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BUZZARDS BAY WATERSHEDS
2005 BENTHIC MACROINVERTEBRATE BIOASSESSMENT

CN 221.3

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INTRODUCTION

Biological monitoring is a useful means of detecting anthropogenic impacts to the aquatic community. Resident biota (e.g., benthic macroinvertebrates, fish, periphyton) in a water body are natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration (Barbour et al. 1999, Barbour et al. 1995). Biological surveys and assessments are the primary approaches to biomonitoring.

As part of the Massachusetts Department of Environmental Protection/Division of Watershed Management's (MassDEP/DWM) 2005 watershed assessments, aquatic benthic macroinvertebrate biomonitoring was conducted to evaluate the biological health of various streams within the Buzzards Bay coastal drainage system. A total of nine biomonitoring stations, in streams previously "not assessed" or "unassessed" by DWM, were sampled to investigate the effects of anthropogenic stressors on the aquatic communities of the watershed. Sampling locations, along with station identification numbers and sampling dates, are noted in Table 1.

To provide information necessary for making basin-wide *Aquatic Life* use-support determinations required by Section 305(b) of the Clean Water Act, all macroinvertebrate biomonitoring stations in the Buzzards Bay watersheds were compared to a reference station most representative of "least disturbed conditions" (LDC reference; see Stoddard, et al. 2006) in the watershed. Use of a watershed reference station is particularly useful in assessing nonpoint source (NPS) pollution originating from multiple and/or unknown sources in a watershed (Hughes 1989). LDC reference stations were established in Angeline Brook (ANG01) for comparisons to the smallest tributary stations in the 2005 survey, and the East Branch Westport River (EBW02) for comparisons to larger stream stations with more comparable drainage areas and flow regimes. Both stations were situated upstream from all known point sources of water pollution, and were also assumed (based on MassDEP water quality data, topographic map examinations, and field reconnaissance) to be minimally impacted (relative to other portions of the watershed) by nonpoint sources. In addition, a third reference station (NB13MAT in the Mattapoisett River) was used for biological comparisons to a study site in the Shingle Island River (NB14SHI). NB13MAT historically has been used as a reference station by MassDEP/DWM as part of an ongoing study in numeric biocriteria development (Lotic, Inc. 1999; Tetra Tech, Inc. 1999). NB13MAT is located in a predominantly low-gradient stream system, with mainly pool/glide flow regimes that are more comparable to habitats in the meandering, wetland-dominated Shingle Island River than either ANG01 or EBW02.

During "Year 1" of its "Five-Year Basin Cycle", problem areas, potential problem areas, and areas lacking historical data within the Buzzards Bay watershed were better defined through such processes as coordination with appropriate groups (MassDEP, EPA, watershed associations, USGS), examining historical data (data >5 years old, i.e., from waters currently "not assessed"), identifying "unassessed" (i.e., waters never before assessed by MassDEP) waters, conducting site visits, examining GIS datalayers (land-use information), reviewing the Massachusetts Stream Classification Program Inventory of Rivers and Streams, and reviewing NPDES and water withdrawal permits. Following these activities, the 2005 biomonitoring plan was formulated and study objectives were defined. Table 2 includes a summary of current and historical conditions and perceived problems identified prior to the 2005 Buzzards Bay watershed biomonitoring survey.

The main objectives of biomonitoring in the Buzzard Bay watershed were: (a) to determine the biological health of rivers/streams within the watershed by conducting assessments based on biological (aquatic macroinvertebrates) communities; and (b) to identify problem stream segments so that efforts can be focused on developing or modifying NPDES and/or Water Management Act permits, stormwater management, and control of other nonpoint source pollution. Specific tasks were:

1. Conduct benthic macroinvertebrate sampling and habitat assessments at locations throughout the Buzzards Bay watersheds;

2. Based upon the macroinvertebrate data, identify river segments with potential point/nonpoint source pollution problems; and

3. Using the benthic macroinvertebrate data and supporting water chemistry and field/habitat data:

- Assess the types of water quality and/or water quantity problems that are present;
- If possible, 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-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 and resource agencies.

Table 1. List of biomonitoring stations sampled during the 2005 Buzzards Bay watershed survey, including station identification number, upstream drainage, station description, and sampling date. Stations are listed hydrologically (from upstream-most drainage in their respective subwatershed to downstream-most) and from west to east in the watershed.

Station ID	**Upstream Drainage Area (mi^2)**	**Buzzard Bay Watershed Station Description**	**Sampling Date**
		WESTPORT RIVER DRAINAGE AREA	
NB14SHI	8.59	Shingle Island River, 100 m downstream from Old Fall River Rd., Dartmouth, MA	11 Aug 2005
EBW02	29.2	East Branch Westport River, 50 m upstream from Forge Pond, Westport, MA	10 Aug 2005
BRCH01	9.27	Bread and Cheese Brook, upstream from American Legion Highway, Westport, MA	10 Aug 2005
SNL00	1.49	Snell Creek, 300 m downstream from Drift Rd., Westport, MA	17 Aug 2005
ANG01	3.25	Angeline Brook, upstream from Cornell Road, Westport, MA	10 Aug 2005
		PASKAMANSET RIVER DRAINAGE AREA	
PASK02	26.1	Paskamanset River, downstream from Russell Mills Rd., Dartmouth, MA	24 Aug 2005
		NEW BEDFORD HARBOR DRAINAGE AREA	
ACUSH01	18.7	Acushnet River, 200 m upstream from Main St., Acushnet, MA	11 Aug 2005
BUT01	2.98	Buttonwood Brook, upstream from Elm St., Dartmouth, MA	11 Aug 2005
		MATTAPOISETT RIVER DRAINAGE AREA	
NB13MAT	18.1	Mattapoisett River, near end of Tinkham Lane, Mattapoisett, MA	24 Aug 2005

Table 2. Existing conditions and perceived problems identified prior to the 2005 Buzzards Bay watershed survey.

Buzzards Bay Watershed Stations	Conditions
EBW02; ACUSH01; BUT01; PASK02; BRCH01	-urban runoff/miscellaneous NPS[1]
ACUSH01	-NPDES (sanitary and process waste)[1]; legacy industrial pollutants[1]
NB14SHI	-303(d) listed for priority organics and metals[2]
SNL00; NB13MAT; NB14SHI; BRCH01; ACUSH01; PASK02	-agriculture related NPS (including cranberry bogs)[1]
ACUSH01	-303(d) listed for nutrients and organic enrichment/low D.O.[1,2]
NB13MAT; PASK02; SNL00; ANG01	-flow reductions (naturally occurring or groundwater withdrawals)[1]
NB14SHI; EBW02; BRCH01; SNL00; ANG01; PASK02;	-"unassessed/not assessed" for Aquatic Life by DEP[1]
ACUSH01; BUT01; NB13MAT ANG01; EBW02; NB13MAT	- "least disturbed condition" reference [1,3]

[1]MassDEP 2003; [2]MassDEP 2007;[3]Stoddard, et al. 2006

WATERSHED DESCRIPTION

Buzzards Bay is a moderately large estuary located between the westernmost part of Cape Cod, southeastern Massachusetts, and the Elizabeth Islands. The Bay is 28 miles long, averages about 8 miles in width, and has a mean depth of 36 feet. It is approximately 228 square miles in size. The coastline stretches over 280 miles and includes 11 miles of public beaches.

The Buzzards Bay drainage basins cover 432 square miles and include all or sections of 17 municipalities in Massachusetts and Rhode Island. The Bay itself is part of an interconnected hydrologic system that includes several rivers. The largest river basins along the western shore include the Agawam, Wankinco, Weweantic, Mattapoisett, Acushnet, Paskamanset, and Westport. The prominent freshwater streams along the eastern shore are the Back, Pocasset, and Wild Harbor rivers and Herring Brook. Groundwater seepage is also part of the inflow to Buzzards Bay. In general, rivers within the drainage system are slow-moving, meandering streams near their headwaters and for most of their freshwater length. Nearing the coast, the action of the tides rapidly widens the channels as the transition occurs from freshwater stream to tidal estuary. On average, Buzzards Bay rivers are considerably shorter (usually much less than 20 miles) and have smaller drainage areas than other rivers within the state.

Today, approximately 373,690 people live in the watershed with approximately 40% residing in the Greater New Bedford area (CBB 2003). Based on the latest land use figures (MassGIS 2008), the residential, commercial, and industrial uses account for about 12% of the watershed, and approximately 79% of the watershed is undeveloped forest, agriculture or wetland areas.

METHODS

Macroinvertebrate Sampling

Macroinvertebrate sampling activities employed for the 2005 Buzzards Bay watershed survey were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (MassDEP 2004). The sampling procedures are described in the standard operating procedures *Water Quality Monitoring In Streams Using Aquatic Macroinvertebrates* (Nuzzo 2003), and are based on US EPA Rapid Bioassessment Protocols (RBPs) for wadeable streams and rivers (Barbour et al. 1999). For the majority of the biomonitoring stations, 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 (Figure 1). Kick-sampling was conducted throughout a 100 m reach, in riffle/run areas with fast currents and rocky (cobble, pebble, and gravel) substrates—generally the most productive habitats, supporting the most diverse communities in the stream system. For those biomonitoring stations lacking sufficient current velocity and hard substrates amenable to kick sampling, other productive habitat types (e.g., snags, vegetated banks, submerged macrophytes) were sampled in approximate proportion to their representation of surface area of the total macroinvertebrate habitat in the reach. Ten kicks in squares approximately 0.46 m x 0.46 m—or a combination of kicks and jabs (i.e., sweeps) if the multihabitat sampling technique was utilized—were composited for a total sample area of approximately 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.

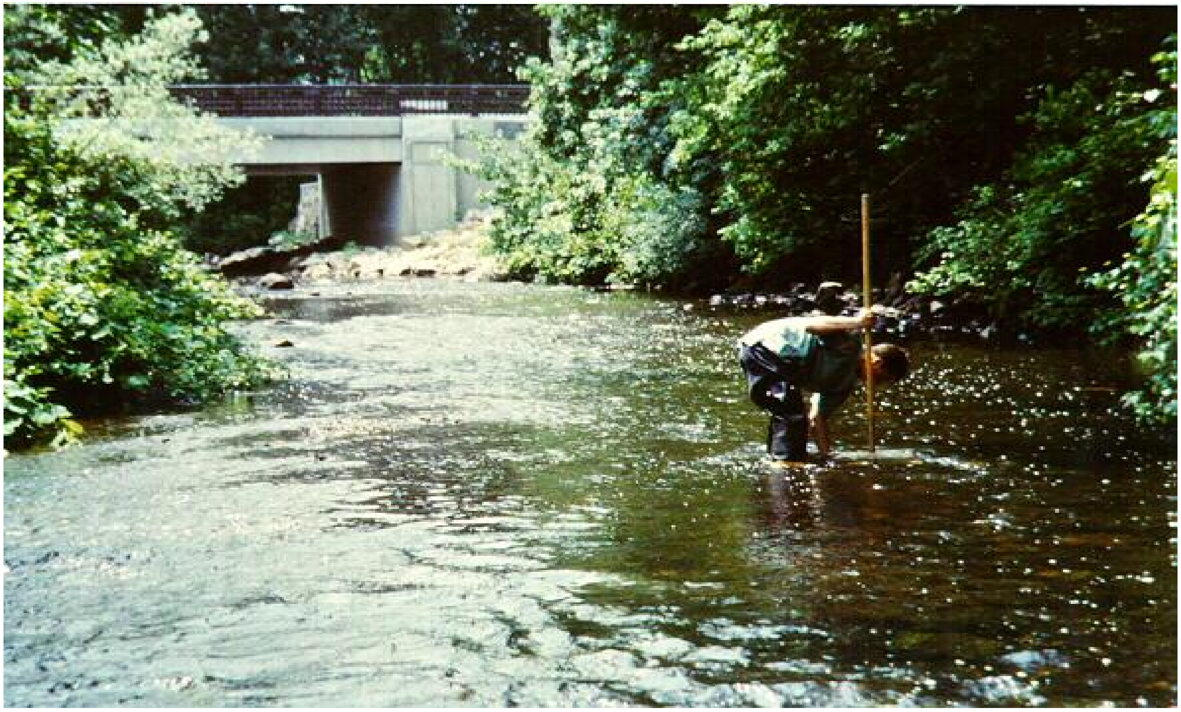

Figure 1. MassDEP/DWM biologist collecting macroinvertebrates using the “kick-sampling” technique.

Macroinvertebrate Sample Processing and Analysis

The macroinvertebrate sample processing and analysis procedures employed for the 2005 Buzzards Bay watershed biomonitoring samples are described in the standard operating procedures (Nuzzo 2003) and were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (MassDEP 2004). Macroinvertebrate sample processing entailed distributing whole samples in pans, selecting grids within the pans at random, and sorting specimens from the other materials in the sample until approximately 100 organisms (±10%) were extracted. Specimens were identified to genus or species as allowed by available keys, specimen condition, and specimen maturity. Taxonomic data were analyzed using a modification of Rapid Bioassessment Protocol III (RBP III) metrics and scores (Plafkin et al. 1989). Based on the taxonomy, various community, population, and functional parameters, or “metrics”, were calculated which allow measurement of important aspects of the biological integrity of the community. This integrated approach provides more assurance of a valid assessment because a variety of biological parameters are evaluated. Deficiency of any one metric should not invalidate the entire approach (Barbour et al. 1999). 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 LDC 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 definition of the *Aquatic Life* use designation is provided 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 2005 Buzzards Bay 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 greater with better 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 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. Tolerance values 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 number 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 (Reference Site Affinity, or RSA)—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 Buzzards Bay 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 reference site affinity approach is based on a modification of the Percent Model Affinity (Novak and Bode 1992). The (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 and biological 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 sample reach during the 2005 Buzzards Bay watershed biosurveys, habitat qualities were assessed and scored 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 for riffle/run dominated (high-gradient; velocities usually >30 cm/s) streams are as follows: instream cover, epifaunal substrate, embeddedness, sediment deposition, channel alteration, velocity/depth combinations, channel flow status, right and left (when facing downstream) bank vegetative protection, right and left bank stability, right and left bank riparian vegetative zone width. The ten habitat parameters for low to moderate gradient (velocities usually <30 cm/s) streams are as follows: bottom substrate/available cover, pool substrate characterization, pool variability, channel alteration, sediment deposition, channel sinuosity, channel flow status, right and left 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 benthic macroinvertebrate biomonitoring (MassDEP 2004). Quality Control procedures included collection of a duplicate sample in the field, taxonomic checks in the lab, and review of all data entry and analysis. These procedures are further detailed in the standard operating procedures (Nuzzo 2003).

RESULTS AND DISCUSSION

The biological and habitat data collected at each sampling station during the 2005 Buzzards Bay watersheds biomonitoring survey are attached as an Appendix (Tables A1 – A6). Table A1 is the macroinvertebrates taxa list for each station and includes organism counts, the functional feeding group designation (FG) for each macroinvertebrate taxon, and the tolerance value (TV) of each taxon.

Summary tables of the macroinvertebrate data analysis, including biological metric calculations, metric scores, and impairment designations, are also included in the Appendix. Table A2 summarizes all small tributary station comparisons to the watershed LDC reference station in Angeline Brook (ANG01). Table A3 is the summary table for larger streams and rivers when compared to East Branch Westport River (EBW02). Table A4 shows comparisons of "multi-habitat" biomonitoring stations—Shingle Island River (NB14SHI) and its reference station in the Mattapoisett River (NB13MAT). Habitat assessment scores for each station are also included in the summary tables, while a more detailed summary of habitat parameters is shown in Tables A5 (high gradient, riffle/run dominated streams) and A6 (low gradient, glide/pool dominated streams).

According to USGS stream discharge data, surface water runoff for the majority of southeastern Massachusetts, and including the Buzzards Bay watersheds, was within normal monthly ranges for May through August 2005 (USGS 2006).

The 2005 biomonitoring data generally indicate various degrees of nonpoint source-related problems in many of the streams examined. Urban runoff, habitat degradation, and other forms of NPS pollution compromise water quality and biological integrity throughout the watershed—most notably in portions of the Acushnet River. That said, several tributaries examined in the Buzzards Bay watershed remain relatively non-impacted and are indicative of “least disturbed conditions” in the watershed. It is imperative that anthropogenic perturbations be kept to a minimum in these unimpaired waterbodies.

Small Stream Biomonitoring Stations (ANG01, SNL00, BRCH01, BUT01)

ANG01—Angeline Brook, approximately 100 m upstream from Cornell Road, Westport, MA

Angeline Brook is a second-order stream that originates from wetlands in an undeveloped portion of Westport near the Village of Woods Corner. The stream flows in a generally southeasterly direction, passing the Macombers Corner section of Westport and dense forest, eventually entering Angeline Cove in the northeastern end of the West Branch Westport River. The majority of the Angeline Brook subwatershed is heavily forested, undeveloped, and inaccessible. The total watershed drainage area upstream from the ANG01 biomonitoring station is 3.25 square miles.

Habitat

ANG01 received a total habitat assessment score of 145/200 (Table A5). This was the designated small-stream LDC reference station for the 2005 biomonitoring survey. It was chosen based on its instream and riparian habitat, physicochemical data indicating good water quality (unpublished data, MassDEP 2005), minimal nonpoint source pollutant inputs, and relatively benign upstream and adjacent land-use impacts (e.g., lack of channelization, minimal development and agricultural activity nearby, undisturbed and well-vegetated riparian zone).

Impacting habitat most at ANG01 was seasonal low baseflow, which affected fish cover—and to a lesser extent, epifaunal substrates for benthos—by rendering habitat unavailable and exposed due to low water levels. Low flows here appear naturally occurring, as there are no registered water withdrawals in the Angeline Brook subwatershed, nor are there impoundments or other potential sources of flow regulation.

Benthos

Because ANG01 is a reference station, the biological attributes of the macroinvertebrate assemblage sampled do not yield a final impairment score for the resident aquatic community. However, the metric values calculated as part of the RBP III analysis reflect a healthy benthic community one would expect to find in a “least disturbed” stream (Table A2). Metric values for Taxa Richness and EPT Index—parameters that measure components of community structure and display low inherent variability (Resh 1988)—performed well and corroborate the designation as a reference station. In addition, the Biotic Index (3.87) was easily the lowest for the entire survey, indicating a benthos assemblage comprised mainly of pollution-sensitive taxa.

BRCH01—Bread and Cheese Brook, immediately upstream from American Legion Highway (Rt. 177), Westport, MA

A third-order stream, Bread and Cheese Brook originates north of Old Bedford Road near the Fall River-Westport border. The stream flows in a southerly direction, crossing routes I-195, U.S. 6, and Massachusetts 177 before making its confluence with the East Branch Westport River just below Forge Pond in Westport. The total watershed drainage area upstream from BRCH01 is 9.27 square miles. Land-use estimates (top three, excluding water) for the subwatershed are 67% forest, 20% residential, 5% agriculture (MassGIS 2008).

Habitat

Low-scoring habitat parameters (instream cover, velocity-depth combinations, channel flow status—all marginal) were directly associated with extremely reduced baseflow here, the result of a channel only 25% full of water (Table A5). It is unknown to what extent baseflow reductions are naturally occurring or anthropogenic. A partially breached dam exists at the pond outlet just upstream from the BRCH01 sampling reach. Bank and riparian habitat parameters were all considered optimal.

Benthos

The BRCH01 macroinvertebrate community received a total metric score of 28, representing 67% comparability to the reference station (ANG01) and resulting in a biological assessment of "Slightly Impacted" (Table A2). Based on the high habitat score here it appears that water quality is most limiting to biological potential in this portion of the stream, though, only minimally so.

SNL00—Snell Creek, approximately 300 m downstream from Drift Road, immediately upstream from unnamed farm road, Westport, MA

From its headwaters west of Main Street, Snell Brook flows southeast, receiving discharge contributions from an unnamed tributary near Snell Corner. From here, the small second-order stream enters a small, unnamed cove along the western shore of the East Branch Westport River in Westport. Land-use estimates (top three, excluding water) for the subwatershed are 64% forest, 17% agriculture, and 15% residential (MassGIS 2008). The total watershed drainage area upstream from SNL00 is 1.49 square miles. Agricultural activities (crop and dairy livestock) associated with the 30-acre Pimental Farm on Drift Road, adjacent to Snell Creek, have historically contributed bacteria and nutrient loads to this portion of Snell Creek (MassDEP 2003).

Habitat

SNL00 received a total habitat assessment score of 143/200 (Table A5). Low baseflow resulted in a stream channel that was less than 25% full of water. Other instream habitat features suffering notable score reductions were sediment deposition, which affected approximately 20% of the available stream bottom. Riparian vegetative zone width was greatly reduced along the left (east) bank due to clearing activities associated with the adjacent farm.

Benthos

The SNL00 macroinvertebrate community received a total metric score of 38, which was highly comparable (90%) to the Angeline Brook reference station and resulted in a biological assessment of "Non-Impacted" (Table A2). This was the highest rated benthos assemblage of all the study sites (i.e., excluding the reference stations) in the 2005 Buzzards Bay survey.

BUT01—Buttonwood Brook, 15 m upstream from Elm Street, Dartmouth, MA

A second-order stream, Buttonwood Brook originates near Oakdale Street in New Bedford. It flows in a generally southerly direction, draining heavily urbanized portions of New Bedford as it makes its course through Buttonwood Park and Zoo, then less urban portions of Dartmouth. The stream enters the northernmost corner of Apponagansett Bay—a large estuary of Buzzards Bay.

The total watershed drainage area upstream from BUT01 is 2.98 square miles. Land-use estimates (top three, excluding water) for the subwatershed are 51% residential, 24% forest, and 14% open land (MassGIS 2008). Buttonwood Brook is cited as the major source of fecal coliform bacteria to Apponagansett Bay (Howes et al. 1999).

Habitat

BUT01 received a total habitat assessment score of 142/200 (Table A5). Low-scoring habitat parameters (instream cover, velocity-depth combinations, channel flow status—marginal/poor) were directly associated with extremely reduced baseflow here, the result of a channel less than 25% full of water. It is unknown to what extent baseflow reductions are naturally occurring or anthropogenic. Buttonwood Brook is a “controlled stream” which has been engineered to provide needed storm water management to the City of New Bedford (Howes et al. 1999). Bank and riparian habitat parameters were all considered optimal, receiving the highest scores possible for each bank.

Benthos

The BUT01 macroinvertebrate community received a total metric score of 34, representing 81% comparability and resulting in an assessment intermediate to the “Non-Impacted” and “Slightly Impacted” categories for biological condition. Only the EPT Index metric scored poorly (score=0) for the BUT01 benthos assemblage. Low baseflow here—and the subsequent elimination of epifaunal habitat—may contribute to reductions in EPT taxa, as many of these organisms are particularly susceptible to substrate exposure and stranding (Minshall 1984). Corroborating the presence of low-flow effects here are the high densities of the chironomid *Tvetenia paucunca*.—a species that is known to survive dry conditions or periods of reduced base-flow (Bode, NY DEC, personal communication 1998). Interestingly, *T. paucunca* was numerically dominant at the other most “flow-stressed” (i.e., channel <25% full of water) streams in the 2005 survey—most notably, Angeline Brook and Snell Creek (Table A1).

Large Stream/River Biomonitoring Stations (EBW02, ACUSH01, PASK02)

EBW02—East Branch Westport River, 50 m upstream from Forge Pond, Westport, MA

The fourth-order East Branch Westport River originates in Noquochoke Lake in Dartmouth. The river flows in a southwesterly direction, receiving the considerable discharge contribution of Bread and Cheese Brook before entering the vast East Branch estuary. The river terminates at Westport Harbor which lies within Rhode Island Sound. The total watershed drainage area upstream from EBW02 is 29.2 square miles. Land-use estimates (top three, excluding water) for the subwatershed are 66% forest, 14% residential, and 9% agriculture (MassGIS 2008).

Habitat

EBW02 received a total habitat assessment score of 156/200, which was the highest score in the entire 2005 Buzzards Bay watersheds biomonitoring survey (Table A5). This was the designated LDC reference station in the 2005 survey for the larger stream/river biomonitoring stations; chosen for its instream and riparian habitat, physicochemical data indicating good water quality (unpublished data, MassDEP 2005), minimal nonpoint source pollutant inputs, and relatively benign upstream and adjacent land-use impacts (e.g., lack of channelization, minimal development and agricultural activity nearby, undisturbed and well-vegetated riparian zone).

Affecting the habitat score at EBW02 most negatively was channel flow status, which was considered marginal due to a channel about 65% full of water. The shallow nature of the sampling reach resulted in a lack of deep riffle areas, and minimally affected instream cover for fish—considered less than optimal yet still adequate for the maintenance of populations. Epifaunal habitat for macroinvertebrates and other instream features remained excellent, along with all bank and riparian habitat parameters. It is unclear to what extent, if any, flow regulation at the outlet of Noquochoke Lake is having on instream baseflow in this portion of the East Branch Westport River.

Benthos

Because EBW02 is a reference station, the biological attributes of the macroinvertebrate assemblage sampled do not yield a final impairment score for the resident aquatic community. However, the metric values calculated as part of the RBP III analysis reflect a healthy benthic community one would expect to find for a “least disturbed” stream in this watershed (Table A3). EPT Index, EPT/Chrionomidae, and Biotic Index metrics performed particularly well relative to other biomonitoring stations in the 2005 survey, a result of high densities of pollution-sensitive EPT taxa and good richness within this group.

ACUSH01—Acushnet River, 200 m upstream from Main Street, Acushnet, MA

The Acushnet River is a fourth-order stream that begins at the outlet of New Bedford Reservoir. The river flows south through cranberry bogs and other rural portions of Acushnet, receiving discharge contributions from Deep Brook and other small tributaries. The Acushnet River nears, then enters, New Bedford with the watershed becoming increasingly urbanized as the river enters a large estuary to become the inner portion of New Bedford Harbor. The total watershed drainage area upstream from ACUSH01 is 18.7 square miles. Land-use estimates (top three, excluding water) for the subwatershed are 51% forest, 22% residential, and 13% open land (MassGIS 2008). The entire length of the Acushnet River is classified as a Category 5 (i.e., impaired) Water in the Massachusetts Year 2006 Integrated List of Waters due to nutrients, organic enrichment, metals, and other pollutants (MADEP 2007).

Due to its close proximity to the Acushnet River estuary, it is possible that the ACUSH01 biomonitoring station is at least occasionally subjected to tidal influence. Capture of mummichogs (*Fundulus heteroclitus*) in the kick-net during sampling, and observations of striped bass (*Morone saxatilis*) in the sampling reach, corroborate the possibility of occasional brackish-water intrusion or tidal effects in this portion of the river.

Habitat

ACUSH01 received a total habitat assessment score of 147/200 (Table A5). Habitat quality at ACUSH01 was mainly impacted by industrial land-uses. Riparian zone disruption resulted from the nearby parking lot and building remnants of a now-defunct mill adjacent to the ACUSH01 sampling reach, as well as a factory built above the river near the top of the reach. Historical industrial activities in this portion of the river have also resulted in rip-rapped banks and other forms of channelization throughout the reach. Trash deposits, both instream and throughout the riparian zone of ACUSH01, were observed.

Benthos

The ACUSH01 macroinvertebrate community received a total metric score of 10, representing only 25% comparability to the reference station in the East Branch Westport River (EBW02) and resulting in a bioassessment near the low end of the “Moderately Impacted” category (Table A3). This was clearly the most degraded benthic community sampled in the 2005 Buzzards Bay watershed survey, with few species present and an overabundance of pollution-tolerant taxa—most notably the gammarid amphipod *Gammarus* sp (n=81). In addition, the abundance of the chironomid *Cricotopus bicinctus* in the ACUSH01 benthos sample may be significant (Table A1). That this taxon has been shown to display resistance to contamination by heavy metals suggests possible toxic impacts to the biota in this portion of the Acushnet River (Beckett and Keyes 1983; Simpson and Bode 1980). As noted above, this segment of the river is classified as a Category 5 Water in the Massachusetts Year 2006 Integrated List of Waters due to metals and other pollutants (MADEP 2007).

PASK02—Paskamanset River, 110 m downstream from Russell Mills Road and USGS gage, Dartmouth, MA

The Paskamanset River is a third-order stream that drains vast wetland areas that contribute to its overall large drainage area. The river originates in Turner Pond in the Acushnet Cedar Swamp, a State Reservation land. Upon leaving Turner Pond the river flows in a southerly direction through the immense Apponagansett Swamp, then crosses routes 196 and 6 as a generally impounded body of water. Continuing its course southward, the river receives the drainage of Deerfield Swamp and other extensive wetlands. The river continues to meander through vast wetland portions of Dartmouth before making its confluence with the Slocums River near the Village of Russells Mills in Dartmouth. The total watershed drainage area upstream from PASK02 is 26.1 square miles. Land-use estimates (top three, excluding water) for the subwatershed are 58% forest, 15% residential, and 11% open land (MassGIS 2008).

Habitat

PASK02 received a total habitat assessment score of 125/200 (Table A5). The stream channel was only about 25% full of water, resulting in marginal channel flow status, and an obvious lack of stable cover for fish due to exposed habitat and unavailable refugia. Other instream habitat features scored in the optimal or suboptimal range. Riparian and bank vegetation was dense and undisturbed; however, both streambanks were moderately unstable and exhibited high erosion potential during floods.

Benthos

The PASK02 macroinvertebrate community received a total metric score of 14, representing 35% comparability to EBW02 and resulting in an assessment of "Moderately Impacted" for biological condition (Table A3). A hyperdominance of filter-feeding taxa, particularly the net-spinning caddisfly *Hydropsyche betteni*, indicates the presence of substantial loads of suspended organic particulates in this portion of the Paskamanset River. Upstream impoundments and extensive wetlands no doubt contribute to the organically enriched conditions evident at PASK02. It is also possible that the very restricted riffle habitat here results in a suppression of EPT taxa and other sensitive forms more common in higher-gradient streams in this watershed (e.g., East Branch Westport River).

Multi-habitat Stations (NB13MAT, NB14SHI)

NB13MAT—Mattapoisett River, near end of Tinkham Lane, Mattapoisett, MA

The Mattapoisett River is a low-gradient and meandering third-order steam that originates in Snipatuit Pond in Rochester. The river flows in a southerly direction through a series of impoundments, including Harley Millpond. From here it continues south, winding its way through mainly undeveloped forest and wetland-dominated areas of Rochester and Mattapoisett. The river becomes tidal near Route 6 as it enters the inner portion of Mattapoisett Harbor. The total watershed drainage area upstream from NB13MAT is 18.1 square miles. Land-use estimates (top three, excluding water) for the subwatershed are 68% forest, 10% residential, and 8% agriculture (MassGIS 2008).

Habitat

Using the habitat scoring parameters modified for use in low to moderate gradient streams, NB13MAT received a total habitat assessment score of 150/200 (Table A6). Though most instream habitat parameters scored generally high for NB13MAT, overall habitat was compromised somewhat by marginal channel flow status. Only about 25% of the stream channel contained water. It is unknown whether observed low baseflow in this portion of the Mattapoisett River is a result of natural conditions (i.e., seasonal low flows) or groundwater withdrawals from public water supplies serving the towns of Fairhaven, Marion, and Mattapoisett (MassDEP 2006). A USGS study published in 1995 indicated that major groundwater withdrawals from shallow streamside public water supply wells may adversely impact streamflows in the Mattapoisett River (Bent 1995). Banks were considered moderately unstable in the NB13MAT sampling reach, and should be considered as one possible source of instream sediment deposition also observed during the biosurvey here. Bank erosion along both stream banks appeared to be exacerbated by four-wheel drive activity—ATV tracks were observed across the stream.

NB13MAT was used for biological comparisons to a study site in the Shingle Island River (NB14SHI). The pool/glide-dominated flow regimes and predominantly fine substrates found at NB13MAT are more comparable to habitats in the meandering, wetland-dominated Shingle Island River than either ANG01 or EBW02. NB13MAT historically has been used as a reference station by MassDEP/DWM as part of an ongoing study in numeric biocriteria development (Lotic, Inc. 1999; Tetra Tech, Inc. 1999). A cursory review of the macroinvertebrate data collected from NB13MAT during the biocriteria study found a diverse, well-balanced benthic community dominated by highly sensitive taxa such as taeniopterygid stoneflies—corroborating the station's reference designation.

Benthos

Because NB13MAT is a reference station, the biological attributes of the macroinvertebrate assemblage sampled here do not yield a final impairment score for the resident aquatic community. However, the metric values calculated as part of the RBP III analysis reflect a healthy benthic community one would expect to find for a "least disturbed" low-gradient stream in this watershed (Table A4). Only the Percent Dominant Taxon metric performed poorly (score=0); however, this was due to a preponderance of *Maccaffertium* sp., an algal-grazing mayfly considered highly intolerant of organic pollution.

NB14SHI—Shingle Island River, approximately 100 m downstream from Old Fall River Road, Dartmouth, MA

The Shingle Island River is a third-order stream that begins at the outlet of a small unnamed pond north of Flag Swamp Road in Dartmouth. The river flows in a southwesterly direction through extensive wetlands, including Shingle Island Swamp. After receiving the drainage contributions of the Copicut River (a Category 5 Water in the Massachusetts Year 2006 Integrated List of Waters due to priority organics and metals--MADEP 2007) subwatershed, which includes Copicut Reservoir and Copicut Swamp, the Shingle Island River continues through sparsely populated portions of Dartmouth—crossing Route I-195 before entering Noquochoke Pond. The total watershed drainage area upstream from NB14SHI is 8.59 square miles. Land-use estimates (top three, excluding water) for the subwatershed are 75% forest, 8% residential, and 5% open land (MassGIS 2008).

Habitat

Using the habitat scoring parameters modified for use in low to moderate gradient streams, NB14SHI received a total habitat assessment score of 149/200, which was highly comparable to the reference conditions at NB13MAT (Table A6). Unlike the Mattapoisett River station, channel flow status was good here, with water filling >75% of the available channel and leaving virtually no substrates exposed. Instream habitat for fish and macroinvertebrates was only marginal, however, with little mix of stable habitat types and mostly mud substrates. In addition, pools lacked variability and were mainly one depth. Bank and riparian parameters rated optimal.

Benthos

The NB14SHI macroinvertebrate community received a total metric score of 18, representing 50% comparability to the low-gradient reference station established in the Mattapoisett River and resulting in a bioassessment of "Moderately Impacted" (Table A4). The paucity of EPT taxa and other pollution sensitive taxa resulted in low-scoring EPT Index, EPT/Chironomidae, and Biotic Index metrics (Table A4). In addition, the NB14SHI benthos assemblage was highly dissimilar to that observed at NB13MAT, as evidenced in a Reference Site Affinity of only 19% (score=0) (Table A4). A habitat assessment score that was highly comparable to the reference station suggests impairment to the NB14SHI biota is mainly due to water quality factors; however, it should be emphasized that, while both stations were considered low gradient and dominated by pool/glide flow regimes, the NB13MAT sampling reach contained a greater mix of stable epifaunal habitat (e.g., snags and other woody material, submerged macrophytes, undercut stream banks, some cobble substrates) than NB14SHI (mainly submerged macrophytes and a few snags, all muck/mud bottom). Subtle difference in instream habitat types and habitat quality, then, may contribute to observed differences in the biota at NB13MAT and NB14SHI.

SUMMARY AND RECOMMENDATIONS

With the exception of a few tributaries that displayed only minimally impacted conditions, biomonitoring stations investigated during the 2005 Buzzards Bay watersheds survey indicated various degrees of impairment. Generally speaking, overall biological health appeared better in the Westport and Mattapoisett River subwatersheds than the Paskamanset River and New Bedford Harbor subwatersheds. Of the nine stations sampled, three were assessed as “Non-“ or “Slightly Impacted” for biological condition, three were “Moderately Impacted”, and three were considered reference quality (i.e., “least disturbed conditions”). Impacts to resident biota were generally a result of habitat degradation and/or other nonpoint source-related water quality impairment, with suspected point source and/or toxic effects observed as well.

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 (“Non-“, “Slightly”, “Moderately”, “Severely Impacted”) 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 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. “Non-Impacted” or “Slightly Impacted” aquatic communities—such as those encountered at ANG01, EBW02, NB13MAT, SNL00, BRCH01, and BUT01—support the Massachusetts Surface Water Quality Standards’ 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). “Moderately Impacted” communities observed at PASK02, NB14SHI, and ACUSH01 do not support the *Aquatic Life* use and fail to meet the goals of the CWA. MassDEP will continue to refine the TALU classifications for Massachusetts surface waters as new biological data become available. This in turn may affect future *Aquatic Life* use determinations (e.g., “Support”, “Impaired”) as they relate to the biological condition categories (“Non-“, “Slightly”, “Moderately”, “Severely Impacted”).

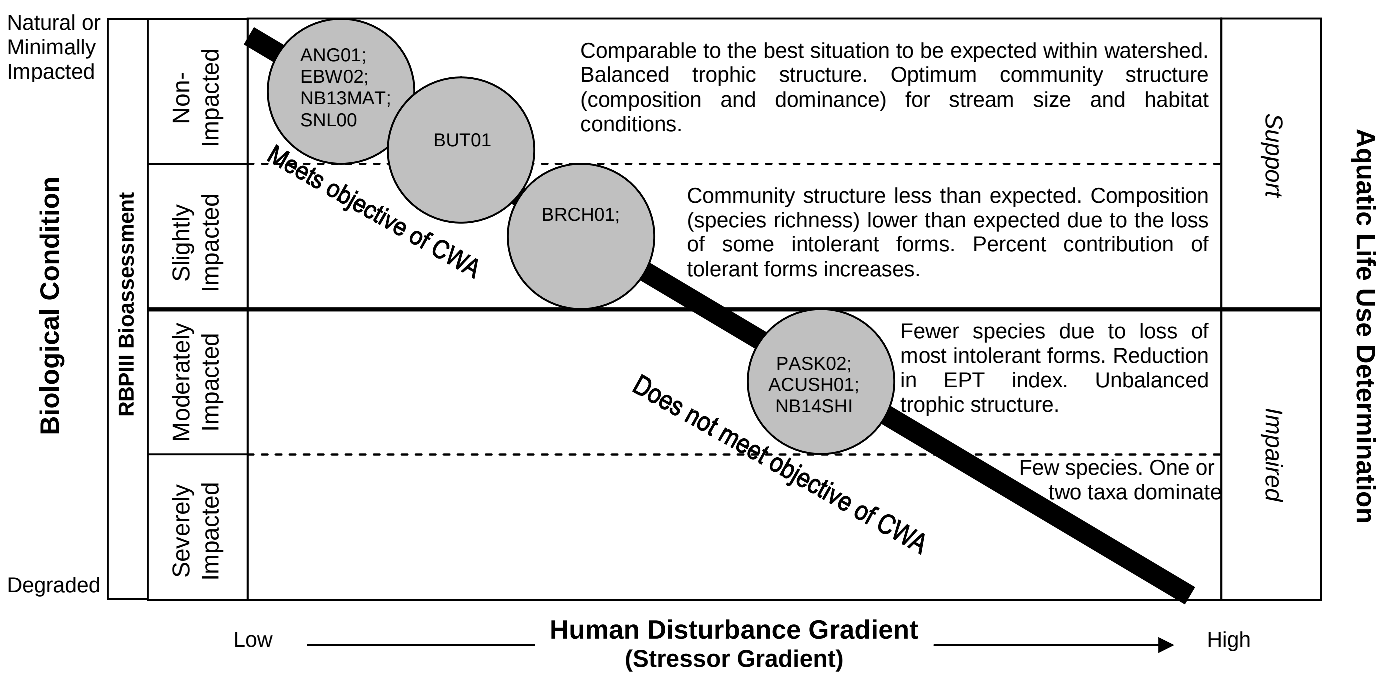

Figure 2. A schematic of results of the RBPIII analysis of the 2005 Buzzards Bay watersheds biomonitoring stations as they relate to Tiered Aquatic Life Use.

While the RBP analysis of benthic macroinvertebrate communities is an effective means of determining severity of water quality impacts, it is less effective in determining what kinds of pollution are causing the impact (i.e., ascertaining cause and effect relationships between potential stressors and affected biota). Nevertheless, in some situations a close examination of individual metric performance, taxon absence or presence, habitat evaluations, or other supporting field data can lead to inferences of potential anthropogenic causes of perturbation. Table 3 lists the potential causes of benthic community impairment, where applicable, observed at each biomonitoring station. The table also includes recommendations addressing the various types of impairment and general conditions observed. The list is by no means exhaustive, but rather a summary of suggestions for additional monitoring efforts, BMP implementation, and other recommendations for follow-up activities while still working within the framework of the "Five-Year Basin Cycle" and using the resources routinely available to DWM personnel.

Table 3. A summary of potential causes of benthos and habitat impairment observed at each biomonitoring station during the 2005 Buzzards Bay watersheds survey. Where applicable, recommendations have been made.

SITE	POSSIBLE CAUSES OF IMPAIRMENT	RECOMMENDATIONS
ANG01	No biological impacts observed; Naturally-occurring low baseflow	Biomonitoring during next (2010) MassDEP Buzzards Bay survey; Water quality monitoring during 2010 MassDEP Buzzards Bay survey; Continued use as "small-stream" biomonitoring reference station for Buzzards Bay watersheds
SNL00	Naturally-occurring low baseflow; Sedimentation; Reduced riparian zone	Biomonitoring during next MassDEP Buzzards Bay survey; Water quality monitoring (including nutrients; DO; bacteria source tracking) during next MassDEP Buzzards Bay survey; Investigate possible sources (Drift Road crossing, Pimental Farm) of sediment inputs—implement BMPs as needed; Improve vegetative buffer along left (east) bank—implement agriculture BMPs as needed
BRCH01	Low baseflow; Water quality degradation; Upstream impoundments	Biomonitoring during next MassDEP Buzzards Bay survey; Water quality monitoring during next MassDEP Buzzards Bay survey; Field reconnaissance in subbasin to investigate land-uses that may contribute NPS inputs
BUT01	Low baseflow; Urbanization	Biomonitoring during next MassDEP Buzzards Bay survey; Water quality monitoring (including nutrients; DO; bacteria source tracking) during next MassDEP Buzzards Bay survey; Field reconnaissance in subbasin to investigate land-uses that may contribute NPS inputs
EBW02	Low baseflow	Biomonitoring during next MassDEP Buzzards Bay survey; Water quality monitoring during next MassDEP Buzzards Bay survey; Investigate possible flow regulation at the outlet of Noquochoke Lake
ACUSH01	Severe water quality degradation--possible toxic impacts, organic enrichment/low DO; Severe riparian habitat degradation (channelized, reduced riparian zone); Trash instream	Water quality monitoring (including nutrients; DO; bacteria source tracking, sediment toxicity, sediment chemistry, metals) during next MassDEP Buzzards Bay survey; Improve vegetative buffer along banks; Stream-cleanup to address trash inputs
PASK02	Organic enrichment/low DO; Low baseflow; Sedimentation	Biomonitoring during next MassDEP Buzzards Bay survey; Water quality monitoring during next MassDEP Buzzards Bay survey; Field reconnaissance in subbasin to investigate land-uses that may contribute NPS-related organic loads; Investigate possible sources of sediment inputs—implement BMPs as needed

Table3. (Cont.)

SITE	POSSIBLE CAUSES OF IMPAIRMENT	RECOMMENDATIONS
NB13MAT	Low baseflow; Sedimentation; Bank erosion	Biomonitoring during next (2010) MassDEP Buzzards Bay survey; Water quality monitoring during 2010 MassDEP Buzzards Bay survey; Continued use as "low gradient" biomonitoring reference station for Buzzards Bay watersheds; Signage to discourage recreational use of ATVs in this portion of the river
NB14SHI	Organic enrichment/low DO; Impoundment effects	Biomonitoring during next MassDEP Buzzards Bay survey; Water quality monitoring during next MassDEP Buzzards Bay survey; Determine if organic enrichment is naturally occurring (e.g., wetland inputs) or anthropogenic

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APPENDIX

Macroinvertebrate taxa list, RBPIII benthos analyses, and Habitat evaluations

CONTENTS

Table A1. Species-level taxa list and counts, functional feeding groups (FG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2005 Buzzards Bay watersheds biomonitoring survey between 10 August and 24 August 2005. Refer to Table 1 for a listing and description of sampling stations.

TAXON	FG	TV	EBW02	BRCH01	ANG01	BUT01	ACUSH01	NB14SHI	SNL00	NB13MAT	PASK02
Hydrobiidae	SC	8				1					
Ancylidae	SC	6						1			
Physa sp.	GC	9								1	
Pisidiidae	FC	6	5		3					2	
Lumbricina	GC	8				1					
Nais communis/variabilis	GC	8	2			2			1		7
Pristina leidyi	GC	8									1
Tubificidae	GC	10			1		2	1			
Lumbriculidae	GC	7		2							
Helobdella stagnalis	PR	7						2			
Caecidotea communis	GC	8						27			
Gammarus sp.	GC	6			11	12	81		7	1	1
Hyalella azteca	GC	8						1			
Acerpenna pygmaea	GC	5								1	
Baetidae (cerci only)	GC	6								1	
Eurylophella sp.	GC	2		1	2						
Maccaffertium sp.	SC	3	13		1					44	
Isonychia sp.	GC	2								1	
Leptophlebiidae	GC	2			3						
Boyeria vinosa	PR	2			1				2		
Hetaerina sp.	PR	6						11			
Coenagrionidae	PR	9						3			
Leuctra sp.	SH	0		9	11				6		
Corydalus sp.	PR	4	1								
Nigronia serricornis	PR	0			1			1	2	1	1
Sialis sp.	PR	4			1						
Brachycentrus sp.	FC	1	9								
Micrasema sp.	SH	2							1		
Cheumatopsyche sp.	FC	5	3			2	1			1	1
Diplectrona sp.	FC	0							3		
Diplectrona modesta	FC	0			3						
Hydropsyche sp.	FC	4		10		7					

Table A1. (cont.)

TAXON	FG	TV	EBW02	BRCH01	ANG01	BUT01	ACUSH01	NB14SHI	SNL00	NB13MAT	PASK02
Hydropsyche betteni	FC	6	22		6				6	25	53
Lepidostoma sp.	SH	1	2						2		
Mystacides sepulchralis	GC	4				1					
Oecetis sp.	PR	5									1
Limnephilidae	SH	4							1		
Hydatophylax sp.	SH	2						3			
Psilotreta sp.	SC	0	1								
Chimarra obscura	FC	4	6	3		10				18	1
Dolophilodes sp.	FC	0			8				5		
Ptilostomis sp.	SH	5						1			
Phylocentropus sp.	FC	5						1			
Rhyacophila sp.	PR	1			2	1					
Rhyacophila fuscula	PR	0	2								
Ancyronyx variegata	GC	5						9			
Optioservus sp.	SC	4		1	2	3			1		2
Optioservus ovalis	SC	4						1			
Oulimnius latiusculus	SC	4				3			5	1	
Promoresia sp.	SC	2		6							
Promoresia tardella	SC	2	6		2	19			1	2	5
Stenelmis sp.	SC	5	13	1	1		1	1	5		1
Stenelmis crenata gr.	SC	5				5					
Ectopria nervosa	SC	5				2					
Psephenus herricki	SC	4		2	2						
Palpomyia/Bezzia sp.	PR	6							4		
Chironomidae	GC	6		3	1	2		6	2		8
Chironomini	GC	6						4			
Chironomus sp.	GC	10					1				
Dicrotendipes sp.	GC	8					3				
Microtendipes pedellus gr.	FC	6							1		
Microtendipes rydalensis gr.	FC	6		1							
Phaenopsectra sp.	SC	7						7			
Polypedilum sp.	SH	6		1	1						
Polypedilum aviceps	SH	4				4			8		
Polypedilum flavum	SH	6				4	1				
Polypedilum illinoense	SH	6	1					5			
Polypedilum tritum	SH	6				1					

Table A1. (cont.)

TAXON	FG	TV	EBW02	BRCH01	ANG01	BUT01	ACUSH01	NB14SHI	SNL00	NB13MAT	PASK02
Tribelos/Phaenopsectra sp.	GC	7						2			
Micropsectra sp.	GC	7		9	1				16		
Micropsectra/Tanytarsus sp.	FC	7			1						
Rheotanytarsus sp.	FC	6									1
Rheotanytarsus exiguus gr.	FC	6		14					5		5
Rheotanytarsus pellucidus	FC	5			9						6
Tanytarsus sp.	FC	6		1	2			4	1		
Diamesa sp.	GC	5				1					
Corynoneura sp.	GC	4									1
Cricotopus sp.	SH	7									
Cricotopus bicinctus	GC	7					15				
Eukiefferiella gracei gr.	GC	4				1					
Heterotrissocladius sp.	GC	4			4						
Nanocladius sp.	GC	7									1
Orthocladius lignicola	SH	5						1			
Parametriocnemus sp.	GC	5		10		3			5		1
Rheocricotopus robacki	GC	5		3						2	5
Thienemanniella sp.	GC	6		2							
Tvetenia paucunca	GC	5		12	12	18			6		
Tvetenia vitracies	GC	5	1							3	
Tanypodinae	PR	7						2		1	1
Ablabesmyia sp.	PR	8						1			
Conchapelopia sp.	PR	6		2	2				2		1
Larsia sp.	PR	7		1	6				2		
Thienemannimyia gr.	PR	6				1					
Chelifera sp.	PR	6				1					
Hemerodromia sp.	PR	6									
Simulium tuberosum cpl.	FC	4	3								
Chrysops sp.	GC	5						1			
Dicranota sp.	PR	3			2						
Tipula sp.	SH	6				1					
TOTAL			90	94	102	106	105	96	100	105	104

[1]Functional Feeding Group (FG) lists the primary feeding habit of each species and follows the abbreviations: SH-Shredder; GC-Gathering Collector; FC-Filtering Collector; SC- Scraper; PR-Predator.
[2]Tolerance Value (TV) is an assigned value used in the calculation of the biotic index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for very tolerant organisms.

Table A2. Summary of RBP III data analysis for macroinvertebrate communities sampled (kick-sampling) in the Buzzards Bay watersheds between 10 and 17 August 2005. Shown are the calculated metric values, metric scores (in italics) based on comparability to the LDC reference station (ANG01), and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a listing and description of sampling stations.

STATION	**ANG01**		**BRCH01**		**SNL00**		**BUT01**	
STREAM	Angeline Brook		Bread & Cheese Brook		Snell Creek		Buttonwood Brook	
HABITAT SCORE	145		151		143		142	
TAXA RICHNESS	27	*6*	20	*4*	25	*6*	24	*6*
BIOTIC INDEX	3.87	*6*	4.64	*4*	4.52	*6*	4.47	*6*
EPT INDEX	8	*6*	4	*0*	7	*4*	5	*0*
EPT/CHIRONOMIDAE	0.92	*6*	0.39	*2*	0.50	*4*	0.60	*4*
SCRAPERS/FILTERERS	0.25	*6*	0.34	*6*	0.57	*6*	1.74	*6*
% DOMINANT TAXON	12%	*6*	15%	*6*	16%	*6*	18%	*6*
REFERENCE SITE AFFINITY	100%	*6*	71%	*6*	85%	*6*	74%	*6*
TOTAL METRIC SCORE		*42*		*28*		*38*		*34*
% COMPARABILITY TO REFERENCE STATION			67%		90%		81%	
BIOLOGICAL CONDITION (DEGREE OF IMPACT)	**REFERENCE**		**SLIGHTLY IMPACTED**		**NON-IMPACTED**		**SLIGHTLY/ NON-IMPACTED**	

Table A3. Summary of RBP III data analysis for macroinvertebrate communities sampled (kick-sampling) in the Buzzards Bay watersheds between 10 and 24 August 2005. Shown are the calculated metric values, metric scores (in italics) based on comparability to the LDC reference station (EBW02), and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a listing and description of sampling stations.

STATION	**EBW02**		**PASK02**		**ACUSH01**	
STREAM	East Branch Westport River		Paska-manset River		Acushnet River	
HABITAT SCORE	156		125		147	
TAXA RICHNESS	16	*6*	18	*6*	8	*2*
BIOTIC INDEX	4.12	*6*	5.70	*4*	6.30	*2*
EPT INDEX	8	*6*	4	*0*	1	*0*
EPT/CHIRONOMIDAE	29.0	*6*	1.87	*0*	0.05	*0*
SCRAPERS/FILTERERS	0.69	*6*	0.12	*0*	1.0	*6*
% DOMINANT TAXON	24%	*4*	51%	*0*	77%	*0*
REFERENCE SITE AFFINITY	100%	*6*	64%	*4*	16%	*0*
TOTAL METRIC SCORE		*40*		*14*		*10*
% COMPARABILITY TO REFERENCE STATION			35%		25%	
BIOLOGICAL CONDITION (DEGREE OF IMPACT)	**REFERENCE**		**MODERATELY IMPACTED**		**MODERATELY IMPACTED**	

Table A4. Summary of RBP III data analysis for low-gradient macroinvertebrate communities sampled (multi-habitat) in the Buzzards Bay watersheds between 11 and 24 August 2005. Shown are the calculated metric values, metric scores (in italics) based on comparability to the LDC reference station (NB13MAT), and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a listing and description of sampling stations.

STATION	**NB13MAT**		**NB14SHI**	
STREAM	Mattapoisett River		Shingle Island River	
HABITAT SCORE	150		149	
TAXA RICHNESS	16	*6*	20	*6*
BIOTIC INDEX	4.18	*6*	6.52	*2*
EPT INDEX	7	*6*	3	*0*
EPT/CHIRONOMIDAE	15.17	*6*	0.16	*0*
SCRAPERS/FILTERERS	1.02	*6*	2.0	*6*
% DOMINANT TAXON	42%	*0*	28%	*4*
REFERENCE SITE AFFINITY	100%	*6*	19%	*0*
TOTAL METRIC SCORE		*36*		*18*
% COMPARABILITY TO REFERENCE STATION			50%	
BIOLOGICAL CONDITION (DEGREE OF IMPACT)	**REFERENCE**		**MODERATELY IMPACTED**	

Table A5. Habitat assessment summary for moderate to high gradient (riffle/run dominated) biomonitoring stations sampled during the 2005 Buzzards Bay watersheds survey. 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 listing and description of sampling stations.

STATION	**EBW02***	**BRCH01**	**SNL00**	**ANG01***	**PASK02**	**ACUSH01**	**BUT01**
PRIMARY PARAMETERS (range is 0-20)				**SCORE**			
INSTREAM COVER	12	9	14	3	6	15	3
EPIFAUNAL SUBSTRATE	18	16	17	14	12	12	15
EMBEDDEDNESS	17	19	17	20	16	15	18
CHANNEL ALTERATION	16	17	17	20	15	11	16
SEDIMENT DEPOSITION	18	18	13	19	15	16	19
VELOCITY-DEPTH COMBINATIONS	11	7	10	4	12	11	6
CHANNEL FLOW STATUS	9	7	5	5	7	15	5
SECONDARY PARAMETERS (range is 0-10 for each bank)				**SCORE**			
BANK VEGETATIVE PROTECTION left	9	9	8	10	9	10	10
BANK VEGETATIVE PROTECTION right	9	10	10	10	8	9	10
BANK STABILITY left	9	10	8	10	4	10	10
BANK STABILITY right	10	10	9	10	5	10	10
RIPARIAN VEGETATIVE ZONE WIDTH left	9	10	5	10	7	6	10
RIPARIAN VEGETATIVE ZONE WIDTH right	9	9	10	10	9	7	10
TOTAL SCORE	**156**	**151**	**143**	**145**	**125**	**147**	**142**

*LDC Reference Station

Table A6. Habitat assessment summary for low to moderate gradient (glide/pool dominated) biomonitoring stations sampled during the 2005 Buzzards Bay watersheds survey. 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 listing and description of sampling stations.

STATION	**NB13MAT***	**NB14SHI**
PRIMARY PARAMETERS (range is 0-20)	**SCORE**	
BOTTOM SUBSTRATE/ AVAILABLE COVER	17	8
POOL SUBSTRATE CHARACTERIZATION	17	6
POOL VARIABILITY	15	6
CHANNEL ALTERATION	20	20
SEDIMENT DEPOSITION	12	19
CHANNEL SINUOSITY	13	19
CHANNEL FLOW STATUS	6	14
SECONDARY PARAMETERS (range is 0-10 for each bank)	**SCORE**	
BANK VEGETATIVE PROTECTION left	10	9
BANK VEGETATIVE PROTECTION right	10	10
BANK STABILITY left	5	9
BANK STABILITY right	5	9
RIPARIAN VEGETATIVE ZONE WIDTH left	10	10
RIPARIAN VEGETATIVE ZONE WIDTH right	10	10
TOTAL SCORE	**150**	**149**

*LDC Reference Station