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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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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

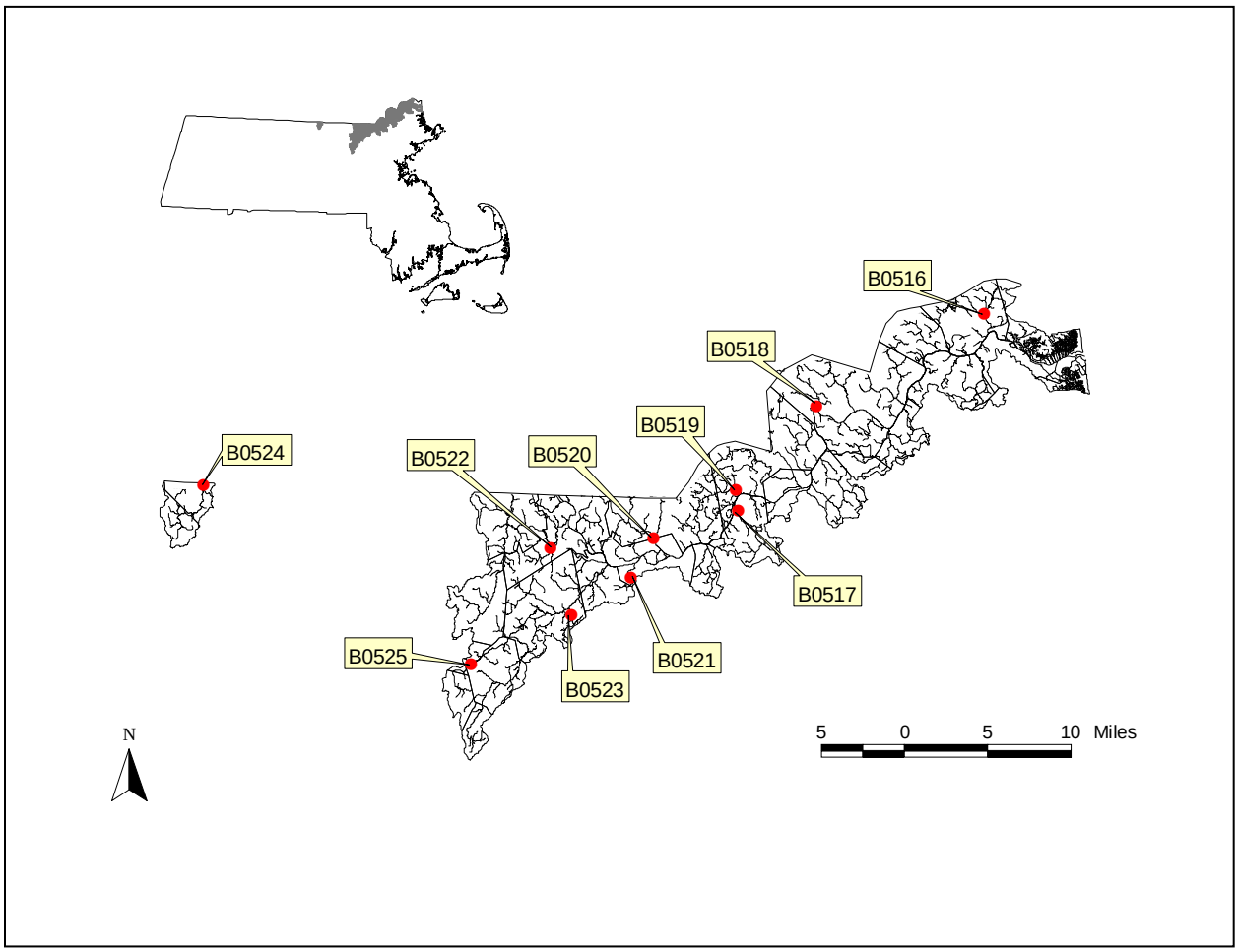

Figure 1. Location map of selected 2004 Merrimack watershed benthic sampling locations.

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.

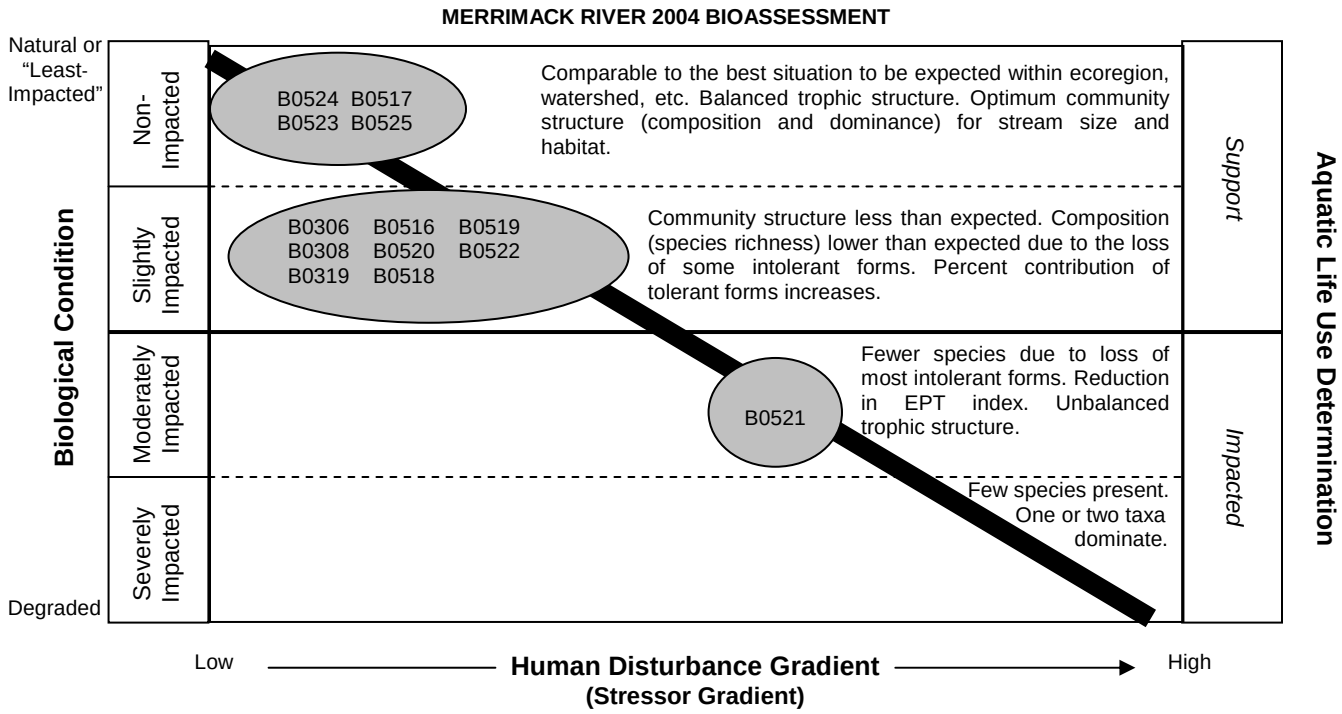

Figure 2. Schematic of the predictive response of aquatic communities to increasing human disturbance. Included is the performance (Biological Condition and Aquatic Life Use determinations) of the Merrimack River watershed 2004 biomonitoring stations along the Human Disturbance Gradient. NOTE: reference 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