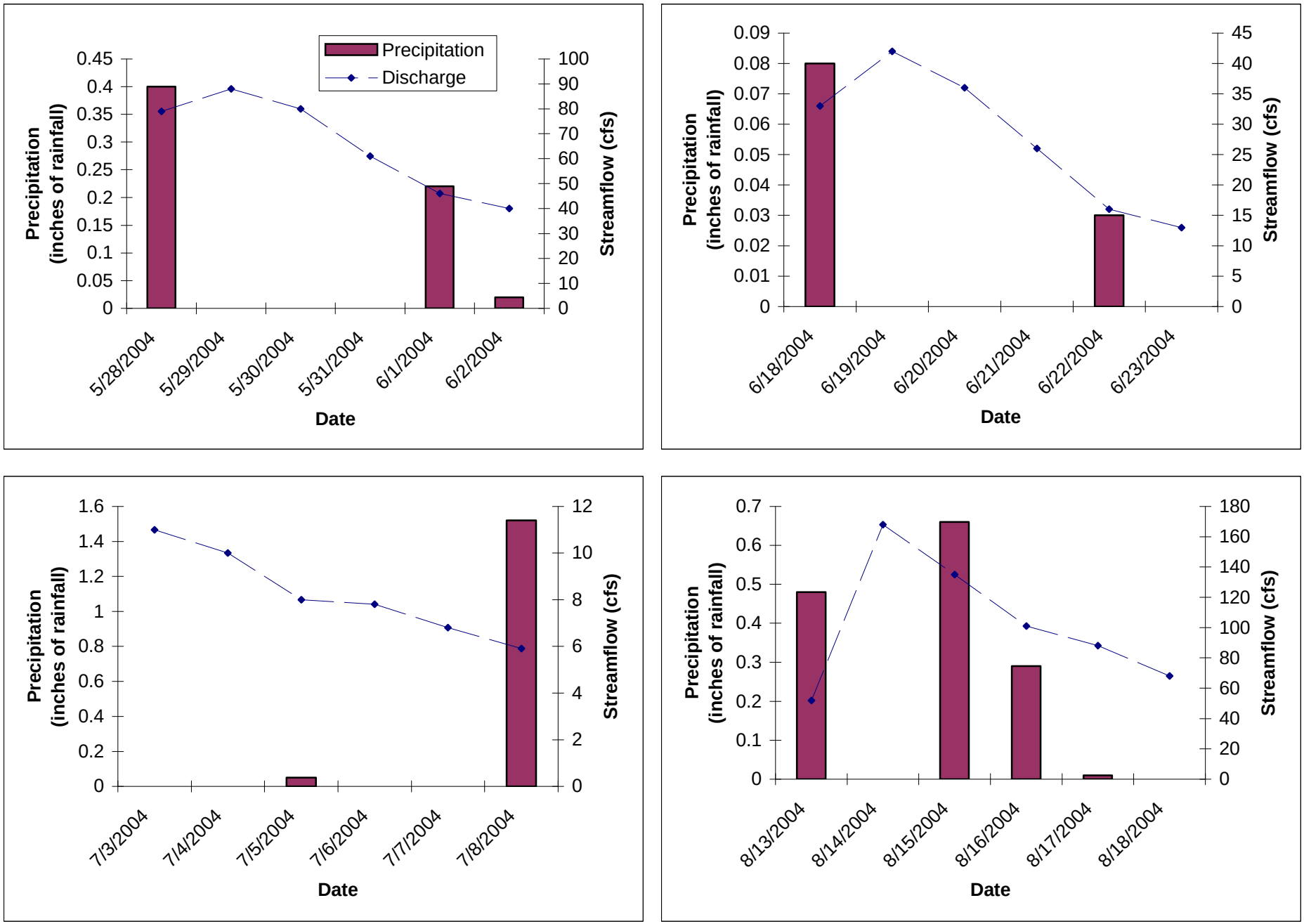
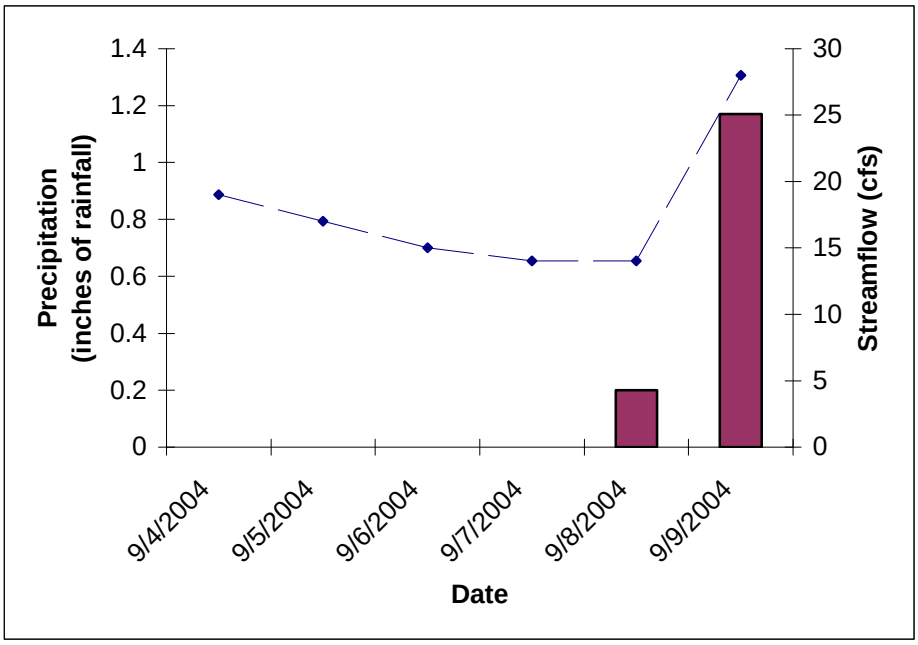


Figure 2 (continued). Streamflow versus precipitation in the Merrimack River Watershed. Streamflow from USGS Gauge #01100600 (Shawsheen River) and precipitation data from Lawrence, MA.



Station Observations

Station BE01- Bennetts Brook- Willow Road crossing, Ayer.

Bennetts Brook originates to the north of Route 2 and west of Shaker Road in Harvard. The brook flows in a northeasterly direction for approximately one half mile before making a 180 degree bend to the north. The brook flows north for one mile to the Harvard/Ayer town line. It again takes a 180-degree turn, enters Shaker Millpond, and flows in an east/northeasterly direction for another 2.2 miles, before finally discharging to Spectacle Pond. The contributing drainage area to Bennetts Brook is 4.6 mi^2. Land use throughout the drainage area is 52% forest, 19% residential, 11% open land, 4% transportation, and 4% agricultural.

Field crews parked in a commercial lot adjacent to the brook. Access to Station BE01 was gained downstream from the Willow Road bridge by walking down a trail on the right bank. Samples were collected from the center of the brook. The light yellow/tan water was slightly to moderately turbid throughout the sampling season. The water was odorless. A floating scum was reported on two occasions (2 June and 18 August). Trash was observed in localized areas. Moderate brown film and filamentous algae were present on the rocky substrates as early as June and continued through September. Substrates were a mix of cobble, gravel, and sand. Potential pollution sources noted by the sampling teams included road runoff and runoff from the parking lot.

Station MRB01- Martins Pond Brook, approximately 180 feet downstream from washed out culvert crossing of Loomis Lane, Groton.

Martins Pond Brook emerges as the outlet of Martins Pond in Groton. The brook flows for 2.3 miles in a southeasterly direction to Lost Lake. The drainage area is two square miles. Forty-one percent of the land use within the drainage area is forest, 19% is residential, and 18% is agricultural. Field crews accessed

Station MRB01 by driving to the end of Loomis Lane in Groton and walking down a trail to a wooden footbridge. Samples were collected center stream. The water in Martins Pond Brook varied from clear to light yellow/tan in color and was slightly to moderately turbid. Sparse aquatic macrophytes (*Sparganium*, *Lemna*, and *Wolffia*) were observed in the brook. Additionally, filamentous, film, and floc algae were documented at various densities throughout the sampling season. Substrates in Martins Pond Brook were cobble, gravel, and sand. No scums, trash, or other objectionable deposits were viewed by field crews. The crews noted that dirt bikes frequently cross the brook resulting in minimal erosion.

Station JG01- Joint Grass Brook- downstream/east of Main Street crossing, Dunstable

Joint Grass Brook rises to the north of Pleasant Street (Route 113) and to the west of Hauk Swamp in Dunstable. The brook flows north for about 1.1 miles. It turns to the east and skirts around Hound Meadow Hill- a distance of about 0.6 miles. Joint Grass Brook then flows in an east/southeasterly direction for 1.3 miles, through a small unnamed pond, before confluencing with Salmon Brook. The sampling location was approximately 30 feet downstream from Main Street. A small unnamed tributary discharges to Joint Grass Brook downstream from Main Street on the left bank. The sampling station was also located downstream from this tributary. Samples were collected from center stream. The water was reddish in color from tannins. With the exception of the 23 June survey where the water was slightly turbid due to wind, the water in Joint Grass Brook was free from turbidity. There were no odors, scums, or other aesthetically objectionable deposits. Sand dominated the substrate composition but coarse gravel and boulder provided some stable habitat for invertebrates. Sparse brown film algae was reported on the rocks in June, July, and August. The drainage area of Joint Grass Brook is three square miles. Land use within the drainage area is 62% forest, 12% agriculture, 11% residential, and 9% open land. Land use within the riparian zone surrounding the sampling station is forest, although a crop field is located less than 0.1 miles upstream. Field crews identified road runoff as a potential pollution source. Additionally, they were concerned with the sediment inputs from no apparent source. A small farm pond (0.01 mi^2) impounds the unnamed tributary 0.2 miles upstream from Joint Grass Brook. Depending upon the outlet control strategies (if any), this pond could contribute to the sedimentation in Joint Grass Brook.

Station SA01- Salmon Brook- Ridge Road crossing, Nashua, New Hampshire

Salmon Brook forms as the outlet of Lower Massapoag Pond, near Route 113 in Dunstable. The brook flows north into New Hampshire. From the pond to the state line, the brook flows a distance of 2.8 miles. The sampling station was located downstream from Ridge Road in Nashua, New Hampshire. Samples were collected from the right bank. There is no canopy cover at the sampling station. The water in Salmon Brook was odorless, slightly turbid, and light yellow to tan in color. The aquatic macrophyte *Sparganium* and thin film algae were observed in Salmon Brook. Substrates at this sampling location were a mix of sand, boulder, cobble, and gravel. Foam was observed in July and August. No scums or trash were reported. Potential pollution sources included road runoff. A quarry/mine is located along the left bank at the state line. The Massachusetts portion of the drainage area is 22.5 mi^2. Land use within the drainage area is 59% forest, 18% residential, and 7% agriculture. Land use in the riparian zone is mostly forest.

Station LWB02- Lawrence Brook- approximately 130 feet downstream/south of Sherburne Avenue, Tyngsborough

Lawrence Brook, a second-order tributary to the Merrimack River begins to the west of Jefferson Drive in Tyngsborough. The brook flows southwest through the locality of Norris Corner, under Lawndale Road, and Sherburne Avenue, before emptying into the Merrimack River 0.8 miles downstream from the Tyngsborough Bridge. The brook is 2.5 miles long. The drainage area of Lawrence Brook is 3.4 mi^2 and includes Althea and Mascuppic lakes. Land use in the watershed is 40% residential, 37% forest, 45% agriculture, and 4% wetlands. The sampling station was located downstream from Sherburne Avenue. A golf course is located less than 150 feet from the left bank. Water clarity varied from clear to slightly turbid. The color of the water in Lawrence Brook was reported by crews to generally be light yellow/tan, however, during the 23 June survey it was grayish. The water never emitted any objectionable odors. Substrates were a mix of cobble, sand, coarse gravel, and boulder. A sparse stand of Arrow arum

(*Peltandra)* was noted. Thin film algae covered 25-50% of the rock substrates in the riffle areas. There were no aesthetically objectionable conditions found within 100 meters of the sampling reach

Station BR01- Bridge Meadow Brook- Downstream/northeast of the unnamed school access road crossing north off Westford Avenue between the localities of Hayward Corner and Swan Corner, Tyngsborough

Bridge Meadow Brook is an approximately 4 mile-long stream that originates to the north of Chestnut Road and west of the locality of Fredericks Corner. The stream flows in a west/northwest direction to Flint Pond. Two former gravel pits adjacent to the brook have been reclaimed. The gravel pit to the north is now the site of an elementary school, while the one to the south has been converted to residential subdivisions. The sampling station was located downstream from the school access road. Samples were collected from center stream. Approximately 95 feet upstream from the road a large beaver dam creates an approximately 2.5 acre impoundment of the brook. Downstream from the road, the culvert creates a large pool and then a riffle area. There was little to no canopy cover shading the brook, visual estimates of percent open sky ranged from 80-100% open. The water was a reddish/light yellow/tan color. During both July surveys and the August bacteria survey the water was described as having an organic odor. During the August pre-dawn survey the water smelled of sulfides. The stream was almost always turbid, but in varying degrees—on 23 June and 18 August the water was slightly turbid, on 8 July and 17 August it was moderately turbid and on 7 July and 9 September it was highly turbid. During the other surveys there was either no turbidity (i.e., clear) or clarity was unobservable due to darkness (i.e., predawn surveys). Algae and periphyton abounded at this station. Floating clumps of blue green algae were documented in the slow moving areas of the brook during the 23 June survey. Moderate to very dense filamentous, film, and floc periphyton were documented during the 8 July, 18 August, and/or 9 September surveys. Freshwater sponges were also observed in Bridge Meadow Brook. Trash, debris and other objectionable deposits were absent from this sampling station. Potential pollution sources include road runoff and runoff from lawns (school athletic fields, nearby houses). The drainage area, upstream from the sampling location is 3.2mi^2. Land use within the upstream drainage area is 57% forest, 35% residential, and 4% open land.

Station TA01- Tadmuck Brook- Lowell Road crossing, Westford

Tadmuck Brook emerges from Tadmuck Swamp just north of Main Street in Westford and flows north for a relatively short distance (0.9 miles) before confluencing with Stony Brook. Land use within the 1.9 mi^2 drainage area of Tadmuck Brook is 42% residential, 33 % forest, and 14% open land. The sampling station was located upstream from Lowell Road in Westford. Samples were collected from the center of the stream. The riparian area surrounding the sampling site was forested and included a mix of shrubs, herbaceous plants, and trees. Canopy cover was visually estimated to be 70-100% open. Sand was the dominant substrate but coarse gravel, mud, silt, and cobble were also encountered. Periphyton coverage varied throughout the sampling season but filamentous, thin film, and loose floc varieties were documented. The water was stained from tannins originating in the wetlands as evidenced by sampling crew reports of reddish, brownish, and light yellow/tan water color. The water was odorless with the exception of the August pre-dawn survey where the water smelled musty. Clarity in Tadmuck Brook varied from clear to moderately turbid. There were no scums, sheens, trash, or other objectionable deposits in Tadmuck Brook. Road runoff was the only potential pollution source identified by field crews.

Station DBR05- Deep Brook- Ledge Road crossing, Chelmsford.

The headwaters to Deep Brook are located in a wetland, east of Route 3 and north of Dunstable Road (Make Peace Road) near the Tyngsborough/Westford/Chelmsford town lines. After flowing in a southeast/ east direction for 2.9 miles, Deep Brook empties into the Merrimack River, about one mile downstream from Tyngs Island. The sampling station was located downstream from Ledge Road. It is important to note that data collected from this sampling station would not reflect any water quality impacts associated with Swains Pond or the urbanized area of North Chelmsford 0.4 miles downstream. The sampling station is surrounded by forest with an herbaceous understory (see inset to the right). Percent open sky was visually estimated to be between 50 and 80%. The color of the water varied from reddish to light yellow/tan. The water smelled musty during the 8 July and 9 September surveys and was slightly to moderately turbid throughout the sampling season. At the sampling station, substrates were coarse gravel, cobble, and sand. Thin film algae covered less than 25% of the rocky surfaces. There were no scums, sheens, trash, or debris at the sampling station. The drainage area upstream from the sampling station is 0.5 mi^2 while the entire Deep Brook drainage area is 2.5 mi^2. Land use in the area upstream from the sampling location is 56% forest, 21% residential, 11% wetlands, and 7% transportation. Land use throughout the entire watershed is 51% forest, 24% residential, 7% transportation, and 7% industrial.

View off end of Marguerite Road, Chelmsford (downstream from Swains Pond)

Sedimentation is a major problem in the lower portion of this stream. Sampling crews were frequently stopped by civilians and told that sand from the Route 3 construction was washing into the brook (Fiorentino personal communication 15 December 2005). Fish population crews gave this reach a score of 10 out of 20 due to sedimentation (Maietta 2004). Pictometry images reviewed in the preparation of this technical memorandum show that the brook is channelized downstream from Swains Pond and large sand bars have filled in the center of the channel (see inset to the left). An unnamed tributary flows under Route 3 and discharges to Deep Brook just downstream from the sampling station. A quarry is located to the west of Route 3 at the headwaters to this unnamed tributary.

Station BB05- Black Brook, Westford Street crossing, Lowell

Black Brook originates in a golf course north of Route 3 in Lowell. The Middlesex Canal ends as the headwaters to Black Brook. The brook flows in a northwesterly direction under Westford Street and into an unnamed pond. The brook then flows past Hadley Field and into two additional unnamed ponds. From the downstream-most pond Black Brook apparently flows underground for the remaining distance to the Merrimack River. The brook is 1.5 miles long and drains an area of 3.3 square miles. Land use within the drainage area is 52% residential, 17% forest, 11% open land, and 10% industrial. The sampling station was accessed by parking in a commercial lot –"Amy's Hair designs" – on the west side of the Westford Street bridge. Field crews crossed over the bridge and collected samples on the right bank, upstream from the bridge. Substrates in the vicinity of the sampling location consisted of sand, coarse gravel, and boulder. Percent open sky was visually estimated to be between 5 and 40%. Thin film periphyton was observed covering less than 25% of the rocky substrates during the June and July surveys. Loose floc periphyton was observed on the bottom of the pools during the August survey. There were no other reports of periphyton, however, it is important to note that the water clarity in Black Brook was described as moderately turbid to highly turbid/murky throughout the sampling season. The water was light yellow/tan in color. Field crews reported some type of aesthetically objectionable conditions (floating scums, trash, duckweed, pollen/dust blankets with coarse particulate matter, flocculent masses) on every survey. Shoreline erosion was noted on the right bank from adjacent yards. Potential pollution sources identified by field crews included garbage dumping, lawns, and road runoff.

Station PO01- Powwow River, approximately 550 feet downstream/east of Route 150 (approximately 225 feet downstream of Amesbury electrical substation but upstream of discharge pipe directly across from 35 Mill Street), Amesbury
Station pipe at PO01- flowing storm water pipe

The Massachusetts portion of the Powwow River begins as the outlet of Tuxbury Pond at the South Hampton, New Hampshire/Merrimac, Massachusetts border. The river meanders in a generally east direction, crosses back into New Hampshire before returning to Massachusetts. The river is impounded to form Lake Gardner. After spilling over the dam, the river continues to meander through the center of Amesbury, flows under Route 110 and Route 495, and meets the Merrimack River, just east of the Amesbury Wastewater Treatment Plant. The sampling station was accessed by walking through a field across from 35 Mill Street. A storm drain discharges on the right bank. Water quality samples were taken upstream from this discharge. The water was generally clear from turbidity except during August when it was slightly to moderately turbid. The water was light yellow/tan in color. On two surveys (July bacteria and August bacteria) the water smelled musty. Substrates in the sampling reach were boulder and cobble. Thin film periphyton covered 25-50% of the rocky substrates. Percent open sky was visually estimated to be between 40 and 60%. Field crews noted no foams or scums or other objectionable deposits. The left bank of the river is channelized for a short distance by a concrete block retaining wall. Downstream from the sampling station, the river widens and the gradient lessens. An unnamed tributary (sometimes referred to as the Back River) confluences with the Powwow approximately 600 feet downstream from the sampling station. The entire drainage area upstream from Station PO01 is 50.2 square miles. Land use within the 6.5 square miles portion in Massachusetts is 40% forest, 20% residential, and 17% agricultural. Commercial and industrial uses abut the riverbanks for 1000 feet upstream from the sampling station.

Samples were also collected from the pipe for bacterial analysis. Data from the pipe station were censored for the July and August surveys as field crews collected the sample from the pool of water under the pipe, rather than from the actual flow from the pipe. Data from the pipe indicated high concentrations of fecal coliform and *E. coli* bacteria during the first two surveys and the last survey. The Northeast Regional Office (NERO) of MassDEP was notified of the elevated counts.

Station ABR01- Unnamed tributary to Powwow River, approximately 50 feet upstream/northeast of R Street, Amesbury

This unnamed tributary originates as the outlet of Clarks Pond and flows 0.4 miles to the Powwow River. The sampling station was located approximately 400 feet downstream from Clarks Pond. The station was accessed via R Street. The R Street bridge was closed to traffic. Crews walked down a steep bank upstream from the bridge. The samples were collected from the right bank upstream from antiquated storm drains. Substrates in the sampling reach were cobble, boulder, and coarse gravel. Thin film periphyton covered between 25 and 50% of the rocky substrates. Percent open sky was estimated to be 25-60%. The water was odorless. Water color varied from clear to brownish to grayish to light yellow/tan. Water clarity varied from slightly turbid to clear. Field crews observed trash and debris at the station on every sampling trip. No scums were observed. Both banks are very steep with a high potential for erosion. Land use in the stream corridor immediately upstream from the sampling station includes high- to medium-density residential, commercial, and industrial. The drainage area upstream from the sampling station is 7.5 square miles and includes areas in New Hampshire, as well as the drainage area for Station ABR02.

Station ABR02- Back River, Clinton Street crossing, Amesbury

The Back River originates in a wetland in South Hampton, New Hampshire. The Massachusetts portion of the river is 2.7 miles long. The river flows around Beech Hill in Amesbury and then flows in a generally southwestern direction into Clark's Pond. The river receives flow from Lucy Brook and two unnamed tributaries. Station ABR02 was located approximately 2400 feet upstream from Clark's Pond at Clinton Street. The bridge abutments are armored with riprap. Field crews walked down the riprap upstream from the bridge on the left bank. Samples were taken close to the left bank or from center stream, depending upon water levels. The water was generally brownish to light yellow/tan in color and moderately turbid. The water generally was free from odors. No scums or other objectionable deposits were observed. Substrates in the sampling reach included mud, sand, silt, boulder, cobble, and coarse gravel. Thin film, filamentous, and loose floc periphyton were observed on various occasions throughout the sampling period. Vegetation in the riparian zone included understory shrubs that provided some canopy cover over the stream (percent open sky was estimated between 50 and 100%). The drainage area upstream from Station ABR02 is 6.4 square miles and includes area in New Hampshire. Land use within the Massachusetts portion of the drainage area is 42% forest, 27% agriculture, and 22% residential.

Station EA01- East Meadow River, Thompson Road crossing, Haverhill

The East Meadow River originates as the outlet from Neal Pond on the Merrimac/Haverhill corporate boundary. The river flows in a southeasterly direction, passing under routes 110 and 495, and under Thompson Road before entering Millvale Reservoir. A large portion of the riparian zone is contiguous wetland. The sampling station (EA01) was located in the Meadow Brook Conservation Area. Thompson Road was really a dirt path through the conservation area and was not accessible by car. Field crews parked at the gated entrance to the conservation area and walked approximately 0.1 miles to the bridge. Samples were collected upstream from the bridge from the right bank. Beaver were active in the vicinity of the sampling station; field crews observed black corrugated pipes from a beaver exclusion device and a dam under the Thompson Road bridge. Percent open sky was estimated to be between 50 and 90%. It was difficult to determine the substrate composition as the water was deep and dark tannin stained in color. The water was also slightly turbid. No objectionable conditions (i.e., scums, trash, odors) were observed by sampling personnel. The upstream drainage area is approximately seven square miles. Land use in the drainage area is 54% forest, 18% residential, and 11% agricultural.

Station AR01- Unnamed Tributary, unnamed tributary to Johnson Creek, locally known as Argilla Brook, west off Baldwin Terrace approximately 1400 feet upstream/east of Main Street crossing, Groveland

The headwaters of this unnamed tributary, locally known as Argilla Brook, begin in a wetland in Crane Pond Wildlife Management Area in Groveland. The brook flows north and east for 3.5 miles before it reaches Johnson Brook. The sampling station was located off Baldwin Terrace. Field crews walked down

a path and followed the railroad tracks for about 0.03 miles to an all-terrain-vehicle (ATV) trail. They then followed the trail to an old/makeshift footbridge over the brook. Samples were collected upstream from the "bridge" in the center of the stream. The water in this unnamed brook was light yellow/tan in color and free from turbidity. Substrates were cobble, bedrock, and coarse gravel. Thin film and filamentous periphyton covered <50% of the cobble substrates during the June survey. Loose floc was observed on the cobble substrates during the July survey. Only thin film periphyton was seen on the cobble during the August survey. Percent open sky was estimated to range from 5 to 15%. Trash, debris, floating scums, and water odors were not found in this stream. Shoreline erosion was evident throughout the sampling reach due in large part to the ATVs crossing the brook. The drainage area upstream from the sampling point is 1.9 square miles. Land use within the drainage area is 55% forest, 30% residential, and 6% open land.

Station JC03- Johnson Creek, Center Street crossing, Groveland

According to the Massachusetts Stream And Rivers Inventory System (SARIS) Johnson Creek originates as the outlet to Johnson Pond. [USGS quadrangles indicate that the creek originates in a wetland south of Salem Street and West of Route 97.] The creek flows due north from Johnson Pond for 1.3 miles to the Merrimack River. The sampling station was located downstream from Center Street. Percent open sky at the sampling station was estimated to be between 50 and 100%. Approximately ten feet downstream from the road, the creek is completely shaded by overhanging vegetation. Cobble, coarse gravel, and sand comprised the substrates in the sampling reach. Periphyton (thin film and filamentous) was observed to cover <50% of the cobble substrates and was concentrated in the areas where sunlight penetrated the canopy (e.g., close to the road). The water was clear and colorless and was not malodorous. This little creek was aesthetically pleasing with no objectionable deposits or floating scums. The drainage area of Johnson Creek is 9.5 square miles. Land use within the drainage area is 48% forest, 21% residential, and 10% agricultural. Land use within the buffer zone upstream from the sampling station is open land, residential, and forest.

Station FI01- Fish Brook, River Road crossing, Andover

The headwaters of Fish Brook lie in a wetland north of Route 133 in Andover. The brook flows in a northeast direction, passing under interstate routes 93 and 495 on its way to the Merrimack River. For much of its 4.1-mile length, Fish Brook is bordered by wetlands. The Massachusetts Highway Department maintains a salt storage shed for treating the highways in winter months at the Route 495/Route 93 cloverleaf interchange. The Fish Brook Initiative task force conducted monitoring in the brook for 30 months between 2004 and 2006 and found elevated chloride levels. The task force solicited bids to conduct a salt balance study and hopes to positively identify the source(s) (Wacker 2006). DWM conducted sampling in Fish Brook downstream from River Road in Andover. Field crews parked on Launching Road and then walked back to the bridge. Samples were collected from the left bank close to the bridge abutment. Substrates at the sampling location consisted of cobble and coarse gravel. Percent open sky was estimated to be between 50 and 80%. The water was slightly turbid and light yellow/tan in color. The water exhibited no odor, nor were there scums floating on the surface. Trash and debris was absent from this sampling reach. Runoff from River Road is eroding the left bank at the bridge. The drainage area upstream from the sampling station is 5.9 square miles. Land use within the drainage area is 46% forest, 27% residential, 6% open land, and 6% wetlands.

Station TB02- Trull Brook, approximately 230 feet downstream/north of River Road, Tewskbury

Trull Brook also originates in a wetland. This wetland is located north of Route 495 and borders Great Swamp in Tewksbury. Trull Brook flows north for approximately two miles to meet the Merrimack River. The drainage area upstream from the sampling station is 4.4 square miles. Land use within the drainage area is 35% residential, 29% forest, and 11% open land. Station TB02 was located near the 10^{th} fairway of the Trull Brook Golf Course. The station was upstream from a small dam and downstream from a chain link fence that marks the property boundary of the golf course. A section of pipe leads from the impoundment to a manmade pond that the golf course uses for irrigation purposes. The pool the samples were collected from was quite deep, averaging about four feet, and as such, bacteria samples were often collected from the left bank. *In situ* measurements were obtained by deploying a multiprobe unit for

approximately 48 hours in the pool about one foot off of the bottom. The purpose of this effort was to gather data during worst-case conditions (i.e., pre-dawn) when the golf course was closed and access to the station was prohibited. The water in Trull Brook varied in clarity from clear to highly turbid, but was generally slightly turbid. The odorless water was light yellow/tan in color. Substrates in the brook consisted of boulder and cobble, however due to the depth of the pool, it was difficult to ascertain if additional substrate types were present. The depth of the water also impeded observations of periphyton, although field crews did find filamentous periphyton during the July survey. Percent open sky estimates ranged between 40 and 80%. Aesthetically objectionable conditions were rarely observed in the brook. The irrigation pond frequently was covered with duckweed and algal mats, which occasionally made their way to the brook via the pipe. Geese were ever-present and their droppings were prevalent in the vicinity of the sampling station.

Station PE01- Peppermint Brook, Lakeview Avenue crossing, Dracut

The headwaters of Peppermint Brook can be found in a small, unnamed pond west of Route 38 near the Pelham, New Hampshire/Dracut, Massachusetts border. The brook flows south through an impoundment, through a wetland, and into the center of Dracut. It continues to flow south, passing under Route 113, before turning west and draining into the main stem Merrimack River. The sampling station was located in an urbanized area of Dracut. Field crews parked their vehicles in a shopping plaza, crossed over the Lakeview Avenue bridge and accessed the brook upstream from the bridge on river right. Crews had to scale down a steep, eroding bank to gain access to the water. Across from the sampling station was another steep bank that was fenced off from an adjacent yard and the shopping plaza parking area. However, this fence did not prevent illegal dumping- trash, plastic bags, a metal bed frame, tires, and wooden boards, all found their way into the center of the stream. Surprisingly, the water was not malodorous. Water clarity varied from clear to moderately turbid. This turbidity was most often documented during rain events. Substrates in Peppermint Brook upstream from Lakeview Avenue consisted of cobble, sand, and coarse gravel. Film periphyton was observed covering <50% of the cobble substrates. Percent open sky varied from 20 to 40%. Storm drains were located in the middle of the Lakeview Avenue bridge and were observed to contain stagnant standing water during the June survey. A smell of natural gas always permeated the air at the bridge. The brook was carried under Lakeview Avenue through two round, corrugated culverts. The drainage area upstream from the sampling station is 1.7 square miles. Land use within the drainage area is 41% residential, 31% forest, and 7% agricultural while in the buffer zone immediately upstream from the sampling station land use is mostly high-density residential.

Station TRB02- Trout Brook, Kenwood Road crossing, Dracut

Trout Brook begins in Dracut to the west of Jones Avenue and east of the power lines. The brook flows in a southwesterly direction for 2.6 miles then empties into Richardson Brook. The sampling station was located upstream from Kenwood Road in Dracut. Samples were collected from center stream. The water was light yellow/tan in color and free from turbidity and odors. Substrates in the sampling reach were composed of boulder, cobble, and sand. Estimates of percent open sky ranged between 5 and 10%. No objectionable scums, trash, debris, or deposits were observed. The drainage area upstream from Station TRB02 is 1.2 square miles. Land use within the drainage area is 46% forest, 26% agriculture, and 15% open land.

Station RBR01- Richardson Brook, Methuen Street crossing, Dracut

Richardson Brook originates at the outlet of a small, unnamed pond, just south of Route 113 (Broadway Street) in Dracut. It then flows in a southeasterly direction into another small, unnamed pond. Trout Brook flows are added to Richardson Brook in this pond. The brook then flows out of the pond and into the Merrimack River. The total length of Richardson Brook is 2.3 miles. Station RBR01 was located upstream from the Methuen Street bridge. The brook flows under the road through a concrete box culvert. During the course of the surveys, the Town of Dracut installed a sewer line under Richardson Brook. They accomplished this by installing a coffer dam and rerouting the water. They had installed similar sewer lines under other brooks that go through town (e.g., Peppermint and Trout brooks). The sampling station was located downstream from this activity. The brook was moderately filled (50%) with aquatic

macrophytes including *Typha sp, Sparganium sp., Polygonum sp., Pontederia sp.,* and *Peltandra sp.* Additionally, thin film and filamentous periphyton were observed growing epiphytically on the macrophytes and on boulder/cobble substrates. Percent open sky was visually estimated to be 100%. The water was clear to light yellow/tan in color. On two occasions (August and September bacteria surveys) the water was slightly turbid. There were no scums, algal mats, trash, or other debris encountered during the sampling events. The drainage area upstream from Station RBR02 (including all of the Trout Brook drainage area) is 4.2 square miles. Land use within the drainage area is 45% forest, 21% residential, 18% agriculture, and 12% open land.

Station BA01- Bartlett Brook, Route 113 (North Lowell Street) crossing, Methuen

Bartlett Brook begins at the New Hampshire/Massachusetts border, just north of Island Pond Road in Dracut. The brook flows generally in a westerly direction and receives inputs from six unnamed tributaries. The brook is impounded between Route 113 and Route 110 to form Mill Pond. Mill Pond empties into the Merrimack River. Upstream from Route 113, Bartlett Brook is braided. The braid comes together just under the Route 113 bridge. Samples were collected from center stream, 20 feet downstream from the bridge abutments. Sparse areas (two individual plants) of the aquatic macrophyte *Pontederia cordata* were observed growing near the right bank. Substrates in the sampling reach included boulder, cobble, coarse gravel, and sand. During the August bacteria survey, silt covered the substrates, however, it was washed away by the September survey. Percent open sky estimates varied widely between field crews and ranged from 5 to 60%. There were no aesthetically objectionable conditions observed within the brook. Yard waste and litter covered the path leading to the brook, close to the road. The drainage area upstream from Station BA01 is 6.7square miles. Land use within the drainage area is 44% forest, 30% residential, and 9% agriculture.

Station BMB01A- Bare Meadow Brook, Renfrew Street crossing, Methuen

Bare Meadow Brook begins north of Bare Meadow Street in Methuen. The brook flows in a northwest direction for 0.8 miles. After passing under Oak Street, the brook turns and flows due east for approximately 0.5 miles. After it flows under Route 213, the brook parallels Route 495 and flows in a northeasterly direction for about 1.8 miles before confluencing with the Merrimack River. Station BMB01A was located roughly 0.5 miles upstream from the confluence. Field crews accessed the station by parking before the Renfrew Road bridge then walking downstream about 30 feet to an area flagged by the survey coordinator on the right bank. Beaver were active at this site and numerous trees had been felled. Substrates at the sampling location were cobble, sand, and coarse gravel. Percent open sky was visually estimated to be between 50 and 80%. Thin film periphyton covered less than 25% of the cobble substrates. The water was observed to be slightly turbid and grayish in color during the July bacteria survey. For the remainder of the surveys water color varied from clear to light yellow/tan and visual instream turbidity varied from none (i.e., clear) to slightly turbid. No floating scums, trash, debris, or other objectionable conditions were found in Bare Meadow Brook. Both the left and right banks were undercut. During the June bacteria survey, the sampling crew encountered a sea lamprey. The drainage area upstream from Station BMB01A is seven square miles. Land use within the drainage area is 39% forest, 36% residential, and 9% open land.

Station CR01- Creek Brook, West Lowell Avenue crossing, Haverhill

Creek Brook flows from the outlet of Crystal Lake to the Merrimack River, a distance of 2.3 miles. Station CR01 was located upstream from West Lowell Avenue in Haverhill. The station was accessed through private property at 574 West Lowell Avenue. Field crews walked down the steep right embankment and collected samples from the center of the stream, about 10 feet upstream from the bridge. Substrates in Creek Brook at the sampling reach consisted of cobble, boulder, and coarse gravel. The water was generally clear and colorless. However, during the September bacteria survey the water was brownish in color and highly turbid/murky. Creek Brook was aesthetically pleasing with no scums, trash, debris or other deposits. The drainage area upstream from the sampling station is 5.6 square miles. Land use within the drainage area is 39% forest, 27% residential, 12% open land, and 10% agriculture.

Station LR01- Little River, Winter Street crossing, Haverhill

The Little River commences at the Haverhill, Massachusetts/New Hampshire state line and is formed by the confluence of three streams. The Little River flows in a southeasterly direction, receiving flow from Fishin Brook and two unnamed tributaries, before passing under Route 495. The brook then receives flow from Snows Brook. The river flows directly through downtown Haverhill. Just upstream from Winter Street the Little River is dammed for manufacturing uses. The sampling station was located approximately 30 feet downstream from the road (~150 feet downstream from the dam) and was closer to the right bank than center stream. The station was accessed via walking down an eroded path leading down from the road/adjacent parking lot. Downstream from the sampling station, the stream disappears, presumably it is culverted underground and discharges to the Merrimack River. The entire drainage area upstream from the sampling location, including a large area in New Hampshire, is 28.3 square miles. The Massachusetts portion is 7.8 square miles. Land use within the Massachuestts portion is 37% forest, 35% residential, 9% open land, and 7% agriculture. Interestingly, the buffer zones upstream and downstream from the sampling station are commercial, industrial, and transportation uses.

This stream suffered the fate of a typical urban stream. The left bank was channelized with concrete blocks. The water was light yellow/tan to grayish to brownish in color. The river was usually slightly turbid; during the July predawn, and August and September bacteria surveys the river was moderately turbid. Often odors were noted including untreated sewage, chlorine, musty basement, and a chemical smell similar to creosote, but it was difficult to discern whether the water or the air had the odor due to the re-aeration over the dam. Two sparse stands of *Pontederia* were noted near the left shoreline. Substrates in the sampling reach were boulder, cobble, coarse gravel, and sand. Brown foam, presumed to be natural, was observed on most of the surveys. An oil sheen was noted during the August bacteria survey. It appeared that the sheen originated from the sediments. The sheen appeared and then moved downstream, but did not cover the entire width of the river and mostly hugged the right bank. Garbage including shopping carts, a scooter, plastic bags, tires, and bicycles blanketed the streambed. A large (3-4 foot) concrete outfall pipe was noted to be flowing downstream from the sampling station on the right bank. Another storm drain coming from the carwash on the left bank was not seen discharging.

Water Quality Data

All MassDEP DWM water quality data are managed and maintained in the *Water Quality Data Access Database.* Tables 5 – 8 below are 2004 data exports for the Merrimack River Watershed. The procedures used to accept, accept with qualification or censor data are based on the DWM SOP for data validation and usability (MassDEP 2005), and are in addition to separate quality assurance activities and laboratory validation steps undertaken by WES. Data validation procedures for 2004 data are described further in Appendix 1. Data qualifiers are listed at the bottom of each page and in Appendix 2.

Table 5. 2004 MassDEP DWM Merrimack River Watershed *In situ* Multi-probe Data.

Unnamed Tributary
Unique_ID: W1209 Station: AR01, Mile Point: 0.473
Description: [unnamed tributary to Johnson Creek, locally known as Argilla Brook, west off Baldwin Terrace approximately 1400 feet upstream/east of Main Street crossing, Groveland]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0075	04:03	0.4	21.8	7.3	369	240	6.9	79
08/17/04	84-0131	04:49	0.1 i	17.3	7.3 c	302	193	8.1 u	85 u
09/08/04	84-0187	04:04	0.2	18.4	7.4 c	366	234	7.6 u	81 u

Unnamed Tributary
Unique_ID: W1196 Station: ABR01, Mile Point: 0.345
Description: [unnamed tributary to Powwow River, approximately 50 feet upstream/northeast of R Street, Amesbury]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0072	02:13	0.5	22.8	7.5	223	145	7.9	92
08/17/04	84-0128	02:27	0.1 i	19.0	7.3 c	211	135	6.9	75
09/08/04	84-0184	02:18	0.2	20.5	7.5 c	247	158	7.8 u	87 u

POWWOW RIVER (Saris: 8450300)
Unique_ID: W1198 Station: PO01, Mile Point: 1.553
Description: [approximately 550 feet downstream/east of Route 150 (approximately 225 feet downstream of Amesbury electrical substation but upstream of discharge pipe directly across from 35 Mill Street), Amesbury]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0071	01:51	0.6	22.9	7.4	175	114	8.4	98
08/17/04	84-0127	01:49	0.9	22.4	7.7 c	176	113	8.3	96
09/08/04	84-0183	01:57	0.2	21.5	7.6 c	163	104	8.5	97

BACK RIVER (Saris: 8450325)
Unique_ID: W1212 Station: ABR02, Mile Point: 0.442
Description: [Clinton Street crossing, Amesbury]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0073(Pooled)	02:35	0.9 r	20.2 r	7.2 r	192 r	125 r	6.2 ru	69 ru
08/17/04	84-0129	02:56	0.4	18.5	7.3 c	191	122	7.6 u	82 u
09/08/04	84-0185	02:37	0.3	18.3	7.3 c	203	130	6.8 u	72 u

" i " = inaccurate readings from Multi-probe <u>likely</u>; may be due to significant pre-survey calibration problems, post-survey checks outside typical acceptance ranges for the low ionic and deionized water checks, lack of calibration of the depth sensor prior to use, or to checks against laboratory analyses. Where documentation on unit pre-calibration is lacking, but SOPs at the time of sampling dictated pre-calibration prior to use, then data are considered <u>potentially</u> inaccurate.

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

" c " = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. Typically used for <u>conductivity</u> (>718, 1,413, 2,760, 6,668 or 12,900 uS/cm) or <u>turbidity</u> (>10, 20 or 40 NTU). It can also be used for <u>TDS and Salinity</u> calculations based on qualified ("c") conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading).

" r " = data not representative of actual field conditions.

EAST MEADOW RIVER (Saris: 8450525)
Unique_ID: W1213 Station: EA01, Mile Point: 0.112
Description: [Thompson Road crossing, Haverhill]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0074	03:30	1.1	20.7	6.6	314	204	1.8	20
08/17/04	84-0130	03:59	0.6	18.7	6.6	273	175	1.7	18
09/08/04	84-0186	03:33	0.4	17.9 u	6.4	362	232	0.2 u	2 u

JOHNSON CREEK (Saris: 8450550)
Unique_ID: W1197 Station: JC03, Mile Point: 0.957
Description: [Center Street crossing, Groveland]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0076	04:25	0.4	15.5	7.2 u	292	190	8.9	89
08/17/04	84-0132	05:18	0.2	17.1	7.3 c	238	152	8.1 u	85 u
09/08/04	84-0188	04:25	0.3	17.3	7.3 c	263	168	8.1	85

LITTLE RIVER (Saris: 8450575)
Unique_ID: W1210 Station: LR01, Mile Point: 0.441
Description: [downstream/south at Winter Street crossing, Haverhill]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0070	05:13	0.3	21.3	7.1 c	424	271	7.8	90
08/17/04	84-0126	04:21	0.2	19.5	7.1	294	191	8.7	95
09/08/04	84-0182	04:37	0.1 i	20.0	7.2	475	309	8.5	93

CREEK BROOK (Saris: 8450700)
Unique_ID: W1203 Station: CR01, Mile Point: 0.154
Description: [West Lowell Avenue crossing, Haverhill]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0069	04:52	0.2	19.6	7.3 c	522	334	7.8	87
08/17/04	84-0125	03:57	0.2	18.3	7.1	400	260	8.3	89
09/08/04	84-0181	04:12	0.2	17.7	7.2	624	406	8.7	92

BARE MEADOW BROOK (Saris: 8450750)
Unique_ID: W1195 Station: BMB01A, Mile Point: 0.596
Description: [Renfrew Street crossing, Methuen]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0068	04:33	0.2	23.5	7.1 c	739 c	473 c	5.2 u	62 u
08/17/04	84-0124	03:36	0.2	18.6	6.9	370	241	6.5 u	70 u
09/08/04	84-0180	03:50	0.2	20.4	7.0	472	307	6.9	77

BARTLETT BROOK (Saris: 8450875)
Unique_ID: W1202 Station: BA01, Mile Point: 0.009
Description: [Route 113 (North Lowell Street) crossing, Methuen]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0067	03:55	0.3	20.9	6.9 c	263	168	6.8	78
08/17/04	84-0122	03:01	0.2 m	18.5 m	6.9 m	319 m	208 m	7.7 m	82 m
09/08/04	84-0178	03:16	0.1 i	18.5	7.1	383	249	7.9	85

" i " = inaccurate readings from Multi-probe likely; may be due to significant pre-survey calibration problems, post-survey checks outside typical acceptance ranges for the low ionic and deionized water checks, lack of calibration of the depth sensor prior to use, or to checks against laboratory analyses. Where documentation on unit pre-calibration is lacking, but SOPs at the time of sampling dictated pre-calibration prior to use, then data are considered potentially inaccurate.

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

" c " = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. Typically used for conductivity (>718, 1,413, 2,760, 6,668 or 12,900 uS/cm) or turbidity (>10, 20 or 40 NTU). It can also be used for TDS and Salinity calculations based on qualified ("c") conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading).

" m " = method not followed; one or more protocols contained in the DWM Multi-probe SOP not followed, i.e. operator error (eg. less than 3 readings per station (rivers) or per depth (lakes), or instrument failure not allowing method to be implemented.

FISH BROOK (Saris: 8450950)
Unique_ID: W1206 Station: FI01, Mile Point: 0.641
Description: [River Road crossing, Andover]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0063	01:43	0.3	22.7	6.6	929 c	595 c	1.9 u	23 u
08/17/04	84-0118	01:13	0.3 m	19.5 m	6.3 m	822 cm	534 cm	1.2 mu	13 mu
09/08/04	84-0174	01:24	0.3	19.0	6.4	573	372	1.3	14

TRULL BROOK (Saris: 8451000)
Unique_ID: W1194 Station: TB02, Mile Point: 0.548
Description: [approximately 230 feet downstream/north of River Road, Tewksbury]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
09/09/04	84-0198	09:37	0.6 m	18.0 m	6.5 mu	242 m	158 m	8.1 mu	85 mu

RICHARDSON BROOK (Saris: 8451025)
Unique_ID: W1192 Station: RBR01, Mile Point: 0.351
Description: [Methuen Street crossing, Dracut]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0086(Pooled)	03:26	0.3 r	22.6 r	7.1 cr	361 r	231 r	6.0 r	71 r
08/17/04	84-0123	02:31	0.2	19.4	6.8	296	192	5.6	61
09/08/04	84-0179	02:46	0.1 i	19.1	7.0	392	255	7.6	82

TROUT BROOK (Saris: 8451050)
Unique_ID: W1193 Station: TRB02, Mile Point: 1.058
Description: [Kenwood Road crossing, Dracut]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0066	03:04	0.1 i	17.2	7.0 c	286	183	7.8	82
08/17/04	84-0121	02:12	0.2	17.2	6.8	365	238	7.7	80
09/08/04	84-0177	02:24	0.1 i	17.0	6.9 u	287	187	7.9 u	82 u

PEPPERMINT BROOK (Saris: 8451100)
Unique_ID: W1211 Station: PE01, Mile Point: 0.178
Description: [Lakeview Avenue crossing, Dracut]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0065	02:28	0.1 i	21.2	7.1 c	751 c	481 c	4.1	48
08/17/04	84-0120	01:45	0.2	19.0	7.2	644	418	6.5	70
09/08/04	84-0176	01:57	0.1 i	19.5	7.1 u	764 c	497 c	6.1	67

BLACK BROOK (Saris: 8451175)
Unique_ID: W1191 Station: BB05, Mile Point: 0.977
Description: [Westford Street crossing, Lowell]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0085	05:59	0.4	19.7	6.7	1,003 c	652 c	5.7	63
08/17/04	84-0141	05:42	0.3	17.3	6.7	878 c	571 c	6.5	68
09/08/04	84-0197	05:01	0.2	19.1	6.7	950 c	617 c	6.0	65

" i " = inaccurate readings from Multi-probe likely; may be due to significant pre-survey calibration problems, post-survey checks outside typical acceptance ranges for the low ionic and deionized water checks, lack of calibration of the depth sensor prior to use, or to checks against laboratory analyses. Where documentation on unit pre-calibration is lacking, but SOPs at the time of sampling dictated pre-calibration prior to use, then data are considered potentially inaccurate.

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

" c " = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. Typically used for conductivity (>718, 1,413, 2,760, 6,668 or 12,900 uS/cm) or turbidity (>10, 20 or 40 NTU). It can also be used for TDS and Salinity calculations based on qualified ("c") conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading).

" r " = data not representative of actual field conditions.

" m " = method not followed; one or more protocols contained in the DWM Multi-probe SOP not followed, i.e. operator error (eg. less than 3 readings per station (rivers) or per depth (lakes), or instrument failure not allowing method to be implemented.

TADMUCK BROOK (Saris: 8451325)
Unique_ID: W1201 Station: TA01, Mile Point: 0.316
Description: [Lowell Road crossing, Westford]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0083	05:05	0.2	21.0	7.1 u	625	406	8.0	89
08/17/04	84-0139	04:47	0.3	17.8	7.0	573	372	9.2	97
09/08/04	84-0195	04:06	0.2	17.5	6.8	448	291	8.3	87

BENNETTS BROOK (Saris: 8451525)
Unique_ID: W1200 Station: BE01, Mile Point: 0.997
Description: [Willow Road crossing, Ayer]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0077	01:48	0.2	21.2	6.9	391	254	6.5	73
08/17/04	84-0133	01:16	0.2	17.9	6.9	323	210	8.2	87
09/08/04	84-0189	01:14	0.2	18.4	6.8	316	205	7.4	79

DEEP BROOK (Saris: 8451550)
Unique_ID: W1190 Station: DBR05, Mile Point: 1.747
Description: [Ledge Road crossing, Chelmsford]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0084	05:33	0.5	19.0	6.7	522	340	7.2	78
08/17/04	84-0140	05:16	0.5	16.9	6.7	513	333	7.9	82
09/08/04	84-0196	04:34	0.4	17.8	6.7	607	394	7.8	82

LAWRENCE BROOK (Saris: 8451600)
Unique_ID: W1189 Station: LWB02, Mile Point: 0.235
Description: [approximately 130 feet downstream/south of Sherburne Avenue, Tyngsborough]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0081	04:07	0.3	24.7	7.0	518	336	6.8	82
08/17/04	84-0137	03:57	0.3	20.6	6.9	495	322	7.7	86
09/08/04	84-0193	03:16	0.2	19.9	6.7	463	301	6.2	68

BRIDGE MEADOW BROOK (Saris: 8451625)
Unique_ID: W1207 Station: BR01, Mile Point: 1.524
Description: [downstream/northeast of the unnamed school access road crossing north off Westford Avenue between the localities of Hayward Corner and Swan Corner, Tyngsborough]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0082	04:36	0.2	21.8	6.4	350	228	3.9	44
08/17/04	84-0138	04:21	0.2	20.1	6.5	345	224	5.2	58
09/08/04	84-0194	03:40	0.2	19.4	6.2	333	216	3.1	34

SALMON BROOK (Saris: 8451675)
Unique_ID: W1199 Station: SA01, Mile Point: -0.525
Description: [Ridge Road crossing, Nashua, New Hampshire]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0080	03:35	0.5	21.7	6.8	236	153	5.6	64
08/17/04	84-0136	03:29	0.6	19.3	6.8	248	161	5.6	61
09/08/04	84-0192	02:45	0.4	19.8	6.7	257	167	4.6	51

JOINT GRASS BROOK (Saris: 8451700)
Unique_ID: W1208 Station: JG01, Mile Point: 1.058
Description: [downstream/east of Main Street crossing (below confluence of unnamed tributary), Dunstable]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0079	03:03	0.2	21.2	6.8	232	151	5.6	63
08/17/04	84-0135	02:58	0.2	18.4	6.9	213 u	138 u	6.5	69
09/08/04	84-0191	02:20	0.2	19.5	6.8	144	94.0	5.1	56

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

MARTINS POND BROOK (Saris: 8451825)
Unique_ID: W1188 Station: MRB01, Mile Point: 0.375
Description: [approximately 180 feet downstream from washed out culvert crossing of Loomis Lane, Groton]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0078	02:23	0.3	21.9 u	7.0	290	189	5.2	59
08/17/04	84-0134	01:59	0.3	18.1	6.9	261	170	5.9	62
09/08/04	84-0190	01:43	0.2	18.1	6.9	277	180	5.9	62

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

Table 6. 2004 MassDEP DWM Merrimack River Watershed Bacteria Data.

Unnamed Tributary
Unique_ID: W1209 Station: AR01, Mile Point: 0.473
Description: [unnamed tributary to Johnson Creek, locally known as Argilla Brook, west off Baldwin Terrace approximately 1400 feet upstream/east of Main Street crossing, Groveland]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0016	--	11:30	45 e	71 e
6/23/2004	84-0047	--	11:05	20 e	33 e
7/8/2004	84-0102	--	11:48	20	20
8/18/2004	84-0158	--	11:15	110 e	140 e
9/9/2004	84-0215	--	11:15	5600 d	3600

Unnamed Tributary
Unique_ID: W1196 Station: ABR01, Mile Point: 0.345
Description: [unnamed tributary to Powwow River, approximately 50 feet upstream/northeast of R Street, Amesbury]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0013	--	09:05	650	440
6/23/2004	84-0044	--	09:15	320	190
7/8/2004	84-0099	--	**	90 p	84 p
8/18/2004	84-0155	--	09:35	130	84
9/9/2004	84-0212	--	09:50	3800 dej	13000 e

POWWOW RIVER (Saris: 8450300)
Unique_ID: W1198 Station: PO01, Mile Point: 1.553
Description: [approximately 550 feet downstream/east of Route 150 (approximately 225 feet downstream of Amesbury electrical substation but upstream of discharge pipe directly across from 35 Mill Street), Amesbury]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0012	--	08:45	110 e	150 e
6/23/2004	84-0043	--	09:00	250	200
7/8/2004	84-0098	--	**	420 e	550 e
8/18/2004	84-0153	--	09:15	800 e	850 e
9/9/2004	84-0210	--	09:30	3400 d	3000

Pipe/Discharge to POWWOW RIVER (Saris: 8450300)
Unique_ID: W1204 Station: pipe@PO01, Mile Point: 0.001
Description: [on right bank directly across from 35 Mill Street (approximately 6 feet downstream of Station PO01), Amesbury]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0020	--	08:50	>40000	>40000
6/23/2004	84-0051	--	09:05	49000	45000
7/8/2004	84-0106	--	**	## r	## r
8/18/2004	84-0154	--	09:20	## r	## r
9/9/2004	84-0211	--	09:35	22000 d	7400

" -- " = No data (i.e., data not taken/not required)
" ** " = Missing data (i.e., data that should have been reported)
" ## " = Censored data (i.e., data that has been discarded for some reason)
" d " = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.
" p " = Samples not preserved per SOP or analytical method requirements
" j " = 'estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.
" r " = Samples collected may not be representative of actual field conditions, including the possibility of "outlier" data and flow-limited conditions (e.g., pooled)

BACK RIVER (Saris: 8450325)
Unique_ID: W1212 Station: ABR02, Mile Point: 0.442
Description: [Clinton Street crossing, Amesbury]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0014	--	10:45	410	390
6/23/2004	84-0045	--	09:30	250 e	290 e
7/7/2004	84-0073(Pooled)	--	02:40	--	--
7/8/2004	84-0100	--	10:05	350 e	480 e
8/18/2004	84-0156	--	09:53	230 e	350 e
9/9/2004	84-0213	--	10:00	6800 dej	25000 e

EAST MEADOW RIVER (Saris: 8450525)
Unique_ID: W1213 Station: EA01, Mile Point: 0.112
Description: [Thompson Road crossing, Haverhill]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0015	--	10:10	65 e	84 e
6/23/2004	84-0046	--	10:30	150	130
7/8/2004	84-0101	--	11:20	110 e	150 e
8/18/2004	84-0157	--	10:30	32 e	77 e
9/9/2004	84-0214	--	10:45	190 de	270 e

JOHNSON CREEK (Saris: 8450550)
Unique_ID: W1197 Station: JC03, Mile Point: 0.957
Description: [Center Street crossing, Groveland]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0017	84-0018	11:55	77	65
6/2/2004	84-0018	84-0017	12:00	90 e	97 e
6/23/2004	84-0048	84-0049	11:20	32 e	110 e
6/23/2004	84-0049	84-0048	11:25	65	52
7/8/2004	84-0103	84-0104	12:05	1200 dep	1800 ep
7/8/2004	84-0104	84-0103	12:05	600 dep	1000 ep
8/18/2004	84-0159	84-0160	11:35	93 e	100 e
8/18/2004	84-0160	84-0159	11:35	71 e	110 e
9/9/2004	84-0216	84-0217	11:25	3400 d	2200
9/9/2004	84-0217	84-0216	11:30	1000 de	1800 e

LITTLE RIVER (Saris: 8450575)
Unique_ID: W1210 Station: LR01, Mile Point: 0.441
Description: [downstream/south at Winter Street crossing, Haverhill]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0011	--	11:30	250 e	310 e
6/23/2004	84-0042	--	11:20	3800	160
7/8/2004	84-0097	--	11:53	270	270
8/18/2004	84-0150	84-0151	11:20	330	200
8/18/2004	84-0151	84-0150	11:20	240	210
9/9/2004	84-0207	84-0208	11:35	4000 de	5400 e
9/9/2004	84-0208	84-0207	11:35	9600 d	6600

" -- " = No data (i.e., data not taken/not required)
" d " = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.
" p " = Samples not preserved per SOP or analytical method requirements
" j " = 'estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.

CREEK BROOK (Saris: 8450700)
Unique_ID: W1203 Station: CR01, Mile Point: 0.154
Description: [West Lowell Avenue crossing, Haverhill]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0010	--	11:15	160	130
6/23/2004	84-0041	--	11:05	200 e	270 e
7/8/2004	84-0096	--	11:35	230	210
8/18/2004	84-0149	--	11:05	45	45
9/9/2004	84-0206	--	11:22	13000 d	12000

BARE MEADOW BROOK (Saris: 8450750)
Unique_ID: W1195 Station: BMB01A, Mile Point: 0.596
Description: [Renfrew Street crossing, Methuen]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0009	--	11:00	210	120
6/23/2004	84-0040	--	10:55	210	190
7/8/2004	84-0095	--	11:25	270	250
8/18/2004	84-0148	--	10:55	130	100
9/9/2004	84-0205	--	11:12	9800 d	6200

BARTLETT BROOK (Saris: 8450875)
Unique_ID: W1202 Station: BA01, Mile Point: 0.009
Description: [Route 113 (North Lowell Street) crossing, Methuen]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0008	--	10:25	200	150
6/23/2004	84-0039	--	10:22	880 e	1000 e
7/8/2004	84-0094	--	11:00	150	140
8/18/2004	84-0147	--	10:28	170 e	230 e
9/9/2004	84-0203	--	10:48	800 de	1000 e

FISH BROOK (Saris: 8450950)
Unique_ID: W1206 Station: FI01, Mile Point: 0.641
Description: [River Road crossing, Andover]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0001	--	08:35	250	200
6/23/2004	84-0032	--	08:37	150	97
7/8/2004	84-0087	--	08:45	52 e	58 e
8/18/2004	84-0142	--	08:41	270	270
9/9/2004	84-0199	--	09:15	190 de	370 e

TRULL BROOK (Saris: 8451000)
Unique_ID: W1194 Station: TB02, Mile Point: 0.548
Description: [approximately 230 feet downstream/north of River Road, Tewksbury]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0002	--	08:55	200	150
6/23/2004	84-0033	--	09:03	710	540
7/8/2004	84-0088	--	09:20	480	450
8/18/2004	84-0143	--	09:05	400	320
9/9/2004	84-0200	--	09:35	21000 d	19000

" -- " = No data (i.e., data not taken/not required)
" d " = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.

RICHARDSON BROOK (Saris: 8451025)
Unique_ID: W1192 Station: RBR01, Mile Point: 0.351
Description: [Methuen Street crossing, Dracut]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0007	--	10:00	71 e	97 e
6/23/2004	84-0038	--	10:00	40	27
7/7/2004	84-0086(Pooled)	--	03:30	--	--
7/8/2004	84-0093	--	10:40	400	200
8/18/2004	84-0146	--	10:08	52	32
9/9/2004	84-0204	--	10:32	1800 dej	6600 e

TROUT BROOK (Saris: 8451050)
Unique_ID: W1193 Station: TRB02, Mile Point: 1.058
Description: [Kenwood Road crossing, Dracut]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0006	--	09:45	58 e	77 e
6/23/2004	84-0037	--	09:50	84 e	100 e
7/8/2004	84-0092	--	10:25	510	500
8/18/2004	84-0145	--	09:57	140 e	230 e
9/9/2004	84-0202	--	10:25	8800 d	6200

PEPPERMINT BROOK (Saris: 8451100)
Unique_ID: W1211 Station: PE01, Mile Point: 0.178
Description: [Lakeview Avenue crossing, Dracut]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0003	84-0004	09:30	310	220
6/2/2004	84-0004	84-0003	09:30	290	270
6/23/2004	84-0034	84-0035	09:27	1800 e	2400 e
6/23/2004	84-0035	84-0034	09:27	1400 e	2800 e
7/8/2004	84-0089	84-0090	09:50	380 e	410 e
7/8/2004	84-0090	84-0089	09:50	470	420
8/18/2004	84-0144	--	09:36	490 e	690 e
9/9/2004	84-0201	--	10:08	4800 de	7400 e

BLACK BROOK (Saris: 8451175)
Unique_ID: W1191 Station: BB05, Mile Point: 0.977
Description: [Westford Street crossing, Lowell]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0029	84-0030	11:55	97	52 d
6/2/2004	84-0030	84-0029	11:55	130	130 d
6/23/2004	84-0060	84-0061	12:15	160 e	170 e
6/23/2004	84-0061	84-0060	12:15	130	110
7/8/2004	84-0115	84-0116	11:32	620 e	700 e
7/8/2004	84-0116	84-0115	11:32	700 e	740 e
8/18/2004	84-0170	84-0171	11:36	210	170
8/18/2004	84-0171	84-0170	11:36	290	140
9/9/2004	84-0227	84-0228	10:55	6200	2400
9/9/2004	84-0228	84-0227	10:55	5000	3800

" -- " = No data (i.e., data not taken/not required)
" d " = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.
" j " = 'estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.

TADMUCK BROOK (Saris: 8451325)
Unique_ID: W1201 Station: TA01, Mile Point: 0.316
Description: [Lowell Road crossing, Westford]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0027	--	10:55	150 e	210 e
6/23/2004	84-0058	--	11:32	280 e	350 e
7/8/2004	84-0113	--	10:47	1400	600
8/18/2004	84-0168	--	10:48	250	190
9/9/2004	84-0225	--	10:20	4200 e	5200 e

BENNETTS BROOK (Saris: 8451525)
Unique_ID: W1200 Station: BE01, Mile Point: 0.997
Description: [Willow Road crossing, Ayer]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0021	--	08:25	330	250
6/23/2004	84-0052	--	08:25	240	230
7/8/2004	84-0107	--	08:25	190 e	210 e
8/18/2004	84-0162	--	08:20	290	240
9/9/2004	84-0219	--	08:40	3600	3400

DEEP BROOK (Saris: 8451550)
Unique_ID: W1190 Station: DBR05, Mile Point: 1.747
Description: [Ledge Road crossing, Chelmsford]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0028	--	11:30	120 e	130 e
6/23/2004	84-0059	--	11:58	200	140
7/8/2004	84-0114	--	11:06	150 e	180 e
8/18/2004	84-0169	--	11:10	270 e	380 e
9/9/2004	84-0226	--	10:39	4000 e	5200 e

LAWRENCE BROOK (Saris: 8451600)
Unique_ID: W1189 Station: LWB02, Mile Point: 0.235
Description: [approximately 130 feet downstream/south of Sherburne Avenue, Tyngsborough]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0025	--	10:05	210	170
6/23/2004	84-0056	--	10:10	13 e	45 e
7/8/2004	84-0111	--	10:05	71 e	84 e
8/18/2004	84-0166	--	10:07	84	71
9/9/2004	84-0223	--	09:52	250	220

BRIDGE MEADOW BROOK (Saris: 8451625)
Unique_ID: W1207 Station: BR01, Mile Point: 1.524
Description: [downstream/northeast of the unnamed school access road crossing north off Westford Avenue between the localities of Hayward Corner and Swan Corner, Tyngsborough]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0026	--	10:30	73 e	87 e
6/23/2004	84-0057	--	11:10	71	52
7/8/2004	84-0112	--	10:25	<6	6
8/18/2004	84-0167	--	10:21	19 e	45 e
9/9/2004	84-0224	--	10:06	200 e	270 e

" -- " = No data (i.e., data not taken/not required)
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.

SALMON BROOK (Saris: 8451675)
Unique_ID: W1199 Station: SA01, Mile Point: -0.525
Description: [Ridge Road crossing, Nashua, New Hampshire]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0024	--	09:45	26	26
6/23/2004	84-0055	--	09:50	120	71
7/8/2004	84-0110	--	09:36	19 e	52 e
8/18/2004	84-0165	--	09:43	52 e	77 e
9/9/2004	84-0222	--	09:35	350 e	500 e

JOINT GRASS BROOK (Saris: 8451700)
Unique_ID: W1208 Station: JG01, Mile Point: 1.058
Description: [downstream/east of Main Street crossing (below confluence of unnamed tributary), Dunstable]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0023	--	09:25	52	19
6/23/2004	84-0054	--	09:35	27 e	80 e
7/8/2004	84-0109	--	09:22	47	47
8/18/2004	84-0164	--	09:12	13 e	52 e
9/9/2004	84-0221	--	09:23	1600	600

MARTINS POND BROOK (Saris: 8451825)
Unique_ID: W1188 Station: MRB01, Mile Point: 0.375
Description: [approximately 180 feet downstream from washed out culvert crossing of Loomis Lane, Groton]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0022	--	08:50	150	110
6/23/2004	84-0053	--	08:50	39 e	65 e
7/8/2004	84-0108	--	08:53	19	19
8/18/2004	84-0163	--	08:45	77 e	84 e
9/9/2004	84-0220	--	09:00	290	230

" -- " = No data (i.e., data not taken/not required)
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.

Quality Control Data

Table 7. 2004 MassDEP DWM Merrimack River Watershed Field Blank Data.

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0019	Blank	11:50	<7	<7
6/23/2004	84-0050	Blank	11:30	<6	<6
7/8/2004	84-0105	Blank	12:10	<6	<6
8/18/2004	84-0161	Blank	11:35	<6	<6
9/9/2004	84-0218	Blank	11:35	<6	<6
8/18/2004	84-0152	Blank	11:31	<6	<6
9/9/2004	84-0209	Blank	11:42	<6 d	<6
6/2/2004	84-0005	Blank	09:35	<7	<7
6/23/2004	84-0036	Blank	09:53	<6	<6
7/8/2004	84-0091	Blank	09:55	<6	<6
6/2/2004	84-0031	Blank	12:00	<7	<7
6/23/2004	84-0062	Blank	12:15	<6	<6
7/8/2004	84-0117	Blank	11:32	<6	<6
8/18/2004	84-0172	Blank	11:45	<6	<6
9/9/2004	84-0229	Blank	10:51	<6	<6

" d " = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.

Table 8. 2004 MassDEP DWM Merrimack River Watershed Field Duplicate Data.

JOHNSON CREEK (Saris: 8450550)
Unique_ID: W1197 Station: JC03, Mile Point: 0.957
Description: [Center Street crossing, Groveland]

Date	OWMID	QAQC	Time	Log10(Fecal)	Log10(E.coli)
			(24hr)	CFU/100mL	CFU/100mL
06/02/04	84-0017	84-0018	11:55	1.886	1.813
06/02/04	84-0018	84-0017	12:00	1.954	1.987
Relative	*Percent*	*Difference*		*3.5%*	*9.2%*
06/23/04	84-0048	84-0049	11:20	1.505	2.041
06/23/04	84-0049	84-0048	11:25	1.813	1.716
Relative	*Percent*	*Difference*		*18.6%*	*17.3%*
07/08/04	84-0103	84-0104	12:05	3.079	3.255
07/08/04	84-0104	84-0103	12:05	2.778	3.000
Relative	*Percent*	*Difference*		*10.3%*	*8.2%*
08/18/04	84-0159	84-0160	11:35	1.968	2.000
08/18/04	84-0160	84-0159	11:35	1.851	2.041
Relative	*Percent*	*Difference*		*6.1%*	*2.0%*
09/09/04	84-0216	84-0217	11:25	3.531	3.342
09/09/04	84-0217	84-0216	11:30	3.000	3.255
Relative	*Percent*	*Difference*		*16.3%*	*2.6%*

LITTLE RIVER (Saris: 8450575)
Unique_ID: W1210 Station: LR01, Mile Point: 0.441
Description: [downstream/south at Winter Street crossing, Haverhill]

Date	OWMID	QAQC	Time	Log10(Fecal)	Log10(E.coli)
			(24hr)	CFU/100mL	CFU/100mL
08/18/04	84-0150	84-0151	11:20	2.519	2.301
08/18/04	84-0151	84-0150	11:20	2.380	2.322
Relative	*Percent*	*Difference*		*5.6%*	*0.9%*
09/09/04	84-0207	84-0208	11:35	3.602	3.732
09/09/04	84-0208	84-0207	11:35	3.982	3.820
Relative	*Percent*	*Difference*		*10.0%*	*2.3%*

PEPPERMINT BROOK (Saris: 8451100)
Unique_ID: W1211 Station: PE01, Mile Point: 0.178
Description: [Lakeview Avenue crossing, Dracut]

Date	OWMID	QAQC	Time	Log10(Fecal)	Log10(E.coli)
			(24hr)	CFU/100mL	CFU/100mL
06/02/04	84-0003	84-0004	09:30	2.491	2.342
06/02/04	84-0004	84-0003	09:30	2.462	2.431
Relative	*Percent*	*Difference*		*1.2%*	*3.7%*
06/23/04	84-0034	84-0035	09:27	3.255	3.380
06/23/04	84-0035	84-0034	09:27	3.146	3.447
Relative	*Percent*	*Difference*		*3.4%*	*2.0%*
07/08/04	84-0089	84-0090	09:50	2.580	2.613
07/08/04	84-0090	84-0089	09:50	2.672	2.623
Relative	*Percent*	*Difference*		*3.5%*	*0.4%*

BLACK BROOK (Saris: 8451175)
Unique_ID: W1191 Station: BB05, Mile Point: 0.977
Description: [Westford Street crossing, Lowell]

Date	OWMID	QAQC	Time	Log10(Fecal)	Log10(E.coli)
			(24hr)	CFU/100mL	CFU/100mL
06/02/04	84-0029	84-0030	11:55	1.987	1.716
06/02/04	84-0030	84-0029	11:55	2.114	2.114
Relative	*Percent*	*Difference*		*6.2%*	*20.8%*
06/23/04	84-0060	84-0061	12:15	2.204	2.230
06/23/04	84-0061	84-0060	12:15	2.114	2.041
Relative	*Percent*	*Difference*		*4.2%*	*8.9%*
07/08/04	84-0115	84-0116	11:32	2.792	2.845
07/08/04	84-0116	84-0115	11:32	2.845	2.869
Relative	*Percent*	*Difference*		*1.9%*	*0.8%*
08/18/04	84-0170	84-0171	11:36	2.322	2.230
08/18/04	84-0171	84-0170	11:36	2.462	2.146
Relative	*Percent*	*Difference*		*5.9%*	*3.9%*
09/09/04	84-0227	84-0228	10:55	3.792	3.380
09/09/04	84-0228	84-0227	10:55	3.699	3.580
Relative	*Percent*	*Difference*		*2.5%*	*5.7%*

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Appendix 1

Data Validation Procedures
Merrimack Watershed 2004 Water Quality Survey

Selected Excerpts from:
Data Validation Report for Year 2004 Project Data (CN 265.0)

October, 2006

Massachusetts Department of Environmental Protection
Division of Watershed Management

4.0 2004 *In-Situ* Multiprobe Data

4.1 QA/QC Objectives and Criteria for 2004 *In-Situ* Multi-probe Data

Trained DWM staff members (and their designees) conducted *in-situ* measurements using Hydrolab® Series 3/4 and YSI 6000 Series multi-probe instruments. These simultaneously measure dissolved oxygen, temperature, pH, conductivity, and depth, and provide calculated estimates for total dissolved solids and % oxygen saturation.

To ensure the quality of the data, the following QA/QC steps were taken before, during and after use:

- Pre-Survey Calibration and Check: Standard pre-survey calibration of each unit was conducted in accordance with the DWM SOP (CN 4.2). After the instrument was calibrated and before the instrument was released to field staff, an instrument check using both a low ionic standard and filtered de-ionized water was performed. The purpose of this check is to make sure that the instrument is providing stable readings as the waters in Massachusetts are typically of low ionic strength. If the instrument failed acceptance criteria, it was not released to field staff until the source of error was identified and corrected.

- Post-Survey Check: A standard post survey check of each unit was performed in accordance with the DWM SOP. Upon return to the lab, a visual inspection was performed to identify any physical damage that may have occurred in the field. The calibration of the unit was then checked against both a low ionic standard and filtered de-ionized water. The results of the post survey calibration check were compared to the pre-calibration results. If visual damage was observed and/or post calibration acceptance criteria were not achieved, the source of error was investigated and data collected in the field may have been subject to qualification or censoring.

- Data Reduction: The Multi-probe Coordinator, QC Analyst and Database Manager reviewed the multi-probe data for problems associated with instability, instrument malfunction, operator error and aberrant trends. If any of these conditions were detected, the data was investigated and may have been recommended for censoring. The Database Manager electronically tagged all data recommended for censoring in the database. Measured data were also evaluated for the following:

• **Consistency with the SOP** (specifically, the requirement for three (minimum)-five (preferred) sequential readings one-minute-apart at appropriate depths, proper field use, etc.).

• **Accuracy and precision** of readings, as assessed through review of pre-survey calibration/check and post-survey check data, field notes for any information on faulty operation and/or unusual field conditions, and accuracy checks.

• **Representativeness** of data (review of fieldsheets and notes for any information that might indicate non-representativeness; eg. not taken at the deep hole).

• Check for **"outliers" or unreasonable data**, based on best professional judgement. Outliers are identified and flagged for scrutiny. For lake depth profiles, more leeway is given to apparently unstable multi-probe data, given that thermal stratification can cause rapid, natural changes in parameters within the thermocline.

• Multi-probe record **acceptance criteria**: Within each set of records for individual OWMID #s, automatically accept the final line of data for each depth where the change in depth from the previous accepted-record-depth is greater than 0.2 meters, subject to review and change by the multiprobe review team.

• The criterion used in 2004 to accept, qualify or censor **Conductivity (and the dependent, calculated estimates for TDS and Salinity)** readings was based on exceedance of the calibration standard concentration. For exceedances greater than two times the standard, the conductivity reading was typically censored. Readings above the calibration standard were qualified whenever the reading was less than two times the calibration standard. NOTE: In cases where readings fell far below the calibration standard concentration (e.g., measured value of 100 uS/cm using 6668 calibration standard), no censoring or qualification was imposed.

• For **D.O.** values less than 0.2 mg/l, 2004 data were accepted without qualification and reported as "<0.2". Similarly for % saturation, values less than 2% were accepted without qualification and reported as "<2%".

• For all parameters taken at the same location and whose range for 3-5 successive readings fluctuated beyond the range (+/-) of probe accuracy, the data was typically qualified or censored (depending on the degree of fluctuation) with "u" (**unstable**). Data exhibiting significant, continuous movement in one direction and that did not appear to reach equilibrium was also qualified or censored.

• For instances **where temperature has been censored, data for Conductivity, pH and D.O. are typically qualified.** (readings for Conductivity, pH and dissolved oxygen are internally-corrected for temperature; conductivity is temperature-compensated to 25 deg. C, D.O. readings are adjusted about 5% per degree C to account for changes in oxygen solubility and membrane permeability, and pH is compensated for electrode effects due to variable sample temperatures.) In cases where temperature has only been qualified, no qualification of data for conductivity, pH and D.O. is imposed.

• Depth criteria:

General Depth Criteria: Apply to each OWMID# for lakes and rivers

- Clearly erroneous readings due to faulty depth sensor: Censor (i)
- Negative and zero depth readings: Censor (i); (likely in error)
- 0.1 m depth readings: Qualify (i); (potentially in error)
- 0.2 and greater depth readings: Accept without qualification; (likely accurate)

Specific Depth Criteria: Apply to entirety of depth data for survey date

- If zero and/or negative depth readings occur more than once per survey date, censor all negative/zero depth data, and qualify all other depth data for that survey (indicates that erroneous depth readings were not recognized in the field and that corrective action (field calibration of the depth sensor) was not taken, ie. that all positive readings may be in error.)

5.0 2004 Discrete Water Sample Data

5.1 QA/QC Objectives and Criteria for 2004 Discrete Water Sample Data

The collection and analysis of discrete water samples in 2004 followed the DWM Standard Operating Procedures and lab analyte-specific SOPs. The majority of river samples were taken via the manual grab and basket sampler techniques (where ambient water enters the sample bottle directly). For Lakes, the samples were taken using the Van Dorn thief-type sampler at depth and manually for epilimnetic "surface" samples.

For river sampling, field quality control samples consisted of approx. 10% ambient blanks and 10% field duplicates (i.e., separate, co-located (side-by-side), simultaneous field duplicates). For lakes, equipment blanks and sequential duplicates were taken using a Van Dorn apparatus.

Using the following criteria, as well as other considerations and input from data reviewers, individual datum were either:
Accepted
Accepted with qualification, or
Censored

In cases where poor quality control (e.g., blank/cross contamination, lab accuracy) affected batched analyses or entire surveys, censoring/qualification decisions were applied to groups of samples (e.g., a specific crew's samples, a specific survey's samples or all samples from a specific batch analysis).

Criteria for acceptance of discrete water quality sample data were as follows:

- For simplicity, samples that were **"lost", "missing", "spilled" and "not analyzed"** were denoted using the 'm' (method not followed) qualifier and ** symbol.

- **Sampling/Analysis Holding Time**: Each analyte has a standard holding time that has been established to ensure sample/analysis integrity. Refer to DWM Standard Operating Procedure CN# 1.2 for a complete listing. If the standard holding time was exceeded, this criterion is violated and the data may be censored, depending on the extent of exceedance. For minor exceedances (e.g., < than 20% of the holding time), the data is typically qualified ("h" for minor holding time violation).

- **Quality Control Sample Frequency**: At a minimum, one field blank and one replicate must be collected for every ten samples by any given sampling crew on any given date. If less than 10% blanks and replicates were collected, the data are typically qualified with "f". If blanks were omitted and duplicates taken, typically no data are qualified, as long as there are no documented historical problems for the survey-specific samplers or station locations with regard to field contamination. If blanks were taken but duplicates were not, the data may be qualified with "f". Typically, no censoring of data takes place for insufficient QC sample frequencies only.

- **Field Blanks:** Field blanks were prepared at the DWM Worcester Laboratory. Reagent grade water was transported into the field in a sample container where it was transferred into a different sample container directly or via a sampling device (equipment blank) using the same methods as for its corresponding field sample (e.g., blank samples were preserved in the same way). All blanks were submitted to the WES laboratory "blind". If the field blank results were greater than the MDL (indicating potential sampling error, airborne contaminants, dirty equipment, etc.), the data may be censored or qualified, depending on extent and other factors. Programmatically, DWM does not correct sample results by subtracting blank concentrations.

- **Field Replicates:** In 2004, field duplicate samples for rivers were taken as co-located, simultaneous duplicates. As a result, these duplicate results include any spatial, natural variability present between side-by-side samples (which should be minimal in most cases where site selection has accounted for

uniform mixing). Duplicate lake samples were sequential and therefore also include any temporal variability. Samples were submitted to WES laboratory "blind".
Results were compared to specific criteria contained in a 2004 QAPP document. If the criteria are not met, the sample/duplicate data may be censored or qualified, depending on extent of exceedance and other factors. Arguably, very poor precision of field duplicate samples reflects poor reproducibility for entire surveys and/or analytical batch runs, and should result in censoring or qualification of the entire survey/batch data. Decisions related to poor precision for entire surveys/batchs were made on a case-by-case basis.

- Results of **Field and/or Lab Audits** and Miscellaneous Survey Information: If, based on the results of field evaluation of implementation of field sampling SOPs, samples are deemed to have been taken incorrectly or to not represent station conditions at the time of sampling, then individual or survey-based sample results may be qualified or censored. Likewise, the results of QC audits of lab(s) analytical accuracy (and precision) for specific parameters are evaluated. If results indicate poor accuracy or repeatability, batch run data may be qualified or censored. In addition, information from survey personnel regarding sample integrity and representativeness may lead to decisions to qualify or censor data.

- **Laboratory assessment of analytical precision and accuracy:** The WES Laboratory is solely responsible for the administration of its Quality Assurance Program and Standard Operating Procedures. WES staff release discrete water sample data when their established QA/QC criteria have been met. When the following criteria cannot be met, data are qualified using appropriate qualifiers:

• Low Calibration Standards – Checks the stability of the instrument's calibration curve; analyzes the *accuracy* of an instrument's calibration within a 5% range.

• Reference Standards – Generally, a second source standard (a standard different from the calibration stock standard) that analyzes the method *accuracy.*

• Laboratory Reagent Blank/Method Blank (LRB) – Reagent grade water (de-ionized) extracted with every sample set used to ensure that the system is free of target analytes (< MDL) and to assess potential blank contamination.

• Duplicate Sample – Measures the *precision* (as Relative Percent Difference or RPD) of the analytical process. The acceptable laboratory %RPD range is typically ≤ 25%. For bacteria, duplicate data are evaluated based the range of logged values.

• Spike Sample (Laboratory Fortified Blank - LFB, Laboratory Fortified Matrix - LFM)– Measures the *accuracy* (% Recovery) of an analytical method. The acceptable laboratory % recovery range is typically between 80 – 120% for LFB samples and 70 –130% for LFM discrete water samples.

2004 Field and Lab Audit Results

Field Audits – Due to limited time and resources, only one (1) field audit was performed by DWM's QC Analyst in 2004. This review for adherence to field protocols was conducted on 9/16/04 for a fish population survey. Survey included one DWM crew lead and two trained seasonal interns. Habitat scoring sheets were filled out by the crew lead and QC analyst to estimate general precision of scoring. This audit indicated acceptable staff performance, did not impact validation of survey sample results, and did not result in any corrective actions.

Appendix 2

2004 Data Symbols and qualifiers
Merrimack Watershed 2004 Water Quality Survey

Selected Excerpts from:
Data Validation Report for Year 2004 Project Data (CN 265.0)

October, 2006

Massachusetts Department of Environmental Protection
Division of Watershed Management

The following data qualifiers or symbols are used in the MADEP/DWM WQD database for qualified and censored water quality and multi-probe data. Decisions regarding censoring vs. qualification for specific, problematic data are made based on a thorough review of all pertinent information related to the data.

General Symbols (applicable to all types):

" ## " = Censored data (i.e., data that has been discarded for some reason). *NOTE: Prior to 2001 data, "**" denoted either censored or missing data.*

" ** " = Missing data (i.e., data that should have been reported). See NOTE above.

" -- " = No data (i.e., data not taken/not required)

* = Analysis performed by Laboratory OTHER than DEP's Wall Experiment Station (WES)

[ ] = A result reported inside brackets has been "censored", but is shown for informational purposes (e.g., high blank results).

Multi-probe-specific Qualifiers:

" i " = inaccurate readings from Multi-probe likely; may be due to significant pre-survey calibration problems, post-survey checks outside typical acceptance ranges for the low ionic and deionized water checks, lack of calibration of the depth sensor prior to use, or to checks against laboratory analyses. Where documentation on unit pre-calibration is lacking, but SOPs at the time of sampling dictated pre-calibration prior to use, then data are considered potentially inaccurate.

Qualification Criteria for Depth (i):

General Depth Criteria: Apply to each OWMID#

- Clearly erroneous readings due to faulty depth sensor: Censor (i)
- Negative and zero depth readings: Censor (i); (likely in error)
- 0.1 m depth readings: Qualify (i); (potentially in error)
- 0.2 and greater depth readings: Accept without qualification; (likely accurate)

Specific Depth Criteria: Apply to entirety of depth data for survey date

- If zero and/or negative depth readings occur more than once per survey date, censor all negative/zero depth data, and qualify all other depth data for that survey (indicates that erroneous depth readings were not recognized in the field and that corrective action (field calibration of the depth sensor) was not taken, ie. that all positive readings may be in error.)

“ m ” = method not followed; one or more protocols contained in the DWM Multi-probe SOP not followed, ie. operator error (eg. less than 3 readings per station (rivers) or per depth (lakes), or instrument failure not allowing method to be implemented.

“ s ” = field sheet recorded data were used to accept data, not data electronically recorded in the Multi-probe surveyor unit, due to operator error or equipment failure.

“ u ” = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly-variable water quality conditions, etc. See Section 4.1 for acceptance criteria.

“ c ” = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. Typically used for conductivity (>718, 1,413, 2,760, 6,668 or 12,900 uS/cm) or turbidity (>10, 20 or 40 NTU). It can also be used for TDS and Salinity calculations based on qualified (“c”) conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading). See Section 4.1 for acceptance criteria.

“ r ” = data not representative of actual field conditions.

“ ? ” = Light interference on Turbidity sensor (Hydrolab error message). Data is typically censored.

Sample-Specific Qualifiers:

“ a ” = accuracy as estimated at WES Lab via matrix spikes, PT sample recoveries, internal check standards and lab-fortified blanks did not meet project data quality objectives identified for program or in QAPP.

“ b ” = blank Contamination in lab reagant blanks and/or field blank samples (indicating possible bias high and false positives).

“ d ” = precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.

“ e ” = not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.

“ f ” = frequency of quality control duplicates did not meet data quality objectives identified for program or in QAPP.

“ h ” = holding time violation (usually indicating possible bias low)

“ j ” = ‘estimated’ value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the ‘reporting’ limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.

“ m ” = method SOP not followed, only partially implemented or not implemented at all, due to complications with sample matrix (eg. sediment in sample, floc formation), lab error (eg. cross-contamination between samples), additional steps taken by the lab to deal with matrix complications, lost/unanalyzed samples, and missing data.

“ p ” = samples not preserved per SOP or analytical method requirements.

“ r ” = samples collected may not be representative of actual field conditions, including the possibility of “outlier” data and flow-limited conditions (e.g., pooled).

Misc. abbrev./symbols:

TY= tygon tubing
AF= ambient field blank
VD= van dorn bottle

2004 MERRIMACK AND FRENCH & QUINEBAUG PERIPHYTON STUDY

Stream Velocity and Canopy Cover Considerations

Prepared by:

Joan L. Beskenis
Watershed Planning Program
Worcester, MA

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Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
Ian Bowles, Secretary
Department of Environmental Protection
Laurie Burt, Commissioner
Bureau of Resource Protection
Glenn Haas, Acting Assistant Commissioner
Division of Watershed Management
Glenn Haas, Director

Introduction

In 2004, biological sampling, including macroinvertebrate, periphyton and habitat assessment, was conducted by MassDEP at primarily first-and second-order (i.e., "headwater") streams in the Merrimack River and French and Quinebaug watersheds. The periphyton data were collected to 1) learn more about the effects of stream velocity and canopy cover on periphyton community structure and function as they pertain to nutrient criteria development and 2) aid in the evaluation of whether or not the designated uses for the waterbody (e.g. aquatic life and aesthetics) were being met as outlined in the Massachusetts Water Quality Standards (MassDEP 2007). Most of MassDEP's biological sampling is conducted in higher order streams or rivers that function differently from these headwater streams.

Headwater streams have newly established stream channels and drain small basin areas (Janish 2006). They also often have wooded riparian zones resulting in shaded reaches that are characterized by waters low in nutrients and dissolved ions (Janish 2006). These shaded areas are highly suitable for heterotrophic organisms that are prevalent in headwater streams as dissolved organic matter from leaves is often readily available. The high gradient and often-closed-canopy affects the biota that can be established.

The determination of what controls the growth of the periphyton is complex. While phytoplankton in lakes are primarily controlled by light and nutrient levels, benthic algal communities respond to several different in-stream variables, including velocity, substrata type, light and nutrient levels. The periphyton were typically sampled in the riffle on cobble substrata, light levels were not measured directly, but the percent canopy cover was estimated. Velocity measurements were also included in the sampling at the stream surface and directly above the surfaces covered with periphyton referred to as the "substrate velocity" (Welch et. al. 1988) to evaluate, experimentally, the usefulness and the difficulties, if any, in obtaining these data.

The periphyton sampling included visual determination of the percent cover within the riffle and reach. Scrapes were made of the substrata to obtain samples for identification. When time allowed, different parts of the same reach were sampled to include both open and closed canopies.

Materials and Methods

Periphyton Identifications and Relative Abundance

The methods for gathering periphyton samples are described in Barbour et al. (1999). Sampling was done by the macroinvertebrate sampling crew and consisted of randomly scraping rocks and cobble substrates, typically within the riffle area, but other habitats were occasionally sampled. Material was removed with a knife or by hand from rock substrata and then added to labeled glass vials containing sample water. Table 1 contains descriptions of the station locations where periphyton was collected in the Merrimack River Basin and Table 2 presents station locations in the French and Quinebaug River basins. The samples were transported to the lab at MassDEP-Worcester in one-liter plastic jars containing stream water to keep them cool. At the lab, they were refrigerated until identifications were completed. Samples held longer than a week were preserved using a Lugol's solution-M^3 with a dose rate of 2 ml of preservative per 100 ml of sample (Reinke 1984).

Large clumps of filamentous algae were removed first from the vials. The vials were then shaken to homogenize the samples before subsampling. The filamentous algae were identified separately and then the remainder of the sample was examined. An Olympus BH2 compound microscope with Nomarski optics was used for the identifications (Appendix A contains the references used for taxonomic identifications). Slides were typically examined under 200 power. A modified method for periphyton analysis initially developed by Bahls (1993) was used. The scheme for describing the relative abundance of the algae in a sample is as follows:

R (rare)	fewer than one cell per field of view at 200x, on the average;
C (common)	at least one, but fewer than five cells per field of view;
VC (very common)	between 5 and 25 cells per field;
A (abundant)	more than 25 cells per field, but countable;
VA (very abundant)	number of cells per field too numerous to count.

In 2004, the percent macroalgal cover and the percent microalgae cover were determined by making a visual estimate of the coverage within the riffle. The microalgae (also described as periphyton) typically appear as a thin film, often green or blue-green, or as a brown floc (loose material without any structure that would break up when touched or when removed from the waterbody). The macroalgae, visible filamentous forms of green algae, are the "nuisance" type algae. Aesthetics, recreational use of the waterbody and aquatic life may be compromised if more than 40% of the substrata in the riffle/run are covered by macroalgal filaments (Barbour et al. 1999).

Table 1. List of benthic biomonitoring stations sampled during the 2004 **Merrimack River** watershed survey, including station identification number, upstream drainage area, station description, sampling date and whether algae or velocity were measured. (adapted from Mitchell, 2007)

Station ID	Upstream Drainage Area (Km^2)	Merrimack Watershed Station Description	Sampling Date	Algal cover (%), Algal ID (A), Velocity (V)
SO01	22.35	South Branch Souhegan River, downstream from Jones Hill Road, 275 m downstream from unnamed tributary, Ashby, MA	27 July 2004	%, A, V
RBR01	10.88	Richardson Brook, 200 m upstream from Methuen Street, Dracut, MA	30 July 2004	%, A, V
TB02	11.29	Trull Brook, 100 m downstream from River Road, Tewksbury, MA	30 July 2004	%, A, V
MRB01	5.15	Martins Pond Brook, 25 m upstream from footpath extending from Loomis Lane, Groton, MA	29 July 2004	%, V-partial
PO01	130.0	Powwow River, 125 m downstream from Rt. 150 (Main Street), off Mill Street, Amesbury, MA	23 August 2004	%, A (but sample disposed of during waste clean-up)
FI09	15.77	Fish Brook, ~300 m upstream from the dam at mouth of stream, south of Brundrett Ave., Andover, MA	2 August 2004	%, V
CR01	14.40	Creek Brook, 25 m upstream from West Lowell Ave., Haverhill, MA	2 August 2004	%, V
BA01	17.43	Bartlett Brook, 5 m upstream from Rt. 113 (North Lowell Street), Methuen, MA	2 August 2004	%, V
PE01	4.48	Peppermint Brook, ~100 m downstream from Lakeview Ave., Dracut, MA	30 July 2004	%, V
BR01	8.29	Bridge Meadow Brook, 80m downstream from road to Tyngsborough Elementary School (205 Westford Road), Tyngsborough, MA	29 July 2004	%, A, V partial
TA01	4.66	Tadmuck Brook, ~200 m upstream from Lowell Road, Westford, MA	29 July 2004	%, A, V partial
BE01	8.52	Bennets Brook, ~100 m downstream from Willow Road, Ayer, MA	27 July 2004	%, A, V partial

Table 2. List of biomonitoring stations sampled during the 2004 **French & Quinebaug River** watershed survey, including station identification number, upstream drainage, station description, and sampling date. Stations are listed hydrologically (from upstream-most drainage in the watershed to downstream-most). (adapted from Fiorentino, 2007)

Station ID	Upstream Drainage Area (mi^2)	French & Quinebaug River Watershed Station Description	Sampling Date	Algal cover (%), Algal ID (A), Velocity (V)
MO01	1.35	Mountain Brook, 100 m downstream from Rt. 20, Brimfield	25 Aug 2004	%
WS01	1.34	West Brook, 140 m upstream from confluence with Mill Brook, Brimfield	25 Aug 2004	%
W1183	5.92	Unnamed tributary to Mill Brook (locally known as "East Brook"), 5 m upstream from Rt. 20, Brimfield	25 Aug 2004	%, A
BR01	5.52	Browns Brook, 230 m upstream from May Brook Road, Holland	24 Aug 2004	%, V
ST01	4.32	Stevens Brook, 200 m upstream from Mashapaug Road, Holland	24 Aug 2004	%, A, V
LE01	2.47	Leadmine Brook, 600 m upstream from Rt. 84, near vacant Rt. 15 rest area, Sturbridge	24 Aug 2004	%, A
HA01	2.54	Hamant Brook, 100 m downstream from sandpit access road off Shattuck Road, Sturbridge	24 Aug 2004	%, A
HC01	3.58	Hatchet Brook, 100 m upstream from South Street, Southbridge	25 Aug 2004	%
MK01	8.11	McKinstry Brook, 140 m upstream from Pleasant Street, Southbridge	25 Aug 2004	%, A
CO01	4.09	Cohasse Brook, 175 m upstream from Cisco Street, Southbridge	26 Aug 2004	%
LB01	9.73	Lebanon Brook, 550 m upstream from Ashland Avenue, Southbridge	26 Aug 2004	%
W1186	8.07	Unnamed tributary to Quinebaug River (locally known as "Keenan Brook"), 550 m upstream from confluence with Quinebaug River, Southbridge	26 Aug 2004	%
TU01	2.40	Tufts Branch, 30 m upstream from Rt. 197, Dudley	26 Aug 2004	%, A
RB01	4.58	Rocky Brook, 100 m downstream from Midstate Trail footpath, off High Street, Douglas	27 Aug 2004	%
BU01	3.82	Burncoat Brook, 350 m upstream from confluence with Town Meadow Brook, Leicester	3 Sept 2004	%, A
GR01	2.82	Grindstone Brook, 170 m downstream from Rt. 56, Leicester	27 Aug 2004	%
FR04-1	15.67	French River, 300 m downstream from Clara Barton Road, Oxford	30 Aug 2004	%, A-but sample disposed of as hazardous waste
LR01	10.43	Little River, 20 m upstream from Turner Road, Charlton	30 Aug 2004	%, A-but sample disposed of as hazardous waste
W1197	13.89	Unnamed tributary to South Fork (locally known as "Potters Brook"), 150 m downstream from Potter Village Road, Charlton	26 Aug 2004	%, A
SU01	2.46	Sucker Brook, 100 m downstream from Kingsbury Road, Webster	27 Aug 2004	%, A
MI01	1.03	Mine Brook, 140 m downstream from Mine Brook Road, Webster	27 Aug 2004	%, A
MI01A	--	Mine Brook, upstream from Mine Brook Road, Webster	27 Aug 2004	%, A
BW01	1.20	Browns Brook, 130 m upstream from Gore Road, Webster	29 Aug 2004	%, A

Percent Canopy Cover

The percent canopy cover was obtained by standing midstream within the previously established reach and by making a visual estimation of the percent of the open sky that is not blocked by the overhead canopy (Table 3).

Table 3 Descriptions of canopy cover used to determine habitat characteristics described as % open to the sky

Percentage sky not blocked by canopy cover	Canopy cover
76-100	Open
51-75	Partially open
26-50	Partially closed
0-25	Closed

Velocity Measurements

A Sontek flow tracker (MassDEP, 1995) was used to determine stream velocity. Typically, three readings were taken within the riffle and averaged (Table 4). The readings for velocity were taken below the surface for the stream value and just above the surface of a rock containing algae for the "substrate velocity". Care was taken that no obstruction, such as another rock surface or aquatic weeds, created turbulent flow instead of laminar flow over the rock.

Results and Discussion

Velocity Considerations

Stream velocity and canopy cover are two important factors in the development of the algal population. In a few locations both open and closed canopies were sampled in the same stream These results are shown in Tables 4, 5 and 6. Since the organisms had the same exposure to nutrients the results help to distinguish the important factors affecting the growth and composition of the algal community.

Velocity can contribute to both the reduction of the algal population by scouring, as well as to growth by increasing the algae's exposure to nutrients. Horner et. al. 1990, examined the response of the periphyton to stream velocities between 0-50 cm/s and found that larger biomass accumulation was found in natural streams at higher velocities than at lower velocities. Above 50 cm/sec, however, scouring of the substrata and a reduction of the biomass often occurs if the benthic material has a lot of sand present (Horner et. al. 1990).

Stream velocity can also affect the constituents of the algal community. For example, McIntire (1966) found in streams with current velocities of approximately 38 cm/s the diatoms were more abundant while at 9 cm/s filamentous green macroalgae dominated. Horner et. al. 1990 also found that diatoms were more likely to dominate at high velocities and low phosphorus. If phosphorus was elevated the cyanobacteria *Phormidium* sp. was likely to dominate while in lower velocities *Mougeotia* sp. (green filamentous alga) predominated. Although we had limited data we wanted to examine if any trends similar to those cited were found, particularly at locations with high or low velocities recorded.

Table 4. Merrimack and French & Quinebaug Rivers - Canopy cover, average velocity and percent micro and macro algae in the riffle, as measured in 2004.

Date	Station	Stream (Watershed)	Canopy Cover (% Open)	Riffle Surface Average Velocity (cm/sec)	Riffle Above algae Average velocity (cm/sec)	% micro algal cover in riffle	% macro algal cover in riffle
Low velocity (0-20 cm/sec)							
27-Jul-04	SO01	South Branch Souhegan River (Merrimack)	20	nd*	17.7	<10	0
30-Jul-04	RBR01	Richardson Brook (Merrimack)	0	20.6	16.6	20	0
3-Aug-04	PO01	Powwow River (Merrimack)	100	nd	7.7	0	10
2-Aug-04	FI01	Fish Brook (Merrimack)	0	15.7	16.8	90	0
2-Aug-04	BA01	Bartlett Brook (Merrimack)	closed - % NR**	17.2	7.3	10	0
Medium velocity (21-50 cm/sec)							
30-Jul-04	RBR01	Richardson Brook (Merrimack)	70	nd	34.1	30	10
30-Jul-04	PE01	Peppermint Brook (Merrimack)	Closed % NR	nd	23.8	80	0
30-Jul-04	TB02	Trull Brook (Merrimack)	35	nd	32.3	80	0
24-Aug-04	ST01	Steven's Brook (French and Quinebaug)	10	nd	30.0	10	0
24-Aug-04	BR01	Browns Brook (French and Quinebaug)	60	nd	45.0	5	0
High velocity (>51 cm/sec)							
3-Aug-04	PO01	Powwow River (Merrimack)	100	66.3	69.3	0	100
27-Jul-04	BE01	Bennetts Brook (Merrimack)	30	nd	53.5	30	0

*nd=not done
**NR=not recorded

Table 5. Merrimack Watershed - Canopy cover and micro and macro algal cover at individual sampling locations and in the reach (July 27-30, 2004)

Station	Waterbody	Habitat	Canopy Cover (% Open)	Sampling location		Sampling Reach	
				% Microalgal cover	% Macroalgal cover	% Microalgal cover	% Macroalgal cover
SO01	S. Branch Souhegan River	Cobble, riffle	20	60	<10	0	<5
RBR01	Richardson Brook	Cobble, riffle	70	30	10	10	<2
RBR01	Richardson Brook	Cobble, riffle	0	20	0	<5	0
TB02	Trull Brook	Cobble, riffle	35	80	0	0	0
MRB01	Martin's Pond Brook	Cobble, riffle	5	10	0	<5	0
PO01	Powwow River	Cobble, riffle	100	0	100	0	80
PO01	Powwow River	Cobble, run	100	0	0	10	0
FI01	Fish Brook	Pool	0	90	0	~10	0
CR01	Creek Brook	Cobble, riffle	0	25	0	75	0
BA01	Bartlett Brook	Cobble, riffle	0	~10	0	<1	0
PE01	Peppermint Brook	Cobble, riffle	0	80	0	40	0
BR01	Bridge Meadow Brook	Cobble, riffle	10	0	0	10	0
BR01	Bridge Meadow Brook	Mat pool	25	0	0	2	0
TA01	Tadmuck Brook	Cobble, riffle	20	60	0	0	0
TA01	Tadmuck Brook	Mat	100	75	<10	25	<5
BE01	Bennetts Brook	Riffle	30	30	0	15	0

Table 6. French and Quinebaug Watersheds - Canopy cover and micro and macro algal cover at individual sampling locations and in the reach (Aug. 24-27, 30, Sept. 3, 2004)

				Station location		Sampling Reach	
Station	Waterbody	Habitat	Canopy Cover (% Open)	% Microalgal cover	% Macroalgal cover	% Microalgal cover	% Macroalgal cover
MO01	Mountain Brook	Riffle	5	0	0	0	0
WS01	West Brook	Riffle	30	0	0	0	0
W1183	Unnamed tributary to Mill Brook (“East Brook”)	Riffle	100	10	2	0	0
W1183	Unnamed tributary to Mill Brook (“East Brook”)	Run	100	0	0	10	2
BR01	Browns Brook	Riffle	10	0	0	0	0
ST01	Stevens Brook	Run	10	10	2	0	0
LE01	Leadmine Brook	Riffle	0	10	5	0	0
HA01	Hamant Brook	Riffle	5	100	0	95	5
HC01	Hatchet Brook	Riffle	10	0	0	0	0
MK01	McKinstry Brook	Riffle	100	100	0	70	0
CO01	Cohasse Brook	Riffle	35	0	0	0	0
LB01	Lebanon Brook	Riffle	15	0	0	0	0
W1186	Unnamed tributary to Quinebaug River (“Keenan Brook”)	Riffle	5	0	0	0	0
TU01	Tufts Branch	Riffle	30	nd*	nd	0	<5
RB01	Rocky Brook	Riffle	5	0	0	0	0
BU01	Burncoat Brook	Riffle	50	nd	nd	<5	0
GR01	Grindstone Brook	Riffle	10	0	0	0	0
FR04-1	French River – no samples	Riffle	5	0	0	0	0
LR01	Little River – no samples	Riffle	0	0	0	0	0
W1197	Unnamed tributary to South Fork (“Potters Brook”)	Riffle	15	nd	nd	20	0
SU01	Sucker Brook	Mat	25	nd	nd	0	10
MI01A	Mine Brook	Riffle	40	nd	nd	60	0
MI01	Mine Brook	Riffle	0	nd	nd	70	0
BW01	Browns Brook	Pool	60	5	<1	0	0

*nd=not done

Neither scour nor accrual were examined experimentally in this study, but when storms occurred with 1 inch or greater of rain the possible effects were noted (Appendix B). Long periods between storms allowed algal accrual to occur. However, if a storm occurred within the five-day antecedent period from the sampling date it was expected that some loss through scouring of algal biomass might have occurred or particular species might have been affected. During the summer of 2004, there were only two rain events that could have negatively affected algae and the invertebrates that graze on them. The two storm dates were July 24 (1.11 inches) and Aug. 21 (2.31 inches) (Appendix B). Because the precipitation data was not collected from a location within or near the basin (Lawrence) in the case of the French and Quinebaug Rivers, Appendix E contains graphs of flow data from both the Merrimack and Quinebaug Rivers to confirm that the storms on the dates described above were not just local events, but resulted in increased flows in these basins

Between July 24 and Aug 21 there were four weeks for algae to accumulate. Stations were not sampled over time so any algal accumulation or scouring can only be conjectured. Stations with measured velocities greater than 30 cm/sec were considered as possible scour candidates since this velocity is sufficient to move sand (Eisma, 1993**).**

Locations from the Merrimack and French and Quinebaug watersheds were grouped by low, medium and high velocity characteristics (Table 4). It was thought that low velocity coupled with open-canopy cover might contribute to a site having the most macroalgae and, correspondingly, microalgae would be elevated where velocity was high and the canopy was closed.

Low Velocity

The Powwow River site (PO01) had both low-and high-velocity areas represented. The low velocity site within the run was open to the sun. Unfortunately, we do not have the samples from this site, but field notes indicated that “green” filamentous algae, gelatinous to the touch, covered approximately 10% of the run sampled. The high-velocity, open-canopy site had 100% algal cover within the riffle. The algae were described as “green” filamentous, but no mention was made of gelatinous texture.

At Richardson Brook (RB01) the low-velocity site was shaded (Table 4) and had very little microalgal biomass on the cobble. The constituents were primarily diatoms and cyanobacteria (i.e. *Plectonema* sp. and *Lyngbya* sp.) surrounded by fungal hyphae (Appendix C).

The percent microalgal growth in the riffle of the low-velocity group peaked (i.e. 90%) at the Fish Brook station, a location with a closed in canopy. Diatoms were rare, but fungal hyphae were abundant. At other stations within the low-velocity group microalgae percent cover never was greater than 30%.

Where velocity was low and the canopy closed (e.g., Souhegan River (SO01) and Bartlett Brook (BA01), the few algal cells present were mainly diatoms although at SO01 filamentous cyanobacteria were also present.

Medium velocity

The medium-velocity site at Richardson Brook had an open-canopy. An algal scrape collected in the riffle was found to be dominated by the green macroalgae *Ulothrix* sp. while another green macroalga *Microspora* sp. was also common. The diatoms *Melosira varians* and *Synedra* sp. were also abundant. The change in environmental conditions at Richardson Brook from the closed to open-canopy and low-to medium-velocity sites had some influence on algal cover. The

sunny, higher-velocity site, exhibited higher macroalgal cover (10 % vs. 0%) and microalgal cover (30 % vs. 20%) in the riffle than the low-velocity, closed-canopy site.

The two sites from the French and Quinebaug rivers included in the velocity measurements were in the medium-velocity grouping. At Browns Brook (BR01) the canopy cover was greater than 50% open and supported a mat composed primarily of the cyanobacteria *Lyngbya* Taylorii. Stevens Brook, with only a 10% open-canopy, exhibited little microalgal cover in the riffle. The sample from this shaded location contained few algal cells, but was dominated by the heterotrophic organisms included in "sewage fungus" i.e. filamentous bacteria, fungi, and protozoa.

From Appendix B it can be seen that 2.3 inches of rain fell at the Lawrence Airport three days prior to our sampling. This could have resulted in scouring of the substrata with no time allowed for recovery of the algal community. Most of the French and Quinebaug River stations were sampled within a week of this precipitation event.

Two tributaries in the Merrimack basin (i.e Peppermint and Trull Brooks) had good microalgal growth in the riffle zone-up to 80%-while the two from the French and Quinebaug-sampled after the 2.3 inches of rain-had no more than 10 % microalgal growth. The increased flow in August may have impacted the substrata.

At medium velocities with open canopies only Richardson Brook (RBR01) had any macroalgal growth present. Brown's Brook (BR01) had a partially open-canopy, but no macroalgae present.

At partially open (35%) Trull Brook and closed (% not recorded) Peppermint Brook diatoms were abundant. Trull Brook also exhibited sewage fungus and the cyanobacteria *Lyngbya* sp.

High velocity

One Powwow River site was a high-velocity, open-canopy station (Table 4). This reach of the river receives nonpoint sources of contamination from a watershed containing areas of dense residential, commercial and historic industrial landuse. Nutrients from these sources along with sunlight may have contributed to the 100% macroalgal cover (Mitchell 2007). The highest percentage of macroalgae through the riffle zone was found at this site. It far exceeds the 40 % coverage which is indicative of algal biomass at nuisance levels (Barbour 1999).

At Bennetts Brook, also in the Merrimack River basin, the lack of irradiance resulting from the only partially open-canopy (30% open) may have reduced macro and microalgal percent cover at this high-velocity station. Macroalgae were not recovered while microalgae covered ~ 30% of the riffle. The microalgae were represented by diatoms and the cyanobacteria *Lyngbya* sp. (Appendix C). Landuse within this watershed is divided between forest and residential uses with a golf course also located upstream (Mitchell 2007).

Canopy and Percent Algal Cover Considerations

The percentages presented in table 3 to describe open and closed habitats are arbitrary, but the sites with their percentage closest to either open or closed-canopy cover are likely to have an algal population and biomass that is altered by light levels available. Lowe et al. (1986) found that chlorophyll a can be 4 to 5 times higher at open-canopy sites compared to sites described as closed. The algal community is also affected by differing amounts of light availability. Some groups like the Chlorophyta (green algae) generally are more prevalent at high light intensity than the Chrysophyta (diatoms) and some Cyanophyta (cyanobacteria). The light intensities are somewhat described by the open and closed-canopy sites. Steinman et al. (1989) found the same type of assemblage differentiation in a laboratory streams with diatoms dominating at < 50

µmole m^{-2} s^{-1}, diatoms and some cyanobacteria genera would be present at 50-100 µmole m^{-2} s^{-1} and the green algae would dominate at the highest light levels (irradiances) > 100 µmole m^{-2} s^{-1}.

Closed-Canopy Sites

Merrimack River Watershed

South Branch Souhegan River (SO01) was a closed-canopy site (Table 4) (Appendix C) with an extensive portion of the riffle area covered by microalgae. Sewage fungus was present in this sample, as well as a minimal amount of algal cells.

Bennetts Brook (BE01) had few phototrophic organisms recovered from the cobble substrata, but mats found on adjacent sand substrata had very abundant amounts of diatoms and the cyanophyceae *Lyngbya*. Other shaded locations, including Tadmuck Brook (TA01), Richardson Brook (RBR01), Trull Brook (TB02) and Bridge Meadow Brook (BR01) also had heterotrophic organisms present, typically fungal hyphae or "sewage fungus". Pennate diatoms were often present at these sites, but in very low numbers.

At Martin's Pond Brook (MRB01) and Creek Brook (CR01) between 0 and 5 % open-canopy was present and both had a small amount of algal material within a biofilm (algae, bacteria, fungi and polysaccharide material) primarily of fungal hyphae. Even at 10 % open-canopy the same trend continued at BR01 Bridge Meadow Brook where the sparse algal material was entangled with fungal hyphae. Macroalgae were not present in either the riffle or the reach.

At Tadmuck Brook (TA01), both an open and a closed location were sampled. But, at the shaded location with 20% open-canopy algal production again appeared limited while fungal hyphae were abundant. By contrast the open-canopy site at Tadmuck Brook (100% open) had algal mats composed of the cyanobacteria *Phormidium* sp. and *Anabaena* sp. as well as the diatom *Cymbella* sp. (Appendix C) These adjacent sites were exposed to the same nutrient inputs.

French and Quinebaug Watersheds

At the shaded Stevens Brook site the heterotrophic organisms (i.e. sewage fungus) were once again dominant in the periphyton. No "active" nonpoint sources of pollution were found at this location (Fiorentino 2007) or point sources, although sewage fungus is often an indicator of organic enrichment.

Hamant Brook, which had only 5% open-canopy, also supported a periphyton assemblage dominated by sewage fungus. At this location, as observed in Fiorentino 2007, additional influences may have factored into the growth of the periphyton. Instream turbidity, perhaps contributed by the local sand and gravel operations, may have led to reduced periphyton growth by limiting sunlight to the benthos, and possibly scouring since this location was sampled after heavy rains.

Leadmine Brook, a shaded stream site, had a few pennate diatoms, but also fungal hyphae and lots of amorphous matter, again indicating organic enrichment. Fiorentino (2007) describes the stream as flowing past wetlands in its upper areas before it passes under Route 84. The riffle was estimated as having 10% microalgae covering the bottom surfaces.

Although the canopy was only partially open at "Potters Brook" (15%) this stream exhibited abundant amounts of filamentous cyanophyceae *Chamaesiphon* sp.

Abundant amounts of cyanobacteria were found at Sucker Brook (SU01). A cyanobacterial mat composed primarily of O*scillatoria* sp.(Appendix D) was present at Sucker Brook. A small

residential development was present along part of the reach. Fiorentino (2007) documented lawn clippings in the riparian zone.

Mine Brook is situated within an undeveloped watershed. Two sites were sampled here, upstream and downstream of Mine Brook Rd. Downstream had a completely closed-canopy and abundant cyanobacteria present *Scytonema* sp. and *Plectonema rupicola*, fungal hyphae were also recovered. At the upstream site algal mats were recovered from rocks and although it was 40 % open the mats were composed of cyanobacteria (Appendix D). The percent microalgal cover was estimated at 60% (Table 6).

Open-Canopy Sites

Merrimack River Watershed

At the Merrimack River Watershed the Powwow River had a 100% open-canopy. Although we do know that the algal coverage was elevated at this location (100%) further information on the algal assemblage is not available. Green macroalgae are believed to be dominant based upon field notes.

One location on Tadmuck Brook (TA01) also was 100% open-canopy. Mats of blue-green algae (cyanophyceae) were recovered in riffles in the open-canopy location. At the closed-canopy site at this location the Cyanophyceae were rare, but fungal hyphae and diatoms were present.

Richardson Brook at RBR01 also had open and closed sites at this location. At the open-canopy site green filamentous algae were identified (*Ulothix* sp., *Microspora* sp.). The centric diatom *Melosira varians,* often found in areas with organic enrichment, was found in abundance. The closed-canopy location was represented by small amounts of algal cells, although fungal hyphae were commonly observed in the sample.

French and Quinebaug Watersheds

McKinstry Brook (MK01) is a second-order stream that had 100% open-canopy over the riffle area. At the time of the 2004 sampling, the substrata were covered by a brown-colored algal film according to Fiorentino (2007). The diatom *Cymbella* was an important contributor to this biofilm along with several unidentified pennate diatoms (Appendix D). The microalgae covered 100% of the substrates in the riffle and 70% in the reach. Landuse in this watershed differed from many that were evaluated during the 2004 survey. It was highly developed with landuse including a golf course, residential, industrial and commercial use as well (Fiorentino 2007). Sources of nutrients to this part of the stream were identified to include Southbridge Municipal Airport and downtown Southbridge.

The lower part of the “East Brook” Brimfield watershed has numerous nonpoint sources of pollution present including several farms and several homes with lawns abutting the stream. As noted by Fiorentino (2007) from Sherman Pond to Mill Brook “East Brook “ is technically an intermittent stream. The stress created by the lack of flow may help to reduce the algal population at this open-canopy site and also restrict the macroalgae from becoming established. An indication of the impact of the nutrients contributed by the nonpoint sources include the presence of mats of the filamentous cyanobacteria *Oscillatoria* sp., as well as green “globs” of the filamentous green *Chaetophora* sp.

The green filamentous alga *Spirogyra* sp. was dominant at the Burncoat Brook (BU01) site with 50% open-canopy. Although dominant in the sample, the alga was present at <5 % in the riffle.

BR01, located in Browns Brook was used for all sites as the reference station for the macroinvertebrate bioassessments. BR01 was situated upstream from all known point sources of water pollution, and was presumed to be minimally impacted by nonpoint sources. Browns Brook (BR01), has a partially open-canopy (60%), had a mat of the cyanobacteria *Lyngbya* sp. and some diatoms, particularly *Synedra* sp. (Appendix D).

Algal Percent Cover

The percent cover of the benthic algae in a waterbody is a way of evaluating if excessive amounts of algal growth have occurred resulting in nuisance conditions and loss of aesthetic appeal (Barbour et al. 1999; Biggs 1996). In Massachusetts, the USEPA criteria (Barbour et al 1999) are used to determine if nuisance algal conditions exist (i.e. green macroalgae cover > 40 % of the benthos in the riffle/run zone) compromising aesthetics. At this amount of biomass, nutrient enrichment may also be indicated (Biggs 1996).

Results from the visual estimation of percent cover (Tables 5 and 6) and identification of dominant algal types (Appendix C and D) indicate that at the Merrimack River watershed macroalgal cover exceeded 40 % at the Powwow River site PO01 with 100% in the riffle area and 80% in the reach.

In the French and Quinebaug River system no station was identified as having macroalgae present in nuisance amounts.

Other Observations

Biggs et al. (1998) found that locations in headwater sites were dominated by filamentous cyanobacteria and diatoms. This observation was also made by Rounick and Winterbourn (1983) who studied two experimental channels located in a forested area, with one exposed to light and the other kept in the dark. An organic layer consisting of slime, fine particles, bacteria and fungi developed in the forested canopy stream, but when exposed to natural light intensities growth of diatoms and filamentous algae was evident that was not found in the darkened channel. The open-canopy headwater stations followed this pattern in this study while closed-canopy sites were more likely to be dominated by heterotrophic organisms.

It is easy to see how lack of light could influence the algal assemblage. Hill (1996) found that in small streams, leaf canopies can intercept 95% or more of incident radiation, reducing maximum photon flux densities to less than 40 umol m^2 s^{-1}. Photosaturation for most benthic algae ranges from 100-400 umol m^2 s^{-1}.

Several stations in the French and Quinebaug subwatersheds lacked algae in the riffle zone. Instead, moss covered large areas of the bottom, another common occurrence in headwater streams. Stations with moss as the dominant aquatic vegetation include: Browns Brook (BW01), Hacket Brook (HC01), Cohasse Brook (CO01), Lebanon Brook (LB01), Keenan Brook (W1186), Rocky Brook (RB01), and Grindstone Brook (GR01).

Use of the Sontek, or other similar instruments, provides a quick means of determining velocity values to which the algae are exposed and may help to determine if comparable habitats exist from one station to another. However, examination of stations where two or more velocity measurements were made reveals that a lot of variability exists in-stream caused by physical barriers, differences in slope and possibly rainfall. An example might be the Powwow River. For this 130 sq. mile watershed average velocity above the algae was 7.7 cm/s yet at another location, in the same reach, the average velocity above the algae was 69.3 cm/sec. In the slower flowing areas one type of algal vegetation appeared to be present while in the faster riffle the physical appearance indicated dominance by a different alga.

Stephenson (1996) discussed the complex relationship between current (velocity) and benthic biomass. He noted that current velocity up to a certain break point stimulates algal metabolism and phosphorus uptake while very high velocities create a drag on the algae and decrease "immigration rates" or recruitment. Biggs and Gerbeaux (1993) found peak benthic algal biomass on natural substrata is usually highest in velocities ranging from 10-20 cm/s, our low-velocity grouping, but this peak biomass development may be more likely in higher-order streams where other forms and quantities of nutrients are present.

The predicted impact of the velocity on the algal assemblage is not evident in these samples. It is not known if this is because they were primarily first-to third-order streams with potentially different nutrient regimes than higher-order streams or if other factors such as, the lack of re-establishment of the algal community following heavy rains was significant. Perhaps velocity data are not as pertinent to our evaluations as other data. For our purposes, the best use of the velocity data is probably for examining station comparability which is a requirement for all biomonitoring parameters.

The local changes in velocities-either substrate or surface- within a reach makes it a less useful parameter for describing wider impacts on communities than are created by differences in more widely applied parameters like light or nutrient regimes. In these headwater streams closed-canopy sites often were dominated by heterotrophic organisms and at open-canopy sites green (Chlorophyceae) or blue-green (Cyanophyceae) species often dominated.

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Appendix A

Taxonomic References for the Identification of Algae

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Appendix B: 2004 Precipitation data recorded at Lawrence Municipal Airport, Lawrence, MA		
	Date	Precipitation (inches)
Sample Date	July 27	Trace
1 day prior	July 26	0.00
2 days prior	July 25	0.00
3 days prior	July 24	1.11
4 days prior	July 23	0.00
5 days prior	July 22	0.00
Sample Date	July 29	0.00
1 day prior	July 28	0.46
2 days prior	July 27	Trace
3 days prior	July 26	0.00
4 days prior	July 25	0.00
5 days prior	July 24	1.11
Sample Date	July 30	0.00
1 day prior	July 29	0.00
2 days prior	July 28	0.46
3 days prior	July 27	Trace
4 days prior	July 26	0.00
5 days prior	July 25	0.00
Sample date	Aug 2	0.00
1 day prior	Aug 1	Trace
2 days prior	July 31	0.00
3 days prior	July 30	0.00
4 days prior	July 29	0.00
5 days prior	July 28	0.46
Sample date	Aug 3	0.29
1 day prior	Aug 2	0.00
2 days prior	Aug 1	Trace
3 days prior	July 31	0.00
4 days prior	July 30	0.00
5 days prior	July 29	0.00
Sample date	Aug 24	0.00
1 day prior	Aug 23	0.01
2 days prior	Aug 22	0.01
3 days prior	Aug 21	2.31
4 days prior	Aug 20	0.08
5 days prior	Aug 19	0.09
Sample date	Aug 25	0.00
1 day prior	Aug 24	0.00
2 days prior	Aug 23	0.01
3 days prior	Aug 22	0.01
4 days prior	Aug 21	2.31
5 days prior	Aug 20	0.08
Sample date	Aug 30	0.09
5 days prior	Aug 29	0.00
4 days prior	Aug 28	0.19
3 days prior	Aug 27	0.00
2 days prior	Aug 26	0.01
1 day prior	Aug 29	0.00
Taken from http://cdo.ncdc.noaa.gov/ulcd/ULCD (NOAA National Climatic Data Center)		

Appendix C Merrimack River Periphyton 2004

				Algae-Phototrophic Organisms			Heterotrophic Organisms	
Station #	Date	Water body	Location	Class	Genus	Abundance	Other organisms	Abundance
SO01	27-Jul	South Branch Souhegan River	South Branch Souhegan River, downstream from Jones Hill Road, 275 m downstream from unnamed tributary, Ashby, MA-riffle, cobble-partially open- canopy	Bacillariophyceae	*Surirella* sp.	R	sewage fungus	C
				Bacillariophyceae	pennate diatoms	R		
				Chlorophyceae	*Coleochaete*	R		
				Cyanophyceae	*Lyngbya*	R		
				Cyanophyceae	*Plectonema*	R		
RBR01	30-Jul	Richardson Brook	Upstream from Methuen St., Dracut, MA-riffle, cobble, open-canopy	Bacillariophyceae	*Cymbella*	R	fungal hyphae	R
				Bacillariophyceae	*Melosira varians*	A		
				Bacillariophyceae	*Synedra*	A		
				Chlorophyceae	*Microspora*	VC		
				Chlorophyceae	*Rhizoclonium*	C		
				Chlorophyceae	*Stigeoclonium*	R		
				Chlorophyceae	*Ulothrix*	VA		
RBR01	30-Jul	Richardson Brook	Upstream from Methuen St., Dracut, MA-riffle, cobble, closed-canopy	Bacillariophyceae	*Cymbella*	R	fungal hyphae	C
				Bacillariophyceae	*Surirella*	R		
				Bacillariophyceae	centric diatoms	R		
				Bacillariophyceae	pennate diatoms	R		
				Chlorophyceae	*Coleochaete*	R		
				Cyanophyceae	*Dictyopshaerium*	R		
TB02	30-Jul	Trull Brook	Downstream from River Rd.above golf course Tewksbury, MA-riffle, cobble-partially open	Bacillariophyceae	diatoms	A	sewage fungus	C
				Cyanophyceae	*Lyngbya*	C	filamentous bacteria	C
				Chlorophyceae	*Coleochaete*	R		
TB02	30-Jul	Trull Brook	Downstream from River Rd.above golf course Tewksbury-riffle, mat, closed-canopy				fungal hyphae	R
							ciliates	

				Algae-Phototrophic Organisms			Heterotrophic Organisms	
Station #	Date	Water body	Location	Class	Genus	Abundance	Other organisms	Abundance
							filamentous bacteria	R
MRB01	29-Jul	Martin's Pond Brook	25 m upstream of footpath extending from Loomis Lane, Groton, MA, riffle, closed-canopy	Bacillariophyceae	*ui pennate diatoms*	R	fungal hyphae	C
				Chlorophyceae	*Closterium*	R		
				Cyanophyceae	*ui filament*	C		
FI01	2-Aug	Fish Brook	Downstream from River Rd., Andover, pool, closed-canopy	Bacillariophyceae	*Fragilaria*	R	fungal hyphae bacterial filaments	
				Bacillariophyceae	*Melosira*	R		
				Bacillariophyceae	*Synedra*	R		
				Bacillariophyceae	*ui spiralled diatom*	R		
				Bacillariophyceae	*ui pennate diatoms*	R		
CR01	2-Aug	Creek Brook	25 m upstream of West Lowell Ave., Haverhill, riffle, closed-canopy	Bacillariophyceae	*Cocconeis*	R	fungal hyphae	R
				Bacillariophyceae	*Cymbella*	R		
				Bacillariophyceae	*Fragilaria*	R		
BA01	2-Aug	Bartlett Brook	Upstream from Rte. 113 Methuen, MA riffle, closed- canopy	Bacillariophyceae	*Cocconeis*	R		
				Bacillariophyceae	*Fragilaria*	R		
				Bacillariophyceae	*Navicula*	R		
				Bacillariophyceae	*ui pennate*	R		
PE01	30-Jul	Peppermint Brook	100 m downstream of Lakeview Ave., Dracut, riffle, closed-canopy	Bacillariophyceae	*Surirella*	R		
				Bacillariophyceae	*Navicula*	C		
				Bacillariophyceae	*Euontia*	R		
				Bacillariophyceae	*ui pennate*	VA		
BR01	29-Jul	Bridge Meadow Brook	Bridge Meadow Brook, 80m downstream from road to Tyngsborough Elementary School (205 Westford Road), Tyngsborough, MA-riffle, cobble, closed- canopy	Bacillariophyceae Bacillariophyceae	*Gyrosigma* pennate diatoms	R R	fungal hyphae	C
BR01	29-Jul	Bridge Meadow Brook	Bridge Meadow Brook, 80m downstream from road to	Chlorophyceae	*Closterium*	R	filamentous bacteria	C

				Algae-Phototrophic Organisms			Heterotrophic Organisms	
Station #	Date	Water body	Location	Class	Genus	Abundance	Other organisms	Abundance
			Tyngsborough Elementary School (205 Westford Road), Tyngsborough, MA-pool, mat, partially closed-canopy					
				Cyanophyceae	*Lyngbya*	R		
				Cyanophyceae	*Plectonema*	R		
				Cyanophyceae	*Spirulina*	R		
				Cyanophyceae	filamentous b-g	C		
TA01	29-Jul	Tadmuck Brook	Upstream from Lowell Rd., Westford, MA-riffle, mat, open-canopy	Bacillariophyceae	*Cymbella*	A	fungal hyphae	A
				Bacillariophyceae	*Gyrosigma*	R		
				Bacillariophyceae	*Navicula*	R		
				Bacillariophyceae	*Surirella*	R		
				Bacillariophyceae	ui pennate diatoms	A		
				Cyanophyceae	*Anabaena*	VC		
				Cyanophyceae	*Phormidium*	VA		
TA01	29-Jul	Tadmuck Brook	Upstream from Lowell Rd., Westford, MA -riffle, cobble-, partially closed-canopy	Bacillariophyceae	*Cymbella*	R	fungal hyphae	A
				Bacillariophyceae	*Fragilaria*	R		
				Bacillariophyceae	*Synedra*	R		
				Bacillariophyceae	ui pennate diatoms	C		
				Cyanophyceae	*Gomphonema*	R		
				Cyanophyceae	*Phormidium*	R		
BE01	27-Jul	Bennetts Brook	Downstream from Willow Road, Ayer, MA-riffle, cobble, partially closed-canopy	Bacillariophyceae	diatoms	R	sewage fungus	
				Chlorophyceae	*Coleochaete*	R	organic floc	
							sheathed bacteria	R
							iron floc	
BE01	27-Jul	Bennetts Brook	Dnst. From Willow Road, Ayer, MA-riffle, mat, partially-open	Bacillariophyceae	Diatoms	VA	bacterial filaments	C
				Bacillariophyceae	*Gyrosigma*	R		

				Algae-Phototrophic Organisms			Heterotrophic Organisms	
Station #	Date	Water body	Location	Class	Genus	Abundance	Other organisms	Abundance
				Bacillariophyceae	*Fragilaria*	R		
				Bacillariophyceae	*Synedra*	R		
				Bacillariophyceae	*Navicula*	R		
				Cyanophyceae	*Lyngbya*	VA		

Appendix D: French and Quinebaug Rivers Periphyton 2004

Quinebaug River Subwatershed

				Algae-Phototrophic Organisms			Heterotrophic Organisms	
Station #	Date	Water body	Location	Class	Genus	Abundance	Organism	Abundance
W1183	25-Aug	Unnamed tributary (East Brook)	Upstream of Route 20, Brimfield, MA-riffle, open-canopy	Bacillariophyceae	*Gyrosigma*	R		
				Bacillariophyceae	*Navicula*	C		
				Bacillariophyceae	*Tabellaria*	R		
				Cyanophyceae	*Anabaena*	R		
				Cyanophyceae	*Oscillatoria*	A		
				Cyanophyceae	*Oscillatoria splendida*	A		
W1183	25-Aug	Unnamed tributary (East Brook)	Upstream of Route 20, Brimfield-2 of 3-riffle, open-canopy	Chlorophyceae	*Chaetophora pisiformis*	A		
W1183	25-Aug	Unnamed tributary (East Brook)	Upstream of Route 20, Brimfield-3 of 3-riffle, open-canopy	Bacillariophyceae	*Cymbella*	R	fungal hyphae	C
				Bacillariophyceae	*Fragilaria*	R		
				Bacillariophyceae	*Navicula*	C		
				Bacillariophyceae	*Nitzchia*	R		
				Bacillariophyceae	*Synedra*	R		
				Chlorophyceae	*Closterium*	R		
				Chlorophyceae	*ui green filament*	R		
				Cyanophyceae	*Lyngbya*	C		
				Cyanophyceae	*Oscillatoria*	C		
BR01	24-Aug	Browns Brook	230 m upstream from May Brook Road, Holland, MA, riffle, partially-closed	Bacillariophyceae	*Eunotia*	R		
				Bacillariophyceae	*Gomphonema*	R		
				Bacillariophyceae	*Synedra*	C		
				Cyanophyceae	*Lyngbya Taylorii*	VA		
ST01	24-Aug	Steven's Brook	upstream of Brimfield Rd., Brimfield, riffle, partially-closed	Bacillariophyceae	ui pennate diatoms	R	sewage fungus	C
				Chlorophyceae	*Cladophora*	R		
				Cyanophyceae	ui b-g filaments	R		

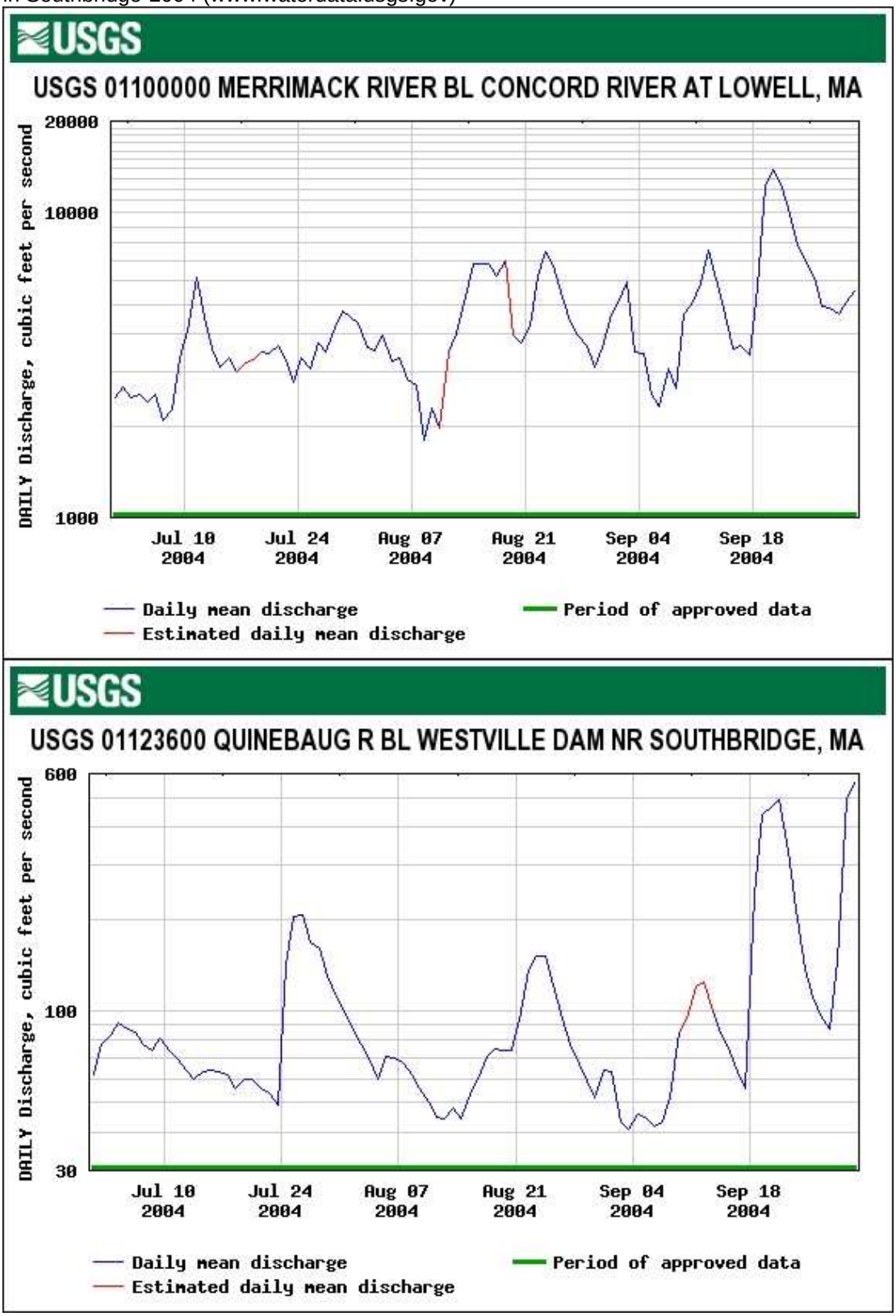
LE01	24-Aug	Leadmine Brook	600 m upstream from Rte. 84, near vacant Rte 15 rest area, Sturbridge, MA	Bacillariophyceae	ui pennate diatoms	R	fungal hyphae	R
HA01	24-Aug	Hamant Brook	100 m downstream from sandpit access road off Shattuck RD, Sturbridge, MA	Bacillariophyceae	*Cymbella*	R	sewage fungus	R
				Bacillariophyceae	*Fragilaria*	R		
				Bacillariophyceae	ui pennate diatoms	R		
				Chlorophyceae	*Cladophora*	R		
HA01	24-Aug	Hamant Brook	100 m downstream from sandpit access road off Shattuck RD, Sturbridge, MA	Chlorophyceae	ui green filaments	VA		
MK01	25-Aug	McKinstry Brook	~140 m upstream from Pleasant St., Southbridge-riffle	Bacillariophyceae	*Cymbella*	C	sewage fungus	C
				Bacillariophyceae	*Melosira*	R		
				Bacillariophyceae	*Synedra*	R		
				Bacillariophyceae	*Surirella*	C		
				Bacillariophyceae	ui pennate	C		
				Chlorophyceae	*Scenedesmus*	C		
TU01	26-Aug	Tufts Branch	~30 m upstream from Rte 197, Dudley-riffle	Cyanophyceae	*Phormidium*	C	fungal hyphae	R

French River Subwatershed

				Algae-Phototrophic Organisms			Heterotrophic Organisms	
Station #	Date	Water body	Location	Class	Genus	Abundance	Organism	Abundance
BU01	3-Sep	Burncoat Brook	350 m upstream from confluence with Town Meadow Brook, Leicester	Chlorophyceae	*Spirogyra*	A		
W1197	26-Aug	Potters Brook	Unknown tributary to South Fork (locally known as "Potters Brook") 150 m downstream from Potter Village Rd., Charlton-1 of 2-riffle	Cyanophyceae	*Chamaesiphon confervioda*	A	fungal hyphae	R
W1197	26-Aug	Potters Brook	Unknown tributary to South Fork (locally known as "Potters Brook") 150 m downstream from Potter Village Rd., Charlton-1 of 2-riffle	Bacillariophyceae	*Cymbella*	R		

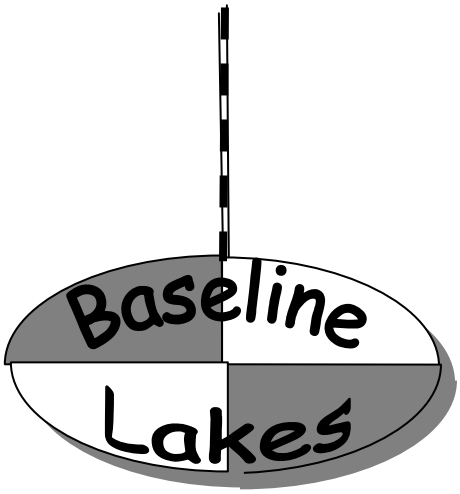
				Bacillariophyceae	*Melosira*	R		
				Bacillariophyceae	*ui pennate diatoms*	R		
SU01	27-Aug	Sucker Brook	downstream Kingsbury Rd., Webster-riffle	Bacillariophyceae	*Surirella*	R		
				Cyanophyceae	*Lyngbya*	C		
				Cyanophyceae	*Oscillatoria*	A		
				Cyanophyceae	*Oscillatoria amphibia*	VA		
MI01a	27-Aug	Mine Brook	upstream from Mine Brook Rd., Webster riffle, on rocks-algal mat	Cyanophyceae	*Lyngbya versicolor*	VA		
				Cyanophyceae	*Plectonema nostocarum*	VA		
MI01	27-Aug	Mine Brook	downstream from Mine Brook Rd., Webster-riffle	Cyanophyceae	*Scytonema*	VA	fungal hyphae	C
				Cyanophyceae	*Lyngbya*	C		
				Cyanophyceae	*Plectonema rupicola*	VA		

Appendix E: USGS flow data recorded at Merrimack River in Lowell and at the Quinebaug River in Southbridge-2004 (www.waterdata.usgs.gov)



***Merrimack River Watershed Lakes Data excerpted from*:**

Baseline Lake Survey 2003
Technical Memo



Division of Watershed Management
Department of Environmental Protection
627 Main Street, Second Floor
Worcester, MA

Baseline Lake Survey 2003
Technical Memo

Prepared by
Albelee A. Haque
&
Mark D. Mattson, PhD
Survey Coordinator

TM-S-16
DWM Control Number CN 205.0
October 23, 2007

Massachusetts Department of Environmental Protection
Division of Watershed Management
Worcester, MA

****Data for lakes sampled in the Merrimack River Watershed are excerpted from the original technical memorandum and are provided below. All methods (field and laboratory) and results (QA/QC, lab audits, field blanks, duplicates and splits) are included in the original technical memorandum and are available upon request to the MassDEP DWM.**

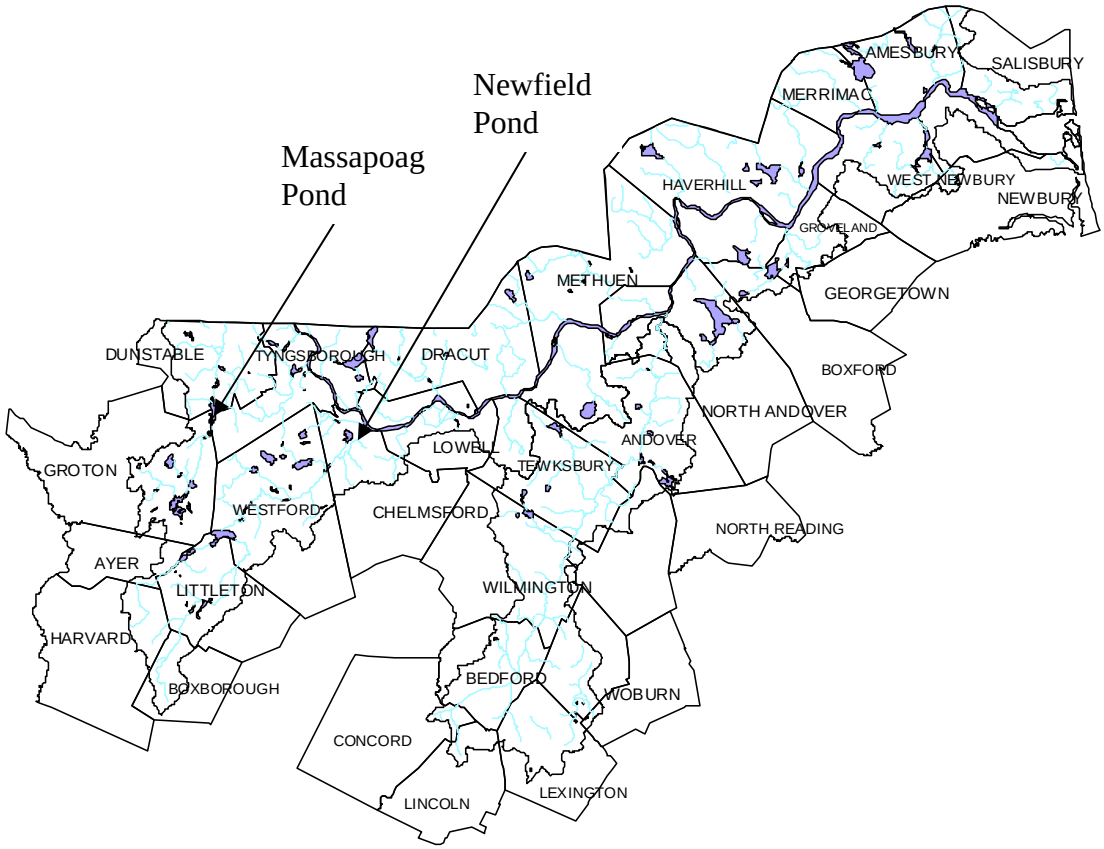


Figure 1. Approximate locations of lakes in the Merrimack Basi

Table 1. Multiprobe Data for 2003 Nutrient Criteria Lakes
Nutrient Criteria, Lakes (2003) (QC Status: 4) Exported: 10/4/2005 11:38:18 AM

Newfield Pond (PALIS: 84046)
Unique_ID: W0716 Station: A
Description: [deep hole in southeastern quadrant near outlet, Chelmsford.]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
08/13/03									
	LC-0231	13:02	0.5	27.8	7.9 c	499	319	8.2	105
	LC-0231	13:19	1.5	27.1 u	7.8 c	499	319	7.9	100
	LC-0231	13:33	2.5	26.0	7.0 c	495	317	5.4 u	68 u
	LC-0231	13:38	3.4	24.3 u	6.8	513 u	328 u	5.0 u	61 u
	LC-0231	13:45	4.5	19.2	6.7	525	336	1.5 u	17 u
	LC-0231	13:50	5.5	14.1 um	6.8 m	527 m	337 m	<0.2 m	<2 m

Massapoag Pond (PALIS: 84087)
Unique_ID: W0718 Station: A
Description: [deep hole, center of large eastern lobe, Dunstable/Tyngsborough.]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/15/03									
	LC-0237	15:41	0.6	25.5 u	7.4 cu	235	150	8.0 u	99 u
	LC-0237	15:49	1.0	24.7	7.4 c	235	150	7.9	96
	LC-0237	16:27	2.1	23.9	7.2 c	236	151	7.9	94
	LC-0237	15:55	3.1	20.3 u	7.1 c	232	149	9.1 u	101 u
	LC-0237	16:00	4.0	14.6 u	6.6	234	150	1.4 u	14 u
	LC-0237	16:09	6.0	8.9 u	6.4	217	139	0.4	3
	LC-0237	16:15	8.0	6.1	6.7 u	240	154	<0.2	<2
	LC-0237	16:21	11.2	5.3	7.3 c	313	200	<0.2	<2

General Data Symbols :

" ## " = Censored data (i.e., data that has been discarded for some reason). *NOTE: Prior to 2001 data, "**" denoted either censored or missing data.*
" ** " = Missing data (i.e., data that should have been reported). See NOTE above.
" -- " = No data (i.e., data not taken/not required)
* = Analysis performed by Laboratory OTHER than MassDEP's Wall Experiment Station (WES)
[ ] = A result reported inside brackets has been "censored", but is shown for informational purposes (e.g., high blank results).

Multi-probe-specific Qualifiers:

" i " = inaccurate readings from Multi-probe likely; pre/post-survey calibration problems etc.
" m " = method not followed; one or more protocols contained in the MassDEP Multi-probe SOP not followed, ie. operator error or instrument failure not allowing method to be implemented.
" s " = field sheet recorded data were used to accept data, not data electronically recorded in the Multi-probe surveyor unit, due to operator error or equipment failure.
" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly-variable water quality conditions, etc. See Section 4.1 for acceptance criteria.
" c " = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. It can also be used for TDS and Salinity calculations based on qualified ("c") conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading).
" r " = data not representative of actual field conditions.

Table 2. Water Quality Data for Nutrient Criteria Lakes
Nutrient Criteria, Lakes (2003) (QC Status: 4) Exported: 10/14/2005 12:03:13 PM

Massapoag Pond (PALIS: 84087)
Unique_ID: W0718 Station: A
Description: [deep hole, center of large eastern lobe, Dunstable/Tyngsborough.]

Date	Secchi	Secchi Time	Station Depth	OWMID	QAQC	Time	SmpTyp	Sample Depth	Chl-a	NO3-NO2-N	TKN	TN	TP	AppColor
	m	24hr	m			24hr		m	mg/m3	mg/L	mg/L	mg/L	mg/L	PCU
07/15/03	3.4	15:40	11.8											
				LC-0234	--	16:10	VDOR	11.3	--	--	--	--	##* m	--
				LC-0233	--	15:50	MNGR	<0.5	--	--	--	--	##* m	35*
				LC-0235	LC-0236	16:05	DINT	0 - 7.0	17.4*	--	--	--	--	--
				LC-0236	LC-0235	16:06	DINT	0 - 7.0	16.5*	--	--	--	--	--

Newfield Pond (PALIS: 84046)
Unique_ID: W0716 Station: A
Description: [deep hole in southeastern quadrant near outlet, Chelmsford.]

Date	Secchi	Secchi Time	Station Depth	OWMID	QAQC	Time	SmpTyp	Sample Depth	Chl-a	NO3-NO2-N	TKN	TN	TP	AppColor
	m	24hr	m			24hr		m	mg/m3	mg/L	mg/L	mg/L	mg/L	PCU
08/13/03	3.8	12:55	8.2											
				LC-0226	LC-0227	13:30	VDOR	0.2	--	<0.06	0.36	--	0.011	<15*
				LC-0227	LC-0226	13:32	VDOR	0.2	--	<0.06	0.35	--	##* m	<15*
				LC-0228	--	13:35	VDOR	6.5	--	<0.02	0.68	--	##* m	--
				LC-0230	--	13:08	DINT	0 - 7.0	22.3*	--	--	--	--	--

Sample-Specific Data Qualifiers:

" a " = accuracy as estimated at WES Lab via matrix spikes, PT sample recoveries, internal check standards and lab-fortified blanks did not meet project data quality objectives identified for program or in QAPP.
" b " = blank Contamination in lab reagent blanks and/or field blank samples (indicating possible bias high and false positives).
" d " = precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.
" e " = not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.
" f " = frequency of quality control duplicates did not meet data quality objectives identified for program or in QAPP.
" h " = holding time violation (usually indicating possible bias low)
" j " = 'estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.

" m " = method SOP not followed, only partially implemented or not implemented at all, due to complications with sample matrix (eg. sediment in sample, floc formation), lab error (eg. cross-contamination between samples), additional steps taken by the lab to deal with matrix complications, lost/unanalyzed samples, and missing data.

" p " = samples not preserved per SOP or analytical method requirements.

" r " = samples collected may not be representative of actual field conditions, including the possibility of "outlier" data and flow-limited conditions (e.g., pooled).

Key to data codes:
" ## " = Censored data; " ** " = Missing data; " -- " =No data; "*" =other lab;
SymTyp: Sample Type- VDOR= Van Dorn; DINT= Depth integrated by vertical hose; MNGR= Manual Grab; NR= not recorded.

Appendix II Duplicates Result

Nutrient Criteria, Lakes (2003) (QC Status: 4) Exported: 10/13/2005 4:02:25 PM Duplicates.

Massapoag Pond (PALIS: 84087)
Unique_ID: W0718 Station: A
Description: [deep hole, center of large eastern lobe, Dunstable/Tyngsborough.]

Date	OWMID	QAQC	Time	Depth	Chl-a	NO3-NO2-N	TKN	TN	TP	AppColor
	--	--	(24hr)	(m)	mg/m3	mg/L	mg/L	mg/L	mg/L	PCU
7/15/2003	LC-0235	LC-0236	16:05	0 - 7.0	17.4*	--	--	--	--	--
7/15/2003	LC-0236	LC-0235	16:06	0 - 7.0	16.5*	--	--	--	--	--
Relative	*Percent*	*Difference*			*5.3%*	--	--	--	--	--

Newfield Pond (PALIS: 84046)
Unique_ID: W0716 Station: A
Description: [deep hole in southeastern quadrant near outlet, Chelmsford.]

Date	OWMID	QAQC	Time	Depth	Chl-a	NO3-NO2-N	TKN	TN	TP	AppColor
	--	--	(24hr)	(m)	mg/m3	mg/L	mg/L	mg/L	mg/L	PCU
8/13/2003	LC-0226	LC-0227	13:30	0.2	--	<0.06	0.36	--	0.011	<15*
8/13/2003	LC-0227	LC-0226	13:32	0.2	--	<0.06	0.35	--	##* m	<15*
Relative	*Percent*	*Difference*			--	*0.0%*	*2.8%*	--	--	*0.0%*

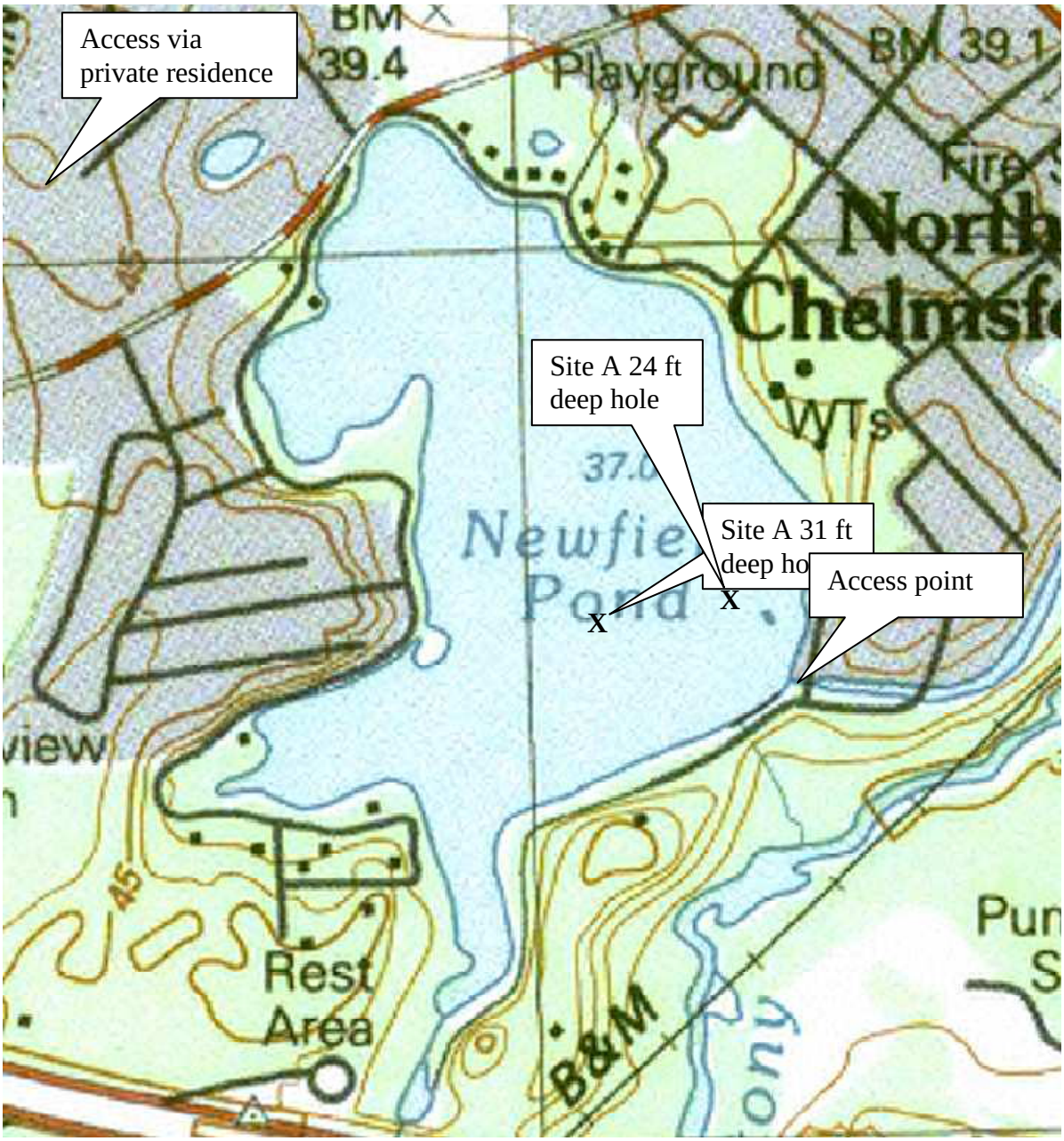
Sample-Specific Data Qualifiers:

" a " = accuracy as estimated at WES Lab via matrix spikes, PT sample recoveries, internal check standards and lab-fortified blanks did not meet project data quality objectives identified for program or in QAPP.
" b " = blank Contamination in lab reagant blanks and/or field blank samples (indicating possible bias high and false positives).
" d " = precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.
" e " = not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.
" f " = frequency of quality control duplicates did not meet data quality objectives identified for program or in QAPP.
" h " = holding time violation (usually indicating possible bias low)
" j " = 'estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.
" m " = method SOP not followed, only partially implemented or not implemented at all, due to complications with sample matrix (eg. sediment in sample, floc formation), lab error (eg. cross-contamination between samples), additional steps taken by the lab to deal with matrix complications, lost/unanalyzed samples, and missing data.
" p " = samples not preserved per SOP or analytical method requirements.
" r " = samples collected may not be representative of actual field conditions, including the possibility of "outlier" data and flow-limited conditions (e.g., pooled).

Key to data codes:

" ## " = Censored data; " ** " = Missing data; " -- " =No data; "*" =other lab;
SymTyp: Sample Type- VDOR= Van Dorn; DINT= Depth integrated by vertical hose; MNGR= Manual Grab; NR= not recorded.

Appendix IV. Local Environs Maps in Palis order.

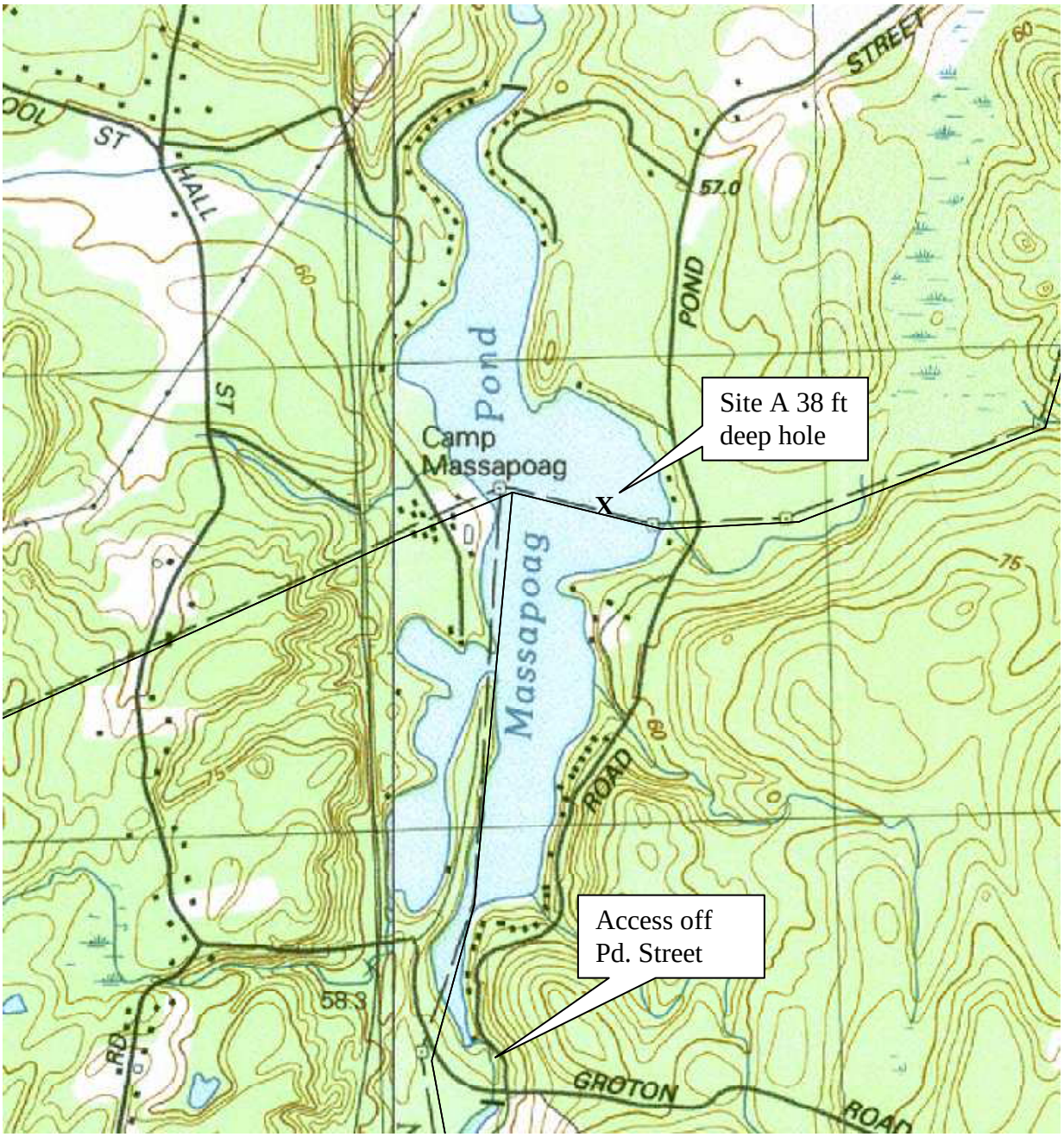


N

Newfield Pond
Chelmsford
84046

200 0 200 400 Meters

700 0 700 1400 Feet



N

Massapoag Pond
Dunstable
84087

200 0 200 400 Meters

700 0 700 1400 Feet