NORTH RIVER WATERSHED
2007 MACROINVERTEBRATE ASSESSMENT
(Franklin County, Massachusetts and Windham County, Vermont)

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EXECUTIVE SUMMARY

- As part of the Deerfield River Watershed Association's (DRWA) commitment to protecting the watershed's resources, the DRWA has performed water quality monitoring to supplement the efforts of regulatory agencies to monitor the watershed's condition. In recognizing the need to more thoroughly assess biological conditions in the Deerfield River watershed, the DRWA implemented in 2005 a long-term macroinvertebrate monitoring program. The objectives of the program are to 1) augment MA DEP/DWM biomonitoring efforts to assess surface waters in the watershed with respect to their aquatic-life-use status and 2) familiarize citizens of the watershed with biological monitoring to increase support for and participation in watershed enhancement and protection activities. The North River watershed was sampled in 2007 under this program.

- Fifteen river and stream reaches were selected in the North River watershed for sampling in 2007. The Cold River, a neighboring watershed, was also sampled to represent reference conditions. Three sites were selected each on the mainstem North River and on the West Branch of the North River. Six sites were selected on the East Branch of the North River. Three larger tributaries: Sanders Brook, Taylor Brook, and Branch Brook were also sampled. Branch Brook was selected as a reference site for comparison with the other sampled tributaries.

- Macroinvertebrate communities in the North River scored exclusively in the non-impaired range relative to reference-reach conditions. Multimetric scores ranged from 38 at NORM01 to 42 at NORM02 and NORM03. One West Branch site, WBNM01, occurred in a drainage area large enough (>50 km^2) to be compared to the Cold River reference. WBNM01 received a total score of 40 and a corresponding rating of not impacted. Individual metrics were similar to those from the Cold River; total richness was higher from WBNM01 (39) than from the Cold river reference reach (35). Five East Branch sites were treated as mainstem sites and compared to the Cold River reference site. All five East Branch sites scored in the non-impaired range, with total scores ranging from 38 at EBNM03 to 42 at EBNM02, EBNM04, and EBNM05.

- Two West Branch reaches, WBNM02 and WBNM03, occur in small drainage areas (33 and 18 km^2, respectively), and were therefore compared to the tributary reference reach, Sanders Brook. Relative to the Sanders Brook reference reach, both reaches scored in the unimpaired range. The uppermost reach in the East Branch of the North River, EBNM06, drains an area of 39 km^2, and was therefore also compared to the Sanders Brook reference reach. EBNM06 received a total score of 38, which corresponds to a non-impacted classification relative to the Sanders Brook reference reach. The Sanders Brook reference site supported a macroinvertebrate community with a high total taxonomic richness (35 taxa) and moderately high EPT richness (20 taxa). Relative to the Sanders Brook reference

reach, the Branch Brook reach scored as non-impacted, with a number of individual metrics outperforming those from Sanders Brook.

- Despite extensive sediment deposition, Taylor Brook also scored as non-impacted relative to the Branch Brook reference reach. While total taxonomic richness was lower (29) than that measured from the reference reach (35), an EPT richness of 22 was higher than that measured in the reference reach. Although the overall score and individual metrics indicated little or no departure from expected conditions, it should be noted that the Taylor Brook reach was dominated by immature larvae of the sediment tolerant mayfly genus, *Ephemerella*, and by the sediment tolerant caddisfly, *Hydropsyche*. These two taxa represented nearly half of the individuals sampled. This dominance by a few sediment-tolerant taxa suggests that elevated sediment loads have altered community structure in Taylor Brook, but not to the extent that significant biological impairment is occurring.

- Maintenance of healthy benthic communities and overall ecological health of the North River watershed rests on continued stewardship of these aquatic resources and adjacent riparian habitats. Prevention of further loss of mature riparian zones in the watershed is necessary to ensure the continued health of these communities. Most importantly, restoration of degraded riparian areas within the watershed would benefit the health of these aquatic systems by reducing sediment loads and increasing channel stability, habitat complexity, shade, and delivery of woody debris and food materials for aquatic life.

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ACKNOWLEDGMENTS

I owe my gratitude to the Deerfield River watershed residents who generously gave their time to this project. Field sampling was performed by Jason Saltman, Jen Audley, Muriel Russell, Gretchen Whitman, and Robert May. Jason Saltman and Jen Audley also sorted macroinvertebrate samples in the lab. Jason Saltman also kindly performed the GIS spatial analyses and created the map in this report. Bob Nuzzo, Peter Mitchell, and John Fiorentino of the MA DEP/DWM reviewed the original DRWA study plan to develop a comprehensive biomonitoring program for the Deerfield River watershed.

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INTRODUCTION

The Massachusetts Department of Environmental Protection, Division of Watershed Management (DWM) currently assesses the biological health in each of the Deerfield River's major tributaries every five years in partial fulfillment of their federal mandate to report on the status of the Commonwealth's waters under the Clean Water Act. DWM suggests that an ideal monitoring plan for the Deerfield River Watershed would include 35-40 biomonitoring stations (MA DWM 2005) to adequately assess the watershed's rivers and streams with respect to assessing attainment of the aquatic-life-use water quality standard. Owing to budgetary and staffing limitations, assessment efforts fall well short of these recommendations. In 2005, for example, DWM sampled from approximately 20 sites distributed throughout the entire Massachusetts portion of the watershed.

As part of the Deerfield River Watershed Association's (DRWA) commitment to protecting the watershed's resources, the DRWA has performed water quality monitoring to supplement the DWM's efforts to monitor the watershed's condition. In recognizing the need to more thoroughly assess biological conditions in the Deerfield River watershed, the DRWA implemented in 2005 a long-term macroinvertebrate monitoring program for the watershed. The objectives of the program are to 1) augment DEP biomonitoring efforts to assess surface waters in the watershed with respect to their aquatic-life-use status and 2) familiarize citizens of the watershed with biological monitoring to increase support for and participation in watershed enhancement and protection activities.

The program includes both professional and volunteer elements, and therefore represents a "hybrid" program. In order to provide useful data to the state, the program uses DWM's professional field and laboratory biomonitoring protocols. Volunteers are trained by the program leader, Michael Cole, to collect field data and to assist with sample sorting. All field sampling and sample processing is overseen by Dr. Cole. Macroinvertebrate identification is performed exclusively by Dr. Cole, who uses the same levels of taxonomic resolution used by the state. The program sampling design is based on the sampling program of the DWM insofar as sampling is rotated through subwatersheds from one year to the next, just as DWM rotates through major watersheds of the state on an annual basis. Under this design, DRWA will survey from five subwatersheds during the first five years of the program. The Green River was assessed in 2005 (Cole 2006), the South River in 2006 (Cole 2007), and the North River was completed in 2007. The Cold and Chickley river subwatersheds are to be sampled in 2008 and then 2009 will focus on the upper watershed in Vermont. Smaller tributaries draining directly to the Deerfield River, such as Pelham and Clesson brooks, will be sampled as well, likely in the same year that neighboring larger drainages are sampled. Under this program, the DRWA has assessed biological conditions in 45 reaches in three years and will assess biological conditions in more than 70 stream and river reaches after the first five years.

The North River subwatershed was selected for the program's third year of sampling. The towns of Shattuckville, MA, Colrain, MA, Jacksonville, VT, and a number of smaller communities occur within the subwatershed. The North River's headwaters occur in southern Vermont. Two major branches – the East Branch and the

West Branch – flow southeast out of Vermont into Massachusetts before confluenting near Griswoldville, MA. From here, the North River flows south three miles through rural residential land before entering the Deerfield River at RM 19.5 north of Shelburne Falls.

The West Branch originates in Vermont as Brown Brook, southwest of Jacksonville. Upon entering Massachusetts, Brown Brook is named the West Branch of the North River, where it turns from a southerly course to southeast, flowing through the village of North Heath. Between North Heath and Adamsville (~4 miles), the West Branch picks up water from several tributaries, including Sanders and Tisdel brooks from the north. Taylor Brook, the subject of past sediment-load investigations, flows into the West Branch in Adamsville. From Adamsville, the West Branch continues southeast another two miles before joining the East Branch.

The East Branch of the North River, the larger of the two branches, originates from a number of small tributary streams just north of Jacksonville, VT. From Jacksonville, the East Branch flows southeast into Massachusetts, picking up volume from Branch Brook and several smaller tributaries. Upon entering Massachusetts, the East Branch flows south through agricultural lands on a wide valley floor before flowing through the town of Colrain. From Colrain, the East Branch flows less than another mile through Foundry Village before joining the West Branch.

A number of water quality and habitat issues that potentially affect instream biological conditions are known to occur in the North River watershed. Significant sedimentation and erosion of the East Branch between Colrain and the Vermont border were reported as far back as 1990 (USDA Soil Conservation Service 1990). Habitat surveys performed in 2004 identified several segments of the East Branch with significant habitat degradation (Lipsky 2004). Local activities that have likely affected aquatic habitat in the East Branch include floodplain agricultural development, streambed gravel extraction, channel straightening, streambank modification, and riparian vegetation clearing. These practices have resulted in stream channel instability, river widening, sediment deposition, and consequent water quality and habitat quality degradation (Lipsky 2004). Despite these degraded conditions, macroinvertebrate communities were found to be non/slightly impaired by a MA Department of Environmental Protection (DEP) assessment of the Deerfield River watershed in 2000 (Fiorentino and Miaetta 2002).

Nonpoint source pollution from agricultural sources and failing septic systems is another area of concern in the North River watershed, as it is in most rural watersheds. Recent bacteria assessments in the North River found elevated bacteria levels in the East Branch downstream of the Rt112 bridge in Colrain (Cole et al. 2008). While the source of these elevated levels was not identified, upriver agricultural operations are a potential cause. A comprehensive biological assessment of the North River Watershed aims to characterize ecological health throughout the watershed and identify river reaches that are potentially impaired by these degraded water quality or physical habitat conditions.

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METHODS

SAMPLE SITE SELECTION

Sample sites for this study were selected to provide coverage of the North River, its two major branches, and its major tributaries (Figure 1). Sixteen river and stream reaches were selected for sampling in 2007, including the Cold River, which occurs outside of the North River watershed. The North River watershed is primarily forested; the percent forested area occurring upstream of each reach averaged 88%, and ranged from 82 to 94% (Table 1). Drainage area upstream of each site ranged from 10.5 km^2 at Sanders Brook to 241 km^2 at the lowest North River site.

Three sites were selected each on the mainstem North River and on the West Branch of the North River (Table 1). Six sites were selected on the East Branch of the North River. Three larger tributaries – Sanders Brook, Taylor Brook, and Branch Brook – were also sampled (Table 1). The Sanders Brook watershed supported the highest percent forested area and therefore was selected as the reference site for comparison with the other tributaries. Owing to small watershed areas, the uppermost East Branch reach (EBNM06) and the two upper West Branch reaches (WBNM02, WBNM03) were included in the tributary reach group for this assessment (Table 1).

Site NORM02 occurs immediately below the Barnhardt Plant in Griswoldville, which discharges treated wastewater into the North River under a NPDES permit. Although NORM02 occurs below the plant, the site was located *upstream* of the point at which the treated effluent enters the mainstem because the effluent is conveyed for nearly 100 m down a side channel before entering the main river flow downstream of the riffle area sample for this assessment.

FIELD DATA COLLECTION

Macroinvertebrate samples were collected between September 22 and September 27, 2007 (one site, EBDM06, was sampled on October 9) using methods employed by the DWM for assessing the condition of macroinvertebrate communities in Massachusetts streams (Nuzzo 2003). These methods are based on the US EPA Rapid Bioassessment Protocols (RBPs) for wadeable streams and rivers (Barbour et al. 1999). Sampling activities were conducted in accordance with the Quality Assurance Project Plan (QAPP) for the DRWA benthic macroinvertebrate monitoring program (Cole and Walk 2005). Macroinvertebrates were collected from each site using kick-sampling, a method by which organisms are sampled by disturbing streambed substrates and catching dislodged organisms in a net. At each sample site, ten kick samples of approximately 0.46 m x 0.46 m were collected and composited for a total sampled area of approximately 2 m^2. Sampling targeted fast-water areas with coarse substrate within each of the sample sites. Samples were labeled and preserved in the field with denatured 95% ethanol for later processing and identification in a laboratory.

SAMPLE SORTING AND MACROINVERTEBRATE IDENTIFICATION

Samples were sorted to remove a 100-organism subsample from the original sample using procedures described in Nuzzo (2003). Samples were first distributed in gridded pans. Macroinvertebrates were sorted from randomly selected grids until 100 organisms (±10%) were removed. The remainder of the unsorted grids was then scanned for large/rare organisms that were not encountered during the 100-organism subsampling. These organisms were then removed and placed in a separate "large/rare" organism vial.

Specimens were identified to the lowest practical taxonomic level (generally genus or species) as allowed by specimen condition and maturity. Taxonomic keys used included Merritt and Cummins 1996, Wiggins 1996, Stewart and Stark 2002, Peckarsky et al. 1990, and Epler 2000.

DATA ANALYSIS

Macroinvertebrate taxonomic data were analyzed using DWM's modification (Nuzzo 2003) of EPA's Rapid Bioassessment Protocol III multimetric scoring and analysis (Barbour et al. 1999) to determine the condition of macroinvertebrate communities. Multimetric analysis employs a set of metrics, each of which describes an attribute of the macroinvertebrate community that is known to be responsive to one or more types of pollution or habitat degradation. Because a number of biological attributes is simultaneously evaluated, the multimetric approach is a robust assessment tool and a deficiency in any one metric should not invalidate assessment results (Barbour et al. 1999). Each attribute value is first calculated from the taxonomic data and then converted to a standardized score by comparison with the reference site score (Table 2). Standardized scores of all metrics are then summed to produce a single multimetric score that is a numeric measure of overall biological integrity. DWM currently employs a 7-metric set for use with fast-water samples from streams (Table 2).

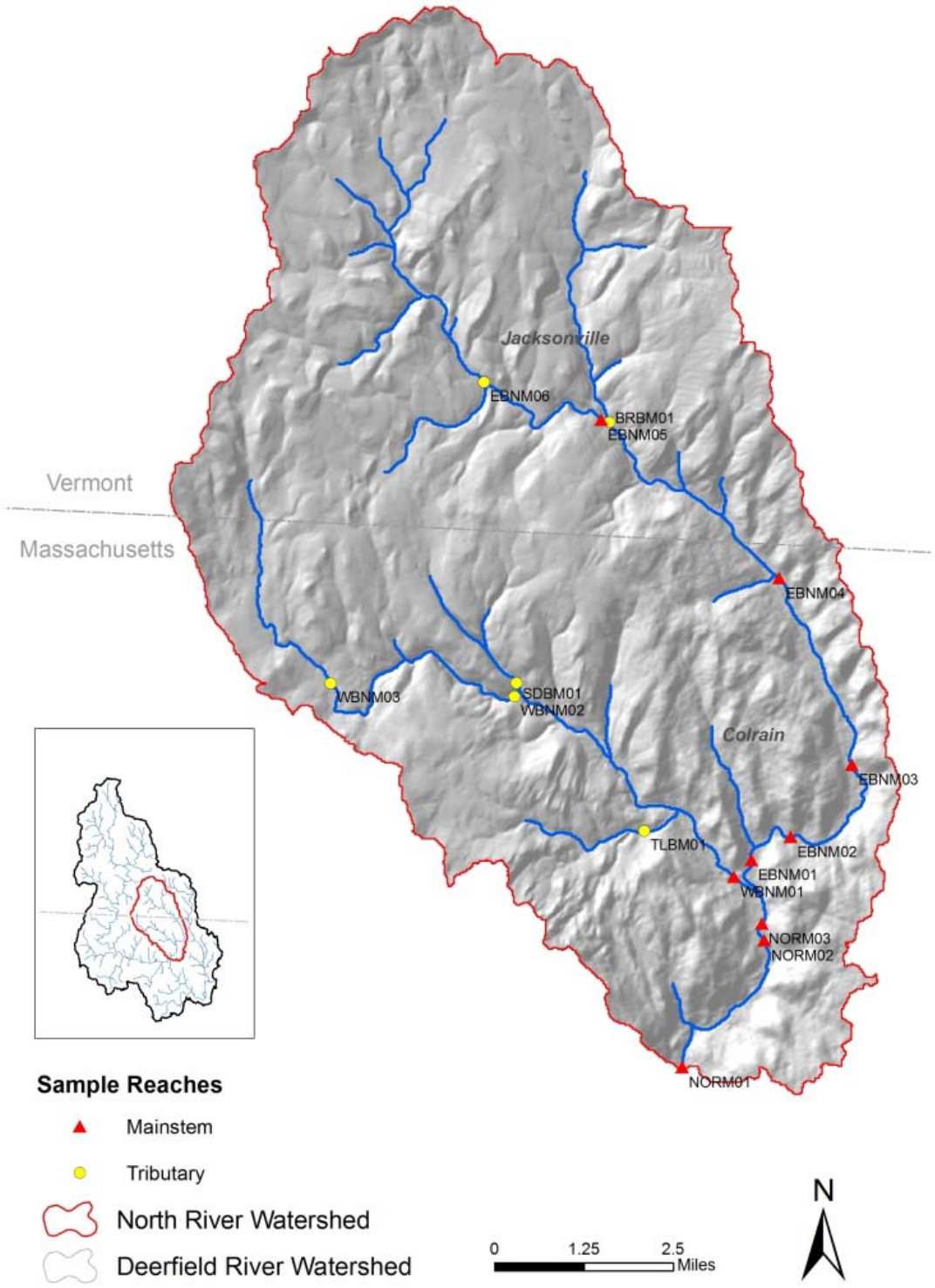

Figure 1. Locations of stream and river reaches in the North River watershed, Franklin County, Massachusetts and Windham County, Vermont, where macroinvertebrates were sampled in September 2007.

Table 1. Stream reaches sampled for macroinvertebrates in the North River watershed, Franklin County, Massachusetts and Windham County, Vermont in September 2007.

Site Code	Waterbody	Watershed Area (km^2)	% Area Forested	Location
NORM01	North River	240.95	87.01	75 m above confluence with Deerfield River
NORM02	North River	221.27	86.64	RM ~2.2, ~150 m below 2nd 112 Xing (immed.below Barnhardt plant)
NORM03	North River	220.62	86.67	RM ~2.7 upstream of Adamsville Road Bridge
WBNM01	W Br North River	78.97	87.45	US Adamsville Road crossing by graveyard
WBNM02	W Br North River	33.05	86.65	above confluence with Sanders Brook
WBNM03	W Br North River	17.77	89.96	downriver side of Rt 8A road crossing in North Heath
EBNM01	E Br North River	139.44	86.48	RM ~3.5, upriver side of Lyonsville Rd Bridge (Arthur A. Smith bridge)
EBNM02	E Br North River	129.45	86.38	RM ~4, downriver end of old dump site adj to Colrain fire dept and town hall
EBNM03	E Br North River	123.06	86.38	RM ~6, ~100 m below Reil Lane
EBNM04	E Br North River	111.07	86.54	Rt 112 crossing just below VT/MA border (bact site NOR006)
EBNM05	E Br North River	59.87	83.1	Above confluence with Branch Brook
EBNM06	E Br North River	38.71	82.13	Upstream Smith Rd/Rt 112 intersection (park on side of road)
BRBM01	Branch Brook	24.84	89.58	Above confluence with E Br North River
TLBM01	Taylor Brook	13.09	86.89	~100 m downstream of N Catamount Road bridge
SDBM01**	Sanders Brook	10.49	94.21	Above Colrain Mountain Road crossing
CDRM01*	Cold River	73.33	92.18	~0.75 km upriver of Mohawk State Forest Campground

*Reference reach located outside of the North River watershed
**Tributaries reference reach

Table 2. MA DEP metric set and scoring criteria (relative to reference station) used to assess the condition of macroinvertebrate communities in the North River watershed, September 2007.

	Scoring Criteria			
Metric	**6**	**4**	**2**	**0**
Taxa Richness	>80%	60-80%	40-59%	<40%
EPT	>90%	80-90%	70-79%	<70%
EPT/Chironomidae (abundance ratio)	>75%	50-75%	25-49%	<25%
HBI (modified)	>85%	70-85%	50-69%	<50%
Scraper/Filtering collector Ratio	>50%	35-50%	20-34%	<20%
% Contribution of Dominant Taxon	<20%	20-29%	30-40%	>40%
Similarity Index: % Reference Affinity	>64%	50-64%	35-49%	<35%

Metric Descriptions (from Fiorentino and Miaetta 2002)

1. Taxa Richness—A count of the number of taxa present. Taxa richness generally increases with increasing water quality and habitat quality.

2. EPT Index—The number of taxa 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. 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—Uses the ratio of EPT to Chironomidae abundance as a measure of community balance. Macroinvertebrate communities with a disproportionately large number of the generally tolerant Chironomidae relative to the more sensitive insect groups may indicate a stressed community.

5. Percent Contribution Dominant Taxon—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.

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—Compares study site community data 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 Deerfield River watershed bioassessment, an index of macroinvertebrate community composition was calculated based on similarity (i.e., affinity) to the reference community, expressed as percent composition of the following organism groups: Oligochaeta, Ephemeroptera, Plecoptera, Coleoptera, Trichoptera, Chironomidae, and Other. This approach is based on a modification of the Percent Model Affinity (Novak and Bode 1992). The reference site affinity (RSA) metric is calculated as:

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

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

Metric values for each study site were scored based on comparability to a "least impacted" reference station, and scores were totaled. The percent comparability of total metric scores for each study site to those for the reference site is then used to assign a

biological condition or impact class to the site. RBP III utilizes four categories in its impact classification of non-impacted (>83% reference comparability), slightly impacted (54-79% reference comparability), moderately impacted (21-50% reference comparability), and severely impacted (<17% reference comparability). For this study, the Cold River, another tributary to the Deerfield River, was used as the reference site for mainstem North River and East and West Branch sites, and Branch Brook was used as the reference site for smaller tributary streams.

QUALITY CONTROL

A Quality Assurance Project Plan (QAPP) was developed and written for this project (Cole and Walk 2005). The QAPP included all required state and federal elements and was approved by MA DEP and the US Environmental Protection Agency prior to the beginning of this assessment. Elements of the QAPP included the project background, site selection rationale, measurement quality objectives, training, documentation, sampling design, protocols, quality control requirements, instrument/equipment testing and maintenance, data management, data review, and data validation. Although the details of the QAPP are too lengthy to present in the context of this report, several of the critical elements of the QAPP are as follows.

Volunteers collecting field samples and data were trained on the day they assisted in the field and worked closely at all times in the field with Dr. Michael Cole. All macroinvertebrate identifications were performed by Michael Cole, a professional aquatic entomologist. Representative specimens of each taxon encountered were labeled and saved as vouchers for later reference and verification, as needed. Sorted macroinvertebrate samples were preserved in 95% ethanol and archived. Unsorted fractions of all samples were also preserved and will be archived for two years following project completion. All data entered into spreadsheets were checked for transcription errors and outliers before analyses were performed. Analyses were also checked for errors in formulae used and results.

RESULTS & DISCUSSION

PHYSICAL CONDITIONS

All three mainstem North River reaches received relatively low physical habitat scores, ranging between 125 and 132. Compared to the Cold River reference reach, these reaches scored low for substrate embeddedness, sediment deposition, habitat diversity, and riparian zone width (Table 3). Substrate conditions were similar among the three mainstem reaches, but NORM01 supported slightly higher proportions of boulder substrate than did the other two reaches (Figure 2). Elevated sediment loading and deposition problems appear to occur throughout the mainstem. Because Rt 112 so closely parallels the North River, the east bank riparian zone of each of these reaches is narrow (a side street limits the riparian zone width at NORM02). Agriculture on the west side of NORM03 reduces the riparian zone to a narrow strip in this reach.

West Branch reaches all scored higher, ranging between 147 and 173, suggesting less degraded habitat conditions than those occurring in the mainstem. The West Branch flows through a tighter valley than does the mainstem or East Branch, precluding extensive agricultural development along much of the floodplain. Consequently, among the three major segments (mainstem, West Branch, and East Branch), the West Branch currently supports the least modified channel or riparian conditions. Substrate composition was similar among the three West Branch reaches; cobble and pebble substrates were generally dominant (Figure 2), and substrate embeddedness was moderately low.

East Branch physical habitat assessment scores ranged widely, from 125 at EBNM01 to 166 at EBNM05. Substrate embeddedness, sediment deposition, and habitat diversity scores generally improved in an upriver direction (Table 4). Among six East Branch sites, EBNM01 received the lowest scores for sediment deposition and embeddedness. EBNM02 and EBNM03 received only slightly higher sediment and embeddedness scores, suggesting that these lower East Branch sites continue to receive and retain elevated sediment loads. Erosion and sedimentation problems occur throughout the lower East Branch. Figure 3 exemplifies the problems occurring in much of the lower watershed: riparian vegetation clearing, channel widening, and bank erosion all contribute to sediment loading and impaired physical and chemical conditions.

The upper East Branch sample sites, EBNM04 through EBNM06, received total habitat scores between 147 and 166, suggesting physical habitat conditions that are only slightly degraded relative to reference conditions. Embeddedness and sediment deposition scores are higher than in downriver reaches (Table 4). However, riparian conditions were generally intact on only one bank, resulting in lower riparian-conditions scores for these reaches relative to the reference condition.

The East Branch tributary, Branch Brook, supported physical habitat conditions that outperformed those from the tributary reference site, Sanders Brook (Table 5). Branch Brook received higher scores for embeddedness and sediment deposition. Eroding streambanks were also noted at Sanders Brook, suggesting potentially altered hydrology within the drainage. Visual estimates of substrate composition indicated that Sanders Book contains larger amounts of deposited sand than does Branch Brook (Figure 4), despite Sanders occurring in a more heavily forested drainage (94 vs 90%).

Taylor Brook received the lowest scores for sediment deposition and embeddedness (Table 5), which resulted in the lowest total habitat assessment score of 121. Taylor Brook is known to have sediment problems from the unpaved section of road that parallels much of the upper section of stream. While Taylor Brook flows through a primarily forested drainage, an access road to a development in its headwaters closely parallels the road for most of the brook's length. Unpaved sections deliver large amounts of sediment-laden runoff during rain events (Figure 5). Sections of this road have been paved to reduce road washouts and stream degradation, but the road continues to supply large quantities of sediment to Taylor Brook.

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Table 3. Habitat assessment scores of nine mainstem sites in the North River watershed sampled for macroinvertebrates in September 2007. The Cold River (CDRM01), a nearby watershed, was sampled to represent reference conditions. For primary parameters (first 7 in table), scores range from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For secondary parameters, 1st value is from left bank and 2nd is from right (last 3 rows in table before "total score"); scores range from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor.

	Mainstem Site									
Variable	CDRM 01	NORM 01	NORM 02	NORM O3	EBNM 01	EBNM 02	EBNM 03	EBNM 04	EBNM 05	WBNM 01
INSTREAM COVER	18	16	15	16	13	16	14	15	17	15
EPIFAUNAL SUBSTRATE	19	16	15	15	14	17	14	17	18	19
EMBEDDEDNESS	16	12	11	12	12	13	13	14	16	12
CHANNEL ALTERATION	18	14	12	14	16	17	16	17	18	18
SEDIMENT DEPOSITION	16	12	12	12	13	14	14	16	17	14
VELOCITY-DEPTH COMBINATIONS	17	14	11	11	12	15	12	15	17	12
CHANNEL FLOW STATUS	18	14	14	16	13	18	16	16	18	15
BANK VEGETATIVE PROTECTION	9,9	7,7	7,7	8,8	5,5	8,8	8,8	8,6	8,8	7,8
BANK STABILITY	9,9	7,7	7,7	7,7	5,5	8,8	8,8	8,5	8,8	9,9
RIPARIAN VEGETATIVE ZONE WIDTH	10,8	7,8	2,10	3,3	3,9	10,10	3,5	7,3	8,5	2,7
TOTAL SCORE	176	125	130	132	125	162	139	147	166	147

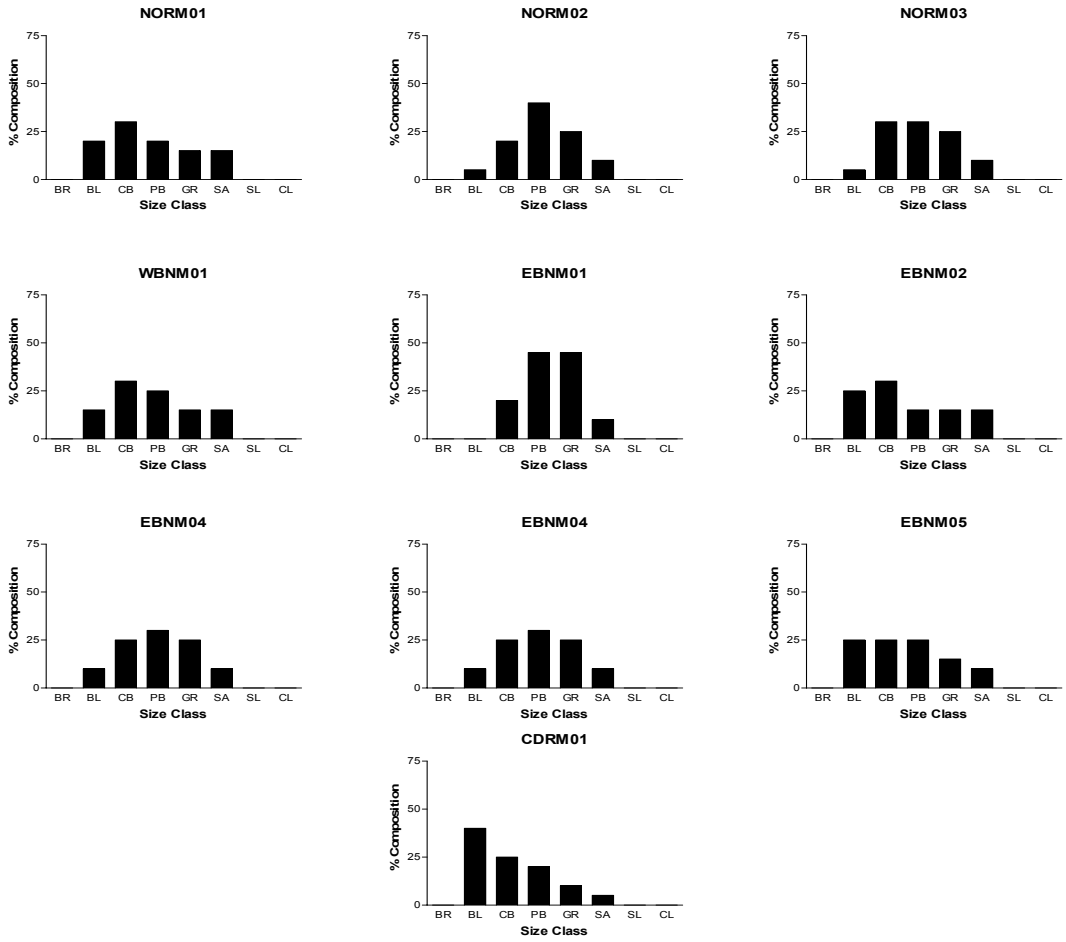

Figure 2. Visual estimates of substrate composition in nine sites in the North River watershed sampled for macroinvertebrates in September 2007. The Cold River (CDRM01), a nearby watershed, was sampled to represent reference conditions. BR = bedrock; BL = boulder, >256 mm, CB = cobble, 64-256 mm; PB = pebble, 16-64 mm; GR = gravel, 2-16 mm; SA = sand, 0.06-2 mm; SL = silt, 0.004-0.06 mm; CL = clay, <0.004 mm.

Variable	SDBM01	EBNM06	BRBM01	WBNM02	WBNM03	TLBM01
INSTREAM COVER	18	13	18	18	17	18
EPIFAUNAL SUBSTRATE	15	17	18	18	17	15
EMBEDDEDNESS	11	16	17	14	14	5
CHANNEL ALTERATION	17	17	18	18	16	15
SEDIMENT DEPOSITION	14	15	18	16	14	5
VELOCITY-DEPTH COMBINATIONS	15	17	17	17	15	15
CHANNEL FLOW STATUS	15	13	14	18	15	15
BANK VEGETATIVE PROTECTION	8,8	7,9	8,8	9,9	8,8	5,5
BANK STABILITY	8,8	8,9	9,9	9,9	8,8	3,3
RIPARIAN VEGETATIVE ZONE WIDTH	5,10	2,9	10,8	8,10	8,5	7,10
TOTAL SCORE	152	152	172	173	153	121

Table 4. Habitat assessment scores of six tributary reaches in the North River watershed sampled for macroinvertebrates in September 2007. For primary parameters (first 7 in table), scores range from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For secondary parameters, 1st value is from left bank and 2nd is from right (last 3 rows in table before "total score"); scores range from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor. Sanders Brook (SDBM01) represents reference conditions.

Figure 3. Widened section of the East Branch of the North River above Colrain center with low habitat diversity, eroding banks, and no riparian buffer along south side.

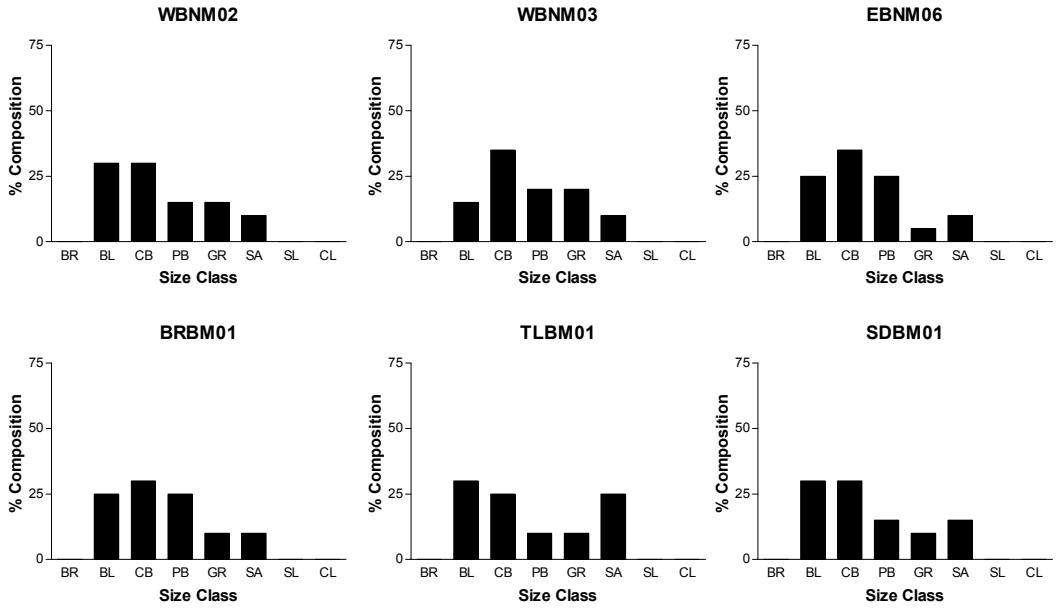

Figure 4. Visual estimates of substrate composition in North River watershed tributary reaches sampled for macroinvertebrates in September 2007. BR = bedrock; BL = boulder, >256 mm, CB = cobble, 64-256 mm; PB = pebble, 16-64 mm; GR = gravel, 2-16 mm; SA = sand, 0.06-2 mm; SL = silt, 0.004-0.06 mm; CL = clay, <0.004 mm.

Figure 5. Taylor Brook receives heavy sediment loads from the adjacent unpaved road that parallels the upper portion of the brook (left), resulting in very turbid water full of suspended sediment during rain events (right). These photographs were taken in summer, 2007.

MACROINVERTEBRATE COMMUNITIES

North River Mainstem Reaches

Macroinvertebrate communities in the North River scored exclusively in the non-impacted range relative to reference-reach conditions (Table 5). Multimetric scores ranged from 38 at NORM01 to 42 at NORM02 and NORM03. Total taxa richness compared favorably at the mainstem sites relative to the 34 taxa sampled from the Cold River reference site; 33 or more taxa were sampled each of these three sites (Table 6 and Figure 7). Hilsenhoff HBI scores were slightly higher at NORM01 and NORM02 than at the Cold River reference reach, suggesting that the macroinvertebrate assemblages in these reaches may be more tolerant to organic enrichment pollution than are those in the Cold River reference reach. As mentioned earlier, NORM02 occurred immediately downriver of the Barnhardt non-woven products plant, but the treated discharge point occurred at the lower end of the riffle that was sampled for this assessment (Figure 6). Therefore, these results do not integrate effects of the plant's treated effluent on the biology in the receiving water.

One West Branch site, WBNM01, occurred in a drainage area large enough (>50 km^2) to be compared to the Cold River reference. WBNM01 received a total score of 40 and a corresponding rating of not impacted. Individual metrics were similar to those from the Cold River; total richness was higher from WBNM01 (39) than from the Cold river reference reach (35).

Five East Branch sites were treated as mainstem sites and compared to the Cold River reference site. All five East Branch sites scored in the non-impacted range, with total scores ranging from 38 at EBNM03 to 42 at EBNM02, EBNM04, and EBNM05 (Table 5). Total taxa richness in all five East Branch sites was higher than in the Cold

River reference site (Table 6). EPT richness was as higher at four of the sites than at the Cold River site. HBI values generally worsened with downriver distance; upper East Branch sites 4 through 6 received HBI scores between 2.4 and 2.8, while downriver East Branch sites 1 through 3 received HBI scores ranging from 3.6 to 3.9. While only slightly lower than the Cold River reference site HBI value (3.2), these values are markedly higher than those of upriver sites within the same waterbody, suggesting that macroinvertebrate communities in the lower East Branch have shifted towards an assemblage structure that is more tolerant to organic pollution.

All Mainstem sites (3 North River, 5 East Branch, and the lowest West Branch site) supported unimpaired communities relative to the Cold River reference reach. While comparing conditions from each site to a designated reference reach is the current standard used to determine benthic conditions, comparing conditions among test sites, such as along a longitudinal series of sites can be informative. While all mainstem reaches scored favorably relative to the reference reach, variability among sites in taxa richness, functional composition, and collective tolerance to organic pollution suggests that slight impairment is likely occurring to benthic communities in the lowest reaches in the drainage, but this impairment has not resulted in significant changes to these communities.

Our results are similar to those obtained by DWM's last published benthic assessment of the North River. In 2000, DWM sampled the lower North River between NORM01 and NORM02 (referred to as NOR01 in their 2004 report; DWM 2004). Based on their assessment site score of 36, DWM classified the lower North River as not impacted. Our 2007 scores of 38 and 42 from NORM01 and NORM02, respectively, suggest that biological conditions in the lower river have not significantly changed since 2000. DWM also sampled the East Branch of the North River in Colrain in 2000. DWM found this reach to be non/slightly-impacted at 81% of the reference condition (DWM 2004) with a total score of 34. Our 2007 result of a total score of 42 from EBNM02 suggests that conditions in this reach have remained unchanged or have even slightly improved over 2000 conditions.

Table 5. RBP III summary scores, reference comparability scores, and corresponding biological condition classifications of macroinvertebrate communities sampled from mainstem sites in the North River watershed in September 2007.

	Mainstem Sites									
	CDRM 01	NORM 01	NORM 02	NORM O3	EBNM 01	EBNM 02	EBNM 03	EBNM 04	EBNM 05	WBM 01
Total Score	42	38	42	42	38	42	38	42	42	40
% Comparability to Reference	100	90	100	100	90	100	90	100	100	95
Biological Condition	REFERENCE	Not impacted	Not Impacted	Not Impacted	Not Impacted	Not Impacted	Not Impacted	Not Impacted	Not Impacted	Not Impacted

Table 6. Metric values (and standardized metric scores) derived from macroinvertebrate samples collected from mainstem sites in the North River watershed in September 2007.

	Mainstem Sites									
Metric	CDRM 01	NORM 01	NORM 02	NORM O3	EBNM 01	EBNM 02	EBNM 03	EBNM 04	EBNM 05	WBM 01
Richness	34	33	38	43	37	40	39	35	35	39
EPT Richness	24	20	25	29	21	27	26	27	24	25
EPT/Chironomidae	5.1	38	26.3	6.7	12.2	21.0	7.3	42.0	25.7	8
HBI modified	3.2	4.0	3.6	3.2	3.9	3.6	3.8	2.6	2.4	3.7
Scraper/Filterer Ratio	0.4	1	1.1	0.8	0.6	0.7	0.4	0.9	0.9	0.6
% Dominant Taxon	15.5	14	11.9	13.1	19.6	14.5	21.3	18.8	10.1	8.1
% Reference Affinity	100	61	68.2	75.9	80.5	76.1	87.6	67.9	74.6	82.3

Figure 6. Area sampled at NORM02 relative to location of Barnhardt plant effluent location of entry into the mainstem (small channel on right).

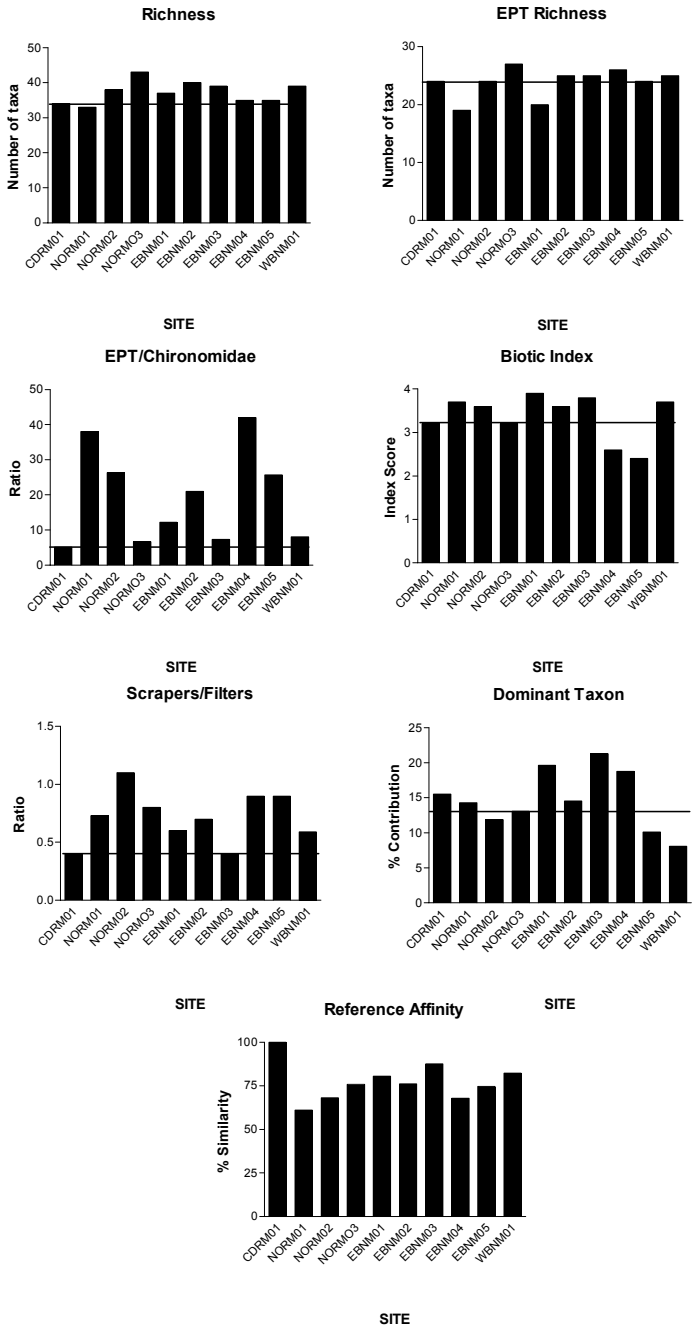

Figure 7. Metric attribute values calculated from macroinvertebrate samples collected from North River mainstem sites in September 2007. Black horizontal lines indicate value of each attribute at the reference site on the Cold River (CDRM01).

North River Tributary Reaches

The Sanders Brook reference site (Table 7) supported a macroinvertebrate community with a high total taxonomic richness (35 taxa) and moderately high EPT richness (20 taxa). A moderately high EPT/Chironomidae ratio suggests dominance by the more sensitive EPT taxa (Table 8, Figure 8). A low HBI score of 2.9 suggests that Sanders Brook supports a benthic community that is largely intolerant of organic-enrichment pollution. The scraper-to-filterer ratio was high, suggesting little influence of elevated levels of suspended organic material on structuring the benthic community. Relative to the Sanders Brook reference reach, the Branch Brook reach scored as non-impacted (Table 7), with a number of individual metrics outperforming those from Sanders Brook (Table 8).

Two West Branch reaches, WBNM02 and WBNM03, occur in small drainage areas (33 and 18 km^2, respectively), and were therefore compared to the tributary reference reach, Sanders Brook. Relative to the Sanders Brook reference reach, both reaches scored in the unimpaired range (Table 7). The uppermost West Branch site, WBNM03, received a total score of 42 and individual metrics were generally similar to those received by the reference site (Table 8). WBNM02 received a total score of 36; while HBI scores were particularly low at WBNM02, percent dominance was high. The community was numerically dominated at this site by the filter-feeding caddisfly, *Brachycentrus solomoni*, resulting in a low scraper-to-filterer ratio and suggesting a shift in community structure at this site relative to other sites in the watershed. The uppermost reach in the East Branch of the North River, EBNM06, drains an area of 39 km^2, and was therefore compared to the Sanders Brook reference reach. EBNM06 received a total score of 38, which corresponds to a "not impacted" classification relative to the Sanders Brook reference reach.

Despite extensive sediment deposition, Taylor Brook also scored as non-impacted relative to the Branch Brook reference reach (Table 7). While total taxonomic richness was lower (29) than that measured from the reference reach (35), an EPT richness of 22 was higher (Table 8). Although the overall score and individual metrics indicated little or no departure from expected conditions, it should be noted that the Taylor Brook reach was dominated by immature larvae of the sediment-tolerant mayfly genus, *Ephemerella*, and by the sediment-tolerant caddisfly, *Hydropsyche*. These two taxa represented nearly half of the individuals sampled from this site. This dominance by a few sediment-tolerant taxa suggests that elevated sediment loads have altered community structure in Taylor Brook, but not to the extent that significant biological impairment is occurring.

Results of BMI surveys of these tributary reaches further suggest that benthic communities throughout the North River watershed show little evidence of impacts from human activity. Local sources of agricultural runoff, although not directly observed, may be resulting in slight shifts in community structure that result in an increased collective tolerance to organic enrichment pollution. Based on observations from this and other studies, elevated amounts of sediment are being deposited in lower reaches of the watershed; consequently, macroinvertebrate communities may also presently be slightly affected by fine sediments in parts of the watershed, although these effects presently appear to be minimal.

Maintenance of healthy benthic communities and overall ecological health of the North River watershed rests on continued stewardship of these aquatic resources and adjacent riparian habitats. Prevention of further loss of mature riparian zones in the watershed is necessary to ensure the continued health of these communities. Most importantly, restoration of degraded riparian areas within the watershed would benefit the health of these aquatic systems by reducing sediment loads and increasing channel stability, habitat complexity, shade, and delivery of woody debris and food materials for aquatic life.

Table 7. RBP III summary scores, reference comparability scores, and corresponding biological condition classifications of macroinvertebrate communities sampled from tributaries in the North River watershed in September 2007.

	Tributary Site					
	SDBM 01	EBNM 06	BRBM 01	WBNM 02	WBNM 03	TLBM 01
Total Score	42	38	42	36	42	40
% Comparability to Reference	100	90	100	86	100	95
Biological Condition	REFERENCE	Not Impacted	Not Impacted	Not Impacted	Not Impacted	Not Impacted

Table 8. Metric values (and standardized metric scores) derived from macroinvertebrate samples collected from North River watershed tributaries in September 2007.

	Tributary Site					
Metric	SDBM 01	EBNM 06	BRBM 01	WBNM 02	WBNM 03	TLBM 01
Richness	35	30	39	31	37	29
EPT Richness	20	18	26	19	23	22
EPT/Chironomidae	6.4	4.6	7.7	12.3	6.5	19.6
HBI modified	2.9	2.8	2.7	2.2	3.0	2.2
Scraper/Filterer Ratio	1.2	0.6	1.4	0.2	0.7	0.7
% Dominant Taxon	12.1	13.2	10.8	31.6	8.6	25.5
% Reference Affinity	100.0	89.5	87.9	62.3	76.7	64.9

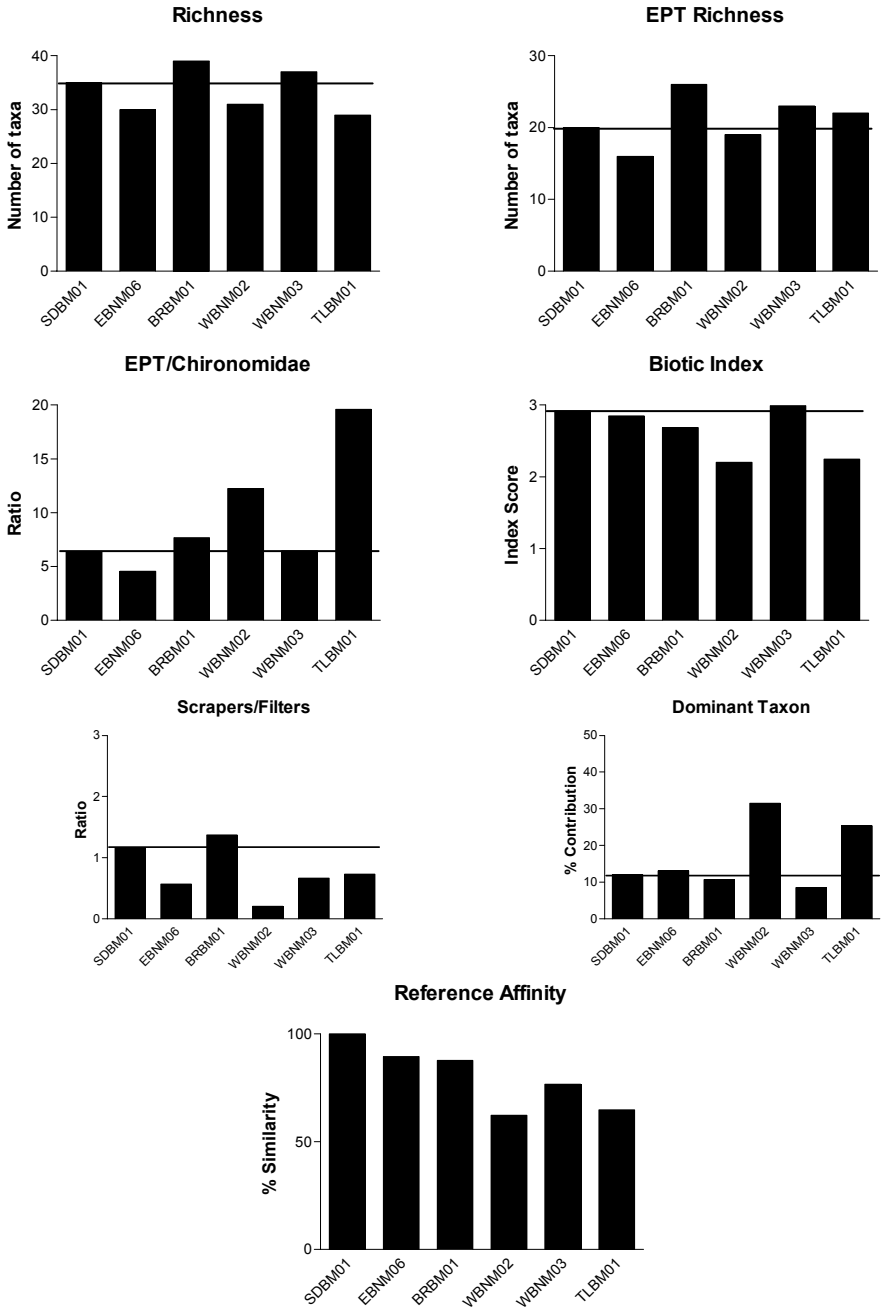

Figure 8. Metric attribute values calculated from macroinvertebrate samples collected from three tributary streams in the North River watershed in September 2007. Black horizontal lines indicate value of attribute at the reference site on the Branch Brook (BRBM01).

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APPENDIX I – SAMPLE SITE PHOTOS

NORM01 – North River: 75 m above confluence with Deerfield River

NORM02 – North River: RM ~2.2, ~150 m below 2nd 112 Xing (immed.below Barnhardt plant)

NORM03 – North River: RM ~2.7 upstream of Adamsville Road Bridge

WBNM01 – West Branch North River: at Adamsville Road crossing by graveyard

WBNM02 – West Branch North River: above confluence with Sanders Brook

WBNM03 – West Branch North River: downriver side of Rt 8A road crossing in North Heath

EBNM01 – East Branch North River: RM ~3.5, upriver side of Lyonsville Rd Bridge (Arthur A. Smith bridge)

EBNM02 – East Branch North River: RM ~4, downriver end of old dump site adj to Colrain fire dept and town hall

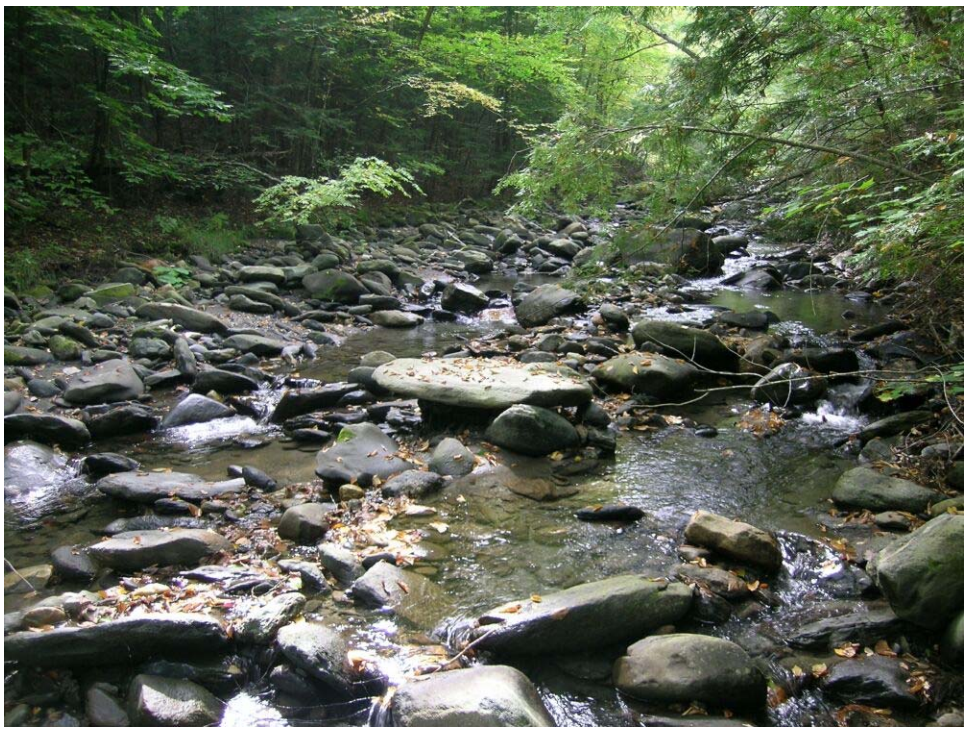
EBNM03 – East Branch North River: RM ~6, ~100 m below Reil Lane

EBNM04 – East Branch North River: Rt 112 crossing just below VT/MA border (DRWA bacteria monitoring site NOR006)

EBNM05 – East Branch North River: above confluence with Branch Brook

EBNM06 – East Branch North River: upstream Smith Rd/Rt 112 intersection (park on side of road)

BRBM01 – Branch Brook: above confluence with E Br North River



TLBM01 – Taylor Brook: ~100 m downstream of N Catamount Road bridge

SDBM01 – Sanders Brook: above Colrain Mountain Road crossing

CDRM01 – Cold River: ~0.75 km upriver of Mohawk State Forest Campground