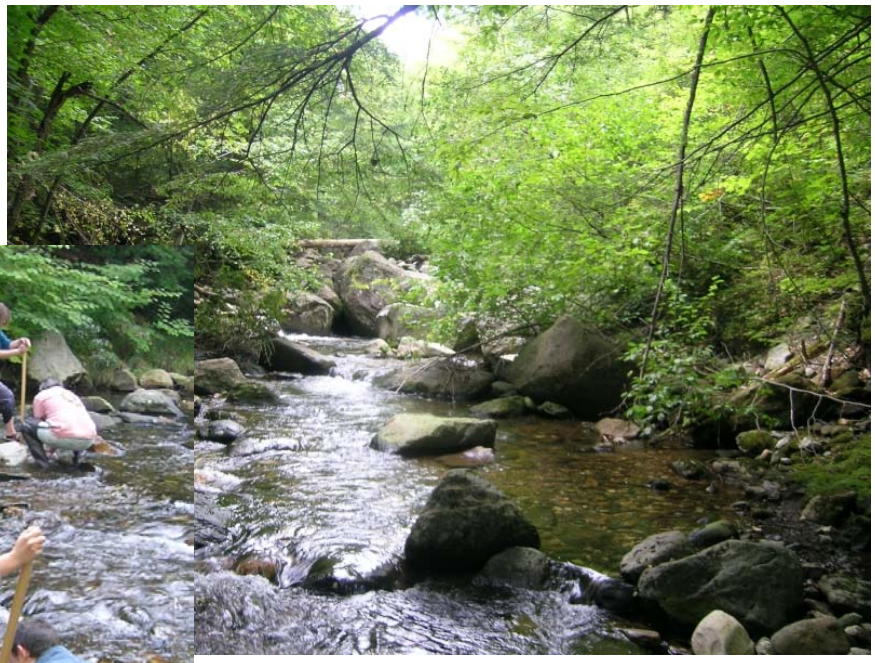
DEERFIELD RIVER TRIBUTARIES
2008 MACROINVERTEBRATE ASSESSMENT
(Franklin & Berkshire Counties, Massachusetts)



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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 augment 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. Since the program's inception in 2005, DRWA has assessed 53 stream and river reaches in the watershed through 2008. This report includes only the results of the 2008 assessment.

- Fifteen tributary reaches were selected for sampling in 2008. Several smaller subwatersheds – including the Cold River, Chickley River, Clesson Brook, and several other smaller brooks – were selected for the program's fourth year of sampling. These tributaries collectively drain the mid portions of the Deerfield River watershed. The North, South, and Green river watersheds, surveyed from 2005 through 2007, all occur downriver, while the Vermont portion of the watershed, to be sampled in 2009, occurs upriver of this central area of the watershed.

- Macroinvertebrate community conditions in the Cold River reference reach (CDRM01) were very similar to those measured at this site in 2007. Relative to these Conditions in the Cold River reference reach, multimetric scores ranged from 28 to 42. Two of the fourteen sites – Dunbar Brook (DNBM01) and Mill Brook south (MLSM01) – scored in the slightly impacted range, receiving total scores of 28 and 30, respectively, while twelve of the fourteen test sites scored in the non-impacted range.

- Dunbar Brook was one of only two sites to receive a slightly impaired determination, an unexpected result because Dunbar Brook is a heavily forested and relatively pristine watershed. Physical habitat conditions were excellent with no apparent degradation of any type. The lower-than-expected macroinvertebrate community conditions can only be explained by sampling error or impaired water quality, perhaps slightly acidic conditions. Further sampling of the macroinvertebrate community and water chemistry in Dunbar Brook is warranted based on the results of this study.

- The tributaries Pelham Brook, Mill Brook north, Tannery Brook, and the Bear River scored in the non-impacted range. While increased sediment deposition

was noted in the Bear River in 2008, the benthic community appeared to be minimally affected by this disturbance, as BBRM01 received a total score of 40

- Clesson Brook total benthic scores ranged from 38 at the uppermost site to 42 at the lowermost site, resulting exclusively in non-impacted determinations. Mill Brook south, a major tributary to Clesson Brook, received low scores for EPT taxa richness and percent dominance by one taxon, which resulted in a slightly impacted determination.

- The lower and upper Cold River reaches, CDRM02 and CDRM03, both scored in the non-impacted range, while the three Chickley River sites included in this assessment also scored exclusively in the non-impacted range. Total benthic scores ranged from 36 at the uppermost Chickley River site (CHRM03) to 42 at each of the two lower sites (CHRM01 and CHRM02).

- Overall, results of the 2008 macroinvertebrates surveys of these Deerfield River tributaries suggest that benthic communities throughout the middle Deerfield River watershed show little evidence of impacts from human activity. Measured impacts in Dunbar Brook are likely related to low pH and require further investigation. Likewise, additional work should be performed on Mill Brook to identify the sources of potential impairment to the benthic community.

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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, Carrie Banks, and Robin Creamer. Jason Saltman also sorted macroinvertebrate samples in the lab and created the map for 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 lead, Dr. 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, 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. Using this design, DRWA will survey from different subwatersheds during each of 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 in 2007 (Cole 2008). In 2008, the Cold River, Chickley River, and Clesson Brook subwatersheds were assessed, as well as were several smaller tributaries that drain directly into the Deerfield River. Through 2008, the DRWA has assessed biological conditions in 53 reaches in four years and will assess biological conditions in nearly 60 stream and river reaches after the first five years.

Several smaller subwatersheds – including the Cold River, Chickley River, Clesson Brook, and several other smaller brooks – were selected for the program's fourth year of sampling. These tributaries collectively drain the mid portions of the Deerfield River watershed. The North, South, and Green river watersheds, surveyed from 2005 through 2007, all occur downriver, while the Vermont portion of the watershed, to the north, occurs upriver of this central area of the watershed. As the Deerfield River flows

south from Vermont into Massachusetts, the river is impounded by Sherman Reservoir, which is bisected by the state line. From Sherman, the river flows another ¾ mile downriver to the Deerfield Number 5 Dam in the town of Monroe, where some of the river water is diverted into a penstock. Dunbar Brook occurs on the river's west side approximately another 2 miles downriver, just upriver of the Bear Swamp project's Lower Reservoir. A small impoundment occurs on the lower end of Dunbar Brook, effectively disconnecting Dunbar Brook from the Deerfield River. Dunbar Brook occurs largely in Monroe State Forest in Massachusetts, but its upper headwaters extend slightly into southern Vermont. Dunbar drains a total watershed area of slightly more than 28 sq km, most of which is heavily forested. Dunbar has never been assessed by DWM, and therefore was considered a priority sampling location for this year's sampling.

Occurring approximately another 8 miles downriver from Dunbar Brook, Pelham Brook enters the Deerfield River from the northeast and drains approximately 35 sq km of land area. While also largely a forested watershed, Pelham Brook flows through the small community of Rowe, where the small impoundment, Pelham Lake, occurs. The town also maintains an active landfill located on Zoar Road and in close proximity to Pelham Brook (DWM 2004). Pelham Brook has been assessed by DWM for aquatic life once; in 2000, DWM sampled Pelham Brook and determined the status to be "non-impacted" (DWM 2004). Pelham Brook was not assessed in 2005 during DWM's most recent assessment of the Deerfield River watershed.

The Cold River enters the Deerfield River about 1 mile downriver of Pelham Brook's confluence point. The largest of the tributary watersheds assessed in 2008, the Cold River drains nearly 80 sq km in Massachusetts. Most of this land area is forested, and much of it occurs within the Savoy and Mohawk Trail State Forests. The Cold River's headwaters occur north of the small village of Florida in the Hoosac Mountain Range. From its headwaters, the Cold River flows south, crossing under Route 2 and into the Savoy Mountain State Forest, where it picks up water volume from Tower, Bog, and Tannery brooks. From Savoy Mountain State Forest, the Cold River continues east towards the Deerfield River, picking up additional water from Black Brook before flowing alongside the Mohawk Trail State Forest Campground before confluenting with the Deerfield River. The sampling reach, CDRM01, has been used by the MA DEP DWM as the Deerfield River watershed's macroinvertebrate community reference reach since the 1990s and has been more recently used by DRWA for the same purpose.

The Chickley River enters the Deerfield River approximately another 1.5 miles downriver of the Cold River confluence. As the second largest watershed in this assessment, the Chickley River drains about 70 sq km of land area on the south side of the Deerfield River. The Chickley River originates to the south of Borden Mountain in Savoy Mountain State Forest. The river first flows in an easterly direction through the Kenneth Dubuque Memorial State Forests. The river continues east into the small hamlet of West Hawley where it turns northward towards the Deerfield. Route 8A parallels the river closely for most of its length from West Hawley downstream to its entry into the Deerfield River. Several small farms occur along this lower section of the Chickley River, one of which has been implicated for producing elevated bacteria levels in the lower reaches of the Chickley (Cole et al. 2008). The lower Chickley River (within 0.2 miles of CHRM01) was last assessed by DWM in 2000, and was found to be slightly impacted (DWM 2004). Mill Brook (herein referred to as Mill Brook South), with its

headwaters in the Kenneth Dubuque Memorial State Forest, is a tributary to the Chickley River. This major tributary to the Chickley River has gone un-assessed by DWM and was therefore added to this year's list of DRWA sample sites.

Clesson Brook, which drains a land area slightly smaller than does the Chickley River, enters the Deerfield River another seven miles downriver from the Chickley River confluence point. Clesson Brook's headwaters occur in Hawley and swiftly flow eastward along Clesson Brook Road through forestland before turning north and entering a floodplain valley in the small hamlet of Buckland Four Corners. Farmland used for hayfields, cornfields, dairy, and livestock occurs throughout the Clesson Brook floodplain, and the town of Buckland also occurs in the lower watershed. Route 112 parallels Clesson Brook from Buckland Four Corners downstream almost to the confluence with the Deerfield River. Clesson Brook was identified by DWM as potentially suffering from road runoff and agricultural non-point-source (NPS) pollution (DMW 2008), and was therefore assessed by DWM for aquatic life in 2005 (DWM 2004). DWM assessed one site in lower Clesson in 2005 (overlaps with site CLBM01 in the present study), where biological conditions were determined to be non-impacted (DWM 2008).

Mill Brook, a tributary that enters the Deerfield River from the north in the town of Charlemont, originates in western Heath, Massachusetts. Along its southward course, Mill Brook picks up water from the acidic Davis Mine Brook, named after the now-defunct Davis Mine, which was actively mined for iron pyrite in the nineteenth century (DWM 2004). Mill Brook has been sampled by DWM from aquatic life in 2000 and again in 2005. In 2000, Mill Brook was sampled at RM 1.1 where benthic conditions were found to be slightly impacted. In 2005, Mill Brook was sampled further upstream at RM 1.9 (closer to the confluence with Davis Mine Brook), where benthic conditions were found to be non-impacted (DWM 2008).

A comprehensive biological assessment of these tributaries to the Deerfield River aims to characterize ecological health in these smaller drainages and identify river and stream reaches that are potentially impaired by degraded water quality or physical habitat conditions. Identification of such reaches will warrant follow-up investigation to determine the cause of any measured impairment.

METHODS

SAMPLE SITE SELECTION

Sample sites for this study were selected to provide coverage of major Deerfield River tributaries occurring west of the North River and south of the Vermont border (because Vermont streams would be sampled in 2009). Fifteen river and stream reaches were selected for sampling in 2008. Two sites that have been sampled in previous DRWA assessment efforts were sampled in 2008, including the Bear River and the middle Cold River site; both were included as reference sites against which conditions in other reaches would be compared. Three other reaches were sampled in the Cold River watershed, including one site in the lower portions of the Cold River, one site in the upper Cold River, and one site in Tannery Brook, a major tributary to the Cold (Figure 1). Three sites were also sampled in both the Chickley River and Clesson Brook to

provide uniform coverage along the length of each of these waterbodies. A sample site was also established on Mill Brook, a major tributary to the Chickley River.

Single sites were sampled from a number of smaller tributaries entering the Deerfield River, including Dunbar Brook, Pelham Brook, and Mill Brook in Charlemont.

FIELD DATA COLLECTION

Macroinvertebrate samples were collected between September 11 and September 23, 2008 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 are 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).

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.

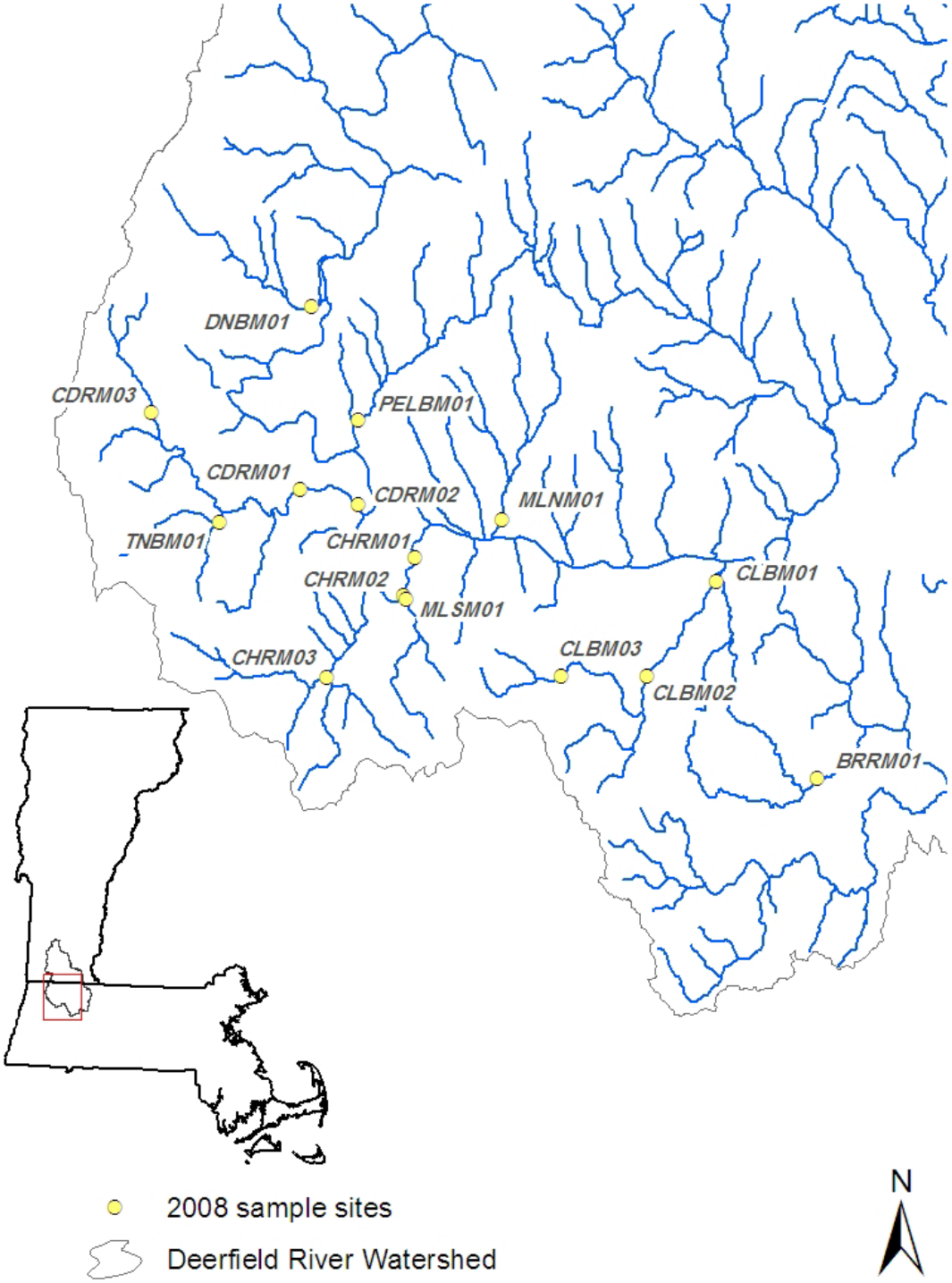

Figure 1. Locations of stream and river reaches in the Deerfield River watershed, Franklin and Berkshire counties, Massachusetts, where macroinvertebrates were sampled in September 2008.

Table 1. Stream reaches sampled for macroinvertebrates in the Deerfield River watershed, Franklin and Berkshire counties, Massachusetts in September 2008.

Site Code	Waterbody	Watershed Area (km^2)	Location
DNBM01	Dunbar Brook	28.0	above impoundment on lower Dunbar
PLBM01	Pelham Brook	30.8	2nd bridge crossing abv Deerfield confl
MLNM01	Mill Brook	30.6	below Bissell Covered Bridge in Charlemont
BRRM01	Bear River**	27.1	above Shelburbe Falls Road
CDRM02	Cold River	76.8	~100 m below MSF entrance bridge
CDRM01	Cold River*	73.3	at ref site above Mohawk Trail SF campground
CDRM03	Cold River	16.8	upriver site - upstream South County Road
TNBM01	Tannery Brook	17.2	~100 m below confluence with Gulf Brook
CHRM01	Chickley River	68.9	lower - 1st 8A road Xing
CHRM02	Chickley River	66.2	middle - below confluence with Mill Brook
CHRM03	Chickley River	22.6	upstream 8A in West Hawley
MLSM01	Mill Brook	16.3	~100 m above confluence with Chickley River
CLBM01	Clesson Brook	47.0	lower - upstream of first 112 Xing
CLBM02	Clesson Brook	36.1	middle - south end of Upper Street in Buckland
CLBM03	Clesson Brook	9.6	upper - at Hawley/Buckland town line

*Reference reach located outside of the North River watershed
**Was going to be used as reference site for smaller watershed areas, but heavy sedimentation at the sample site prevented its use for such purposes.

Table 2. MA DEP metric set and scoring criteria (relative to reference station) used to assess the condition of macroinvertebrate communities in the Deerfield River watershed, September 2008.

	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%

5. Percent Contribution Dominant Taxon—The percent contribution of the numerically dominant taxon (genus or species) to the total numbers of organisms. A community dominated by few species indicates environmental stress.

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 reach, CDRM01, was used as the reference site for comparison with all other sites sampled.

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. Duplicate samples were collected at three sample sites during the assessment to ascertain repeatability and reliability of field and laboratory methods. 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 HABITAT CONDITIONS

Physical habitat scores ranged from 126 in Mill Brook south (MLSM01) to 189 in Tannery Brook (TNBM01; Table 3). The Cold River reference reach (CDRM01) scored 160 (Table 4). The Bear River (BRRM01), initially included in this year's assessment as a reference site, received a total habitat score of 148. The Bear River received a score of

only 9/20 for sediment deposition and 11/20 for substrate embeddedness. Sediment levels had increased significantly since 2006, when the reach was last sampled for the South River assessment (Figure 2). Accordingly, the Bear River was not used as a reference site for smaller drainages in the present study, as was originally intended.

Dunbar Brook, DNMB01, received the highest habitat scored of 189 (Table 3). Pelham Brook (PELM01) and Tannery Brook (TNBM01) supported intact and well-functioning physical habitat conditions, as well, with total scores of 174 and 175, respectively (Table 3).

Physical habitat scores in Clesson Brook sites ranged from 132 to 145 and were generally lower than reference conditions because of higher sediment levels, narrower riparian zones, and a larger proportion of eroding banks (Table 3). Fine substrate occurred in elevated levels in the upper and lower Clesson Brook reaches, in particular (Figure 3). Chickley River sites received scores comparable to those at the Cold River reference site, ranging from 153 to 160. Substrate composition, including low levels of fine sediment, were similar between the Chickley River sites and the Cold River reference site (Table 4, Figure 4). The upper (CDRM03) and lower (CDRM02) Cold River sites were also comparable to the Cold River reference site (CDRM01, 160), with total scores of 161 and 165, respectively (Table 4).

Mill Brook north (MLBM01), received a total physical habitat score of 148. Ratings for instream cover and velocity-depth combinations were low relative to reference conditions, but otherwise conditions were comparable. Mill Brook south (MLSM01), a tributary to the Chickley River, received a lower total physical habitat score of 126 (Table 3). Mill Brook south received low scores for embeddedness, sediment deposition, bank stability, and riparian zone width (Table 3, Figure 3).

Figure 2. Photograph of heavy sediment deposition observed at the macroinvertebrate sampling site, BRRM01, in the Bear River, Franklin County, Massachusetts in September 2008.

Table 3. Habitat assessment scores of nine Deerfield River tributary reaches sampled for macroinvertebrates in September 2008. The Cold River (CDRM01), a nearby watershed, was sampled to represent reference conditions. For primary parameters (first 7 in table), scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For secondary parameters (last 3 in table), scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor.

	Clesson, Bear, and smaller tributary Sites								
Variable	DNB M01	PELB M01	MLN M01	BRR M01	TNB M01	MLS M01	CLB M01	CLB M02	CLB M03
INSTREAM COVER	19	19	12	17	16	16	14	17	16
EPIFAUNAL SUBSTRATE	19	15	15	17	18	16	16	17	19
EMBEDDEDNESS	19	16	16	11	17	11	11	15	12
CHANNEL ALTERATION	19	17	14	18	19	16	17	10	12
SEDIMENT DEPOSITION	19	16	15	9	16	11	10	15	11
VELOCITY-DEPTH COMBINATIONS	19	19	12	17	17	15	13	16	17
CHANNEL FLOW STATUS	19	19	14	16	16	17	17	16	12
BANK VEGETATIVE PROTECTION	9,9	10,8	7,7	6,6	8,8	5,4	8,8	6,8	5,6
BANK STABILITY	9,9	10,10	7,7	6,6	10,10	5,3	8,6	5,9	3,5
RIPARIAN VEGETATIVE ZONE WIDTH	10,10	10,5	10,7	10,9	10,10	4,3	7,10	5,5	4,10
TOTAL SCORE	189	174	143	148	175	126	145	144	132

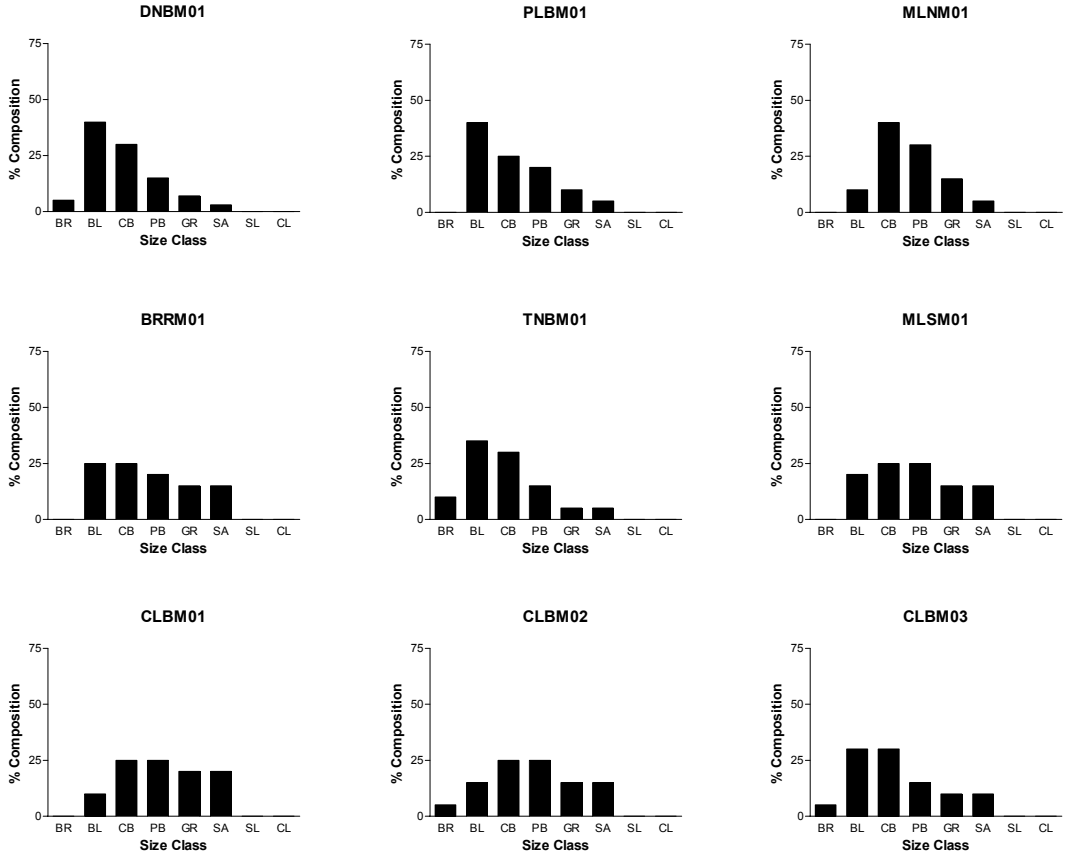

Figure 3. Visual estimates of substrate composition in nine Deerfield River tributary sites sampled for macroinvertebrates in September 2008. BR = bedrock; BL = boulder, >256 mm, CB = cobble, 64-256 mm; PB = pebble, 16-64 mm; GR = gravel, 2-16 mm; SA = sand, 0.06-2 mm; SL = silt, 0.004-0.06 mm; CL = clay, <0.004 mm (slick).

Table 4. Habitat assessment scores of six reaches in the Cold and Chickley rivers sampled for macroinvertebrates in September 2008. For primary parameters (first 7 in table), scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For secondary parameters (last 3 in table), scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor. Sanders Brook (SDBM01) represents reference conditions.

Variable	CDRM02	CDRM01	CDRM03	CHRM01	CHRM02	CHRM03
INSTREAM COVER	16	16	16	16	16	16
EPIFAUNAL SUBSTRATE	16	17	17	18	18	16
EMBEDDEDNESS	15	15	15	15	15	15
CHANNEL ALTERATION	15	15	18	14	16	15
SEDIMENT DEPOSITION	15	14	17	14	15	15
VELOCITY-DEPTH COMBINATIONS	14	15	15	16	16	14
CHANNEL FLOW STATUS	16	15	15	17	18	16
BANK VEGETATIVE PROTECTION	8,10	9,9	8,8	9,6	6,6	8,10
BANK STABILITY	8,10	9,9	9,9	9,5	6,6	8,10
RIPARIAN VEGETATIVE ZONE WIDTH	8,9	10,8	10,8	10,3	5,10	8,9
TOTAL SCORE	160	161	165	152	153	160

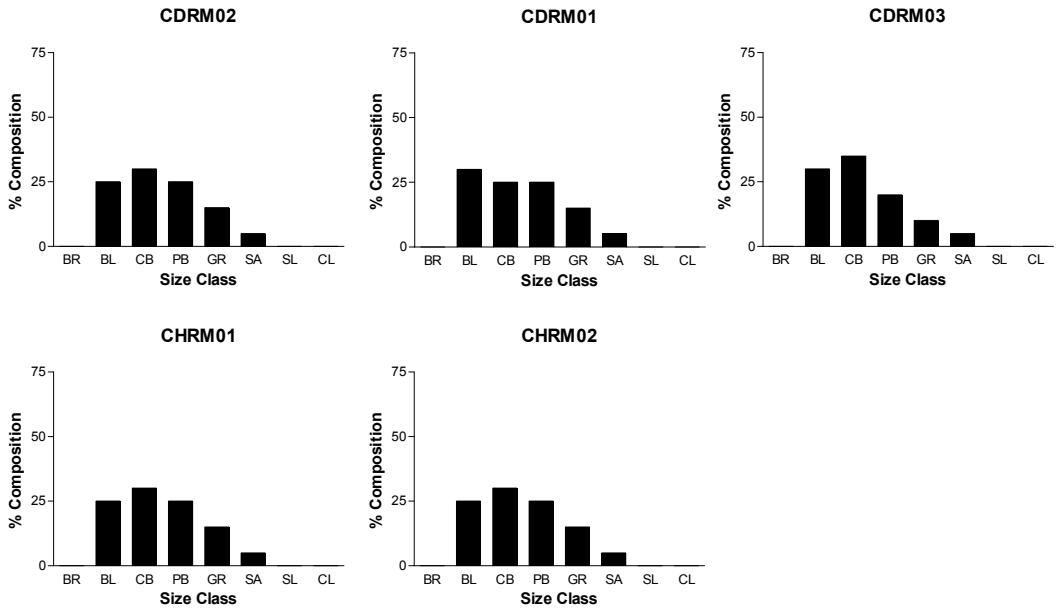

Figure 4. Visual estimates of substrate composition in Cold and Chickley river reaches sampled for macroinvertebrates in September 2008. BR = bedrock; BL = boulder, >256 mm, CB = cobble, 64-256 mm; PB = pebble, 16-64 mm; GR = gravel, 2-16 mm; SA = sand, 0.06-2 mm; SL = silt, 0.004-0.06 mm; CL = clay, <0.004 mm (slick).

MACROINVERTEBRATE COMMUNITIES

Macroinvertebrate community conditions in the Cold River reference reach (CDRM01) were very similar to those measured at this site in 2007. Total taxa richness (41 vs 34) and HBI scores (3.8 vs 3.2) were higher than in 2007. EPT taxa richness was similar (22 vs 24), as were the scraper-to-filterer ratio and percent dominance by one taxon. Relative to these conditions measured in the Cold River reference reach, multimetric scores ranged from 28 to 42. Two of the fourteen sites – Dunbar Brook (DNBM01) and Mill Brook south (MLSM01) – scored in the slightly impacted range, receiving total scores of 28 and 30, respectively (Table 5), while twelve of the fourteen test sites scored in the non-impacted range (Tables 5 & 7).

Dunbar Brook was one of only two sites to receive a slightly impaired determination relative to conditions measured in the Cold River reference site (Table 5). Among Dunbar community metrics, total taxa richness, EPT richness, and the EPT-to-Chironomidae ratio scored poorly relative to reference conditions (Table 6). Fewer EPT taxa (13 taxa) were sampled from Dunbar than from any other stream sampled in 2008, and Chironomidae represented nearly half of the abundance in the sample. These results are unexpected because Dunbar Brook is a heavily forested and relatively pristine watershed. Physical habitat conditions were excellent, with no apparent degradation of any type. The lower-than-expected macroinvertebrate community conditions can only be explained by sampling error or impaired water quality, perhaps slightly acidic conditions.

Further sampling of the macroinvertebrate community and water chemistry in Dunbar Brook is warranted based on the results of this study.

Pelham Brook received a total benthic community score of 38, resulting in 90% comparability to conditions at the Cold River reference site (Table 5). Pelham Brook was scored identically by DWM during their last assessment of this waterbody in 2000 (DWM 2004; Table 9). Mill Brook north also scored in the non-impacted range, receiving a total benthic community score of 36. This score was also identical to the score it last received by DWM in 2005 (DWM 2008; Table 9). Tannery Brook (TNBM01) also scored in the non-impacted range, receiving a total benthic score of 40 (Table 5).

While increased sediment deposition was noted in the Bear River in 2008, the benthic community appeared to be minimally affected by this disturbance, as BRRM01 received a total score of 40 and a corresponding non-impacted determination (Table 5). The Bear River was last assessed for aquatic life by DWM in 2005, at which time it was also determined to be non-impacted (DWM 2008). While scoring in the non-impacted range, it is worth noting that the Bear River sample (and its duplicate sample) was dominated by the mayfly, *Eurylophella*, which is potentially tolerant of elevated sediment levels.

Clesson Brook total benthic scores ranged from 38 at the uppermost site to 42 at the lowermost site (Table 5). EPT richness among the three sites ranged only from 22 to 24, suggesting similar conditions among the three sites (Table 6). Lower Clesson Brook was last sampled by DWM in 2005, when it also received a total benthic score of 42 and a non-impacted rating (DWM 2008), suggesting that conditions are similar to those occurring in 2005 (Table 9).

The Clesson Brook tributary, Mill Brook south, received low scores for EPT taxa and percent dominance by one taxon (Table 6), which resulted in the slightly impacted determination (Table 5). The Mill Brook south site was numerically dominated by the sediment-tolerant mayfly, *Ephemerella* (likely *E. subvaria* and *E. invaria*), likely a result of the elevated sediment levels in lower Mill Creek south. While actively eroding banks were observed in Mill Brook south, the source of the elevated sediment levels in the lower segment of this stream are currently unknown. Shoreline surveys of the Chickley River, organized by Riverways and performed by local volunteers in 2006, did not include Mill Brook. Additional survey work and sampling to identify potential sources of elevated sediment loading in the Mill Brook south watershed is recommended.

The lower and upper Cold River reaches, CDRM02 and CDRM03, both scored in the non-impacted range (Table 7). The lower Cold River site, located below the Mohawk Trail State Forest Campground, supported high total taxa richness (43) and EPT richness (25), second in this assessment only to those measured from the middle Chickley River (Table 8). The upper Cold River site, while also scoring in the non-impacted range, exhibited community characteristics that were inferior to those at the two lower Cold River sites, including lower total taxa richness and lower EPT taxa richness.

The three Chickley River sites included in this assessment also scored exclusively in the non-impacted range (Table 7). Total benthic scores ranged from 36 at the uppermost site (CHRM03) to 42 at each of the two lower sites (CHRM01 and CHRM02). The middle Chickley River site (CHRM02) boasted the highest total taxa richness (44 taxa) and EPT taxa richness (26 taxa – tied with the Bear River) among all of the sites

sampled in 2008. Among sites previously assessed by DWM, the lower Chickley River site in distinct from the others in that it is the only site that received a total score and impact determination that deviated from the last DWM assessment. In 2000, DWM assessed the lower Chickley River and determined the benthic community to be slightly impacted (DWM 2004), while the results of this assessment suggest that the lower Chickley River is currently non-impacted. In 2000, the site scored particularly low for the scraper/filterer metric, largely owing to the abundance of Hydropsychidae and Philopotamidae caddisflies in the sample (DWM 2000). In 2008, these numbers were moderately lower, and the ratio was further improved in 2008 by an increase in the number of scraper organisms at the site. It is plausible that some improvement in water quality has occurred, and this is being reflected in these subtle changes in the benthic community if any improvement has been made to upriver livestock management practices.

Duplicate field samples were collected at three sites in 2008: BRRM01, CHRM02, and CLBM02. Total benthic scores at BBRM01 were identical (40 and 40), while those at CHRM02 and CLBM02 differed by only two points (42 vs 40 in each case). All duplicate pairs received the same determination of non-impacted, speaking to the reliability and repeatability of the field and laboratory methods utilized in this study.

Overall, results of the 2008 BMI surveys of these Deerfield River tributaries suggest that benthic communities throughout the middle Deerfield River watershed show little evidence of impacts from human activity. Measured impacts in Dunbar Brook are likely related to low pH and require further investigation. Likewise, additional work should be performed on Mill Brook to identify the sources of potential impairment to the benthic community. While not investigated in this assessment, monitoring should also continue on Davis Mine Brook to assess the status of that stream in the face of continued acid-mine-drainage inputs.

Maintenance of healthy benthic communities and overall ecological health of the Deerfield River watershed rests on continued stewardship of these aquatic resources and adjacent riparian and upland habitats. Prevention of further loss of mature riparian zones in the watershed is necessary to ensure the continued health of these communities. Implementation of agricultural best management practices to reduce soil erosion and improve ground water recharge will also benefit these waterbodies.

Table 5. RBP III summary scores, reference comparability scores, and corresponding biological condition classifications of macroinvertebrate communities sampled from smaller tributaries in the Deerfield River watershed in September 2008.

	Tributary Sites								
	DNB M01	PELB M01	MLN M01	BRR M01	TNB M01	MLS M01	CLB M01	CLB M02	CLB M03
Total Score	**28**	**38**	**36**	**40**	**40**	**30**	**42**	**40**	**38**
% Comparability to Reference	**67**	**90**	**86**	**95**	**95**	**71**	**100**	**95**	**90**
Biological Condition	**Slightly impacted**	Not Impacted	Not Impacted	Not Impacted	Not Impacted	**Slightly impacted**	Not Impacted	Not Impacted	Not Impacted

Table 6. Metric values (and standardized metric scores) derived from macroinvertebrate samples collected from smaller tributaries in the Deerfield River watershed in September 2008.

	Tributary Sites								
Metric	DNB M01	PELB M01	MLN M01	BRR M01	TNB M01	MLS M01	CLB M01	CLB M02	CLB M03
Richness	23	36	36	38	34	31	37	30	34
EPT Richness	13	19	19	26	21	15	24	23	22
EPT/Chironomidae	1.1	2.7	1.8	44.5	8.6	4.4	18.0	12.9	4.4
HBI modified	4.3	3.5	4.2	2.7	3.2	2.4	3.5	2.5	2.9
Scraper/Filterer Ratio	0.73	0.74	0.35	2.00	1.00	0.78	1.88	2.43	0.15
% Dominant Taxon	12.5	11.5	17.5	19.8	17.4	30.4	19.2	16.9	10.7
% Reference Affinity	65.1	82.1	78.5	57.2	67.8	83.0	77.9	84.8	81.7

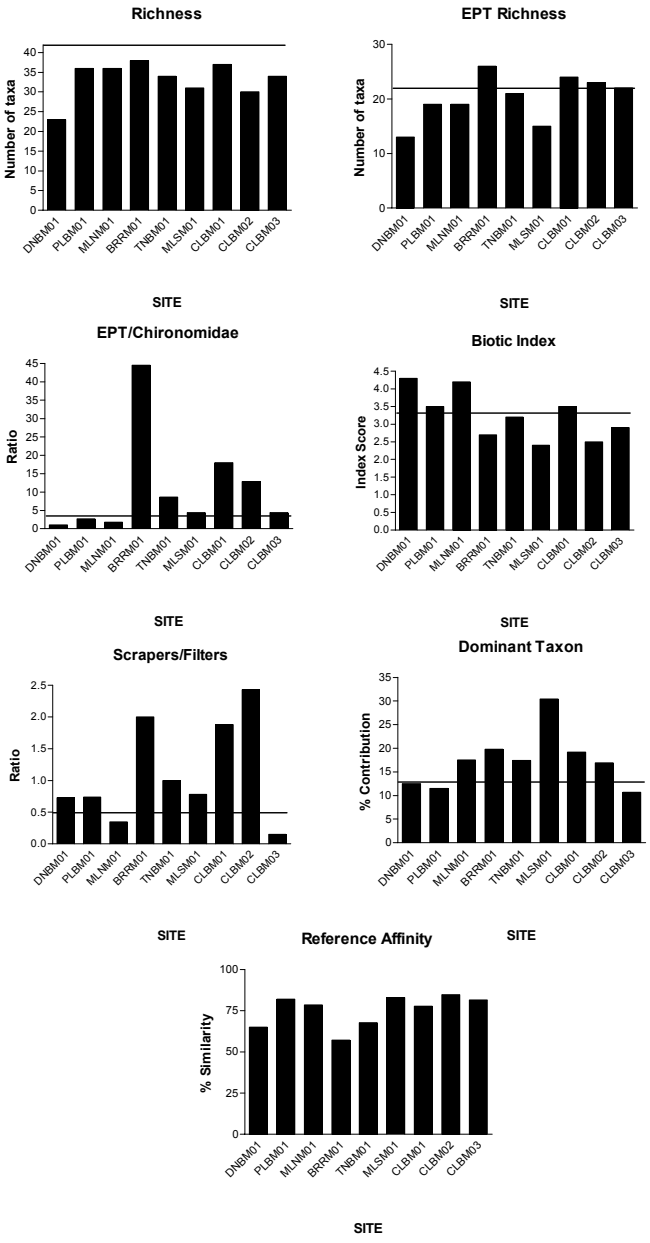

Figure 5. Metric attribute values calculated from macroinvertebrate samples collected from smaller tributaries to the Deerfield River in September 2008. Black horizontal lines indicate value of each attribute at the reference site on the Cold River (CDRM01).

Table 7. RBP III summary scores, reference comparability scores, and corresponding biological condition classifications of macroinvertebrate communities sampled from the Cold and Chickley rivers in September 2008.

	Cold & Chickley River Sites					
	CDRM02	CDRM01	CDRM03	CHRM01	CHRM02	CHRM03
Total Score	**42**	**42**	**36**	**42**	**42**	**36**
% Comparability to Reference	**100**	**100**	**86**	**100**	**100**	**86**
Biological Condition	Not Impacted	**REFERENCE**	Not Impacted	Not Impacted	Not Impacted	Not Impacted

Table 8. Metric values (and standardized metric scores) derived from macroinvertebrate samples collected from the Cold and Chickley rivers in September 2008.

	Cold & Chickley River Sites					
Metric	CDRM 02	**CDRM 01**	CDRM 03	CHRM 01	CHRM 02	CHRM 03
Richness	43	**41**	32	38	44	27
EPT Richness	25	**22**	16	25	26	22
EPT/Chironomidae	5.3	**4.0**	5.3	6.7	7.2	26.5
HBI modified	3.7	**3.8**	3.7	3.2	3.2	3.0
Scraper/Filterer Ratio	0.58	**0.58**	0.85	0.83	0.58	1.71
% Dominant Taxon	14.2	13.0	15.6	11.2	13.8	33.0
% Reference Affinity	88.3	100.0	92.8	88.0	85.6	76.0

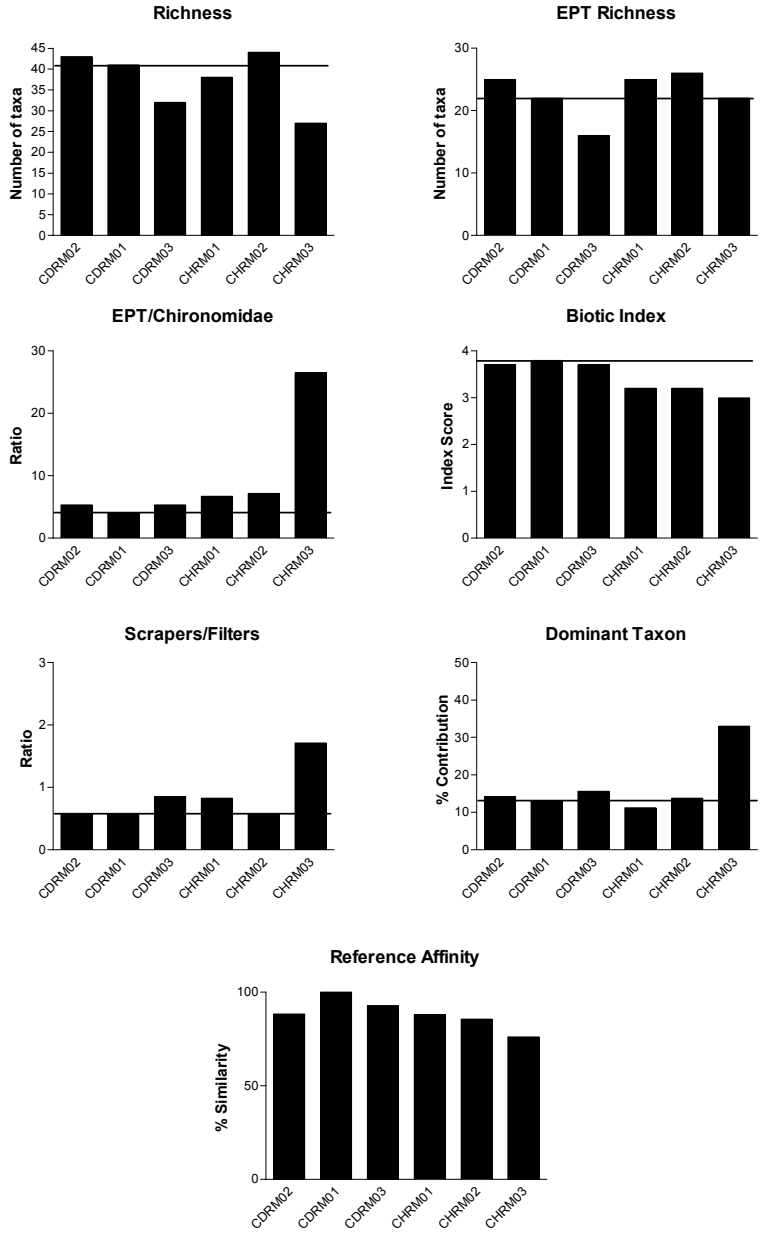

Figure 6. Metric attribute values calculated from macroinvertebrate samples collected from the Cold and Chickley rivers in September 2007. Black horizontal lines indicate value of each attribute at the Cold River reference site (CDRM01).

Table 9. Comparison of results of the 2008 Deerfield River tributaries macroinvertebrate assessment with results from previous DWM macroinvertebrate assessments.

Waterbody	2000 DWM Result	2005 DWM Result	2008 DRWA Result	Change from Last Survey
Cold River	Reference	Reference	Reference	NA
Bear River	Reference	42 (Non-Impacted)	40 (Non-Impacted)	None
Pelham Brook	38 (Non-Impacted)		38 (Non-Impacted)	None
Lower Chickley River	32 (Slightly Impacted)		42 (Non-Impacted)	Apparent Improvement*
Mill Brook	30 (Slightly Impacted)	36 (Non-Impacted)	36 (Non-Impacted)	None**
Lower Clesson Brook		42 (Non-Impacted)	42 (Non-Impacted)	None

*2008 DRWA lower Chickley site was located 0.3 km upstream of the 2000 DWM site.
** 2008 DRWA Mill Brook site was located 2.1 km downstream of the 2005 DWM site.

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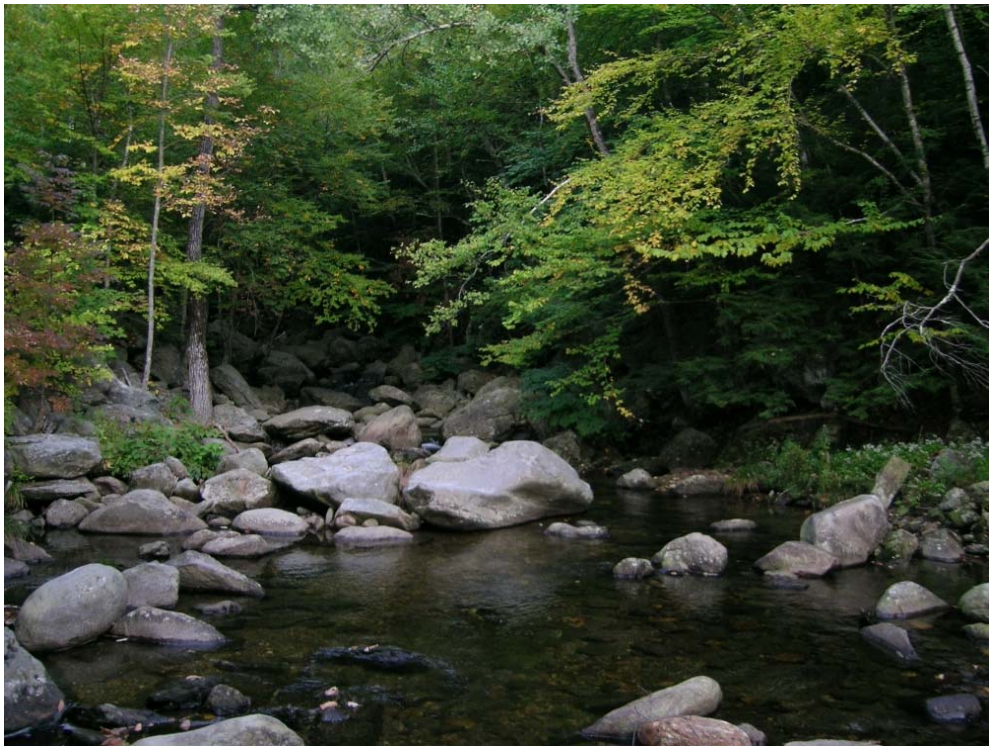
APPENDIX I – SAMPLE SITE PHOTOS

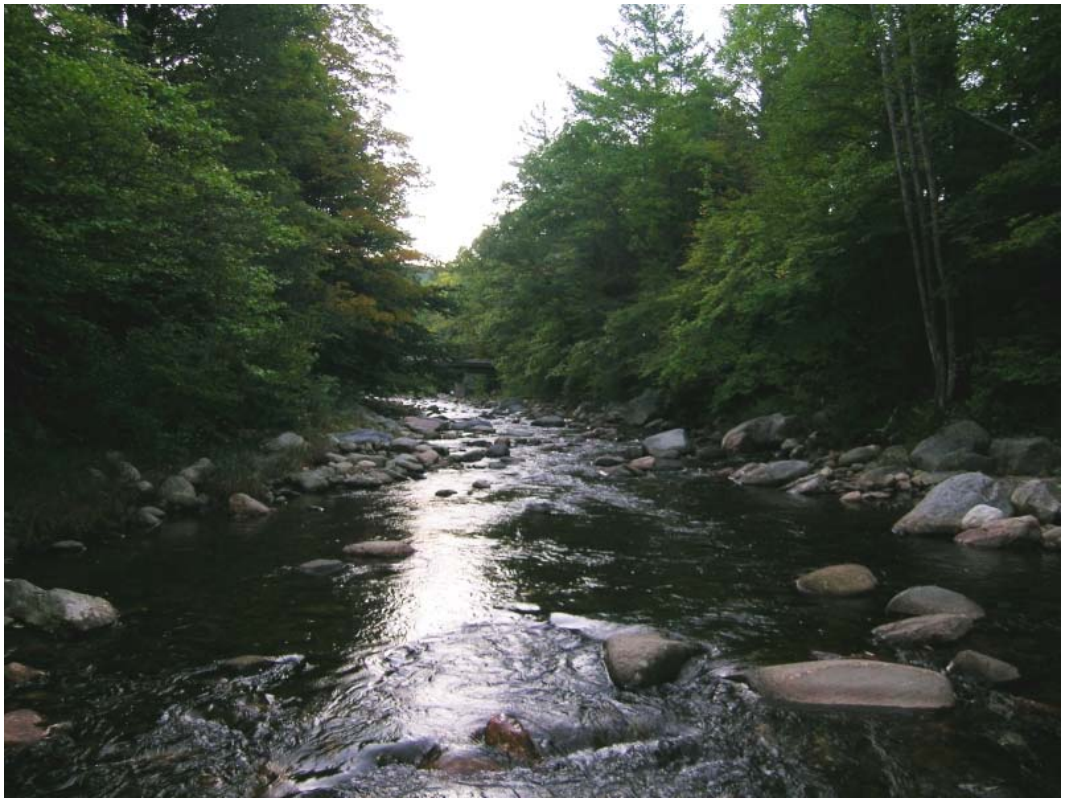
DNBM01 – Dunbar Brook



PLBM01 – Pelham Brook

MLNM01 – Mill Brook

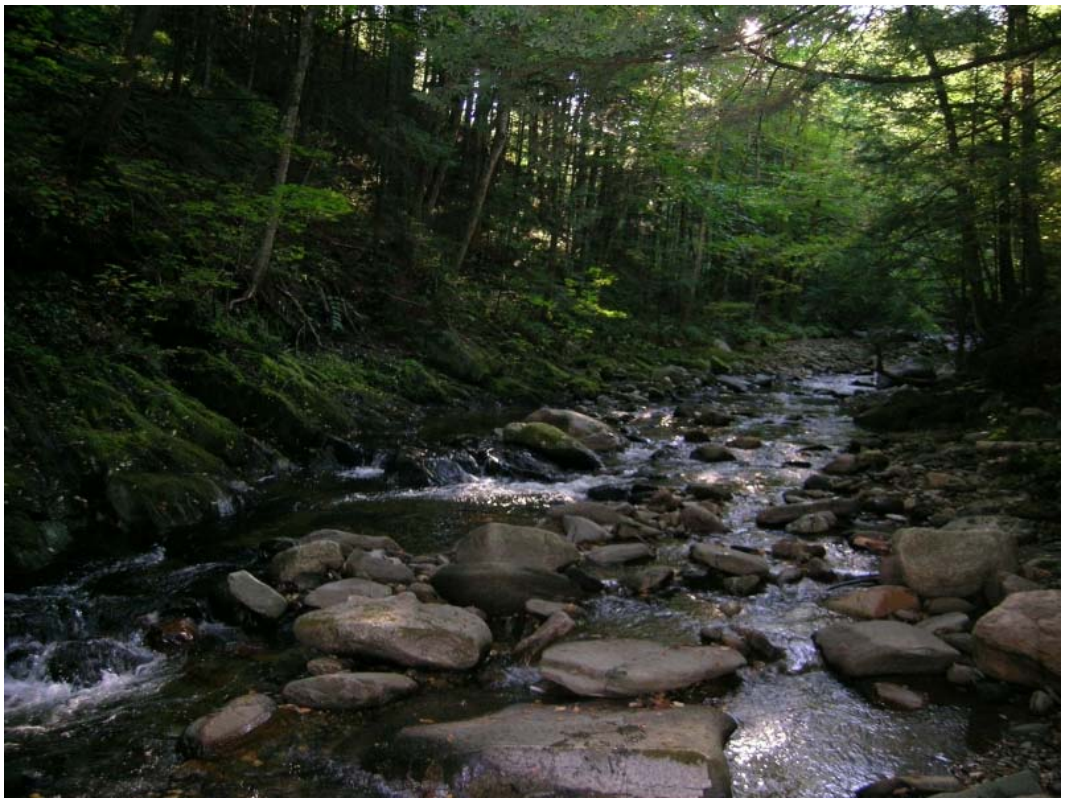
BRRM01 – Bear River



CDRM02 – lower Cold River

CDRM01 – middle Cold River (reference site)

CDRM03 – upper Cold River



TNBM01 – Tannery Brook

CHRM01 – lower Chickley River

CHRM02 – middle Chickley River

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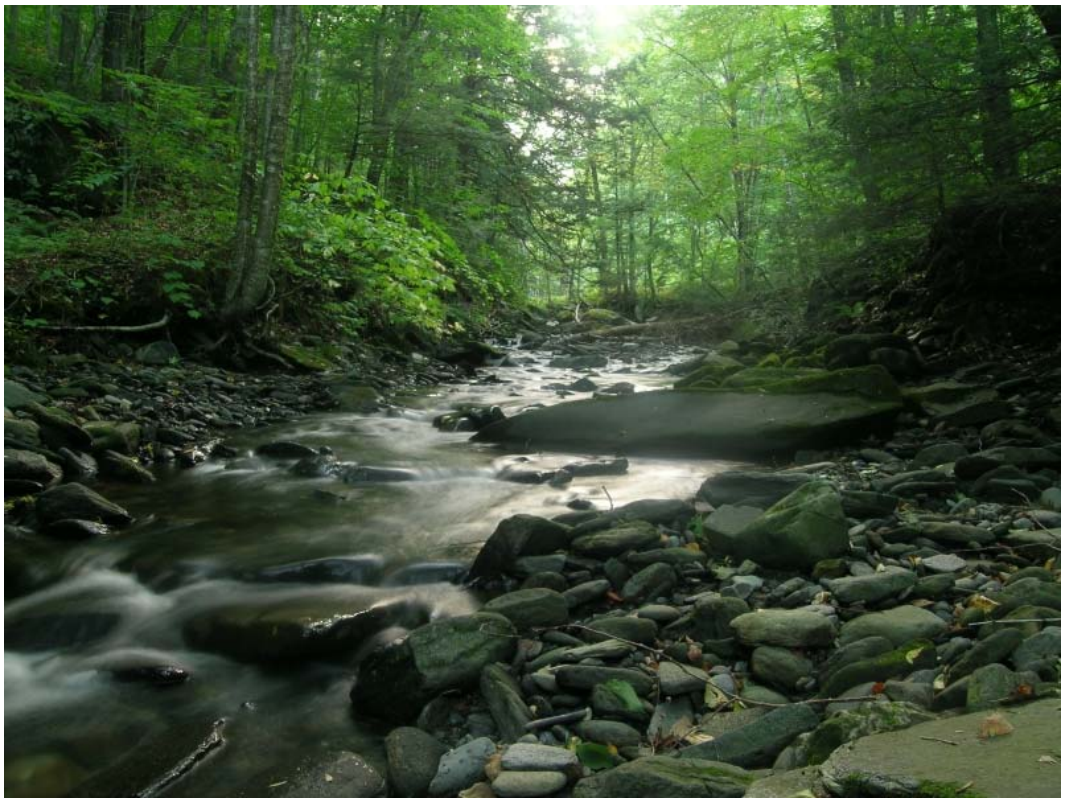
NO PHOTO FOR CHRM03

MLSM01 – Mill Brook

CLBM01 – lower Clesson Brook

CLBM02 – middle Clesson Brook



CLBM03 – upper Clesson Brook