Appendix C

Technical Memorandum TM-34-6

CONNECTICUT RIVER WATERSHED 2003 BIOLOGICAL ASSESSMENT

BENTHIC MACROINVERTEBRATES

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INTRODUCTION

Biological monitoring is a useful, cost-effective method of detecting anthropogenic impacts to the aquatic community. Resident biota (e.g., benthic macroinvertebrates, fish, periphyton) in a water body are natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration (Barbour et al. 1999, Barbour et al. 1995). Surveying and assessing the status of these aquatic communities and the quality of their habitats are the principle tools of biomonitoring.

As part of the Massachusetts Department of Environmental Protection/Division of Watershed Management’s (MassDEP/DWM) 2003 Connecticut River watershed assessments, aquatic benthic macroinvertebrate biomonitoring and habitat assessment were conducted to evaluate the biological health of selected portions of the watershed. A total of six benthic stations were sampled to investigate the effects of a variety of potential stressors on resident biological communities.

Collection and analysis of macroinvertebrate data provide information necessary for making aquatic life use-support determinations required by Section 305(b) of the Clean Water Act. All Connecticut River watershed biomonitoring stations were compared to a reference station (Amethyst Brook - station B0514) most representative of the “best attainable” (i.e., least-impacted) conditions in the watershed. The selection of the reference station to use for comparisons to a study site was based on comparability of stream morphology, flow regimes, and drainage area. Use of a watershed reference station is particularly useful in assessing nonpoint source pollution originating from multiple and/or unknown sources in a watershed (Hughes 1989). Both the quality and quantity of available habitat affect the structure and composition of resident biological communities. Effects of habitat features can be minimized by comparing collected data to reference stations with similar habitats (Barbour et al. 1999). Sampling highly similar habitats also reduces metric variability attributable to factors such as current speed and substrate type.

During "year 1" of its “5-year basin cycle”, areas of concern within the Connecticut River watershed were defined more specifically through such processes as coordination with appropriate groups, assessing existing data, and conducting site visits. Following these activities, the 2003 biomonitoring plan was more closely focused and the study objectives better defined. The main objectives of the 2003 biomonitoring in the Connecticut River watershed were: (a) to determine the biological health of streams within the watershed by conducting assessments based on aquatic macroinvertebrate communities; and (b) to identify impaired stream segments so that efforts can be focused on developing remediation strategies. Specific tasks were:

1. Conduct benthic macroinvertebrate sampling and habitat assessments at locations throughout the Connecticut River watershed;
2. Based upon the benthic macroinvertebrate and habitat data, identify river segments within the watershed with potential impairments and pollution problems; and
3. Using the benthic macroinvertebrate community data, and supporting water chemistry (when available) and field/habitat data:
    - assess the types of water quality and/or water quantity problems that are present.
    - make recommendations for remedial actions or additional monitoring and assessment.
    - provide macroinvertebrate and habitat data to MassDEP/DWM’s Environmental Monitoring and Assessment Program for assessments of aquatic life use and aesthetics use-support status required by Section 305(b) of the Federal Clean Water Act (CWA).
    - provide macroinvertebrate and habitat data for other informational needs of Massachusetts regulatory agencies, non-governmental organizations, and others.

Biomonitoring station locations, along with station identification numbers and sampling dates, are noted in Table 1. Sampling locations are also shown in Figure 1.

Table 1. List of benthic biomonitoring stations sampled during the 2003 Connecticut River watershed survey, including station identification number, mile point (distance from mouth), upstream drainage area, station description, and sampling date.

Station ID	Mile Point	Upstream Drainage Area (mi^2)	Connecticut River Watershed Benthic Station Description	Sampling Date
B0507	2.0	21	Stony Brook, ~30-meters upstream of powerlines, downstream from Route 116, South Hadley, MA	22 July 2003
B0508	0.5	14.6	Cushman Brook, ~300-meters upstream of Factory Hollow Pond, State Street, Amherst, MA	22 July 2003
B0509	3.6	54	Mill River (Northampton), West of Vernon Street, ~300-meters upstream of USGS gage 01171500, Northampton, MA	23 July 2003
B0510	9.3	35	Mill River (Hatfield), ~100-meters upstream of Mountain Drive, below the confluence of West Brook, Hatfield, MA	23 July 2003
B0514	0.8	9.3	Amethyst Brook, upstream of swale off end of Allen Mill Road, Amherst, MA	22 July 2003
B0515	2.5	31	Sawmill River, upstream at South Ferry Road, Montague, MA	22 July 2003

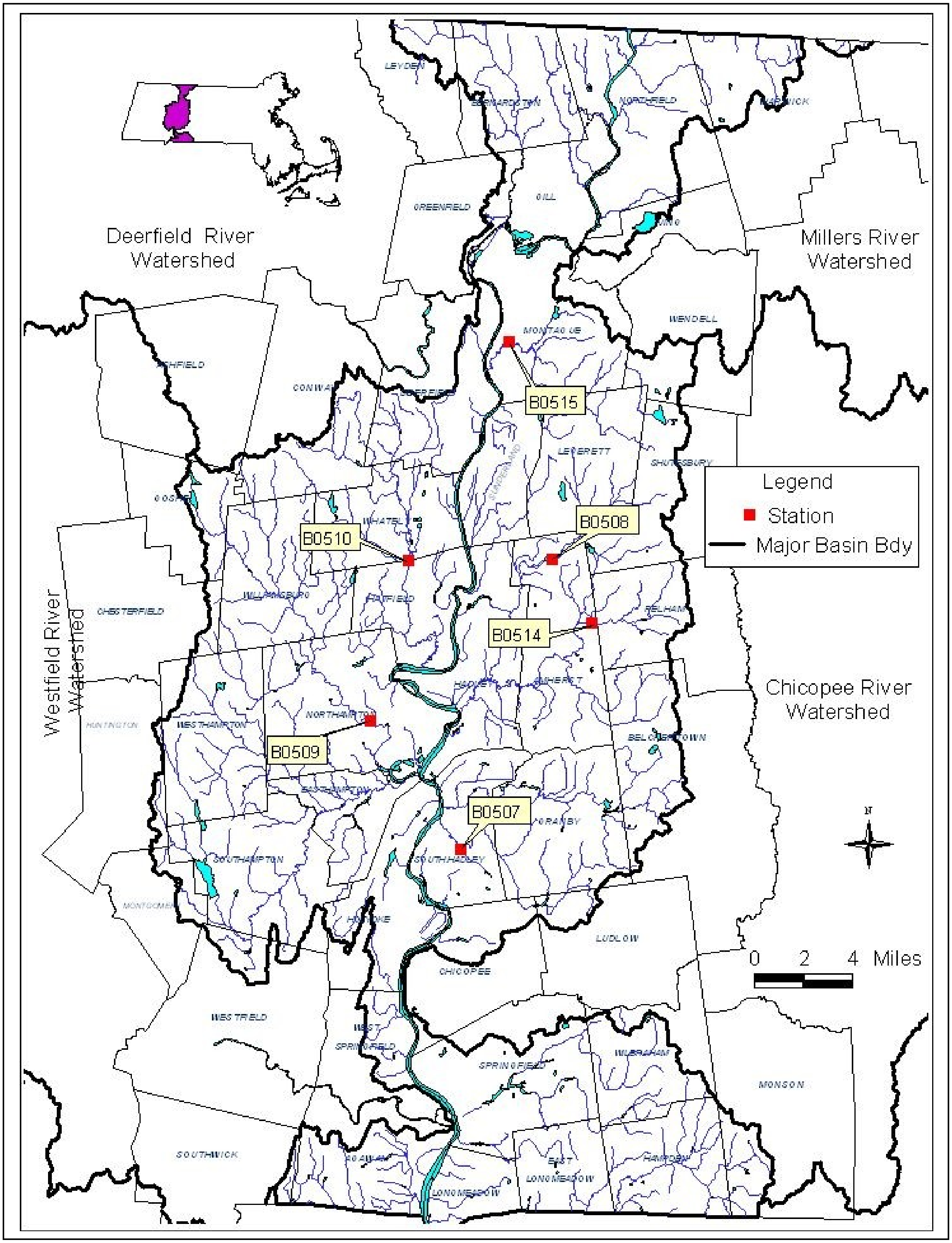

Figure 1: 2003 Connecticut River Watershed Biomonitoring Stations

METHODS

MACROINVERTEBRATE SAMPLING

The macroinvertebrate sampling procedures employed during the 2003 Connecticut River Watershed biomonitoring survey are described in the *Standard Operating Procedures (Draft): Water Quality Monitoring in Streams Using Aquatic Macroinvertebrates* (Nuzzo 2002), and are based on US EPA Rapid Bioassessment Protocols (RBPs) for wadeable streams and rivers (Barbour et al. 1999). The macroinvertebrate collection procedure utilized kick-sampling, a method of sampling benthic organisms by kicking or disturbing bottom sediments and catching the dislodged organisms in a net as the current carries them downstream. Sampling activities were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (MassDEP 2003a). Sampling was conducted by MassDEP/DWM biologists throughout a 100 m reach, in riffle/run areas with fast currents and rocky (boulder, cobble, pebble, and gravel) substrates—generally the most productive habitats, supporting the most diverse communities in the stream system. Ten kicks in squares approximately 0.46 m x 0.46 m were composited for a total sample area of about 2 m^2. Samples were labeled and preserved in the field with denatured 95% ethanol, then brought to the MassDEP/DWM lab for further processing.

MACROINVERTEBRATE SAMPLE PROCESSING AND ANALYSIS

The macroinvertebrate sample processing and analysis procedures employed for the 2003 Connecticut River watershed biomonitoring samples are described in the standard operating procedures (Nuzzo 2002) and were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (MassDEP 2003a). Macroinvertebrate sample processing entailed random selection of specimens from the other materials in the sample until approximately 100 organisms (±10%) were extracted. Specimens were identified to genus or species as allowed by available keys, specimen condition, and specimen maturity. Taxonomic data were analyzed using a modification of Rapid Bioassessment Protocol III (RBP III) metrics and scores (Plafkin et al. 1989). Metric values for each station were scored based on comparability to the reference station, and scores were totaled. The percent comparability of total metric scores for each study site to those for a selected "least-impacted" reference station yields an impairment score for each site. The analysis separates sites into four categories: non-impacted, slightly impacted, moderately impacted, and severely impacted. Each impact category corresponds to a specific aquatic life use-support determination used in the CWA Section 305(b) water quality reporting process—non-impacted and slightly impacted communities are assessed as "support" in the 305(b) report; moderately impacted and severely impacted communities are assessed as "impaired." A description of the *Aquatic Life* use designation is outlined in the *Massachusetts Surface Water Quality Standards* (SWQS) (MassDEP 1996). Impacts to the benthic community may be indicated by the absence of generally pollution-sensitive macroinvertebrate taxa such as Ephemeroptera, Plecoptera, and Trichoptera (EPT); dominance of a particular taxon, especially the pollution-tolerant Chironomidae and Oligochaeta taxa; low taxa richness; or shifts in community composition relative to the reference station (Barbour et al. 1999). Those biological metrics calculated and used in the analysis of 2003 Connecticut River watershed macroinvertebrate data are listed and defined below [For a more detailed description of metrics used to evaluate benthos data, and the predicted response of these metrics to increasing perturbation, see Barbour et al. (1999)]:

1. Taxa Richness—a measure based on the number of taxa present. Generally increases with increasing water quality, habitat diversity, and habitat suitability. The lowest possible taxonomic level is assumed to be genus or species.

2. EPT Index—a count of the number of genera/species from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). As a group these are considered three of the more pollution 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 1987). Organisms have been assigned a value ranging from zero to ten based on their tolerance to organic pollution. Tolerance values (TV) currently used by MassDEP/DWM biologists were originally developed by Hilsenhoff and have since been supplemented by Bode et al. (1991) and Lenat (1993). A value of zero indicates the

taxon is highly intolerant of pollution and is likely to be found only in pollution-free waters. A value of ten indicates the taxon is tolerant of pollution and may be found in highly polluted waters. The number of organisms and the individually assigned values are used in a mathematical formula that describes the degree of organic pollution at the study site. The formula for calculating HBI is:

$$HBI = \sum \frac{x_i t_i}{n}$$

where
x_i = number of individuals within a taxon
t_i = tolerance value of a taxon
n = total number of organisms in the sample

4. Ratio of EPT and Chironomidae Abundance—The EPT and Chironomidae abundance ratio uses relative abundance of these indicator groups as a measure of community balance. Skewed populations having a disproportionate number of the generally tolerant Chironomidae (“midges”) relative to the more sensitive insect groups may indicate environmental stress.

5. Percent Contribution Dominant Taxon—is the percent contribution of the numerically dominant taxon (genus or species) to the total numbers of organisms. A community dominated by few species indicates environmental stress. Conversely, more balance among species indicates a healthier community.

6. Ratio of Scraper and Filtering Collector Functional Feeding Groups—This ratio reflects the community food base. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source (Barbour et al. 1999). Scrapers predominate when diatoms are the dominant food resource, and decrease in abundance when filamentous algae and mosses prevail. Filtering collectors thrive where filamentous algae and mosses are prevalent and where fine particulate organic matter (FPOM) levels are high.

7. Community Similarity—is a comparison of a study site community to a reference site community. Similarity is often based on indices that compare community composition. Most Community Similarity indices stress richness and/or richness and abundance. Generally speaking, communities with comparable habitat will become more dissimilar as stress increases. In the case of the Connecticut 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%.

HABITAT ASSESSMENT

An evaluation of physical habitat quality is critical to any assessment of ecological integrity (Karr et al. 1986, Barbour et al. 1999). Habitat assessment supports understanding of the relationship between physical habitat quality and biological conditions, identifies obvious constraints on the attainable potential of a site, assists in the selection of appropriate sampling stations, and provides basic information for interpreting biosurvey results (US EPA 1995). Before leaving the sampling reach during the 2003 Connecticut River watershed macroinvertebrate biosurveys, habitat qualities were scored, and assessed, using a modification of the evaluation procedure in Barbour et al. (1999). The matrix used to assess habitat quality is based on key physical characteristics of the water body and related streamside features. Most parameters evaluated are instream physical attributes often related to overall land-use and are potential sources of limitation to the aquatic biota (Barbour et al. 1999). The ten habitat parameters are as follow: instream cover, epifaunal substrate, embeddedness, sediment deposition, channel alteration, velocity/depth combinations, channel flow status, right and left (when facing downstream) bank vegetative protection, right and left bank stability, right and left bank riparian vegetative zone width. Habitat parameters are scored, totaled, and compared to a reference station to provide a final habitat ranking.

QUALITY CONTROL

Field and laboratory Quality Control (QC) activities were conducted in accordance with the Quality Assurance Project Plan (QAPP) for biomonitoring and habitat assessment (MassDEP 2003a). Quality Control procedures are further detailed in the standard operating procedures (Nuzzo 2002).

FIELD SAMPLING QUALITY CONTROL

Field Sampling QC entails: 1) Pre- and post-sampling rinses, inspection of, and picking of nets, sieves, and pans to prevent organisms collected from one station to be transferred to samples taken elsewhere. 2) On-site preservation of benthos sample in 95% ethanol to ensure proper preservation, and 3) collection of a duplicate sample at one in ten biomonitoring stations. A duplicate is collected as a “side by side” (where different assessment results are not expected due to the apparent absence of additional stressors) to each of the 10 kicks making up the “original” sample. A duplicate sample is composited in a similar manner to the original sample, yet, is preserved in a separate sample bottle marked “duplicate” and with all other information regarding station location remaining the same. Duplicate samples are used for the calculation of Precision of the benthos data.

FIELD ANALYTICAL QUALITY CONTROL

Habitat analysis QC entails multiple observers (at least both DWM benthic biologists, and often a third person) performing the Habitat Assessment at each macroinvertebrate biomonitoring station. A standardized Habitat Assessment Field Scoring Sheet is completed at all biomonitoring stations. Disagreement in habitat parameter scoring is discussed and resolved before the Habitat Assessment can be considered complete.

FIXED LABORATORY QUALITY CONTROL

Fixed Laboratory QC entails the following: 1) Taxonomy bench sheets are examined by a reviewer (the DWM biologist not responsible for the initial taxonomic identifications) for errors in transcription from bench notebook, count totals, and spelling. All bench sheets are examined, and detected errors are brought to the taxonomist’s attention, discussed, and corrected. 2) Taxonomic duplication, in which “spot checks” are performed by a reviewer (the DWM biologist not responsible for the initial taxonomic identifications) on taxonomy, are performed at the reviewer’s discretion. In general, all taxa that are rarely encountered in routine benthos samples, or taxa that the primary taxonomist may be less than optimally proficient at identifying, are checked. Spot checks are performed for all stations. Specimens may be sent to authorities for particular taxonomic groups. 3) Data reduction and analysis, including biological metric scoring (metric values are calculated through queries run in the DWM Benthic Macroinvertebrate Database), comparisons to reference station metrics, and impairment designations, are checked by a reviewer (the DWM biologist not responsible for performing the initial taxonomy and data analysis) for all benthos data at all stations. Detected errors are brought to the original taxonomist’s attention and resolved. 4) Precision, a measure of mutual agreement among individual measurements or enumerated values of the same property of a sample and usually expressed as a standard deviation in absolute or relative terms, is compared using raw benthos data and metric values. If metric values and resulting scoring are significantly different (i.e., beyond an acceptable Relative Percent Difference) between the original and duplicate samples, the investigators will attempt to determine the cause of the discrepancy. Guidance regarding the calculation of Precision, including Relative Percent Difference (RPD) calculations and recommendations, can be found in US EPA (1995) and Barbour et al. (1999).

BASIN DESCRIPTION

The Connecticut River is the longest river in New England (USFWS 2006). It flows 405 miles from the Canadian border to Long Island Sound, and occupies a watershed area of 11,250 square miles (Kennedy and Weinstein 2000). In Massachusetts the Connecticut River watershed is, "located in Franklin, Hampshire, and Hampden Counties of west-central Massachusetts, and contains all or part of 46 cities and towns, including the cities of Holyoke, Chicopee, Westfield, Springfield, and Northampton. The elevation of the valley floor ranges from about 40 ft, where the Connecticut River crosses into Connecticut, to about 330 ft, except for long ridges of volcanic rock that reach altitudes of 600 to almost 1,000 ft. Elevations in the upland areas of the basin are as much as 1,500 ft." (USGS 2006a).

The mainstem of the Connecticut River within Massachusetts runs 67-miles from the VT / NH border to the CT border. Along this course, the Connecticut River receives the waters from the Millers, Deerfield, Chicopee and Westfield rivers. While these rivers are tributaries of the Connecticut, each of them is treated by MassDEP as a separate watershed for monitoring, assessment and other water quality management activities. The influence of these four major rivers is not inconsequential. Their combined discharge has a significant influence on flows within the Connecticut River (Mitchell 2006). The in-state watershed area of the Connecticut River watershed is 670 square-miles (Kennedy and Weinstein 2000) exclusive of the four major tributaries. The watershed areas of the four major tributaries are:

Millers River:	310 square-miles (Massachusetts portion only) (total area = 392 square-miles)
Deerfield River:	347 square-miles (Massachusetts portion only) (total area = 665 square-miles)
Chicopee River:	723 square-miles (entire watershed lays within Massachusetts)
Westfield River:	517 square-miles (Massachusetts portion only) (total area = 537 square-miles).

If the above watersheds were included with the Massachusetts portion of the Connecticut River Watershed, then the Connecticut River watershed would be 1,897 square-miles (Massachusetts portions only). This is roughly 18% of the entire area of Massachusetts.

According to the USGS streamflow within the Connecticut River Watershed was "Normal" during the time of biological sample collection (USGS 2006b).

RESULTS AND DISCUSSION

B0514 **-** Amethyst Brook

Mile point 0.8, Upstream of swale off end of Allen Mill Road, Amherst, MA

Habitat

Amethyst Brook is a "Class B" water (MassDEP 1996), and has never been assessed by the DWM. The brook begins at the confluence of Buffum and Harris brooks, in the Town of Pelham, MA. From this point, Amethyst Brook flows through a rather high-gradient reach within a narrow valley. Aside from a solitary road crossing (North Valley Road in Pelham), the abutting landuse is primarily forested. The brook then enters a small impoundment (one-mile from the Buffum Brook / Harris Brook confluence). The high-gradient nature of the stream continues upon leaving this impoundment, and Amethyst Brook enters B0514 0.4-miles from the upstream impoundment.

The within-reach habitat conditions were quite good (157 / 200)(Table A3). This score ranks B0514 third of the six stations examined. B0514 scored "marginal" in only one area – "Velocity / Depth Combinations" (10 / 20). This was due to the lack of any deep habitats. Indeed, the riffles were estimated at 0.1 meters deep, the runs at 0.2 meters deep, and the pools at 0.3 meters deep. However, this may be the natural state of the brook, as the water filled much of the available bed, and resulted in optimal Channel Flow

Status. Instream cover was assessed as “suboptimal” (12 / 20) due to few pools and a lack of stable refugia for fish, although the substrate was dominated by cobble (80%).

The brook, within this reach, is bordered by heavily used trails on both sides of the channel – and appears to be favored by dog-walkers. On the right bank, the trails run through a forested area. On the left bank, the trails run between the brook and residential land. The left bank vegetative protection score was 8 / 10 (suboptimal). This is due to the presence of residences and lawns along the left bank. The Riparian Vegetative Zone Width scored “suboptimal” (7 / 10) for both banks. The primary detraction was from the heavily used trails. The Bank Stability along the right bank also scored sub-optimally (8 / 10). There were extensive areas of “cut-bank” erosion along the right bank.

Amethyst Brook had extensive canopy cover (95%). Trees along both banks provided the shade. The types of trees observed included: Hemlock (*Tsuga canadensis*), Hornbeam (*Carpinus caroliniana*), Red Oak (*Quercus rubra*), Yellow Birch (*Betula lutea*), White Pine (*Pinus strobus*), Striped Maple (*Acer pensylvanicum*), Ash (*Fraxinus* sp.), White Oak (*Quercus alba*), and Elm (*Ulmus* sp.). Aquatic vegetation covered 5% of the available habitat and consisted entirely of mosses. There was no algae coverage within the reach.

Benthos

The collected benthos was dominated by the Filtering - Collectors (28%) and the Shredders (27%) functional feeding groups. B0514 had the lowest (best) Biotic Index score (3.48) of all stations examined. B0514 also had the lowest percent dominant taxa (14%), and the second highest taxa richness. The dominant taxon collected was Leuctra sp., a highly sensitive stonefly. The combination of these conditions makes Amethyst Brook a very satisfactory reference condition for wadeable streams within the Connecticut River Basin.

B0507 – Stony Brook

Mile point 2.0, approximately 30-meters upstream of powerlines, downstream from Route 116, South Hadley, MA

Habitat

Stony Brook – within this segment – is classified as Class B water as defined in the Massachusetts Surface Water Quality Standards (MassDEP 1996). The watershed contributing to B0507 is 21 mi^2. Stony Brook begins at the confluence of two unnamed, first-order streams east of Chicopee Road in Granby. It then passes through the Westover Municipal Golf Course in Ludlow. From here, it passes into Chicopee and Westover Metropolitan Airport. Stony Brook then flows north-northeast, back into Granby, and then into South Hadley. In South Hadley (both near and on the Mount Holyoke College campus) Stony Brook is impounded into Upper Pond and Lower Pond. Stony Brook flows out of these ponds and makes its way generally southward. The approximately 450-meters immediately upstream of Benthic Station B0507 finds Stony Brook paralleling Route 116. This stream reach is rather high-gradient, and Stony Brook flows under an old mill building, and is crossed by several small bridges that access commercial properties along Route 116. There is very little shading or canopy cover in the stream reach along Route 116.

The immediate habitat conditions within B0507 were deemed to be the highest of all stations examined during the 2003 Connecticut River Watershed Benthic Survey (160 / 200), including the regional reference station B0514. (Table A3). The Riparian Vegetative Zone Width (both left and right banks) and Riparian Bank Protection (both left and right banks) scored high. This is due, in part, to the lack of human activity within the sampled reach. Many rose bushes and stinging nettles were found along both banks. This condition dissuades people from accessing this reach. While open upstream the canopy cover at the sampling site was estimated at 80% and shaded the entire vicinity of the station. The riparian trees included Catalpa (*Catalpa speciosa*), Silver Maple (*Acer saccharinum*), Ash (*Fraxinus* sp.), Red Maple (*Acer rubrum*), and Elm (*Ulmus* sp.).

The sampled reach contained extensive riffles, and the Channel Flow Status was rated as optimal. The riffle depths were estimated at 0.2 meters deep, the runs at 0.4 meters deep, and the solitary pool (at the top of the reach) at 0.6 meters deep. Cobble dominated the inorganic substrates (80%), and detritus (CPOM – Coarse Particulate Organic Matter = >1mm) dominated the organic substrates (90%). The epifaunal substrate was optimal (17 / 20) for benthic macroinvertebrates due to the extensive areas of riffles, but there was poor (7 / 20) instream cover for fish due to the lack of pools and refugia. The within-reach algae coverage was estimated at 2%. Observed algae included both green filamentous and brown thin-film types. All algae were observed to be in the riffle zones. There were no aquatic plants observed within the sampled reach.

Benthos

The B0507 sample from Stony Brook was 76% comparable to the reference sample (Amethyst Brook, Amherst, MA), resulting in an assessment of "slightly impacted". The benthic community was dominated by filter-collectors from the families Hydropsychidae and Philopotamidae. The upstream presence of impoundments (including Upper Pond and Lower Pond) augments the conditions favorable for the propagation of each of these families (Mackay and Waters 1986, Whiles and Dodds 2002). The dominance of filter – collectors alludes to an increase in nutrients and/or FPOM (Fine Particulate Organic Matter = <1mm). Although CPOM was the dominant organic substrate component observed within this reach, it is possible that, due to the stream velocities, FPOM was not being deposited within this reach.

The macroinvertebrate assemblage from Stony Brook had the highest (worst) Biotic Index score (5.05) and the lowest Taxa Richness (23) of all six Connecticut benthic stations examined during the 2003 Connecticut Benthic Survey. The elevated biotic index score indicates that the benthic community is dominated by species tolerant of eutrophication and/or organic pollution. The lower species diversity points towards a community with somewhat reduced health and function. Based on the high habitat score for this station, it is likely that the impact is due to water quality conditions.

B0508 – Cushman Brook

Mile point 0.5, approximately 300-meters upstream of Factory Hollow Pond, State Street, Amherst, MA

Habitat

Cushman Brook, a Class B water (MassDEP 1996), has never been assessed by MassDEP. Cushman Brook begins at the outfall of Atkins Reservoir (a drinking water supply for the Town of Amherst) in Shutesbury, MA. It flows through a narrow valley, paralleling East Leverett Road for 1.25 miles. Cushman Brook then flows under the road, and enters the Mill River conservation area. This conservation area contains trails that both parallel and cross Cushman Brook. The trails appeared to be well maintained, and not causing any instream habitat degradation. The 2003 benthic sample was collected from within this area.

The total habitat score for Cushman Brook was 154 / 200 (Table A3). This score ranks Cushman Brook fourth among the 6 stations examined during the 2003 Connecticut River Benthic Survey. Both banks were steep and only marginally stable – making them prone to erosion. Fallen trees were observed along the left bank. The Velocity-Depth Combinations parameter was reduced (10 / 20), and the sediment deposition was increased. The increase in sediment deposition may be responsible for the reduction in the number and size of the riffle areas, as well as an increase in the embeddedness of the substrates. Sediment deposition may be a natural occurrence. There is a gravel pit across State Street from this benthic station, and similar gravel rich soils most likely exist within the sampled stream reach. Nonetheless, the above-mentioned conditions reduced the overall habitat score.

Canopy cover was estimated to be 80%, providing adequate shading to the stream. The trees providing this cover included: Hemlock (*Tsuga canadensis*), Yellow Birch (*Betula lutea*), Hornbeam (*Carpinus caroliniana*), Striped Maple (*Acer pennsylvanicum*), Sycamore (*Platanus occidentalis*), Red Oak (*Quercus rubra*), and Sugar Maple (*Acer saccharum*). The Channel Flow Status was optimal (18 / 20). The riffle depths were estimated at 0.2 meters. Run depth was not recorded, and there were no pools (> 0.5

meters) within the sampled reach. Even though there were no deep (> 0.5 meters) habitats within the sampling reach, both the Instream Cover, and Epifaunal Substrate habitat measures scored in the "optimal" range. There was a good assortment of snags, logs and other refugia for fish, as well as a good variety of velocities flowing through the riffle zones. Cobble dominated the inorganic portion of the substrates within the sampled reach (80%), and CPOM dominated the organic fraction. Algal coverage was less than 5% throughout the reach, and was represented by green, thin-film algae.

Benthos

The total metric score for Cushman Brook is 86% comparable to the reference station (Amethyst Brook) in terms of community structure, resulting in an assessment of "non-impacted" (Table A2). The functional feeding groups (FFG) were well represented, with the exception of Scrapers (6% of the collected benthics). The low number of Scrapers collected may be related to the reduced algal coverage (especially thin-film periphyton) within the reach. The Gathering – Collector functional feeding group were the most dominant FFG (30%), but other FFGs were also well represented: Filter – Collectors (25%), Predators (13%), and Shredders (26%). The Gathering – Collectors were (with the exception of the mayfly genus *Paraleptophlebia* sp.) dominated by Chironomidae (78%). The Biotic Index for Cushman Brook was 3.86 – the second best score of all stations examined. This low Biotic Index points towards a community with good representation by intolerant species. The Cushman Brook benthic community had a Taxa Richness of 28. This ranks Cushman Brook as fourth of the six stations sampled in terms of richness.

B0509 **–** Mill River (Northampton)

Mile Point 3.6, west of Vernon Street, approximately 300-meters upstream of USGS gage 01171500, Northampton, MA

Habitat

The Mill River – Northampton (within this segment) is classified as Class B water (MassDEP 1996). The watershed contributing to B0509 is 54 mi^2. The Mill River – Northampton begins in the Town of Williamsburg at the confluence of the East and West Branches of the Mill River. The river flows 8.5 miles from this confluence to B0509. Along its way, it flows through many industrial revolution era impoundments, and heavily developed residential areas – including the city of Northampton. Station B0509 was located within a city-operated park (off of Burts Pit Road – locally known as "The Fields"). This park consists of an array of trails through old farmland. The overall habitat score for within reach conditions was 149 / 200 (Table A3). The bank stability of the right bank was marginal (4 / 10). This stands in contrast to the left bank that received a score of 10 / 10 for bank stability. The high scoring left bank contained a 2 meter high, concrete retaining wall that ran approximately 60-meters along the left bank from the top of the reach. This wall greatly affected flow conditions and bank conditions along the opposite bank. The wall forces the water towards the right bank. As a result, the right bank consisted of deposits of cobble, gravel and sand – with very little herbaceous cover. Also, heavy foot-traffic has further removed vegetation from the right bank. The foot traffic and deposition of coarse substrates on the right bank also reduced the bank vegetative protection score to a marginal level (4 / 10). The retaining wall on the left bank, and the trail atop the wall, reduced the bank vegetative protection score to a suboptimal level (7 / 10). The retaining wall also represents an alteration to natural channel morphology. As a result, the channel alteration score was observed to be suboptimal (13 / 20). Also, the riparian vegetative zone width scores (for both banks) were reduced. The effects of the retaining wall and the trail along the left bank reduced the riparian vegetative zone width score to suboptimal (8 / 10). The deposited gravel and foot traffic reduced the right bank riparian vegetative zone width score to marginal (4 / 10).

While the above habitat parameters diminished the overall habitat score, there were several habitat measures that scored well. The Channel Flow Status was optimal (17 / 20). The depth at the riffles was 0.3 meters. The depth at the runs was 1 meter, and the depth at the pools was 1.5 meters. Cobble dominated the inorganic portion of the instream substrates (50%). CPOM dominated the organic component of the instream substrates (95%). Algae coverage was estimated at 90%. Green, thin-film algae represented the observed type of algae and it was attached to rocks in both the pools and riffles. Canopy cover to the stream was estimated at 50%. The trees providing the shade included Red Oak

(*Quercus rubra*), Sycamore (*Platanus occidentalis*), Grey Birch (*Betula populifolia*), Red Maple (*Acer rubrum*), Ash (*Fraxinus sp*.), Elm (*Ulmus* sp.), Hornbeam (*Carpinus* sp.), White Pine (*Pinus strobus*), and Cottonwood (*Populus* sp.).

Benthos

The total metric score for B0509 is 81% comparable to the reference condition (Amethyst Brook, Amherst, MA) in terms of metric performance, resulting in an assessment of "slightly impacted" (Table A2). The functional feeding groups from B0509 were dominated by Scrapers (34%), and Filtering – Collectors (33%). The high percentage of Scrapers is to be expected given the extensive algal coverage. However, no single taxon accounted for more than 10% of the entire sample. This reduced percent dominant taxa denotes diversity among the taxa collected. The percent dominant taxa score at B0509 was the lowest (best) of all 6 stations examined in the Connecticut Watershed. There were 30 different taxa collected at B0509 which was the third highest of all six stations examined. The Biotic Index score for B0509 was the second highest (worst) of all six stations (4.98). This high score alludes to a community populated by taxa tolerant of eutrophication and organic pollution.

B0510 **–** Mill River (Hatfield)

Mile Point 9.3, upstream of Mountain Drive, below the confluence with West Brook, Hatfield, MA

Habitat

Mill River – Hatfield is classified as Class B water (MassDEP 1996). The Mill River – Hatfield watershed (serving B0510) is 35 mi^2. The river begins on the northeast slope of Fisher Hill in Conway, MA. The stream is very high-gradient, and flows over a bedrock, boulder, and cobble bed as it parallels Route 116. This portion of the watershed is heavily forested, with many conifers. Just as the stream enters the Town of Deerfield, the nature of the stream changes dramatically. Immediately below a "blown-out" dam, the stream enters the Connecticut River valley floor. Here, the stream becomes a low-gradient, meandering stream. It flows through fields and pastures, and loses much of its shading. In the Town of Whatley, the sandy soils allow for extensive meanders, and, during the summer months, portions of the stream have been known to dry up. After receiving the flows from Bloody Brook, Roaring Brook, and Great Swamp, the Mill River - Hatfield begins to parallel Route 91. The Mill River – Hatfield then enters the Town of Hatfield. The benthic station B0510 is located near the Hatfield / Whately border.

The overall habitat score for B0510 was 158 / 200 (second only to the Stony Brook station B0507)(Table A3). Four of the 13 habitat measures scored below the optimal range. Channel Alteration scored sub-optimally (14 / 20) due to the boulders placed along the left bank to stabilize Route 91. The Left Bank Riparian Vegetative Zone Width score also received a designation of "suboptimal" (8/10). This is also due to the highway stabilization. The Sediment Deposition score was "suboptimal" (13 / 20) due to gravel deposits within the stream reach. These gravel deposits may be emanating from West Brook, which enters the Mill River – Hatfield immediately upstream of this reach. Channel Flow Status received a "marginal" score (9 / 20). Many of the substrates (primarily gravel) were left exposed. This condition may be due to water withdrawals from Roaring Brook by the Town of South Deerfield, or ground water recharge. All other habitat measures scored within the optimal range.

Although the Channel Flow Status was found to be suboptimal, the instream depths were adequate. Riffle zones were noted to be 0.3 meters deep, as were the run areas. The pools were deeper at 0.6 meters. The stream had a canopy coverage estimated at 50%. Thin lines of trees populated both banks. These included, Cottonwood (*Populus* sp.), Ash (*Fraxinus* sp.), Sugar Maple (*Acer saccharinum*), Sycamore (*Platanus occidentalis*), Elm (*Ulmus* sp.), and Dogwood (*Cornus florida*). Behind the trees, on the right bank was an area of field and behind the trees on the left bank was Route 91.

The instream habitat contained a large riffle zone - one of the last riffle zones available (not associated with a dam) before the river enters the Connecticut River. Cobble was the dominant inorganic portion of the substrates (65%), and CPOM was the dominant organic portion (100%). Algae coverage was estimated at 65%. Observed algae types included green filamentous and green mats. Both types were attached to rocky substrates and found in both pools and riffles. Aquatic macrophyte coverage was also extensive, with 40% coverage noted within the reach.

Benthos

The B0510 total metric score is 71% comparable to the reference station (Amethyst Brook, Amherst, MA). This condition results in an assessment of “slightly impacted” (Table A2). All functional feeding groups were well represented, with the most even distribution of all stations examined. The dominant functional feeding group was Scrapers (36%). The dominant family within this group was Chironomidae (55%). The presence of many members of this family is considered to be a sign of reduced water quality. However, the four genera of Chironomidae collected had tolerance values of either five or six. These tolerance values classify the collected genera as mid-to-slightly tolerant. The Biotic Index score for B0510 was 4.70. While tolerance values are prescribed as a measure of a macroinvertebrates ability to tolerate eutrophication and organic pollution, the presence of tolerant taxa are to be expected from within a low-gradient stream, downstream of an extensive wetland. Mill River – Hatfield had the second lowest Taxa Richness (24). This reduced diversity points towards a community that may be structurally and functionally compromised. The high habitat evaluation, dense algal and macrophyte coverage, and lowest total metric score of all stations, points towards a community that reflects water quality limitations – likely related to nutrient loading.

B0515 – Sawmill River

Mile Point 2.5, upstream at South Ferry Road, Montague, MA

Habitat

The Sawmill River begins at the outfall of Lake Wyola in Shutesbury, MA. The river flows through a high-gradient valley of sparse residential development in the towns of Leverett and Montague. At 6.2 miles from Lake Wyola, the Sawmill River passes under Route 63 in Montague. The gradient downstream from this bridge to B0515 is not as high as it is upstream of Route 63. Here, the stream enters the Connecticut River valley floor. The Sawmill River begins to meander through an area of pastures and the thickly settled village of Montague. The river then passes down a bedrock falls that was once the site of an industrial revolution-era dam. This is the last large drop the river takes before it enters the Connecticut River. B0515 is located 0.8 miles from the bedrock falls, and approximately 10 miles from Lake Wyola.

The within-reach habitat conditions at B0515 were deemed to be the worst of all six stations examined (137 / 200)(Table A3). The reductions in the habitat score are primarily due to abutting agricultural practices. The reach flows through an area of pasture that contains cows. These cows have direct access to the stream and have worn paths to, and through, the stream. This has caused degradation of the vegetation on both banks. The reduced Bank Vegetative Protection score for both banks exemplifies the condition of obvious disruption. The right bank received a score of 4 / 10, and the left bank received a score of 5 / 10. Most of the herbaceous plants that are preferentially consumed by ruminants (such as cows) were not present. There is a very limited understory beneath the thin rows of trees along each bank. Much of the understory consisted of rose bushes (*Rosa* sp.). The Riparian Vegetative Zone Width score was also reduced on both banks. The left bank received a score of 3 / 10. This is a “marginal” rating, with the riparian zone being reduced to between 6 – 12 meters. The left bank received a score of 2 / 10. This is a “poor” rating with the riparian zone being reduced to less than 6 meters. The reduction in score is due to the removal of trees to create pastureland, and the impact that grazing animals have had on the native vegetation.

The Bank Stability along the right bank was rated as “marginal” (4 / 10), with “cut-bank” erosion being quite obvious. This may be a natural occurrence as the reach was within the Connecticut River valley floor. Here, the soils are much more sandy, and prone to erosion. Sediment Deposition was rated as suboptimal with some new increases in bar formation. This, also, may be a natural occurrence due to the sandy nature of the localized soils. The Instream Cover available to aquatic biota was marginal (8 / 20). Only 10-30% of the area had a stable habitat and the substrates (dominated by cobble – 80%) were often disturbed.

Channel Flow Status scored in the optimal range, with water reaching the base of both banks and minimal amounts of substrates exposed. The Velocity-Depth combinations were also optimal with all four patterns (shallow-fast, shallow-slow, deep-fast, deep-slow) being represented. The depths of the instream habitats within this 5-meter wide river were adequate. The riffles were estimated at 0.2 meters deep. The runs were 0.3 meters deep, and the pools were 0.4 meters deep.

The canopy cover was estimated at 70%. The trees providing this shade included: Sugar Maple (*Acer saccharum*), Elm (*Ulmus* sp.), Willow (*Salix* sp.), and Hornbeam (*Carpinus caroliniana*). No algae, or aquatic macrophytes were observed within this reach.

Benthos

The benthic community collected at B0515 did not reflect the perturbation observed in the within-reach habitat. The community appeared to be in good health. The total metric score for B0515 is 90% comparable to the reference condition (B0514 – Amethyst Brook)(Table A2) resulting in an assessment of "non-impacted". The Scraper functional feeding group (34%) dominated the collected benthic community from B0515. In turn, the family Elmidae dominated the Scraper functional feeding group (69%). This family is known to feed on attached algae and diatoms. The dominant taxon within the family Elmidae was Optioservus sp. This taxon is fairly sensitive to pollution, and requires high concentrations of dissolved oxygen. The Biotic Index score was 4.31. This score ranks B0515 third in comparison to the five other stations examined. When compared with other stations assessed, the collected benthic community from B0515 exhibited the highest number of different taxa (Taxa Richness = 35). This condition points towards a diverse community with good health and function. The EPT Index score (16) was also the best of all stations examined in the Connecticut Basin.

SUMMARY AND RECOMMENDATIONS

Benthic monitoring stations within the Connecticut River Basin included wadeable streams that were monitored employing DWM kick-net methodologies (Nuzzo 2002). The reference station (B0514 – Amethyst Brook) was chosen based on the reduced development within the contributing watershed, the lack of significant water withdrawals upstream of B0514, and high scoring metric values.

Cushman Brook (B0508) was initially considered a potential reference station. Contributing to B0508 is a Class A drinking water supply (Atkins Reservoir), and the watershed supplying that reservoir is well protected. However, the withdrawal of water could potentially affect the instream community, and there is significant agricultural and residential activity below the reservoir, and along East Leverett and Market Hill Roads. These two roads parallel the course of Cushman Brook, on either side of the stream.

Overall habitat scores (with the exception of B0515 – Sawmill River) were fairly comparable. They ranged from 149 / 200 at B0509 (Mill River – Northampton) to 160 / 200 at B0507 (Stony Brook). This is quite a tight range (11 points). The Sawmill River (B0515) stands out with the lowest habitat score (137 / 200).

The biomonitoring station used for a reference condition in the Connecticut River Watershed was Amethyst Brook (B0514). This station supports the diverse and well-balanced aquatic community expected in a "least-impacted" stream system. Including the reference station, three Connecticut River watershed biomonitoring study stations were found to be non-impacted. The other three stations were considered slightly impacted relative to reference conditions. Impacts to resident biota in this watershed were generally a result of habitat degradation and/or nonpoint source-related water quality impairment, with potential point source effects, observed as well.

Overall, collected benthic communities revealed "Non-Impacted" conditions at the following stations:

Stations with Non-Impacted Benthic Communities

Cushman Brook	B0508	
Amethyst Brook	B0514	(Reference Station)
Sawmill River	B0515	

Benthic communities revealed "slightly impacted" conditions at the following stations:

Stations with Slightly Impacted Benthic Communities

Stony Brook	B0507
Mill River – Northampton	B0509
Mill River – Hatfield	B0510

The schematic below (Figure 2) is based on a proposed conceptual model that predicts the response of aquatic communities to increasing human disturbance. It incorporates both the biological condition impact categories outlined in the RBPIII biological assessment methodology currently used by MassDEP and the Tiered Aquatic Life Use (TALU) conceptual model developed by the US EPA and refined by various state environmental agencies (US EPA 2003). The model summarizes the main attributes of an aquatic community (in this case the benthic macroinvertebrate community **only**) that can be expected at each level of the biological condition category, and how these metric-based bioassessments can then be used to make aquatic life use determinations as part of the 305(b) reporting process. Slightly or non-impacted aquatic communities, such as those encountered at all Connecticut stations, *support* the Massachusetts SWQS designated *Aquatic Life* use in addition to meeting the objective of the Clean Water Act (CWA), which is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Environmental Law Reporter 1988). No benthic communities assessed in this study failed to support the *Aquatic Life* use goal of the CWA. This is not to say that stations achieving a designation of *non-impacted* should be considered pristine. There may be stressors affecting water quality, aesthetics, and other biotic communities that have little impact upon the benthic community.

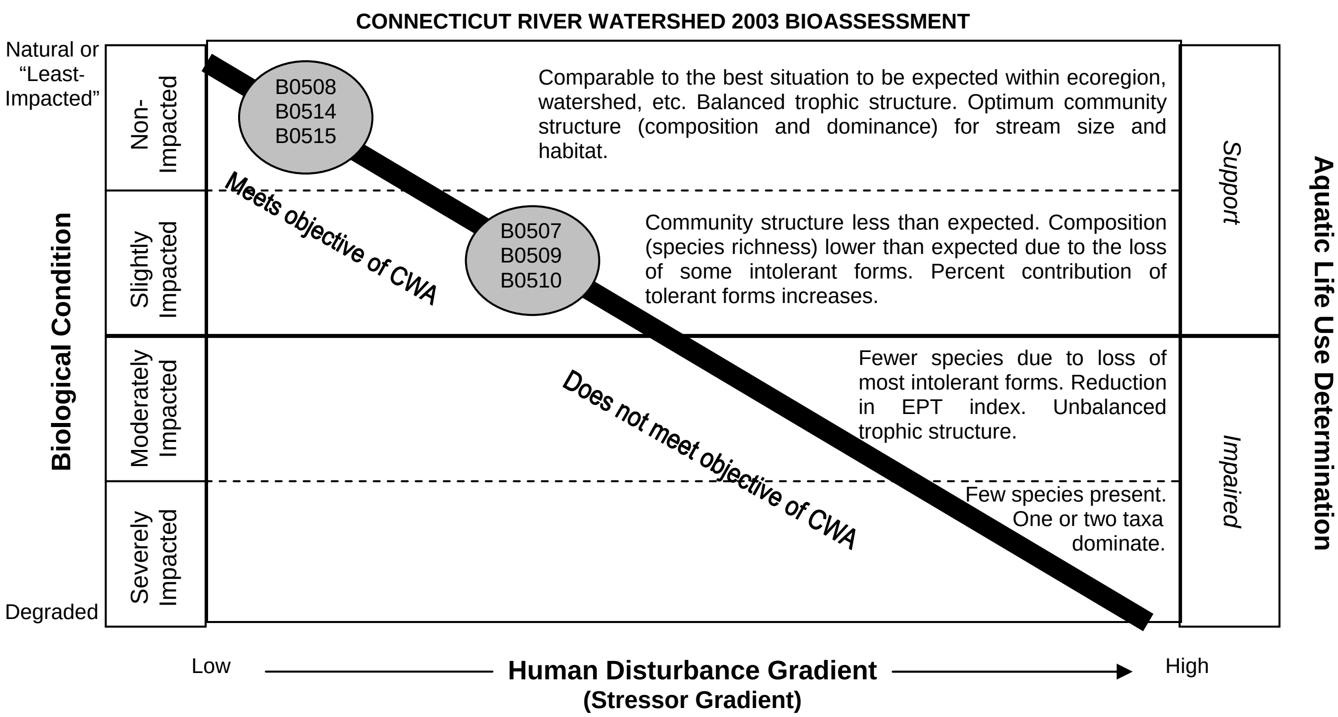

Figure 2. Schematic of the predictive response of aquatic communities to increasing human disturbance. Included is the performance (Biological Condition and Aquatic Life Use determinations) of the Connecticut River watershed 2003 biomonitoring stations along the Human Disturbance Gradient. NOTE: reference station (B0514) is considered to represent the "best attainable" conditions and to be supportive of the *Aquatic Life* use.

Amethyst Brook

Benthos: “Non-Impacted” (Reference Station)
Habitat: 157 / 200

Observations and Recommendations:

B0514 was used as the regional reference station to which all other Connecticut River Watershed benthic stations were compared. Amethyst Brook runs through a high-gradient area from its headwaters (the confluence of Harris Brook and Buffum Brook) all the way through station B0514. The contributing watershed is sparsely populated and mostly forested.

Much of the area surrounding B0514 is conservation land owned by the Town of Amherst. There are many trails that cross, and parallel, Amethyst Brook. These include the Metacomet-Monadnock Trail, and the Robert Frost Trail. Mountain bikers and dog walkers heavily utilize the trails around Amethyst Brook. Although there were obvious signs of recreational use, the trail system did not appear degraded. Nor did there appear to be any major impacts to the stream as a result of recreational activity. The homes on the left side of the brook were set back far enough from the brook so as to not have a major impact on the instream habitat. The Town of Amherst has a history of preserving open space, and maintaining conservation lands. It is recommended that the Town of Amherst continue with its sound trail maintenance and conservation efforts.

Stony Brook

Benthos: “Slightly Impacted”
Habitat: 160 / 200 (100% Comparability to Reference Station)

Observations and Recommendations:

It is highly probable that the aquatic health of Stony Brook could be greatly improved with the application of sound Non-Point Source (NPS) pollution reduction practices. NPS best management practices can reduce the amount of nutrients and toxins that enter surface waters (MassDEP 2006).

Cushman Brook

Benthos: “Non – Impacted”
Habitat: 154 / 200 (98% Comparable to Reference Station)

Observations and Recommendations:

The presence of a gravel pit across State Street from this station indicates that large amounts of gravel and sand occur within the localized soils. It is quite likely that this same gravel deposit extends within the B0508 area. If so, this condition will always leave B0508 exposed to potential stream bank erosion and sediment deposition. Continued good maintenance of trails within this conservation area would tend to reduce future sediment deposition and bank erosion. If erosion and sediment deposition can be reduced, then the health of the aquatic fauna may be improved.

Mill River – Northampton

Benthos: “Slightly Impacted”
Habitat: 149 / 200 (95% Comparable to Reference Station)

Observations and Recommendations:

Many mills were established along the Mill River – Northampton during the industrial revolution. This development required the installation of associated dams to ensure adequate water supply during the summer months. Manufacturing practices, and other development, within the Mill River watershed have had a significant impact upon the instream and riparian habitats. Many of these mills are now gone; yet many of their impacts (and dams) still exist. The dams pose a barrier to fish passage, and can have a deleterious effect upon habitat, flow, and water chemistry.

The area surrounding B0509 showed signs of heavy recreational pressure. The extensive trail network (on both sides of the examined reach) is often frequented by runners and dog-walkers. The heavy foot traffic has compacted the soils, and removed much of the grasses and herbaceous vegetation. The retaining wall along the left bank has increased the deposition of gravel and cobble onto the right bank. Also, as a result of the left bank retaining wall, spring flooding can only “over bank” on the right bank. This (along with the foot traffic) has reduced the presence of grasses and herbaceous vegetation.

Sound within-watershed development, and remediation of past impacts, should be followed to improve the quality of aquatic life in the Mill River – Northampton. It is quite likely that upstream NPS pollution (including storm-water runoff) is a primary impact to the instream biota. Assessments of storm drains and abutting land use should be made, and remediated as conditions require. Also, upstream dams should be examined to determine if they continue to serve beneficial purposes or may be candidates for removal.

Mill River – Hatfield

Benthos: “Slightly Impacted”
Habitat: 158 / 200 (101% Comparable to Reference Station)

Observations and Recommendations:

The Mill River – Hatfield has two distinctly different habitats. The upstream portion (upstream of Route 116, Deerfield, MA) is very high-gradient and the streambed contains large amounts of bedrock, boulders and cobble. The portion downstream of Route 116 is lower gradient and the streambed contains large amounts of gravel, sand, and mud / muck. B0510 was located in the lower gradient portion of the river. This was done in order to assess the biological condition in response to the largest amount of contributing watershed.

The lower portion of Mill River – Hatfield (downstream of Route 116) parallels Route 91 for much of its course. The result is the straightening of what would otherwise be a meandering river. Also, the proximity of Route 91 greatly increases the potential for road-run off into the river. Road salt, motor oil, and solid waste can easily enter the river. Aside from Route 91, the proximal upstream landuse consists of heavily developed agriculture. While much of this agriculture consists of pastureland, there are also extensive areas of tilled land. Chemical applications, without adequate buffering, can find their way into this river.

Continued monitoring of watershed conditions, such as those being performed by Smith College (Clark Science Center 2000), is recommended. Agricultural Best Management Practices should be followed to reduce the potential for groundwater and stream impacts. Highway maintenance (along Route 91 and Route 116) should be performed with care. Stormwater runoff – from the industrialized portion of South Deerfield – should be mitigated. Monitoring of Bloody Brook should also continue as this stream receives much of the runoff from South Deerfield. Water withdrawal volume from Roaring Brook reservoir should be monitored to assure adequate instream flows in Mill River – Hatfield.

Sawmill River

Benthos: “Non-Impacted”
Habitat: 137 / 200 (87% Comparable to Reference Station)

Observations and Recommendations:

B0515 had the poorest habitat score of all station examined. This is primarily due to livestock having created trails into and through the river. The livestock (primarily cows) have browsed and trampled much of the riparian vegetation. They also contribute manure to the banks and the river. The stream banks are quite prone to erosion within this reach. The stream, at this point, has entered the Connecticut River Valley floor. Here, the sediments are much finer (sand) than those encountered in headwaters (cobble and boulder). In the presence of conditions such as these, it is important to preserve as much of the stabilizing vegetation as possible.

This portion of the Sawmill River could benefit from a more active land management strategy. Since the pastureland that abuts both sides of the Sawmill River is used for grazing cattle, it may be necessary to apply agricultural BMPs (Best Management Practices). These practices may include the construction of a bridge and fencing to keep cattle out of the river, yet allow them access to both pastures.

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APPENDIX

Macroinvertebrate taxa list, RBPIII benthos analyses, and Habitat evaluations

Table A1. Taxa list and counts, functional feeding groups (FFG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2003 Connecticut River watershed survey July 2003.

TAXON	FFG[1]	TV[2]	B0507	B0515	B0514[3]	B0508	B0510	B0509
Hydrobiidae	SC	8	4					
Ferrissia sp.	SC	6						2
Pisidiidae	FC	6	3					
Enchytraeidae	GC	10			1			
Nais behningi	GC	6		1	2	2		1
Lumbriculidae	GC	7		3			3	3
Erpobdellidae	PR	8	1					
Caecidotea communis	GC	8	3					
Hydrachnidia	PR	6			1			1
Baetis (subeq. term.) sp.	GC	6	2		2			8
Baetidae (short term. fil.)	GC	6					2	
Baetidae (subeq. term.)	GC	6		6				
Caenis sp.	GC	6		1				
Serratella sp.	GC	2		3	2			2
Heptageniidae	SC	4	10	2		1	5	5
Epeorus (Iron) sp.	SC	0				1		
Isonychia sp.	GC	2	2					1
Leptophlebiidae	GC	2		2	1			
Habrophlebia sp.	GC	4			1			
Paraleptophlebia sp.	GC	1				5		
Chloroperlidae	PR	1					1	
Leuctridae	SH	0				11		
Leuctra sp.	SH	0			14			
Leuctridae/Capniidae	SH	2		5				
Perlidae	PR	1		1		2		
Acroneuria sp.	PR	0			3	2		
Agnetina sp.	PR	2		1		1		
Paragnetina sp.	PR	1	2	1				
Nigronia sp.	PR	0		1				
Nigronia serricornis	PR	0			2			
Brachycentrus sp.	FC	1		1				
Glossosomatidae	SC	0					3	
Agapetus sp.	SC	0		3				
Glossosoma sp.	SC	0		1		2		
Helicopsyche sp.	SC	3		2				
Hydropsychidae	FC	4						1
Cheumatopsyche sp.	FC	5	19		7	1	8	6
betteni	FC	6	15				21	
Hydropsyche morosa gr.	FC	6		7	2	2		4
Lepidostoma sp.	SH	1	1		4			
Oecetis sp.	PR	5	1					
Apatania sp.	SC	3			1			1
Odontoceridae	SH	0			2			
Philopotamidae	FC	3				1		
Chimarra sp.	FC	4	14					3
Dolophilodes sp.	FC	0		1	3			
Polycentropus sp.	PR	6			1			
Rhyacophila sp.	PR	1		1		4		
Neophylax sp.	SC	3	1	3				3
Optioservus sp.	SC	4		21			12	4
Oulimnius latiusculus	SC	4		1	5	1	1	2
Promoresia sp.	SC	2			5	1	5	1
Stenelmis sp.	SC	5	8	3			9	10
Dineutus sp.	PR	4		1			3	
Psephenus herricki	SC	4	3				1	6
Chironomini	GC	6		1				
Microtendipes pedellus gr.	FC	6		1	1			
Microtendipes rydalensis gr.	FC	6			2	1		

TAXON	FFG[1]	TV[2]	B0507	B0515	B0514[3]	B0508	B0510	B0509
Polypedilum sp.	SH	6		2				
Polypedilum aviceps	SH	4		3	5	16		
Polypedilum fallax	SH	6					1	1
Polypedilum flavum	SH	6	3	1				2
Micropsectra dives gr.	GC	7			1	3		
Micropsectra polita gr.	GC	7		1	2	5		
Micropsectra/Tanytarsus sp.	FC	7		2		1		
Rheotanytarsus sp.	FC	6	1					
Rheotanytarsus exiguus gr.	FC	6	3	3			2	9
Rheotanytarsus pellucidus	FC	5	4	2	1		1	3
Stempellina sp.	GC	2			1			
Sublettea coffmani	FC	4						7
Tanytarsus sp.	FC	6		8	11	20		
Zavrelia/Stempellinella sp.	GC	4				2		
Diamesa sp.	GC	5	6				13	
Pagastia sp.	GC	1					2	
Potthastia longimana gr.	GC	2		1				
Orthocladiinae	GC	5		1				
Corynoneura sp.	GC	4			1			
Cricotopus triannulatus	SH	7						4
Cricotopus vierriensis	SH	7						4
Eukiefferiella sp.	GC	6		1				
Eukiefferiella devonica gr.	GC	4					1	
Nanocladius (Plecopteracoluthus) sp.	GC	3				1		
Parachaetocladius sp.	GC	2			1	3		
Parametriocnemus sp.	GC	5			3	4		
Rheocricotopus sp.	GC	6			1			
Rheocricotopus robacki	GC	5						1
Tvetenia paucunca	GC	5	1		3	7	2	
Tanypodinae	PR	7		1				
Ablabesmyia mallochi	PR	8				1		
Conchapelopia sp.	PR	6		2	2	1	1	1
Chelifera sp.	PR	6						1
Hemerodromia sp.	PR	6		2		1	1	
Simulium sp.	FC	5	2				1	
Tipulidae	SH	5						1
Antocha sp.	GC	3						3
Dicranota sp.	PR	3		1	3	1		
Hexatoma sp.	PR	2				1		
Tipula sp.	SH	6	1		1		1	
TOTAL NUMBER OF ORGANISMS			**110**	**105**	**98**	**105**	**100**	**101**

[1]Functional Feeding Group (FFG). The feeding habit of each taxon. SH-Shredder; GC-Gathering Collector; FC-Filtering Collector; SC-Scraper; PR-Predator.
[2]Tolerance Value (TV). An assigned value used to calculate the biotic index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for organisms very tolerant.
[3] Reference station

Table A2. Summary of RBP III data analysis for macroinvertebrate communities sampled during the Connecticut River watershed survey – July 2003. Shown are the calculated metric values, metric scores (in italics) based on comparability to the Amethyst Brook (B0514) reference station, and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a complete listing and description of sampling stations.

STATION	B0514		B0507		B0508		B0509		B0510		B0515	
STREAM	Amethyst Brook		Stony Brook		Cushman Brook		Mill River - Northampton		Mill River – Hatfield		Sawmill River	
HABITAT SCORE	157		160		154		149		158		137	
TAXA RICHNESS	34	*6*	23	*4*	28	*6*	30	*6*	24	*4*	35	*6*
BIOTIC INDEX	3.48	*6*	5.05	*2*	3.86	*6*	4.98	*2*	4.70	*4*	4.31	*4*
EPT INDEX	12	*6*	10	*4*	10	*4*	9	*2*	6	*0*	16	*6*
EPT/CHIRONOMIDAE	1.23	*6*	3.72	*6*	0.51	*2*	1.06	*6*	1.74	*6*	1.37	*6*
SCRAPER/FILTERER	0.41	*6*	0.43	*6*	0.23	*6*	1.03	*6*	1.09	*6*	1.44	*6*
% DOMINANT TAXON	14%	*6*	17%	*6*	19%	*6*	10%	*6*	21%	*4*	20%	*4*
REFERENCE SITE AFFINITY	100%	*6*	62%	*4*	73%	*6*	76%	*6*	67%	*6*	78%	*6*
TOTAL METRIC SCORE	*42*		*32*		*36*		*34*		*30*		*38*	
% COMPARABILITY TO REFERENCE	100%		76%		86%		81%		71%		90%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	Reference		Slightly Impacted		Non-Impacted		Slightly Impacted		Slightly Impacted		Non-Impacted	

Table A3. Habitat assessment summary for biomonitoring stations sampled during the Connecticut River watershed survey – July 2003. For primary parameters, scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For secondary parameters, scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor. Refer to Table 1 for a complete listing and description of sampling stations.

Habitat Parameter	B0514*		B0507		B0508		B0509		B0510		B0515	
Instream Cover	12		7		18		17		16		8	
Epifaunal Substrate	19		17		18		16		18		18	
Embeddedness	16		15		14		14		16		19	
Channel Alteration	18		18		19		13		14		18	
Sediment Deposition	16		14		9		17		13		15	
Velocity-Depth Combinations	10		15		10		18		17		16	
Channel Flow Status	18		17		18		17		9		16	
Bank Vegetative Protection	8[L]	9[R]	10	10	9	8	7	4	10	10	5	4
Bank Stability	9	8	9	9	5	7	10	4	9	9	9	4
Riparian Vegetative Zone Width	7	7	9	10	10	9	8	4	8	9	3	2
TOTAL SCORE	**157**		**160**		**154**		**149**		**158**		**137**	

L = Left Bank
R = Right Bank
* = Reference Station