HOWARD COUNTY BIOLOGICAL MONITORING AND ASSESSMENT UPPER BRIGHTON DAM, LOWER BRIGHTON DAM, AND CATTAIL CREEK WATERSHEDS 2012

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EXECUTIVE SUMMARY

The Howard County Department of Public Works, Stormwater Management Division, initiated the Howard County Biological Monitoring and Assessment Program in the spring of 2001. The County initiated the monitoring program to establish a baseline ecological stream condition for all of the County's watersheds. The program involves monitoring the biological and physical condition of the County's water resources and is designed on a five-year rotating basis such that each of the County's 15 watersheds, or primary sampling units (PSUs), is sampled once every five years.

To allow for paired site comparisons with both Rounds 1 and 2, 30 sites from Round 1 and 30 sites from Round 2 will be randomly selected for repeat sampling in Round 3. The remaining 90 sites in Round 3 will be new random sites. More specifically, 2 sites in each Round 3 watershed will be randomly chosen from the 10 Round 1 sites and 2 sites will be randomly chosen from the 10 Round 2 sites; the remaining 6 sites will be new random sites. In 2012, ten sites were sampled in each of three subwatersheds: Upper Brighton Dam, Lower Brighton Dam, and Cattail Creek. These subwatersheds were also sampled in Round 1 (2001) and Round 2 (2005) of the countywide assessment. The monitoring involved sampling instream water quality, collection and analysis of the biological community (benthic macroinvertebrates) using Maryland Biological Stream Sampling (MBSS) protocols, cross sectional analysis, particle size distribution, and assessment of the physical habitat using the United States Environmental Protection Agency's (EPA) Rapid Bioassessment Protocols (RBP) and the MBSS's Physical Habitat Index (PHI). The sampling methods used are compatible with those used in the first two rounds of the assessment, with updates where applicable.

All biological data collection occurred between April 5 and April 20, 2012, as required by the MBSS protocols. The positions of the sites were collected using a GPS unit accurate to within 2 meters.

Biological results for 2012 in Upper Brighton Dam, Lower Brighton Dam, and Cattail Creek indicate subwatersheds that are in good to fair condition. Twenty-two of the sites sampled received overall BIBI ratings of "Good" and six received ratings of "Fair." Only two sites (one in Lower Brighton Dam and one in Cattail Creek) received ratings of "Poor."

RBP habitat assessment results indicate average subwatershed physical habitat conditions that were 'Supporting' in all three subwatersheds. Nine sites were "Comparable to Reference," 18 were "Supporting," one was "Partially Supporting" (located in Lower Brighton Dam), and two were "Non-Supporting" (located in Lower Brighton Dam and Cattail Creek). The PHI results indicate average subwatershed physical habitat conditions that were "Supporting" in Lower Brighton Dam and Cattail Creek, while Lower Brighton Dam had an average PHI rating of "Minimally Degraded."

The geomorphic assessment results indicate a variable system. Many of the channels sampled throughout the subwatersheds were classified as stable type B, C, and E channels;

however, a good portion of channels were classified as unstable, incised F and G channels. Gravel was the dominant substrate type in the majority of sampling reaches, while sand- and cobble-dominant streams were also present.

The average percentage of impervious area in the upstream catchments in the Upper Brighton Dam is 2%. Six percent of the land in the upstream catchments in Lower Brighton Dam and Cattail Creek is impervious surface. Imperviousness in the areas draining to each sampling site ranges from less than 1% to 13% (see Appendix A for impervious values). The benthic community in a freshwater stream can be adversely affected by impervious cover and associated runoff at values as low as 10% (CWP 2003).

Pearson correlations between the BIBI scores and four parameters (RBP physical habitat, PHI physical habitat, percent imperviousness, and conductivity) showed significant relationships.

Comparisons to Rounds 1 and 2 of the assessment indicate stable biological conditions, with no significant changes in the mean BIBI scores among the three rounds (2001, 2005, and 2012). In contrast, there were significant changes in the RBP physical habitat assessment among the three rounds. Conditions changed differently in each subwatershed. For example, in Upper Brighton Dam, the RBP scores for Rounds 1 and 2 were not significantly different from each other, but the Round 3 score was significantly higher than previous rounds.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

Page

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LIST OF TABLES

LIST OF FIGURES

Figure No. **Page**

1.0 BACKGROUND AND OBJECTIVES

The Howard County Department of Public Works, Stormwater Management Division, initiated the Howard County Biological Monitoring and Assessment Program in the spring of 2001. The program involves monitoring the biological and physical condition of the county's water resources to monitor status and detect trends at the stream level, the watershed level, and ultimately the county level. The Department of Public Works initiated the program to establish a baseline ecological stream condition for all of the county's watersheds. The program is designed on a 5-year, rotating basis such that each of the county's 15 watersheds, or primary sampling units (PSU), is sampled once every 5 years. In general three PSUs are sampled each year, and 10 sites are sampled in each PSU.

The first sampling rotation (Round 1) was completed in only 3 years (2001 to 2003; Table 1-1). Sampling conducted in PSUs 2, 5, and 3 in 2001 addressed requirements of the Patuxent Reservoir Watershed Group in addition to sampling conducted in the Little Patuxent watersheds (PSUs 11, 12, and 13) under a Watershed Restoration Action Strategy (WRAS) grant. In 2002, only the Middle Patuxent sites (PSUs 6, 7, and 8) were sampled. Additional WRAS funding in 2003 allowed sampling to be completed in the Patapsco River tributaries (PSUs 1, 4, and 10) in addition to Rocky Gorge, Hammond Branch, and Dorsey Run, which were sampled to supplement the data collected in 2001 for the Little Patuxent. Round 1 (2001-2003) was sampled and assessed by Tetra Tech.

Round 2 (2005 to 2009) focused on Upper and Lower Brighton Dam (PSUs 2 and 5, respectively) and Cattail Creek (PSU 3) during the first year of sampling. The Little Patuxent River subwatersheds (PSUs 11, 12, and 13) were sampled in 2006. The Middle Patuxent subwatersheds (PSUs 6, 7, and 8) and the Patapsco River subwatersheds (PSUs 1, 4, and 10) were re-sampled in 2007 and 2008, respectively. In 2009, 30 newly selected sites were sampled in the Rocky Gorge Dam (PSU 9), Hammond Branch (PSU 14), and Dorsey Run (PSU 15) sub-watersheds to fulfill sampling requirements. Tetra Tech completed the first year of Round 2 sampling and assessment (2005), while KCI was responsible for the remainder of the second Round (2006-2009).

Round 3 (2012 to 2016) of county-wide sampling began with sampling at Upper Brighton Dam (PSU 2), Lower Brighton Dam (PSU 5), and Cattail Creek (PSU 3). Round 3 sampling will continue through 2016 and PSUs will be sampled in the same order as in Round 2. Round 3 sampling will include a combination of repeat site samples and new random site samples to improve trend detection. Figure 1-1 illustrates the progress made to date on the county-wide biological monitoring program.

Assessment methods follow those developed by Maryland Department of Natural Resources' (DNR) Maryland Biological Stream Survey (MBSS) and the standard operating procedures (SOPs) found in the Quality Assurance Project Plan (QAPP) for the Howard County Biological Monitoring and Assessment Program (Howard County 2001). The sampling methods used in 2012 are compatible with those used in Rounds 1 and 2 and have been updated where applicable.

Table 1-1. Summary of Howard County bioassessment progress

Year	Number of Sites	Primary Sampling Unit (Code and Name)
Round 1		
2001	60	11 – Upper Little Patuxent 12 – Middle Little Patuxent 13 – Lower Little Patuxent 2 – Upper Brighton Dam 5 – Lower Brighton Dam 3 – Cattail Creek
2002	30	6 – Upper Middle Patuxent 7 – Middle Middle Patuxent 8 – Lower Middle Patuxent
2003	60	9 – Rocky Gorge Dam 14 – Hammond Branch 15 – Dorsey Run 10 – S Branch Patapsco River Tributaries 1 – Patapsco River L Branch A 4 – Patapsco River L Branch B
Round 2		
2005	30	2 – Upper Brighton Dam 5 – Lower Brighton Dam 3 – Cattail Creek
2006	30	11 – Upper Little Patuxent 12 – Middle Little Patuxent 13 – Lower Little Patuxent
2007	30	6 – Upper Middle Patuxent 7 – Middle Middle Patuxent 8 – Lower Middle Patuxent
2008	30	10 – S Branch Patapsco River Tributaries 1 – Patapsco River L Branch A 4 – Patapsco River L Branch B
2009	30	9 – Rocky Gorge Dam 14 – Hammond Branch 15 – Dorsey Run
Round 3		
2012	30	2 – Upper Brighton Dam 5 – Lower Brighton Dam 3 – Cattail Creek
2013	30	11 – Upper Little Patuxent 12 – Middle Little Patuxent 13 – Lower Little Patuxent
2014	30	6 – Upper Middle Patuxent 7 – Middle Middle Patuxent 8 – Lower Middle Patuxent30
2015	30	10 – S Branch Patapsco River Tributaries 1 – Patapsco River L Branch A 4 – Patapsco River L Branch B
2016	30	9 – Rocky Gorge Dam 14 – Hammond Branch 15 – Dorsey Run

All three subwatersheds sampled in 2012 are located in the northwestern portion of the county and are crossed by several major transportation routes (Figure 1-2). Interstate 70 and Frederick Road (Route 40) run roughly east-west through the northern portion of Cattail Creek. Route 97 runs north-south through Cattail Creek as well as a small portion of Lower Brighton Dam. Woodbine Road also runs north-south through Cattail Creek and Upper Brighton Dam.

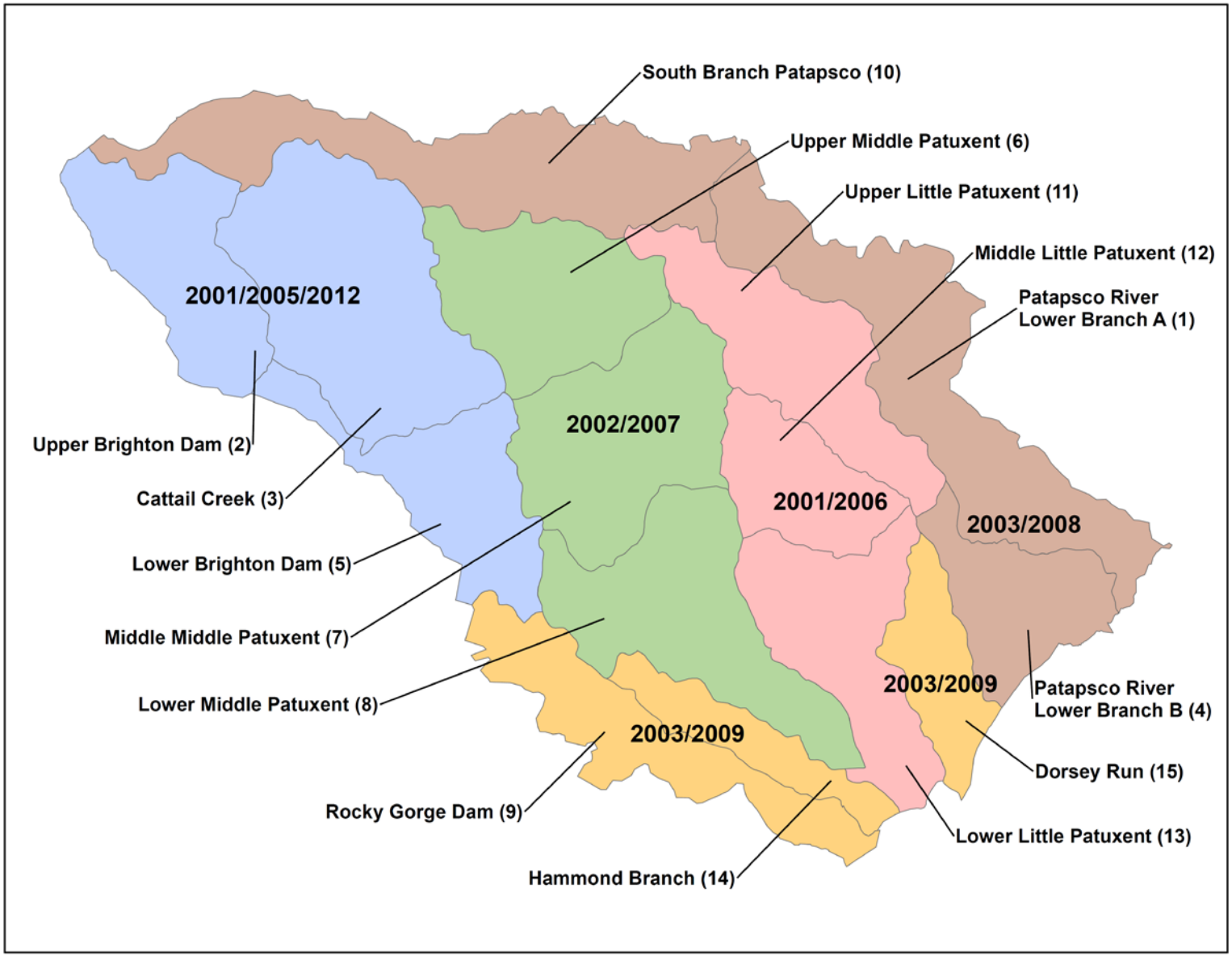

Figure 1-1. Howard County bioassessment subwatersheds and schedule

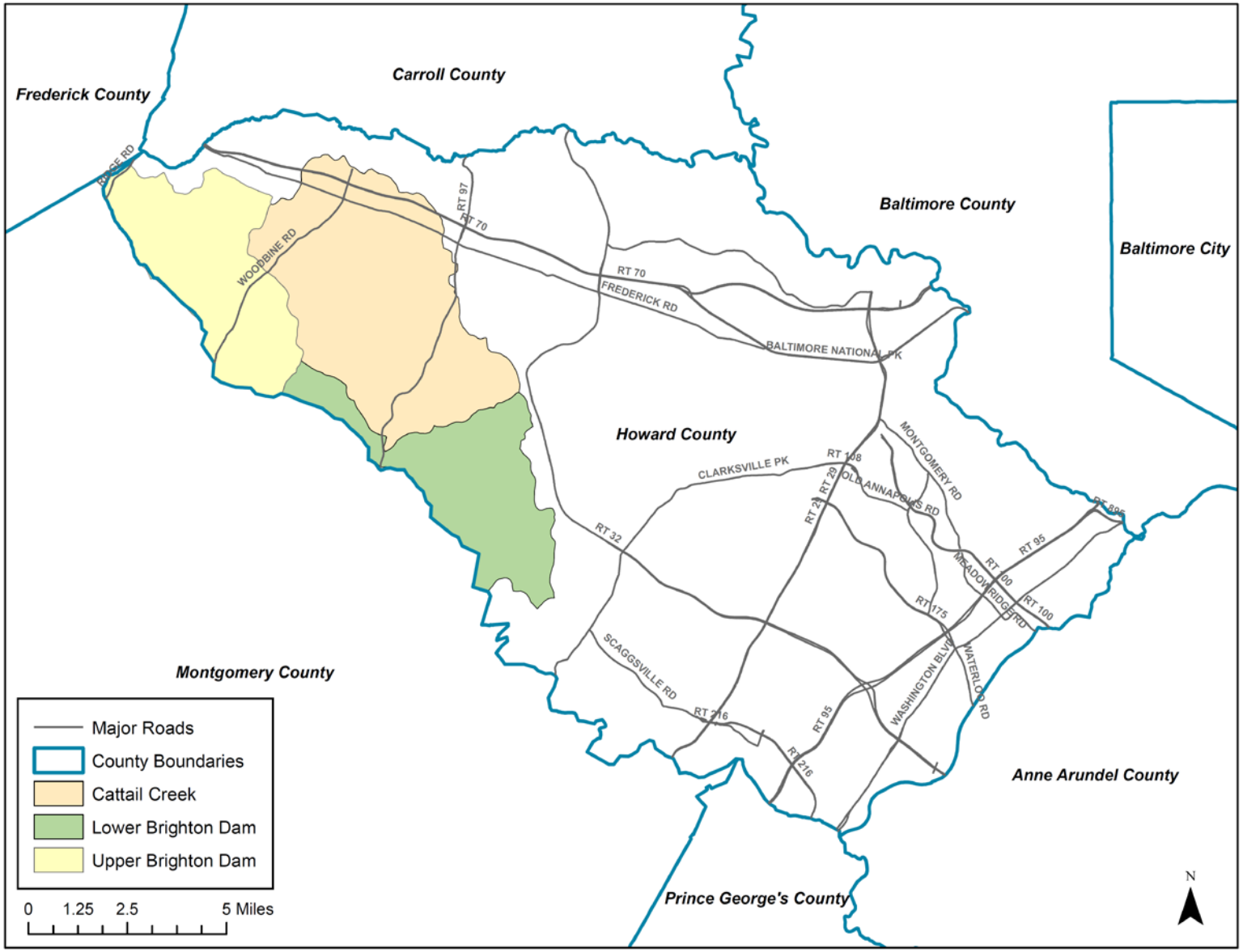

Figure 1-2. Location map of Upper Brighton Dam, Lower Brighton Dam, and Cattail Creek subwatersheds

2.0 METHODS

Stream monitoring conducted throughout the watershed includes measuring instream water quality, sampling and assessing the biological community (benthic macroinvertebrates), visually assessing the instream and riparian physical habitat, and performing cross sectional analysis, and measuring substrate particle size. During 2012, monitoring was conducted at 10 sites in each of the 3 PSU's - Lower Brighton Dam, Upper Brighton Dam, and Cattail Creek. The assessment methods followed the current MBSS protocols (DNR 2010) and the SOPs described in the county's QAPP (Howard County 2001). All biological data were collected between April 5 and April 20, 2012, within the spring index period as required by MBSS sampling protocols. The location of each site was identified using a global positioning system (GPS) unit that is accurate to within 2 meters. All data were entered into a customized geodatabase created by Versar for Howard County's countywide biological monitoring program. Photographs were taken to document conditions at the time of data collection.

2.1 SELECTION OF SAMPLING SITES

A total of 150 sampling sites were selected at random per round of sampling for Rounds 1 and 2 to provide robust assessments of stream condition for the county and its 15 watersheds (or PSUs). Rounds 1 and 2 provide two unbiased assessments of stream condition with the ability to compare changes in the area-wide mean condition between rounds. Round 3 will provide a third unbiased assessment of stream condition while improving the ability to detect change over time (i.e., trends) by incorporating fixed sites (i.e., repeated sampling of sites selected at random for Rounds 1 and 2). New randomly selected sites also will be sampled during Round 3. This "partial replacement" design meets the objective of improved trend detection, while continually improving the accuracy of the status assessment.

To allow for paired site comparisons, 30 sites from Round 1 and 30 sites from Round 2 will be randomly selected for repeat sampling in Round 3. The remaining 90 sites in Round 3 will be new, randomly selected sites. This is consistent with the recommendation of standard statistical texts (e.g., Cochran 1977) to fix between 25% and 50% of the sites. More specifically, 2 sites in each Round 3 watershed will be randomly chosen from the 10 Round 1 sites, and 2 sites will be randomly chosen from the 10 Round 2 sites; the remaining 6 sites in each watershed will be new, randomly selected sites.

The randomly selected sites are distributed in proportion to the length of stream in each stream order within each watershed to ensure adequate coverage of stream sizes. To select primary and alternate sampling sites, stream lengths were summed by stream order within each subwatershed. The length of stream by stream order and its percentage of the total length within the subwatershed determined the number of sites selected on that order stream.

A random number generator was used to select sampling reaches for 2012. Both primary and alternate sites were selected in case the primary site was ephemeral (dry), inaccessible, or unsafe to sample. Site codes contain the PSU code and initials of the watershed (02BD), stream

order (1), a two-digit sequential number (01), either an "R" or an "F" indicating that the site is a randomly selected site or a fixed "revisit" site, the year sampled (2012), and a letter used in the field to differentiate sampling sites (A).

One duplicate site will be monitored in each PSU for a total of 3 duplicate sites per year (45 QC duplicate sites over the course of Round 3). Only the biological assessment will be conducted at the duplicate sites. These sites were selected using aerial photography and then verified in the field. Duplicate sites (including alternates) will be immediately upstream of a sampling site, will have similar habitat characteristics, and will not be affected by road crossings or confluences.

2.2 LAND USE ANALYSIS

The acreage and percentage of various land use categories were calculated for the drainage area to each site using county GIS data. Drainage areas to each sampling site were first delineated using 2-foot contours. Land use was derived from Maryland Department of Planning (MDP) 2010 land use for Howard County. Since the Patuxent River is a large watershed draining several counties, additional GIS data from Carroll, Frederick, and Montgomery counties also were used to delineate drainage areas and calculate land use percentages. Impervious values were derived using Howard County's 2004 planimetric layers, including roads, buildings, parking lots, driveways and sidewalks.

A table with the percentage of land use, including impervious surface, in each sub-watershed is included in Appendix A.

2.3 WATER QUALITY SAMPLING

To supplement the macroinvertebrate sampling and physical habitat assessment, water quality is measured in the field at all monitoring stations. All parameters are measured *in situ* with a YSI® multi-probe data storage device. A calibration log is kept to ensure that the equipment is working properly during field visits. Field-tested parameters include:

- pH (standard pH units)
- Temperature (degrees Celsius, °C)
- Dissolved oxygen (milligrams per liter, mg/L)
- Conductivity (microSiemans per centimeter, µS/cm)
- Turbidity (NTU)

The Maryland Department of the Environment (MDE) has established acceptable standards for several water quality parameters for each designated Stream Use Classification. These standards are listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-03 - Water Quality* (MDE, 1994). The Lower Brighton Dam, Upper Brighton Dam, and Cattail Creek drainage areas are in *COMAR* Sub-Basin 02-13-11: Patuxent River Area. All three drainage areas are classified as III-P Nontidal Cold Water and Public Water Supply. The acceptable standards for Use III-P are

listed in Table 2-1. Data collected at each station are compared with these standards in the site summaries in Section 3.0.

Table 2-1. Water quality sampling and COMAR standards, use III-P

Parameter	**Units**	**Acceptable COMAR Standard**
pH	standard pH units	6.5 to 8.5
Temperature	degrees Celsius, °C	maximum of 68 °F (20 °C) or ambient temperature of the surface water, whichever is greater
Dissolved Oxygen (DO)	milligrams per liter, mg/L	may not be less than 5 mg/L at any time
Conductivity	microSiemans per centimeter, µS/cm	no COMAR standard set
Turbidity	Nephelometer Turbidity Units, NTU	maximum of 150 NTUs and maximum monthly average of 50 NTUs

2.4 BIOLOGICAL SAMPLING

Biological monitoring was conducted throughout the Lower Brighton Dam, Upper Brighton Dam, and Cattail Creek watersheds following methods detailed in the county's QAPP (Howard County 2001). Biological assessment methods within Howard County are designed to be consistent and comparable with the methods used by Maryland DNR in its MBSS. The county adopted the MBSS methodology to be consistent with statewide monitoring programs and programs adopted by other Maryland counties. The methods were developed locally and are calibrated to Maryland's physiographic regions and stream types. To maintain comparability with prior years of sampling, physical habitat condition was assessed using the EPA's Rapid Bioassessment Protocol (RBP; Barbour et. al 1999) habitat assessment for high-gradient streams. The MBSS habitat parameters required to calculate the MBSS Physical Habitat Index (PHI) were also collected (Paul et al. 2002). Many of the MBSS habitat parameters included in the PHI are usually sampled during the summer index period. For example, percent shading is often misrepresented during the spring index period when leaves typically have not yet opened. Therefore, the PHI score should be used with that particular caveat. Figure 2-1 shows the locations of the bioassessment sites on the Howard County stream layer.

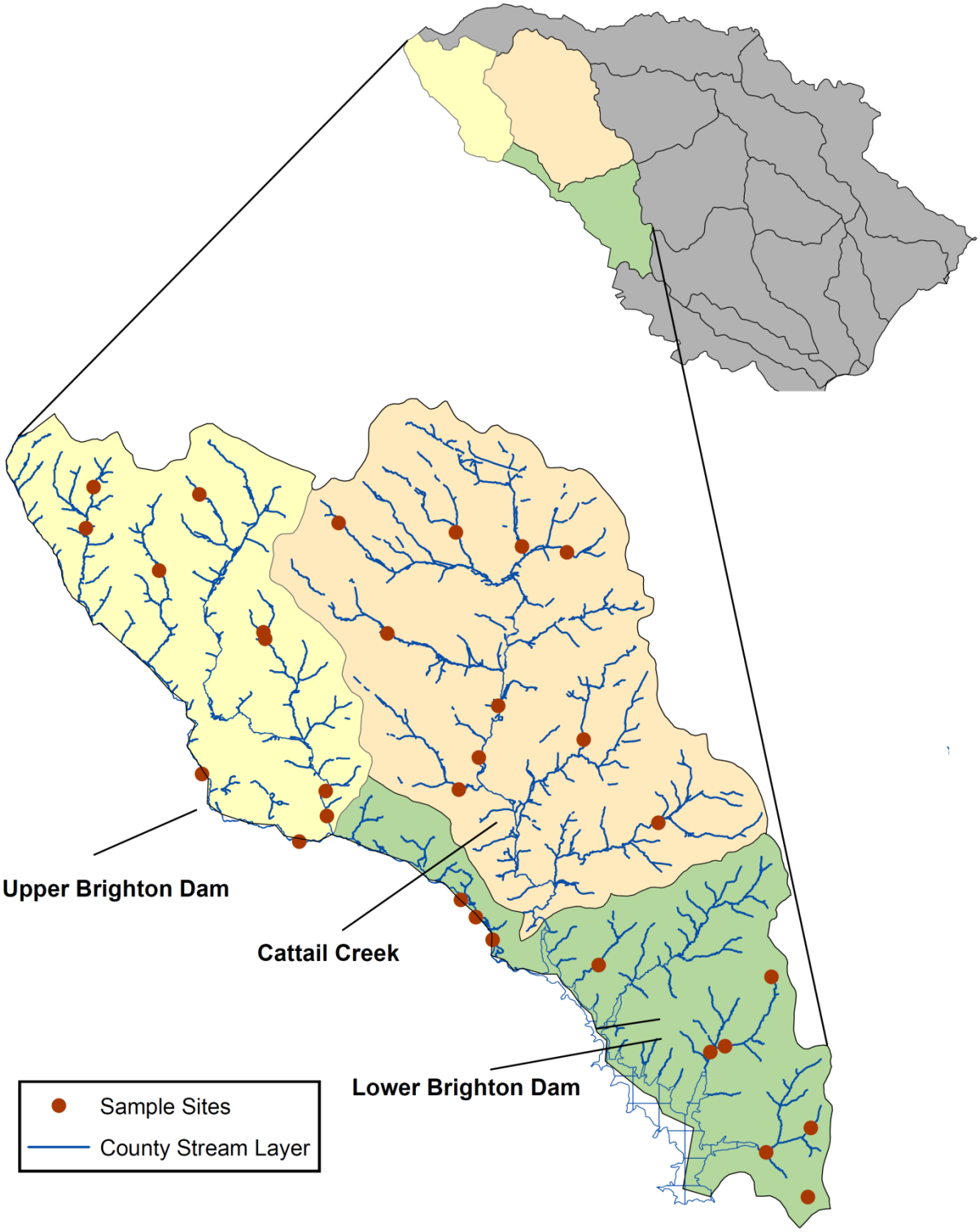

Figure 2-1. Upper Brighton Dam, Lower Brighton Dam, and Cattail Creek bioassessment sampling locations

2.4.1 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate collection followed the QAPP, which closely mirrors MBSS procedures (DNR 2010). Benthic macroinvertebrate sampling is conducted during the spring index period (March 1 to April 30) along a 75-meter reach. Systematic field collections of the benthic macroinvertebrate community provide a measure of the biological health of the stream. The multi-habitat, D-frame net approach was used to sample a range of the most productive habitat types within the reach. In this sampling approach, 20 square feet distributed among the best available habitats within the stream system are sampled and combined into one composite sample. Sampled habitats include riffles, rootwads, rootmats and woody debris, leaf packs, submerged aquatic vegetation, and undercut banks.

2.4.2 Sample Processing and Laboratory Identification

Benthic macroinvertebrate samples are processed and subsampled according to methods described in the MBSS Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy (Boward and Friedman 2000). Subsampling is conducted to standardize the sample size and reduce variation caused by samples of different size. In this method, the sample is spread evenly across a gridded tray and a randomly selected grid is picked clean (sorted) of organisms. Grids are selected and sorted until a count of 120 is reached. The last grid selected is sorted entirely even if the count of 120 is reached (i.e., if 2 grids contain only 110 organisms an additional grid is selected and sorted completely). The 120 target allows for proper identification of specimens that are missing parts or are early instars that cannot be identified easily.

Organisms were identified by Versar's benthic taxonomist, who is certified by the North American Benthological Society for all macroinvertebrate identifications for East Coast specimens. Most organisms are identified to the genus level, including Chironomidae and Oligochaeta when possible. Individuals of early instars or those that may be damaged were identified to the lowest possible level with certainty. Most taxa are identified using a stereo-scope, but permanent slide mounts were used to identify Chironomidae and Oligochaeta to genus level. Results were recorded on a bench sheet and entered into an Access database for analysis.

2.4.3 Biological Data Analysis

Data were analyzed using methods developed by MBSS as outlined in the *New Biological Indicators to Better Assess the Condition of Maryland Streams* (Southerland et al. 2005). The Benthic Index of Biotic Integrity (BIBI) approach involves statistical analysis using metrics that have a predictable response to water quality and habitat impairment. The metrics selected fall into five major groups, including taxa richness, taxa composition, tolerance to perturbation, trophic (feeding) classification, and habit.

Raw values for each metric are given a score of 1, 3, or 5 based on ranges of values developed for each metric. The results are combined into a scaled BIBI score ranging from 1.0 to 5.0, and a corresponding narrative rating is applied. Three sets of metric calculations have

been developed for Maryland streams based on broad physiographic regions. These include the Coastal Plain, Eastern Piedmont, and Combined Highlands ecoregions. The Upper Brighton Dam, Lower Brighton Dam, and Cattail Creek subwatersheds are all located in the Eastern Piedmont region; therefore, that formulation of the IBI was used in this report.

DNR updated the benthic metrics, scoring criteria, and individual species tolerance in 2005. The data collected Round 1 sampling of the Upper Brighton Dam, Lower Brighton Dam, and Cattail Creek subwatersheds were analyzed using the old metrics (Stribling et. al. 1998); consequently, those results are not directly comparable to the current sampling data. All data from the 2003 sampling were recalculated using the updated metrics to allow for direct comparison with the Round 2 and Round 3 data. For this report, any mention of 2003 BIBI scores refer to these recalculated values.

The following metrics and BIBI scoring were used for data analysis:

Eastern Piedmont BIBI Metrics:

- *Number of Ephemeroptera Taxa* – Equals the total number Ephemeroptera Taxa in the sample. Ephemeroptera (mayflies) are generally considered pollution sensitive, thus communities dominated by Ephemeroptera usually indicate better water quality.

- *Total Number of Taxa* – Equals the richness of the community in terms of the total number of taxa at the genus level or higher. A large variety of genera typically indicate better overall water quality, habitat diversity and/or suitability, and community health.

- *Number of EPT Taxa* – Equals the richness of genera within the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). EPT taxa are generally considered pollution sensitive, thus higher numbers of EPT taxa would be indicative of better water quality.

- *Percent Intolerant Urban* – Equals the percentage of individuals in the sample that are considered intolerant to urbanization (tolerance values [TV] = 0 – 3). The percent of intolerant urban is expected to decrease with decreasing water quality.

- *Percent Chironomidae* – Equals the percentage of individuals in the sample that are in the Chironomidae (nonbiting midge) family. An increase in the percentage of Chironomidae is generally an indicator of decreasing water quality.

- *Percent Clingers* – Equals the percentage of the total number of individuals who are adapted to attaching to surfaces in stream riffles. Higher percentages of clingers are representative of a decrease in stressors and better water quality.

Information on trophic or functional feeding group and habit were based heavily on information compiled by DNR and from Merritt and Cummins (1996). Scoring criteria for the Piedmont BIBI are shown in Table 2-2. The raw metric value ranges are given with the

corresponding scores of 1, 3, or 5. Table 2-3 provides the BIBI scoring ranges and corresponding biological condition ratings.

Table 2-2. Biological index scoring for Piedmont benthic macroinvertebrates

Metric	Score		
	1	**3**	**5**
Total Number of Taxa	< 15	15 – 24	≥ 25
Number of EPT Taxa	< 5	5 – 10	≥ 11
Number of Ephemeroptera Taxa	< 2	2 – 3	≥ 4
Percent Intolerant Urban	< 12	12 – 50	≥ 51
Percent Chironomidae	> 63	24 – 63	≤ 24
Percent Clingers	< 31	31 – 73	≥ 74

Table 2-3. BIBI scoring and rating

BIBI Score	Narrative Rating
4.0 – 5.0	Good
3.0 – 3.9	Fair
2.0 – 2.9	Poor
1.0 – 1.9	Very Poor

2.5 PHYSICAL HABITAT ASSESSMENT

Each biological monitoring site is characterized based on physical characteristics and various habitat parameters following the Environmental Protection Agency's Rapid Bioassessment Protocol (RBP) habitat assessment for high gradient streams (Barbour et. al, 1999). The RBP habitat assessment consists of visually assessing 10 biologically significant habitat parameters that evaluate a stream's ability to support an acceptable level of biological condition. Each parameter is given a numerical score from 0 to 20 and a categorical rating of optimal, suboptimal, marginal or poor. Overall habitat quality typically increases as the total score for each site increases. The parameters assessed for high gradient streams are listed in Table 2-4.

Table 2-4. RBP habitat parameters for high gradient streams

Parameters Assessed	
Epifaunal substrate/available cover	Channel alteration
Embeddedness	Frequency of riffles/bends
Velocity/depth regime	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian vegetative zone width

The above parameters for each site were summed to obtain a total habitat score. Since local reference conditions were not available for comparison, the percent comparability was calculated based on the highest attainable score (200). The percent comparability score is then used to place each site into corresponding narrative rating categories as shown in Table 2-5.

Table 2-5. RBP habitat score and ratings

Percent of Reference	Narrative Rating
> 90.0	Comparable to Reference
75.1 – 89.9	Supporting
60.1 – 75.0	Partially Supporting
< 60.0	Non-supporting

MBSS stream habitat assessment methods (Paul et al. 2002) were used to assess the physical habitat at each site using the Piedmont Physical Habitat Index (PHI). In developing the PHI, MBSS identified eight parameters that have the most discriminatory power for Piedmont streams. These parameters were evaluated on a 0 to 20 scale at each sampling site and used to calculate the PHI (Table 2-6).

The PHI is scored based on Table 2-7.

Table 2-6. Parameters assessed in MBSS's habitat assessment procedure (Physical Habitat Index or PHI) for Piedmont streams

Parameter	Rating Scale
Remoteness	0 to 20
Shading	0 to 20
Epibenthic Substrate	0 to 20
Instream Habitat	0 to 20
Woody Debris and Rootwads	0 to 20
Bank Stability	0 to 20
Riffle Quality	0 to 20
Embeddedness	0 to 20

Table 2-7. MBSS Physical Habitat Index (PHI) score and rankings

>81	Minimally Degraded
66-81	Partially Degraded
51-65	Degraded
< 51	Severely Degraded

2.6 GEOMORPHIC ANALYSIS

A stream geomorphic assessment was conducted to foster a better understanding of the physical processes and features shaping the storm channels in these subwatersheds and to support strategic decisions on how to best protect, manage, and restore watershed resources. Assessment techniques include the cross sectional survey, substrate particle size analysis, and measurement of channel slope.

2.6.1 Cross Section Analysis

Cross sections at each monitoring station were surveyed according to Howard County's SOP to characterize the channel and measure cross sectional area and discharge. Each cross section was located on a representative riffle whenever possible and was surveyed with a laser level and stadia rod.

The cross sections include survey of the floodplain and all pertinent channel features including:

- Top of bank
- Bankfull elevation
- Edge of water
- Limits of point and instream depositional features
- Thalweg
- Floodprone elevation

Sinuosity was calculated using GIS based on the stream length between the upstream and downstream ends of the reach and the straight-line distance between these points. The flood-prone width was estimated at an elevation two times the bankfull depth.

Additional survey points were taken near the upstream and downstream ends of the sampling reach to estimate the slope through the reach in order to estimate discharge. Survey points for slope calculations typically were taken at the top of like features (e.g., top of riffle to top of riffle), although this was not always possible.

2.6.2 Particle Size Analysis

The channel bed and bank materials were characterized at each cross section using pebble count analysis. One modified Wolman pebble count (Wolman 1954) was conducted in each reach to determine the composition of channel materials and the median particle size for each site. The pebble count procedure was adapted from *Stream Channel Reference Sites: An Illustrated Guide to Field Technique* (Harrelson et. al. 1994). Pebble counts were conducted at 10 transects across the entire assessment reach. Transects were positioned based on the proportion of riffles, pools, runs, and glides in the assessment reach as estimated by visual inspection.

The count was conducted within the entire bankfull channel. The pebble counts provide roughness values necessary for calculations of velocity and discharge.

2.6.3 Rosgen Classification

The stream cross section, bed and bank material data, and slope were analyzed using the Ohio Department of Natural Resources Reference Reach Spreadsheet Version 4.3L (ODNR 2012). The following values and ratios were calculated:

Sinuosity	Entrenchment ratio	Bankfull cross section
Slope	Bankfull height	Velocity
Floodprone width	Bankfull width	Discharge
Width / depth ratio	Mean depth	Shear stress

A Rosgen Level II characterization (Rosgen 1996) was assigned to each stream reach based on field-collected data. Table 2-8 includes general descriptions for each channel type classification based on the Rosgen classification system for natural rivers (Rosgen 1996). The types are determined by a combination of factors including entrenchment, width-to-depth ratio, planform, and slope. Soil types, basin relief, and valley morphology also contribute to the channel type.

Table 2-8. Rosgen Level II channel type description

Channel Type	General Description (from Rosgen 1996)
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.
A	Steep, entrenched, confined, cascading, step/pool streams. High energy/ debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.
B	Moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools. Moderate width/depth ratio. Narrow, gently sloping valleys. Very stable plan and profile. Stable banks.
C	Low gradient, meandering, slightly entrenched, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks. Active lateral adjustment, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well-vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.
E	Low gradient, Highly sinuous, riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander/width ratio.
F	Entrenched, meandering riffle/pool channel on low gradients with high width/depth ratio and high bank erosion rates.
G	Entrenched “gully” step/pool and low width/depth ratio on moderate gradients. Narrow valleys. Unstable, with grade control problems and high bank erosion rates.

3.0 RESULTS

A total of 30 sites were sampled in the Upper Brighton Dam, Lower Brighton Dam, and Cattail Creek subwatersheds, 10 within each individual subwatershed. Site coordinates are provided in Appendix A. One biological QA/QC sample was collected in each subwatershed at stations where upstream habitat was considered to be similar. The summary results of the habitat assessment, biological assessment, land use, and Rosgen characterization (Rosgen 1996) are divided among the three subwatersheds and presented in detail in this section. A map of each subwatershed displaying the results of the RBP habitat assessment and BIBI is also presented. Full data results are displayed in Appendices A through F.

3.1 UPPER BRIGHTON DAM

In 2012, 5 of the 10 sampling sites in Upper Brighton Dam were on first-order streams, 3 were on second-order streams, and 2 were on third-order streams. The field QC sample was collected at site 02BD-210-R-2012D. The subwatershed had an average BIBI score of 4.33 and a "Good" condition rating; scores ranged from 3.33 to 4.67. The average RBP habitat assessment comparability score was 79.5 or "Supporting," and scores ranged from 76 ("Supporting") to 84 ("Supporting"). The average PHI score was 81.5 ("Minimally Degraded"). Channels in Upper Brighton Dam generally were classified as Rosgen type C or F channels, except for one B channel. Channel substrate at all sites was predominantly gravel. Table 3-1 summarizes the results for the Upper Brighton Dam subwatershed and Figure 3-1 shows the sites with BIBI and RBP comparability scores on a map.

Table 3-1. Upper Brighton Dam sampling results

SiteID	Drainage Area (acres)	Impervious Surface Percent	BIBI Score	BIBI Narrative Rating	Habitat Comparability Score	Habitat Narrative Rating	PHI Score	PHI Narrative Rating	Rosgen Channel Type
02BD-101-R-2012A	363.52	2.87	4.00	Good	84	Supporting	75.95	Partially Degraded	B4
02BD-104-R-2012B	526.60	4.63	4.67	Good	84	Supporting	76.30	Partially Degraded	C4
02BD-107-R-2012C	156.84	1.89	3.33	Fair	82	Supporting	82.29	Minimally Degraded	C4
02BD-120-F-2012G	358.78	2.88	4.67	Good	76	Supporting	74.08	Partially Degraded	F4
02BD-121-F-2012H	304.44	1.89	4.67	Good	80	Supporting	88.21	Minimally Degraded	F4
02BD-210-R-2012D*	5,513.41	3.12	4.00	Good	80	Supporting	84.09	Minimally Degraded	C4
02BD-216-R-2012F	5,651.27	3.05	4.00	Good	76	Supporting	84.87	Minimally Degraded	F4
02BD-226-F-2012J	845.80	1.90	4.67	Good	76	Supporting	82.00	Minimally Degraded	F4
02BD-313-R-2012E	10,537.50	0.97	4.67	Good	79	Supporting	83.71	Minimally Degraded	F4
02BD-323-F-2012I	8,447.41	1.12	4.67	Good	78	Supporting	83.03	Minimally Degraded	C4
Minimum	156.84	0.97	3.33	Fair	76.00	Supporting	74.08	Partially Degraded	
Maximum	10,537.50	4.63	4.67	Good	84.00	Supporting	88.21	Minimally Degraded	
Mean	3,270.56	2.43	4.33	Good	79.50	Supporting	81.45	Minimally Degraded	
Standard Deviation	3931.87	1.098	0.47		3.10		4.52		

* QC Sampling was conducted at this site

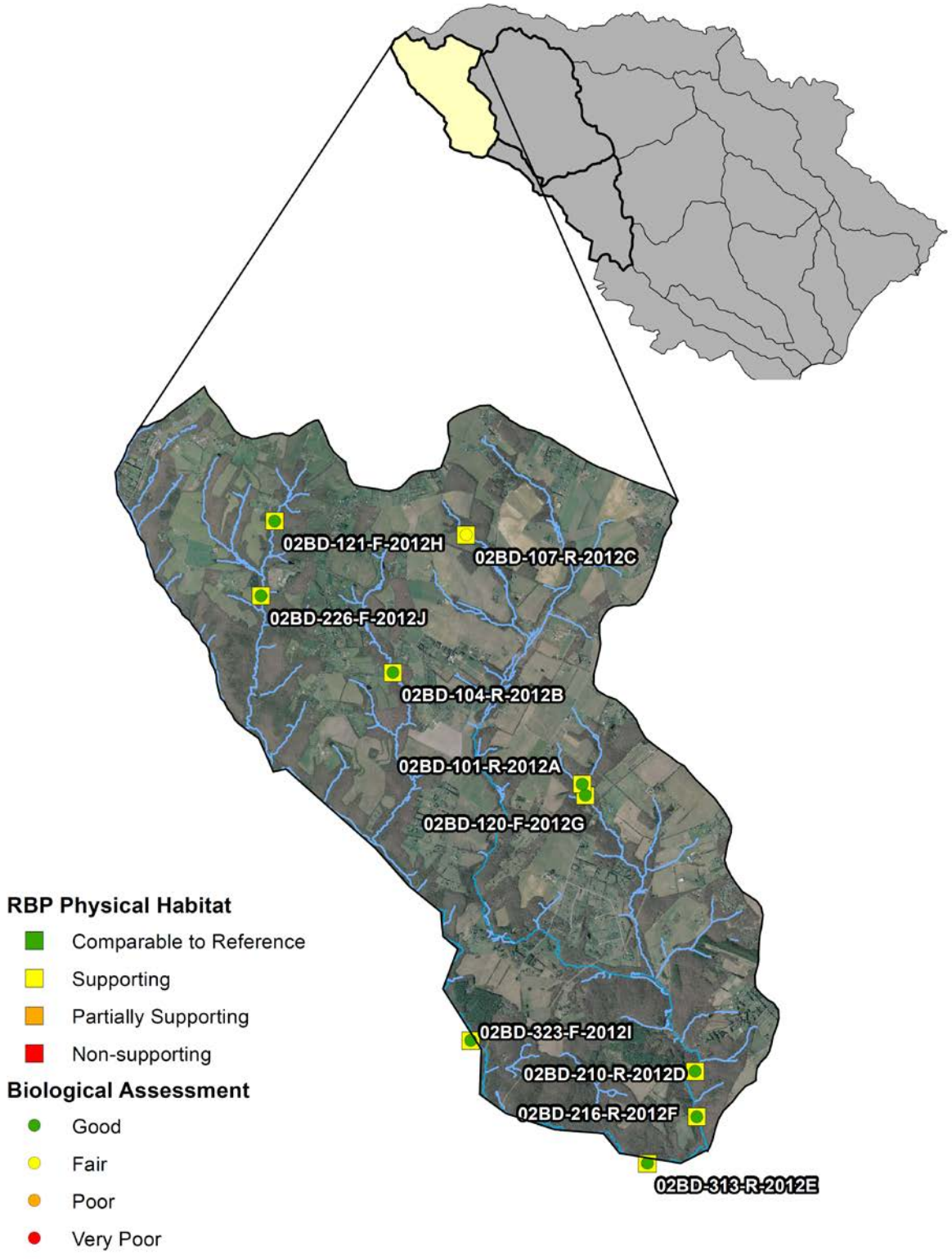

Figure 3-1. Upper Brighton Dam sampling results

02BD-101-R-2012A - This site is located adjacent to a gravel road; not surprisingly, gravel dominates the substrate in this B4 channel. Within the 364-acre drainage area, agriculture is the dominant land use (60%), followed by forested land (30%), and low-density residential development (10%). Impervious land cover accounts for only 3% of the drainage area. The RBP habitat assessment resulted in the highest comparability score in the subwatershed, an 84 ("Supporting"); the PHI score was 75.9 ("Partially Degraded"). Although no riparian buffer is present on the bank adjacent to the gravel road, the substrate is not embedded and provides excellent habitat for benthic macroinvertebrate species. A total of 36 taxa were present in the benthic macroinvertebrate sample, including 17 Ephmeroptera, Plecoptera, and Tricoptera (EPT) taxa. This site's overall BIBI score of 4.00 corresponds to a "Good" biological classification. All water quality parameters were within acceptable COMAR standards.

02BD-104-R-2012B - This site is located in a straight stream in a mature forested wetland. Gravel dominates the substrate of the C4 channel. Within the 527-acre drainage area, agriculture is the dominant land use (44%), followed by forested land (32%), and low-density residential development (25%). Five percent of the drainage area is impervious surface. The RBP habitat assessment resulted in a comparability score of 84, the highest in the subwatershed ("Supporting"); the PHI score was 76.3 ("Partially Degraded"). This is a generally nice stream with a variety of habitats and little bank erosion. A total of 33 taxa were present in the benthic macroinvertebrate sample, including 17 EPT taxa. Sixty percent of the individuals in the sample were rated as intolerant to urban stressors. This site's overall BIBI score of 4.67 corresponds to a "Good" biological classification. All water quality parameters were within acceptable COMAR standards.

02BD-107-R-2012C - This site is located in a mature forested wetland. Gravel dominates the substrate of the C4 channel. The 157-acre drainage area makes it the smallest drainage area in the subwatershed. Agriculture is the dominant land use in the upstream catchment (54%), followed by forested land (34%), and low-density residential development (12%). Only 2% of the drainage area is impervious surface. The RBP habitat assessment resulted in a comparability score of 82 ("Supporting"); the PHI score was 82.3 ("Minimally Degraded"). This is a remote stream with good benthic macroinvertebrate habitat, minimal bank erosion, and no embedded substrate; however, the benthic macroinvertebrate sample contained only 21 taxa and included only 8 EPT taxa. Forty-one percent of the individuals in the sample were in the family Chironomidae (midges). The site's overall BIBI score of 3.33 corresponds to "Fair" biological condition and was the lowest in the subwatershed. All water quality parameters were within acceptable COMAR standards.

02BD-120-F-2012G - This site is located on a small, shallow stream in a wetland, just downstream of site 02BD-101-R-2012A. Substrate in this F4 channel is predominately gravel. The dominant land use in the 359-acre drainage area is agriculture (62%), followed by forested land (29%), and low-density residential development (10%). Impervious surface accounts for only 3% of the drainage area. The RBP habitat assessment resulted in a comparability score of 76 ("Supporting"); the PHI score was 74.1 ("Partially Degraded"). Some bank erosion was evident. A total of 31 taxa were present in the benthic macroinvertebrate sample, including 18 EPT taxa. The sample had the highest percentage of individuals that are rated intolerant to urban

stressors (71%). The site's overall BIBI score of 4.67 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

02BD-121-F-2012H - This site is located on a small stream in a mature forested wetland. Substrate in this F4 channel is predominately gravel. The surrounding forest is used extensively for hunting, all-terrain vehicles, and horseback riding. The dominant land use in the 304-acre drainage area is agriculture (74%), followed by forested land (21%), and low-density residential development (5%). Only 2% of the drainage area is impervious surface. The RBP habitat assessment resulted in a comparability score of 80 ("Supporting"); the PHI score was 88.2 ("Minimally Degraded"). The stream has good habitat for benthic macroinvertebrates but exhibit some erosion. A total of 34 taxa were present in the benthic macroinvertebrate sample, including 13 EPT taxa. The sample had a high percentage of individuals that are intolerant to urban stressors (67%). The overall BIBI score of 4.67 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

02BD-210-R-2012D - This site is located in Patuxent State Park. Substrate in the C4 channel is predominately gravel. The dominant land use in the 5,513-acre drainage area is agriculture (54%), followed by forested land (31%), and low-density residential development (14%). Less than 1% of the drainage area is institutional land and wetlands. Impervious surface accounts for 3% of the drainage area. The RBP habitat assessment resulted in a comparability score of 80 ("Supporting"); the PHI score was 84.1 ("Minimally Degraded"). This is a well-riffled stream with a good amount of benthic habitat, but it shows moderate signs of erosion. A total of 37 taxa were present in the benthic macroinvertebrate sample, including 16 EPT taxa. The sample contained the smallest percentage of individuals that are intolerant to urban stressors (32%) among sites in the subwatershed. The site's overall BIBI score of 4.00 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

02BD-216-R-2012F - This site is a deep, second-order stream dominated by pools and runs. Gravel dominates the substrate of the F4 channel. The dominant land use in the 5,651-acre drainage area is agriculture (53%), followed by forested land (32%), and low-density residential development (14%). Less than 1% of the drainage area is institutional land and wetlands. Impervious surface accounts for 3% of the drainage area. The RBP habitat assessment resulted in a comparability score of 76 ("Supporting"); the PHI score was 84.9 ("Minimally Degraded"). The stream banks show a moderate degree of erosion. A total of 39 taxa were present in the benthic macroinvertebrate sample, including 19 EPT taxa. The site's overall BIBI score of 4.00 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

02BD-226-F-2012J - This site was located in the northwestern portion of the subwatershed. Gravel the substrate of the F4 channel. The dominant land use in the 846-acre drainage area is agriculture (54%), followed by forested land (43%), and low-density residential development (3%). Only 2% of the drainage area is impervious surface. The RBP habitat assessment resulted in a comparability score of 76 ("Supporting"); the PHI score was 82 ("Minimally Degraded"). This site has good benthic macroinvertebrate habitat but shows evidence of signs of erosion, especially at a large, deep pool. A total of 31 benthic macroinvertebrate taxa were present in the

sample, including 21 EPT taxa. Only 5% (the lowest in the subwatershed) of individuals in the sample belonged to the family Chironomidae (midges), and 70% of the individuals present were intolerant to urban stressors (the highest in the subwatershed). The site's overall BIBI score of 4.67 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

02BD-313-R-2012E - This site is located on the Patuxent River in a mature forest at the extreme southern portion of the subwatershed. Gravel dominates the substrate of the F4 channel. The 10,537-acre drainage area is the largest in the subwatershed. The catchment upstream of the site is fairly evenly divided between agricultural land use (43%) and forested land use (47%). Low-density residential development accounts for 8% of the land use in the upstream catchment. The remaining 2% of the drainage consists of small areas of commercial/industrial land, institutional land, medium-density residential development, and open water. The RBP habitat assessment resulted in a comparability score of 79 ("Supporting"); the PHI score was 83.7 ("Minimally Degraded"). Although the site has good benthic habitat, it exhibits signs of moderate bank erosion. The sample had the highest total number of benthic macroinvertebrate taxa in the subwatershed (47), as well as the highest number of EPT taxa (22). The site's overall BIBI score of 4.67 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

02BD-323-F-2012I - This site is located on the Patuxent River and is characterized by a large pool at the midpoint. Gravel dominates the substrate of the C4 channel. The 8,447-acre drainage area is fairly evenly divided between agricultural land use (44%) and forested land use (44%). Low-density residential development accounts for 10% of the land use in the upstream catchment. The remaining 2% of the drainage consists of small amounts of commercial/ industrial land, institutional land, medium-density residential development, and open water. One percent of the catchment consists of impervious surface. The RBP habitat assessment resulted in a comparability score of 78 ("Supporting"); the PHI score was 83 ("Minimally Degraded"). The site has good habitat for benthic macroinvertebrates but is characterized by signs of bank erosion, especially at the large pool. A total of 35 benthic macroinvertebrates were present in the sample, including 20 EPT taxa. Only 9% of the total individuals present in the sample were in the family Chironomidae (midges). The site's overall BIBI 4.67 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

3.2 LOWER BRIGHTON DAM

In 2012, 7 of the 10 sampling sites in Lower Brighton Dam were on first-order streams, and 3 were on third-order streams. The field QC sample was collected at site 05BD-125-F-2012J. The subwatershed had an average BIBI score of 3.83 and a "Fair" condition rating; scores ranged from 3.33 to 5.00. The average RBP habitat assessment comparability score was 72 or "Partially Supporting," and scores ranged from 48 ("Non-Supporting") to 84 ("Supporting"). The average PHI score was 67.6 ("Partially Degraded"). Half of the stream channels assessed in Lower Brighton Dam were classified as Rosgen type F. Two of the remaining channels were classified as C, two as E, and one as a G stream. Substrates were predominantly gravel, but two sites had predominately sand substrates. Table 3-2 summarizes the results

for the Lower Brighton Dam subwatershed and Figure 3-2 shows the sites with BIBI and RBP comparability scores on a map.

Table 3-2. Lower Brighton Dam sampling results

SiteID	Drainage Area (acres)	Impervious Surface Percent	BIBI Score	BIBI Narrative Rating	Habitat Compara-bility Score	Habitat Narrative Rating	PHI Score	PHI Narrative Rating	Rosgen Channel Type
05BD-101-R-2012A	825.86	7.09	4.00	Good	66	Partially Supporting	74.34	Partially Degraded	E4
05BD-104-R-2012B	98.73	7.87	3.33	Fair	74	Partially Supporting	71.19	Partially Degraded	C4
05BD-107-R-2012C	1,205.97	6.28	4.67	Good	76	Supporting	68.04	Partially Degraded	F4
05BD-110-R-2012D	94.64	13.07	2.00	Poor	48	Non-supporting	43.74	Severely Degraded	E5
05BD-121-F-2012H	377.63	3.90	3.00	Fair	75	Partially Supporting	58.77	Degraded	G4
05BD-124-F-2012I	52.15	11.55	3.33	Fair	72	Partially Supporting	63.79	Degraded	C5
05BD-125-F-2012J*	668.74	7.82	5.00	Good	78	Supporting	71.19	Partially Degraded	F4
05BD-314-R-2012E	20,868.12	1.36	4.00	Good	84	Supporting	76.06	Partially Degraded	F4
05BD-316-R-2012F	18,995.95	1.49	4.67	Good	71	Partially Supporting	71.83	Partially Degraded	F4
05BD-319-F-2012G	21,030.13	1.37	4.33	Good	76	Supporting	76.62	Partially Degraded	F4
Minimum	52.15	1.36	2.00	Poor	48.00	Non-supporting	43.74	Severely Degraded	
Maximum	21,030.13	13.07	5.00	Good	84.00	Supporting	76.62	Partially Degraded	
Mean	6,421.79	6.18	3.83	Fair	72.00	Partially Supporting	67.56	Partially Degraded	
Standard Deviation	9597.13	4.17	0.92		9.65		10.02		

* QC Sampling was conducted at this site

05BD-101-R-2012A - This site is located on an easement where half the stream is in a grassy area and the other is in forest. Three exposed pipes lay on the stream bed. Gravel dominates the substrate of this E4 channel. Within the 826-acre drainage area, the predominant land use is low-density residential (57%), followed by agriculture (34%) and forest (9%). Impervious land cover accounts for 7% of the drainage area, which is just above the subwatershed average of 6%. The RBP habitat assessment resulted in a comparability score of 66 ("Partially Supporting"); the PHI score was 74.3 ("Partially Degraded"). Banks appear to be extremely unstable; slumping is extensive. A total of 43 taxa were present in the benthic macroinvertebrate sample, including 11 EPT taxa. Although 41% of the individuals in the sample were in the Chironomidae family (midges), the site's overall BIBI score of 4.00 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

05BD-104-R-2012B - This site is a relatively straight stream along which one bank is a manicured lawn and the other is forest. Gravel dominates the substrate of this C4 channel. Within the 99-acre drainage area, the predominant land use is low-density residential development (72%), followed by forest (19%) and agriculture (9%). Impervious cover accounts for 8% of the drainage area. The RBP habitat assessment resulted in a comparability score of 74 ("Partially Supporting"); the PHI score was 71.2 ("Partially Degraded"). Banks appeared somewhat unstable. A total of 37 taxa were present in the benthic macroinvertebrate sample, including 10 EPT taxa. This site's overall BIBI score of 3.33 (corresponds to "Fair" biological condition) us just below the subwatershed average of 3.83. All water quality parameters were within acceptable COMAR standards.

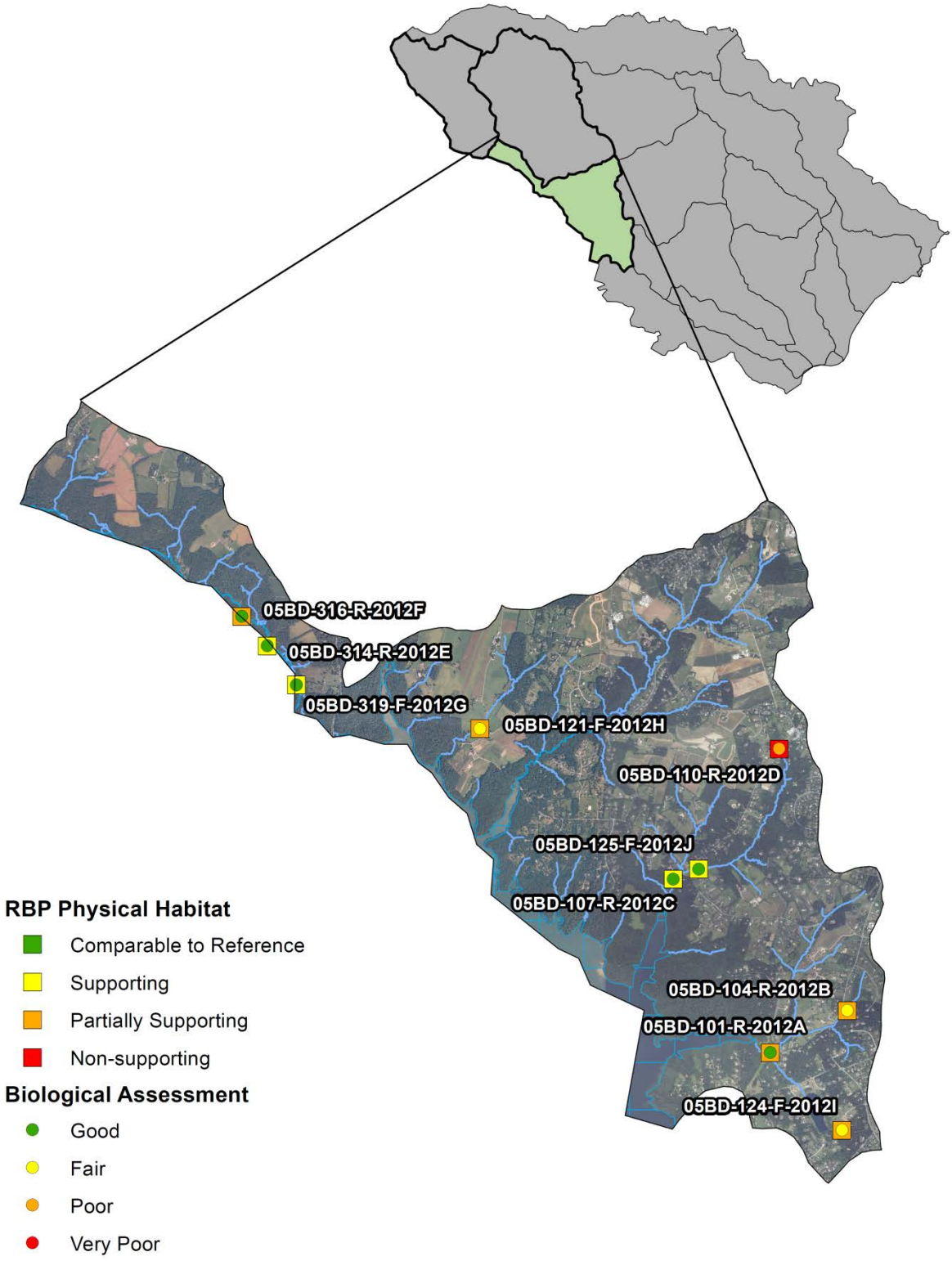

Figure 3-2. Lower Brighton Dam sampling results

05BD-107-R-2012C - Gravel dominates the substrate in this F4 channel. Within the 1,206-acre drainage area, land use is distributed fairly evenly between low-density residential (37%), agriculture (32%), and forested land (30%). The remaining 1% of the drainage encompasses small areas of commercial/industrial, open water, and institutional land. Impervious cover accounts for 6% of the drainage area. The RBP habitat assessment resulted in a comparability score of 76 ("Supporting"); the PHI score was 68 ("Partially Degraded"). This site is directly adjacent to a road and has moderately unstable banks, especially in the pool at the 25-meter mark. Fifty percent of the substrate was embedded. A total of 39 taxa were present in the benthic macroinvertebrate sample, including 18 EPT taxa. This sample contained one of the greatest percentages of taxa intolerant to urban stressors (61%). The site's overall BIBI score of 4.67, corresponding to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

05BD-110-R-2012D - This site contained many pieces of asphalt and is overgrown with multiflora rose. Sand is the dominant substrate in this E5 channel. Within the 95-acre drainage area, the dominant land use is low-density residential (74%), followed by agriculture (18%). Eight percent of the land use upstream of the site is commercial/industrial, and less than 1% is institutional. Impervious cover accounts for 13% of the drainage area, which is the largest percentage of impervious cover in the subwatershed. The RBP habitat assessment resulted in a comparability score of 48 ("Non-Supporting"); the PHI score was 43.7 ("Severely Degraded"). Both of these habitat scores were the lowest ones in the subwatershed. The site is located directly adjacent to a road and has highly embedded substrate (90%), poor habitat for benthic macroinvertebrates, and moderately unstable banks. A total of 30 benthic taxa were present in the benthic macroinvertebrate sample, including only 3 EPT taxa. This sample had one of the highest percentages of individuals in the subwatershed in the family Chironomidae (midges) at 72%. It also had the lowest percentage of individuals intolerant to urban stressors (13%). The site's overall BIBI score of 2.00 corresponds to "Poor" biological condition (the lowest in the subwatershed). All water quality parameters were within acceptable COMAR standards.

05BD-121-F-2012H - This site is located in a fenced off cow pasture where cows have access to the stream. Gravel dominates the substrate in this G4 site. Within the 378-acre drainage area, the dominant land use is agriculture (63%), followed by low-density residential development (28%), and forested land (9%). Only 4% of the drainage area is impervious surface. The RBP habitat assessment resulted in a comparability score of 75 ("Partially Supporting"); the PHI score was 58.8 ("Degraded"). The only shading (10%) provided to this site is from multiflora rose, there are no trees adjacent to the stream. A total of 37 benthic taxa were present in the benthic macroinvertebrate sample, including only 5 EPT taxa. This sample had one of the highest percentages of individuals in the family Chironomidae (midges) at 72%. It also had the second lowest percentage of individuals intolerant to urban stressors (19%). The site's overall BIBI score of 3.00 corresponds to "Fair" biological condition. Water quality results indicated that all parameters were within acceptable COMAR standards.

05BD-124-F-2012I - This site is a fairly straight stream located in a wooded area in the middle of residential property. Sand was the dominant substrate in this C5 stream. The 52-acre drainage area is the smallest one in this subwatershed. The catchment is nearly 100% low-density

residential development; less than 1% of the area is forested land. Impervious land cover accounts for 12% of the drainage area, one of the highest values in the subwatershed. The RBP habitat assessment resulted in a comparability score of 72 ("Partially Supporting"); the PHI score was 63.8 ("Degraded"). A total of 36 benthic taxa were present in the benthic macroinvertebrate sample, including 9 EPT taxa. The site's overall BIBI score of 3.33 corresponds to "Fair" biological condition. All water quality parameters were within acceptable COMAR standards.

05BD-125-F-2012J – This 669-acre drainage area is dominated by low-density residential land use (53%), followed by forested land (27%) and agriculture (19%). One percent of the catchment upstream of the site is commercial/industrial land and less than 1% of the land use is institutional. Eight (8) percent of the drainage area is impervious land cover. Gravel dominates the substrate of this F4 channel. The RBP habitat score was 78 ("Supporting"); the PHI score was 71.2 ("Partially Degraded"). A total of 32 benthic taxa were present in the benthic macroinvertebrate sample, including 15 EPT taxa, the highest percentage of EPT taxa in the subwatershed. Only 17% of individuals in the sample were from the family Chironomidae, and the sample contained the highest percentage of individuals intolerant to urban stressors (78%). The site's "perfect" overall BIBI score of 5.00 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

05BD-314-R-2012E – This site is a wide, high-banked stream with diverse riffle habitat on the mainstem of the Patuxent River. Gravel dominates the substrate of this F4 channel. Land use in the very large (20,868 acres) upstream catchment is almost evenly split between agriculture (47%) and forested land (43%). Eight (8) percent of the land use is low-density residential development, and the remaining 2% is split amongst small amounts of commercial/industrial, institutional, medium-density residential development, open water, and wetlands. Impervious land cover accounts for only 1% of the drainage area. The RBP habitat comparability score was the highest in the subwatershed, a 84 ("Supporting"); the PHI score was 76.1 ("Partially Degraded"). This site has 100% shading, no embedded substrate, and minimal bank erosion. A total of 29 benthic taxa were present in the benthic macroinvertebrate sample, including 11 EPT taxa. The site's overall BIBI score of 4.00 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

05BD-316-R-2012F – Gravel dominates the substrate of this F4 channel. Within the 18,996-acre drainage area of this site, land use is almost evenly split between agriculture (46%) and forested land (44%). Nine (9) percent of the land use is low-density residential development, and the remaining 2% is split amongst small amounts of commercial/industrial, institutional, medium-density residential development, open water, and wetlands. Impervious land cover accounts for only 1% of the drainage area. The RBP habitat assessment resulted in a comparability score of 71("Partially Supporting"); the PHI score was 71.8 ("Partially Degraded"). One bank is severely eroded. A total of 31 benthic taxa were present in the benthic macroinvertebrate sample, including 15 EPT taxa. The sample had the lowest percentage of individuals (12%) in the Chironomidae family (midges). The site's overall BIBI score of 4.67 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

05BD-319-F-2012G – This site is a broad, quick moving stream dominated by pools. Gravel dominates the substrate of this F4 channel. With a catchment area of 21,030 acres, this site has the largest catchment area in the subwatershed. Land use in the drainage area is almost evenly split between agriculture (48%) and forested land (43%). Eight percent of the land use is low-density residential development, and the remaining 1% is split amongst small amounts of commercial/industrial, institutional, medium-density residential development, open water, and wetlands. Only 1% of the drainage area is impervious. The RBP habitat assessment resulted in a comparability score of 76 ("Supporting"); the PHI score was 76.6 ("Partially Degraded"). A total of 32 benthic taxa were present in the benthic macroinvertebrate sample, including 15 EPT taxa. The site's overall BIBI score of 4.33 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

3.3 CATTAIL CREEK

In 2012, 7 of the 10 sampling sites in Cattail Creek were on first-order streams, 1 was on a second-order stream, and 2 were on third-order streams. The field QC sample was collected at site 03CC-316-R-2012F. The subwatershed had an average BIBI score of 3.87 and a "Fair" condition rating; scores ranged from 2.67 to 4.33. The average RBP habitat assessment comparability score was 75.7 or "Supporting," and scores ranged from 52 ("Non-Supporting") to 86 ("Supporting"). The average PHI score was 69.4 ("Partially Degraded"). Most channels were classified as Rosgen type C or F, except for one B channel and one G channel. Gravel was the dominant channel substrate at all sites but one, where cobble dominated. Table 3-3 summarizes the results for the Cattail Creek subwatershed and Figure 3-3 shows the sites with BIBI and RBP comparability scores on a map.

Table 3-3. Cattail Creek sampling results

iteID	Drainage Area (acres)	Impervious Surface Percent	BIBI Score	BIBI Narrative Rating	Habitat Comparability Score	Habitat Narrative Rating	PHI Score	PHI Narrative Rating	Rosgen Channel Type
03CC-101-R-2012A	1,669.43	8.56	4.00	Good	72	Partially Supporting	71.16	Partially Degraded	C4
03CC-104-R-2012B	905.58	6.72	4.00	Good	78	Supporting	76.15	Partially Degraded	F4
03CC-109-R-2012C	375.05	8.63	3.67	Fair	70	Partially Supporting	81.43	Minimally Degraded	C4
03CC-110-R-2012D	249.49	2.91	4.00	Good	83	Supporting	82.64	Minimally Degraded	F4
03CC-119-F-2012G	1,044.95	3.99	3.33	Fair	82	Supporting	80.65	Minimally Degraded	F4
03CC-121-F-2012H	1,476.54	8.14	2.67	Poor	70	Partially Supporting	56.54	Degraded	C4
03CC-125-F-2012J	1,317.88	4.27	4.33	Good	81	Supporting	71.78	Partially Degraded	B4
03CC-215-R-2012E	708.85	6.35	4.00	Good	52	Non-supporting	25.27	Severely Degraded	G4
03CC-316-R-2012F*	9,521.95	5.56	4.33	Good	83	Supporting	65.66	Severely Degraded	C4
03CC-323-F-2012I	9,886.56	5.53	4.33	Good	86	Supporting	82.76	Minimally Degraded	F3
Minimum	249.49	2.91	2.67	Poor	52.00	Non-supporting	25.27	Severely Degraded	
Maximum	9,886.56	8.63	4.33	Good	86.00	Supporting	82.76	Minimally Degraded	
Mean	2,715.63	6.07	3.87	Fair	75.70	Supporting	69.40	Partially Degraded	
Standard Deviation	3711.64	1.99	0.53		10.14		17.66		

* QC Sampling was conducted at this site

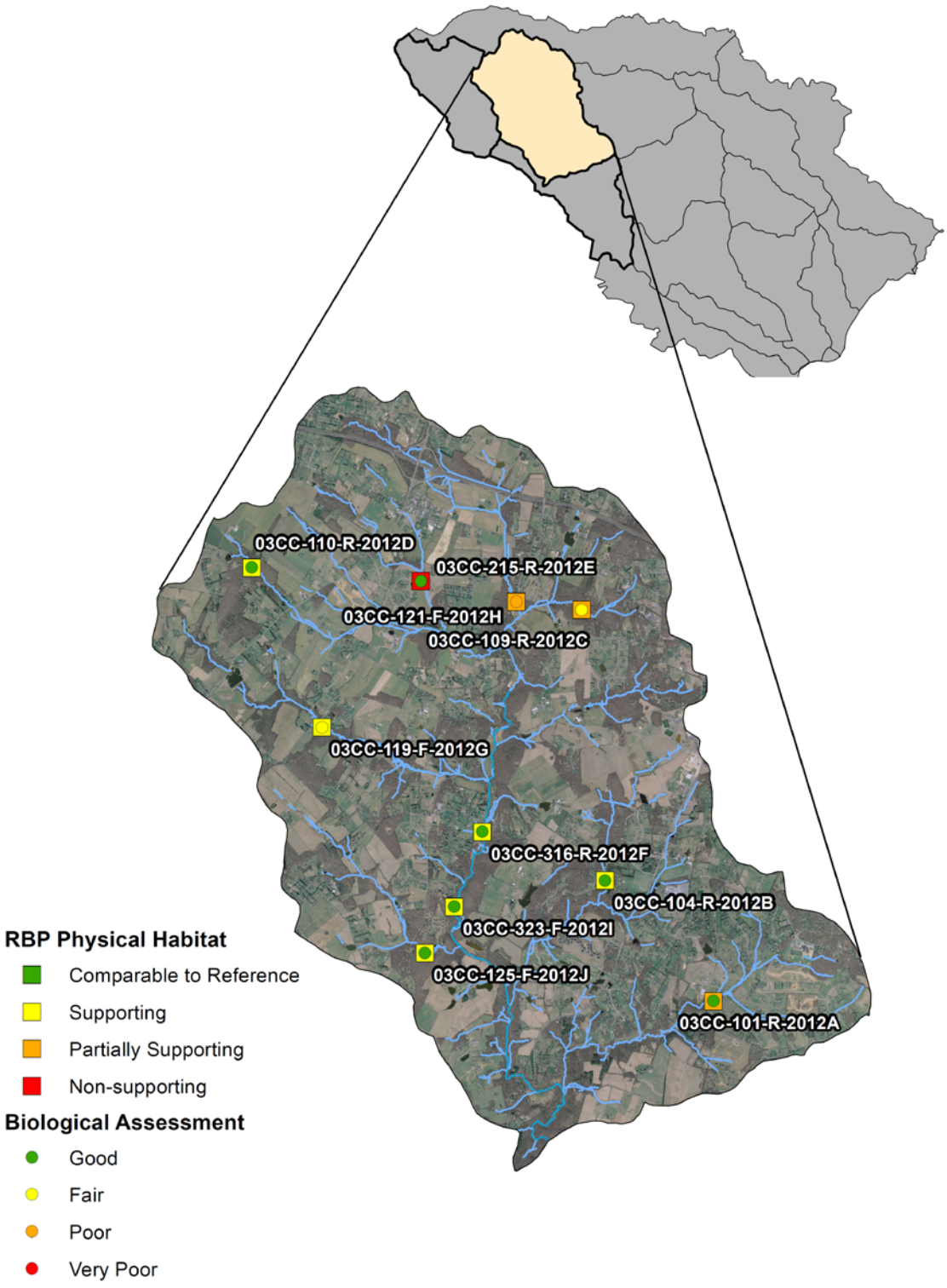

Figure 3-3. Cattail Creek sampling results

03CC-101-R-2012A – Gravel substrate dominates the C4 channel. The land use in the 1,669-acre drainage area is fairly evenly distributed between agricultural land use (42%) and low-density residential development (47%). Eight (8) percent of the catchment is forested land, and the remaining 3% is institutional. Impervious surface accounts for 9% of the upstream catchment. The RBP habitat assessment resulted in a comparability score of 72 ("Partially Supporting"); the PHI score was 71.2 ("Partially Degraded"). The site has good habitat for benthic macroinvertebrates, but exhibits signs of bank erosion. A total of 36 benthic macroinvertebrate taxa were present in the sample, including 13 EPT taxa. The site's overall BIBI score of 4.00 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

03CC-104-R-2012B – This is a slow moving stream on Longwood Estate. Gravel substrate dominates the F4 channel. Land use in the 905.6-acre drainage area is predominantly agriculture (53%), followed by low-density residential development (23%). Fifteen (15) percent of the catchment area is forested land, and 8% is institutional land. Less than 1% of the catchment is commercial/industrial land. Impervious surface accounts for 7% of the drainage area. The RBP habitat assessment resulted in a comparability score of 78 ("Supporting"); the PHI score was 76.2 ("Partially Degraded"). This is a good quality stream except for some evidence of moderate bank erosion. There were a total of 28 benthic macroinvertebrate taxa in the sample, with 12 of them EPT taxa. The site's overall BIBI score of 4.00 corresponds with "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

03CC-109-R-2012C – This C4 stream is located in a forested area. Gravel dominates the substrate. The land use in the 375-acre drainage area is nearly evenly distributed between low-density residential development (41%) and forested land (38%). Agriculture makes up the remaining 19% of the land use in the catchment. Impervious surfaces account for 9% of the drainage area. The RBP habitat assessment resulted in a comparability score of 70 ("Partially Supporting"); the PHI score was 81.4 ("Minimally Degraded"). This stream has good habitat for benthic macroinvertebrates and minimal erosion. A total of 38 benthic macroinvertebrate taxa were present in the sample, including 12 EPT taxa. Forty-eight percent of the individuals in the sample were in the family Chironomidae (midges), and 27% were rated as intolerant to urban stressors. The site's overall BIBI score of 3.67 corresponds to "Fair" biological condition. All water quality parameters were within acceptable COMAR standards.

03CC-110-R-2012D – Gravel substrate dominates this F4 stream. The 249-acre drainage area is the smallest in the subwatershed. Agriculture dominates land use (84%), followed by forested land (12%) and low-density residential development (4%). Three (3) percent of the catchment area is impervious surface. The RBP habitat assessment resulted in a comparability score of 83 ("Supporting"); the PHI score was 82.6 ("Minimally Degraded"). This stream has good habitat for benthic macroinvertebrates but exhibits evidence of signs of bank erosion. A total of 43 benthic macroinvertebrate taxa were present in the sample, including 13 EPT taxa. The sample from this site had one of the highest percentages of individuals (48%) in the family Chironomidae (midges) in the subwatershed but also had one of the highest percentages of individuals rated as intolerant to urban stressors (47%). The site's overall BIBI score of 4.00 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

03CC-119-F-2012G – Gravel substrate dominates this F4 stream. The 1045-acre drainage area is dominated by agricultural land use (78%), followed by forested land (17%), low-density urban development (5%). The RBP habitat assessment resulted in a comparability score of 82 ("Supporting"); the PHI score was 80.7 ("Minimally Degraded"). This stream has good habitat and minimal signs of erosion. A total of 37 benthic macroinvertebrate taxa were present in the sample, including only 9 EPT taxa. The sample from this site had one of the highest percentages of individuals in the family Chironomidae (midges; 48%) in the subwatershed and one of the lowest percentages of individuals rated as intolerant to urban stressors (15%). The site's overall BIBI score of 3.33 corresponds to "Fair" biological condition. All water quality parameters were within acceptable COMAR standards.

03CC-121-F-2012H – Gravel substrate dominates this G4 stream. Land use in the 1,477-acre drainage area varies significantly; agriculture dominates (53%), followed by low-density residential development (21%), and forested land (15%). Small amounts of numerous other land uses contribute to the remaining 11% of the drainage area: transportation (4%), open land (4%), commercial/industrial (2%), institutional (2%), and medium-density residential development (< 1%). Impervious surface accounts for 8% of the drainage area. The RBP habitat assessment resulted in a comparability score of 70 ("Partially Supporting"); the PHI score was 56.5 ("Degraded"). This is a sinuous stream with severely eroded banks. A total of 30 macroinvertebrate taxa were present in the sample, including only 3 EPT taxa (the lowest in the subwatershed). The percentage of individuals in the family Ephemeroptera (mayflies) was only 12%; whereas, the percentage of individuals in the family Chironomidae (midges) was the highest in the subwatershed (52%). The percentage of individuals intolerant to urban stressors was one of the lowest in the subwatershed at 22%. The site received the lowest overall BIBI score in the subwatershed, a 2.67 (biological classification of Poor). All water quality parameters were within acceptable COMAR standards.

03CC-125-F-2012J – Gravel substrate dominates this B4 stream. Land use in the 1,318-acre drainage area is predominately agriculture (72%), followed by forested land (19%), and low-density residential development (9%). Four (4) percent of the drainage area was accounted for by impervious surfaces. The RBP habitat assessment resulted in comparability score of 81 ("Supporting"); the PHI score was 71.8 ("Partially Degraded"). The stream has moderate habitat available to benthic macroinvertebrates and little or no evidence of erosion. A total of 33 benthic macroinvertebrate taxa were present in the sample, including 15 EPT taxa. The sample had the lowest percentage of individuals in the family Chironomidae (midges; 15%) in the subwatershed and the highest percentage of individuals intolerant to urban stressors (49%). The site's overall BIBI score of 4.33 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

03CC-215-R-2012E – This stream runs through a retired pasture and is a gravel-dominated G4 channel. Land use in this 709-acre drainage area is predominately agriculture (62%), followed by low-density residential development (24%), and forested land (9%). The remaining 5% of the drainage area is divided among institutional land (3%), commercial industrial land (2%), and medium-density residential development (< 1%). Six (6) percent of the land use in the drainage area is impervious surface. The RBP habitat assessment resulted in the lowest comparability score in the subwatershed, a 52 ("Non-supporting"). The PHI score was also the lowest in the

subwatershed, a 25.3 ("Severely Degraded"). This stream has no natural shading and embedded substrate throughout 50% of the stream channel. Benthic macroinvertebrate habitat quality is degraded, and signs of moderate erosion are apparent throughout the area. Nevertheless, a relatively high number of benthic macroinvertebrate taxa were present in the sample (38), including a relatively high number of EPT taxa (11). The sample had the highest percentage of individuals in the family Chironomidae (midges; 52%) in the subwatershed. The site's overall BIBI score of 4.00 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

03CC-316-R-2012F – Gravel substrate dominates this C4 stream. Land use in the 9,522-acre drainage area is predominately agriculture (57%), followed by forested land (22%), and low-density residential development (18%). Small amounts of numerous other land uses contribute to the remaining 3% of the drainage area. One percent of the land use is institutional, and each of the following types represents less than 1% of the drainage area: commercial/ industrial, medium-density residential development, open land, open water, and transportation. Six (6) percent of the drainage area is covered in impervious surface. The RBP habitat assessment resulted in a comparability score of 83 ("Supporting"); the PHI score was 65.6 ("Severely Degraded"). Although the site has adequate habitat for benthic macroinvertebrates, it is only 30% shaded and has evidence of signs of bank erosion. A total of 36 benthic macroinvertebrate taxa were present in the sample, including 13 EPT taxa. The site's overall BIBI score of 4.33 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

03CC-323-F-2012I – Cobble substrate dominates this F3 stream located in a forested area. The 9,887-acre drainage area is the largest in the subwatershed. Land use in the upstream catchment is predominately agriculture (56%), followed by forested land (23%), and low-density residential development (18%). Small amounts of numerous other land uses contribute to the remaining 3% of the drainage area. One percent of the land use is institutional, and each of the following types represents less than 1% of the drainage area: commercial/industrial, medium-density residential development, open land, open water, and transportation. Six percent of the drainage area is covered in impervious surface. The RBP habitat assessment resulted in the highest comparability score in the subwatershed, an 86 ("Supporting"); the PHI score was 82.8 ("Minimally Degraded"). This cobbled stream has some severe erosion issues. A total of 31 benthic macroinvertebrate taxa were present in the sample, including 16 EPT taxa. The site's overall BIBI score of 4.33 corresponds to "Good" biological condition. All water quality parameters were within acceptable COMAR standards.

4.0 DISCUSSION AND COMPARISON

4.1 DISCUSSION OF 2012 ASSESSMENT RESULTS

Bioassessment – Biological results for 2012 in Upper Brighton Dam, Lower Brighton Dam, and Cattail Creek indicate subwatersheds that are in good to fair condition. Twenty-two (22) of the sites sampled received overall BIBI ratings of "Good," and six received ratings of "Fair." Only two sites (one in Lower Brighton Dam and one in Cattail Creek) received ratings of "Poor." Duplicate benthic samples were taken at three sites, one within each subwatershed. Comparisons between the original sample and the duplicate were analyzed (see Appendix F for detailed analyses including performance standards).

Physical Habitat – RBP habitat assessment results indicate average subwatershed physical habitat conditions that are "Supporting" in all of Upper Brighton Dam and Cattail Creek. Average RBP habitat conditions are "Partially Supporting" in Lower Brighton Dam. None of the sites sampled in any of the three subwatersheds were "Comparable to Reference." (as defined as > 90% of the maximum score) Twenty sites, including all of the sites in Upper Brighton Dam, were "Supporting." Eight sites were "Partially Supporting" and two were "Non-Supporting" (one each located in Lower Brighton Dam and Cattail Creek). Site 05BD-110-R-2012D in Lower Brighton Dam rated "Non-Supporting" and also received a "Poor" biological condition rating.

The PHI results indicate average subwatershed physical habitat conditions that are "Partially Degraded" in all of Lower Brighton Dam and Cattail Creek. Upper Brighton Dam had an average PHI score that indicated "Minimally Degraded" conditions. Eleven sites were "Minimally Degraded" (7 in Upper Brighton Dam and 4 in Cattail Creek). Thirteen sites were "Partially Degraded" (7 in Lower Brighton Dam, 3 in Upper Brighton Dam, and 3 in Cattail Creek). Three sites were "Degraded" (2 in Lower Brighton Dam and 1 in Cattail Creek), and three were "Severely Degraded (1 in Lower Brighton Dam and 2 in Cattail Creek). Again, site 05BD-110-R-2012D in Lower Brighton Dam received the lowest possible narrative rating for the index.

Water Quality – All sites in all subwatersheds showed water quality values (i.e., temperature, dissolved oxygen, pH, conductivity, and turbidity) well within accepted COMAR ranges. A site-by-site breakdown of field-measured water quality parameters is included in Appendix B.

Geomorphology – The geomorphic assessment indicates a variable system. Many of the channels sampled throughout the subwatersheds were classified as stable type B, C, and E channels; however, a good portion of channels were classified as unstable, incised F and G channels. Gravel is the dominant substrate type in most of the sampled reaches; however, sand- and cobble-dominant streams also were present.

Imperviousness – The average percentage of impervious area in the upstream catchments in the Upper Brighton Dam is 2%. Six percent of the land in the upstream catchments in Lower

Brighton Dam and Cattail Creek is impervious surface. Imperviousness in the areas draining to each sampling site ranges from less than 1% to 13% (see Appendix A for impervious values). The benthic community in a freshwater stream can be adversely affected by impervious cover and associated runoff at values below 10% (CWP 2003). A statistical correlation between imperviousness and the BIBI was identified and is discussed in the following section.

Pearson Correlations - The Pearson correlation coefficient measures the linear association between two variables. Values of the coefficient range from -1 to 1. Negative values indicate an inverse relationship between the two values (i.e., when one variable increases the other decreases), while positive values indicate a positive relationship (i.e., both variables increase). The absolute value of the number indicates the strength of the association, with larger absolute values indicating stronger associations between the two variables. The significance level is a measure of the likelihood that the two variables are related, with smaller values indicating a stronger likelihood of relation. A significance level of 0.05 is typically used as a cutoff for strong correlations. The interpretation of a correlation is somewhat arbitrary, especially as values move away from +/- 1. Table 4-1 includes correlation and significance values. For the purposes of this analysis and because they were all significantly correlated with each other, percentage impervious was used as a proxy for all of the other land use types (percent low-density development, percent forested land, and percent agricultural land).

Table 4-1. Pearson correlations

		RBP Habitat Assessment	**PHI Habitat Assessment**	**Percent Imperviousness**	**Specific Conductance**
BIBI n=30	Correlation	0.47	0.44	-0.55	-0.49
	Significance	0.0086	0.0138	0.0017	0.0056
RBP Habitat Assessment n=30	Correlation		0.77	-0.58	-0.43
	Significance		< 0.001	0.0007	0.0164
PHI Habitat Assessment n=30	Correlation			-0.55	-0.47
	Significance			0.0017	0.009
Percent Imperviousness n= 30	Correlation				0.68
	Significance				< 0.001

Correlations were significant between BIBI scores and four parameters: percentage imperviousness, RBP Habitat Score, PHI Habitat Score, and Specific Conductance. The percentage of imperviousness indicates a strong negative relationship to the BIBI score (correlation of -0.55 with a significance level of 0.0017), implying biological condition decreases with increased watershed imperviousness. Specific conductance and BIBI scores also showed a strong negative correlation (correlation of -0.49 with a significance level of 0.0056). These results support the notion that overall water quality and biological condition are likely being affected by the amount of development (i.e., imperviousness) in the watershed. There was also a strong positive correlation between percent imperviousness and specific conductance (correlation of 0.68 with a

significance level of < 0.001), suggesting that increased conductivity is due in a large part to urban runoff. In addition, there was a strong negative correlation between both measures of habitat quality and imperviousness, inferring that hydrologic regimes are degrading the physical habitat through more intense discharges and higher peak flows in more developed watersheds.

The correlation with both measures of habitat quality and the BIBI scores were also positively significant (correlation of 0.47 with a significance value of 0.0086 for the RBP habitat assessment and correlation of 0.44 with a significance value of 0.0138 for the PHI assessment). This suggests that physical habitat conditions directly affect to the biological condition of a stream.

4.2 COMPARISON OF 2001, 2005, AND 2012 BIOASSESSMENT DATA

BIBI - Table 4-2 summarizes the 2001, 2005, and 2012 biological index data, and Figure 4-1 is a box plot comparing BIBI scores for each subwatershed (current BIBI calculations were used for all rounds).

In Upper Brighton Dam, the Round 1 assessment (2001) indicated that the subwatershed was in "Good" biological condition overall, according to the updated BIBI scores (BIBI = 4.00 ± 0.38). Round 2 results (2005) similarly showed "Good" biological condition (BIBI = 4.18 ± 0.58). Round 3 results (2012) also show an average "Good" biological condition (BIBI = 4.33 ± 0.47). The narrative rating of the biological condition in this subwatershed did not change over time, an ANOVA test for differences amongst the years showed that the changes in BIBI score were not significant ($p < 0.0001$).

In Lower Brighton Dam, the Round 1 biological condition was "Fair" overall (BIBI=3.53 ± 0.80). Round 2 results show a slight increase in biological condition, and the subwatershed received a "Good" rating (BIBI=4.00 ± 0.82). In Round 3, the biological condition decreased again slightly to "Fair" (BIBI=3.83 ± 0.92). The ANOVA test also showed that the difference in BIBI scores in this subwatershed was not significant ($p < 0.0001$).

In Cattail Creek, the biological condition in all three rounds was "Fair" (BIBI=3.50 ± 0.69, BIBI=3.47 ± 0.74, and BIBI=3.87 ± 0.53; respectively). The ANOVA test also showed that the difference in BIBI scores in this subwatershed was not significant ($p < 0.0001$).

RBP Physical Habitat Assessment – Table 4-3 summarizes the 2001, 2005 and 2012 RBP comparability scores, and Figure 4-2 is a box plot illustrating RBP comparability scores. Results of the Round 1 (2001) and Round 2 (2005) assessments indicated that the Upper Brighton Dam subwatershed rated "Partially Supporting" (RBP scores of 67 ± 3 and 72.4 ± 10, respectively). In the Round 3 assessment (2012), the subwatershed received an average comparability score of "Supporting" (RBP score of 80 ± 3), indicating some improvement in the habitat condition in the subwatershed. For this subwatershed, Round 1 and Round 2 habitat assessment scores were not significantly different from each other, but the Round 3 score was significantly greater than both Round 1 and Round 2 ($p = 0.007$).

Table 4-2. Comparison of 2001, 2005, and 2012 BIBI data								
Sampling Year		**Number of Sites Sampled**	**Min RBP Score**	**Max RBP Score**	**Median RBP Score**	**Mean RBP Score**	**Narrative Rating**	**Standard Deviation**
2001	Upper Brighton Dam	10	3.33	4.67	4.00	4.00	Good	0.38
	Lower Brighton Dam	10	2.00	4.33	3.83	3.53	Fair	0.80
	Cattail Creek	10	1.67	4.00	3.67	3.50	Fair	0.69
2005	Upper Brighton Dam	10	2.67	4.67	4.00	4.18	Good	0.58
	Lower Brighton Dam	10	3.00	5.00	4.33	4.00	Good	0.82
	Cattail Creek	10	2.00	4.33	3.67	3.47	Fair	0.74
2012	Upper Brighton Dam	10	3.33	4.67	4.67	4.33	Good	0.47
	Lower Brighton Dam	10	2.00	5.00	4.00	3.83	Fair	0.92
	Cattail Creek	10	2.67	4.33	4.00	3.87	Fair	0.53

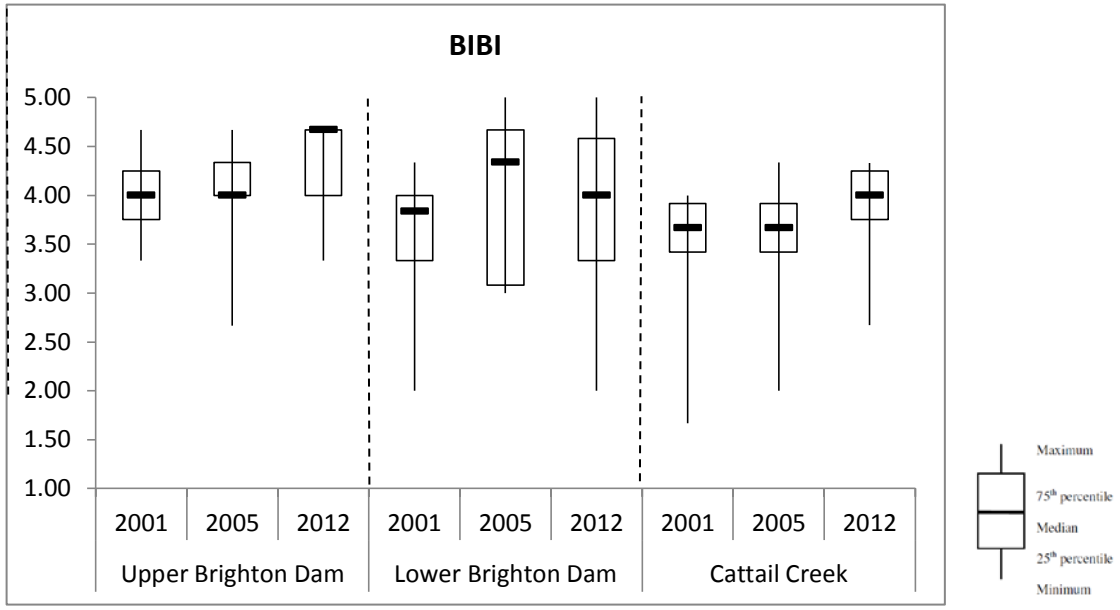

Figure 4-1. Comparison of 2001, 2005, and 2012 BIBI scores

Table 4-3. Comparison of 2001, 2005, and 2012 RBP assessment data								
Sampling Year		**Number of Sites Sampled**	**Min RBP Score**	**Max RBP Score**	**Median RBP Score**	**Mean RBP Score**	**Narrative Rating**	**Standard Deviation**
2001	Upper Brighton Dam	10	62	71	67	67	Partially Supporting	3.055050463
	Lower Brighton Dam	10	45	69	64.5	60.5	Partially Supporting	7.877534865
	Cattail Creek	10	41	78	60.5	59.3	Non-Supporting	12.45480719
2005	Upper Brighton Dam	10	60	89	69	72.4	Partially Supporting	10.16748631
	Lower Brighton Dam	10	61	85	69.5	71.5	Partially Supporting	8.695464974
	Cattail Creek	10	56	86	62.5	66.3	Partially Supporting	9.54579605
2012	Upper Brighton Dam	10	76	84	79.5	79.5	Supporting	3.1
	Lower Brighton Dam	10	48	84	74.5	72	Partially Supporting	9.564
	Cattail Creek	10	52	86	79.5	75.7	Supporting	10.14

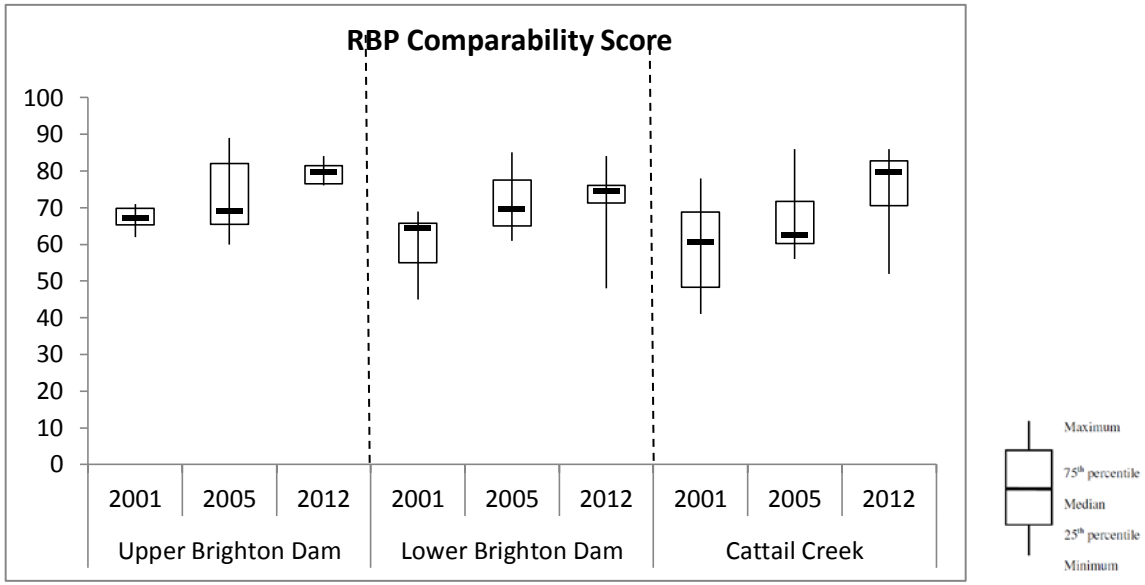

Figure 4-2. Comparison of 2001, 2005, and 2012 RBP assessment scores

In Lower Brighton Dam, results of all Rounds of the assessments indicated that the subwatershed rated "Partially Supporting" (RBP scores of 60.5 ± 8, 71.5 ± 9, and 72 ± 10, respectively). In this subwatershed, the Round 1 habitat assessment score was significantly lower than both the Rounds 2 and 3 habitat assessment scores (p=0.0100).

In Cattail Creek, the Round 1 assessment indicated that the subwatershed rated "Non-Supporting" (59.3 ± 12). The habitat comparability score increased slightly in Round 2 to a rating of "Partially Supporting" (66.3 ± 10). The improvement in habitat condition continued in Round 3, when the subwatershed scored "Supporting" (75.7 ± 10). In this subwatershed, Round 1 and Round 3 are significantly different from each other (Round 3 being two narrative ratings higher than Round 1), but neither is statistically significant from Round 2 (p = 0.0079).

5.0 CONCLUSIONS AND RECOMMENDATIONS

This report is the first of five annual reports that describe Round 3 (2012-2016) of the Howard County Biological Monitoring and Assessment Program. More definitive Round 3 conclusions and comparisons with Rounds 1 and 2 will be provided at the completion of Round 3. These preliminary conclusions and recommendations provide context for interpretation of results and possible future revisions.

5.1 WATERSHED CONDITIONS

Additional Water Quality Sampling - Habitat conditions and BIBI scores are not always strongly correlated with each other, indicating that stressors other than habitat are affecting stream conditions. This can be an indication of degraded water quality conditions. Although none of the water quality parameters measured were outside the acceptable COMAR standards, additional sampling, especially on those streams rated as "Poor" or "Very Poor" for biological condition, may identify other chemical stressors that are affecting the biota. Supplementary sampling could include additional parameters such as nutrients and metals, which may be of concern. It is also likely that high levels of these chemical stressors may only occur in first flush of stormwater runoff. Because biological monitoring is usually conducted under baseflow conditions, concomitant chemical sampling may fail to identify the effects of pollutants associated with stormwater runoff, specifically in more urban portions of the watershed. Wet weather monitoring in these watersheds can be conducted to determine the presence of additional water quality stressors. The cost of wet weather monitoring is prohibitive for an extensive bioassessment, but wet weather monitoring could be incorporated into the design as representative downstream sampling in each subwatershed.

Expanded Physical Habitat Assessment - 2012 was the first year the bioassessment collected the metrics for the MBSS Physical Habitat Index (PHI) and calculated the PHI for comparison with the RPB scores. The PHI was significantly positively correlated with the RBP physical habitat assessment (Pearson correlation of 0.77, with a p-value of < 0.001), indicating that the PHI score did not improve the overall assessment of the subwatersheds or individual sites. However, certain metrics that contribute to the overall PHI score did prove useful in site assessments (especially "shading" and "embeddedness"). In addition, collection of the PHI information allows full integration with the MBSS regional assessments. We recommend that the PHI collection be retained through Round 3 and reevaluated prior to Round 4.

Additional MBSS Parameters - Howard County adopted the DNR's MBSS methods in 2001. The MBSS program continues to evolve and refine its sampling design, field procedures, and data analysis protocols; the most recent field sampling protocols were updated in 2010 (MDNR 2010). Although the benthic macroinvertebrate collection methods implemented herein were not changed during that update, additional surveys were added to the MBSS data collection efforts (i.e., steam salamander sampling in the summer and a seasonal pool search in the spring) that may be of interest to the county. Round 4 of the MBSS will also likely include collecting simple geomorphic parameters. We recommend that Howard County consider adding these additional salamander, seasonal pool, and geomorphic parameters, in addition to updating methods as

needed to stay current with the latest MBSS sampling protocols. Certification by the MBSS is now being provided for both field and laboratory protocols and should be required for conducting this bioassessment. For the 2012 sampling conducted for this project, Versar's fieldcrew leader, benthic sample processor/subsampler, and benthic taxonomist have all received MBSS certification for their respective tasks.

5.2 WATERSHED STUDIES

The Howard County Biological Monitoring and Assessment Program provides valuable information that supports countywide management of aquatic resources. For example, it serves as the most accurate indicator of watershed condition and supports assignment of preservation and restoration priorities. It is a spatial intensification of the statewide MBSS that leverages the regionwide condition assessment and stressor identification tools employed by both Maryland DNR and MDE. In addition, bioassessment results are an essential part of watershed management plans to support the Howard County MS4 permit and Watershed Implementation Plan (WIP) of the Chesapeake Bay TMDL.

Currently, Howard County is developing a Countywide Implementation Strategy (CIS) that will identify restoration projects and programs to meet MS4 permit requirements for treatment of impervious surfaces and reductions in loads of nutrients, sediments, and other pollutants to local waters and the Chesapeake Bay. Phase II of the CIS will involve preparation of small watershed action plans with recommendations for site-specific restoration. The results of the biological and physical monitoring in the Upper Brighton Dam, Lower Brighton Dam, and Cattail Creek subwatersheds (and other subwatersheds in subsequent years) will help target areas with the greatest restoration potential.

The CIS will also include a monitoring strategy to demonstrate compliance with the MS4 permit and Bay WIP. Both intensive local monitoring and extensive watershed-scale monitoring will be needed to monitor progress in a cost-effective manner. We recommend that the Howard County Biological Monitoring and Assessment Program serve as the framework for assembling this integrated MS4 permit and WIP monitoring strategy.

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