Technical Memorandum CN 289.3

HOUSATONIC RIVER WATERSHED
2007 BENTHIC MACROINVERTEBRATE BIOASSESSMENT

Division of Watershed Management
Watershed Planning Program
Worcester, MA

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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. 1995, Plafkin et al. 1989). Impacts to the benthic community are typically 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 total taxa richness; or shifts in community composition relative to the reference station (Plafkin et al. 1989). As part of the Massachusetts Department of Environmental Protection/Division of Watershed Management's (MassDEP/DWM) 2007 Housatonic River Watershed assessment, aquatic benthic macroinvertebrate biomonitoring was conducted to evaluate the biological health of selected stream reaches that comprise both the tributaries and the mainstem to determine their status with respect to the support of the *Aquatic Life* use, as designated in the *Massachusetts Surface Water Quality Standards* (SWQS) (MassDEP 2006). These assessments form the basis for reporting and listing waters pursuant to sections 305(b) and 303(d) of the Clean Water Act (CWA). A total of fourteen stations on eleven named streams were sampled to investigate the effects of potential point and nonpoint sources of pollution—both historical and current—on the aquatic invertebrate populations throughout the watershed. While specific monitoring locations and protocols governing sample collection and data analysis differed over time, MassDEP biologists had previously assessed some of the streams studied in 2007 (Mitchell, 2005, Mitchell, 2006, Kennedy and Weinstein, 2000). Repeated sampling at the same station allows for comparisons of the biological conditions over time. The 2007 sampling location descriptions, along with station identification numbers, sampling dates and biomonitoring history are presented in Table 1.

To provide information for making *Aquatic Life* use-support determinations, macroinvertebrate communities present at biomonitoring stations in the Housatonic River Watershed were compared with the community occurring at regional reference stations. Two reference stations were determined to be necessary due to the extensive drainage area of the three mainstem stations. As such, macroinvertebrate biomonitoring stations were divided between stations with watershed areas less than 100 square miles and stations with greater than 100 square miles. The monitoring station with the highest habitat score, within these two groups, was chosen as the reference station. Station RA01 (Rawson Brook – with a watershed area of 8.8 square miles) was chosen as the reference station for all stations with less than a 100 square-mile catchment area. Station HR19E (Housatonic River – with a watershed area of 279 square miles) was chosen as the reference station for all stations with greater than a 100 square mile area. (USGS, 2012) Station HR19E also served as a reference station during the 2002 Benthic Macroinvertebrate survey.

METHODS

Macroinvertebrate Sampling - RBPIII

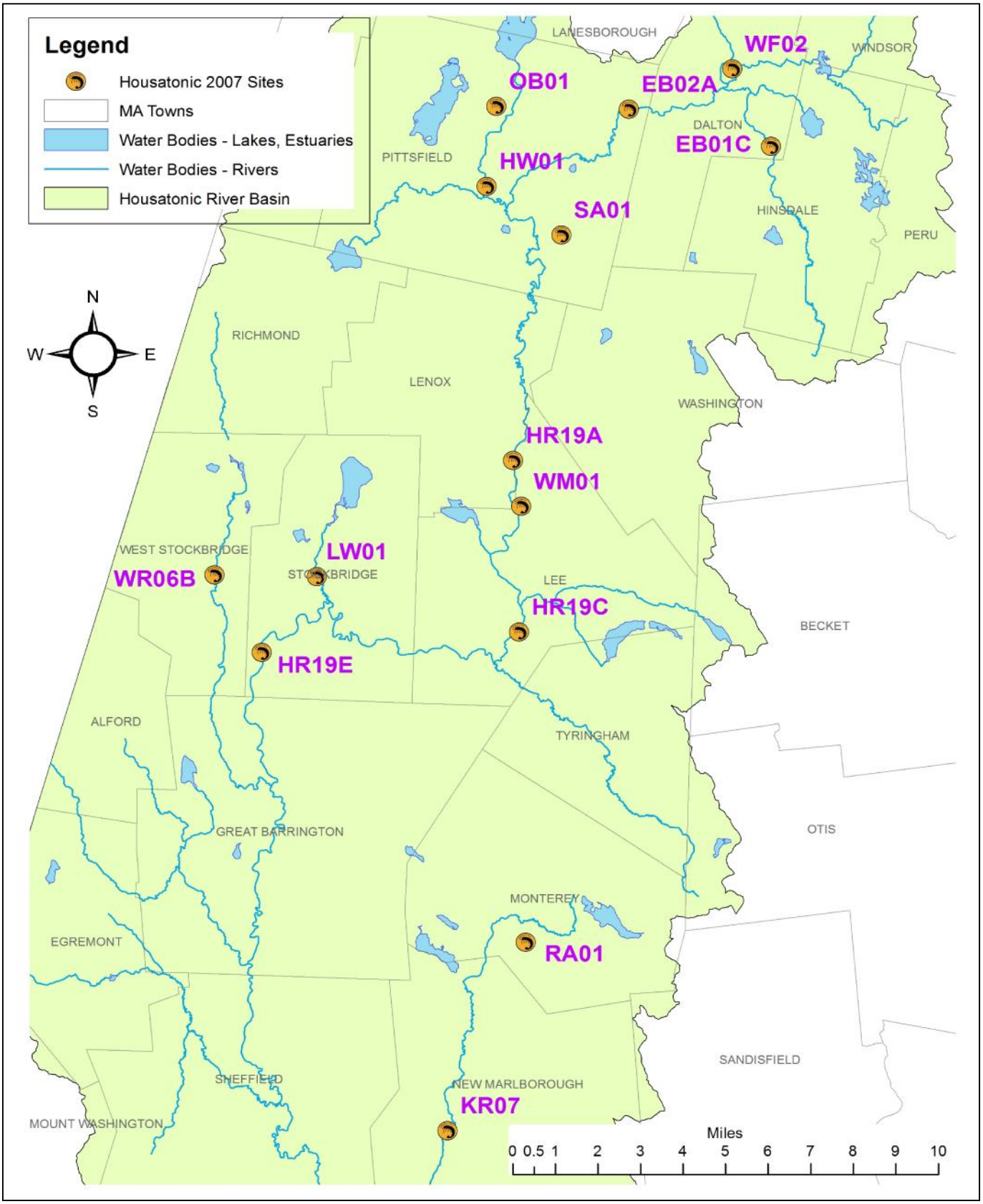
Macroinvertebrate sampling activities employed for the 2007 Housatonic River Watershed survey were conducted in accordance with the Sampling & Analysis Plan (SAP) for the Housatonic River Watershed (MassDEP 2007). The sampling procedures are described in the standard operating procedures *Water Quality Monitoring in Streams Using Aquatic Macroinvertebrates* (Nuzzo 2003), and are based on US EPA Rapid Bioassessment Protocols (RBPs) for wadeable streams and rivers (Plafkin et al. 1989). The macroinvertebrate collection procedure utilized kick-sampling, a method of sampling benthic organisms by kicking or disturbing bottom sediments and catching the dislodged organisms in a net as the current carries them downstream. Sampling was conducted 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.

Table 1. List of biomonitoring stations sampled during the 2007 Housatonic River Watershed survey, including station and unique identification numbers, drainage areas, sampling site descriptions, and sampling dates. Sites at which previous MassDEP benthic macroinvertebrate assessments were performed are also indicated.

Station ID	Unique ID	Drainage Area (mi^2)	Sampling Site Description	Sampling Date
Small Tributary Watersheds (<100 square miles)				
SA01	B0630	8.7	Sackett Brook - ~10m upstream/east from East New Lenox Road, Pittsfield, MA	29-Aug-2007
WM01	B0628	8.8	Washington Mountain Brook - Upstream/east from Mill Street and downstream/south from Washington Mountain Road, Lee, MA	30-Aug-2007
RA01[R]	B0629	8.8	Rawson Brook - upstream/south of Wellman Road (~130m downstream from Gould Farm (MA0022705) discharge), Monterey, MA	28-Aug-2007
OB01	B0627	11.1	Onota Brook - ~15m upstream/north from Pecks Road crossing nearest Robert Street, Pittsfield, MA	29-Aug-2007
LW01	B0624	14.3	Larrywaug Brook - Upstream/west of the Route 183 crossing downstream of Route 90, Stockbridge, MA (below the old stone crossing.	28-Aug-2007
WF02	B0633	19.1	Wahconah Falls Brook - ~30m upstream/north of the Route 9/8A crossing nearest Anthony Road, Dalton, MA	29-Aug-2007
EB01C	B0632	26.8	East Branch Housatonic River - ~25m upstream/east from the Route 8 crossing nearest Hinsdale Border in Dalton, MA	29-Aug-2007
WR06B	B0625	36.4	Williams River - ~120m downstream/south from East Alford Road, West Stockbridge, MA	28-Aug-2007
HW01[1,2]	B0021	36.6	West Branch Housatonic River - ~300m downstream/south from Route 20 bridge, Pittsfield, MA	29-Aug-2007
KR07[1,2]	B0012	38.5	Konkapot River - downstream/south from Mil River Southfield Road, adjacent to Clayton Mill River Road, (Village of Mill River), New Marlborough, MA	28-Aug-2007
EB02A[2]	B0503	57.5	East Branch Housatonic River - ~50m upstream from Hubbard Avenue, Pittsfield, MA	29-Aug-2007
Large Mainstem Watersheds (>100 square miles)				
HR19A[2]	B0504	171	Housatonic River - Immediately upstream from driveway to Crescent Mills, Lenox, MA	30-Aug-2007
HR19C[2]	B0505	205	Housatonic River - Downstream from Lee WWTP and power lines, Lee, MA	30-Aug-2007
HR19E[2,R]	B0496	279	Housatonic River - Off Route 183, ~150m downstream from railroad crossing, Stockbridge, MA	28-Aug-2007

[1] RBP III performed here by MassDEP/DWM in 1997 (Fiorentino 1999)
[2] RBP III performed here by MassDEP/DWM in 2002 (Mitchell 2005)
[R] 2007 Reference Site

Figure 1. Geographic locations of benthic macroinvertebrate sampling locations during the 2007 Housatonic River Watershed surveys.



Macroinvertebrate Sample Processing and Data Analysis

The macroinvertebrate sample processing and analysis procedures employed for the 2007 Housatonic River Watershed biomonitoring samples are described in the standard operating procedures (Nuzzo 2003). Macroinvertebrate sample processing entailed distributing whole samples in pans, randomly selecting grids within the pans, 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.

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 macroinvertebrate community. This integrated approach provides more assurance of a valid assessment because a variety of biological parameters are evaluated, and the deficiency of any one metric should not invalidate the entire approach (Plafkin et al. 1989). Taxonomic data were analyzed using a modification of Rapid Bioassessment Protocol III (RBP III) metrics and scores (Plafkin et al. 1989). The modifications were: substitution of "reference site affinity" (RSA) for the Community Loss Index and elimination of the shredder/total ratio (no separate leaf-pack material was collected). The reference site affinity metric is a modification of Percent Model Affinity (Novak and Bode 1992). Instead of using the model's percentages for Oligochaeta, Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Chironomidae, and "other," these percentages were taken from the reference site data. The RSA score is then 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 RBP III scores as follows: 0 points for <35%; 2 points in the range from 35 to 49%; 4 points for 50 to 64%; and 6 points if ≥65%. The entire suite of metrics used for the analysis was:

- Richness—the total number of different species present in the subsample plus those detected from a "large/rare" search of the whole sample (those taxa missed in subsampling);

- HBI—Hilsenhoff Biotic Index (Hilsenhoff 1982), as modified in Nuzzo (2003); the HBI is the sum of the products of each taxon's abundance and its corresponding pollution tolerance value, divided by the total count in the subsample;

- EPT—sum of richness among the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) as determined from the specimens in the subsample plus those detected in a "large/rare" search of the whole sample; these orders tend to be dominated by species generally considered to be pollution sensitive;

- $EPT_a/Chiro_a$—ratio of total abundance among EPT taxa to total abundance among Chironomidae taxa;

- SC/FC—ratio of the proportion of sample that is represented by individuals that predominantly feed by scraping to those that are primarily filter-feeders;

- % Dominant—most abundant taxon as a percent of the assemblage; >20% is generally considered hyperdominant and indicative of a stressor impact;

- RSA—reference site affinity (described above).

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 the selected "least-impacted" reference station yielded an impairment score for each site. RBP III analysis separates sites into four categories: "non-impaired", "slightly impaired", "moderately impaired", and "severely impaired". Each impairment category corresponds to a specific *Aquatic Life* use-support determination used in the CWA Section 305(b) water quality reporting process—non-impaired and slightly impaired benthic invertebrate

communities are generally indicative of conditions supporting the *Aquatic Life* use, whereas water bodies exhibiting moderately or severely impaired communities are generally assessed as “non-support.”

Habitat Assessment

Habitat qualities were scored for each sampling reach using the assessment procedure in Plafkin et al. (1989), as modified in Barbour et al. (1999). An evaluation of physical and biological habitat quality is critical to any assessment of ecological integrity (Karr et al. 1986; Plafkin et al. 1989). 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). The matrix used to assess habitat quality is based on key physical characteristics of the water body and the immediate riverfront area. Most parameters evaluated are instream physical attributes that are potential sources of limitation to the aquatic biota (Plafkin et al. 1989). 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 bank vegetative protection, right and left bank stability, and right and left bank riparian vegetative zone width. Habitat parameters are scored, totaled, and compared to the reference station to infer the extent to which the condition of the habitat, rather than water quality effects, may account for differences in macroinvertebrate community structure at the study sites.

RESULTS AND DISCUSSION

Two reference sites were used for the 2007 biomonitoring survey. Rawson Brook (RA01) was used as the reference condition for tributary streams with watersheds less than 100 square miles. The Housatonic River at Station HR19E was used as the reference condition for mainstem sites with watershed areas greater than 100 square miles. Habitat quality was excellent at both of these reference sites. Rawson Brook (RA01) and the Housatonic River site HR19E scored 86% and 92%, respectively, of the maximum attainable value of 200 (Appendix 1) . Geomorphic and land-use characteristics, at the sub-watershed scale, were also examined. StreamStats (USGS, 2012) data describes the contributing watershed of each benthic sampling location (Table 2). Perhaps most noteworthy from the StreamStats data, is the fact that all watersheds are at least 50% forested, and have at least a 5% slope.

A Human Disturbance Index (HDI) (Meek, 2013) was also examined. This index compiles such measures as population density, agricultural land use, NPDES discharges, dam density, and impervious surface density, and responds with a score for each HUC 12 (12-digit Hydrologic Unit Code) watershed. The lower the resultant score, the less measureable human disturbance (Table 2). The high percentage of forested area (89.75%) along with the low HDI score (1.50) found for site RA01 makes it an ideal choice for a reference site. Also, site RA01 obtained the highest habitat score of all small watershed stations examined in the Housatonic Watershed during 2007.

Although the HDI scores and forested portions of the contributing watersheds to all of the large watershed sites (HR19A, HR19C, and HR19E) are essentially the same, the localized habitat score for HR19E was much better than HR19A and HR19C. For this reason, HR19E was chosen as the reference site for large watersheds.

A taxonomic list of the macroinvertebrate organisms collected at each sampling station during the 2007 biomonitoring survey is provided in Appendix 2. Included in the list are total organism counts, the functional feeding group designation (FFG) for each macroinvertebrate taxon, and the tolerance value (TV) of each taxon. Tables 3 and 4 present summaries of the habitat and RBP III macroinvertebrate data analyses for sites in the Small Watershed and Large Watershed groups, respectively. Included for each sampling site are the habitat comparability to the reference condition, biological metric calculations, metric scores, and impairment designations.

Table 2. Subwatershed-scale Habitat Measures for the 2007 Housatonic River Watershed Benthic Macroinvertebrate Sites; USGS StreamStats, MassDEP Human Disturbance Index (HDI), MassDEP Benthic Habitat Assessment Scores.

Site	RA01	SA01	WM01	OB01	LW01	WF02	EB01C	WR06B	HW01	KR07	EB02A	HR19E	HR19A	HR19C
Watershed Area (mi^2)	8.8	8.74	8.75	11.1	14.3	19.1	26.8	36.4	36.6	38.5	57.5	279	171	205
% Slope	5.45	9.25	7.27	8.14	8.27	5.82	5.04	8.07	8.51	7.13	5.71	7.61	6.97	7.2
Stream Length (mi)	15.2	16.4	12.4	25.6	18.3	29.2	43.8	61.6	80	60.9	95.8	475	324	372
% Forested	89.75	83.96	80.85	61.7	53.49	83.93	75.62	61.91	58.46	85.4	76.74	66.09	63.79	64.25
% Sand and Gravel	0.21	0.1	3.3	12.49	0.46	4.79	17.36	9.85	13.38	10.91	13.91	12.07	13.2	12.45
HDI Score	1.5	3.0	3.5	4.5	4.0	2.0	3.0	3.0	4.0	2.0	3.5	3.5	3.5	3.5
Habitat Score	171	139	152	102	133	131	170	144	101	150	145	184	154	172

The benthic macroinvertebrate community at site RA01 (Rawson Brook) ranked best of all the small watershed sites investigated in the key metrics of Total Richness, EPT Richness, and Biotic Index. This, along with the low Human Disturbance Index, supports the designation of this site as the reference condition to which all other small watershed sites may be compared (Table 3).

The macroinvertebrate communities present at all of the sites in the small watersheds draining to the Housatonic River were found to be either non-impaired or only slightly impaired when compared to the reference site (RA01). The most common reductions in comparative scoring were due to a reduction in the EPT Richness. Quite often, the EPT orders (Ephemeroptera, Tricoptera, and Plecoptera) are the most sensitive to organic enrichment. However, any perceived degradation in community structure is only slight, at worst. Some variations in community structure may be attributed to watershed habitat characteristics. A correlation value of 0.837 was observed when comparing Percent Forested Land-Use and Taxa Richness across all small watershed benthic collection sites.

Conditions at the large watershed sites (HR19A, HR19C, HR19E) were noticeably different from each other (Table 4). The reference site (HR19E) scored best in five of the seven metrics (EPT Richness, Biotic Index, EPT\Chironomidae Ratio, and Percent Dominant Taxon). All metrics were much poorer at site HR19A, resulting in a determination of “Moderately Impaired”. Scores for the metrics EPT Index, and EPT\Chironomide were “0” for site HR19A. Reductions in these metrics, along with an increase in the Biotic Index, all point toward organic enrichment at site HR19A. Results from site HR19C revealed only slight impairment.

Six of the sites investigated in 2007 were the subjects of previous bioassessments performed by the MassDEP/DWM (Table 1). Four indicative community metrics from the RBP III analyses and the overall impairment status assessments resulting from those analyses were compared from year to year to determine whether the biological condition had changed at those sites (Table 4). While a determination of true statistical trends is not possible using screening level techniques such as the RBP, the overall assessment of most sites remained consistent over the time represented by these surveys.

Table 3. Summary of habitat analysis (i.e. comparability to the reference habitat condition) and RBP III analysis of macroinvertebrate communities sampled in the Small Watersheds during the Housatonic River Watershed survey on 28, 29, and 30 August 2007. Shown are the calculated metric values, metric scores (in italics) based on comparability to the reference station (RA01), and the corresponding assessment designation for each biomonitoring station. Complete habitat evaluations are presented in Appendix 1. Refer to Table 1 for a listing and description of sampling stations.

SAMPLING STATION	RA01		SA01		WM01		OB01		LW01		WF02		EB01C		WR06B		HW01		KR07		EB02A	
STREAM	Rawson Brook		Sacket Brook		Washington Mountain Brook		Onota Brook		Larrywaug Brook		Wahconah Falls Brook		East Branch Housatonic River		Williams River		West Branch Housatonic River		Konkapot River		East Branch Housatonic River	
HABITAT SCORE	171		139		152		102		133		131		170		144		101		150		145	
HABITAT % REFERENCE	--		81%		89%		60%		78%		77%		99%		84%		59%		88%		85%	
HABITAT COMPARABILITY	--		Support		Support		Non - Support		Support		Support		Comparable		Support		Non - Support		Support		Support	
TAXA RICHNESS	35	*6*	32	*6*	32	*6*	19	*2*	22	*4*	33	*6*	34	*6*	30	*6*	20	*2*	31	*6*	33	*6*
BIOTIC INDEX	3.78	*6*	4.29	*6*	4.44	*6*	4.52	*4*	4.32	*6*	4.40	*6*	3.87	*6*	4.45	*4*	4.83	*4*	4.15	*6*	5.26	*4*
EPT INDEX	17	*6*	14	*4*	13	*2*	11	*0*	9	*0*	15	*4*	16	*6*	13	*2*	8	*0*	10	*0*	9	*0*
EPT/CHIRONOMIDAE	6.45	*6*	0.93	*0*	1.21	*0*	17.8	*6*	18.8	*6*	2.13	*2*	2.10	*2*	2.30	*2*	3.93	*4*	2.58	*2*	0.65	*0*
SCRAPER/FILTERER	0.50	*6*	0.72	*6*	0.06	*0*	0.27	*6*	0.52	*6*	0.19	*4*	0.22	*4*	1.24	*6*	0.67	*6*	1.13	*6*	1.00	*6*
REFERENCE AFFINITY	100%	*6*	67%	*6*	68%	*6*	64%	*4*	71%	*6*	83%	*6*	76%	*6*	71%	*6*	74%	*6*	76%	*6*	55%	*4*
% DOMINANT TAXON	11%	*6*	8%	*6*	17%	*6*	19%	*6*	35%	*2*	16%	*6*	11%	*6*	14%	*6*	21%	*4*	14%	*6*	10%	*6*
TOTAL METRIC SCORE	*42*		*34*		*26*		*28*		*30*		*34*		*36*		*32*		*26*		*32*		*26*	
% COMPARABILITY TO REFERENCE	--		81%		62%		67%		71%		81%		86%		76%		62%		76%		62%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	**REFERENCE**		**NON/ SLIGHTLY IMPAIRED**		**SLIGHTLY IMPAIRED**		**SLIGHTLY IMPAIRED**		**SLIGHTLY IMPAIRED**		**NON/ SLIGHTLY IMPAIRED**		**NON-IMPAIRED**		**SLIGHTLY IMPAIRED**		**SLIGHTLY IMPAIRED**		**SLIGHTLY IMPAIRED**		**SLIGHTLY IMPAIRED**	

Table 4. Summary of habitat analysis (i.e. comparability to the reference habitat condition) and RBP III analysis of macroinvertebrate communities sampled in the Mainstem Biomonitoring Stations during the Housatonic River Watershed survey on 28, 29 and 30 August 2007. Shown are the calculated metric values, metric scores (in italics) based on comparability to the reference station (HR19E), and the corresponding assessment designation for each biomonitoring station. Complete habitat evaluations are presented in Appendix 1. Refer to Table 1 for a listing and description of sampling stations.

SAMPLING STATION	HR19E		HR19A		HR19C	
STREAM	Housatonic River		Housatonic River		Housatonic River	
HABITAT SCORE	184		154		172	
HABITAT % REFERENCE	--		84%		93%	
HABITAT COMPARABILITY	--		Support		Comparable	
TAXA RICHNESS	27	*6*	16	*4*	28	*6*
BIOTIC INDEX	4.34	*6*	5.28	*4*	4.63	*6*
EPT INDEX	18	*6*	7	*0*	14	*2*
EPT/CHIRONOMIDAE	14.00	*6*	0.94	*0*	2.50	*0*
SCRAPER/FILTERER	0.47	*6*	0.14	*2*	0.47	*6*
REFERENCE AFFINITY	100%	*6*	57%	*4*	71%	*6*
% DOMINANT TAXON	14%	*6*	37%	*2*	15%	*6*
TOTAL METRIC SCORE	*42*		*16*		*32*	
% COMPARABILITY TO REFERENCE	--		38%		76%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	**REFERENCE**		**MODERATLEY IMPAIRED**		**SLIGHTLY IMPAIRED**	

Table 5. Selected macroinvertebrate RBPIII community metrics and impairment status for six sampling stations in the Housatonic River Watershed sampled by MassDEP/DWM in 2007 and on at least one previous occasion. See text for a description of the metrics.

Water Body	Year	Community Metrics				Impairment Status
		Total Richness	EPT Richness	Biotic Index	% Dominant Taxon	
West Branch Housatonic, Pittsfield	1997	19	5	5.64	23	Slight - Moderate
	2002	23	5	6.84	34	Slight
	2007	20	8	4.83	21	Slight
Konkapot River, New Marlborough	1997	25	8	4.59	20	Non - Slight
	2002	28	12	4.08	22	Non
	2007	31	10	4.15	14	Slight
East Br. Housatonic River, Dalton	2002	38	11	5.11	11	Non
	2007	33	9	5.26	10	Slight
Housatonic River , Lenox	2002	21	6	4.87	29	Slight
	2007	16	7	5.28	37	Moderate
Housatonic River, Lee	2002	22	10	4.72	19	Slight
	2007	28	14	4.63	15	Slight
Housatonic River, Stockbridge	2002	28	13	4.29	15	Reference
	2007	27	18	4.34	14	Reference

SUMMARY

Sampling of the benthic macroinvertebrate community was carried out in August, 2007 at fourteen sites in the Housatonic River Watershed to evaluate the biological health of selected streams and to determine their status with respect to the support of the *Aquatic Life* use, as designated in Massachusetts' Surface Water Quality Standards. Results of these assessments form the basis for reporting and listing waters under sections 305(b) and 303(d) of the Clean Water Act. Field and laboratory methods and data analysis were based on the USEPA's Rapid Biomonitoring Protocols. Sampled sites were divided into two categories: Small Watersheds, and Large (Mainstem) Watersheds. Station RA01 on Rawson Brook served as the reference site for Small Watersheds, and Station HR19E on the mainstem Housatonic River (Stockbridge, MA) served as the reference site for all mainstem sites.

With the exception of the Housatonic River at Lenox, MA (HR19A), all sites supported the *Aquatic Life Use*. Site HR19A was found to be moderately impaired and did not support the *Aquatic Life Use*. The limitation at HR19A is due to the reduction in scores primarily from the EPT Index and EPT / Chironomidae Metrics. Both of these metrics are indicative of nutrient enrichment at this site. Non-support of the *Aquatic Life Use* at this site may, potentially, be traced back to the upstream proximity of Woods Pond. It is likely that warm, nutrient-rich, waters flowing over the top of the dam from this impounded portion of the Housatonic River are affecting the benthic community structure. The dam exists approximately 1/3 of a mile upstream from the sampled location.

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Appendix 1. Habitat assessment summary for biomonitoring stations sampled during the 2007 Housatonic River Watershed survey. For within-reach parameters, scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For riparian parameters, scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor. Maximum habitat score for any site = 200. Refer to Table 1 for a listing and description of sampling stations.

STATION	RA01	SA01	WM01	OB01	LW01	WF02	EB01C	WR06B	HW01	KR07	EB02A	HR19E	HR19A	HR19C
PRIMARY PARAMETERS (range is 0-20)	**SCORE**													
INSTREAM COVER	17	10	16	8	10	10	17	11	7	18	16	19	15	13
EPIFAUNAL SUBSTRATE	19	19	19	16	17	16	19	16	10	17	17	18	16	18
EMBEDDEDNESS	16	16	19	17	19	19	19	17	9	14	18	19	15	18
CHANNEL ALTERATION	19	19	18	12	13	16	19	18	7	13	8	16	14	19
SEDIMENT DEPOSITION	15	17	18	17	17	19	18	19	15	11	19	19	18	17
VELOCITY-DEPTH COMBINATIONS	14	10	15	10	10	10	11	10	9	15	15	18	15	11
CHANNEL FLOW STATUS	16	9	7	14	11	9	13	9	17	17	17	17	18	19
SECONDARY PARAMETERS (range is 0-10 for each bank)	**SCORE**													
BANK VEGETATIVE PROTECTION left	10	10	8	1	7	7	10	10	4	7	4	10	7	9
BANK VEGETATIVE PROTECTION right	9	10	8	1	7	8	9	10	3	9	4	10	9	10
BANK STABILITY left	8	9	5	1	5	7	8	9	8	9	8	10	9	9
BANK STABILITY right	9	6	8	1	7	7	8	10	7	7	9	10	10	10
RIPARIAN VEGETATIVE ZONE WIDTH left	9	2	6	2	4	1	9	2	2	10	8	10	2	10
RIPARIAN VEGETATIVE ZONE WIDTH right	10	2	5	2	6	2	10	3	3	3	2	8	6	9
TOTAL SCORE	**171**	**139**	**152**	**102**	**133**	**131**	**170**	**144**	**101**	**150**	**145**	**184**	**154**	**172**

Appendix 2. Species-level taxa list and counts, functional feeding groups (FFG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2007 Housatonic River Watershed survey from 28 to 30 August 2007. Refer to Table 1 for a listing and description of sampling stations.

TAXON	FFG[1]	TV[2]	Sampling Stations													
			RA01[3]	SA01	WM01	OB01	LW01	WF02	EB01C	WR06B	HW01	KR07	EB02A	HR19E[3]	HR19A	HR19C
Gyraulus sp.	SC	8														1
Pisidiidae	FC	6								2	3				1	
Tubificidae	GC	10	1													
Lumbriculidae	GC	7									1					
Hygrobates sp.	PR	6			1											
Lebertia sp.	PR	6								1	1					
Sperchon sp.	PR	6							1	1		1	1			
Sperchonopsis sp.	PR	6											1			1
Baetidae	GC	4		4				3	2			3				4
Acentrella turbida	SC	4				1		1	1			5	1	2		2
Acerpenna sp.	GC	5								1						
Baetis sp.	GC	6			3									1	1	
Baetis flavistriga	GC	4		6		1		1	2		2		1	1	4	1
Baetis intercalaris	GC	6	6		3		1		6					4	1	5
Baetis tricaudatus	GC	6		6	1			1				4				
Heterocloeon anoka	SC	2		1										1		5
Heterocloeon curiosum	GC	2								1				2		
Plauditus sp.	GC	4	3					2	8							
Ephemerella sp.	GC	1	5	2	13			5	2							5
Serratella deficiens	GC	2								8				2		
Heptageniidae	SC	4								1						
Epeorus vitreus	SC	0		1	1											
Maccaffertium sp.	SC	3	6	2		6	12		3			7		5		5
Maccaffertium modestum	SC	1									6					
Maccaffertium vicarium	SC	2						4					2			
Stenacron interpunctatum	SC	7									1					
Isonychia bicolor	FC	2	4			1	1	1	10			3		1	1	1
Tricorythodes sp.	GC	4		1												
Leptophlebiidae	GC	2		3	1											
Paraleptophlebia sp.	GC	1	2					3								
Boyeria grafiana	PR	2				1										
Paracapnia sp.	SH	1		1												
Alloperla sp.	GC	0							1							
Tallaperla maria	SH	0			1											
Acroneuria abnormis	PR	0	1							1			1			1
Agnetina capitata	PR	2						1								
Paragnetina sp.	PR	1	1							1						
Paragnetina immarginata	PR	1	1						2							
Paragnetina media	PR	5	1						1							
Nigronia serricornis	PR	0	1		1		1		3			2				
Brachycentridae	FC	1												2		
Micrasema sp.	SH	2								2						
Glossosoma sp.	SC	0	4						1			4				
Helicopsyche borealis	SC	3	2							5				1		
Cheumatopsyche sp.	FC	5	4			19	8	14			7		4	3	9	6
Hydropsyche sp.	FC	4	11	2	5	9		17	8	2	4	3		12	6	6

Hydropsyche betteni	FC	7		1	1	14	7				11				1	
Hydropsyche bronta	FC	6			1		2									
Hydropsyche morosa	FC	6	5	1	13	1		3	4			2	7	14	8	10
Hydropsyche morosa gr.	FC	6					1									
Hydropsyche scalaris	FC	2														1
Hydropsyche slossonae	FC	4			1			1								
Hydropsyche sparna	FC	6	5		6		3	4	1	4		14	6			
Macrostemum sp.	FC	3								3				8		2
Hydroptila sp.	GC	6		4				2		4			2	1		6
Leucotrichia sp.	SC	6			1	2					1		8	1		
Lepidostoma sp.	SH	1		4												
Limnephilidae	SH	4												1		
Psilotreta labida	SC	0	1													
Philopotamidae	FC	3				3										
Chimarra sp.	FC	4								4		1				
Chimarra aterrima	FC	4	8			21	37		8	4	15			1		
Chimarra obscura	FC	4				9	3				8			7	15	5
Chimarra socia	FC	2								5						
Dolophilodes distinctus	FC	0		4	1			1	1			1				
Polycentropus sp.	PR	6	1													
Rhyacophila fuscula	PR	0				2						2				
Elmidae	SC	4								2		5	1			1
Optioservus sp.	SC	4				4			1	4		10	11			
Optioservus ovalis	SC	4	2	8			6	2				1				
Optioservus trivittatus	SC	4									2	1		4		2
Oulimnius latiusculus	SC	4	1	1			1		1	4		1			1	
Promoresia tardella	SC	2	1				3			2		2	1	1	1	1
Stenelmis sp.	SC	5					7			15	22		5		4	3
Stenelmis concinna	SC	5					2			2				11		
Stenelmis crenata	SC	5				7	1	1	1	1						
Psephenus herricki	SC	4	4			2	1	2	1		6	3	1	1		
Atherix sp.	PR	4							2				1			
Palpomyia/Bezzia sp.	PR	6	1													
Cryptochironomus sp.	PR	8								1						
Dicrotendipes sp.	GC	8								1						
Microtendipes pedellus gr.	FC	6		2												
Microtendipes rydalensis gr.	FC	6										1				
Phaenopsectra sp.	SC	7											1			
Polypedilum sp.	SH	6			1											
Polypedilum aviceps	SH	4	2	7	18		2	4	1			1				
Polypedilum flavum	SH	6	2		1			2	1	6		5	6	2	38	16
Polypedilum illinoense gr.	SH	6			1								1			
Polypedilum laetum	SH	6											1			
Micropsectra sp.	GC	7	1	4	2			9								
Rheotanytarsus exiguus gr.	FC	6	1	2				3			3		3		1	
Rheotanytarsus pellucidus	FC	5		4		2		2		2	3		3			2
Stempellinella sp.	GC	2	1													
Sublettea coffmani	FC	4	1	2	2			1	3			1				
Tanytarsus sp.	FC	6								1	3		5			
Diamesa sp.	GC	5				2										
Pagastia sp.	GC	1		1								1				
Potthastia gaedii gr.	GC	2		2	1			1	4							
Orthocladiinae	GC	5								1						
Cardiocladius obscurus	PR	5							1				4	2	3	
Corynoneura sp.	GC	4			1											
Cricotopus sp.	SH	7			3			1			3		2		4	
Cricotopus bicinctus	GC	7		1						6		1				
Cricotopus tremulus gr.	SH	7										1				
Cricotopus trifascia gr.	SH	6							1				1		1	2

Cricotopus/Orthocladius sp.	GC	7		6	4			1	1				3			
Eukiefferiella devonica gr.	GC	4										3				
Eukiefferiella pseudomontana gr.	GC	8										2				
Lopescladius sp.	GC	4	2													
Nanocladius sp.	GC	7								2						
Orthocladius sp.	GC	6			2				2		2		3			1
Orthocladius dubitatus	GC	6		3				2				1				
Orthocladius (Symposiocladius) Lignicola	SH	5						1								
Parametriocnemus sp.	GC	5		5	3	1	1	3	12			1	1			
Rheocricotopus sp.	GC	6		3					3				2			
Tvetenia sp.	GC	5										1				
Tvetenia paucunca	GC	5		1	1		1						1			
Tvetenia vitracies	GC	5	1										11	1	2	4
Helopelopia sp.	PR	6			1											
Thienemannimyia gr.	PR	6		3	2								1			1
Empididae	PR	6					1									
Clinocera sp.	PR	6			1											
Hemerodromia sp.	PR	6						1		2						1
Neoplasta sp.	PR	6		1												
Simulium sp.	FC	5	3		4		2	1	1	2		4	2	5		5
Antocha sp.	GC	3		7	6	1	1	3	4		1	5	1	1		1
Dicranota sp.	PR	3	1		1											
Hexatoma sp.	PR	2	3					2								
TOTAL			100	106	109	109	105	106	105	104	105	103	106	98	102	107

[1]Functional Feeding Group (FFG) 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.

[3] Reference station