Technical Memorandum CN 222.3

MILLERS RIVER WATERSHED
2005 BENTHIC MACROINVERTEBRATE BIOASSESSMENT

Division of Watershed Management
Watershed Planning Program
Worcester, MA

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Commonwealth of Massachusetts
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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 (Plafkin et al. 1989, Barbour et al. 1995).

As part of the Massachusetts Department of Environmental Protection/Division of Watershed Management's (MassDEP/DWM) 2005 Millers River Watershed assessments, aquatic benthic macroinvertebrate biomonitoring was conducted to evaluate the biological health of selected tributaries within the watershed and 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). A total of nine biomonitoring stations on five named streams were sampled to investigate the effects of potential point and nonpoint sources of pollution—both historical and current—on the aquatic communities of the watershed. Although three sampling station locations were new for 2005, all of the streams had been previously assessed by MassDEP (Nuzzo 2003a; Kennedy and Rojko 2004). Table 1 presents the sampling locations, along with station identification numbers and sampling dates.

To provide information for making *Aquatic Life* use-support determinations required by Section 305(b) of the Clean Water Act, macroinvertebrate communities present at biomonitoring stations in the Millers River Watershed were compared with the community occurring at a regional reference station most representative of "least disturbed" conditions in the watershed. The watershed reference station (PR01) was established on Priest Brook at a site unaffected by point sources of water pollution, and assumed [based on historical water quality data (Kennedy and Rojko 2004), topographic map examinations, and field reconnaissance] to be minimally impacted (relative to other portions of the Millers Watershed) by nonpoint sources. 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 total taxa richness; or shifts in community composition relative to the reference station (Plafkin et al. 1989).

Table 1. List of biomonitoring stations sampled during the 2005 Millers River watershed survey, including station and unique identification numbers, drainage areas, sampling site descriptions, and sampling dates.

Station ID	Unique ID	Drainage Area (mi^2)	Sampling Site Description	Sampling Date
PR01	B0448	18.9	Priest Brook, downstream from Winchendon Road, Royalston	12 Sep 2005
OT03	B0223	45.2	Otter River, downstream from Route 202, Templeton	12 Sep 2005
BB01	B0450	6.2	Beaver Brook, downstream from Templeton Development Center outfall, Templeton	13 Sep 2005
BB02	B0557	6.2	Beaver Brook, upstream from Templeton Development Center outfall, Templeton	13 Sep 2005
B0221	B0221	44.5	Otter River, upstream from Route 202, Templeton	13 Sep 2005
OT05	B0219	34.1	Otter River, upstream from Turner Street, Gardner	14 Sep 2005
OTSE	B0556	42.4	Otter River, upstream from Main Street, Templeton	14 Sep 2005
WM16EBT	B0227	52.7	East Branch Tully River, upstream from Tully Road, Orange	14 Sep 2005
WM15WBT	B0670	5.9	West Branch Tully River, upstream from Flagg Road, Orange	14 Sep 2005

METHODS

Macroinvertebrate Sampling - RBPIII

Macroinvertebrate sampling activities employed for the 2005 Millers River Watershed survey were conducted in accordance with the Sampling & Analysis Plan (SAP) for the Millers River Watershed (MassDEP 2005). The sampling procedures are described in the standard operating procedures *Water Quality Monitoring in Streams Using Aquatic Macroinvertebrates* (Nuzzo 2003b), 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.

Macroinvertebrate Sample Processing and Data Analysis

The macroinvertebrate sample processing and analysis procedures employed for the 2005 Millers River watershed biomonitoring samples are described in the standard operating procedures (Nuzzo 2003b). 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 (2003b); 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 (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 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

The quality of the habitat encountered at the 2005 Millers River Watershed biomonitoring stations was generally very good (Table 2), with all but one site (i.e., OT05) scoring higher than 80% of the maximum attainable value. When compared with the reference site (PR01), habitat scores of the other monitoring sites were found to be highly comparable. Total habitat scores for station BB01 on Beaver Brook and for station WM16EBT on the East Branch Tully River exceeded that of the reference site. Only station OT05 exhibited habitat conditions that were considered less than fully comparable with the reference condition.

A taxonomic list of the macroinvertebrate organisms collected at each sampling station during the 2005 biomonitoring survey is attached as an Appendix. Included in the list are total organism counts, the functional feeding group designation (FG) for each macroinvertebrate taxon, and the tolerance value (TV)

of each taxon. Table 3 presents a summary of the RBP III macroinvertebrate data analyses, including biological metric calculations, metric scores, and impairment designations.

Table 2. Habitat assessment summary for biomonitoring stations sampled during the 2005 Millers River Watershed survey. For within-reach 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. 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	PR01*	OT03	BB01	BB02	B0221	OT05	OTSE	WM15WBT	WM16EBT
WITHIN-REACH PARAMETERS (range is 0-20)	**SCORE**								
INSTREAM COVER	18	16	17	16	16	11	12	14	17
EPIFAUNAL SUBSTRATE	14	16	18	16	18	18	19	17	19
EMBEDDEDNESS	17	13	19	17	18	13	18	19	16
CHANNEL ALTERATION	17	16	20	20	16	16	15	18	16
SEDIMENT DEPOSITION	18	18	19	16	18	12	16	20	18
VELOCITY-DEPTH COMBINATIONS	15	17	10	13	15	10	16	10	17
CHANNEL FLOW STATUS	12	16	15	10	17	17	12	9	15
RIPARIAN PARAMETERS (range is 0-10 for each bank)	**SCORE**								
BANK VEGETATIVE PROTECTION left	10	8	10	10	8	9	10	10	10
BANK VEGETATIVE PROTECTION right	10	10	10	10	10	10	10	10	10
BANK STABILITY left	10	9	10	10	9	6	10	10	8
BANK STABILITY right	9	10	10	10	10	10	9	10	10
RIPARIAN VEGETATIVE ZONE WIDTH left	10	9	10	10	9	2	3	8	9
RIPARIAN VEGETATIVE ZONE WIDTH right	10	10	10	10	1	10	10	10	10
TOTAL SCORE	**170**	**168**	**178**	**168**	**165**	**144**	**160**	**165**	**175**

* Reference Station

The benthic macroinvertebrate community at Priest Brook (PR01) received a total metric score of 40 out of a possible 42, supporting its designation as the reference site despite being outperformed by the community at Station B0221 on the Otter River which received the maximum attainable total metric score. The macroinvertebrate communities at five biomonitoring stations – BB01 on Beaver Brook; OT03, B0221 and OTSE on the Otter River; and WM16EBT on the East Branch Tully River – were all equal to or more than 90% comparable to the reference site community and were judged "non-impaired". Otter River Station OT05 ("slightly/non-impaired") and the West Branch Tully River ("slightly impaired") exhibited slight deviations from the reference condition, but were considered to be in support of the designated *Aquatic Life Use.* Habitat conditions may have limited slightly the potential to support macroinvertebrate

Table 3. Summary of RBP III analysis of macroinvertebrate communities sampled during the Millers River Watershed survey between 12 and 14 September 2005. Shown are the calculated metric values, metric scores (in italics) based on comparability to the regional reference station (PR01), and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a listing and description of sampling stations.

SAMPLING STATION	PR01		OT03		BB01		BB02		B0221		OTO5		OTSE		WM16EBT		WM15WBT	
STREAM	Priest Brook		Otter River		Beaver Brook		Beaver Brook		Otter River		Otter River		Otter River		East Branch Tully River		West Branch Tully River	
HABITAT SCORE	170		168		178		168		165		144		160		175		165	
TAXA RICHNESS	18	*6*	18	*6*	25	*6*	14	*4*	25	*6*	16	*6*	20	*6*	26	*6*	30	*6*
BIOTIC INDEX	4.49	*6*	5.19	*6*	4.89	*6*	9.22	*0*	4.41	*6*	4.65	*6*	4.58	*6*	4.51	*6*	4.97	*6*
EPT INDEX	8	*6*	7	*4*	7	*4*	--	*0*	10	*6*	11	*6*	11	*6*	7	*4*	7	*4*
EPT/CHIRONOMIDAE	2.61	*6*	2.89	*6*	0.89	*2*	--	*0*	4.92	*6*	95.00	*6*	11.86	*6*	2.58	*6*	0.39	*0*
SCRAPER/FILTERER	0.27	*6*	0.63	*6*	0.50	*6*	--	*0*	0.56	*6*	0.07	*2*	0.25	*6*	0.16	*6*	0.04	*0*
% DOMINANT TAXON	30%	*4*	27%	*4*	19%	*6*	49%	*0*	15%	*6*	23%	*4*	17%	*6*	18%	*6*	19%	*6*
REFERENCE AFFINITY	100%	*6*	61%	*4*	76%	*6*	40%	*2*	66%	*6*	47%	*2*	59%	*4*	81%	*6*	57%	*4*
TOTAL METRIC SCORE	*40*		*36*		*36*		*6*		*42*		*32*		*40*		*40*		*26*	
% COMPARABILITY TO REFERENCE	--		90%		90%		15%		105%		80%		100%		100%		65%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	**REFERENCE**		**NON-IMPAIRED**		**NON-IMPAIRED**		**SEVERELY IMPAIRED**		**NON-IMPAIRED**		**SLIGHTLY/ NON-IMPAIRED**		**NON-IMPAIRED**		**NON-IMPAIRED**		**SLIGHTLY IMPAIRED**	

communities at OT05.

The macroinvertebrate community at Station BB02 on Beaver Brook was only 15% comparable to that of the reference site, resulting in a bioassessment of "severely impaired". No EPT taxa were present, and the HBI value (9.22) was indicative of a community made up of forms that are very tolerant of low dissolved oxygen concentrations. In fact, the entire sample comprised only worms, midges and isopods. It is noteworthy that this site was established directly upstream from the wastewater discharge from the Templeton Development Center to serve as a "control" site for evaluating potential effects of this discharge on the biota of Beaver Brook. Nonetheless, the station upstream from the outfall was found to be impaired, whereas the downstream site was not, and no evidence was found to suggest that the outfall from the Templeton Development Center was adversely affecting the biota of Beaver Brook. Still, the poor condition of the benthic community at Station BB02 requires further investigation. While the habitat score was lower at BB02 than at BB01, the difference was not large, and both sites scored well when compared with the reference site on Priest Brook. Therefore, it is unlikely that the limitations in channel flow status and velocity-depth combinations alone can account for the deleterious effects on macroinvertebrate community structure exhibited at this site.

Beaver Brook at BB02 drains approximately 6 $mi.^2$ of mostly forested (~80%) watershed with no apparent sources of pollution. However, the brook meanders through extensive wetlands immediately upstream from the Templeton Developmental Center. Thus, the macroinvertebrate community at BB02 may have been structured in response to the naturally enriched conditions and characteristically low dissolved oxygen levels associated with wetland drainage, and not to any kind of human disturbance.

SUMMARY AND RECOMMENDATIONS

Station PR01 on Priest Brook, while not receiving the highest overall RBP III metric score, was deemed a suitable reference site for the 2005 Millers River Watershed biomonitoring survey. All but one of the water bodies evaluated were found to be "non- or slightly impaired" and these waters can be considered in support of their designated *Aquatic Life Use.* Only Station BB02 on Beaver Brook ("severely impaired") exhibited a benthic macroinvertebrate community degraded to the extent that the *Aquatic Life Use* was not supported. This site, located upstream from the wastewater discharge from the Templeton Development Center, requires further investigation. Dissolved oxygen depletion associated with the expansive wetland area just upstream from Station BB02 may have limited the biological potential of Beaver Brook at this site. The wastewater effluent from the Templeton Development Center had no discernible effect on the biota of Beaver Brook.

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APPENDIX

Species-level taxa list and counts, functional feeding groups (FG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2005 Millers River Watershed survey between 12 and 14 September 2005. Refer to Table 1 for a listing and description of sampling stations.

Taxon	FG[1]	TV[2]	Sampling Stations								
			PR01[3]	OT03	BB01	BB02	B0221	OT05	OTSE	WM16EBT	WM15WBT
Pisidiidae	FC	6			20				1	1	2
Enchytraeidae	GC	10								1	
Naididae	GC	9				3					
Chaetogaster diaphanus	PR	7				2					
Dero sp.	GC	10				46					
Nais communis/variabilis	GC	8				1				1	
Pristinella jenkinae	GC	10									1
Pristinella osborni	GC	10				1					
Ripistes parasita	GC	8								1	
Tubificidae IWB	GC	10				1					
Tubificidae IWP	GC	10				1					
Lumbriculidae	GC	7				1			1	1	1
Glossiphoniidae	PR	7				1					
Caecidotea communis	GC	8				7					
Caecidotea racovitzai racovitzai	CG	8				16					
Sperchon sp.	PR	6					2				
Sperchonopsis sp.	PR	6									1
Baetis sp.	GC	6					1	1	2	1	
Baetis flavistriga	GC	4						4	3		
Baetis pluto	GC	6						1	3		
Ephemerella sp.	GC	1					8		2		
Ephemerella subvaria	GC	1						1			
Eurylophella sp.	GC	2			1						1
Maccaffertium sp.	SC	3	11		12			1	3	5	
Stenacron interpunctatum	SC	7		1							
Leptophlebiidae	GC	2	1		2						
Boyeria sp.	PR	2									1
Calopteryx sp.	PR	6	1								
Gomphidae	PR	5			1						
Acroneuria sp.	PR	0		1							
Acroneuria abnormis	PR	0								2	
Paragnetina sp.	PR	1					1				
Corydalus cornutus	PR	4								1	
Nigronia serricornis	PR	0			2						4
Apatania sp.	SC	3							1		
Brachycentridae	FC	1									1
Brachycentrus numerosus	FC	1	2								
Micrasema sp.	SH	2	1	1	5		1	2	4		
Glossosomatidae	SC	0						1			
Hydropsychidae	FC	4									1
Cheumatopsyche sp.	FC	5	5	12	5		7	14	6		1
Hydropsyche sp.	FC	4	5		2		11	23	8	10	8
Hydropsyche betteni	FC	6	8	29	4		15	19	15	4	2
Hydropsyche sparna	FC	6		6			2	9	10		
Macrostemum sp.	FC	3					1				
Macrostemum zebratum	FC	3								9	
Oecetis sp.	PR	5									1
Chimarra sp.	FC	4							2		
Chimarra aterrima	FC	4	12		2		4	5	6	17	6
Chimarra obscura	FC	4					8	14	18		
Psychomyia sp.	GC	2		2							

Rhyacophila sp.	PR	1								1	1
Rhyacophila minor	PR	1	2								
Microcylloepus pusillus	GC	3		2							
Optioservus sp.	SC	4		2			6				
Optioservus trivittatus	SC	4						1			
Oulimnius latiusculus	SC	4			1						
Promoresia tardella	SC	2	3		3		4		2	2	2
Stenelmis sp.	SC	5	4	23	5		16	2	5	3	
Stenelmis crenata	SC	5						1			
Psephenus herricki	SC	4		6			4		6		
Atherix sp.	PR	4	1								
Chironomini	GC	6				1					5
Chironomus sp.	GC	10				1					
Dicrotendipes sp.	GC	8				1					
Kiefferulus sp.	GC	10				10					
Microtendipes pedellus gr.	FC	6									2
Microtendipes rydalensis gr.	FC	6								1	2
Polypedilum aviceps	SH	4									8
Polypedilum flavum	SH	6		6	1		1		1		
Tribelos sp.	GC	7									
Micropsectra sp.	GC	7			13						
Rheotanytarsus exiguus gr.	FC	6		4	1		2			1	
Rheotanytarsus pellucidus	FC	5	3		1					3	
Tanytarsus sp.	FC	6			6						19
Cardiocladius obscurus	PR	5					1				
Corynoneura sp.	GC	4			2						1
Cricotopus bicinctus	GC	7								2	2
Diplocladius sp.	GC	8									2
Eukiefferiella sp.	GC	6									1
Eukiefferiella brehmi gr.	GC	4		2							
Eukiefferiella devonica gr.	GC	4					1		1		
Nanocladius sp.	GC	7								1	
Parametriocnemus sp.	GC	5			2						2
Rheocricotopus robacki	GC	5	4		1					4	
Thienemanniella sp.	GC	6					1				
Thienemanniella xena	GC	6									1
Tvetenia paucunca	GC	5		6	3		5		5	1	5
Tvetenia vitracies	GC	5	5				1	1		5	
Tanypodinae	PR	7									2
Conchapelopia sp.	PR	6	6		7					1	3
Thienemannimyia gr.	PR	6									2
Hemerodromia sp.	PR	6	1	2		1	1			1	4
Simulium sp.	FC	5	32		1		4	1	1	15	1
Simulium verecundum cplx.	FC	5								1	
Antocha sp.	GC	3		1	1		1	1			2
Tipula sp.	SH	6		1							
Total			107	107	104	94	109	102	106	96	98
HBI			4.49	5.19	4.89	9.22	4.41	4.65	4.58	4.51	4.97

[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.

[3] Reference Station