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CHARLES RIVER WATERSHED 2002 BIOLOGICAL ASSESSMENT

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CONTENTS

Tables and Figures

INTRODUCTION

Biological monitoring is a useful means 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). Biological surveys and assessments are the primary approaches to biomonitoring.

As part of the Massachusetts Department of Environmental Protection/ Division of Watershed Management's (MassDEP/DWM) 2002 Charles River watershed assessments, aquatic benthic macroinvertebrate biomonitoring was conducted to evaluate the biological health of various streams within the watershed. A total of fourteen biomonitoring stations were sampled to investigate the effects of nonpoint and point source stressors—both historical and current—on the aquatic communities of the watershed. Some stations sampled during the 2002 biomonitoring survey were previously "unassessed" by DEP, while historical DEP biomonitoring stations—sampled most recently in 1997 (MassDEP 2000)—were reevaluated to determine if water quality and habitat conditions have improved or worsened over time. To minimize the effects of temporal (seasonal and year-to-year) variability, sampling was conducted at approximately the same time of the month as the 1997 biosurveys. Sampling locations, along with station identification numbers and sampling dates, are noted in Table 1. Sampling locations are also shown in Figure 1.

In some cases (e.g., point source investigations), a site-specific sampling approach was implemented, in which the aquatic community and habitat downstream from the perceived stressor (downstream study site) were compared to an upstream reference station (control site) representative of "least disturbed" biological conditions for that waterbody. While the alternative to this site-specific approach is to compare the study site to a regional or watershed reference station (i.e., "best attainable" condition), the site-specific approach is more appropriate for an assessment of a known or suspected stressor, provided that the stations being compared share basically similar instream and riparian habitat characteristics (Barbour et al. 1999). Since both the quality and quantity of available habitat affect the structure and composition of resident biological communities, effects of such features can be minimized by sampling similar habitats at stations being compared, providing a more direct comparison of water quality conditions (Barbour et al. 1999). Sampling highly similar habitats also reduces metric variability, attributable to factors such as current speed and substrate type. Upstream reference stations were established in the Charles (CR03) and Stop (SR01) rivers to assess potential impacts of downstream wastewater treatment facility discharges.

To provide additional information necessary for making basin-wide aquatic life use-support determinations required by Section 305(b) of the Clean Water Act, all Charles River watershed macroinvertebrate biomonitoring stations were compared to a regional reference station most representative of the "best attainable" conditions in the watershed. 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). Two regional reference stations were used for the 2002 Charles River bioassessments—one on the mainstem Charles River (CR03), and the other on Stony Brook (ST01). Both stations have historically been used as reference conditions by DEP for bioassessment purposes (MassDEP 2000). CR03 serves as the primary reference station for mainstem Charles River biomonitoring stations, while ST01 is the primary reference for tributary stations. The reference stations were situated upstream from all known point sources of water pollution, and were also assumed (based on historical DEP water quality data, topographic map examinations, and field reconnaissance) to be minimally impacted (relative to other portions of the watershed) by nonpoint sources.

During "year 1" of its "5-Year Basin Cycle", problem areas within the Charles River watershed were better defined through such processes as coordination with appropriate groups (EOEA Charles River Watershed Team, Charles River Watershed Association, MassDEP/DWM), assessing existing data, conducting site visits, and reviewing NPDES and water withdrawal permits. Following these activities, the 2002 biomonitoring plan was more closely focused and the study objectives better defined. Table 2 includes a summary of the important current and historical conditions and perceived problems identified prior to the 2002 Charles River watershed biomonitoring survey.

The main objectives of 2002 biomonitoring in the Charles River watershed were: (a) to determine the biological health of streams within the watershed by conducting assessments based on aquatic macroinvertebrate communities; and (b) to identify problem stream segments so that efforts can be focused on developing NPDES permits, Water Management Act (WMA) permits, stormwater management, and control of other nonpoint source (NPS) pollution. Specific tasks were:

1. Conduct benthic macroinvertebrate sampling and habitat assessments at locations throughout the Charles River watershed.

2. Based upon the macroinvertebrate data, identify river segments within the watershed with potential point/nonpoint source pollution problems; and

3. Using the benthic macroinvertebrate data and supporting water chemistry and field/habitat data:
   - Assess the types of water quality and/or water quantity problems that are present, and
   - if possible, make recommendations for remedial actions or additional monitoring and assessment.
   - Provide macroinvertebrate and habitat data to MassDEP/DWM's Environmental Monitoring and Assessment Program for assessments of aquatic life use-support status required by Section 305(b) of the Federal Clean Water Act (CWA).
   - Provide macroinvertebrate and habitat data for other informational needs of Massachusetts regulatory and resource agencies.

Table 1. List of biomonitoring stations sampled during the 2002 Charles River watershed survey, including station identification number, mile point, site description, and sampling date. Stations are listed hydrologically (from upstream-most drainage in the watershed to downstream-most) with mainstem stations listed first.

Station ID	Upstream Drainage Area (mi^2)	River Mile	Charles River Watershed Site description	Sampling Date
CR03	65.6	53.6	Charles River, 150 m dnst. from Walker Street, Medway, MA	15 July 2002
CR04	84.2	50.7	Charles River, 120 m dnst. from Dean Street, Millis, MA	15 July 2002
CR02A	182.6	28.8	Charles River, 100 m dnst. from Dover Dam, near gage, Dover-Needham, MA	17 July 2002
CR00	271.5	9.1	Charles River, 100 m dnst. from Watertown Dam, Watertown, MA	16 July 2002
HB01	9.9	1.0	Hopping Brook, 200 m dnst. from West Street, Medway, MA	15 July 2002
MB02	10.3	4.5	Mine Brook, 50 m dnst. from Route 140, Franklin, MA	15 July 2002
CK01	6.2	1.0	Chicken Brook, 100 m dnst. from Winthrop Street, Medway, MA	15 July 2002
MR01A	10.7	0.1	Mill River, 500 m dnst. from Main Street, Norfolk, MA	18 July 2002
SR01	1.2	8.2	Stop River, 110 m dnst. from Pond Street, Norfolk, MA	16 July 2002
SR03	13.8	2.0	Stop River, 30 m dnst. from Noon Hill Street, Medfield, MA	16 July 2002
TB01	3.7	0.9	Trout Brook, 100 m dnst. from Haven Street, Dover, MA	17 July 2002
FB02	4.8	0.9	Fuller Brook, 10 m upst. from Cameron Street, Wellesley, MA	17 July 2002
PB01	1.4	0.5	Powissett Brook, 100 m dnst. from Wilsondale Street, Dover, MA	17 July 2002
RM01	1.8	1.1	Rock Meadow Brook, 100 m upst. from Summer Street, Westwood, MA	18 July 2002
ST01	10.5	2.4	Stony Brook, 100 m downstream from Church Street, Weston, MA	16 July 2002

Table 2. Existing conditions and perceived problems identified prior to the 2002 Charles River watershed survey.

Charles River Watershed Stations	Conditions
CR04; CR00; TB01; MB02; CK01; HB01; FB02; MR01A; SR03	-urban runoff/miscellaneous NPS pollution (includes road/agricultural runoff)[1]
CR04; SR03	-point source discharges – WWTPs[1,2]
CR04; CR02A; CR00; SR03; FB02	-303d listed for nutrients and/or organic enrichment/low D.O.[1,3]
MB02; SR03	-water withdrawals/flow reductions[1]
HB01; CK01; RM01; CR02A;	-"unassessed" for Aquatic Life by DEP
ST01; SR01; CR03	-reference (i.e., minimally impacted) condition[1]

[1]MassDEP 2000; [2]MassDEP 2005; [3]MassDEP 2004

CHARLES RIVER WATERSHED
2002 BIOMONITORING STATIONS

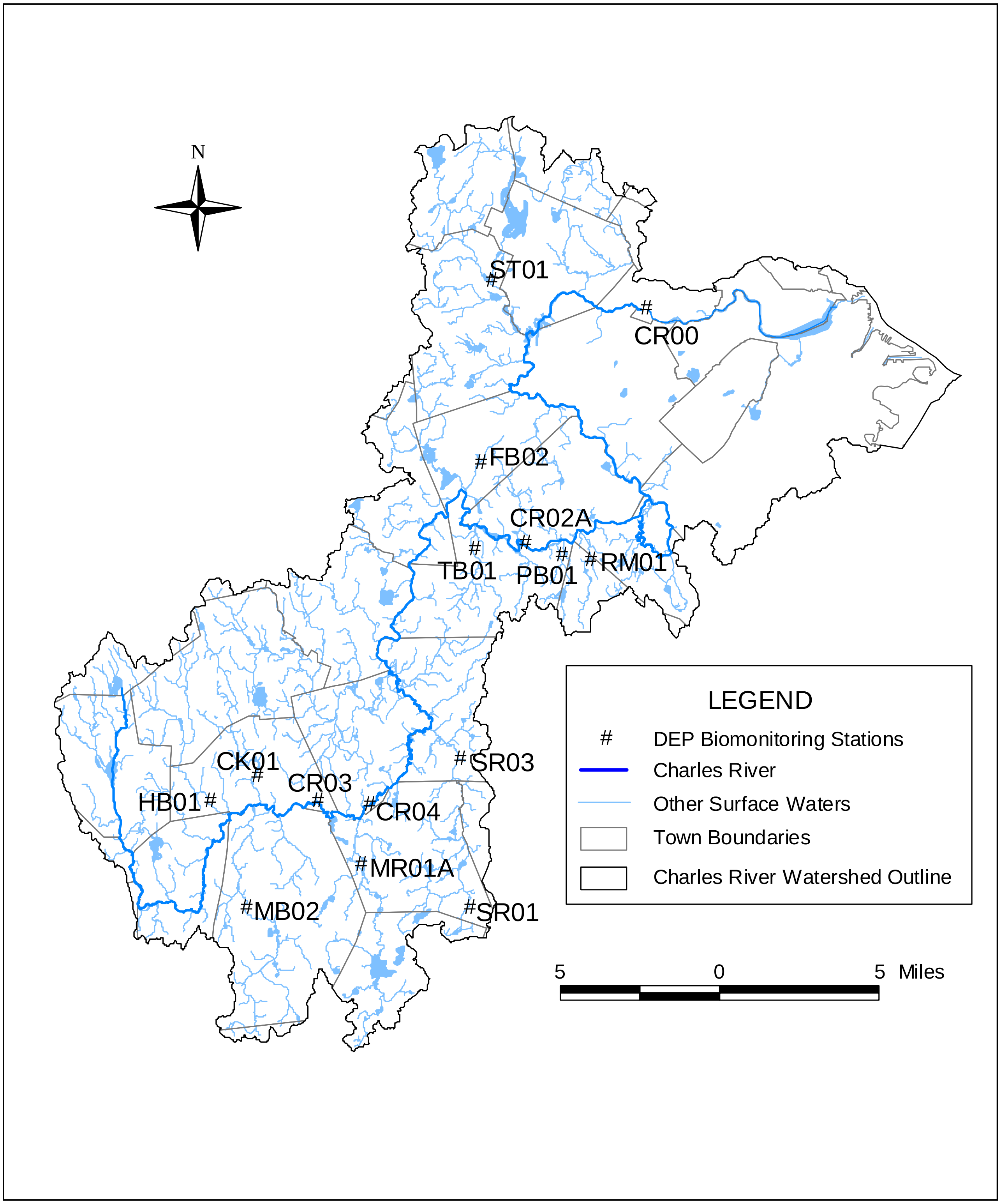

Figure 1. Location of MassDEP/DWM biomonitoring stations for the 2002 Charles River watershed survey.

BASIN DESCRIPTION

The Charles River Watershed is geographically and economically a vital part of the largest employment and population complex in New England. The watershed contains all or portions of five cities and thirty towns. Extending inland from Boston Harbor southwesterly toward the Massachusetts-Rhode Island border, the Charles River Watershed has an hour-glass shape which encompasses 307 square miles. The River meanders approximately 80 miles from its headwaters to its mouth.

Originating at an elevation of 500 feet, the Charles River rises from springs on the southerly slope of Honey Hill about a mile from Hopkinton Center. One mile downstream and nearly 150 feet lower is Echo Lake, often referred to as the source of the Charles. The upper third of the Charles River Watershed is largely rural in character and some agriculture is still being practiced. Terrain in the upper watershed is generally gently rolling to hilly, with the highest altitudes approaching 500 feet. The eastern and southern section of the upper watershed is characterized by rolling topography with extensive swampy areas. The combination of moderate slopes, sandy pervious soil, extensive wetlands, small mill dams, and lake storage contribute to making the upper section of the river unusually slow in responding to heavy rains.

The upper area of the Charles River Watershed extends from Echo Lake to Populatic Pond on the Franklin-Norfolk town line. In the upper watershed, the Charles River covers approximately 20 miles and falls around 220 feet. Nine dams, many of which were built by riparian mill owners for power sources, interrupt the mainstem flow. The environs are largely woodlands interspersed with small manufacturing towns and farms. The 12 miles between Populatic Pond and Route 27 embrace the largest Charles natural valley storage area, the so-called “marshes” of the Upper Charles. In this and the next two downstream reaches, the river flows at very low gradient – an average of only one-foot fall per mile. As an area of natural flood-water storage and wildlife habitat, this reach retains runoff from snow-melt and storm events and substantially reduces flood flows in the river. Below Route 27 to the South Natick Dam, the wide marsh area narrows and pine-forested banks rise abruptly from the river shore. These six miles of riverway are largely in estate or trust ownership.

The middle third of the Charles River Watershed includes the area between the outlet of Populatic Pond and the South Natick Dam. This area is suburban and less populated and developed than the lower Charles. The secluded estate character of the river upstream of the South Natick Dam changes gradually from suburban land, then to sweeping lawns and finally to urban development as the river approaches the Silk Mill Dam at Hemlock Gorge in Newton/Needham. In this 11-mile stretch lies the second largest natural valley storage area—“The Dedham Loop”—and the Mother Brook Diversion (capable of diverting up to one-third the flow of the Charles to the Neponset River).

From the Silk Mill Dam to the Watertown Dam, the Charles River drops 75 feet in 10 miles, principally at seven dam sites. Within this reach one finds sharp contrasts in the aesthetic quality of the riverscape. Upstream of the Moody Street Dam, the river meanders through the Lakes District. Downstream of Moody Street, the river becomes channelized as it flows through a much more urbanized portion of the watershed.

The lower third of the watershed extends from the South Natick Dam to the New Charles River Dam. This area forms a large segment of the Boston urban complex and is densely populated and intensively developed except for several major public or semi-public reservations. This lower segment has hydrologic conditions that differ substantially from the remainder of the watershed. During periods of high precipitation, a large portion of the precipitation runs off this urbanized area into the River within a very short period of time. Normally, the high run off rate would not create any drastic problems; however, the hydraulic situation is complicated by the fact that the Charles River empties into a harbor which at high tide is higher than the level of the Charles River.

The river downstream of the Watertown Dam, known locally as “the Basin”, is formed by the Charles River Dam located 1.2 miles above the mouth of the river. The Basin is 8.6 river miles long and covers some 675 acres at its design water service level of 2.38 feet above mean sea level. The major portion of the Basin downstream of the BU Bridge has a length of 2.6 miles and widths varying form 300 to 2,000 feet; the latter width prevails throughout the central 1.5 miles of this reach.

The volume and configuration of the Charles River has been greatly affected by two factors, 1) the numerous dams which widen the mainstream and slow its pace, and 2) the extensive natural storage provided by wetland areas in the middle and upper watershed. Flood peaks in these areas are so retarded in natural valley storage areas that they do not reach the Lower Charles until three to four days after the flood peak generated downstream has passed. And, not only do upstream wetlands buffer the effects of high flow periods, they also mitigate the consequences of low flow and extended drought. By releasing their stored waters gradually in the summer months, stream flows are sustained through periods of low precipitation.

METHODS

Macroinvertebrate Sampling

The macroinvertebrate sampling procedures employed during the 2002 Charles River watershed biomonitoring survey are described in the standard operating procedures *Water Quality Monitoring In Streams Using Aquatic Macroinvertebrates* (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 (Figure 2). Sampling activities were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (Fiorentino 2002). Sampling was conducted at each station by MassDEP/DWM biologists throughout a 100 m reach, in riffle/run areas with fast currents and rocky (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.

Figure 2. MassDEP/DWM biologist collecting macroinvertebrates in the Charles River using the “kick-sampling” technique.

Macroinvertebrate Sample Processing and Analysis

The macroinvertebrate sample processing and analysis procedures employed for the 2002 Charles 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 (Fiorentino 2002). Macroinvertebrate sample processing entailed distributing whole samples in pans, selecting grids within the pans at random, and sorting 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). Based on the taxonomy, various community, population, and functional parameters, or "metrics", were calculated which allow measurement of important aspects of the biological integrity of the community. This integrated approach provides more assurance of a valid assessment because a variety of biological parameters are evaluated. Deficiency of any one metric should not invalidate the entire approach (Barbour et al. 1999). 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 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 "impaired." A definition of the *Aquatic Life* use designation is provided 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 2002 Charles 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 greater with better 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 sensitive aquatic insect orders. Therefore, the greater the contribution to total richness from these three orders, the healthier the community.

3. Biotic Index—Based on the Hilsenhoff Biotic Index (HBI), this is an index designed to produce a numerical value to indicate the level of organic pollution (Hilsenhoff 1982). Organisms have been assigned a value ranging from zero to ten based on their tolerance to organic pollution. Tolerance values 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—The EPT and Chironomidae abundance ratio uses 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 Contribution Dominant Taxon—is the percent contribution of the numerically dominant taxon (genus or species) to the total number 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—This ratio reflects 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—is 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 Charles 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 reference site affinity approach is based on a modification of the Percent Model Affinity (Novak and Bode 1992). The (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 and biological 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 during the 2002 Charles River watershed biosurveys, 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 related streamside features. 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 follows: 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 provide a final habitat ranking.

QUALITY CONTROL

Field and laboratory Quality Control (QC) activities were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (Fiorentino 2002). Quality Control procedures included collection of a duplicate sample in the field, taxonomic "checks" in the lab, and review of all data entry and analysis. These procedures are further detailed in the standard operating procedures (Nuzzo 2002).

RESULTS AND DISCUSSION

The biological and habitat data collected at each sampling station during the 2002 biomonitoring survey are attached as an Appendix (Tables A1 – A5). Table A1 is the macroinvertebrates taxa list for each station and includes organism counts, the functional feeding group designation (FG) for each macroinvertebrate taxon, and the tolerance value (TV) of each taxon.

Summary tables of the macroinvertebrate data analysis, including biological metric calculations, metric scores, and impairment designations, are also included in the Appendix. Table A2 summarizes Charles River biomonitoring station comparisons to the mainstem reference station (CR03). Table A3 is the summary table for tributary station comparisons to the regional reference site (ST01). Table A4 shows results of upstream-downstream (i.e., site-specific) comparisons for paired stations CR03-CR04 and SR01-SR03 respectively. Habitat assessment scores for each station are also included in the summary tables, while a more detailed summary of habitat parameters is shown in Table A5.

The Charles River watershed was affected by drought-induced low flows during the 2002 biomonitoring survey (MA DCR 2003). Drought conditions and below normal precipitation persisted for several months (February-September 2002) prior to the September macroinvertebrate sampling period, reducing stream flow well below the expected mean for the period of record (MA DCR 2003; USGS 2003). The net effect was a reduction in available instream habitat, including exposure of stream bottom substrates during the 2002 biosurveys. These habitat constraints may result in the stranding or concentration of biota (both benthic macroinvertebrates and fish) into the remaining available habitats. In addition, these conditions tend to increase the stress upon sensitive species, and increase the metabolic rate of poikilothermic biota.

The 2002 biomonitoring data for this watershed generally indicate various degrees of nonpoint source-related problems in many of the streams examined. Urban runoff, habitat degradation, and other forms of NPS pollution compromise water quality and biological integrity throughout the watershed—most notably at CR02A, CR00, CK01, MB01, FB02, and MR01A. Serious water quality and biological impairment were also evident at CR04 and SR03, most likely the result of upstream wastewater treatment discharges. That said, some tributaries examined in the Charles River watershed remain relatively non-impacted and are indicative of the "best attainable" conditions in the watershed. It is imperative that anthropogenic perturbations be kept to a minimum in these unimpaired waterbodies.

Charles River

CR03—Charles River, mile point 53.6, 150 m downstream from Walker Street, Medway, MA

Habitat

The CR03 macroinvertebrate sampling reach began approximately 150 m downstream from Walker Street in Medway. This portion of the river was about 9 m wide and minimally shaded, with depths ranging from about 0.20 m in the riffles to 0.30 m in pool areas. Habitat assessment at CR03 found instream substrates and flow regimes to offer excellent epifaunal habitat for macroinvertebrates, with an abundance of cobble substrates subjected to varying velocity/depth combinations. Fish cover was considered suboptimal, with approximately 30% of the sampling area offering a mix of stable habitat. Instream aquatic vegetation covered approximately 50% of the stream bottom, with beds of arrowhead (*Sagittaria* sp.) the dominant taxon. Mosses provided additional epifaunal microhabitat as well. Channel flow status was slightly less than optimal—water filled >75% of the available channel and resulted in only minimal amounts of exposed substrates along the margins of the channel. Algal cover was minimal (<5% of reach covered) and consisted of thin filamentous green algae and blue-green mats in the slower, pooled areas of the reach. Both stream banks were well vegetated and stable, although patches of Japanese knotweed (*Polygonum cuspidatum*) along the left (north) bank suggest past disruption of native vegetation. A relatively undisturbed riparian zone comprised of vines (riverbank grape, *Vitis riparia*), shrubs (dogwood, *Cornus* sp.), trees (red oak, *Quercus rubra*; red maple, *Acer rubrum*, slippery elm, *Ulmus rubra*), and herbaceous growth (ferns; Japanese knotweed, *Polygonum cuspidatum*) predominated on the right (south) bank, while commercial development encroached somewhat along the left (north) bank. Nevertheless, potential nonpoint source pollution inputs appeared well buffered along both banks, and the road crossing just upstream from the sample reach showed little indication of NPS source impacts to the downstream aquatic community.

CR03 received a total habitat assessment score of 158 out of a possible 200 (Table A5). This station was designated an upstream reference station for CR04, which was established further downstream and downgradient of the Charles River Pollution Control District's (CRPCD) regional wastewater treatment facility (NPDES permit no. MA00102598) in Medway. In addition to bracketing the discharge effects of the CRPCD discharge, CR03 was used as a reference station for the CR00 biomonitoring station in the lower Charles River basin. The designation as reference station at CR03 was based on the habitat evaluation conducted there, historical bioassessments, surrounding land use, and overall water quality relative to other segments of the mainstem Charles River.

Benthos

Because CR03 is a reference station, the biological attributes of the macroinvertebrate assemblage sampled do not yield a final impairment score for the resident aquatic community. However, the metric values calculated as part of the RBP III analysis reflect a healthy benthic community one would expect to find in a "least impacted" stream (Table A2). Metric values for Biotic Index and EPT Index—parameters that measure components of community structure and display low inherent variability (Resh 1988)—scored well and corroborate the designation as a reference station. The Percent Dominant Taxon (17%) metric also performed extremely well relative to other stations in the survey, indicating good overall balance in the CR03 benthic community. CR03 received a total metric score of 42 out of a possible 42 (Table A2).

CR04—Charles River, mile point 50.7, 120 m downstream from Dean Street, Millis, MA

Habitat

The CR04 sampling reach began approximately 120 m downstream from Dean Street in the Rockville section of Millis. This portion of the river was wide (17 m) and uniformly shallow (0.10 – 0.20 m deep), with minimal canopy cover (<5% shaded) despite the forested nature of the surrounding area. Small "islands" and sediment "bars" rendered the center of the reach unavailable for kick sampling; however, long riffle areas with cobble-dominated substrates provided ample excellent macroinvertebrate habitat along both sides of the channel. Fish habitat was considered suboptimal, with occasional boulders and dense beds of macrophytes providing the majority of stable cover. The shallow nature of the CR04 reach, despite the optimal channel flow status, compromised fish habitat as well. In addition to virtually 100% cover by aquatic vegetation (mostly milfoil, *Myriophyllum* sp. and some waterweed, *Elodea* sp.), algal growth covered almost 50% of the reach, mainly in the form of filamentous green forms in both riffle areas and pools. Both stream banks were highly stabilized as a result of stone "rip-rap" along both sides of the channel. Vines (riverbank grape, *Vitis riparia*), shrubs (dogwood, *Cornus* sp.), grasses, and herbaceous vegetation (jewelweed, *Impatiens capensis*; purple loosestrife, *Lythrum salicaria*; pickerelweed, *Pontedaria* sp.) provided additional bank stability and good vegetative protection throughout the reach. Streambank vegetation gave way to an undisturbed and forested (red maple, *Acer rubrum*; ash, *Fraxinus americana*) riparian zone along the right bank. Similar riparian vegetation existed along the left bank in the lower half of the sampling reach; however, the manicured lawn of an adjacent residence has displaced most riparian vegetation in the upper half of the reach. In addition to potential NPS pollution inputs (grass clippings, yard wastes, etc.) originating from this residential property, the upstream road crossing offered potential sources as well. Origins of the substantial sedimentation (especially in the form of depositional bars) observed at CR04 were unknown; however, numerous sand/gravel pits are located in this portion of the watershed. The water column at CR04 was slightly turbid, and a sewage odor (i.e., treated effluent) was detected during the time of the biosurvey.

CR04 received a total habitat assessment score of 147/200 (Table A2). With the exception of instream sediment deposition, which was less severe at the upstream reference station, habitat quality was highly comparable to CR03, allowing for a direct comparison of biological conditions above and below the CRPCD discharge. The CRPCD, which discharges to the Charles River approximately 2 km upstream from CR04, has historically had problems meeting whole effluent toxicity testing limits as well as ammonia nitrogen permit limits (MassDEP 2000; MassDEP 2005). In an attempt to reduce nutrient loads that contribute to eutrophication in this portion of the Charles River—the segment of the river containing CR04 is currently listed as a “Category 5 Water” (i.e., reported to Congress and EPA as 303(d)-listed) for nutrients (MassDEP 2004)—the CRPCD underwent facility upgrades and permit limit changes (including new phosphorus limits) in 2000, and is currently being reissued a new NPDES permit that may include an even more stringent phosphorus limit (MassDEP 2005; Kathleen Keohane, MassDEP, personal communication, 2005; David Pincumbe, US EPA, personal communication, 2005).

Benthos

The CR04 benthic community received a total metric score of only 16, representing 38% comparability to the upstream reference station, CR03, and resulting in a bioassessment of “moderately impacted” for biological condition (Tables A2 and A4). This was easily the worst benthic community assessment received by a biomonitoring station in the 2002 Charles River watershed survey, and a similar assessment to the one received following the 1997 biomonitoring survey here (MassDEP 2000). In terms of benthic community composition and structure at CR04, little appears to have changed here since the 1997 biosurvey, despite facility upgrades at CRPCD and implementation of a new phosphorus limit in its NPDES permit.

That habitat quality is similar at both the upstream (CR03) and downstream (CR04) stations implies that detected impacts at CR04 can be attributed to water quality factors. The rich filter-feeding macroinvertebrate assemblage (filter-feeders comprised almost 70% of the benthos sample) found here appears to reflect the effects of considerable organic enrichment, and is indicative of an unbalanced community responding to an overabundance of a food resource (in this case, fine particulate organic material—FPOM). Populatic Pond, which is a eutrophic, Category 5 Water (i.e., reported to Congress and EPA as 303(d)-listed) impaired by turbidity and noxious aquatic plants (MassDEP 2004), is located just upstream of the CR04 sample reach and is probably at least partially responsible for the delivery of FPOM loads to CR04. Lentic systems can be a major source of dissolved and suspended particulate matter to downstream lotic communities—particularly when these systems are subjected to increasingly enriched conditions (Merritt et al. 1984). However, the hyperdominance of the filter-feeder *Simulium vittatum* cpl.—a taxon highly tolerant (TV=9) of conventional organic pollutants and often associated with municipal wastewater discharges (Adler and Kim 1986)—and virtually 100% cover of instream substrates by aquatic vegetation and filamentous algae, suggest the effects of nutrient loads and excessive organic enrichment one might associate with a wastewater discharge. Dissolved oxygen data collected by DEP during summer water quality surveys in 2002 found super-saturated daytime oxygen levels on more than one occasion at CR04 (MassDEP 2005a), corroborating the highly productive nature of this portion of the river.

Other metrics values, including a low EPT Taxa Index (5), a high Biotic Index (6.96—the highest of all the biomonitoring stations in the 2002 survey), and a high (37%) Dominant Taxon percentage, indicate an unbalanced benthic community structured in response to organic pollution or other types of water quality degradation.

CR02A—Charles River, mile point 28.8, 100 m downstream from Dover Dam, near USGS gaging station, Dover-Needham, MA

Habitat

The CR02A sampling reach began approximately 110 m downstream from South Street, ending at the base of the Dover Dam in Charles River Village. A USGS gaging station was located near the bottom of the reach. A narrow island divided the sampling reach into an east and west channel, with the east channel containing considerably more water (i.e., optimal channel flow status) due to a large culvert that discharged most of the river’s flow through this side of the dam. The western channel was only about half full of water, leaving a good deal of exposed substrates along its margins. The two channels converged about 100 m downstream from the dam, and much of the sampling took place at this confluence, where the open-canopied (5% shaded) river was approximately 15 m wide and with a depth of about 0.40 m in riffle dominated flow regimes. Additional kicks were made in the shallow (0.10 – 0.20 m) west channel near the base of the dam. Both channels offered excellent epifaunal habitat for macroinvertebrates, as they were mainly comprised of cobble and boulder substrates and swift current velocity. Fish habitat was also considered optimal, especially in the east channel where boulder, submerged logs, and undercut banks provided stable cover in the riffles and deep (0.40 m) pools of the sampling reach. Luxuriant macrophyte and algal growth covered virtually all available substrates through the reach—instream vegetation consisted of rooted submergent macrophytes (milfoil, *Myriophyllum* sp.; waterweed, *Elodea* sp.; coontail, *Ceratophyllum* sp.) and mosses, while the algae communit comprised filamentous, matted, and globose forms. Streambanks along both channels were stabilized with a combination of introduced boulder ("rip-rap") and both shrubby (buttonbush, *Cephalanthus occidentalis*; dogwood, *Cornus* sp.; buckthorn, *Rhamnus* sp.) and herbaceous (grasses; ferns; purple loosestrife, *Lythrum salicaria*) forms of vegetation. The riparian zone was heavily forested (mostly red maple, *Acer rubrum*; slippery elm, *Ulmus rubra*) and wide (> 18 m) along the east bank, but thinner (12 m) along the west bank due to a nearby road (Mill Street). Nonpoint source pollution inputs were not observed in the sampling reach during the biosurvey here, although the upstream road crossing and brush clearing activities (in the riparian zone just above the west channel sampling area) offered potential sources. The water column appeared highly turbid, and a "raw" (i.e., untreated) sewage odor of unknown origin was detected.

CR02A received a total habitat assessment score of 169/200 (Table A5). This was the highest score received by a mainstem Charles River biomonitoring station, including the reference station upstream, during the 2002 survey.

Benthos

The CR02A benthic community received a total metric score of 32, representing 76% comparability to the mainstem reference condition at CR03 and resulting in a bioassessment of "slightly impacted" (Table A2). Water quality rather than habitat quality (i.e., habitat was highly comparable to reference conditions) appears to limit biological potential in this portion of the river.

The CR02A macroinvertebrate assemblage was not dominated by a single taxon (three taxa made up 85% of the sample), but rather, a single functional feeding group—filter-feeders, which comprised almost 80% of the sample and displaced virtually all scraping taxa, indicating substantial suspended FPOM loads in this segment of the Charler River (Table A1). The hyperdominace of filter-feeders is probably most directly related to the productive nature of this portion of the watershed. The entire length of the Charles River from Populatic Pond to CR02A (and beyond) is classified as an impaired, Category 5 Water due to nutrients, organic enrichment, and associated low dissolved oxygen (MassDEP 2004). Potential sources of organic and nutrient inputs are numerous, and include contributions from tributaries and extensive upstream wetlands, point source discharges [both the CRPCD and Medfield WWTP (NPDES permit no. MA0100978) are located upstream], riverfront golf courses, and miscellaneous NPS pollution. The effects of nutrient enrichment are also reflected in other types of resident biota at CR02A—as mentioned above, instream macrophytes and algae (filamentous and matted forms) covered virtually all available surfaces in the CR02A sampling reach. Primary production of these luxuriant biological communities probably accounts for the dramatic fluctuations (continuous D.O. measurements ranged from midday super-saturation levels to predawn concentrations that violated surface water quality standards) in dissolved oxygen documented by DEP during July/August/September 2002 water quality surveys here (MassDEP 2005a).

CR00—Charles River, mile point 9.1, 100 m downstream from Watertown Dam, Watertown, MA

Habitat

The CR00 sampling reach began approximately 100 m downstream from the Watertown Dam and the mouth of Laundry Brook. This is the beginning of the long, impounded segment of the river known as "the Basin" which meanders slowly for several miles before reaching the Charles River Dam and canal locks near Boston Inner Harbor. CR00 is a wide (60 m) and open-canopied (0% shaded) segment of the river dominated by fast water due to its location near the base of the dam. The combination of varying (0.2 –

1.0 m) riffle depths and cobble-dominated substrates provided some of the best benthos habitat observed in the entire 2002 survey. Fish habitat was also excellent (a major herring run occurs here each spring), with deep (> 1 m) pools and riffle/run areas containing a variety (boulder, submerged logs, snags) of stable cover. Channel flow status was optimal, with water easily reaching the base of both banks and leaving very little exposed substrates. The CR00 sampling reach had considerably less water in it during the last biomonitoring survey here in 1997, when almost half of the river bottom was exposed. Aquatic vegetation, mainly comprised of mosses and some milfoil (*Myriophyllum* sp.) covered half of the available bottom substrates, while algal cover was even more extensive. Filamentous green algae and thin film algae covered virtually the entire reach in both pools and riffle areas. While instream habitat parameters were optimal, riparian and bank habitat were compromised by human activities. Lawns and foot traffic (this is a popular fishing area) along both banks resulted in the removal of bank vegetation in approximately one-third of the reach. Removal of streamside vegetation probably exacerbated the bank instability observed along both banks—erosion and bank failure were particularly severe along the right (south) bank. A thin layer of shrubs (dogwood, *Cornus* sp.; rose, *Rosa* sp.; honey locust, *Robinia* sp.) and trees (red maple, *Acer rubrum*; silver maple, *Acer saccharinum*; birch, *Betula* sp.; willow, *Salix* sp.; slippery elm, *Ulmus rubrum*) provided only a minimal vegetative buffer from an office building near the left bank and the potential NPS pollution inputs from a park and road (California Street) near the right bank.

CR00 received a total habitat assessment score of 152/200 (Table A5). This was a considerably better assessment than the one received during the 1997 biosurvey here, when shallow water resulted in limited fish habitat, and instream sediment deposition threatened epifaunal habitat potential (MassDEP 2000).

Benthos

The CR00 macroinvertebrate community received a total metric score of 28, representing 67% comparability to the mainstem reference station and resulting in a biological condition assessment of “slightly impacted “ (Table A2). As was the case during the 1997 biosurvey here, filter-feeders were well represented among the 2002 benthos sample, indicating the importance of FPOM as a food resource in this portion of the river. The highly urbanized and productive nature [(this segment of the river is listed as an impaired, Category 5 Water due to organic enrichment, nutrients, and other pollutants) (MassDEP 2004)] of this portion of the Charles River no doubt provides ample organic inputs to the CR00 aquatic community. However, filter-feeders do not hyperdominate the CR00 community as they did in 1997 when they comprised 60% of the sample. Indeed, high scoring (score=6) Scraper/Filterer and Percent Dominant Taxon metric values suggest the CR00 benthos assemblage collected in 2002 is more balanced than the 1997 assemblage in terms of community structure and function.

The current evaluation of the biota at CR00 shows an improvement over DWM’s 1997 bioassessment, when comparisons to CR03 resulted in a macroinvertebrate community assessment of “moderately impacted” (MassDEP 2000). It is unclear whether improved biological integrity here is a result of improvements in water quality or simply a result of greater assimilative capacity in the river (due to greater stream discharge in 2002 compared to 1997 baseflow) compared to 1997 conditions. Interestingly, scrapers were completely absent from the 1997 benthos assemblage, corroborating the shift towards improved trophic structure (i.e., an increased periphyton food resource) at CR00 since then. Nevertheless, CR00 remains generally dissimilar (Reference Affinity=45%; score=2) to reference conditions at CR03, despite highly comparable instream habitat conditions. Sources of water quality degradation associated with urban runoff (e.g., stormwater), which limit biological potential in this segment of the river, will be difficult to isolate due to the highly urbanized nature of this portion of the Charles River watershed.

Tributaries

ST01—Stony Brook, mile point 2.4, 100 m downstream from Church Street, Weston, MA

Habitat

The ST01 sampling reach began approximately 100 m downstream from Church Street in a forested portion of the watershed near the Kendall Green section of Weston. Well developed riffles and runs of uniform depth (0.20 m) and an abundance of cobble substrates provided macroinvertebrates with excellent habitat. Dense beds of aquatic mosses provided additional epifaunal microhabitat, while occasional patches of rooted emergent (smartweed, *Polygonum* sp.) and submergent (water starwort, *Callitriche* sp.; watercress, *Nasturtium* sp.) macrophytes were noted as well. Algal coverage was absent, perhaps due to the limited sunlight penetration resulting from the dense (90% shaded) overhead canopy. Fish cover was slightly less than optimal, with a mix of boulder, snags, and other stable habitat in the deeper (0.75 m) pool areas of about half the reach. Bank and riparian habitat parameters rated optimal. Banks were stabilized with boulders and well vegetated with a profusion of vines (Virginia creeper, *Parthenocissus quinquefolia*; greenbrier, *Smilax rotundifolia*), shrubs (dogwood, *Cornus* sp.; barberry, *Berberis* sp.; rose, *Rosa* sp.; buckthorn, *Rhamnus* sp.), and herbaceous (ferns; grasses; arrow arum, *Peltandra virginica*; forget-me-not, *Myosotis* sp.) growth. The deciduous forest extended undisturbed from both banks, offering a wide and unimpacted riparian zone and a good vegetative buffer from potential NPS pollution inputs. Instream sediment deposition was not observed, as it was during the 1997 biosurvey here when it was presumed to originate from the Church Street crossing.

ST01 received a total habitat assessment score of 182/200 (Table A5). As was the case during the 1997 biosurveys in the Charles River watershed, this was a designated watershed reference station for all tributary biomonitoring stations by virtue of its instream and riparian habitat quality (highest habitat assessment score in 1997 and 2002), historically excellent water quality, absence of nonpoint source pollution inputs, and minimal upstream/adjacent land-use impacts (e.g., absence of point source inputs, lack of channelization, minimal development and agricultural activity nearby, undisturbed and well vegetated riparian zone).

Benthos

The ST01 biomonitoring station was characterized by a macroinvertebrate assemblage indicating a healthy aquatic community, with metric values indicative of clean water and "least-impacted" conditions (Table A3). In particular, those attributes that measure components of community structure (i.e., Taxa Richness, Biotic Index, EPT Index)—which display the lowest inherent variability among the RBP metrics used (Resh 1988)—scored well, further corroborating the designation as a reference station. An extremely low Biotic Index (2.79—easily the lowest of all the Charles River watershed biomonitoring stations), and high EPT Index and Scraper/Filterer metric values relative to other biomonitoring stations in the survey indicated the dominance of pollution-sensitive taxa among the ST01 benthos assemblage, and good overall trophic balance. Only the Percent Dominant Taxon metric suffered point reductions (score= 4); however, this was the result of high densities of the stonefly, *Leuctra* sp. (Table A1)—a highly intolerant (TV= 0) taxon that requires high quality, well-oxygenated waters. The ST01 benthic community received a total metric score of 40 out of a possible score of 42 (Table A3).

HB01—Hopping Brook, mile point 1.0, 200 m downstream from West Street, Medway, MA

Habitat

The HB01 sampling reach began approximately 200 m downstream from West Street in an area of light residential development and forest. The stream was narrow (2 m) and well shaded by the surrounding forest which was comprised of stands of evergreens (mostly white pine, *Pinus strobus*), ash (*Fraxinus americana*), and red maple (*Acer rubrum*). The sampling reach began as a long, straight riffle (0.30 m deep) that entered a large pool (0.40 m deep) area before splitting to form two channels (i.e., a "braided stream")—one with shallow water and one completely dry. As a whole, baseflow throughout the reach was low, resulting in marginal channel flow status (channel only half full) and much of the stream bottom exposed. Nevertheless, benthic habitat remained good, with a diverse mix of rocky substrates (cobble, pebble, and the boulder remnants of an old dam) and swift current velocity above and below the pool area that was located midreach. Mosses provided additional epifaunal microhabitat, while other forms of aquatic vegetation (i.e., macrophytes and algae) were sparse—save for a few small beds of bur-reed (*Sparganium* sp.), water starwort (*Callitriche* sp.), and watercress (*Nasturtium* sp.). Fish habitat was suboptimal—comprised of a mix of snags, logs, and boulder—and would have rated much higher with a slight increase in water level. Banks were well vegetated with vines (greenbrier, *Smilax rotundifolia*; riverbank grape, *Vitis riparia*), shrubs (dogwood, *Cornus* sp.; honeysuckle, *Lonicera* sp.; elderberry, *Sambucus canadensis*), and herbaceous (jewelweed, *Impatiens capensis*; ferns; nightshade, *Solanum dulcamara*; arrow arum, *Peltandra virginica*) growth along both sides of the stream and between the two channels of the bottom half of the reach. The right bank was highly stable due to bank vegetation and boulders, while a small clearing near the top of the reach resulted in small areas of erosion along the left bank. Riparian vegetative zone width was about 18 m and 12 m along the left and right banks respectively. The yards of adjacent residences along the right bank offered potential sources (e.g., grass clippings, yard wastes, trash) of NPS pollution. Moderate deposition of both inorganic and organic (FPOM) sediments compromised habitat quality throughout the reach and especially in the pool areas, although obvious sources of sedimentation were not observed.

HB01 received a total habitat assessment score of 136/200 (Table A5). The effects (low baseflow, exposed substrates, unavailable fish cover) of drought conditions, coupled with instream sediment deposition, contributed most to habitat scoring reductions.

Benthos

The HB01 benthic community received a total metric score of 24, representing 60% comparability to the tributary reference station, ST01, and resulting in a bioassessment of “slightly impacted” (Table A3). Although reductions in the number of EPT taxa at HB01 resulted in low scoring (score=0) EPT Index and EPT/Chrironomidae metric values, the HB01 benthos assemblage displayed a high total Taxa Richness (27—the second highest Taxa Richness in the entire survey). In addition, values for Scraper/Filterer and Percent Dominant Taxon metrics outperformed those of the reference station, indicating good trophic structure and community balance among the HB01 biota. It is possible that the habitat limitations at HB01 have resulted in the displacement of EPT taxa—which are highly vulnerable to both sedimentation and the effects (e.g., stranding, drift-induced dispersal) from decreasing stream discharge (Minshall 1984; Johnson et al. 1993)—by a diverse group of taxa more tolerant of these instream conditions. Indeed, the Chironomidae—which have been shown to display adaptations to low baseflow as well as instream sedimentation (Bode, NYDEC, personal communication; Zweig and Rabeni 2001)—were well represented (n=34) in the HB01 sample, contributing to some of the lowest EPT/Chironomidae and Reference Affinity metric values in the entire Charles River watershed survey (Table A3).

Although it is unclear as to the extent that water quality may limit biological integrity in this portion of Hopping Brook (DEP did not conduct water quality sampling at HB01 in 2002), instream sediments no doubt pose a serious threat to habitat quality and biological potential throughout the HB01 sampling reach. Sand and other fine sediments drastically reduce macroinvertebrate microhabitat by filling the interstitial spaces of epifaunal substrates. In addition, the filling of pools with sediment reduces fish cover and may be detrimental to fish egg incubation and survival. Sediment inputs may originate from multiple sources in the Hopping Brook subwatershed—upstream road crossings, parking lots and other impervious surfaces, and numerous upstream sand/gravel operations all may contribute to the instream deposition observed at HB01.

MB02—Mine Brook, mile point 4.5, 50 m downstream from Route 140, Franklin, MA

Habitat

The MB02 sampling reach began approximately 50 m downstream of Route 140 in Franklin. Although much of Mine Brook is characterized by a slow moving channel bordered by wetland vegetation, this portion of the stream had a variety of flow regimes, adequate gradient, and diverse instream substrates more typical of lotic stream systems. Macroinvertebrate habitat was slightly less than optimal—riffles were plentiful and contained rocky substrates (cobble and pebble) but were uniformly shallow (0.20 m) despite the optimal channel flow status of this small (2 m wide) stream. Pool areas were also shallow, and while they contained some stable cover for fish in the form of snags, and introduced debris (trash), moderate deposition of fine sediments compromised overall fish habitat quality. Instream vegetation and algal cover were absent—possibly the result of the shaded (90% canopy cover) nature of this reach. Both stream banks were relatively stable and well vegetated with herbaceous (grasses; jewelweed, *Impatiens capensis*) plants and vines (poison ivy, *Rhus radicans*), with the exception of a few small areas of erosion along the steeper left bank. While the undisturbed riparian zone along the right bank was well vegetated with vines (bittersweet, *Celastrus* sp.; Virginia creeper, *Parthenocissus quinquifolia*; riverbank grape, *Vitis riparia*) and shrubs (*Viburnum* sp.) near the bank and trees (white ash, *Fraxinus americana*; red maple, *Acer rubrum*; slippery elm, *Ulmus rubra*) further from the channel, the riparian zone along the left bank was very narrow (2 m wide), offering minimal protection from NPS inputs from the adjacent road. As a result, considerable amounts of instream trash and sediment were observed, no doubt originating along the poorly buffered bank and adjacent road. Runoff from the upstream road crossing also probably contributed to the moderate levels of instream embeddednes and deposition. In addition, severe channelization upstream from the sampling reach (the result of a mill) may impact habitat quality at MB02.

MB02 received a total habitat assessment score of 130/200 (Table A5). Instream habitat was most compromised by sedimentation and trash deposits, which were also documented here during the 1997 biosurvey and habitat assessment (MassDEP 2000). Removal of vegetation, erosional areas, and other disruption (road) impacted the riparian zone along the left bank. In addition, the effects (shallow water, exposed fish habitat) from drought conditions—though not as extreme as the previously discussed station (HB01)—observed during the biosurvey here may have been further exacerbated by baseflow reductions related to water withdrawals. Several public groundwater withdrawals currently exist in the Mine Brook subwatershed (MassDEP 2000)—all are in Franklin and are located upstream from MB02.

Benthos

MB02 received a total metric score of 26, representing 65% comparability to the reference station and resulting in a bioassessment of “slightly impacted” (Table A3). The benthic community supported a diverse (Taxa Richness, 24, was higher than at ST01) assemblage of macroinvertebrates relative to the reference station at ST01. And while the EPT Index scored poorly compared to the reference station, an index of 8 was high relative to most biomonitoring stations in the Charles River watershed (Tables A2 and A3). In general, the MB02 sampling reach appears to support a fairly well-balanced community, and the series of impoundments upstream do not seem to contribute excessive amounts of fine particulate organic material (FPOM). The lack of an overly dominant taxon and a high ratio of Scrapers/Filterers (1.04; score=6) corroborate the apparent balance in community and trophic structure. Impairment to the aquatic community here is probably the result of habitat impacts rather than water quality degradation. Reduced substrate microhabitat due to embeddedness and sediment deposition may contribute to the suppression of the EPT community at MB02, as these forms may be susceptible to increases in sediment loading (Johnson et al. 1993).

Biological condition at MB02 appears to remain unchanged since the last biosurvey conducted here in 1997, when the benthic community was assessed as “slightly impacted” (MassDEP 2000). Impairment to the biota sampled in 1997 also was attributed to habitat degradation related to sediment deposition and substrate embeddedness.

CK01—Chicken Brook, mile point 1.0, 100 m downstream from Winthrop Street, Medway, MA

Habitat

The CK01 sampling reach began approximately 100 m downstream from Winthrop Street in the village of West Medway, approximately 1.5 km from the stream’s confluence with the Charles River. With the exception of a single residence, the stream flowed through an undeveloped area of forest and dense shrub/herbaceous vegetation. Because the majority of trees were restricted to one side of the stream, the sampling reach was minimally (30% canopy cover) shaded. Stream width was about 3 m, although it widened slightly in the lower half of the reach. Flow regimes were dominated by riffles of uniform depth (0.30 m), with the exception of the middle of the reach which contained a large (0.40 m deep) pool. Cobble substrates were prevalent throughout the area, offering excellent epifaunal habitat for macroinvertebrates. Mosses and small beds of bur-reed (*Sparganium* sp.) and water starwort (*Callitriche* sp.) provided additional benthic microhabitat, but overall macrophyte and algae cover was minimal. Fish habitat was marginal at best, however, due to a lack of stable cover save for the overhanging bank vegetation. Channel flow status was suboptimal—water filled more than 75% of the available channel but left some substrates exposed along the stream margins. Both stream banks were quite stable as a result of the dense vegetative cover throughout the reach. Bank vegetation was diverse, especially along the right bank where grasses, vines (riverbank grape, *Vitis riparia*), shrubs (dogwood, *Cornus* sp.; rose, *Rosa* sp.; honeysuckle, *Lonicera* sp.), and herbaceous (ferns; purple loosestrife, *Lythrum salicaria*; jewelweed, *Impatiens capensis*; nightshade, *Solanum dulcamara*) vegetation extended far into the wide and undisturbed riparian zone. Shrubs and herbaceous vegetation along the left bank gave way to a wide band of deciduous (red maple, *Acer rubrum*; white ash, *Fraxinus americana*; slippery elm, *Ulmus rubrum*; hickory, *Carya* sp.) forest that offered a good riparian buffer from the adjacent residence and a nearby road. NPS pollution was not observed, and while the upstream road crossing offered potential NPS inputs there were no signs (i.e., sediment deposition) of runoff during the biosurvey.

CK01 received a total habitat assessment score of 158/200 (Table A5). The limited fish habitat, a result of inadequate cover and slightly reduced baseflow, affected the total score most negatively. Nevertheless, only two tributary study stations received a better habitat evaluation than CK01 (Table A5).

Benthos

The CK01 benthos received a total metric score of 22, which represented 55% comparability to the reference tributary and resulted in a biological condition assessment of “slightly impacted” (Table A3). The impairment designation seemed mainly the result of a displacement of EPT taxa by chironomids, resulting in low scoring EPT Index, EPT/Chironomidae, and Biotic Index metric values. The high density (n=28) of Chironomidae here, coupled with numerous (n=33) filter-feeding caddisflies, may be indicative of elevated organic enrichment in this portion of Chicken Brook. The suppression of taxa sensitive to organic pollutants (e.g., EPTs), despite the optimal instream habitat afforded them, would seem to corroborate the effects of water quality degradation in this segment of the stream.

MR01A—Mill River, mile point 0.10, 500 m downstream from Main Street, Norfolk, MA

Habitat

The MR01A sampling reach began approximately 500 m downstream from Main Street and the outlet of City Mills Pond. Because the pond’s outlet structure is several meters above the river, the constant head created by this drop in elevation results in swift current velocity for several hundred meters downstream from the outlet. As a result, the MR01A sampling reach was dominated by riffle areas throughout its length. However, the river quickly loses gradient downstream from MR01A and meanders sluggishly through extensive wetland before reaching its confluence with the Charles River. Rocky substrates were common throughout the reach; however, their small size (small cobble and pebble) and the shallow (0.10 m – 0.20 m in riffles, runs, and pools) nature of the stream resulted in less than optimal benthic habitat despite the preponderance of riffles and good channel flow status. Fish habitat also was limited due to a lack of deep areas and stable cover that was either lacking or exposed (i.e., unavailable to fish). The stream was approximately 4 m wide and partially shaded (75% canopy cover) by the dense surrounding forest. Algae and instream vegetative cover were extremely limited and comprised only a few small patches of a matted green alga and water starwort (*Callitriche* sp.). An abundance of diverse shrubs (rose, *Rosa* sp.; sweet pepperbush, *Clethra alnifolia*; *Viburnum* sp.; buckthorn, *Rhamnus* sp.; barberry, *Berberis* sp.; honeysuckle, *Lonicera* sp.; dogwood, *Cornus* sp.), vines (Virginia creeper, *Parthenocissus quinquefolia*; greenbrier, *Smilax rotundifolia*), and herbaceous (grasses; ferns; jewelweed, *Impatiens capensis*) vegetation provided good stability and cover along the left bank before giving way to a wide and wooded (red maple, *Acer rubrum*; slippery elm, *Ulmus rubrum*) riparian zone. Bank stability and vegetative protection remained good along the right bank, although anthropogenic debris (metal drums, broken pipes, scrap metal), presumably originating from nearby industrial activity, impacted the riparian zone slightly.

MR01A received a total habitat assessment score of 146/200 (Table A5). Extremely shallow water impacted both fish and invertebrate habitat quality, while instream sediment deposition compromised overall habitat potential as well. Sources of sedimentation are unknown; however, upstream road crossings and numerous sand/gravel operations within the Mill River drainage area may contribute sediment inputs to the river. Severe instream sediment deposition and substrate embeddedness (score=3 out of a possible 20 for both parameters) were also documented during the 1997 DEP biosurvey in the Mill River which was conducted a short distance downstream from MR01A (MassDEP 2000).

Benthos

The MR01A macroinvertebrate community received a total metric score of 24, representing 60% comparability to the ST01 benthos and resulting in a bioassessment of “slightly impacted” (Table A3). Taxa Richness was extremely reduced (14—the lowest richness in the survey) compared to other biomonitoring stations in the Charles River watershed survey, the result of a dominance of the resident benthos by only a few taxa—pisidiid clams and the philopotamid caddisfly, *Chimarra* sp. Occurring in densities of 22 and 40 respectively, these filter-feeding taxa suggest an abundance of FPOM in this portion of the Mill River. A reduced EPT Index and an elevated Biotic Index corroborate the enriched conditions that appear to shape community structure and composition at MR01A. Suspended FPOM is not the only important food resource at MR01A, however, as the presence of numerous (especially Elmidae) scaping taxa (Scrapers/Filterers metric score=6) in the MR01A sample indicates the presence of a periphyton-based feeding guild here as well.

It should be mentioned that DEP did conduct biomonitoring in this portion of the Mill River during the 1997 Charles River watershed survey. However, the 1997 biosurvey utilized artificial substrate samplers (Hester-Dendy multiplates) which often selectively sample certain taxa, thereby misrepresenting relative abundances of these taxa in the natural substrate (Plafkin et al. 1989). In addition, the multiplate sample collected here in 1997 did not receive an impairment designation due to its use as an upstream control station for comparisons to downstream communities potentially affected by water withdrawals. Results of the 1997 Mill River biomonitoring efforts will not be discussed here, as the differing sampling methodologies employed for the 1997 and 2002 biosurveys make comparisons between benthos samples inappropriate.

SR01—Stop River, mile point 8.2, 110 m downstream from Pond Street, Norfolk, MA

Habitat

The SR01 sampling reach began approximately 110 m downstream from Pond Street (Route 115) in the Pondville section of Norfolk. The stream was small, with a maximum depth of only 0.20 m despite the optimal channel flow status, and a width of 2 m. Riffle areas were shallow (0.10 m) but long, and the cobble and pebble substrates provided optimal epifaunal habitat for macroinvertebrates. Aquatic vegetation, consisting of mostly mosses and small areas of rooted submergent macrophytes (water starwort, *Callitriche* sp.; watercress, *Nasturtium* sp.), provided additional benthic microhabitat in about 10% of the reach. Algal cover was minimal (<5% coverage) and limited to a green filamentous alga observed in the riffles. Fish habitat was only marginal due to the shallow nature of the reach and a mix of stable cover (overhanging shrubs, undercut banks, snags) in only about 25% of the sampling area. Bank vegetation was diverse and well established, providing added bank stability. The profusion of grasses, shrubs (speckled alder, *Alnus rugosa*; honeysuckle, *Lonicera* sp.; *Viburnum* sp.; rose, *Rosa* sp.), vines (Virginia creeper, *Parthenocissus quinquefolia*), and herbaceous (jewelweed, *Impatiens capensis*; ferns; cattail, *Typha latifolia*; skunk cabbage, *Symplocarpus foetidus*) forms along both banks gave way to wide riparian zones of “wet” forest (red maple, *Acer rubrum*; slippery elm, *Ulmus rubra*; white pine, *Pinus* *strobus*) and wetland (cattail-dominated marsh) that completely (100% canopy cover) shaded the SR01 sampling reach.

SR01 received a total habitat assessment score of 147/200 (Table A5). Habitat quality was most compromised by sediment deposition. Potentially detrimental instream deposits of sediments were also observed in the SR01 sampling reach during the 1997 DEP biosurvey (MassDEP 2000). In addition to commercial development along Route 1A which runs parallel to this segment of the river, a large sand/gravel facility actively operates immediately upstream and adjacent to the sampling reach and should be considered as a potential source of sediment loading to SR01.

SR01 was the upstream reference station for SR03, which was located further downstream near the mouth of the Stop River. This upstream-downstream comparison was made to assess the cumulative impacts of multiple point source discharges to downstream aquatic communities. There are three NPDES discharges to the Stop River—the Norfolk MCI wastewater treatment facility (NPDES permit no. MA0102253), Wrentham State School's WWTP (NPDES permit no. MA0102113), and Southwood Community Hospital's wastewater treatment facility (NPDES permit no. MA0102288). Compounding the effects of these point source inputs may be a reduction in stream flow resulting from several groundwater withdrawals (Norfolk MCI Well nos. 1, 2, 3, and 4; Southwood Hospital Well nos. 1 and 2) within the Stop River subwatershed.

Benthos

The SR01 macroinvertebrate community received a total metric score of 26, representing 65% comparability to the watershed reference station in Stony Brook (Table A3). The resulting assessment of biological condition was “slightly impacted”.

The impact status observed at SR01 may be a result of natural conditions related to its location near the source waters of the Stop River rather than anthropogenic factors, as some pristine or minimally impacted headwater streams are naturally unproductive (Plafkin et al. 1989). As a result, periphyton and particulate organic inputs have yet to become an important food resource this far upstream in the watershed, and thus, macroinvertebrate taxa that harvest these food types (i.e., scrapers, filter-feeders) are not well represented in the SR01 assemblage. This is evidenced in the low Scraper/Filterer metric (score=2) and a low overall density of filter-feeders at SR01, as well as a general dissimilarity (Reference Affinity=52%) to other reference conditions (i.e., ST01) in the Charles River watershed.

Other benthic community metrics at SR01 suggest generally good overall biological integrity in this portion of the Stop River. Richness metrics, both for total taxa and EPT taxa, outperformed all other biomonitoring stations in the 2002 survey. In addition, the Percent Dominant Taxon contribution (8%) was easily the lowest in the entire survey, indicating good community balance at SR01. That the Chironomidae were well represented (n=30; EPT/Chironomidae=1.27) among the SR01 benthos assemblage may reflect the effects of sediment deposition, low baseflow, or other unknown factors.

SR03—Stop River, mile point 2.0, 30 m downstream from Noon Hill Street, Medfield, MA

Habitat

The SR03 sampling reach began approximately 30 m downstream from Noon Hill Street in a relatively undeveloped portion of the watershed where vast tracts of wetland extended from both sides of the 5 m wide channel and offered virtually no canopy cover. Due to limited riffle habitat, sampling was conducted immediately upstream and downstream from the Noon Hill Street crossing, where the culverting of the river provided swift-flowing, albeit shallow (0.10 m), water on both sides of the road before flow regimes slowed and deepened (>1.0 m) to become more typical (i.e., glide/pool dominated, meandering, deep) of this portion of the river. Cobble and boulder substrates, probably introduced as part of the culverting process, were abundant in the short riffle near the road, but were replaced by sand and mud farther downstream. Overall epifaunal habitat was considered suboptimal, as was fish habitat which was composed of a mix of stable cover (boulder, undercut banks, deep pools) in about half the reach. Well established beds of burreed (*Sparganium* sp.) covered the majority of the reach, while algal coverage was minimal. Channel flow status was optimal, easily reaching the base of both banks and leaving virtually no exposed substrates or vegetation. Grasses, shrubs (speckled alder, *Alnus rugosa*), and typical wetland herbaceous vegetation (purple loosestrife, *Lythrum salicaria*; cattail, *Typha latifolia*) covered both stream banks and extended into the wide, marshy riparian zone. Occasional trees (birch, *Betula* sp.; slippery elm, *Ulmus rubra*; willow, *Salix* sp.; red maple, *Acer rubrum*) covered the higher elevation further from the streambanks. Instream sedimentation resulted in new bar formation and deposition in pools, but appeared to be localized and associated with the Noon Hill Street crossing and erosional areas caused by a footpath (fishing access). Instream deposition appeared less severe than during the 1997 biosurvey here when half of the reach was affected and rocky substrates were deeply embedded (MassDEP 2000).

SR03 received a total habitat assessment score of 152/200, which was slightly higher than the upstream reference station. (Table A5). This was also an improvement over the 1997 habitat evaluation here, mainly due to greater availability of epifaunal substrates as macroinvertebrate habitat.

Benthos

The SR03 benthic community received a total metric score of 26, representing 65% comparability to the watershed reference station (ST01) and resulting in a bioassessment of “slightly impacted “ (Table A3). Comparisons to the upstream reference station (SR01) resulted in a similar assessment (“slightly impacted”) based on a total metric score of 26 and 62% comparability to the SR01 benthos (Table A4).

An extremely reduced EPT Index (3), an elevated Biotic Index (5.18), and a high Percent Dominant Taxon metric value (40%) indicate pollution sensitive taxa at SR03 have become displaced by a single, more tolerant taxon—in this case, the net-spinning caddisfly *Cheumatopsyche* sp. The numerical dominance (n=40) of this filter-feeder suggests an abundance of FPOM in this portion of the river. However, filter-feeder densities were not observed at the levels seen in 1997, when hydropsychids hyperdominated (n=75) the SR03 assemblage, displacing virtually all other feeding groups and contributing to a “moderately impacted” bioassessment compared to both the ST01 and SR01 reference conditions (MassDEP 2000). This suggests that additional food resources (e.g., periphyton) now influence trophic structure in this portion of the Stop River. Nevertheless, the SR03 benthic community remains structured in response to organic enrichment and associated low levels of dissolved oxygen. Indeed, the entire river is classified as an impaired, Category 5 Water due to organic pollutants (MassDEP 2004). Dissolved oxygen measurements recorded at SR03 by DEP showed levels (D.O. concentrations <5.0 mg/l; <55% saturation) that consistently did not meet water quality standards during 2002 summer (July through September) surveys (MassDEP 2005a), corroborating water quality limitations in this segment of the Stop River.

Although organic enrichment continues to persist at SR03, it is not clear if organic inputs and reduced dissolved oxygen concentrations are natural occurrences resulting from upstream wetlands or a function of upstream effluent contributions. This most recent assessment of biological condition, however, suggests some improvement in biological integrity at SR03, possibly attributable to improved habitat quality at SR03, effluent quality at one of the upstream facilties, or other unknown factors.

TB01—Trout Brook, mile point 0.90, 100 m downstream from Haven Street, Dover, MA

Habitat

The TB01 sampling reach began approximately 100 m downstream from Haven Street in a forested portion of the watershed not far from Trout Brook’s confluence with the Charles River. A “wetted” forest completely shaded the 3 m wide reach; in fact, the density of overhanging vegetation made it impossible to extend the kick sampling reach any further downstream. Nevertheless, the TB01 sampling area was dominated by a long and well developed (0.2 m deep) riffle before entering a large, deep (>1 m) pool at the top of the reach. An abundance of cobble substrates of uniform size and overall excellent epifaunal habitat throughout the reach led to the decision of DWM biologists to collect an additional (i.e., duplicate) benthos sample at this station, as outlined in the QAPP (Fiorentino 2002). Fish cover was also optimal, with a good mix of stable habitat in the form of undercut banks, snags, submerged logs, and boulder in both the riffles and pool areas. Instream algal growth and vegetation were minimal with the exception of aquatic mosses and a small bed of submergent macrophytes (burreed, *Sparganium* sp.; water starwort, *Callitriche* sp.). Mosses, grasses, and various wetland vegetation (skunk cabbage, *Symplocarpus foetidus*; ferns) provided good stability and vegetative protection along both banks. Riparian vegetative zone width was optimal, comprised of shrubs (buckthorn, *Rhamnus* sp.; rose, *Rosa* sp.; *Viburnum* sp.), red maple (*Acer rubrum*), and floodplain vegetation (ferns, skunk cabbage) in the understory, and providing an adequate buffer from adjacent agricultural activities near the left bank. NPS pollution inputs were absent, although the road crossing, a paved "swale" leading to the stream, and an unpaved parking area offered potential sources of runoff.

TB01 received a total habitat assessment score of 182/200 (Table A5). Along with the watershed reference station in Stony Brook, this was easily the highest quality habitat observed in the 2002 biomonitoring survey. Only one parameter, velocity-depth combinations, rated less than optimal as a result of a lack of deep riffle areas.

Benthos

The original TB01 benthos assemblage and its duplicate sample received total metric scores of 20 and 28, respectively, resulting in 50% and 70% comparability to the watershed reference station. The discrepancy in metric scores between the TB01 samples resulted in two different assessments of biological health—"moderately impacted" and "slightly impacted" (Table A3).

Metric scoring reductions were mainly the result of a displacement of EPT taxa by Chironomidae such as *Tvetenia paucunca*. That this taxon is well represented in the TB01 assemblage is significant, as its utility as an indicator species has been well documented—it has been found to occur in large numbers in cool, small streams impacted by nutrient-enriched conditions (Bode and Novak 1998). *Tvetenia paucunca* does not hyperdominate the TB01 assemblage, however, as was the case during the 1997 biosurvey when it comprised half of the sample and contributed to a "moderately impacted" assessment of biological condition (MassDEP 2000). In fact, TB01 displayed some of the highest Taxa Richness values (for duplicate and original sample) in the entire survey, and was one of only two stations (along with the reference, ST01) populated with multiple families of Plecoptera—generally considered the most pollution sensitive insect order.

DEP did not conduct water quality monitoring in Trout Brook during the 2002 Charles River watershed survey; thus, it is unknown to what extent water quality degradation—specifically nutrient loadings—may compromise biological integrity at TB01. However, the fact that habitat quality here was exceptional, as was the case during the 1997 biosurvey, strongly suggests that water quality continues to limit biological potential in this portion of Trout Brook, though perhaps not at the level of severity observed in 1997.

FB02—Fuller Brook, mile point 0.90, 10 m upstream from Cameron Street, Wellesley, MA

Habitat

The FB02 sampling reach began approximately 10 upstream from Cameron Street in a park area near the Hunnewell School and downtown Wellesley Center. The reach was mostly (80%) shaded by a narrow band of trees along both sides of the stream. The top of the sampling reach was immediately below the mouth of a small unnamed tributary that drains a "duck pond" before entering Fuller Brook from the north (right) bank. Riffle areas as wide as the stream channel (4 m) were common throughout the reach, although their short and shallow (0.1 m) nature resulted in suboptimal macroinvertebrate habitat despite the abundance of cobble substrates present. Fish habitat was only marginal—run (0.10 – 0.50 m) and pool (>1.0 m) depth was good due to optimal channel flow status, but a lack of stable cover resulted in habitat availability that was less than desirable. Aquatic vegetation covered about 10% of the available bottom substrates and was limited to mosses. Algal coverage was minimal (<1%). Half of the sampling reach was affected by sediment deposition. Instream deposits included both inorganic and organic

(FPOM) materials—pools showed obvious signs of filling, sediment bars were common throughout the stream, and rocky substrates were approximately 40% embedded. Banks were poorly vegetated (bank vegetation was limited to ferns and grasses)—especially along the right bank where most of the native plants have been replaced with a manicured lawn—and as a result, the majority of the reach showed signs of bank erosion. The few trees and shrubs present in the riparian zone along the right bank offered very little buffering from the potential NPS pollution inputs from the adjacent lawn, footpath, and nearby manicured playing fields. Riparian vegetative zone width was considerably wider along the left bank, with grasses and herbaceous (fern, jewelweed, *Impatiens capensis*) vegetation interspersed with additional trees (buckthorn, *Rhamnus* sp.; maples, *Acer* spp.; slippery elm, *Ulmus rubrum*; white pine, *Pinus strobus*), vines (bittersweet, *Celastrus* sp.), and shrubs (barberry, *Berberis* sp.; elderberry, *Sambucus* sp.; rose, *Rosa* sp.) and providing an adequate buffer from numerous adjacent residences.

FB02 received a total habitat assessment score of 124/200, which was worst evaluation of habitat in the entire 2002 survey (Table A5). Instream habitat degradation related to sedimentation, and anthropogenic disruption of bank and riparian parameters affected the score most negatively. Sources of sediment inputs may be numerous in this highly urbanized portion of the watershed, and the stream's vulnerability to sedimentation is probably exacerbated by vegetative removal and erosion along its banks and riparian zone. Habitat was rated slightly better here in 1997, receiving an overall score of 138 and less impacted by instream sediment deposition (MassDEP 2000).

Benthos

The FB02 benthic macroinvertebrate community received a total metric score of 20, representing 50% comparability to the reference tributary station and resulting in a biological assessment of "moderately impacted" (Table A3). An elevated Biotic Index (5.77—the highest of all the tributary biomonitoring stations) and extremely reduced EPT Index are strongly suggestive of a benthic community structured in response to organic enrichment. EPT taxa have been displaced by a single hyperdominant (n=54) taxon, the hydropsychid caddisfly *Cheumatopsyche* sp., whose filter-feeding foraging habits corroborate the excessive amounts of organic materials in this portion of Fuller Brook. Community structure and function at FB02 is highly similar to the benthos assemblage collected here in 1997, which was also hyperdominated by the Hydropsychidae and found to be moderately impacted (MassDEP 2000). The 1997 assessment of Fuller Brook documented runoff from waterfowl activity that originated from the unnamed tributary entering FB02 as a major contributor of organic inputs and elevated bacteria levels in the FB02 reach. As a result, the stream was listed as a Category 5 Water impaired by organic enrichment and pathogens (MassDEP 2004). It is unknown if waterfowl presence remains a persistent NPS problem in this portion of the stream or if other anthropogenic factors are to blame. Elevated (range of 370 – 4400 cfu) fecal coliform bacteria levels were indeed documented by DEP just downstream from FB02 on four separate occasions (April, June, July, August) in 2002, indicating that water quality impairment continues to be a problem in this portion of Fuller Brook (MassDEP 2005a).

In addition to questionable water quality related to organic loadings, sediment inputs responsible for instream habitat degradation at FB02 probably compromise biological potential as well. Reduced substrate microhabitat due to embeddedness and sediment deposition may contribute to the suppressed EPT community (EPT Index was only 1) observed here, as these forms may be susceptible to increases in sediment loading due to their inability to burrow (Johnson et al. 1993). More recently, a study by Zweig and Rabeni (2001) found EPT density and EPT richness to be significantly negatively correlated with deposited sediment.

PB01—Powissitt Brook, mile point 0.50, 100 m downstream from Wilsondale Street, Dover, MA

Habitat

The PB01 sampling reach began approximately 100 m downstream from the Wilsondale Street crossing in a heavily forested and undeveloped portion of the watershed. The stream was small, with a width of about 2 m and depth ranging from 0.10 m in the riffle areas to 0.30 m in the deepest pools. Moss-covered cobble substrates subjected to swift current velocity occupied most of the stream bottom; however, the extremely shallow conditions (water filled less than 75% of the channel) here resulted in less than optimal habitat for macroinvertebrates. Fish habitat was even more limiting, as most of the potential stable cover (submerged logs, snags, undercut banks) was exposed. Bank and riparian vegetation was extensive, providing good bank stability and shading approximately 60% of the reach. Vegetation along the margins of the sampling reach consisted of a diverse mix of vines (greenbrier, *Smilax rotundifolia*; riverbank grape, *Vitis riparia*), shrubs (*Viburnum* sp.; rose, *Rosa* sp.; sweet pepperbush, *Clethra alnifolia*) and herbaceous growth (various ferns, grasses and sedges; skunk cabbage, *Symplocarpus foetidus*; smartweed, *Polygonum* sp.) before giving way to a vast deciduous (red maple, *Acer rubrum*; oak, *Quercus* sp.; white ash, *Fraxinus americana*) forest. The upstream road crossing was the only potential source of NPS pollution, and it did appear that road runoff had affected the sampling area in the form of new bar formation.

PB01 received a total habitat assessment score of 149/200 (Table A5). Baseflow reductions, which are probably naturally occurring (there are no water withdrawals in the Powissitt Brook subbasin) and exacerbated by the drought conditions present during the 2002 biosurvey, appear most responsible for habitat constraints at FB02, with fish habitat availability impacted the most.

Benthos

The PB01 benthic community received a total metric score of 16, representing only 40% comparability to the ST01 community and resulting in a bioassessment of “moderately impacted” (Table A3). The assessment was somewhat unexpected given the high quality epifaunal habitat available to benthos and the “pristine” nature of the surrounding subwatershed. Total Taxa Richness (15) and EPT richness (EPT Index=3) were reduced, as was the EPT/Chironomidae metric value, a result of the presence of numerous chironomids and their displacement of sensitive EPT taxa. The benthos here received a similar bioassessment (45% comparability to ST01; moderately impacted) following the 1997 biosurvey (MassDEP 2000). As was the case during the 1997 biosurvey, low flow conditions appear to be an important determinant of benthic community composition in this portion of Powissitt Brook. It is unknown to what extent water quality may limit biological potential at PB01, as DEP was unable to successfully monitor physicochemical parameters in Powissitt Brook during the 2002 Charles River watershed water quality survey due to instream water levels that precluded the ability to take grab samples or deploy a multiprobe meter (Susan Connors, MassDEP, personal communication 2005). However, there is a virtual absence of significant areas of residential development, agricultural activitiy, and other types of land-uses in this subbasin that would contribute nonpoint sources of pollution to Powissitt Brook and its resident biota.

RM01—Rock Meadow Brook, mile point 1.1, 100 m upstream from Summer Street, Westwood, MA

Habitat

The RM01 sampling reach began 100 m upstream from Summer Street in a heavily forested portion of Westwood. Overhanging shrubs and trees provided a canopy cover offering 95% shading over the sampling reach. The stream was small, with a width of 2 m and a uniform depth of only 0.10 m throughout the pools and riffle areas of the reach. Cobble and boulder substrates were plentiful throughout the reach and subjected to swift current velocity. Mosses provided additional epifaunal habitat for macroinvertebrates, while other forms of aquatic vegetation and algae were absent. A mix of stable fish habitat, especially boulder and woody debris, occupied about 30% of the sampling reach. Overall habitat for both macroinvertebrates and fish was suboptimal, and would have rated excellent with slightly higher water levels. Nevertheless, channel flow status was considered optimal, with water reaching the base of both banks and leaving only minimal amounts of substrates exposed. There was no evidence of NPS pollution in the reach, nor were potential sources documented. Both stream banks were well vegetated with grasses, vines (riverbank grape, *Vitis riparia*), herbaceous vegetation (ferns; jewelweed, *Impatiens capensis*; skunk cabbage, *Symplocarpus foetidus*), and shrubs (speckled alder, *Alnus rugosa*; dogwood, *Cornus* sp.; *Viburnum* sp.). Stability was excellent along both banks due to the dense bank vegetation and several large boulders. The surrounding forest, which was comprised of a mix of hardwoods (white ash, *Fraxinus americana*; musclewood, *Carpinus caroliniana*; red oak, *Quercus rubra*; slippery elm, *Ulmus rubra*) and white pine (*Pinus strobus*), provided an unlimited riparian zone in all directions.

RM01 received a total habitat assessment score of 165/200 (Table A5). Shallow water and its effect on aquatic habitat, especially fish cover, affected the total score most negatively. Habitat qualities rated much better here than during the 1997 biosurvey, when extremely reduced baseflow resulted in virtually no productive riffle habitat or fish cover and precluded the ability to conduct RBPIII kick sampling in the RM01 reach. As a result of these habitat constraints (total habitat score=121 in 1997), only a qualitative screening of the resident benthos was conducted here in 1997.

Benthos

The RM01 benthic community received a total metric score of 18, representing 45% comparability to ST01 and resulting in a biological condition assessment of "moderately impacted" (Table A3). Although total Taxa Richness (24; score=6) reflected the diverse epifaunal habitat available here, several other metrics (EPT Index, EPT/Chironomidae, and Scrapers/Filterers) received scores of 0. And while no one taxon dominated the benthos assemblage (Percent Dominant Taxon=18%), filter-feeders (especially the net-spinning caddisflies *Chimarra* sp., *Cheumatopsyche* sp., *Hydropsyche betteni*) were by far the predominant feeding guild, comprising 65% of the total sample. In addition to the high densities of filter-feeders, numerous chironomids (n=28) were observed. Conversely, scraping forms and other generally intolerant EPT taxa were far less numerous in the RM01 assemblage (Table A1).

Thus, while overall community structure remains optimal at RM01, as evidenced by high scoring Taxa Richness and Percent Dominant Taxon metrics, trophic structure appears unbalanced. The preponderance of filter-feeders and an elevated Biotic Index at RM01 point towards a community structured in response to organic enrichment and increased levels of suspended FPOM. It is unknown where the FPOM food resource originates; however, upstream impoundments and the urbanized nature (especially in the vicinity of downtown Westwood and along Route 109) of the upper portion of the Rock Meadow Brook subbasin should be considered as sources of organic and/or nutrient inputs.

SUMMARY AND RECOMMENDATIONS

With the exception of a few tributaries that displayed minimally impacted conditions for the Charles River watershed, most biomonitoring stations investigated during the 2002 survey indicated various degrees of impairment. Impacts to the resident biota at these sites were generally a result of habitat degradation and/or nonpoint source-related water quality impairment, with occasional point source effects observed as well.

The schematic below (Figure 3) 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 (non-, slightly, moderately, severely impacted) 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 (US EPA 2003). The model summarizes the main attributes of an aquatic community that can be expected at each level of the biological condition category, 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 impacted or non-impacted aquatic communities—such as those encountered at ST01, CR03, CR02A, CR00, SR01, SR03, HB01, MB02, MR01A, CK01, and TB01—support the Massachusetts SWQS designated *Aquatic Life* use in addition to meeting the objective of the Clean Water Act (CWA), which is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Environmental Law Reporter 1988). Moderately impacted communities observed at CR04, FB02, PB01, and RM01 do not support the *Aquatic Life* use and fail to meet the goals of the CWA. It should be mentioned that MassDEP will continue to refine the TALU classifications for Massachusetts surface waters as new biological data becomes available. This in turn may affect future Aquatic Life use determinations (e.g., support, impaired) as they relate to the biological condition categories (non-, slightly, moderately, severely impacted).

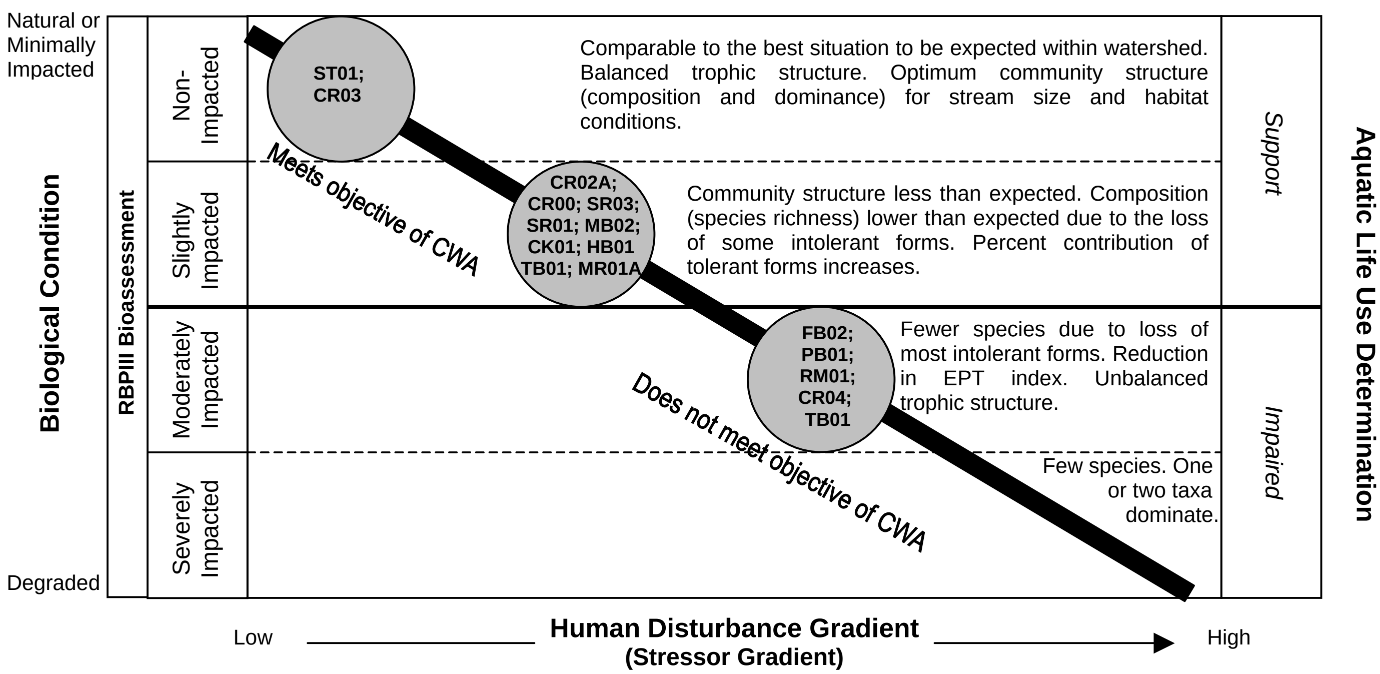

Figure 3. A schematic of results of the RBPIII analysis of the 2002 Charles River watershed biomonitoring stations as they relate to Tiered Aquatic Life Use.

While the RBP analysis of benthic macroinvertebrate communities is an effective means of determining 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. The table below (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.

Table 3. A summary of potential causes of benthos and habitat impairment observed at each biomonitoring station during the 2002 Charles River watershed survey. Where applicable, recommendations have been made.

SITE	POSSIBLE CAUSES OF IMPAIRMENT	RECOMMENDATIONS
CR03	None observed	Biomonitoring during next (2007) DEP Charles River watershed survey; Water quality monitoring during 2007 DEP Charles River watershed survey
CR04	Organic/nutrient enrichment; Sedimentation	Review of current CRPCD NPDES draft permit and DMR data as they become available; Investigate possible sources of sediment inputs—implement BMPs as needed; Biomonitoring during next DEP Charles River watershed survey; Water quality monitoring (nutrients, DO) during next DEP Charles River watershed survey
CR02A	Organic/nutrient enrichment; Dissolved oxygen sags from primary production	Biomonitoring during next DEP Charles River watershed survey; Water quality monitoring (nutrients, DO) during next DEP Charles River watershed survey
CR00	Water quality degradation; Riparian habitat degradation	Improve vegetative buffer along river—replace adjacent lawn with natural vegetation; Biomonitoring during next DEP Charles River watershed survey; Water quality monitoring during next DEP Charles River watershed survey
HB01	Low baseflow; Sedimentation; Riparian habitat degradation	Investigate possible sources of sediment inputs—implement BMPs as needed; Outreach to address NPS inputs (yard waste) from adjacent residences
MB02	Sedimentation; Riparian habitat degradation	BMPs to address sediment deposition from road runoff at Route 140; Improve vegetative buffer along left bank; Stream clean-up to address trash along left bank and instream; Signage to discourage dumping along Route 140
CK01	Organic enrichment	Water quality monitoring during next DEP Charles River watershed survey to determine sources (e.g., golf course, agriculture) of nutrient and/or organic inputs
MR01A	Organic enrichment; Sedimentation; Trash in riparian zone	BMPs to address sediment deposition from road runoff at Main Street; Stream clean-up to address trash near left bank
SR01	Sedimentation	BMPs to address road runoff at Pond Street and especially the adjacent sand/gravel operation
SR03	Organic enrichment Low dissolved oxygen	Determine if naturally occurring (wetlands) or anthropogenic (e.g., upstream point sources)
TB01	Nutrient enrichment or other water quality degradation	Biomonitoring during next DEP Charles River watershed survey; Water quality monitoring (including nutrients) during next DEP Charles River watershed survey; Field reconnaissance in subbasin to investigate land-uses that may contribute NPS inputs
FB02	Organic enrichment; Sedimentation; Reduced riparian zone	Review 2002 DEP water quality data; Water quality monitoring (including nutrients; bacteria source tracking) during next DEP Charles River watershed survey; Improve vegetative buffer along both banks; Outreach to address potential impacts from upstream waterfowl population (near town hall)
PB01	Low baseflow; Unknown causes	Water quality monitoring during next DEP Charles River watershed survey; Biomonitoring during next DEP Charles River watershed survey; Field reconnaissance in subbasin to investigate land-uses that may contribute NPS inputs
RM01	Organic enrichment; Water quality degradation from unknown causes	Water quality monitoring during next DEP Charles River watershed survey to determine sources of nutrient and/or organic inputs; Biomonitoring during next DEP Charles River watershed survey; Field reconnaissance in subbasin to investigate land-uses that may contribute NPS inputs

ST01	None observed	Biomonitoring during next DEP Charles River watershed survey; Water quality monitoring during next DEP Charles River watershed survey;

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APPENDIX

Macroinvertebrate taxa list, RBPIII benthos analysis, and Habitat evaluations

Table A1. Species-level taxa list and counts, functional feeding groups (FG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2002 Charles River watershed biomonitoring survey between 15 and 18 July 2002. Refer to Table 1 for a listing and description of sampling stations.

TAXON	FG[1]	TV[2]	HB01	CK01	CR03	CR04	MB02	SR01	SR03	CR00	ST01	FB02	CR02A	TB01	TB02 (dup)	PB01	MR01A	RM01
Hydrobiidae	SC	8								3				5	1			
Physidae	GC	8				1						4						
Helisoma sp.	SC	6				3				1				2	1		2	1
Pisidiidae	FC	6	2	1		22	1	3	2	13	1	2	20	1	2		22	6
Lumbricina	GC	8															1	
Enchytraeidae	GC	10	1										1					
Nais communis	GC	8		2														
Nais pardalis	GC	8								1								
Nais variabilis	GC	10	1				1	1				1						
Ophidonais serpentina	GC	6										1						
Pristina leidyi	GC	8	1															
Tubificidae (IWH)	GC	10										2				1		1
Lumbriculidae	GC	7	2	2	2		7	8				1		4	3			2
Glossiphoniidae	PR	7										2						
Caecidotea communis	GC	8		2				2	2			5	1	1	3	8		1
Crangonyx sp.	GC	6								1					2			
Gammarus sp.	GC	6				11			10	11	1						4	
Hyalella azteca	GC	8							1									1
Hydrachnidia	PR	6	1	1				1	1	2		3	1		1			
Baetidae	GC	4		3							3						2	
Baetis (cerci only) sp.	GC	6											2					
Baetis (short terminal filament) sp.	GC	6		2			4											
Baetis (subequal terminal filament) sp.	GC	6	1		11		6											
Baetidae (cerci only)	GC	6				6												
Baetidae (subequal terminal filament)	GC	6						2										
Ephemerellidae	GC	1												1				
Eurylophella sp.	GC	2						5										
Serratella deficiens	GC	2									10							
Heptageniidae	SC	4						1	10		2		2	1	2		4	
Stenonema sp.	SC	3	2				5											
Isonychia sp.	GC	2	1															
Leptophlebiidae	GC	2												1	1			
Tricorythodes sp.	GC	4				3				1			1					
Boyeria vinosa	PR	2																1

TAXON	FG[1]	TV[2]	HB01	CK01	CR03	CR04	MB02	SR01	SR03	CR00	ST01	FB02	CR02A	TB01	TB02 (dup)	PB01	MR01A	RM01
Argia sp.	PR	6							4									1
Gomphidae	PR	5	1															
Leuctridae	SH	0																2
Leuctra sp.	SH	0						5			21			4	7			
Paragnetina sp.	PR	1									3							
Perlesta sp.	PR	5												5	2			
Perlodidae	PR	2						3										
Corydalus cornutus	PR	4			1													
Nigronia serricornis	PR	0						2										
Micrasema sp.	SH	2					4											
Glossosoma sp.	SC	0			3			3			5				2			
Protoptila sp.	SC	1			6													
Cheumatopsyche sp.	FC	5		8	8			5	40	3	7	54	32		2	13	6	11
Diplectrona sp.	FC	0						2										
Hydropsyche betteni	FC	6	12	14	17	1	10	3		1			9	9	21			17
Hydropsyche morosa gr.	FC	6	1			4					6						1	
Macrostemum sp.	FC	3			9													
Hydroptila sp.	GC	6					2			1								
Lepidostoma sp.	SH	1						2										
Leptoceridae	PR	4													1			
Ceraclea sp.	GC	3								1								
Setodes sp.	GC	2							1									
Limnephilidae	SH	4						1										
Apatania sp.	SC	3	1															
Pycnopsyche sp.	SH	4														1		
Chimarra sp.	FC	4	12	11	15	1	11	1		17	14		14			7	40	18
Dolophilodes sp.	FC	0						5			2							
Wormaldia sp.	FC	0												1				
Neureclipsis sp.	FC	7									1							
Neophylax sp.	SC	3		1													1	
Parapoynx sp.	SH	5							1									
Ancyronyx variegata	GC	5	1															
Optioservus sp.	SC	4				1									11			
Oulimnius latiusculus	SC	4	5		11		2				6		2	30	9		13	
Promoresia sp.	SC	2			2		1							6	2	1		
Promoresia tardella	SC	2	7								5							
Stenelmis sp.	SC	5		28	6	5	20	1	14	7		19	5	1	1	31	9	3
Stenelmis crenata gr.	SC	5	7															
Dineutus sp.	PR	4							1									

TAXON	FG[1]	TV[2]	HB01	CK01	CR03	CR04	MB02	SR01	SR03	CR00	ST01	FB02	CR02A	TB01	TB02 (dup)	PB01	MR01A	RM01
Hydrobius sp.	PR	5	1															
Ectopria sp.	SC	5									1							
Probezzia sp.	PR	6																1
Chironomidae	GC	6	1															
Micropsectra polita gr.	GC	7	2					5							1	2		3
Microtendipes pedellus gr.	FC	6	3					1										
Microtendipes rydalensis gr.	FC	6			4	2												
Parachironomus sp.	PR	10											1					
Polypedilum aviceps	SH	4									1					1		
Polypedilum flavum	SH	6		1						1		1				9		
Polypedilum halterale gr.	SH	6										2						
Polypedilum illinoense	SH	6								2								
Polypedilum scalaenum gr.	SH	6							1									
Tribelos sp.	GC	7										1						
Xenochironomus sp.	PR	0		2									3					
Micropsectra sp.	GC	7						1								2		1
Micropsectra dives gr.	GC	7						2								2		
Rheotanytarsus exiguus gr.	FC	6				1	1		1	2			2					7
Rheotanytarsus pellucidus	FC	5		1	1		1	1	1									3
Stempellinella sp.	GC	2	4															
Tanytarsus sp.	FC	6	4	1		2	1		1							8		1
Diamesa sp.	GC	5						1										
Potthastia longimana gr.	GC	2					1			1				2				
Brillia sp.	SH	5					1											
Cardiocladius sp.	PR	5								3								
Chaetocladius sp.	GC	6						1										
Corynoneura sp.	GC	4									1			2				
Cricotopus sp.	SH	7								1								
Cricotopus annulator	SH	7								1								
Cricotopus tremulus gr.	SH	7								3								
Cricotopus vierriensis	SH	7								1								
Cricotopus/Orthocladius sp.	GC	7								4								
Eukiefferiella sp.	GC	6													2			
Eukiefferiella claripennis gr.	GC	8										1						
Eukiefferiella devonica gr.	GC	4												1				
Limnophyes sp.	GC	8												1				
Parametriocnemus sp.	GC	5	6	3				6						1	5	2		6
Thienemanniella sp.	GC	6												1				
Tvetenia paucunca	GC	5	14	15	3		3	8			6	1		21	7		1	6

TAXON	FG[1]	TV[2]	HB01	CK01	CR03	CR04	MB02	SR01	SR03	CR00	ST01	FB02	CR02A	TB01	TB02 (dup)	PB01	MR01A	RM01
Tvetenia vitracies	GC	5			1	1				11			2					
Conchapelopia sp.	PR	6	4	3			1		2					1		2		1
Larsia sp.	PR	7						2										
Meropelopia sp.	PR	6					1											
Natarsia sp.	PR	8										1						
Nilotanypus sp.	PR	6		2														
Rheopelopia sp.	PR	4					2		1									
Thienemannimyia sp.	PR	6						2	1			1			1			
Chelifera sp.	PR	6					2	1						2	1			1
Clinocera sp.	PR	6														1		
Hemerodromia sp.	PR	6	2						1				1					2
Simulium sp.	FC	5		1	1		2		4		1		2				1	1
Simulium tuberosum cpl.	FC	4						5										
Simulium vittatum cpl.	FC	9				37				1		4						
Dicranota sp.	PR	3						2										
Hexatoma sp.	PR	2						1										
TOTAL			**100**	**104**	**101**	**101**	**90**	**95**	**100**	**94**	**97**	**106**	**101**	**91**	**104**	**91**	**107**	**98**

[1]Functional Feeding Group (FG) lists the primary feeding habit of each species and follows the abbreviations: SH-Shredder; GC-Gathering Collector; FC-Filtering Collector; SC- Scraper; PR-Predator.
[2]Tolerance Value (TV) is an assigned value used in the calculation of the biotic index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for very tolerant organisms.

Table A2. Summary of RBP III data analysis for macroinvertebrate communities sampled in the mainstem Charles River between 15 and 17July 2002. Shown are the calculated metric values, metric scores (in italics) based on comparability to the reference station (CR03), and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a listing and description of sampling stations.

STATION	**CR03**		**CR04**		**CR02A**		**CR00**	
STREAM	Charles River		Charles River		Charles River		Charles River	
HABITAT SCORE	158		147		169		152	
TAXA RICHNESS	17	*6*	16	*6*	18	*6*	23	*6*
BIOTIC INDEX	4.47	*6*	6.96	*2*	5.14	*6*	5.51	*4*
EPT INDEX	7	*6*	5	*2*	6	*4*	6	*4*
EPT/CHIRONOMIDAE	7.67	*6*	2.50	*2*	7.50	*6*	0.80	*0*
SCRAPERS/FILTERERS	0.51	*6*	0.13	*2*	0.11	*2*	0.30	*6*
% DOMINANT TAXON	17%	*6*	37%	*2*	32%	*2*	18%	*6*
COMMUNITY SIMILARITY (REFERENCE AFFINITY)	100%	*6*	29%	*0*	77%	*6*	45%	*2*
TOTAL METRIC SCORE		*42*		*16*		*32*		*28*
% COMPARABILITY TO REFERENCE STATION	100%		38%		76%		67%	
BIOLOGICAL CONDITION (DEGREE OF IMPACT)	**REFERENCE**		**MODERATELY IMPACTED**		**SLIGHTLY IMPACTED**		**SLIGHTLY IMPACTED**	

Table A3. Summary of RBP III data analysis for macroinvertebrate communities sampled in selected tributaries during the Charles River watershed survey between 15 and 18 July 2002. Shown are the calculated metric values, metric scores (in italics) based on comparability to the regional reference station (ST01), and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a listing and description of sampling stations.

STATION	**ST01**		**HB01**		**MB02**		**CK01**		**MR01A**		**SR01**		**SR03**		**TB01***		**FB02**		**PB01**		**RM01**	
STREAM	Stony Brook		Hopping Brook		Mine Brook		Chicken Brook		Mill River		Stop River		Stop River		Trout Brook		Fuller Brook		Powissett Brook		Rock Meadow Brook	
HABITAT SCORE	182		136		130		158		146		147		152		182		124		149		165	
TAXA RICHNESS	20	*6*	27	*6*	24	*6*	20	*6*	14	*4*	34	*6*	21	*6*	24 25	*6* *6*	19	*6*	15	*4*	24	*6*
BIOTIC INDEX	2.79	*6*	4.93	*2*	5.06	*2*	5.14	*2*	4.73	*2*	4.25	*2*	5.18	*2*	4.57 4.71	*2* *2*	5.77	*0*	5.54	*2*	5.31	*2*
EPT INDEX	11	*6*	7	*0*	7	*0*	5	*0*	6	*0*	13	*6*	3	*0*	7 8	*0* *2*	1	*0*	3	*0*	4	*0*
EPT/CHIRONOMIDAE	9.25	*6*	0.79	*0*	3.50	*2*	1.39	*0*	54.0	*6*	1.27	*0*	6.38	*4*	0.73 2.38	*0* *2*	6.75	*4*	0.75	*0*	1.71	*0*
SCRAPERS/FILTERERS	0.59	*6*	0.65	*6*	1.04	*6*	0.78	*6*	0.41	*6*	0.19	*2*	0.49	*6*	4.09 1.16	*6* *6*	0.32	*6*	1.14	*6*	0.06	*0*
% DOMINANT TAXON	22%	*4*	14%	*6*	22%	*4*	27%	*4*	37%	*2*	8%	*6*	40%	*2*	29% 23%	*4* *4*	51%	*0*	34%	*2*	18%	*6*
COMMUNITY SIMILARITY (REFERENCE AFFINITY)	100%	*6*	54%	*4*	69%	*6*	61%	*4*	58%	*4*	52%	*4*	70%	*6*	45% 66%	*2* *6*	59%	*4*	47%	*2*	53%	*4*
TOTAL METRIC SCORE		*40*		*24*		*26*		*22*		*24*		*26*		*26*		*20* *28*		*20*		*16*		*18*
% COMPARABILITY TO REFERENCE STATION	100%		60%		65%		55%		60%		65%		65%		50% 70%		50%		40%		45%	
BIOLOGICAL CONDITION (DEGREE OF IMPACT)	**REFERENCE**		**SLIGHTLY IMPACTED**		**SLIGHTLY IMPACTED**		**SLIGHTLY IMPACTED**		**SLIGHTLY IMPACTED**		**SLIGHTLY IMPACTED**		**SLIGHTLY IMPACTED**		**MODERATELY/ SLIGHTLY IMPACTED**		**MODERATELY IMPACTED**		**MODERATELY IMPACTED**		**MODERATELY IMPACTED**	

*metric values and scores represent original sample and duplicate sample collected at this station

Table A4. Summary of RBP III data analysis for macroinvertebrate communities sampled during the Charles River watershed survey on 15 and 16 July 2002. Shown are the calculated metric values, metric scores (in italics) based on comparability to an upstream reference station (CR03; SR01), and the corresponding assessment designation for each test station (CR04; SR03). Stations CR03 and CR04 bracket the CRWPCD discharge; Stations SR01 and SR03 bracket multiple wastewater discharges—Norfolk-Walpole MCI, Southwood Community Hospital, and the Wrentham State School.

STATION	**CR03**		**CR04**		**SR01**		**SR03**	
STREAM	Charles River		Charles River		Stop River		Stop River	
HABITAT SCORE	158		147		147		152	
TAXA RICHNESS	17	*6*	16	*6*	34	*6*	21	*4*
BIOTIC INDEX	4.47	*6*	6.96	*4*	4.25	*6*	5.18	*4*
EPT INDEX	7	*6*	5	*2*	13	*6*	3	*0*
EPT/CHIRONOMIDAE	7.67	*6*	2.50	*2*	1.27	*6*	6.38	*6*
SCRAPERS/FILTERERS	0.51	*6*	0.13	*2*	0.19	*6*	0.49	*6*
% DOMINANT TAXON	17%	*6*	37%	*2*	8%	*6*	40%	*2*
REFERENCE AFFINITY	100%	*6*	29%	*0*	100%	*6*	59%	*4*
TOTAL METRIC SCORE		*42*		*16*		*42*		*26*
% COMPARABILITY TO REFERENCE	100%		38%		100%		62%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	**REFERENCE**		**MODERATELY IMPACTED**		**REFERENCE**		**SLIGHTLY IMPACTED**	

Table A5. Habitat assessment summary for biomonitoring stations sampled during the 2002 Charles River watershed 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.

Station	CR03	CR04	CR02A	CR00	HB01	MB02	CK01	MR01A	SR01	SR03	TB01	FB02	PB01	RM01	ST01
Primary Habitat Parameters	**Score (0-20)**														
INSTREAM COVER	11	12	18	18	13	12	8	7	9	15	17	7	6	11	15
EPIFAUNAL SUBSTRATE	19	18	19	20	17	15	17	14	16	11	18	15	13	15	18
EMBEDDEDNESS	18	18	17	17	17	15	17	18	16	16	17	14	20	17	19
CHANNEL ALTERATION	19	13	12	16	15	12	17	19	19	15	20	20	20	20	19
SEDIMENT DEPOSITION	14	6	19	19	8	8	18	12	5	11	19	7	11	17	19
VELOCITY-DEPTH COMBINATIONS	9	6	16	16	11	7	8	7	8	6	14	13	7	7	13
CHANNEL FLOW STATUS	15	19	14	18	8	16	14	15	16	20	19	18	13	18	19
Secondary Habitat Parameters	**Score (0-10)**														
BANK VEGETATIVE PROTECTION left	8	9	10	6	9	6	10	10	10	9	9	8	10	10	10
BANK VEGETATIVE PROTECTION right	8	10	9	6	9	10	10	9	10	10	9	3	10	10	10
BANK STABILITY left	9	10	10	6	6	8	10	10	9	9	10	5	10	10	10
BANK STABILITY right	9	10	9	6	10	9	10	8	9	10	10	4	10	10	10
RIPARIAN VEGETATIVE ZONE WIDTH left	9	6	10	2	8	2	9	10	10	10	10	9	10	10	10
RIPARIAN VEGETATIVE ZONE WIDTH right	10	10	6	2	5	10	10	7	10	10	10	1	9	10	10
Total Score	**158**	**147**	**169**	**152**	**136**	**130**	**158**	**146**	**147**	**152**	**182**	**124**	**149**	**165**	**182**