Department of Public Works
Bureau of Environmental Services
Stormwater Management Division

Biological Assessment of the Little Patuxent River, Cattail Creek, and Brighton Dam Watersheds, Howard County, Maryland

Spring 2001 Index Period

Lower Little Patuxent River

Lower Brighton Dam

October, 2001
Final Report

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The principal authors of this report are Kristen L. Pavlik and James B. Stribling, both of Tetra Tech. They were assisted by Erik W. Leppo, S. Abby Markowitz, and Blaine D. Snyder, also of Tetra Tech. This report represents results from the first year of sampling by the Howard County Biological Monitoring and Assessment Program. The County understands the importance of assessing its water quality using biological indicators and employing those assessments to make environmental management decisions. Howard County also recognizes the necessity to design and implement a biological monitoring program that compatible with those efforts undertaken by the State of Maryland Department of Natural Resources (DNR) Maryland Biological Stream Survey (MBSS). The Technical Advisory Committee (TAC) assembled by Howard County, which included: Howard Saltzman and Angela Morales, Stormwater Management Division (SWMD), Susan Overstreet, Department of Planning and Zoning (DPZ) and Brenda Belinsky, Department of Recreation and Parks (DRP), Ron Klauda, (MBSS), Wayne Davis (USEPA Region III), and Keith Van Ness (Montgomery County Department of Environmental Protection), were instrumental in the support and guidance of the County's Biological Monitoring Program. Niles Primrose of DNR's Watershed Restoration Division (WRD) coordinated all fieldwork in the Little Patuxent River Watershed. Corrine Marino and Carolina Gallardo, both of VJB office services, performed laboratory processing of the Cattail Creek and Brighton Dam watersheds (sorting and subsampling). Carmela Biddle, Colin Hill (both of Tetra Tech) and Corrine Marino also complete quality assurance/quality control assessments on data entered into and retrieved from Ecological Data Application System (EDAS). Colin Hill also participated in the fieldwork in the Cattail Creek and Brighton Dam watersheds. Benthic macroinvertebrates from these watersheds were identified by R. Deedee Kathman, of Aquatic Resources Center (ARC). Niles Primrose of WRD performed identifications of benthic macroinvertebrates and Kevin Coyne (WRD) was responsible for fish identification in the Little Patuxent River watershed. Jennifer Jaber, Beth Habic, and John McCoy of WRD provided laboratory and field work in support of the Little Patuxent sampling. Additional field assistance was provided by the Maryland Conservation Corps and DNR Resource Assessment Service, Monitoring and Non-Tidal Assessment Service. Hunter Loftin, Linda Shook, and Brenda Fowler, all of Tetra Tech, provided budget tracking and some clerical support. The appropriate citation for this report is:

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ABSTRACT

Stream biota rely on the quality of physical habitat, hydrology, and water chemistry for their survival and reproduction. When human activities, such as the conversion of land cover alter stream conditions, biota are also affected. Thus, many biological monitoring and assessment programs use composite biological indicators as a measure of stream ecological response to conversion of land cover, and as an overall descriptor of water resource integrity.

For this study, several indicators (benthic macroinvertebrates, fish, physical habitat quality, sediment particle size distribution, and channel size) were sampled or measured at 60 stream locations in the Little Patuxent River, Brighton Dam, and Cattail Creek watersheds of Howard County, Maryland. The Little Patuxent River watershed was divided into three subwatersheds (Upper, Middle, and Lower). The Brighton Dam watershed was also divided, into Upper and Lower subwatersheds. A total of six subwatersheds were sampled in the Spring 2001 Index Period. Sampling site locations were selected at random, and were pre-stratified by subwatershed and stream order, so that 10 sites were selected in each subwatershed. Benthic macroinvertebrates were collected using Maryland Biological Stream Survey (MBSS) methods (multihabitat, 20-jab). Assessment of physical habitat quality combined MBSS methods and USEPA's Rapid Bioassessment Protocols (RBP). Sampling was performed jointly by the Maryland Department of Natural Resources (MDNR) Watershed Restoration Division (WRD) and the Howard County Stormwater Management Division (SWMD).

This report presents the results of the sampling and assessments for all six subwatersheds during the Spring Index Period (March 1 - April 15). Composite assessments are presented for watershed-scale biological and habitat assessments. The report also presents individual site by site assessments.

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EXECUTIVE SUMMARY

The Howard County Department of Public Works (DPW) Stormwater Management Division (SWMD) recently initiated biological monitoring for its streams and wadeable rivers on an annual, rotating basin cycle. The primary goal of this biological monitoring program is to assess the current status of the County's stream biological resources (including benthic macroinvertebrates, fish, and physical habitat quality) and to establish a baseline for comparing future assessments. The County has identified the need to base the initial program design and to address more specific questions at three geographic scales: stream-specific, watershed wide; and, after the five-year sampling rotation is complete, county-wide. In an effort to work with the state's environmental reporting requirements, the data collected in this effort will be comparable to that collected by the Maryland Department of Natural Resources (DNR) Maryland Biological Stream Survey (MBSS). Comparability provides a higher density of sampling locations in the County, and an increased potential for problem identification. The state has already targeted the Little Patuxent River for restoration initiatives. To facilitate work in this watershed, the Watershed Restoration Division (WRD) of DNR assisted the County in fieldwork, laboratory processing, and taxonomic identification. Sampling methods were identical to those used by the MBSS: benthic macroinvertebrates sampled using a D-frame net in multiple habitats (20-jab method), visual-based assessment of physical habitat quality, and selected field chemistry. In addition, substrate particle size distribution and stream channel cross sectional area were evaluated for approximately 50% of the sites. Fish were also sampled at half of the sites. Biological condition scores were derived using the MBSS's Benthic Index of Biological Integrity (B-IBI). Results of the study will be related to specific programmatic activities, such as best management practice (BMP) siting and installation, stormwater permits, and protection/restoration activities. The public will also be able to access the yearly report via the County website, as well as through brochures that highlight specific watersheds.

Six subwatersheds were sampled during a single index period (March 1 - April 15): Upper, Middle, Lower Little Patuxent River, Cattail Creek, and Upper and Lower Brighton Dam. All three subwatersheds of the Little Patuxent River received "poor" biological quality ratings and "non supporting" physical habitat assessments. The Cattail Creek and Upper and Lower Brighton Dam subwatersheds received "fair" mean biological condition ratings. Lower Brighton Dam had the lowest mean physical assessment of "non-supporting" (Table 1).

Table 1. Means of the biological and physical habitat scores of each subwatershed, with their corresponding narrative ratings.

	Narrative Rating	Metric Mean Score
Cattail Creek		
Physical Habitat	"Non Supporting"	$\bar{X}$ = 108.00 ± 21.74
Biology	"Fair"	$\bar{X}$ = 3.60 ± 0.63
Lower Brighton Dam		
Physical Habitat	"Non Supporting"	$\bar{X}$ = 111.64 ± 14.85
Biology	"Fair"	$\bar{X}$ = 3.49 ± 0.69
Upper Brighton Dam		
Physical Habitat	"Partially Supporting"	$\bar{X}$ = 120.55 ± 5.96
Biology	"Fair"	$\bar{X}$ = 3.82 ± 0.46
Lower Little Patuxent River		
Physical Habitat	"Non Supporting"	$\bar{X}$ = 105.25 ± 26.8
Biology	"Poor"	$\bar{X}$ = 2.06 ± 0.54
Middle Little Patuxent River		
Physical Habitat	"Non Supporting"	$\bar{X}$ = 97.67 ± 24.86
Biology	"Poor"	$\bar{X}$ = 2.14 ± 0.64
Upper Little Patuxent River		
Physical Habitat	"Non Supporting"	$\bar{X}$ = 110.00 ± 28.70
Biology	"Poor"	$\bar{X}$ = 2.74 ± 0.59

Recommendations are given for rehabilitation and protection action. Specifically, they will allow the results of the first year of monitoring to be used in natural resource management decisions, including possibilities for:

- protection and rehabilitation,
- further diagnostic analysis,
- baseline condition for future monitoring,
- public outreach, and
- quality assurance/quality control activities.

Section I. INTRODUCTION/PROGRAM OVERVIEW

Background

The ecological condition of streams and watersheds can be determined through the direct sampling and analysis of instream biota. Benthic macroinvertebrates (bottom-dwelling organisms without a backbone) and fish were used in this study to assess the condition of individual streams and overall watershed quality. Understanding biological response to environmental alteration is essential to interpreting the results of biological monitoring. Streams serve as indicators of cumulative environmental effects, and, if healthy, they also provide direct benefits to human health and safety, quality of life, and economic conditions; reduce deposits of nutrients and sediments farther downstream; and lessen the adverse effects of flooding. While streams are dynamic ecological systems in and of themselves, they also function ecologically as hierarchical components of larger systems: watersheds (Vannote et al. 1980, Frissell et al. 1986, Pringle et al. 1988, Power et al. 1988). Knowledge of the current state of those streams and watersheds will aid in understanding not only conditions within the County, but across Maryland. Watersheds cross county boundaries, absorbing the impacts of small streams all over the state, making them targets of conservation or restoration activities. Once problem sites are identified, educated decisions can be made about how to improve those degraded streams and watersheds.

Streams and rivers in Howard County are tributaries of the Patuxent and Patapsco Rivers, which empty into the Chesapeake Bay. The primary goals of this biological monitoring program are to assess the current status of biological stream resources (including benthic macroinvertebrates and physical habitat quality) and to establish a baseline for comparing future assessments. Results will also be related to specific programmatic activities, such as best management practice (BMP) siting, installation, and evaluation; stormwater permits; restoration; and guidelines for low impact development, as in Stribling et al. (2001).

This report represents the first year results of a five year, rotating basin biological monitoring program. Six of the 15 subwatersheds in Howard County were sampled during the Spring 2001 Index Period for benthic macroinvertebrates, fish (3 subwatersheds), physical habitat quality, and field chemistry.

Purpose of Biology and Habitat Assessment

The biological indicators used in this project are based on the Index of Biological Integrity (IBI; Karr et al. 1986). This multimetric biological index uses characteristics of the benthic macroinvertebrate and fish assemblage structure and function to assess the overall water resource conditions. Benthic and fish IBIs were developed by the Maryland Biological Stream Survey (MBSS) and calibrated for different geographic areas of Maryland (Stribling et al. 1998, Roth et al. 1997).

Physical habitat quality is another indicator assessed at each sampling location, and is taken to reflect the potential of the stream to support a vigorous biota and to maintain normal

hydrogeomorphic function (Barbour et al. 1999). As land use/land cover conversions occur in a watershed, there are changes in stream and watershed hydrology that cause acceleration of stream channel erosion. Impacts on physical habitat through increased farming operations, housing density, and other urban-suburban developments cause sedimentation, degradation of riparian vegetation, installation of impervious surfaces, and bank instability, which then cause reduced overall habitat quality.

Even though alteration in habitat quality can reduce the suitability of a stream for certain organisms, there are multiple factors that affect the biological quality of any stream or watershed (Figure 1). In addition to degraded habitat quality and disruption of natural hydrologic regimes, changes in sources of food energy, water quality (e.g., toxic chemical input or nutrient enrichment, temperature extremes, elevated levels of suspended sediment), and nonnatural biological interactions (e.g., increased frequency of diseases, parasites, nonnative predators or competitors) can cause degradation of stream biology (Karr et al. 1986). While interpretation of the results in this report can provide evidence of stressors and stressor sources, it does not directly identify specific cause and effect relationships (i.e., individual environmental stressors [cause] resulting in biological responses [effect]).

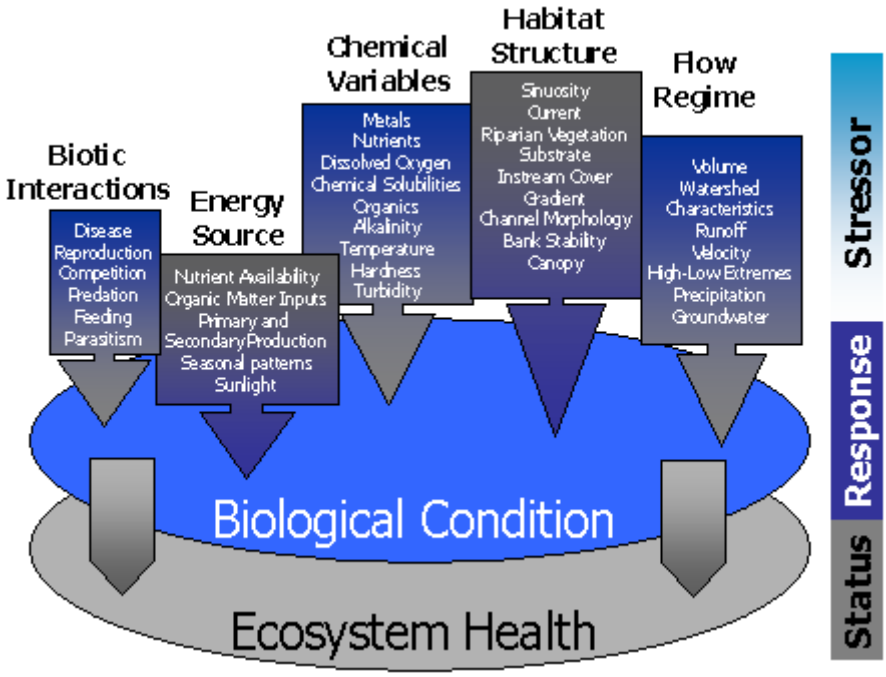

Figure 1. Five classes of environmental variables that affect water resource integrity and overall biological condition (modified from Karr et al. 1986).

Participating Agencies

Membership on the County's Technical Advisory Committee (TAC) included Howard County Government (Stormwater Management Division, Department of Recreation and Parks, and Planning and Zoning), the State of Maryland Department of Natural Resources Biological Stream Survey (MBSS), Montgomery County DEP, and representatives from USEPA Region III. The Watershed Restoration Division (WRD) of the Maryland Department of Natural Resources (DNR) performed all fieldwork in the Little Patuxent River watershed; Howard County performed all fieldwork in the Upper and Lower Brighton Dam and Cattail Creek watersheds.

METHODS

Network Design

Summary of Sampling Design

The management and data quality objectives on which the Howard County biological monitoring program is based can be found in the *Quality Assurance Project Plan (QAPP) for Howard County Biological Monitoring and Assessment Program* (DPW 2001). The overall sampling design was developed to be directly comparable to the MBSS. Comparability will allow the county to contribute data directly to statewide stream monitoring program run by the MBSS. The design process resulted in a monitoring plan for which ten sites in three subwatersheds per year would be sampled. A total of 15 subwatersheds will be sampled in a span of five years. Specific details of the sampling design can be found in *Design of the Biological Monitoring and Assessment Program for Howard County Maryland* (Pavlik et al. 2001). Spatial allocation of the sampling segments was based on random selection within Strahler (1957) stream orders. The number of sampling locations within each of the first, second, third, and fourth order channel distances (m) was proportional to their total lengths. Thus, final selection and placement of sampling segments was random, and stratified by subwatershed and stream order.

To address issues of measurement error (= systematic error), duplicate biological samples were taken at 10% of the overall number of sites. Sites where this repeat sampling occurred were chosen at random, before the sampling event took place. Sampling error (= random error) was also addressed using multiple sites that were randomly selected and happen to fall in close proximity (< 1000 m) to other sampling locations.

Site Selection

Howard County is in the process of developing a Watershed Restoration Action Strategy (WRAS) for the Little Patuxent River Watershed. In coordination with that strategy, the County chose to prioritize the Little Patuxent for sampling and assessment during year 1, in combination

with the Brighton Dam (Upper and Lower) and Cattail Creek subwatersheds. While DNR's Watershed Restoration Division (WRD) performed field sampling in the Little Patuxent River Watershed (Upper, Middle, and Lower), Howard County sampled in the other three. The remaining 12 subwatersheds were randomly selected, three more during the first year (Figure 2), nine over the next four years (Table 2). Ten percent of the sites in each watershed were randomly selected as quality control sites, and one additional sample (biology, chemistry, and habitat) was taken per site. Figure 3 displays the location of all of the sites sampled in Year 1.

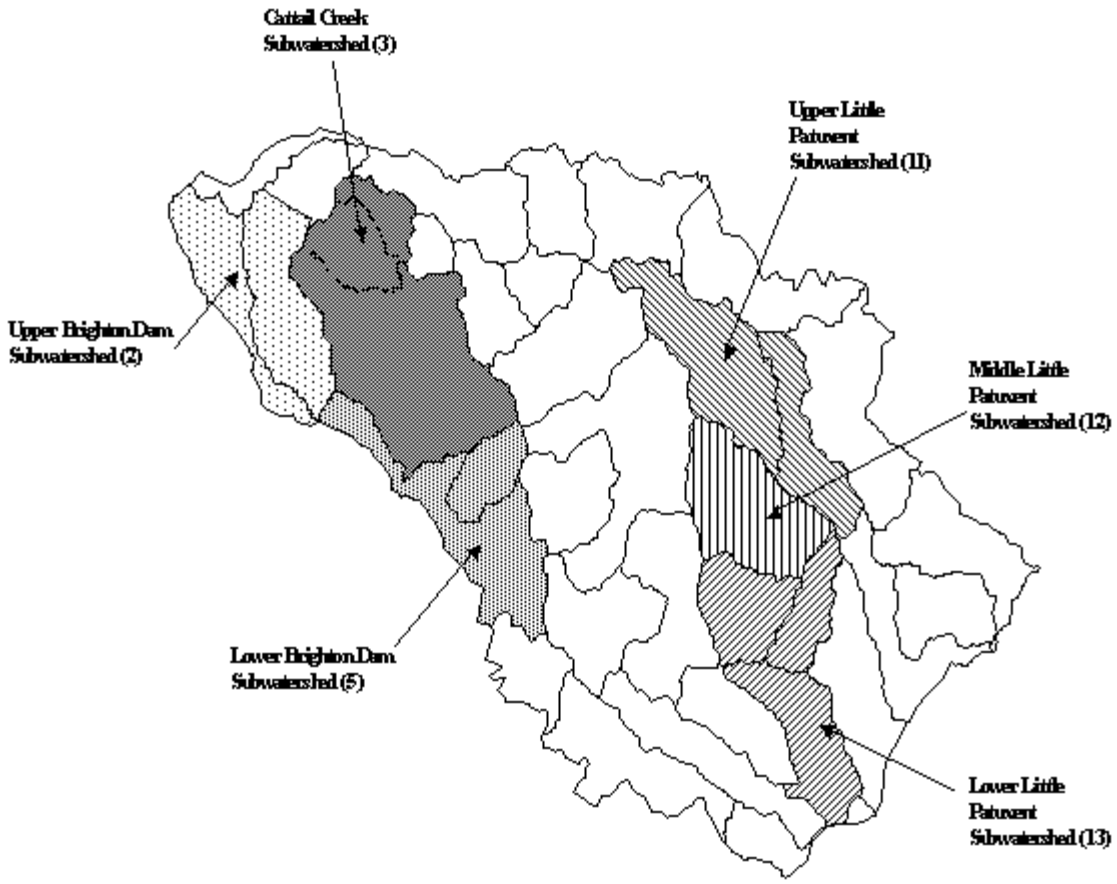

Figure 2. Howard County, Maryland. Watersheds sampled as part of the 2001 Spring Index Period. Numbers in parentheses correlate to the subwatershed numbers in Table 2.

Table 2. Howard County sampling schedule by watershed. WRD indicates that field sampling and laboratory processing of benthic samples was performed by MDNR Watershed Restoration Division. Numbers preceding each PSU are the subwatershed numbers.

Year	Watershed Name or Surrogate	Primary Sampling Unit (PSU)
1 (2001)	Little Patuxent River Brighton Dam Cattail Creek	11 Upper Little Patuxent (10 sites, WRD) 12 Mid Little Patuxent (10 sites, WRD) 13 Lower Little Patuxent (10 sites, WRD) 2 Upper Brighton Dam (10 sites) 5 Lower Brighton Dam (10 sites) 3 Cattail Creek (10 sites)
2 (2002)	Middle Patuxent River	6 Upper Middle Patuxent (10 sites) 7 Mid Middle Patuxent (10 sites) 8 Lower Middle Patuxent (10 sites)
3 (2003)	Boundary Tributaries	10 S Branch Patapsco R Tribs (10 sites) 9 Rocky Gorge Dam (10 sites)
4 (2004)	Boundary Tributaries	1 Patapsco River L Br A (10 sites) 4 Patapsco River L Br B (10 sites)
5 (2005)	Little Patuxent River	14 Hammond Branch (10 sites) 15 Dorsey Run (10 sites)

Field Sampling and Laboratory Processing

Benthic macroinvertebrate sampling and physical habitat assessments were conducted in accordance with the Standard Operating Procedures (SOP FLD003/09.07.00; FLD005/02.27.01) contained within the Quality Assurance Project Plan (QAPP) for the Howard County Biological Monitoring and Assessment Program (DPW 2001), as well as methods explained in the MBSS Sampling Manual (Kazyak 2000). Field chemistry sampling, Modified Wolman Pebble Count, and Channel Cross Sections in the Cattail Creek, and Upper and Lower Brighton Dam subwatersheds were conducted according to SOPs BRF050/07.07.97, FLD032/01.25.99, and FLD043/07.19.99, respectively. WRD used a levelometer to measure stream gradient. Benthic and physical habitat assessments were completed during the Spring Index Period (March 1-April 15) 2001. Fish sampling in the Little Patuxent River watershed was conducted during the month of June by WRD.

Benthic Sampling and Processing

Benthic macroinvertebrates were collected from 75 m reaches by sampling 20 ft^2 of the available habitat with a D-frame net (595 µ mesh), in proportion to the frequency of habitat types (riffles, snags, vegetated banks, sandy bottom) found within the sampling reach. All sampled material was composited in a 595 µ sieve bucket, placed in one or more 1 L sample containers and preserved in 70 - 80% ethanol. Internal and external labels were completed for each container.

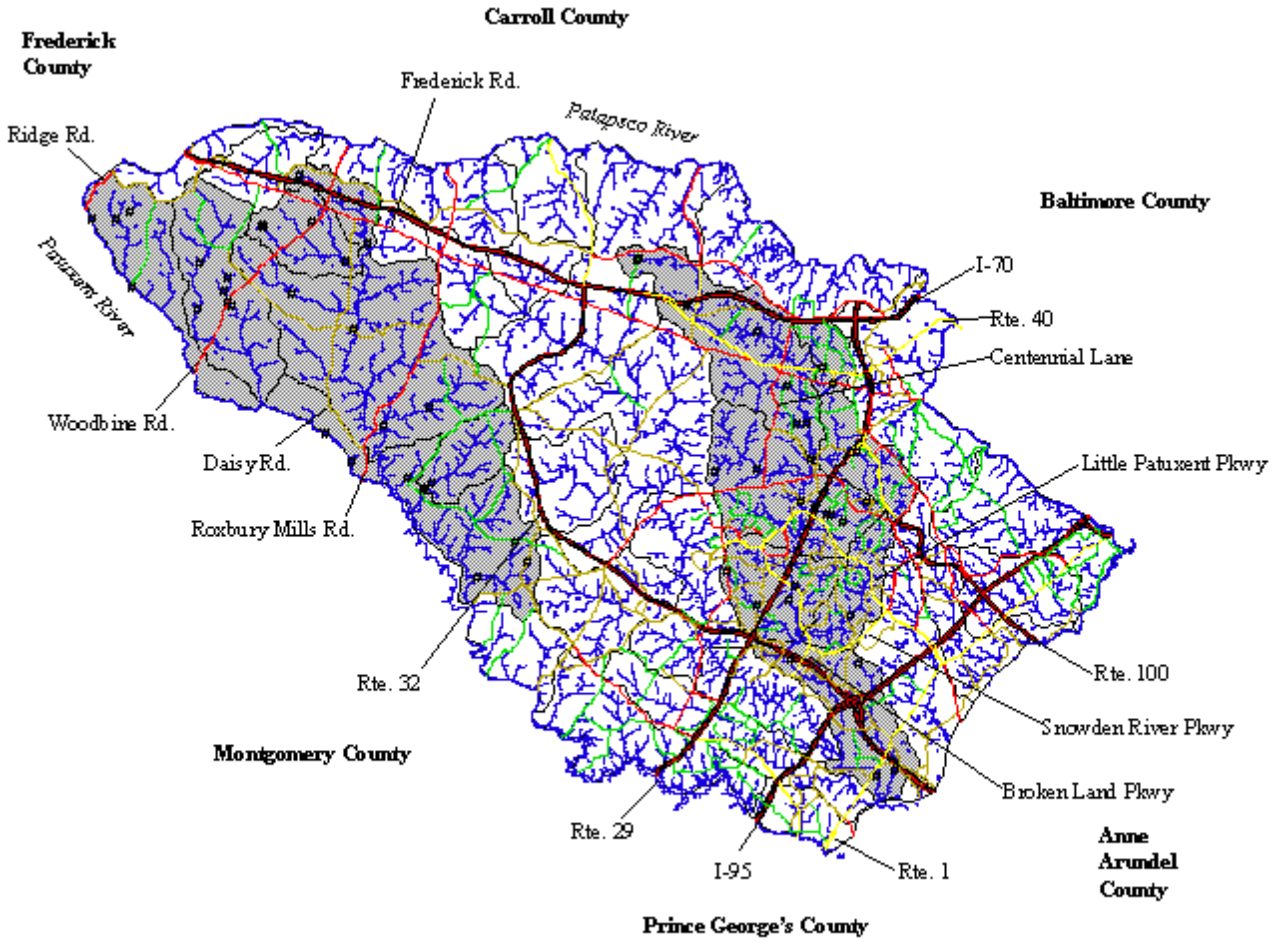

Figure 3. Sites sampled in relation to major roadways in Howard County.

Samples were recorded on chain-of-custody forms for each subwatershed. In the lab, the composited samples were randomly subsampled to approximately 100 organisms and identified to genus level (Howard County DPW/SWMD 2001, Boward and Friedman 2000).

Benthic Taxonomy

Benthic macroinvertebrates were usually identified to the taxonomic level of genus. In some cases, e.g., when individuals were of early instars or had damaged or missing diagnostic morphological features, identification was restricted to a higher taxonomic level, such as family. Benthic samples from the Little Patuxent River Watershed were identified by MDNR/WRD (N. Primrose). All identifications of samples from Brighton Dam and Cattail Creek Watersheds were performed by Aquatic Resources Center, College Grove, Tennessee (R. D. Kathmann, principal). Taxonomic data entered were received from each taxonomist in Excel or Access. Data were then

loaded into the Ecological Data Application System, Version 3.0 (EDAS; Tetra Tech 1999). Functional feeding group, habit, and tolerance value designations were assigned to each taxon according to Meritt and Cummins (1996), Barbour et al. (1999), and Stribling et al. (1998). Tolerance of a taxon is based on its ability to survive short and long term exposure to physicochemical stressors that result from chemical pollution, hydrologic alteration, or habitat degradation (Stribling et al. 1998). Following Hilsenhoff's basic framework (1982), tolerance values were assigned to individual taxa on a scale of 0-10, with 0 identifying those taxa with greatest sensitivity (least tolerance) to stressors, and 10, those taxa with the least sensitivity (greatest tolerance) to stressors.

Fish Sampling and Identification

Fish were collected in the Little Patuxent River watershed by WRD in accordance with the MBSS Sampling Manual (Kazyak 2000). WRD also recorded the length and weight of the first 30 fish collected from each species (N. Primrose, personal communication). Fish site classification and statements on pollution tolerance were based on Roth et al. 2000.

Physical Habitat Rating (Methods for Calculation and Scoring)

Ten parameters describing physical habitat quality and stability were visually assessed in 75 m reaches, as outlined in the QAPP (DPW 2001). They follow the categories outlined in the Rapid Bioassessment Protocols (RBPs; Barbour et al. 1999). These parameters were ranked as optimal, suboptimal, marginal, or poor based on a 20 point scale, with 20 being the best possible (optimal) conditions and 0 representing the worst (poor) conditions. A reference database, and thus, a degraded/non-degraded threshold has not been developed by the MBSS to allow direct comparison to physical habitat characteristics. For this reason, the values were summed and compared to the maximum possible score (200) for overall percent comparability for each site. The ten RBP parameters evaluated are:

- *Epifaunal substrate/available cover.* Includes the relative quantity and variety of natural structures in the stream, such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as refuge, feeding, or sites for spawning and nursery functions of aquatic macrofauna.
- *Embeddedness.* Refers to the extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, or mud of the stream bottom.
- *Velocity/depth regime.* The occurrence of flow patterns relates to the stream's ability to provide and maintain a stable aquatic environment.
- *Sediment deposition.* Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition.
- *Channel flow status.* The degree to which a stream is filled with water.
- *Channel alteration.* Measures large-scale (usually anthropogenic) changes in the shape of the stream channel.

- *Frequency of riffles/bends.* Measures the heterogeneity occurring in a stream. Riffles are a source of high-quality habitat and diverse fauna. Therefore, increased frequency of occurrence greatly enhances the diversity of the stream community.
- *Bank stability.* Measures whether the stream banks are eroded (or have potential for erosion).
- *Vegetative protection.* Measures the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone.
- *Riparian vegetative zone width.* Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone.

The final three parameters evaluate each bank separately. The range of scores for each bank is 0 (poor) to 10 (optimal). Left and right bank were assessed looking downstream. Example forms can be found in the QAPP, SOP FLD005/02.27.01. Table 3 provides narrative ratings that correspond to possible physical habitat quality scores. These scores express the potential of a stream or watershed to support a healthy biological community. Percentages and their narrative ratings were adapted from Plafkin et al. 1989.

Table 3. Total habitat scores as a percentage of maximum possible and corresponding ratings.

% of Maximum	Narrative Habitat Rating
90.0	Comparable
75.1 - 89.9	Supporting
60.1 - 75.0	Partially Supporting
60.0	Non-Supporting

MBSS Spring Habitat forms were also filled out at each site in all six subwatersheds. These sheets evaluated land use/land cover designations, occurrence/severity of refuse, buffer breaks (storm drains, roads, pastures, etc.), and channelization. Information available from these forms was used in the narrative watershed and site-by-site assessments.

RBP and MBSS Spring Habitat forms were completed at all 60 sites. At the three subwatersheds in the Little Patuxent, the MBSS Summer Index Period Data Sheet and a WRD Field Data Form were also completed. These forms had additional parameters as well as some that were similar to the RBP habitat sheet (Table 4). The parameters were scored in the same 0 - 20 range detailed above. The forms also had physical characteristics of the site (i.e., sediment/water odors, oils, etc.) that were used in the narrative assessments. Metrics for physical habitat assessment were calculated only from those sites where the RBP Habitat Assessment Field Data Sheet - High Gradient Streams were completed.

Table 4. Habitat parameter comparison between MBSS and WRD. Definitions for the MBSS parameters can be found in the MBSS Sampling Manual (Kazyak 2000).

MBSS Parameters	WRD Parameters
Instream Habitat	Local watershed characteristics
Epifaunal Substrate	Bank characteristics
Velocity/Depth Diversity	Streamside cover
Pool/Glide/Eddy Quality	Channel characteristics
Riffle/Run Quality	Bottom substrate at riffle
Embeddedness	Embeddedness
Shading	Filamentous algae
Trash Rating	

Water Quality

Conductivity, dissolved oxygen, pH, and temperature were measured at each site using a Hydrolab Surveyor 4a (SOP BRF050/07.07.97). This instrument was calibrated for each parameter at the start of each sampling day, and the readings recorded on a calibration log sheet. WRD collected additional chemical data that was sent to the University of Maryland, Chesapeake Biological Lab, Soloman's Island, Maryland (contact: Carl Zimmerman). The raw data is listed in Appendix D.

Modified Wolman Pebble Count

This additional physical habitat feature was measured for all stream sites in the Cattail Creek and Upper and Lower Brighton Dam subwatersheds. While not a part of the MBSS protocols, the County performed pebble counts in order to obtain more specific data on stream substrates. Ten transects were proportionally distributed (approximately one every 7.5 m) through the assessment segment spanning the width of the active channel, beginning on each bank at approximate bankfull level. A total of 10 particles per transect (each particle is defined as a size of geologic substrate material within various classes: silt/clay, sand, gravel, cobble, boulder, and bedrock) were selected by hand. Each particle was chosen, measured, and recorded at evenly spaced intervals across the channel. To reduce sampler bias, each particle was chosen without the sampler looking in the stream at what was being collected (SOP FLD 032/01.25.99, Harrelson et al. 1994). Calipers and a sand card were used for particle measurement.

Channel Cross-Section

This measurement is intended to give a coarse characterization of channel cross-sectional area and channel volume. It was also completed only for the Cattail Creek, Upper and Lower Brighton Dam subwatersheds. After a thorough visual assessment of the channel characteristics, a representative section was selected for analysis as the cross-section area. Measurement of channel cross-sections followed the procedures outlined in SOP FLD043/07.19.99.

Inability to Sample Stream Sites

Ten primary sampling sites were chosen for each subwatershed. In addition to the primary sites, ten secondary sites were randomly chosen for each subwatershed as replacement sites, to provide backup locations in the event that the primary sampling site was deemed unsampleable (i.e., landowner denied access, no water in channel, channel too deep). There were three primary sites in the Little Patuxent River watershed that were replaced with secondary sites. Three primary sites in each of the Cattail Creek and Lower Brighton Dam subwatersheds were replaced with secondary sites. The Upper Brighton Dam subwatershed had one primary site replaced by a secondary site.

Data Analysis

Data Structure

Benthic macroinvertebrate, physical habitat, and water quality data, were entered into EDAS, Version 3.0 (Tetra Tech 1999). This relational database allows for the management of location and other metadata, taxonomic and count data, raw physical habitat scores, the calculation of metric values, physical habitat and water quality rankings, and B-IBI values.

Biological Index Rating (Methods for Calculation and Scoring)

The benthic metrics used were those selected and calibrated by the MBSS (Stribling et al. 1998) for Maryland non-Coastal plain streams. The nine metrics calculated for each of the benthic macroinvertebrate samples are:

- *Total number of taxa.* The taxa richness of a community is commonly used as a qualitative measure of stream water and habitat quality. Stream degradation generally causes a decrease in the total number of taxa (Resh and Grodhaus 1983).
- *Number of EPT taxa.* Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are generally sensitive to degraded stream conditions. A low number of insects within these orders is indicative of stream degradation (Lenat 1988).

- *Number of Ephemeroptera taxa.* Mayflies are generally sensitive to pollution and the number of mayfly genera represented by individuals in a sample can be an indicator of stream conditions, generally decreasing with increasing stress.
- *Number of Diptera taxa.* As an order, Dipterans are relatively diverse, as well as variable in their tolerance to stress. Many taxa, especially Chironomidae, have wide distributions and may occur even in highly polluted streams. However, a high diversity of Diptera taxa generally suggests good water and habitat quality.
- *Percent Ephemeroptera.* The degree to which mayflies dominate the community can indicate the relative success of these generally pollution intolerant individuals in sustaining reproduction. The presence of stresses will reduce the abundance of mayflies relative to other, more tolerant individuals; although, some mayfly groups, such as several genera of the family Baetidae, are known to increase in numbers in cases of nutrient enrichment.
- *Percent Tanytarsini.* The tribe Tanytarsini is a relatively intolerant group of midges. A high percentage of Tanytarsini, proportional to the overall sample is taken to indicate lower levels of stress. This metric increases with high numbers of Tanytarsini and decreases with high numbers of non-tanytarsini.
- *Number of Intolerant Taxa.* Intolerant taxa are the first to be eliminated by perturbations. Often, intolerant taxa are specialists and perturbations can alter or eliminate specialized habitat or water quality requirements. Taxa with tolerance ratings from 0 - 3 were considered intolerant (Hilsenhoff 1987).
- *Percent Tolerant.* As stressor intensity increases, tolerant individuals (tolerance values 7 - 10) tend to dominate samples. Values for this metric increase in cases of elevated stress. Intolerant individuals become less abundant as stress increases, leading to more opportunity for tolerant taxa to colonize a stream (Hilsenhoff 1987).
- *Percent Collectors.* Abundance of detritivores, which feed on fine particulate organic matter in deposits, typically decreases with increased disturbance. This ecological response may be highly represented by intolerant taxa.

Each metric is scored on a 5, 3, 1 basis (5 being the best, 1 being the worst) according to stream health. Metric scoring criteria are listed in Table 5. Overall biological index scores are obtained by simple summation of the metric scores for each site, and divided by the number of metrics (9). The resulting value is then compared to the index scoring criteria for translation into narrative categories (Table 6), in the format established by the MBSS (Roth et al. 1997, Stribling et al. 1998). If the total number of organisms in a sample was less than 60, metrics were not calculated, according to MBSS procedures (D. Boward, personal communication). Unless there was evidence that this represented a natural condition, low organism numbers are taken to indicate "very poor" conditions (Stribling et al. 1999). It should be noted that five of the samples collected by WRD had high subsample numbers (number of organisms exceeding 120), and three of those received a "fair" biological assessment rating. Judging from the physical habitat assessment scores and the biological assessment ratings from other sites in the Little Patuxent River watershed, it is possible this rating is a consequence of having a higher number of organisms. Since one of the biological metrics is total taxa, subsampling to more organisms than

the target number (100 ± 20%; SOP BRF004/02.23.01) could artificially raise the score for that metric.

Fish were also sampled in the Little Patuxent River watershed by WRD. These samples were not used in calculating metrics to assign biological condition scores to any subwatershed. Fish were sampled in order to create a baseline for future abundance comparisons.

Table 5. Metric scoring criteria for the Benthic IBI (Stribling et al. 1998).

Benthic Macroinvertebrate Metrics	Criteria		
	5	**3**	**1**
Total number of taxa	>22	16 - 22	<16
Number of EPT taxa	>12	5 - 12	<5
Number of Ephemeroptera taxa	>4	2 - 4	<2
Number of Diptera taxa	>9	6 - 9	<6
% Ephemeroptera	>20.3	5.7 - 20.3	<5.7
% Tanytarsini	>4.8	0.0 - 4.8	0.0
Number of intolerant taxa	>8	3 - 8	<3
% tolerant	<11.8	11.8 - 48.0	>48.0
% collectors	>31.0	13.5 - 31.0	<13.5

Table 6. Benthic IBI score ranges and corresponding narrative ratings.

Benthic IBI Score Range	Narrative Biological Rating
4.0 - 5.0	Good
3.0 - 3.9	Fair
2.0 - 2.9	Poor
1.0 - 1.9	Very Poor

QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance/Quality Control (QA/QC) is a series or program of activities designated to ensure data quality and document data characteristics. To this end, Howard County has:

- documented standard operating procedures (SOPs) for field sampling and laboratory processing and chain-of-custody form completion

The SOPs and procedures for these QC activities are documented in the Howard County Biological Monitoring and Assessment Program plan (DPW 2001). All SOPs are cited in the methods section of this report. Chain-of-custody and sample log sheets were maintained to track the inventory and processing status of all samples. Sample documentation forms are kept in 3-ring binders in the BRF.

- held annual orientation sessions for field sampling

The County field orientation is held as a "refresher" for experienced samplers and as an introduction for new samplers. All 2-person field teams are divided into Team Leader and Crew Member. Team Leaders are required to have completed one prior field season as a Crew Member. Crew Members have completed either the introductory or "refresher" field orientation. The orientation for this index period was held on March 2, 2001 at an unnamed tributary of the Patuxent River. At least one person from each field crew also attended the MBSS training session conducted by DNR staff, which was held on February 27 and 28, at Morgan Run Natural Environmental Area.

- conducted field audits

The County field crew was visited on-site by an experienced field ecologist who was not involved in the fieldwork for the project. MBSS staff also conducted independent audits of each field team (Howard County and WRD). Field team procedures were observed for adherence to SOPs, consistency in completion of all data collection requirements, field data sheets, sample preservation, and photo documentation. Results of field audits can be found in Appendix H.

- repeated continual training and QC checks for sample sorting and subsampling

All sorting and subsampling of samples taken by the County was performed by a single individual in the Tetra Tech BRF. Early sorting was checked by the laboratory manager and principal project taxonomist to ensure that there were no missed specimens in removed grid debris. Once a 90% sorting efficiency was attained, random checks were performed on approximately 1 out of 10 samples. WRD sorted samples according to MBSS protocols (Boward and Friedman 2000). Every 20th sample was respread after initial subsampling and identification by the same subsorter, which was then re-picked and identified.

- made consistent use of technical taxonomic literature

The target level of taxonomic identification for benthic macroinvertebrates for this project was genus. State-of-the-science technical literature was used throughout and included references listed in Table 7.

Table 7. The following table lists the taxonomic references used for organism identification.

Burch, J. B. 1989. *North American freshwater snails*. Malacological Publ., Hamburg, Michigan. 365p.
Burch, J. B. 1982. *Freshwater snails (Mollusca: Gastropoda) of North America.* EPA-600/3-82-026, USEPA, Cincinnati, Ohio. 294 p.
Edmunds, G. F., Jr., Jensen, S. K. and Berner, L. 1976. *The mayflies of North and Central America*. Univ. Minn. Press, Minneapolis. 330 p.
Epler, J. H. 1995. *Identification manual for the larval Chironomidae (Diptera) of Florida*. rev. ed. Dept. Environ. Prot., Tallahassee, FL. 9 sections.
Epler, J. H. 1996. *Identification manual for the water beetles of Florida (Coleoptera: Dryopidae, Dytiscidae, Elmidae, Gyrinidae, Haliplidae, Hydraenidae, Hydrophilidae, Noteridae, Psephenidae, Ptilodactylidae, Scirtidae).* Dept. Environ. Prot., Tallahassee. 15 sections.
Epler, J.H. 1995. *Identification manual for larval Chironomidae (Diptera) of Florida*. Revised. Tallahassee, FL.
Kathman, R. D. and Brinkhurst, R. O. 1998. *Guide to the freshwater oligochaetes of North America.* Aquatic Resources Center, College Grove, TN. 264 p.
McAlpine, J. F., Peterson, B. V., Shewell, G. E., Teskey, H. J., Vockeroth, J. R. and Wood, D. M. (Coords.) 1981. *Manual of Nearctic Diptera*. Vol. 1, Monogr. 27. Can. Govt. Publ. Centre, Hull, Quebec. 674p.
Merritt, R. W. and Cummins, K. W. 1996. *An introduction to the aquatic insects of North America. 3rd, Edition.* Kendall/Hunt Publ. Co., Dubuque, Iowa. 862p.
Needham, J. G. and Westfall, M. J., Jr. 1954. *A manual of the dragonflies of North America (Anisoptera).* Univ. Calif. Press, Berkeley. 615 p.
Oliver, D. R. and Dillon M. E. 1990. *A catalog of nearctic Chironomidae*. Research Branch, Agriculture Canada. Publ. 1857/B:1-89.
Peckarsky, B.L., P.R. Fraissinet, M.A. Penton, and D.J. Conklin Jr. 1995. *Freshwater macroinvertebrates of northeastern North America.* Comstock Publishing Associates, Ithaca ands London.
Pennak, R.W. (editor). *Freshwater invertebrates of the United States*. Protozoa to Molluscs, 3rd Interscience Publication, New York. Stewart, K. W. and Stark, B. P. 1988. Nymphs of North American stonefly genera (Plecoptera). The Thomas Say Foundation, Vol. 12. Entomol. Soc. Amer. Publ., Maryland. 460 p.
Westfall, M. T., Jr. and May, M. L. 1996. *Damselflies of North America.* Scientific Publishers, Gainesville, Florida. 649 p.
Wiederholm, T. (ed.) 1983. Chironomidae of the Holarctic region. Keys and diagnoses. Part l. Larvae. *Entomol. Scand. Suppl.* 19. 457 p.
Wiederholm, T. (ed.) 1986. Chironomidae of the Holarctic region. Keys and diagnoses. Part 2. Pupae. *Entomol. Scand. Suppl.* 28. 482 p.
Wiggins, G.B. 1996. *Larvae of North American Caddisfly Genera (Trichoptera), 2nd Ed.* University of Toronto Press, Toronto. 457 p.

- verified taxonomy for questionable invertebrate specimens by senior taxonomists or independent specialists

There are two principal sources of error that can cause uncertainty in some taxonomic identifications. One is that the specimens in question are of very early instars (juvenile) and lack morphological structures necessary for positive identification. Another is that any specimen can have damaged or missing morphological features (gills, antennae, legs, caudal filaments) rendering final, positive identification problematic. In addition, for midges, inadequate mounting medium can make genus level identification nearly impossible. When the principal project taxonomist used a taxonomic certainty rating (TCR) of 3, 4, or 5 (1 is the most certain, 5 is the least), the specimen was checked by the senior taxonomist.

- created, maintained, and used reference collection and voucher samples

During this first sampling year, Howard County created and will maintain and update in the future, a taxonomic reference collection for benthic macroinvertebrates collected in the county. One or more specimens removed from samples are kept to be representative of the taxonomy used. Specimens in the reference collection were identified by Aquatic Resources Inc., College Grove, TN (R. Deedee Kathman, Ph.D.). Voucher samples (stored in ~ 75% ethanol) are kept from all sampling in Howard County for at least three years in the Tetra Tech BRF.

- standardized data entry and management system

All biological, physical habitat, chemical, and ancillary data were entered directly from field data sheets or Excel spreadsheets into EDAS. The data and analytical results from future index periods will be managed in this system.

- conducted independent QC checks of all data entry

One hundred percent of the data set, once entered, was checked by hand against the original, hand-written field sheets. If discrepancies were encountered, they were corrected in EDAS.

- performed hand calculation of approximately 10% of computer generated metric values

Using a pocket calculator, 10% of all metric values were calculated (one metric through all sites, one site with all metrics, and a diagonal section of value cells throughout the matrix). Differences between the resulting values and those calculated by spreadsheet query in EDAS or Statistica led to additional scrutiny of the constructed queries. If errors were discovered, they were corrected in EDAS and recalculated for all sites.

- taken duplicate samples for estimating precision using Relative Percent Difference (RPD)

Duplicate samples were taken at three sites in the Brighton Dam/Cattail Creek subwatersheds, and at two sites in the Little Patuxent River watershed. Habitat duplicates were performed only in the Brighton Dam/Cattail Creek subwatersheds. Comparisons of the differences between the results from these sites provide estimates of the precision of the biological assessments and the consistency of sampling activity. Relative percent difference (RPD) provides an estimate of the difference between sample pairs (Table 8).

Table 8. Relative Percent Difference (RPD) calculations for sites in the Brighton Dam, Cattail Creek, and Little Patuxent Watersheds.

Sampling Team	Howard County						WRD			
Station #	007	007	022	022	087	087	065	065	103	103
Location	Cattail Creek	Cattail Creek	Patuxent River	Patuxent River	UT of Cabin Branch	UT of Cabin Branch	UT of Little Patuxent	UT of Little Patuxent	UT of Little Patuxent	UT of Little Patuxent
Sample Type	Routine Sample	Field Duplicate	Routine Sample	Field Duplicate	Routine Sample	Field Duplicate	Routine Sample	Field Duplicate	Routine Sample	Field Duplicate
Stream Order	3	3	3	3	1	1	1	1	1	1
Metric Score	3.44	3.22	3.89	3.67	4.33	4.11	NA	1.67	3.44	3.67
Narrative Rating	Fair	Fair	Fair	Fair	Good	Good	Very Poor	Very Poor	Fair	Fair
Total Organisms	108	120	109	109	119	112	55	102	107	129
RPD	6.7%		5.8%		5.2%		NA		6.5%	

NA = RPD not calculated due to total organism count below the minimum (60) for calculating metrics.

- compared sample variation with design assumptions

The standard deviations from the six wubwatersheds were compared to standard deviations from MBSS samples (reference and test) used in assigning a target number for samples per subwatershed.

- Reference = 0.69
- MBSS Test = 0.83
- Spring 2001 Sampling = 0.60

Section II. Watershed Assessments

WATERSHED BACKGROUND

Listings of all sites, water body names, and sampling locations are contained in Appendix F. Appendix G details the land use/land cover designations for each site. The coverage is based on Maryland Department of Planning 1997 data. Watersheds on County borders (Brighton Dam) have large amounts of unclassified area as those drainage areas are classified by Montgomery County.

Little Patuxent River

The Little Patuxent River watershed (comprised of the Upper, Middle, and Lower Little Patuxent) is in the eastern half of Howard County (refer to Figure 2). Headwaters are in the north-eastern part of the county, originating primarily in agricultural areas. The river flows through the heavy commercial/transportation corridor of the Baltimore National Pike (Rte. 40). From there, it flows south/south-east through residential developments, adjacent to the Columbia Town Center mall, and through Columbia to join with the Middle Patuxent River near Savage. Land use/land cover in the watershed is dominated by urban, residential, and commercial areas. The watershed has experienced rapid increases in the numbers of schools, shopping centers, and housing communities primarily around Ellicott City and Columbia.

Brighton Dam

The Upper and Lower Brighton Dam watersheds are in the western portion of Howard County, bordering Montgomery County (refer to Figure 2). The major land uses are agriculture (both crops and pasture), residential, and forest. The forested areas are mainly concentrated around the Patuxent River State Park. Most of the newer (past 5-10 years) residential communities are converted farms. The Triadelphia reservoir is also located in the southern portion of this watershed. It is owned by the Washington Suburban Sanitary Commission (WSSC), and provides drinking water primarily to Montgomery and Prince George's County, as well as a small portion of Howard County. The reservoir is also used for limited recreational activities (fishing and canoeing).

Cattail Creek

The Cattail Creek watershed is very similar to the Brighton Dam watershed. It is also in the western part of the County, shares a border with Montgomery County (refer to Figure 2), and the major land uses are crop and pasture agriculture, as well as limited residential and forested areas. There is a mixture of older farm houses and communities, along with newer communities that seem to be on what was once farming land.

WATERSHED ASSESSMENTS

The mean and standard deviation for benthic macroinvertebrates and physical habitat were calculated for each watershed in MS Excel. The subwatersheds of the Little Patuxent (Upper, Middle, Lower) did not have RBP physical habitat sheets completed for all sites. In those cases, the watershed mean only includes the sites where RBP sheets were completed.

"Percent of maximum" values presented in the appendix were calculated by dividing the total habitat score by the total possible score represented on the habitat data sheets (method maximum), rather than a field-measured mean or median from a set of reference sites, which does not exist for the Maryland non-Coastal plain. RBP data sheets have a total possible score of 200, WRD Field Data Forms have a total possible 140.

In this report, a narrative explanation of the biological condition and physical habitat quality scores is given for each site. Important features recorded during sampling or found during subsampling are used to further illustrate potential reasons for site rating. Table 9 provides an overview of mean scores and narrative characterization for each subwatershed.

Table 9. Means of the biological and physical habitat scores of each subwatershed, with their corresponding narrative ratings. Confidence limits are represented by a single standard deviation.

	Narrative Rating	**Index Mean Score**
Cattail Creek		
Physical Habitat	"Non Supporting"	$\bar{X}$ = 108.00 ± 21.74 (n=10)
Biology (B-IBI)	"Fair"	$\bar{X}$ = 3.60 ± 0.63 (n=10)
Lower Brighton Dam		
Physical Habitat	"Non Supporting"	$\bar{X}$ = 111.64 ± 14.85 (n=10)
Biology (B-IBI)	"Fair"	$\bar{X}$ = 3.49 ± 0.69 (n=10)
Upper Brighton Dam		
Physical Habitat	"Partially Supporting"	$\bar{X}$ = 120.55 ± 5.96 (n=10)
Biology (B-IBI)	"Fair"	$\bar{X}$ = 3.82 ± 0.46 (n=10)
Lower Little Patuxent River		
Physical Habitat	"Non Supporting"	$\bar{X}$ = 105.25 ± 26.8 (n=4)
Biology (B-IBI)	"Poor"	$\bar{X}$ = 2.06 ± 0.54 (n=9)

Table 9 continued. Means of the biological and physical habitat scores of each subwatershed, with their corresponding narrative ratings.

Middle Little Patuxent River		
Physical Habitat	"Non Supporting"	$\bar{X}$ = 97.67 ± 24.86 (n=9)
Biology (B-IBI)	"Poor"	$\bar{X}$ = 2.14 ± 0.64 (n=10)
Upper Little Patuxent River		
Physical Habitat	"Non Supporting"	$\bar{X}$ = 110.00 ± 28.70 (n=10)
Biology (B-IBI)	"Poor"	$\bar{X}$ = 2.74 ± 0.59 (n=11)

There are a number of sites that have biological ratings substantially above what would be expected based on the physical habitat quality (e.g., Sites 002, 004, 029, 085, 087, 088, and 109). This phenomenon is generally observed where nutrient enrichment (eutrophication) artificially raises the biological score above the stream's natural potential. Another potential reason that streams in the Little Patuxent River watershed have higher biological ratings than what would be expected from their physical condition (e.g., Sites 050, 101, and 102) can be attributed to larger numbers of individual organisms included in the subsample. Howard County's method of subsampling allows for the sorting of 100 ± 20%. The MBSS subsampling method can result in a much larger range in total organism count. Taxa richness metrics (total number of taxa, number of Ephemeroptera taxa, number of EPT taxa) are most affected by the number of organisms subsampled (Barbour and Gerritsen 1996). If too many or too few organisms are subsampled, a site could receive a higher or lower metric score due to differences in method alone.

WATERSHED RESULTS

Cattail Creek

Data Overview

Two 3rd -order, one 2nd-order, and seven 1st-order streams were sampled in this subwatershed (Figure 4). Of the ten sites sampled, seven were rated as "non-supporting" for physical habitat quality, the other three sites received a "partially supporting" rating (Table 10). The mean rating for the subwatershed is "non-supporting" ($\bar{X}$ = 108 ± 21.74, n = 10). The mean biological condition for this subwatershed is "fair" ($\bar{X}$ = 3.60 ± 0.63). Three sites received "good" biological condition ratings, six rated as "fair" and one received a "poor" rating.

Table 10. Summary of biological and habitat scores in the Cattail Creek subwatershed.

Site	Benthic IBI Score	Biological Rating	Habitat Score	Habitat Rating	Stream Order
002	3.22	Fair	81	Non Supporting	1
003	4.11	Good	127	Partially Supporting	1
004	3.44	Fair	74	Non Supporting	3
006	3.66	Fair	110	Non Supporting	1
007	3.44	Fair	99	Non Supporting	3
009	4.33	Good	141	Partially Supporting	1
010	3.44	Fair	108	Non Supporting	2
012	2.33	Poor	131	Partially Supporting	1
013	3.44	Fair	84	Non Supporting	1
014	4.56	Good	117	Non Supporting	1

Site Specific Results

Site 002 - Located in a cow pasture off Woodbine Rd. (Rte. 94), this first-order stream received a "fair" (3.22) biological condition rating. The 3.22 score is the lowest in the subwatershed. Thirty-eight total taxa were found in the subsample, representing 114 total individuals subsampled. Only five percent were mayflies (Ephemeroptera), the lowest percentage in the subwatershed. Twenty-five percent of the sample was comprised of pollution tolerant organisms, mostly midges. However, 24% of the individual organisms in the sample were Tanytarsini, a midge that is relatively intolerant of pollution. This site received a "non-supporting" (81) physical habitat quality rating. The stream was surrounded by grass, all other riparian buffer having been removed. Cattle had full access to the stream. Pebble count data revealed that 72% of the channel bottom was covered with fine sediments (sands, silt/clay). Approximately 30% of the stream had stable epifaunal substrates for cover. There was a moderate amount of watershed erosion and obvious non-point sources (NPS) were observed. Other habitat parameters that scored in the marginal to poor categories included: velocity/depth regime, channel flow status, frequency of riffles, bank stability, and vegetative protection.

Site 003 - This site is located on a first-order stream, unnamed tributary (UT) of Cattail Creek, near St. Michael's Catholic Church. Biological condition was rated as "good" (4.11). In the subsample, there were 107 total individuals representing 43 different taxa. There were 24 Diptera and 17 EPT taxa. Physical habitat was rated as "partially supporting" (127). Although there was a field near the stream, there was a fairly wide (~ 20 m) riparian buffer of trees between the stream and the field on the right bank. However, vegetative protection and bank stability both scored in the marginal category, with only 50% of the streambank surfaces covered with bank stabilizing vegetation.

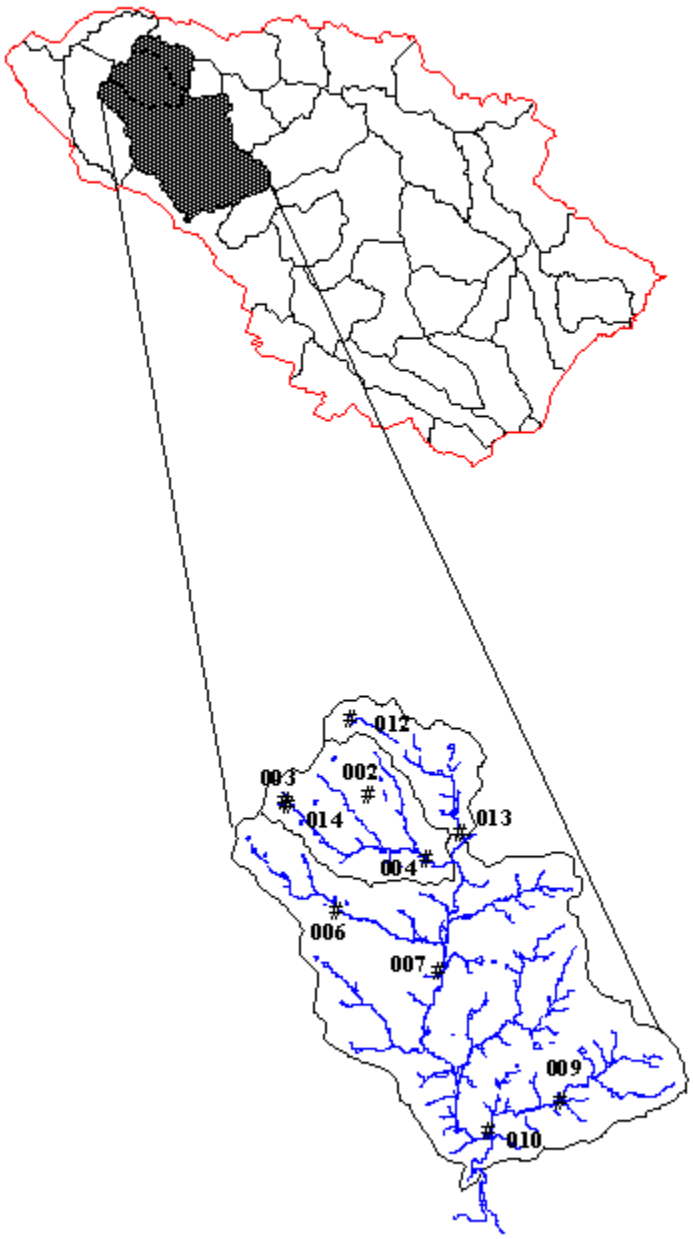

Figure 4. Cattail Creek subwatershed.

Site 004 - This third-order stream (UT of Cattail Creek) is also located in the middle of a cow pasture, off Daisy Rd. Since the stream is farther down in the watershed, than sites 002 or 003, it has more opportunity to assimilate poor water quality. In fact, it received the lowest rating for physical habitat quality in this subwatershed, "non-supporting" (74). Streams that run through a pasture often have little or no riparian buffer. Cattle graze on the vegetated banks, which negatively impacts bank stability, sediment deposition, and embeddedness. Only two of the four possible velocity/depth combinations were present, indicating a less stable aquatic environment. However, this site received a "fair" (3.44) biological condition rating. The 27 total taxa found represented the lowest total in this subwatershed. Twenty-two percent of the 104 total individuals subsampled were *Orthocladius/Cricotopus* (Diptera: Chironomidae), with a tolerance value (t.v.) equal to 7.0. Streams that run through cow pastures have a tendency to display a higher biological condition score, in response to nutrient enrichment, than their physical habitat score would suggest could necessarily support.

Site 006 - This first-order stream (UT of Cattail Creek) was rated as "poor" (3.67). The 112 total individuals subsampled represented 33 total. Approximately 28% of the organisms are categorized as tolerant to pollution. Physical habitat was rated as "non-supporting" (110). Surrounding land use consisted of forest and residential areas. The right bank had mowed lawn approximately 2 m from the stream. Seventy-seven percent of the bottom substrates were embedded with fines, leading to marginal scores not only in the embeddedness category, but the sediment deposition category as well. Substantial disruption of bank vegetation was also observed.

Site 007 - The downstream end of this third-order stream (Cattail Creek) was under the bridge on Union Chapel Rd. Channelization of the stream for the bridge contributed to the "non-supporting" (99) rating this site received. Rip rap was present along both banks and the bottom of the channel approximately 20 m into the sampling segment. Surrounding land use was residential, pasture, and forest. The riparian buffer was narrow on both banks (5 - 10 m). An old depositional bar was observed, with trees and grass growing. Some new sediment was also being deposited along the sides of the stream from bare, unstable banks. Biological condition was rated as "fair" (3.44). Thirty-one percent of the 108 total individuals subsampled were mayflies (Ephemeroptera). Only 16% of the organisms were pollution tolerant, such as *Prosimulium* (Diptera: Simuliidae; t.v. = 7.0).

Site 009 - Dorsey Branch is a first-order stream. Biological condition was rated as "good" (4.33). Forty-four total taxa were subsampled. Twenty-six percent of the 107 total individuals subsampled were Ephemeroptera (mayflies). There were also 23 different Diptera taxa found, and eight percent of the total sample were Tanytarsini, a relatively intolerant midge. Physical habitat was rated as "partially supporting" (141). This is the highest raw score of the ten sites sampled in the Cattail Creek subwatershed. The riparian buffer was relatively wide on both

banks, although a slight buffer break was noted in the form of a dirt road about 15 m from the stream. Approximately 70% of the banks were covered by oak trees and grasses.

Site 010 - East Branch is a second-order stream that was rated as "fair" (3.44) for biological condition. The highest number of total taxa in this subwatershed, 46, was found here. However, only 11% of the 109 total individuals in the subsample were mayflies, only 8 of the 46 taxa had tolerance values < 7.0, such as Ephemerellidae (Ephemeroptera). Physical habitat was rated as "non-supporting" (108). Surrounding land use was forest, field/pasture, and residential. Heavy watershed erosion was observed. Pebble count data indicated that 93% of the bottom substrates were embedded with fines. This, as well as the marginal score for sediment deposition, could be due, in part, to the substantial erosional scarring observed on the right bank.

Site 012 - This site is located on a first-order stream (UT of Cattail Creek). It received a "poor" biological rating (2.33). The 114 total organisms subsampled represented 20 total taxa. Only 1% of the total taxa were Ephemeroptera: Heptageniidae. Physical habitat quality was rated as "partially supporting" (131). There is a tributary that enters the stream in the middle of the segment. Surrounding land use is forest and residential, with moderate local watershed erosion observed. All habitat parameters scored in the suboptimal range, except for channel alteration, which received a low optimal score.

Site 013 - This first-order stream (UT of Cattail Creek) received a "fair" (3.44) biological condition rating. There were 114 organisms subsampled. Thirty-three different taxa were represented, however, only eight were EPT, the lowest found in this subwatershed. Also, the highest tolerant percentage (25%) was found at this site. Physical habitat quality was rated as "non- supporting" (84). This site bordered a residential lawn that was also used as a horse pasture on the right bank. The riparian buffer on the left bank was narrow (5 m) between the stream and Carr's Mill Rd. Conductivity at this site was measured as 362 µmho/cm, suggesting higher suspended sediment levels that are generally associated with poor water quality (Paul & Meyer 2001, Herlihy et al. 1998, Wang & Yin 1997, Lenat & Crawford 1994). Sixty-four percent of the stream bottom was affected by deposition of fine sediments with substantial deposition in pools and at stream bends.

Site 014 - This site is located on a first-order stream (UT of Cattail Creek), downstream of site 003. Biological condition was rated as "good" (4.56). There were 18 EPT taxa found, the highest number in this subwatershed. The percentage of Ephemeroptera in the subsample (31%), was the highest in the subwatershed. Moreover, only 5% of the 110 total individuals subsampled had tolerance values greater than 7.0, which is the lowest amount found in this subwatershed. Physical habitat quality was rated as "non-supporting" (117). Surrounding land use is cropland, residential, and forest. Abundant amounts of solid trash were observed. Other habitat parameters that were rated in the marginal and poor categories are: velocity/depth regime, bank stability, and vegetative protection. A high score for biological condition combined with a low

physical habitat score suggests possible nutrient enrichment occurring at this site, artificially enhancing the biological community.

Lower Brighton Dam

Data Overview

Of the ten sites sampled in the Lower Brighton Dam subwatershed, two were on 3rd-order streams, one was on a 2nd-order stream, and the remaining seven sites were located on 1st-order streams (Figure 5).

The overall physical habitat rating for this subwatershed was "non-supporting" ($\bar{X}$ = 111.64 ± 14.85, n = 10). Seven of the ten sites were rated as "non-supporting." The other three received "partially supporting" physical habitat ratings (Table 11). Overall biological condition was rated as "fair" ($\bar{X}$ = 3.49 ± 0.69). Two sites were rated as "good", five sites rated as "fair" and the remaining three sites received "poor" ratings. Many of the primary and secondary sites were randomly placed in the Triadelphia reservoir, which made them impossible to sample. In order to address this issue, Howard County reallocated the stream orders to be sampled to maintain the correct proportion of sampling sites on 1st, 2nd, and 3rd order streams. Sites 72948 and 77679 are the random numbers that resulted from the reallocation process. In the interest of time, they were not included in the original numbering scheme.

Table 11. Summary of biological and habitat scores in the Lower Brighton Dam subwatershed.

Site	Benthic IBI Score	Biological Rating	Habitat Score	Habitat Rating	Stream Order
022	3.89	Fair	120	Partially Supporting	3
023	3.89	Fair	105	Non Supporting	1
024	3.89	Fair	118	Non Supporting	1
025	3.67	Fair	95	Non Supporting	1
028	2.56	Poor	97	Non Supporting	1
029	4.11	Good	116	Non Supporting	1
030	3.44	Fair	118	Non Supporting	2
032	2.78	Poor	125	Partially Supporting	3
72948	2.33	Poor	82	Non Supporting	1
77679	4.33	Good	122	Partially Supporting	1

Site Specific Results

Site 022 - This site is located on the mainstem of the Patuxent River, within the Patuxent River State Park. The Patuxent is a third-order stream at this point. The river is stocked with trout periodically, and was stocked the morning of sampling. Biological condition was rated as "fair"

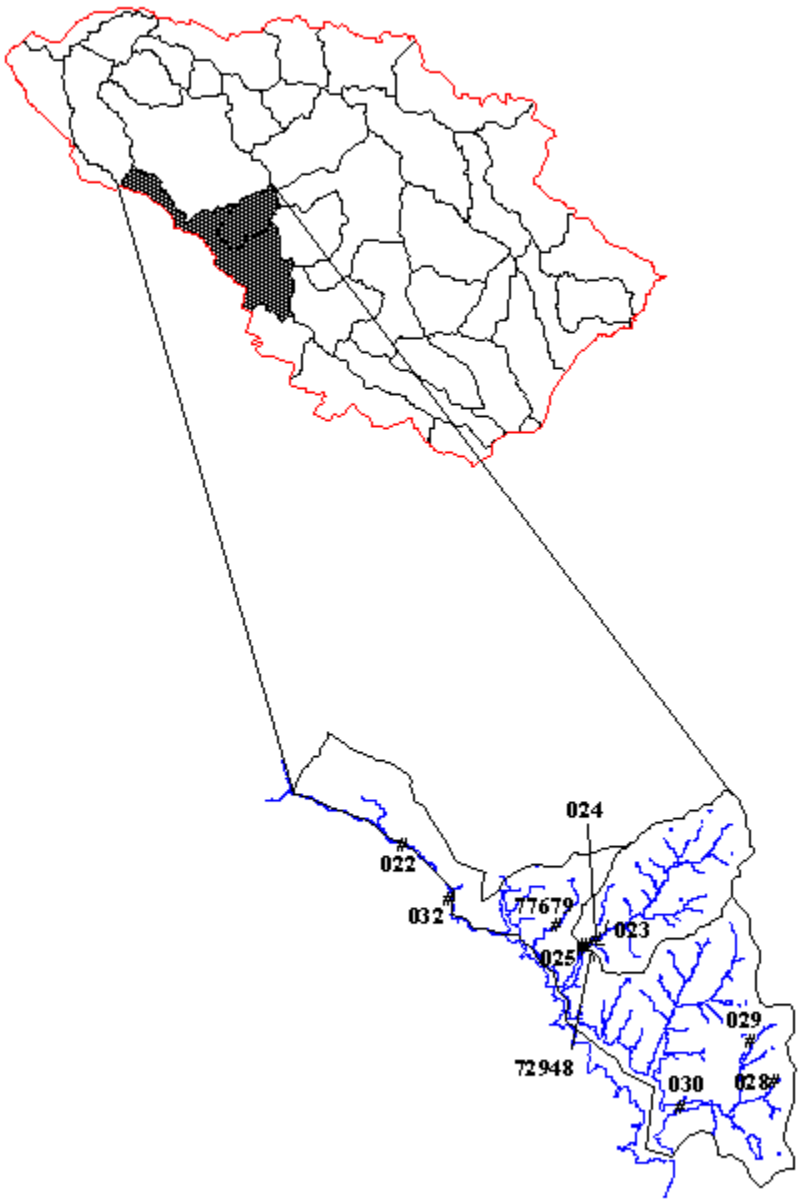

Figure 5. Lower Brighton Dam subwatershed.

(3.89). There were 109 individuals subsampled, representing 29 different taxa. Mayflies (Ephemeropera) comprised 22% of the subsample. Physical habitat at this site was rated as "partially supporting" (120). The surrounding land use was forest. The area is also designated as a trout fishing "catch and release" zone, and there was a trail for easier access that paralleled the stream until 50-100 m before the sampling segment began. Pebble count data revealed that over 60% of the bottom of the segment was covered with fine sediments (sands, silt/clay), which lowers the amount of stable, available habitat for organisms to colonize. There was also a moderate amount of deposition along the banks and in pools. Both banks were moderately unstable, and there was obvious disruption of bank vegetative protection, which could lead to more sediment washing into the stream.

Site 023 - This site, on a first-order stream, is an unnamed tributary of the Patuxent River and empties into the Triadelphia reservoir. This stream received a "fair" (3.89) biological condition rating. Of the 39 total taxa, 15 were EPT. There were 23 Diptera taxa, 15% of the sample consisted of Tanytarsini. In the Lower Brighton Dam watershed this site had the highest Diptera and EPT scores. However, this site received a "non-supporting" (105) physical habitat rating. The predominant surrounding land uses were forest and residential. Moderate local watershed erosion was observed. Both banks showed over 50% unstable areas. There was a human-made trail along the left bank between the stream and some houses, which reduced the riparian zone. The allocation of sampling effort also reflects a lack of productive habitat, with 30% of the effort in sandy bottom substrates, generally the least productive area in a stream.

Site 024 - This site is downstream of site 023 and is still a first order stream. It received a "fair" (3.89) biological condition rating. The subsample contained 107 individuals and 33 taxa. There were 13 EPT taxa; 21% of the total sample were mayflies (Ephemeroptera). However, 15% of the sample contained pollution tolerant organisms, such as *Prosimulium*. This site received a "non-supporting" (118) physical habitat rating. Land use was forest with some residential. Pebble count data showed over 60% of this segment had fine sediments on the stream bed. Also, numerous sand bars were observed along the banks. Bank stability and vegetative protection scored in the marginal category, which could account for the additional sediment in the channel.

Site 77679 - Downstream of site 024, this site is still on a first order section of stream. It was chosen as an alternate to a site that was randomly placed inside the Triadelphia reservoir. Biological condition was rated as "good" (4.33). There were 102 total individuals, representing 30 total taxa. Fifty-three percent of the subsample consisted of mayflies (Ephemeroptera), exhibiting the highest percentage in this subwatershed. Of the four sites sampled on this section of the Patuxent River, this site had the lowest percentage of organisms tolerant to pollution (6%). Physical habitat at this site was rated as "partially supporting" (122). Compared to the maximum (200), this score (122) ranks the site at 61%. The limit for "non-supporting" is 60%. The majority of the surrounding land use was forest with some residential. There was a moderate amount of sediment deposition, with just over half the bottom of the segment having fine substrates.

Site 025 - This site is downstream of site 77679. It received a "fair" (3.67) biological condition score. Thirty total taxa were found at this site. Forty-five percent of the 107 total individuals subsampled were Ephemeroptera (mayflies). However, 20% of the total sample consisted of taxa with tolerance values > 7.0. Only 4% of the sample were Tanytarsini, and only five EPT taxa were found, accounting for the "fair" biological score. This site also received a "non-supporting" (95) physical habitat rating. Surrounding land use was forest, with no evidence of NPS pollution. However, there was moderate watershed erosion, and conductivity at this site measured 173.2 µmho, which is higher than what might be expected in a relatively undeveloped area. There was only one riffle that could be sampled at the upstream portion of the reach. Due to high water and lack of other productive habitat to sample, 30% of the sampling effort was allocated to sandy bottom. Pebble count data indicated that over 80% of this segment was embedded with fine substrate particles. This substantially reduces the area available for organisms to colonize. Bank stability was marginal, with obvious erosion and disruption of vegetated areas. This site is very close to where the stream empties into the reservoir, and could be influenced by backflow from the reservoir.

Site 028 - This site is on a first-order, unnamed tributary of the Patuxent River. There was construction of new homes on Highland Rd., about 200 m uphill from the stream. The adjacent land cover was characterized as an old field, and the riparian buffer was only about 5 m wide. This site was rated as "poor" (2.56) for biological condition. Of the 29 total taxa found, only one was EPT, *Diplectrona* (Trichoptera: Hydropsychidae). Twenty-one percent of the 108 total individuals were pollution tolerant. This site was rated as "non-supporting" (97) for physical habitat quality. Pebble count data revealed that over 80% of the streambed was composed of fine substrates. This stream also had very few riffles and bends, reducing the availability of stable habitat required by benthic organisms in order to live in a stream.

Site 029 - This first-order stream (UT of Patuxent) received a "good" (4.11) biological condition rating. Forty-one total taxa were found, the highest diversity in this subwatershed. There were 22 different Dipteran taxa. Twenty-one percent of the 103 total individuals subsampled were EPT. However, 22% of the sample was comprised of pollution tolerant organisms. This site's "non-supporting" (116) physical habitat score is just below the 60% cutoff to the "partially supporting" category. The "good" (4.11) score, is just above the "fair" cutoff for biological condition. Habitat scores and surrounding land use suggest that the site might be more adequately represented through the "fair" biological and "partially-supporting" physical habitat rating. The right bank of the stream runs alongside a cow pasture, which allows the animals to access the stream practically at any point, evidenced by hoof prints along the bank. Pebble counts showed that roughly 60% of the stream bottom was covered by fine sediments, which adversely affects the ability of organisms to colonize the stream. The channel flow status and vegetative protection parameter also scored in the marginal category.

Site 030 - The original replacement of this site was inside the reservoir. A randomly selected secondary site (that was the same order as the primary site) was chosen as the replacement site.

It is a second order stream (UT of Patuxent) and received a "fair" (3.44) biological condition rating. Of the 111 total individuals subsampled, 20% were EPT. However, another 20% of the sample were individuals with tolerance values > 7.0, such as *Orthocladius/Cricotopus* (t.v. = 7.0; Diptera: Chironomidae) and *Limnodrilus* (t.v. = 10.0; Tubificida: Tubificidae). The site received a "non-supporting" (118) physical habitat rating. Surrounding land use was forest. There was moderate deposition of sand along the banks, restricting full channel flow. Disruption of bank vegetation was obvious over approximately 50-60% of the segment, lessening bank stability.

Site 032 - This site is located on the mainstem Patuxent River (third order), within the boundaries of the Patuxent River State Park. It is downstream of site 022, also in the park. Biological condition was rated as "poor" (2.78). Twenty-two taxa were subsampled, half of which were EPT (11). Four of the EPT taxa were Ephemeroptera (mayflies). Twenty-one percent of the 103 total individuals were pollution tolerant organisms. Since this site is the farthest downstream in this subwatershed, the effects of farming and development are compounded, resulting in "poor" biological conditions and "non-supporting" (118) physical habitat. The riparian buffer on the right bank was wide, but the left bank had a trail leading to the site, and a pasture on the hillside. Epifaunal substrate/available cover and frequency of riffles (or bends) scored in the marginal category.

Site 72948 - This site was chosen as an alternate to a randomly selected site in the reservoir drainage. It is on a first-order unnamed tributary of the Patuxent River. The stream runs in the middle of cattle pasture. It received a "poor" (2.33) biological condition rating. Of the 109 total individuals subsampled, 60% were pollution tolerant. This site displayed the highest percentage of tolerant organisms in this subwatershed, and was the only site not having any mayflies in the sample. Physical habitat quality was rated as "non-supporting" (82). Substantial bank failure and loss of bank vegetation was noted, due to cattle having constant access to the stream. Bottom substrates were embedded with large amounts of sediment deposition.

Upper Brighton Dam

Data Overview

Of the ten sites sampled in this subwatershed (Figure 6), there was one third-order stream, two second-order, and seven first-order streams.

Overall physical habitat quality rated as "partially supporting" ($\bar{X}$ = 120.55 ± 5.96, n = 10). Six individual sites were rated "partially supporting." The remaining four rated as "non-supporting" (Table 12). Mean biological condition was rated as "fair" ($\bar{X}$ = 3.82 ± 0.46). Three of the ten sites received "good" ratings, six rated as "fair" and one received a "poor" rating.

Table 12. Summary of biological and habitat scores in the Upper Brighton Dam subwatershed.

Site	Benthic IBI Score	Biological Rating	Habitat Score	Habitat Rating	Stream Order
081	3.44	Fair	122	Partially Supporting	1
082	4.11	Good	122	Partially Supporting	1
084	2.77	Poor	126	Partially Supporting	3
085	3.89	Fair	112	Non Supporting	1
086	3.89	Fair	127	Partially Supporting	1
087	4.33	Good	114	Non Supporting	1
088	4.33	Good	117	Non Supporting	1
089	3.67	Fair	119	Non Supporting	2
090	3.89	Fair	125	Partially Supporting	2
091	3.89	Fair	129	Partially Supporting	1

Site Specific Results

Site 081 - This site is on a first-order unnamed tributary of the Patuxent River, and received a "fair" (3.44) biological condition rating. Of the 104 individuals subsampled, 28 total taxa were represented, eight of which were EPT. However, 49% of the total individuals were pollution tolerant organisms. Physical habitat was rated as "partially supporting" (122). Surrounding land use/land cover was primarily deciduous forest and horse pasture. There was a barbed wire fence with wooden stakes built over one section of the stream. This seemed to only minimally impact the reach. Some depositional bars were noted along the moderately unstable banks. The instability of the banks led to obvious disruption in bank vegetation.

Site 082 - Biological condition rated as "good" (4.11) at this site on the mainstem of the Patuxent River. Of the 36 total taxa, 17 were EPT. Five of those 17 EPT were mayflies (Ephemeroptera), which are generally very sensitive to stressors. Physical habitat rated as "partially supporting" (122). Surrounding land use/land cover was deciduous forest, with little or no human refuse visible. However, moderate local watershed erosion was observed. Approximately 30% of the stream bottom was affected by recent sediment deposition, especially along the banks and at bends. Pebble count data revealed over 40% of the stream contained fine sediments, such as silt/clay and various sizes of sands. Bank stability and vegetative protection were both marginal. Sediment deposition along the banks could be due to bank instability and higher erosion potential in areas where vegetation is sparse.

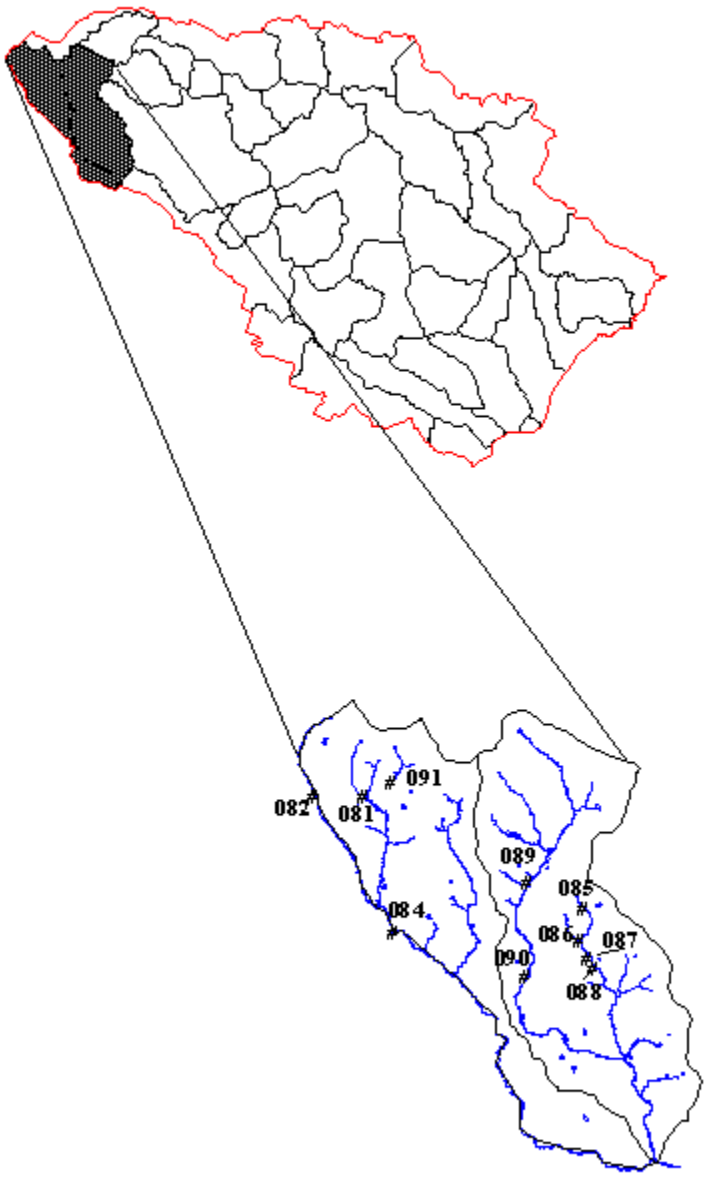

Figure 6. Upper Brighton Dam subwatershed.

Site 084 - This site is located on a third-order portion of the Patuxent River mainstem that forms the border between Howard and Montgomery counties. Biological condition was rated as "poor" (2.77). Sixty-four percent of the 117 total individuals subsampled were pollution tolerant organisms (Diptera: Simuliidae: *Prosimulium*, t.v. = 7.0). Only 4% were mayflies (Ephemeroptera). This site rated as "partially supporting" (126) for physical habitat quality. Surrounding land use was predominantly deciduous forest. Both banks at this site were moderately stable, however a substantial amount of sediment deposition created a fairly large island in the middle of the channel, as well as bars at the bends in the segment, both of which restricted the flow of the channel. The trail along the right bank allowed for easy human access to the stream, and could possibly account for the minor amount of refuse observed at the site.

Site 085 - This site is located on a first-order stream (UT of Cabin Branch). Biological condition received a "fair" (3.89) rating. Twenty-six of the 37 total taxa subsampled were dipterans. Organisms in this order are relatively tolerant to pollution. Approximately 23% of the 110 total individuals belong to the tribe Tanytarsini, a comparatively pollution sensitive midge. Both of these percentages were the highest found in this subwatershed. Physical habitat received a "non-supporting" (112) rating. The segment was downhill of a few houses in a wooded pasture area most likely used for cattle grazing. Inside the electric fence, which crossed the stream just above and below both the upstream and downstream flags, cattle have access to the stream. Moderate local watershed erosion and obvious non-point source (NPS) pollution sources (cattle) were observed. This segment did not display fast- or slow-deep regimes, lowering the overall habitat diversity. The banks were moderately unstable, due to both cattle walking up and down the banks to get into the stream, as well as low vegetative protection along the banks, which is also affected by cattle grazing and walking.

Site 086 - This site is located downstream of site 085, also on UT of Cabin Branch. It received a "fair" (3.89) biological condition rating. There were 102 total organisms subsampled, representing 33 different taxa. Twenty-three percent of the total individuals were mayflies (Ephemeroptera). However, 24% of the subsample was comprised of pollution tolerant organisms, such as *Prosimulium* (Diptera: Simuliidae). Physical habitat was rated as"partially supporting" (127). While there was moderate local watershed erosion, there were no obvious NPS inputs. The surrounding land use was deciduous forest. Pebble count data showed approximately a 50-50 split between cobble and fines making up bottom substrate. Bank stability and vegetative protection were both marginal, with some depositional bars observed along the banks.

Site 087 - This site is also on UT of Cabin Branch, on the downstream side of Woodbine Rd. (Rte. 94). The stream runs through New Horizon Farm, which serves as pasture-land for horses. Biological habitat rated as "good" (4.33). Fifty-one total taxa were represented in 119 total individuals. This is the highest total taxa amount in this subwatershed, and displays a high diversity of organisms. However, this site also received a "non-supporting" (114) physical habitat rating. The location of this site on a horse pasture, suggests that eutrophication could be

raising the biological scores above its natural potential in a physically degraded stream. The bank stability and vegetative protection are marginal, along with a narrow riparian buffer. One section of the stream has been leveled on both banks to allow for tractor and/or horse crossing. Obvious NPS sources exist at this site.

Site 088 - This site is about 50 m downstream of site 087. It received a "good" (4.33) biological rating. Of the 36 total taxa, 14 were EPT. Twenty-four percent of the 109 total individuals were mayflies (Ephemeroptera). The site received a "non-supporting" (117) physical habitat rating. The pastures on the New Horizon Farm property upstream, still seem to impact this segment. Bank stability and vegetative protection were both marginal, with about 30% of the banks displaying eroded areas. Poor bank stability upstream, as well as at this segment of the stream, is affecting the amount of sediment deposited on the bottom. Due to this deposition, water is being restricted from completely filling the channel.

Site 089 - This site is located on Cabin Branch. At this point, the stream is classified as second-order. It received a "fair" (3.67) biological rating. Of the 34 total taxa subsampled, only seven taxa represented pollution intolerant organisms. Thirty-one percent of the 117 total individuals subsampled were organisms with tolerance values greater than 7.0. This site received a "non-supporting" (119) physical habitat rating. The surrounding land use was forest and field/pasture. Moderate local watershed erosion was observed, as well as some potential sources of NPS pollution from the farmland as well as from Florence Rd., which parallels the stream at this point. While the riparian buffer received scores in the suboptimal category, the majority of the vegetation were young and regenerating trees and shrubs. There was a moderate amount of sediment deposited along the banks, preventing water from completely filling the channel. Bank stability and vegetative protection also received marginal scores on the right bank, which was closer to the farmland.

Site 090 - This site is located downstream of site 089 on Cabin Branch. Biological condition rated as "fair" (3.89). Of the 106 total individuals subsampled, 38 different taxa were represented. There were 16 EPT taxa. Nineteen percent of the sample was composed of mayflies (Ephemeroptera). Physical habitat was rated as "partially-supporting" (125). The stream runs behind a new housing development, as well as through wooded and pasture areas. The right bank has a partially forested pasture on it, which creates a minor break in the already narrow riparian buffer. The canopy cover is partly open due to the pasture. An abundance of multiflora rose was also observed at this site.

Site 091 - This site is on a first-order stream (UT of Patuxent). It received a "fair" (3.89) biological rating. Forty-three percent of the 101 individuals subsampled were pollution tolerant. The site received a "partially-supporting" (129) physical habitat rating. The stream has a wide riparian zone, with no evidence of NPS pollution or breaks in the riparian zone. There was a moderate amount of local watershed erosion. Pebble count data revealed that only about 35% of

the stream bottom was covered with fine substrates. A few small depositional bars were noted along the banks. Refuse was observed in moderate amounts.

Lower Little Patuxent River

Data Overview

Nine sites were sampled in the Lower Little Patuxent River subwatershed (Figure 7). Five were 1st-order streams, three were 3rd-order, and one was a 4th-order stream.

Four of the nine sites rated "very poor" for biological condition, four rated "poor" and one scored "fair" (Table 13). The overall narrative B-IBI rating for this subwatershed is "poor" ($\bar{X}$ = 2.06 ± 0.54, n = 9).

Overall physical habitat quality in this subwatershed rated as "non-supporting" ($\bar{X}$ = 105.25 ± 26.8, n = 4). Five of the nine sites sampled were rated as "partially supporting," the other four were "non-supporting".

Fish were sampled in this subwatershed by a WRD crew. However, the biological scores reflect only the B-IBI, no fish metrics were included. Blacknose dace (*Rhinicythys atratulus*) and tessellated darters (*Etheostoma olmstedi*) were the most commonly found species of fish. Both are known to be extremely tolerant of pollution (Roth et al. 2000). Fish were found at all of the sites sampled for fish, with site 050 having the highest number of different species (24) and site 044 having the lowest (1).

Table 13. Summary of biological and habitat scores in the Lower Little Patuxent River subwatershed. Total number of fish sampled also shown.

Site	BenthicIBI Score	Biological Rating	Habitat Score	Habitat Rating	No. Fish Species	No. Individual Fish Collected	Stream Order
041*	1.89	Very Poor	69	Non Supporting	18	304	3
042*	2.78	Poor	84	Partially Supporting	NA	NA	3
043	1.67	Very Poor	125	Partially Supporting	6	200	1
044	1.44	Very Poor	74	Non Supporting	1	29	1
045	2.11	Poor	92	Non Supporting	3	295	1
046*	2.11	Poor	83	Non Supporting	20	445	3
047	2.11	Poor	130	Partially Supporting	3	181	1
049*	1.44	Very Poor	86	Partially Supporting	10	221	1
050*	3.00	Fair	92	Partially Supporting	24	1433	4

*WRD Habitat sheet completed, maximum score = 140.

NA = Fish not sampled at this site.

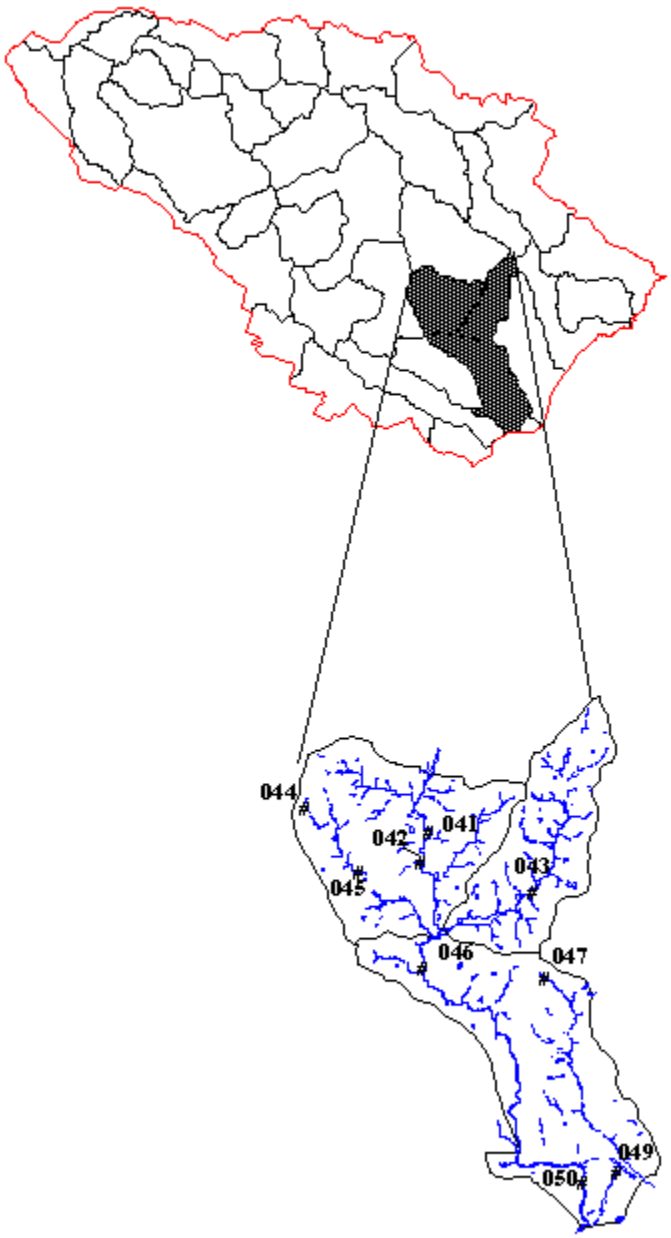

Figure 7. Lower Little Patuxent River subwatershed.

Site Specific Results

Site 041 - This site is located at a point where the mainstem of the Little Patuxent River is designated as a third-order stream. Biological condition was rated as "very poor" (1.89). Forty-six percent of the 104 total individuals were known to be pollution tolerant. Thirteen total taxa were found. Physical habitat rated as "non-supporting" (69). Predominant surrounding land use was deciduous forest, with some residential areas. There was concrete or gabion over a majority of the channel bottom. A moderate amount of refuse was also present. Eighty percent of the surface substrates were surrounded by fines, which reduces optimal habitat for organisms to colonize. Eighteen different species of fish were found at this site. Tessellated darter (*Etheostoma olmstedi*) and fallfish (*Semotilus corporalis*) were the most common, comprising 40% and 13% of the sample, respectively. Fallfish are considered to be relatively intolerant to human stressors.

Site 042 - This site is also on a third-order segment of the mainstem of the Little Patuxent River. The site received a "poor" (2.78) rating for biological condition. Nineteen total taxa were represented in the 116 total individuals subsampled. Six were EPT taxa. Physical habitat at this site was rated as "partially supporting" (84). This site had a wide riparian buffer, with the surrounding land use/land cover consisting mostly of woodland, and some commercial areas. However, a moderate amount of erosion was noticed along the banks, contributing to the 50-60% embeddedness of surface substrates.

Site 043 - This site (UT of Little Patuxent) was rated as "very poor" (1.67) for biological condition. Twenty-three percent of the 111 total individuals were pollution tolerant. Fifteen total taxa were identified. Physical habitat rated as "partially supporting" (125). While the riparian buffer was wide (50 m), there were storm drains emptying into the stream at the site. The surrounding land use was decidous forest, and commercial/industrial areas. Refuse was abundant. Only six different fish species were found at this site. Blacknose dace (*Rhinichythys atratulus*) was the most common, comprising in 59% of the sample.

Site 044 - This first-order stream (UT of Little Patuxent) rated "very poor" (1.44) for biological condition. Only eleven total taxa were represented in the subsample (97). Fourteen percent of the total individuals are considered tolerant to pollution. There was minor channelization present at this site, evidenced by rip rap along both banks and along the stream bottom. The surrounding land use was predominantly residential, with some wooded areas. Black coloring was noticed on embedded stones, suggesting anaerobic conditions. Dissolved oxygen at the site was measured at 9.7 ppm. The very narrow riparian buffer (2 - 10 m) consisted mainly of regenerating shrubs and young trees. A substantial amount of refuse was also observed. The site received a "non-supporting" (74) physical habitat quality rating due, in large part, to the factors described above. Only 29 total fish were found at this stream. They were all blacknose dace (*Rhinichythys atratulus*).

Site 045 - This site (UT of Little Patuxent) had a biological condition rating of "poor" (2.11). Eighteen total taxa were found. While 52% of the 102 total individuals were pollution tolerant, almost 9% of the sample consisted of the tribe Tanytarsini (Diptera: Chironomidae), midges that are relatively sensitive to stress. Physical habitat rated as "non-supporting" (92). Ninety percent of the bottom substrate was considered embedded, reducing the colonization potential. Refuse was also moderately abundant. The surrounding land use/land cover was deciduous forest and residential areas. The site was rated as "non-supporting" for physical habitat quality. Three different species of fish were sampled at this site 99% of which were blacknose dace (*Rhinichythys atratulus*).

Site 046 - The biological condition at this third-order stream (mainstem Little Patuxent) also rated as "poor" (2.11). The subsample consisted of 116 individuals representing 18 taxa. Thirty-three percent of the organisms were pollution tolerant. There were only three EPT taxa found, none of which were Ephemeroptera. One of the three EPT taxa was a *Hydropsyche* (Trichoptera: Hydropsychidae) a net spinning caddisfly, more pollution tolerant than many other genera of caddisflies. The surrounding land use/land cover at this site was deciduous forest and commercial/industrial areas. While there was no obvious buffer breaks or stream channelization, there was a moderate amount of refuse and substantial bank failure. These factors likely led to the 65% estimate of embeddedness of surface substrates. This site received a "non-supporting" (83) physical habitat rating. This site had one of the higher diversity of fish species in the subwatershed with 20 different types of fish found. Tessellated darter (*Etheostoma olmstedi*) was the most prevalent single species (26%). However, fallfish (*Semotilus corporalis*) and swallowtail shiner (*Notropis procne*), species that are relatively intolerant to pollution, made up 23% and 16% of the sample, respectively.

Site 047 - This site is a first-order stream (UT of Little Patuxent). Out of 97 individuals subsampled, 21 total taxa were found. Biological condition at this site received a "poor" (2.11) rating. Thirty-four percent of the individuals had tolerance ratings $\geq$ 7.0. Physical habitat at this site rated as "partially-supporting" (130). The immediate area surrounding the stream was deciduous forest. There was refuse present in minor amounts, and about 50% of the surface substrate was surrounded by fines (sands, silt/clay). The stream was moderately turbid, which could have been influenced by the preceding weather conditions (rain). This could also be influencing the "poor" biological rating by flushing organisms out of the stream during high-flow events . Blacknose dace was the most commonly found fish at this site, comprising 98% of the fish sample.

049 - This first-order stream (UT of Little Patuxent) received a "very poor" (1.44) biological rating. There were only 13 total taxa found. Sixteen percent of the 99 total individuals were pollution tolerant organisms. The majority of the surrounding land use was commercial/ industrial, with some deciduous forest. There was a minor amount of rip rap on the left bank of the stream. A substantial amount of refuse was observed at the site. Physical habitat was rated as "partially supporting" (86). Ten different fish species were found at this site. Tessellated

darter (*Etheostoma olmstedi*), green sunfish (*Lepomis cyanellus*), and white sucker (*Catostomus commersoni*) all considered to be pollution tolerant (Roth et al. 2000), combined made up 81% of the sample.

050 - This was the only fourth-order stream sampled in the Little Patuxent River watershed. It is located on the mainstem of the Little Patuxent River near Rte. 1. It received a "fair" (3.00) biological rating. Twenty-six total taxa were found, eight of which were EPT taxa. Nine percent of the total sample was composed of Tanytarsini, a midge with a relatively low tolerance to pollution. This site is a reflection of what could occur without a designated ceiling number for laboratory subsampling. The lowest number of taxa that could still receive the highest metric score (5) is 22 taxa. Six of the taxa identified were represented by only one organism. Subsampling to 133 organisms is 13 over the 100 ± 20% County method. Excluding these 13 individuals would lower the EPT metric score from a 5 to a 3, which would therefore lower the overall biological rating from a "fair" to a "poor" rating. Physical habitat quality rated as "partially supporting" (92). Surrounding land use/land cover consisted mostly of deciduous forest, with some commercial/industrial area. A minor amount of refuse was present at the site. There was no buffer breaks or stream channelization observed. Approximately 75% of the surface substrate was embedded by fines, reducing the optimal habitats available for colonization. This site had the highest diversity of fish species, with 24 different types represented. Fallfish, a species that is relatively intolerant of pollution, were the most abundant species (245, 17% of the total 1433 fish). Sixteen percent of the sampled was made up of tessellated darters (*Etheostoma olmstedi*), 15% were glassy darters (*Etheostoma vitreum*).

Middle Little Patuxent River

Data Overview

Ten sites were sampled in the Middle Little Patuxent River subwatershed (Figure 8). Eight of the sites sampled were 1st-order streams, one was a 2nd-order stream, and one a 3rd-order stream.

Six of the sites were rated as "very poor" for biological condition (Table 14), three rated as "poor," and one as "fair." The mean B-IBI rating for this watershed is "poor" ($\bar{X}$ = 2.14 ± 0.64, n = 10). Physical habitat assessment results indicate that eight of the streams rated as "non-supporting," and two received "partially-supporting" ratings. The mean physical habitat quality rated as "non-supporting" ($\bar{X}$ = 97.67 ± 24.86, n = 9). Due to logistical limitations, RBP Habitat Assessments were only completed at nine of the ten sites in this subwatershed. Only those sites were used to calculate the subwatershed mean physical habitat score.

Fish were also sampled by WRD in this subwatershed. Blacknose dace (*Rhinichythys atratulus*), commonly found in even the most heavily degraded streams in the Mid-Atlantic, were found at all of the sites where fish were sampled. No fish were found at site 064.

Table 14. Summary of biological and habitat scores in the Middle Little Patuxent River subwatershed. Total number of fish sampled also shown.

Site	Benthic IBI Score	Biological Rating	Habitat Score	Habitat Rating	No. Fish Species	No. Individual Fish Collected	Stream Order
061*	2.78	Poor	58	Non Supporting	18	345	3
062	3.22	Fair	126	Partially Supporting	8	711	2
063	2.78	Poor	138	Partially Supporting	2	269	1
064	1.44	Very Poor	74	Non Supporting	0	0	1
065	NA**	Very Poor	99	Non Supporting	12	249	1
066	1.89	Very Poor	92	Non Supporting	1	174	1
067	2.11	Poor	87	Non Supporting	5	469	1
068	1.89	Very Poor	110	Non Supporting	5	1214	1
069	1.67	Very Poor	57	Non Supporting	4	38	1
075	1.44	Very Poor	96	Non Supporting	15	343	1

*WRD Habitat sheet completed, maximum score = 140.
**NA - 55 organisms found, no metric score calculated.

Site Specific Results

Site 061 - This is the only station in this subwatershed located on the mainstem of the Little Patuxent River and is on the only third-order stream sampled in the middle subwatershed. Biological conditions at this site rated as "poor" (2.78). There were 21 total taxa found. Eighteen percent of the 140 individuals subsampled were pollution tolerant organisms (t.v. > 7.0). There were only five EPT taxa found at this site. Subsampling over the County's convention of 100 ± 20% to 140 organisms did not seem to affect the overall biological condition, as the site received a "poor" rating. The substrate that makes up the riffle areas in the stream was severely embedded by finer substrates (sands, silt/clay). As noted before, embedded substrates tend to be inhabited by more pollution tolerant organisms, such as worms (Oligochaeta) and midges (Chironomidae). The surrounding area is mainly deciduous forest, with some residential homes. There was refuse present in moderate amounts. The highest fish diversity in the subwatershed occurred at this site, with 18 different species found. Of 345 total individuals, 24% were tessellated darters (*Etheostoma olmstedi*), a pollution tolerant fish. However, substantial numbers of fish were also represented, such as fallfish (*Semotilus corporalis*), swallowtail shiner (*Notropis procne*), and satinfin shiner (*Cyprinella analostana*) comprised a combined 52% of the sample.

Site 062 - This site is on an unnamed tributary of the Little Patuxent River. It was the only second-order stream sampled in this subwatershed. Biological condition received a "fair" (3.22) rating. There were 22 total taxa identified at this site and approximately 18% of the 107 individuals subsampled were Ephemeroptera (mayflies). Twenty-three percent of the total individuals represented collector taxa, which are generally sensitive to anthropogenic stressors. The riparian vegetative zone width at this site was rated in the optimal category. However, the land use outside of the riparian buffer was predominantly old pasture/fields and residential areas. The trash rating for this site scored in the poor category, with refuse being abundant. These

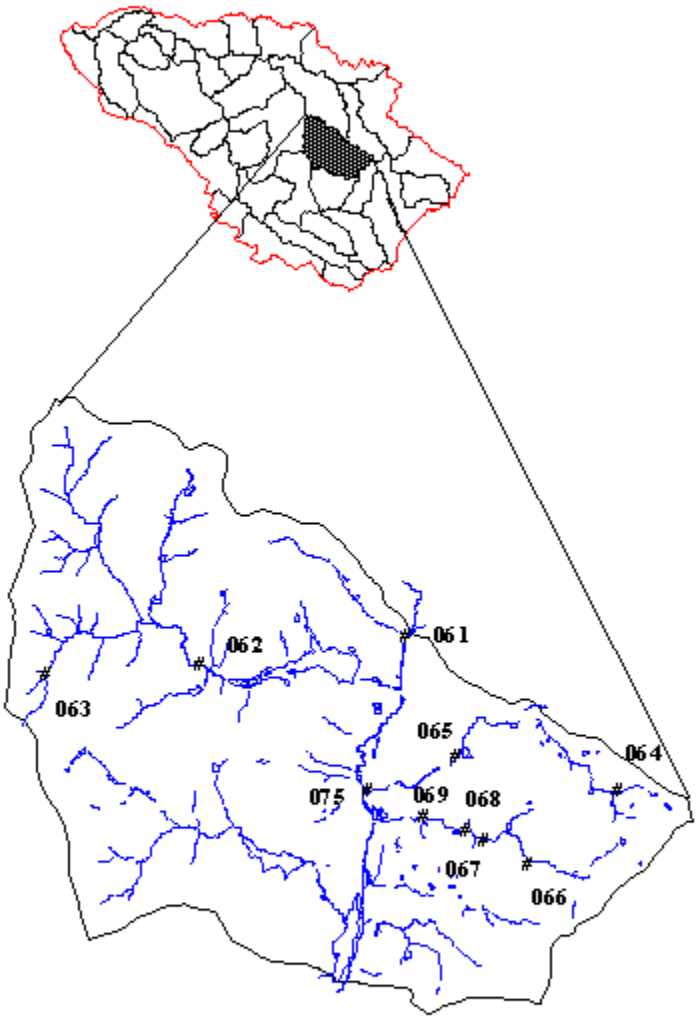

Figure 8. Middle Little Patuxent River subwatershed.

features led to the "partially-supporting" (126) habitat score this site received. Blacknose dace (*Rhinichthys atratulus*) made up 61% of the fish sample at this site. Longnose dace (*Rhinichthys cataractae*), a fish that is known to be relatively intolerant of pollution, made up 20% of the sample.

Site 063 - This site is also on an unnamed tributary of the Little Patuxent River. It is one of the eight first-order streams sampled in this subwatershed. Biological condition at this site received a "poor" (2.78) rating, with 18% of the organisms found to be tolerant to pollution. There were 20 total taxa at this site. Of the 115 total individuals, only about 8% were mayflies (Ephemeroptera). Habitat at this site was rated as "partially-supporting" (138). The stream was surrounded primarily by cropland with some deciduous forest. The riparian buffer was relatively narrow (3 m) and bank failure was common. Pollution tolerant fish comprised 100% of the sample at this site. Of the 269 total individuals, blacknose dace (*Rhinichythys atratulus*) were 99% of the sample. Green sunfish (*Lepomis cyanellus*) completed the sample.

Site 064 - This site is a first-order stream, on an unnamed tributary of the Little Patuxent River. Biological condition was rated as "very poor" (1.44). There was only one EPT taxon found (Trichoptera: Uenoidae: *Neophylax*). Eighty-one percent of the total 101 organisms found were pollution tolerant. The subsample was dominated by *Hydrobaenus* (Diptera: Chironomidae). Physical habitat rated as "non-supporting" (74). At some point in the past, a footbridge was built and the stream channelized. This stream section is in a narrow greenway between commercial manufacturing/warehouse facilities. Storm water is directed into the stream from all adjacent parking lots across rip rapped spillways and low herbaceous forest ground cover. This site scored particularly low in the embeddedness parameter, which suggests a high occurrence of fines around larger bottom substrates. Embeddedness also lowers the amount of epifaunal substrate that organisms prefer for cover. The conductivity at this site was measured at 826 µmho/cm, which generally indicates urban inputs are affecting the stream with higher suspended sediment levels (Paul & Meyer 2001, Herlihy et al. 1998, Wang & Yin 1997, Lenat & Crawford 1994). Fish were sampled at this site, but none were found.

Site 065 - This site is located on a first-order stream (UT of Little Patuxent). The biology received a "very poor" rating. After sorting all 100 grids, only 55 total individuals were found. Unless there is evidence that this represents the natural stream condition, which in this case there was not any evidence that would suggest a naturally degraded stream condition, low organism numbers are taken to indicate "very poor" habitat conditions (Stribling et al., 1999). When this occurs, no metrics are calculated and a numeric rating is not applied. Forty percent of the total individuals were organisms that are pollution tolerant. However, approximately 11% were Tanytarsini. Habitat at this site was rated as "non-supporting" (99). There was refuse present in moderate amounts, poor epifaunal substrate for colonization, and the surrounding land use was mainly residential. Over half of the fish found at this site were blacknose dace (*Rhinichythys atratulus*). Rosyside dace (*Clinostoms elongatus*), considered to be intolerant to pollution, were the second most abundant, comprising 29% of the sample.

Site 066 - This first-order stream (UT of Little Patuxent) scored "very poor" (1.89) for biology. The 102 total individuals were distributed among only 9 different taxa, the majority of them Chironomidae, with tolerance values ≥6.0. Habitat was rated as "non-supporting" (92). Most of the site was surrounded by residential area, cutting the width of the riparian vegetative zone on the right bank to 5 m or less. Roughly half of the bottom substrate was surrounded by fine sediments (sands, silt/clay). The entire fish sample was comprised of 174 blacknose dace (*Rhinichythys atratulus*).

Site 067 - This site is located on a first-order stream (UT of Little Patuxent). Biological condition was rated as "poor" (2.11). There were 19 total taxa, of which three were EPT. Thirteen percent of the 120 total individuals were pollution tolerant organisms. Habitat was rated as "non-supporting" (87). The majority of the surrounding land use was classified as residential; and refuse was abundant. A storm drain and a gully both created severe buffer breaks in the already narrow riparian zone. Seventy-five percent of the fish sampled at this site were blacknose dace (*Rhinichythys atratulus*). White sucker (*Catostomus commersoni*) was the second most populous, comprising 14% of the sample.

Site 068 - This site is about 150 m downstream of site 067. At this first-order stream, biological condition was rated as "very poor" (1.89). Only 14 total taxa were found, and were dominated by *Orthocladius* (Diptera: Chironomidae). Forty-two percent of the total 98 individuals were pollution tolerant. Habitat was rated as "non-supporting" (110). The surrounding land use was half wooded, half commercial/residential. While no single habitat parameter received a "poor" score (most were in the marginal category), there were storm drains on both banks that produced severe buffer breaks. This site had the highest number of individual fish found in this subwatershed, 1,214. Eighty-five percent of the total individuals were blacknose dace (*Rhinichythys atratulus*).

Site 069 - This site was located entirely under a box culvert (Figure 9). This first-order stream (UT of Little Patuxent) received a "very poor" (1.67) biological rating. Only 8 different taxa were found, none of them were EPT. Forty percent of the subsample was comprised of organisms that are pollution tolerant. Physical habitat was rated as "non-supporting" (57). Surrounding land use was forest and residential. About a third of the substrate was bare concrete. The remaining areas were covered with sand and gravel several inches deep. There was no vegetative cover on either bank to provide food or shelter for organisms. While the presence of the culvert keeps the banks stable, it also allows storm flow to wash through the site swiftly, easily clearing out (or scouring) any benthic macroinvertebrates that begin to colonize the area. Blacknose dace (*Rhinichythys atratulus*) comprised 76% of the fish sampled at this site.

Site 075 - The first-order stream (UT of Little Patuxent) received a "very poor" (1.44) biological rating. There were 12 taxa found out of 110 total individuals subsampled. Twenty-six percent of the organisms found were tolerant to pollution. Habitat at this site was rated as "non-supporting" (96). The surrounding land use was approximately half residential, half golf course. The riparian

buffer was narrow (10-15 m), and was disturbed by a storm drain and a tile drain, on the right bank, suggesting that this area was once used for some type of agriculture. Fifteen different species of fish were found at this site. Blacknose dace (*Rhinichythys atratulus*) were the most abundant, making up 19% of the sample. Creek chub (*Semotilus atromaculatus*), another pollution tolerant fish, was found in 18% of the sample.

Figure 9. Culvert almost completely covering an unnamed tributary in the Middle Little Patuxent River subwatershed (site 069).

Upper Little Patuxent River

Data Overview

Eleven sites were sampled in the Upper Little Patuxent River subwatershed (Figure 10). Two of the sites were located on 2nd-order streams, the remaining eight were on 1st-order streams.

One site in this subwatershed rated as "very poor" for biological condition (Table 15), six rated as "poor," and the remaining four sites received "fair" ratings. The mean B-IBI rating for this subwatershed is "poor" ($\bar{X} = 2.74 \pm 0.59$, n = 11). As in the rest of the Little Patuxent waterhsed, only benthic macroinvertebrates were used to calculate biological condition. Physical habitat assessment results place seven of the sites in the "non-supporting" category, and four sites in the "partially-supporting" category. The mean physical habitat quality rated as "non-supporting" ($\bar{X} = 110.00 \pm 28.70$, n = 10). The RBP Habitat Assessment forms were only filled out at ten of the eleven sites sampled in this subwatershed due to logistical restrictions. This difference in methods required that the habitat mean be calculated only for those sites where the RBP Habitat sheet was completed.

Fish were sampled in this subwatershed by WRD. The most commonly found was blacknose dace (*Rhinichythys atratulus*), a pollution tolerant fish (Roth et al. 2000). Three different species were found at site 104 and 18 different species were found at sites 105 and 106.

Table 15. Summary of biological and habitat scores in the Upper Little Patuxent River subwatershed. Total number of fish sampled also shown.

Site	B-IBI Score	Biological Rating	Habitat Score	Habitat Rating	No. Fish Species	No. Individual Fish Collected	Stream Order
101	3.44	Fair	118	Non Supporting	4	74	1
102	3.44	Fair	110	Non Supporting	4	65	1
103	3.44	Fair	147	Partially Supporting	9	347	1
104	1.67	Very Poor	41	Non Supporting	3	240	1
105*	2.78	Poor	86	Partially Supporting	18	821	2
106	2.78	Poor	85	Non Supporting	18	595	1
108	3.00	Fair	113	Non Supporting	8	307	2
109	2.33	Poor	125	Partially Supporting	14	678	1
110	2.78	Poor	118	Non Supporting	15	930	1
115	2.11	Poor	125	Partially Supporting	6	392	1
117	2.33	Poor	118	Non Supporting	11	615	1

*WRD Habitat sheet completed, maximum score = 140.

Site Specific Results

Site 101 - This site is on a first-order segment of the Little Patuxent River mainstem. It received a "fair" (3.44) biological rating. There were 25 total taxa found, 8 of which were EPT. Eighteen percent of the total individuals were Ephemeroptera (mayflies). Physical habitat rated as "non-supporting" (118). The surrounding land use was a mixture of pasture, cropland, deciduous forest, and residential. Conductivity at this site was 176 µmho/cm. Aspects of physical habitat quality that were the most degraded include width of riparian vegetative zone, bank stability, and embeddeddness. Fish sampling resulted in a total of 74 fish, 84% of which were blacknose dace.

Site 102 - Biological conditions were rated as "fair" (3.44) at this first order segment of the Little Patuxent River. There were 20 total taxa found, 7 of which were EPT. Twenty-eight percent of the sample was composed of mayflies (Ephemeroptera); the highest in the watershed. This site received a "non-supporting" physical habitat score (110). As with site 101 surrounding land use at this site was pasture, cropland, deciduous forest, and residential. The width of the undisturbed riparian buffer was narrow, approximately 4 m. A large proportion of the streambanks were actively eroding, and about 50% of the bottom substrate was embedded with fine sediments (silt/clay, sands). This site was also dominated by blacknose dace (89%).

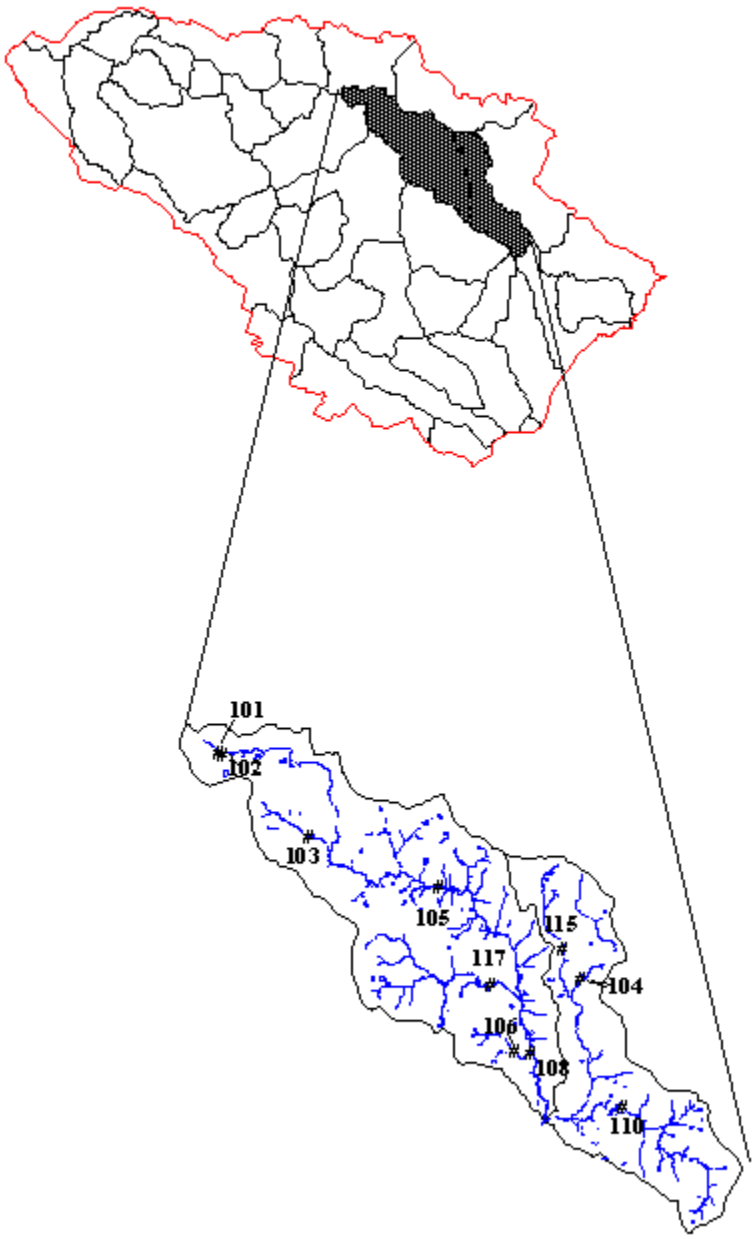

Figure 10. Upper Little Patuxent River subwatershed.

Site 103 - This site is located on a first order unnamed tributary (UT) of the Little Patuxent and received a "fair" (3.44) biological rating. There were a total of 107 individuals subsampled, representing 30 different taxa. This was the highest taxa count in the Little Patuxent watershed. Seventeen percent of the total individuals were mayflies (Ephemeroptera). The right bank was only about 5 m from a parking lot/commercial/industrial area, but the left bank displayed a wide riparian buffer (50 m). Overall ratings placed this site in the "partially-supporting" (147) category for physical habitat. Three hundred forty-seven individual fish were found at this site. Over half (53%) were blacknose dace. Two relatively intolerant fish, longnose (*Rhinichthys cataractae*) and rosyside dace (*Clinostomus elongatus*) combined to comprise 33% of the sample.

Site 104 - This first-order stream (UT of Little Patuxent) exhibits "very poor" (1.67) biological condition. Among the total 110 individuals found, there were no mayflies, stoneflies, or caddisflies (EPT). Eighty-two of the 110 individuals (75% of the sample) were identified as either *Orthocladius* or *Cricotopus* (Diptera: Chironomidae), which have a pollution tolerance value of $\geq$ 6.0. Physical habitat rated as "non-supporting" (41). Adjacent land use consisted of apartments and single family homes. Less than 10% of the available habitat was stable enough for colonization. Over 75% of the gravel, cobble, and boulder particles were surrounded by fine sediments. This segment was also channelized, and rip rap was noted on both banks as well as across the bottom of the stream. Only three species of fish were found at this site, 95% of which were blacknose dace.

Site 105 - This is one of the two second-order streams sampled in the Upper Little Patuxent subwatershed. The site is located on the mainstem of the Little Patuxent River off Pebble Bend Rd. Biological condition was rated as "poor" (2.78). Twenty-one percent of the 116 total organisms found were pollution tolerant. Twenty-four total taxa were identified. Physical habitat quality rated "partially-supporting" (86) at this site. Surrounding land use was deciduous forest, but there was substantial bank failure and substrate embeddedness. Logistical reasons forced this site to be rated for physical habitat using the MBSS Habitat Assessment Sheet. While the physical characteristics of the site can be used in characterizing the area, methods differences preclude the scores from being compared with the rest of the subwatershed, and were not included in the mean score. Over half (52%) of the fish found at this site are known to be pollution tolerant. Tolerant individuals included: 182 tessellated darters (*Etheostoma olmstedi*), 135 swallowtail shiners (*Notropis procne*), and 111 blacknose dace.

Site 106 - This site (UT of Little Patuxent) received a "poor" (2.78) biological rating. Thirty-seven percent of the 104 total individuals were pollution tolerant organisms, the majority of which were midges (Diptera: Chironomidae). The surrounding land use was approximately half residential and half forested area. There was a storm drain that produced a minor buffer break. The lack of productive habitat meant that two ft^2 of bedrock had to be sampled. Overall, this site was rated "non-supporting" (85) for physical habitat quality. Eighteen different fish species were

found, totalling 595 individuals. Blacknose dace were the most dominant fish, with 102 individuals found.

Site 108 - Biological condition received a "fair" (3.00) rating in this second-order section of the Little Patuxent River. There were 109 total individuals identified, representing 23 total taxa, including six EPT. Almost 20% of the total individuals in the subsample were of the tribe Tanytarsini, a relatively intolerant group of midges. While this site had a wide riparian vegetative zone, most of the trees and shrubs were young or regenerating. Only marginal amounts of cobble or woody debris were available for colonization, and bank failure and embeddedness were common. The physical habitat was rated as "non-supporting" (113). Blacknose dace comprised 79% of the fish found at this site.

Site 109 - This first-order stream (Hill Branch) received a "poor" (2.33) biological rating. While eight of the 23 total taxa found were EPT, 52% of the 101 individuals subsampled were pollution tolerant organisms (Chironomidae). Physical habitat was rated as "partially-supporting" (125). Riparian vegetation consisted of mostly tall grasses, as well as young and regenerating trees and shrubs. There was noticeable erosion due to high water. Surrounding land use/land cover consisted of pasture, residential, wetland, and deciduous forest. Over 50% of the stream bottom was embedded with fines (sands, silt/clay). Of the 14 species present in the fish sample, blacknose dace comprised 49% of the fish found. Other fish that were moderately abundant included: bluegill sunfish (*Lepomis macrochirus*), rosyside dace (*Clinostomus elongatus*), and tessellated darter (*Etheostoma olmstedi*). Of these, the rosyside dace is the only one that is considered to be intolerant to pollution (Roth et al. 2000).

Site 110 - Biological condition at this site, also located on Hill Branch (1st order), was rated as "poor" (2.78). There were 26 total taxa identified. Of the 94 total individuals, 34% had tolerance values $\geq$ 7.0. Physical habitat quality received a "non-supporting" rating (118). More than 50% of the surface sediment were surrounded with fines (embeddedness). The left bank had a very narrow riparian buffer (5 m) before housing and mowed lawns began. The surrounding land use/land cover was similar to site 109, with pasture, residential, wetland, and deciduous forest. Some bank failure was also noted. Fifteen different fish species were found at this site. The most common was blacknose dace (51%). Other fish found frequently were rosyside dace, a relatively pollution intolerant species, and creek chub (*Semotilus atromaculatus*), another pollution tolerant fish.

Site 115 - This site (Plumtree Branch) displayed "poor" (2.11) biological condition. There were only 14 total taxa observed. Twenty percent of the 107 total individuals were pollution tolerant, primarily represented by *Tvetenia* (Diptera: Chironomidae). Physical habitat was rated as "partially-supporting" (125). This stream is completely surrounded by residential neighborhoods. A moderate amount of refuse was observed. The narrow riparian buffer (2 m) was disrupted by storm drains on both banks of the stream. Rip rap was also evident along the

left bank, possibly constructed to improve bank stability. There is also a road within 5m of the stream. Seventy-one percent of the fish sampled at this site were blacknose dace.

Site 117 - This first order stream (UT of Little Patuxent) received a "poor" (2.33) rating for biological condition. It is located in the Font Hill watershed, and is a stream sampled in the County National Pollution Discharge Eurmination System (NPDES) program. Conditions observed during the course of this biological assessment were similar to those during Fall 2000 and Spring 2001 NPDES sampling conducted by Howard County. There were 119 total individuals found, representing 16 total taxa. There were only four EPT taxa. This site rated as "non-supporting" (118) for physical habitat quality. Minor channelization was present in the form of rip rap over 15 m of the left bank. Surrounding land use consisted of mostly residential (90%) and some woodland (10%). Approximately 50% of the surface sediments were surrounded by fines (sands, silt/clay). An old beaver dam was also present. Of the 615 total fish found at this site, 52% (322) were blacknose dace.

Section III. Conclusions and Recommendations

The results of these biological assessments lend themselves to recommendations in six areas:

- watershed protection and rehabilitation actions
- directions for further diagnostic analyses
- ensuring baseline condition for comparison with long-term monitoring activities
- public outreach strategies
- maintaining comparability with State methods
- maintaining quality assurance/quality control standards.

In this section, summary recommendations are provided that will facilitate using the results in natural resource management decisions and in communicating the ecological status of watersheds to the public.

Protection and Rehabilitation

- Use aggregated biological index scores to prioritize watersheds for protection or rehabilitation activities. The processes of protection and rehabilitation of natural resources work together to maintain a healthy environment. Exclusion of stressors from moderate to high quality streams (protection) is as important as removing stressors (rehabilitation/restoration) from the fair to very poor quality streams. Where streams exhibit "good" biological condition, effective protection and preservation will require excluding the introduction of new stressors.

- Diagnostic sampling and analysis should be performed on streams with "fair', "poor", or "very poor" biological condition to determine the characteristics of the stressors. If the stream is unstable, determination and correction of upstream hydrologic alteration is recommended. If nutrient enrichment or toxic contamination is probable, perform sediment and water column chemical analysis and toxicity testing to determine, correct, and eliminate sources.

Further Diagnostic Analysis

- Perform detailed geomorphic stability assessments for streams where there are unknown causes of hydrologic alteration.

- For priority watersheds (Little Patuxent River) and streams, determine appropriate combination of Best Management Practices (BMPs), such as stream rehabilitation, chemical controls, and community/land owner involvement for elevating and improving ecological condition.

- Perform additional analyses of Spring 2001 Index Period data: a) investigate individual metrics for correspondence with known stressors/stressor sources, b) evaluate ability to

sample streams, that is, report on frequency of intermittent or dry streams, streams heavily influenced by beaver activity, streams destroyed (filled in) or enclosed by pipes due to development, or those streams inaccessible due to landowner issues.

- Target possible "problem areas" that are found within each subwatershed for further monitoring and analysis; perform more detailed analyses of land use/land cover distribution.

Baseline Condition for Future Monitoring

- Ensure continuation of 5-year, rotating basin program.

- Select several individual, probability-based, sites for annual monitoring to detect changes (selected probability sites become targeted).

- Select 10% of biological monitoring sites to perform detailed physical habitat monitoring. Base selections on land use strata and on different levels of bank instability.

- Collect and maintain historic data on channel size through cross-sectional measurements to allow for identification of major changes in stream channel shape.

- Supplement MBSS sampling throughout the county.

- Select biological monitoring sites to perform analysis of current BMP activity, or identify sites where BMPs (retention ponds, riparian revegetation, bank stabilization, grade control structures, or limiting access of cattle to streams) could be installed to improve physical habitat and biological conditions.

- Perform Countywide assessment for condition after completing 5-year rotation cycles.

Public Outreach

- Provide broad access to this report through a variety of mechanisms including: subwatershed brochures, internet PDF files, advertisement to citizens, presentation at community meetings, and press releases announcing availability of the report. Expedite printing and public release of the report.

- Make results public (formal technical presentation to the Maryland Water Monitoring Council, the North American Benthological Society, the National Water Quality Monitoring Council).

- Use the report to increase interest in volunteer monitoring activities.

Comparability with State methods

- Continue TAC meetings prior to each sampling season.
- Attend MBSS refresher-training sessions prior to each sampling season.
- Expand communication and collaboration with other state organizations (WRD, University of Maryland) that could potentially assist with future sampling.

Quality Assurance/Quality Control (QA/QC)

- Maintain QA/QC training and documentation for program
- Continue attendance at MBSS training in order to ensure comparability with State program.
- Perform blind re-identification of 10% total benthic samples using an independent taxonomist.

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Section V. Appendices