HOWARD COUNTY BIOLOGICAL MONITORING AND ASSESSMENT UPPER LITTLE PATUXENT, MIDDLE LITTLE PATUXENT, AND LOWER LITTLE PATUXENT WATERSHEDS 2013

NPDES Permit Number 00-DP-3318 MD0068322

December 15, 2013

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AND ASSESSMENT
UPPER LITTLE PATUXENT,
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Prepared for

Department of Public Works
Bureau of Environmental Services
Stormwater Management Division
NPDES Watershed Management Programs

Prepared by

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December 15, 2013

ACKNOWLEDGEMENTS

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The appropriate citation for this report is:

Rogers, G., B. Franks, and M. Southerland. 2013. Howard County Biological Monitoring and Assessment, Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent Watersheds – 2013. Prepared by Versar, Inc., Columbia, MD for Howard County, Department of Public Works, Stormwater Management Division, Columbia, MD. December 2013.

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 were 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 2013, ten sites were chosen for sampling in each of three subwatersheds: Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent. These subwatersheds were also sampled in Round 1 (2001) and Round 2 (2006) 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 March 19 and April 14, 2013, 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 2013 in the Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent subwatersheds indicate areas that are in poor to very poor condition. Fifteen of the sites sampled received overall BIBI ratings of "Poor" and 11 sites received ratings of "Very Poor". Only three sites, all located in the Upper Little Patuxent subwatershed received "Good" ratings.

RBP habitat assessment results indicate average subwatershed physical habitat conditions that are "Partially Supporting" in all of the Upper Little Patuxent and Lower Little Patuxent subwatersheds. Average RBP habitat conditions are "Non-Supporting" in the Middle Little Patuxent subwatershed. None of the sites sampled in any of the three subwatersheds were "Comparable to Reference." The PHI results indicate average subwatershed physical habitat conditions that are "Degraded" in all three subwatersheds sampled in 2013. No sites were "Minimally Degraded".

The geomorphic assessment indicates a variable system. Some of the channels sampled throughout the subwatersheds were classified as stable type B, C, and E channels; however, more than half of the channels were classified as unstable, incised F and G channels. Gravel is the dominant substrate type in almost all of the sampled reaches; however, sand- and cobble-dominant streams also were present.

The average percentage of impervious area in the upstream catchments in the Upper Little Patuxent subwatershed is 12%. Twenty-four percent of the land in the upstream catchments in the Middle Little Patuxent and 21% of the land in the Lower Little Patuxent subwatershed is impervious surface. Imperviousness in the areas draining to each sampling site ranges from less than 5% to 41% (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).

Regression relationships between the BIBI scores and land use, habitat, and water quality parameters showed several significant results. There was a negative relationship between impervious surface and the BIBI score (R^2= 0.22, p = 0.009). Although not very strong, there were significant positive relationships between the BIBI and both the RBP habitat assessment score and the PHI score (R^2= 0.15, p = 0.04, for both parameters).

Comparisons to Rounds 1 and 2 of the assessment indicate that the Upper Little Patuxent and Middle Little Patuxent subwatersheds stayed either in “Poor” or “Very Poor” biological condition in all three Rounds. The Lower Little Patuxent subwatershed remained in “Very Poor” condition in all three Rounds of the assessment. All three subwatersheds received average RBP habitat assessment scores of “Non-Supporting” in Round 1 and all three subwatersheds increased slightly in average habitat quality to “Partially-Supporting” in Round 2. While the habitat in the Upper Little Patuxent and Lower Little Patuxent subwatersheds remained “Partially Supporting” in Round 3, the average score in the Middle Little Patuxent subwatershed decreased again to “Non-Supporting”.

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1 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) during 2012. During 2013, Round 3 sampling continued with the sampling of the Little Patuxent River subwatersheds (PSUs 11, 12, and 13). 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

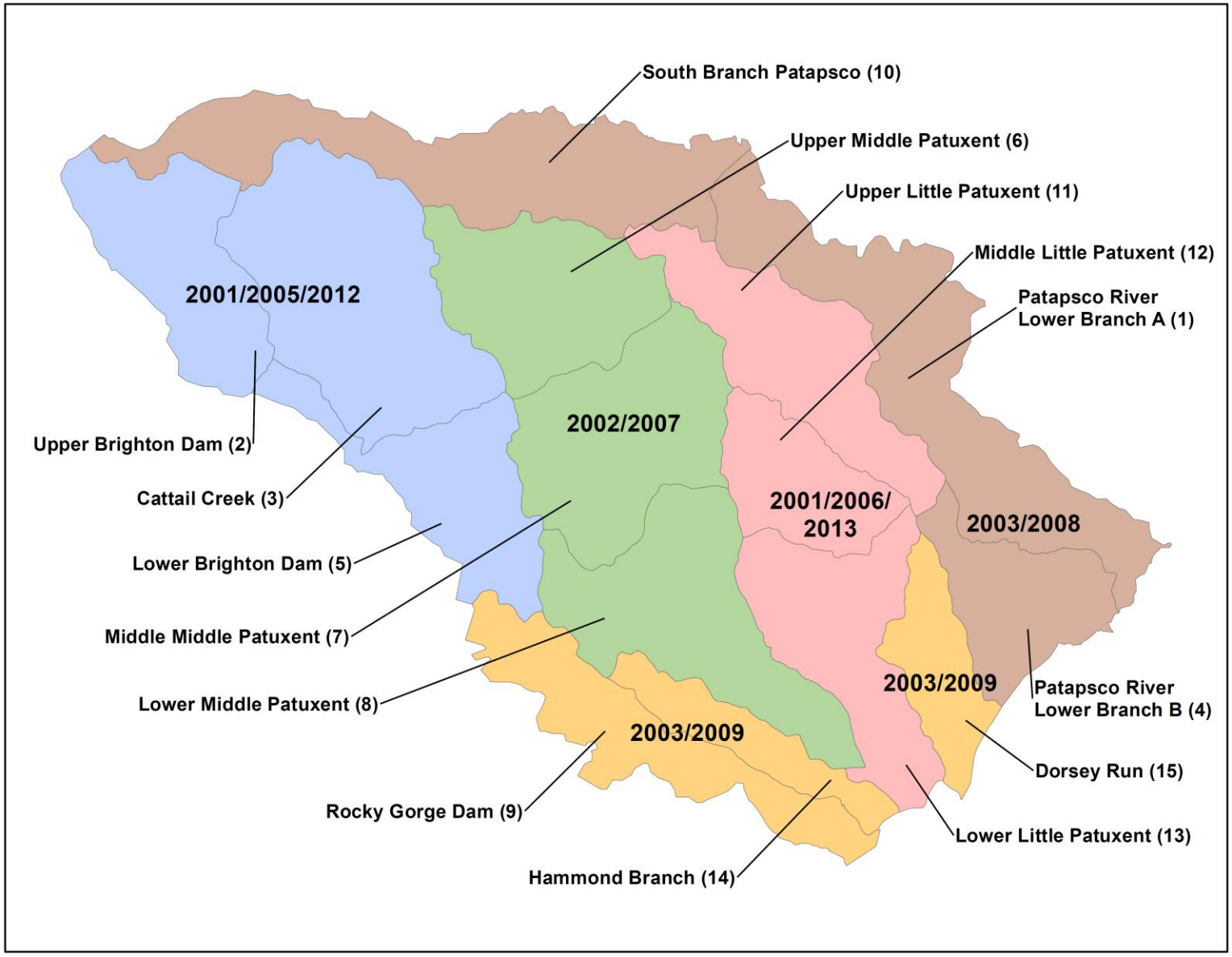

Figure 1-1. Summary of Howard County bioassessment progress (2001-2013)

used in Round 3 are compatible with those used in Rounds 1 and 2 and have been updated where applicable.

Table 1-1. Howard County bioassessment subwatersheds and schedule

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 Patuxent

Table 1-1. (Continued)

Year	Number of Sites	Primary Sampling Unit (Code and Name)
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 2013 are located in the central portion of the county and are crossed by several major transportation routes (Figure 1-2). Maryland Route 29 runs roughly north-south through a portion of each of the three subwatersheds. Interstate 70 and Frederick Road (Route 40) run roughly east-west through the Upper Little Patuxent subwatershed. Routes 108 and 175 run east-west through the Middle Little Patuxent subwatershed. The Lower Little Patuxent subwatershed is also traversed by Route 175, as well as Route 32 in the southern portion. Interstate 95 and Washington Boulevard (Route 1) bisect the southern portion of the Lower Little Patuxent subwatershed.

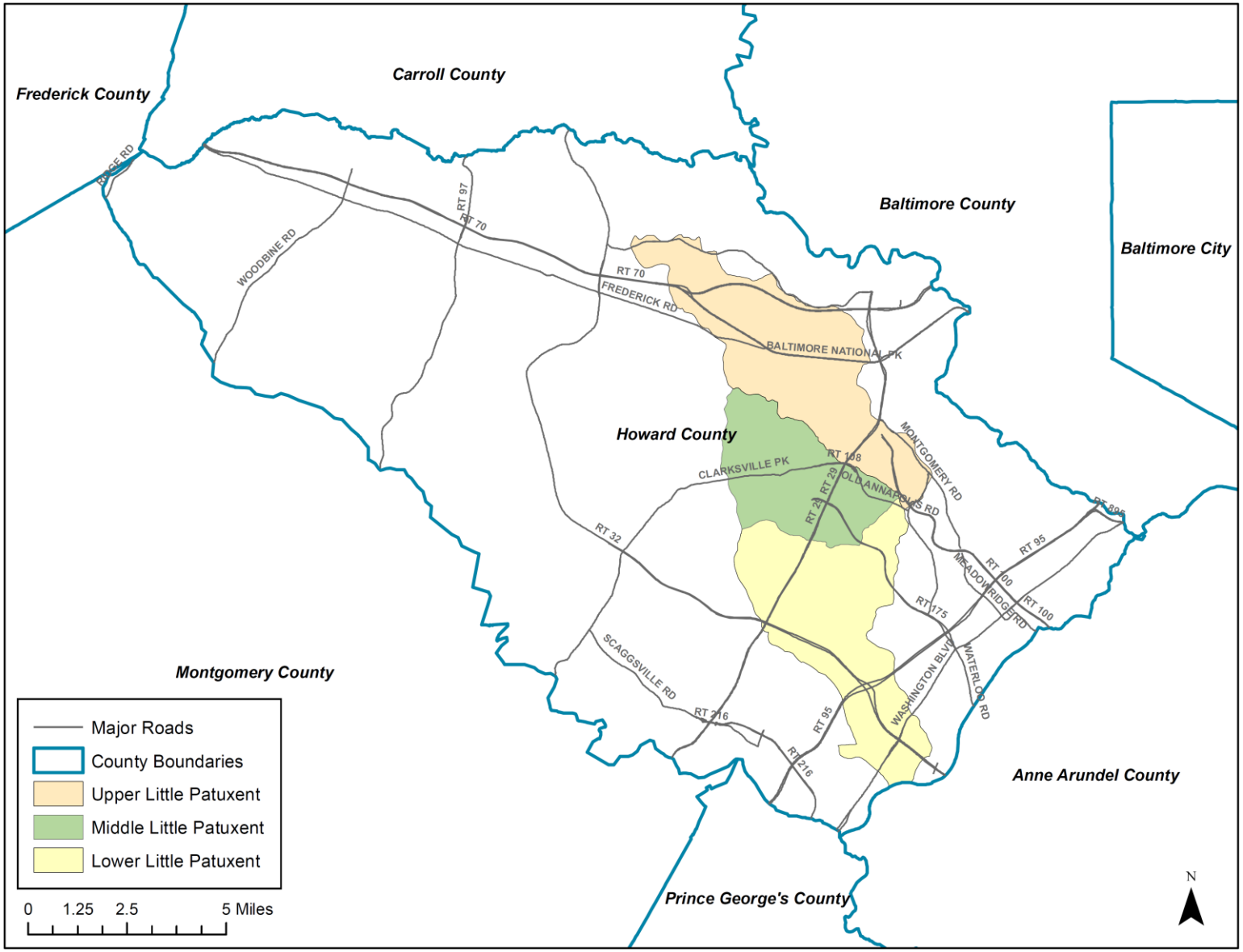

Figure 1-2. Location map of the Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent subwatersheds

2 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 2013, 10 sites were selected for sampling in each of the 3 PSU's – Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent. 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 March 19 and April 14, 2013, 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 2013. 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 (11LP), 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 (2013), 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 (15 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 Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent drainage areas are in *COMAR* Sub-Basin 02-13-11: Patuxent River Area. The majority of all three drainage areas are classified as IV-P: Recreational Trout Waters and Public Water Supply. One stream and its tributaries, located in the southern portion of the Lower Little Patuxent

subwatershed, are classified as I-P: Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply. The acceptable standards for Use IV-P are listed in Table 2-1. Of the parameters sampled in this study, temperature is the only one that differs in Use I-P. The maximum temperature should be 90 °F (32 °C) in those waters. 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 IV-P

Parameter	Units	Acceptable COMAR Standard
pH	standard pH units	6.5 to 8.5
Temperature	degrees Celsius, °C	maximum of 75 °F (23.9 °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 Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent subwatersheds 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.

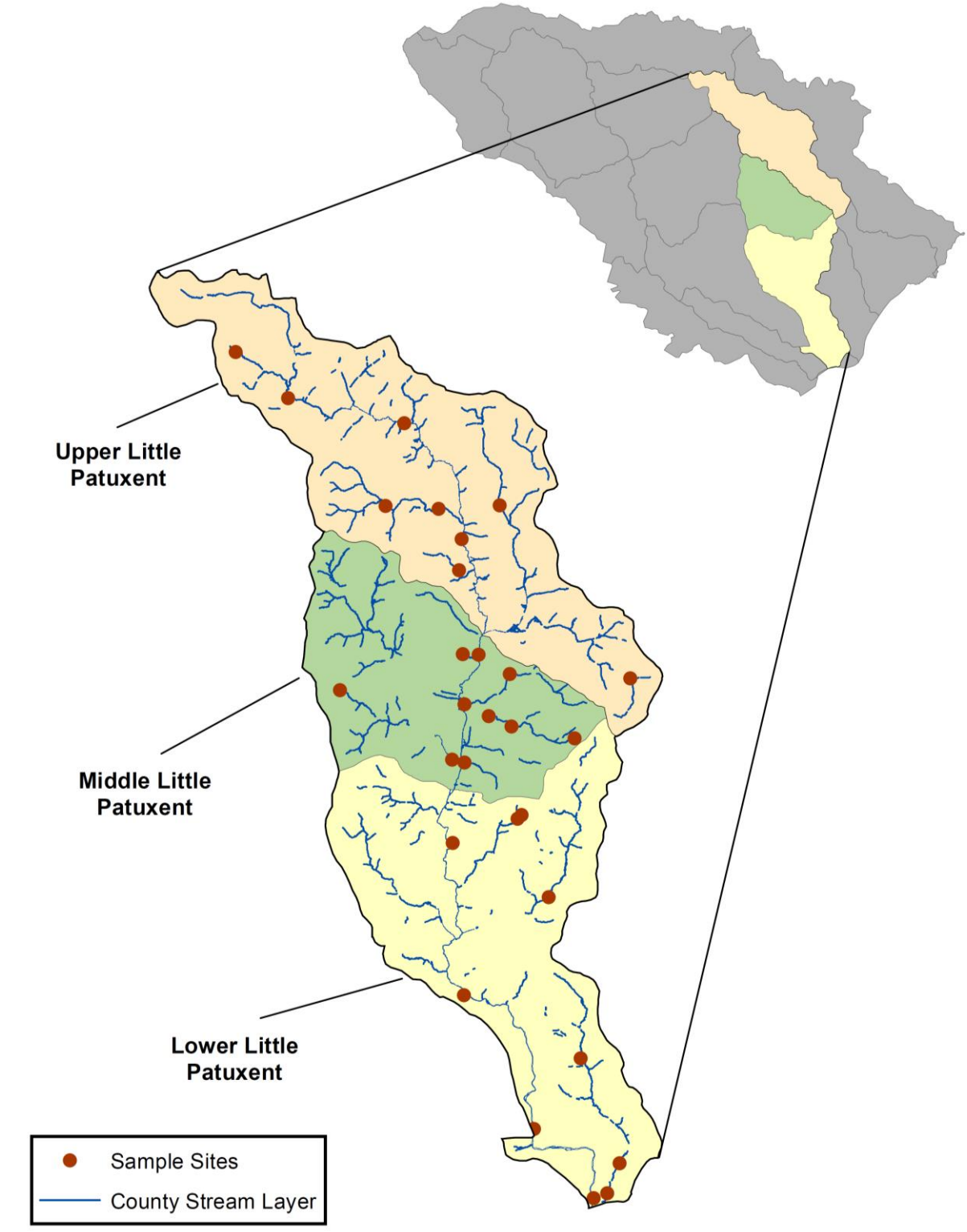

Figure 2-1. Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent bio-assessment sampling locations

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 Society for Freshwater Science (formerly 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 stereoscope, 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 Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent 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 during Round 1 sampling of the Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent subwatersheds were originally 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 2001 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 2001 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).

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

PHI is scored based on Table 2-7.

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 area
Slope	Bankfull height	Velocity
Floodprone width	Bankfull width	Discharge
Width / depth ratio	Mean depth	

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 RESULTS

A total of 29 sites were sampled in the Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent subwatersheds, 10 within both the Middle and Lower Little Patuxent and 9 in the Upper Little Patuxent subwatershed. It was discovered during post-processing analysis that a site sampled believed to be in the Upper Little Patuxent was actually located in the South Branch Patapsco subwatershed, so this site was dropped from any analysis, but sampling results are included in Appendix G. 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 LITTLE PATUXENT

In 2013, 6 of the 9 sampling sites in the Upper Little Patuxent subwatershed were on first-order streams, and 3 were on second-order streams. The field QC sample was collected at site 11LP-216-R-2013F. The subwatershed had an average BIBI score of 2.70 and a "Poor" condition rating; scores ranged from 1.00 to 4.00. The average RBP habitat assessment comparability score was 68.2 or " Partially Supporting," and scores ranged from 55 ("Non-supporting") to 81 ("Supporting"). The average PHI score was 60.1 ("Degraded"). Channel types in the Upper Little Patuxent generally were classified as Rosgen type F or G channels, with two B channels and one E channel. Channel substrate at all sites was predominantly gravel. Table 3-1 summarizes the results for the Upper Little Patuxent subwatershed and Figure 3-1 shows the sites with BIBI and RBP comparability scores on a map.

Table 3-1. Upper Little Patuxent Sampling Results

Site ID	Drainage Area (acres)	% Impervious	BIBI Score	BIBI Rating	RBP Score	RBP Rating	PHI Score	PHI Rating
11LP-101-R-2013A	258.70	18.25	2.33	Poor	73	Partially Supporting	65.98	Degraded
11LP-104-R-2013B	994.19	7.67	4.00	Good	74	Partially Supporting	68.88	Partially Degraded
11LP-107-R-2013C	505.58	17.68	2.00	Poor	55	Non-supporting	40.30	Severely Degraded
11LP-110-R-2013D	117.49	5.43	4.00	Good	81	Supporting	67.17	Partially Degraded
11LP-213-R-2013E	1,876.88	8.54	4.00	Good	73	Partially Supporting	62.25	Degraded
11LP-216-R-2013F*	3,392.80	9.47	2.00	Poor	66	Partially Supporting	61.76	Degraded
11LP-119-F-2013G	379.00	21.14	1.00	Very Poor	57	Non-supporting	49.91	Severely Degraded
11LP-122-F-2013H	1,511.07	11.43	2.67	Poor	73	Partially Supporting	67.53	Partially Degraded
11LP-225-F-2013J	6,230.53	11.92	2.33	Poor	62	Partially Supporting	56.67	Degraded
Minimum	117.49	5.43	1.00	Very Poor	55.00	Non-supporting	40.30	Severely Degraded
Maximum	6,230.53	21.14	4.00	Good	81.00	Supporting	68.88	Partially Degraded
Mean	1,696.25	12.39	2.70	Poor	68.22	Partially Supporting	60.05	Degraded
Standard Deviation	1,990.91	5.41	1.07		8.73		9.56	

* QC sampling was conducted at this site

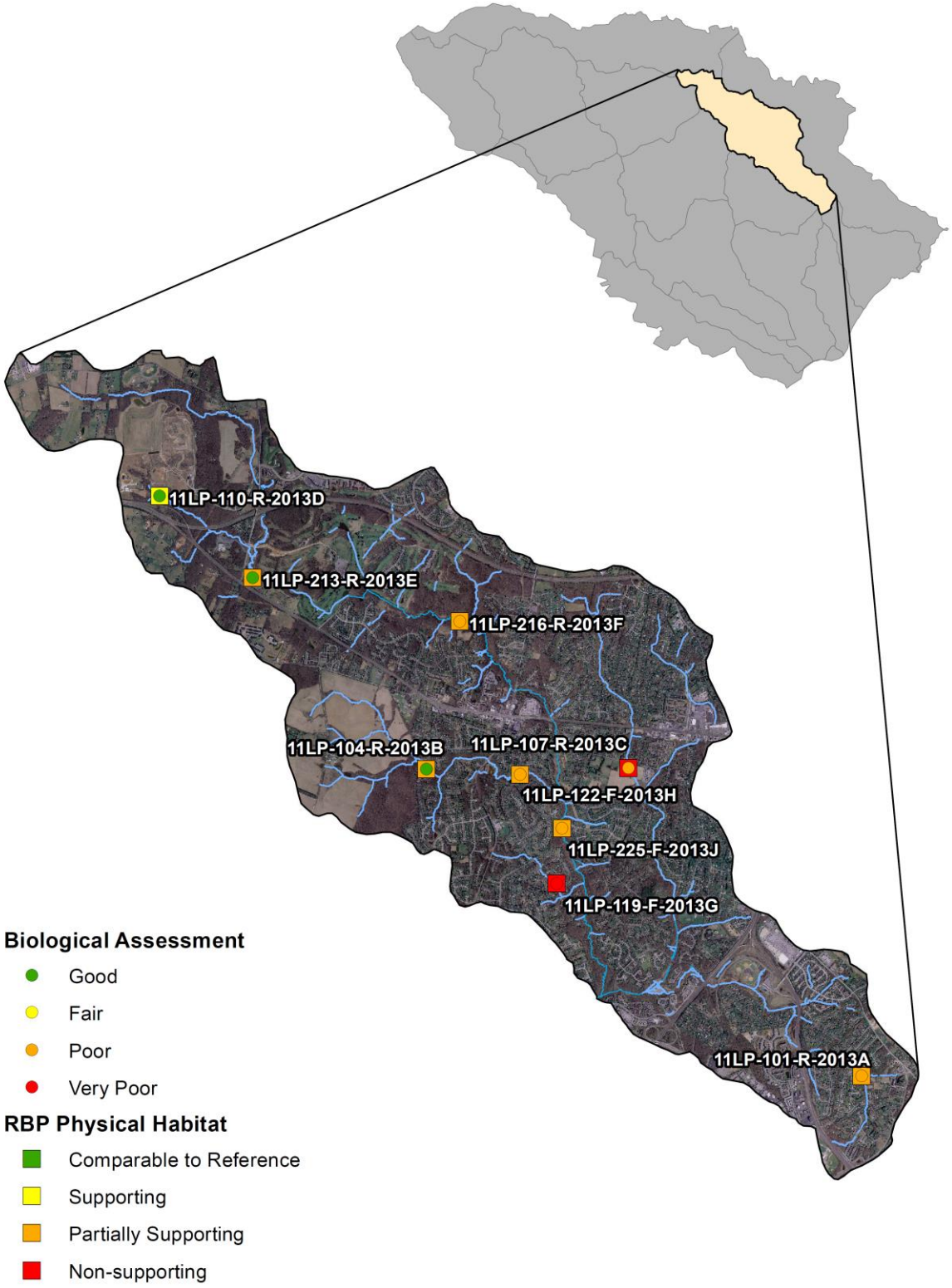

Figure 3-1. Upper Little Patuxent sampling results

11LP-101-R-2013A – This site flows through an open woodland area between two low-density housing developments. The lower 10 meters of this site was redirected and channelized to run alongside a large pond. A small timber dam was constructed at this point in the stream, leading to downstream erosion. This is a G4 channel dominated by gravel. Within the 259-acre drainage area, low-density residential development is the dominant land use (61%), followed by medium-density residential development (15%). Eight percent of the land use is institutional and seven percent of the drainage area is forested. The remaining nine percent of the land is either in high-density residential development, transportation, or commercial/industrial. Impervious cover accounts for 18% of the drainage area. The RBP habitat assessment resulted in a score of 73 ("Partially Supporting"); the PHI score was 65.9 ("Degraded"). A total of 23 taxa were present in the benthic macroinvertebrate sample, including six Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa. Only four percent of the individuals in the benthic macroinvertebrate sample were intolerant to urban stressors. The site's overall BIBI score of 2.33 corresponds to a "Poor" biological classification. Stream pH at this site was acidic (5.70), measuring below the acceptable COMAR standard of 6.5 pH units. Other water quality parameters were within acceptable COMAR standards.

11LP-104-R-2013B – This site is a nicely wooded stream that runs between two housing developments. It is a G4 channel type dominated by gravel substrate. Within the 994-acre drainage area, the land use is dominated by agriculture (60%). A combined 27% of the drainage area is in low- or medium-density residential development, while 13% is forested. Small amounts of land in this drainage are also in commercial/industrial, institutional, low-density residential development, open urban land, and transportation land uses. Impervious cover accounts for 8% of the drainage area. The RBP habitat assessment resulted in a score of 74 ("Partially Supporting"); the PHI score was 68.9 ("Partially Degraded"). A severely eroded left bank may account for the lower habitat assessment scores. A total of 34 taxa were present in the benthic macroinvertebrate sample, including 12 Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa. Twenty-nine percent of the individuals in the sample were intolerant to urban stressors. This was one of only three sites in the subwatershed that had an overall BIBI score of 4.00, corresponding to a "Good" biological classification. Stream pH at this site was acidic (5.95), measuring below the acceptable COMAR standard of 6.5 pH units. Other water quality parameters were within acceptable COMAR standards.

11LP-107-R-2013C – This site is located on the southern side of Frederick Road. The stream flows from a medium-density residential area to an open agricultural field. A combined library/ historical center was recently constructed immediately adjacent to the right bank of this stream, contributing to increased erosion, sediment deposition, and poor riparian buffers at this site. This site is an E4 channel dominated by gravel substrate. The land use in this 506-acre drainage area is dominated by medium-density residential development (52%), followed by low-density residential development (19%). Seventeen percent of the drainage area is forested land, followed by nine percent in agriculture. Small amounts of land in this drainage are in commercial/industrial, high-density residential development, and transportation land uses. Impervious cover accounts for 18% of the drainage area. The RBP habitat assessment resulted in the lowest score in the subwatershed, a 55 ("Non-supporting"); the PHI score was 40.3 ("Severely Degraded"), also the lowest in the subwatershed. The stream substrate was 90% embedded and the banks were both moderately eroded, with only 25% of the stream adequately

shaded. A total of 31 taxa were present in the benthic macroinvertebrate sample, including only two Plecoptera or Tricoptera taxa. No Ephemeroptera taxa were found in the sample. More than 50% of the individuals in the sample were from the highly tolerant Chironomidae family and only three percent of the individuals are found to be resistant to urban stressors. The site's overall BIBI score was 2.00, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

11LP-110-R-2013D – This is a small, 117-acre drainage that is immediately downstream of the Howard County Alpha Ridge Landfill. It is a F4 channel stream dominated by gravel substrate. Due to the proximity to the landfill, the drainage area is dominated by bare ground (85%). Eight percent of the land use in the drainage is agriculture and another seven percent is forested land. Only 5% of the drainage area is impervious cover, the smallest in the subwatershed. The RBP habitat assessment resulted in the highest score in the subwatershed, an 81 ("Supporting"); the PHI score was 67.2 ("Partially Degraded"). The stream banks showed minimal impacts from erosion and the stream was well-shaded (75% of the sample segment was shaded). A total of 38 taxa were present in the benthic macroinvertebrate sample, including 11 Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa. Twenty-seven percent of the individuals in the sample were intolerant to urban stressors. This was one of only three sites in the subwatershed that scored an overall BIBI score of 4.00, corresponding to a "Good" biological classification. Water quality parameters were all within acceptable COMAR standards.

11LP-213-R-2013E – This is a stream site located on the edge of an open area near an old, unused portion of Turf Valley Golf Course. It is an F4 channel dominated by a gravel substrate. The 1,877-acre drainage area is somewhat evenly divided between forested land (30%) and agricultural land use (27%). The site is downstream of the Howard County Alpha Ridge Landfill; therefore 19% of the drainage area is classified as bare ground. Small amounts of land in this drainage are in commercial/industrial, extractive, high-density residential, institutional, low-density residential, medium-density residential, open urban land, and transportation land uses. Impervious cover accounts for 9% of the drainage area. The RBP habitat assessment resulted in a score of 73 ("Partially Supporting"); the PHI score was 62.3 ("Degraded"). A total of 35 taxa were present in the benthic macroinvertebrate sample, including 14 Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa (the highest number in the subwatershed). This was one of only three sites in the subwatershed that scored an overall BIBI score of 4.00, corresponding to a "Good" biological classification. Water quality parameters were all within acceptable COMAR standards.

11LP-216-R-2013F – This is a nicely wooded site that runs along the back of a residential area. It is an F4 channel dominated by gravel substrate. The 3,393-acre drainage area has a mixed land use. It is predominantly forested land (29%), followed by open urban land (19%), and agricultural land use (17%). The site is downstream of the Howard County Alpha Ridge Landfill; therefore 10% of the drainage area is classified as bare ground. Small amounts of land in this drainage area are in commercial/industrial, extractive, high-density residential development, institutional, low-density residential development, medium-density residential development, and transportation land uses. Impervious cover accounts for 9% of the drainage area. The RBP habitat assessment resulted in a score of 66 ("Partially-Supporting"); the PHI score was 61.8 ("Degraded"). A total of 27 taxa were present in the benthic macroinvertebrate

sample, including six Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa. Eighty-two percent of the individuals in the sample were in the highly tolerant Chironomidae family and only 4% of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.00, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

11LP-119-F-2013G – This is a site located in a dense residential area that has very recently undergone a full restoration effort. At the time of sampling, there was little time to establish a forested buffer; the banks are almost entirely biodegradable vegetation stabilization matting. The 379-acre drainage area is dominated by medium-density residential development (80%), with 14% of the land use in low-density residential development. Five percent of the drainage is agricultural land use. Small amounts of land in this drainage are in forested or institutional land uses. Impervious cover accounts for 21% of the drainage area, the highest in the subwatershed. The RBP habitat assessment resulted in a score of 57 ("Non-Supporting"); the PHI score was 49.9 ("Severely Degraded"). Due to the recent restoration work in the segment, there was no erosion on either bank, but there was also very little stream shading (5%). Also due to the recent work, the percentage of embedded stream substrate was very low (10%). Only 14 taxa were present in the benthic macroinvertebrate sample, the lowest in the subwatershed; only two of those taxa were Plecoptera or Tricoptera taxa. No Ephemeroptera taxa were found in the sample. Eighty-three percent of the individuals in the sample were in the highly tolerant Chironomidae family and only 2% of the individuals identified were intolerant to urban stressors. This site received the lowest overall BIBI score in the subwatershed, a 1.00, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

11LP-122-F-2013H – This site is located near the western edge of Font Hill Park. The riparian buffer is narrow, but wooded in most places. This is a B4 stream dominated by gravel substrate. Within the 1,511-acre drainage area, agricultural land (39%) and medium-density residential development (35%) are somewhat evenly distributed. Fifteen percent of the drainage is forested land. Small amounts of land in the drainage are also in commercial/industrial, institutional, low-density residential, open urban land, and transportation land uses. Impervious cover accounts for 11% of the drainage area. The RBP habitat assessment resulted in a score of 73 ("Partially-Supporting"); the PHI score was 67.5 ("Partially Degraded"). A total of 36 taxa were present in the benthic macroinvertebrate sample, including eight Ephmeroptera, Plecoptera, and Tricoptera (EPT) taxa. Only 8% of the individuals in the sample were intolerant to urban stressors. The site's overall BIBI score was 2.67, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

11LP-225-F-2013J – This is a nicely wooded site that runs between two residential developments. It is a G4 channel dominated by gravel substrate. The 6,231-acre drainage area is somewhat evenly distributed between forested land (25%), medium-density residential development (23%), and agricultural land use (20%). Small amounts of land in this drainage area are in bare ground, commercial/industrial, extractive, high-density residential, institutional, low-density residential, open urban land, and transportation. Impervious cover accounts for 12% of the drainage area. The RBP habitat assessment resulted in a score of 62 ("Partially-Supporting"); the PHI score was 56.7 ("Degraded"). Substrate in this segment was 100%

embedded. A total of 38 taxa were present in the benthic macroinvertebrate sample, including 10 Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa. Only six percent of the individuals in this sample were intolerant to urban stressors. The site's overall BIBI score was 2.33, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

3.2 MIDDLE LITTLE PATUXENT

In 2013, 8 of the 10 sampling sites in the Middle Little Patuxent were on first-order streams, one was on a second-order stream, and one was on a third-order stream. The field QC sample was collected at site 12LP-113-R-2013E. The subwatershed had an average BIBI score of 1.80 and a "Very Poor" condition rating; scores ranged from 1.00 to 2.67. The average RBP habitat assessment comparability score was 59.9 or "Non-Supporting," and scores ranged from 46 ("Non-Supporting") to 71 ("Partially Supporting"). The average PHI score was 53.5 ("Degraded"). Six of the stream channels assessed in the Middle Little Patuxent were classified as Rosgen type F. Two of the remaining channels were classified as G, one as B, and one as a C stream. Substrates were predominantly gravel at all sites. Table 3-2 summarizes the results for the Middle Little Patuxent subwatershed and Figure 3-2 shows the sites with BIBI and RBP comparability scores on a map.

Table 3-2. Middle Little Patuxent Sampling Results

Site ID	Drainage Area (acres)	% Impervi-ous	BIBI Score	BIBI Rating	RBP Score	RBP Rating	PHI Score	PHI Rating
12LP-101-R-2013A	336.04	17.95	1.00	Very Poor	55	Non-supporting	53.92	Degraded
12LP-104-R-2013B	44.54	28.00	1.33	Very Poor	46	Non-supporting	42.76	Severely Degraded
12LP-107-R-2013C	370.80	20.68	1.67	Very Poor	54	Non-supporting	47.94	Severely Degraded
12LP-110-R-2013D	119.12	23.73	2.00	Poor	71	Partially Supporting	67.03	Partially Degraded
12LP-113-R-2013E*	390.00	40.68	2.00	Poor	67	Partially Supporting	47.96	Severely Degraded
12LP-216-R-2013F	2,284.01	6.25	1.67	Very Poor	60	Non-supporting	53.80	Degraded
12LP-119-F-2013G	566.72	21.78	2.67	Poor	66	Partially Supporting	56.40	Degraded
12LP-121-F-2013H	572.26	36.20	1.33	Very Poor	70	Partially Supporting	64.01	Degraded
12LP-123-F-2013I	1,238.41	25.09	2.33	Poor	56	Non-supporting	47.88	Severely Degraded
12LP-325-F-2013J	11,265.20	16.43	2.00	Poor	54	Non-supporting	53.51	Degraded
Minimum	44.54	6.25	1.00	Very Poor	46.00	Non-supporting	42.76	Severely Degraded
Maximum	11,265.20	40.68	2.67	Poor	71.00	Partially Supporting	67.03	Partially Degraded
Mean	1,718.71	23.68	1.80	Very Poor	59.90	Non-supporting	53.52	Degraded
Standard Deviation	3418.62	9.82	0.50		8.27		7.53	

* QC sampling was conducted at this site

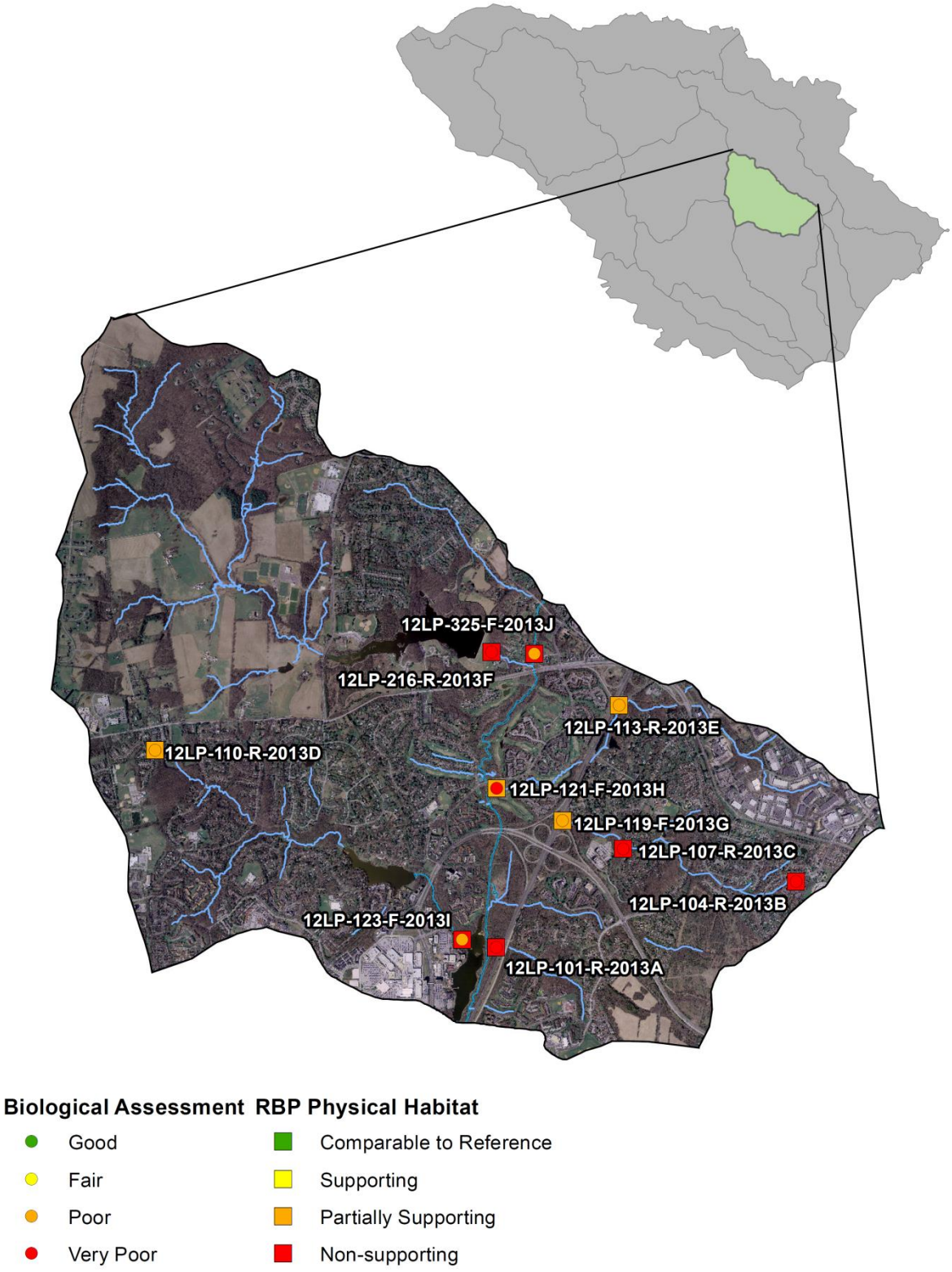

Figure 3-2. Middle Little Patuxent sampling results

12LP-101-R-2013A – This site flows into Lake Kittamaqundi in the heart of Columbia Town Center. It is a C4 channel dominated by gravel substrate. The 336-acre drainage area is fairly evenly split between high-density residential development (28%), medium-density residential development (23%), forested land (21%), and agricultural land use (15%). There are also small amounts of land in commercial/industrial, institutional, and transportation land uses. Impervious cover accounts for 18% of the drainage area. The RBP habitat assessment resulted in a score of 55 ("Non-Supporting"); the PHI score was 53.9 ("Degraded"). Stream banks showed minimal erosion and 80% of the stream segment was adequately shaded. A total of 14 taxa were present in the benthic macroinvertebrate sample, including only one Plecoptera, or Tricoptera taxa. No Ephemeroptera taxa were present in the sample. Ninety-three percent of the individuals in the sample were in the highly tolerant Chironomidae family and only 4% of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 1.00, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

12LP-104-R-2013B – This is an urban stream paralleling Phelps Luck Drive in Columbia. It is a G4 channel dominated by gravel substrate. This very small, 45-acre drainage area is dominated by medium-density residential land use (70%). Sixteen percent of the drainage area is institutional land use and 14% is low-density residential land use. Less than one percent of land in this drainage area is in high-density residential land use. Impervious cover accounts for 28% of the drainage area. The RBP habitat assessment resulted in a score of 46 ("Non-Supporting"), the lowest in the subwatershed; the PHI score of 42.8 ("Severely Degraded") was also the lowest in the subwatershed. The stream is only 5 meters from the road and both banks show evidence of severe erosion. Part of the site flows through a large culvert just upstream of the midpoint of the site. A total of 12 taxa were present in the benthic macroninvertebrate sample, with no Ephemeroptera, Plecoptera, or Tricoptera taxa present. None of the individuals present in the sample were intolerant to urban stressors. The site's overall BIBI score was 1.33, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

12LP-107-R-2013C – This stream enters a wooded area after flowing through a housing development in Columbia. It is a F4 channel dominated by gravel substrate. This 371-acre drainage area is dominated by medium-density residential land use (69%), while 24% of the drainage is forested land use. Small amounts of the drainage area are in high-density residential, institutional, and low-density residential land use. Impervious cover accounts for 21% of the drainage area. The RBP habitat assessment resulted in a score of 54 ("Non-Supporting"); the PHI score was 47.9 ("Severely Degraded"). There is moderate evidence of erosion on both banks and the substrate is 70% embedded. A total of 31 taxa were present in the benthic macroinvertebrate sample, only three Plecoptera or Tricoptera taxa were present. No Ephemeroptera taxa were found in the sample. Seventy percent of the individuals in the sample were in the highly tolerant Chironomidae family and only 4% of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 1.67, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

12LP-110-R-2013D – This site is located on the north side of Cedar Lane Park, just off Route 108 in Columbia. A paved walking path crosses the site on a wooden bridge near the beginning of the site. It is a G4 channel dominated by gravel substrate. This 119-acre drainage area is somewhat evenly divided between low-density residential land use (23%), high-density residential land use (23%), and open urban land (19%). Small amounts of land in the drainage are in agriculture, commercial/industrial, forest, institutional, and low-density residential land uses. Impervious cover accounts for 24% of the drainage area. The RBP habitat assessment resulted in a score of 71 ("Partially Supporting"), the highest in the subwatershed; the PHI score was 67.0 ("Partially Degraded"), also the highest in the subwatershed. A total of 23 taxa were present in the benthic macroinvertebrate sample, with five Plecoptera or Tricoptera taxa present. No Ephemeroptera taxa were found in the sample. Sixty-three percent of the individuals in the sample were in the highly tolerant Chironomidae family and none of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.00, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

12LP-113-R-2013E – This site parallels Route 29, north of the 108 eastbound ramp in Columbia. There is evidence of past channelization in the site. It is an F4 channel dominated by gravel substrate. The 390-acre drainage area is dominated by commercial/industrial land use (55%). There are small amounts of land in the drainage in forest, high-density residential, institutional, low-density residential, medium-density residential, open urban land, and transportation land uses. Impervious cover accounts for 41% of the drainage area, the highest in the subwatershed. The RBP habitat assessment resulted in a score of 67 ("Partially Supporting"); the PHI score was 48.0 ("Severely Degraded"). There is evidence of moderate bank erosion and the substrate is 70% embedded. A total of 16 taxa were present in the benthic macroinvertebrate sample, with only two Plecoptera or Tricoptera taxa present. No Ephemeroptera taxa were found in the sample. Fifty percent of the individuals in the sample were in the highly tolerant Chironomidae family and none of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.00, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

12LP-216-R-2013F – This site is located just below the dam outflow at Centennial Lake. It is an F4 channel dominated by gravel substrate. The 2,284-acre drainage area is somewhat evenly split between agricultural land use (38%) and forested land use (30%). There are small amounts of land in the drainage in institutional, low-density residential development, medium-density residential development, open urban land, and open water. Impervious land cover accounts for only 6% of the drainage area, the lowest in the subwatershed. The RBP habitat assessment resulted in a score of 60 ("Non-Supporting"); the PHI score was 53.8 ("Degraded"). A total of 16 taxa were present in the benthic macroinvertebrate sample, with no Ephemeroptera, Plecoptera, or Tricoptera taxa present. Forty-eight percent of the individuals in the sample were in the highly tolerant Chironomidae family and less than one percent of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 1.67, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

12LP-119-F-2013G – This site is located just upstream of Route 29 in Columbia. The main feature of this site is a large debris jam that has caused a large drop in stream elevation and severe bank erosion downstream. This is a B4 channel dominated by gravel substrate. This 567-acre drainage area is dominated by medium-density residential land use (54%). There are small amounts of land in the drainage in commercial/industrial, forest, high-density residential, institutional, low-density residential, open urban land, and transportation land uses. Impervious cover accounts for 22% of the drainage area. The RBP habitat assessment resulted in a score of 66 ("Partially Supporting"); the PHI score was 56.4 ("Degraded"). A total of 15 taxa were present in the benthic macroinvertebrate sample, with only three Plecoptera or Tricoptera taxa present. No Ephemeroptera taxa were found in the sample. Less than one percent of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.67, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

12LP-121-F-2013H – This site flows through a wooded area adjacent to Fairway Hills Golf Course and Columbia Road in Columbia. It is an F4 channel dominated by gravel substrate. The 572-acre drainage area is predominately commercial/industrial land use (37%), followed by high-density residential development (19%). There are small amounts of land in the drainage in forest, institutional, low-density residential development, medium-density residential development, open urban land, and transportation land uses. Impervious cover accounts for 36% of the drainage area. The RBP habitat assessment resulted in a score of 70 ("Partially Supporting"); the PHI score was 64.0 ("Degraded"). A total of 19 taxa were present in the benthic macroinvertebrate sample, with only three Plecoptera or Tricoptera taxa present. No Ephemeroptera taxa were found in the sample. Seventy-seven percent of the individuals in the sample were in the highly tolerant Chironomidae family and none of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 1.33, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

12LP-123-F-2013I – This site is located in Columbia Town Center, just upstream of Lake Kittamaqundi. It runs parallel to a paved walking path that crosses towards the bottom of the site on a wooden bridge. It is an F4 channel dominated by gravel substrate. The 1,238-acre drainage area is somewhat evenly distributed between medium-density residential development (28%) and high-density residential development (27%). There are small amounts of land in the drainage in agricultural, commercial/industrial, forest, institutional, low-density residential development, open urban land, and open water land uses. Impervious cover accounts for 25% of the drainage area. The RBP habitat assessment resulted in a score of 56 ("Non-Supporting"); the PHI score was 47.9 ("Severely Degraded"). Both banks showed evidence of severe erosion. A total of 32 taxa were present in the benthic macroinvertebrate sample, with only two Plecoptera or Tricoptera taxa present. No Ephemeroptera taxa were found in the sample. Fifty-seven percent of the individuals in the sample were in the highly tolerant Chironomidae family and less than one percent of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.33, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

12LP-325-F-2013J – This is a large stream that parallels a paved hiking path on one bank and is either woodland or open area designated as a forest retention area on the other. There is a large debris jam in the sample segment. It is an F4 channel dominated by gravel substrate. The large, 11,265-acre drainage area is a mixed use area that contains medium-density residential development (32%) and forested land (20%). There are small amounts of agriculture, bare ground, commercial/industrial, extractive, high-density residential development, institutional, low-density residential development, open urban land, and transportation land uses in the drainage area. Impervious cover accounts for 16% of the drainage area. The RBP habitat assessment resulted in a score of 54 ("Non-Supporting"); the PHI score was 53.5 ("Degraded"). The left bank of the stream showed evidence of severe erosion and only 35% of the sample segment was adequately shaded). A total of 32 taxa were present in the benthic macroinvertebrate sample, with only 5 Ephemeroptera, Plecoptera, or Tricoptera taxa present. Eighty percent of the individuals in the sample were in the highly tolerant Chironomidae family and only ten percent of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.00, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

3.3 LOWER LITTLE PATUXENT

In 2013, six of the ten sampling sites in the Lower Little Patuxent subwatershed were on first-order streams, three were on third-order streams, and one was on a fourth-order stream. The field QC sample was collected at site 13LP-123-F-2013I. The subwatershed had an average BIBI score of 1.73 and a "Very Poor" condition rating; scores ranged from 1.00 to 2.67. The average RBP habitat assessment comparability score was 66.0 or "Partially Supporting," and scores ranged from 50 ("Non-Supporting") to 81 ("Supporting"). The average PHI score was 59.8 ("Degraded"). Five streams were classified as Rosgen type F channels, three were type G channels and two were B channels. Gravel was the dominant channel substrate at all but three sites. Two sites were dominated by sand and one was dominated by cobble. Table 3-3 summarizes the results for the Lower Little Patuxent subwatershed and Figure 3-3 shows the sites with BIBI and RBP comparability scores on a map.

Table 3-3. Lower Little Patuxent Sampling Results

Site ID	Drainage Area (acres)	% Imperv-ious	BIBI Score	BIBI Rating	RBP Score	RBP Rating	PHI Score	PHI Rating
13LP-103-R-2013A	646.09	14.73	1.00	Very Poor	81	Supporting	70.07	Partially Degraded
13LP-104-R-2013B	1,735.83	26.41	2.00	Poor	51	Non-supporting	51.03	Degraded
13LP-107-R-2013C	70.32	20.96	1.33	Very Poor	62	Partially Supporting	53.97	Degraded
13LP-310-R-2013D	25,397.29	20.21	1.33	Very Poor	75	Partially Supporting	54.75	Degraded
13LP-313-R-2013E	24,123.08	19.82	2.67	Poor	60	Non-supporting	69.57	Partially Degraded
13LP-416-R-2013F	63,344.51	13.47	2.00	Poor	75	Partially Supporting	61.20	Degraded
13LP-319-F-2013G	18,603.34	17.78	2.00	Poor	73	Partially Supporting	64.52	Degraded
13LP-121-F-2013H	1,545.55	29.97	2.00	Poor	69	Partially Supporting	65.74	Degraded
13LP-123-F-2013I*	1,555.43	24.49	1.33	Very Poor	64	Partially Supporting	62.30	Degraded
13LP-125-F-2013J	36.30	21.69	1.67	Very Poor	50	Non-supporting	44.66	Severely Degraded
Minimum	36.30	13.47	1.00	Very Poor	50.00	Non-supporting	44.66	Severely Degraded
Maximum	63,344.51	29.97	2.67	Poor	81.00	Supporting	70.07	Partially Degraded
Mean	13,705.77	20.95	1.73	Very Poor	66.00	Partially Supporting	59.78	Degraded
Standard Deviation	20317.81	5.06	0.49		10.45		8.38	

* QC sampling was conducted at this site

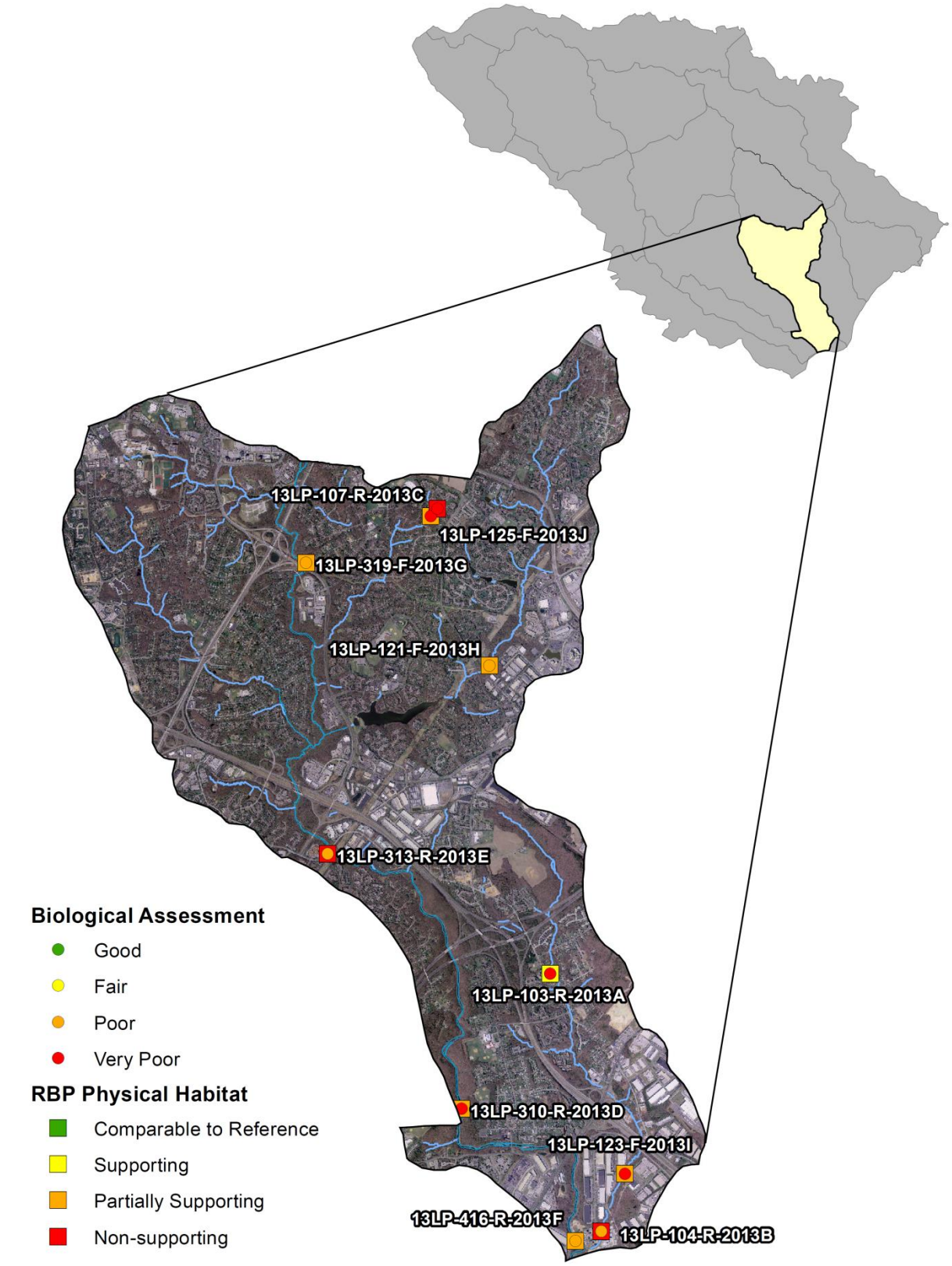

Figure 3-3. Lower Little Patuxent sampling results

13LP-103-R-2013A – This site flows behind a housing development on Guilford Road. It is an F4 channel dominated by gravel substrate. This 646-acre drainage area is predominantly forested land use (40%); with small amounts of agriculture, commercial/industrial, high-density residential development, institutional, low-density residential development, medium-density residential development, open urban land and transportation land uses. Impervious land cover accounts for 14% of the drainage area. The RBP habitat assessment resulted in a score of 81 ("Supporting"); the PHI score was 70.1 ("Partially Degraded"). Overall, there was minimal evidence of erosion at the site. A total of 12 taxa were present in the benthic macroinvertebrate sample, with only four Plecoptera or Tricoptera taxa present. There were no Ephemeroptera taxa present in the sample. Ninety percent of the individuals in the sample were in the highly tolerant Chironomidae family and less than one percent of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 1.00, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

13LP-104-R-2013B – This site is located completely within the confines of the Little Patuxent Water Reclamation Plant in Savage. It is a G5 channel dominated by sand substrate. This 1,736-acre drainage area is fairly even divided between forested land use (31%) and commercial/ industrial land use (29%). There are small amounts of agriculture, high-density residential development, institutional, low-density residential development, medium-density residential development, open urban land, and transportation land uses in the drainage area. Impervious cover accounts for 26% of the drainage area. The RBP habitat assessment resulted in a score of 51 ("Non-Supporting"); the PHI score was 51.0 ("Degraded"). Ninety-five percent of the substrate in the stream bottom was embedded. A total of 18 taxa were present in the benthic macroinvertebrate sample, with only two Plecoptera or Tricoptera taxa present. There were no Ephemeroptera taxa present in the sample. None of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.00, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

13LP-107-R-2013C – This is a small stream in a residential area. There are two sizeable debris jams in the upper portion of the site. It is an F4 channel dominated by gravel substrate. This 70-acre drainage area is dominated by medium-density residential land use (64%) and also contains 31% agricultural land use. There are also small amounts of forested land use and medium-density residential development in the drainage area. Impervious cover accounts for 21% of the drainage area. The RBP habitat assessment resulted in a score of 62 ("Partially Supporting"); the PHI score was 54.0 ("Degraded"). Evidence of moderate bank erosion was present. A total of 13 taxa were present in the benthic macroinvertebrate sample, with no Ephemeroptera, Plecoptera, or Tricoptera taxa present. None of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 1.33, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

13LP-310-R-2013D – This site is located in Savage Park, just above the junction of the Little Patuxent River with the Middle Patuxent River. It is a large F3 channel dominated by cobble substrate. The 25,397-acre drainage area contains a mix of land uses, but is split predominantly by medium-density residential development (29%) and forested land use (20%).

There are also small amounts of land in agriculture, bare ground, commercial/industrial, high-density residential development, institutional, low-density residential development, open urban land, open water, and transportation land uses. Impervious cover accounts for 20% of the drainage area. The RBP habitat assessment resulted in a score of 75 ("Partially Supporting"); the PHI score was 54.8 ("Degraded"). There is evidence of severe erosion on both banks of the sample segment. A total of 20 taxa were present in the benthic macroinvertebrate sample, with only two Ephemeroptera, Plecoptera or Tricoptera taxa present. Seventy-four percent of the individuals in the sample were in the highly tolerant Chironomidae family and less than one percent of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 1.33, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

13LP-313-R-2013E – This site is the mainstem Little Patuxent River as it flows under Guilford Road near the intersection with Murray Hill Road in Columbia. The majority of the segment is in wooded land behind a residential development, but approximately one-quarter of the sample segment is in a transmission line right-of-way with little to no riparian buffer. There is a USGS gauging station at the midpoint of the segment, where a small dam was built. This is a large G5 channel dominated by sandy substrate. The 24,123-acre drainage area contains a mix of land uses, but is split predominantly by medium-density residential development (29%) and forested land use (20%). There are also small amounts of land in agriculture, bare ground, commercial/industrial, high-density residential development, institutional, low-density residential development, open urban land, open water, and transportation land uses. Impervious cover accounts for 20% of the drainage area. The RBP habitat assessment resulted in a score of 60 ("Non-Supporting"); the PHI score was 69.6 ("Partially Degraded"). There is evidence of severe erosion, especially on the left bank of the sample site. A total of 30 taxa were present in the benthic macroinvertebrate sample, with seven Ephemeroptera, Plecoptera or Tricoptera taxa present. Sixty-three percent of the individuals in the sample were in the highly tolerant Chironomidae family and seven percent of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.67, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

13LP-416-R-2013F – This is the mainstem Little Patuxent River as it flows behind the Little Patuxent Water Reclamation Plant in Savage. It is a large F4 channel dominated by gravel substrate. The 63,345-acre drainage area contains a mix of land uses, but is split predominantly by forested land use (24%), agriculture (24%), and low-density residential development (20%). There are also small amounts of land in bare ground, commercial/industrial, high-density residential development, institutional, medium-density residential development, open urban land, open water, and transportation land uses. Impervious cover accounts for 13% of the drainage area, the lowest in the subwatershed. The RBP habitat assessment resulted in a score of 75 ("Partially Supporting"); the PHI score was 61.2 ("Degraded"). There is evidence of severe bank erosion at the site, particularly on the left bank. A total of 30 taxa were present in the benthic macroinvertebrate sample, with six Ephemeroptera, Plecoptera or Tricoptera taxa present. Sixty-eight percent of the individuals in the sample were in the highly tolerant Chironomidae family and eight percent of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.00, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

13LP-319-F-2013G – This is the mainstem Little Patuxent River where it partially flows through a transmission line right-of-way in Columbia, just north of Broken Land Parkway. The portion of the stream not in the right-of-way is wooded, but the section in the right-of-way has little to no riparian buffer. It is a large B4 channel dominated by gravel substrate. The 18,603-acre drainage area contains a mix of land uses, but is split predominantly by medium-density residential development (27%) and forested land use (20%). There are also small amounts of land in agriculture, bare ground, commercial/industrial, high-density residential development, institutional, low-density residential development, open urban land, open water, and transportation land uses. Impervious cover accounts for 18% of the drainage area. The RBP habitat assessment resulted in a score of 73 ("Partially Supporting"); the PHI score was 64.5 ("Degraded"). A total of 31 taxa were present in the benthic macroinvertebrate sample, with five Ephemeroptera, Plecoptera or Tricoptera taxa present. Seventy-two percent of the individuals in the sample were in the highly tolerant Chironomidae family and three percent of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.00, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

13LP-121-F-2013H – This site is located in Columbia, not far from Dobbin Road. It is an F4 channel dominated by gravel substrate. The land use in this 1,546-acre drainage area is somewhat evenly split between medium-density residential development (35%), commercial/ industrial land (20%), and forested land (20%). There are also small amounts of land in agriculture, high-density residential development, institutional, low-density residential development, open urban land, and transportation in the drainage area. Impervious cover accounts for 30% of the drainage area, the largest in the subwatershed. The RBP habitat assessment resulted in a score of 69 ("Partially Supporting"); the PHI score was 65.7 ("Degraded"). A total of 27 taxa were present in the benthic macroinvertebrate sample, with only five Plecoptera or Tricoptera taxa present. No Ephemeroptera taxa were present in the sample. Seventy-eight percent of the individuals in the sample were in the highly tolerant Chironomidae family and less than one percent of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 2.00, corresponding to a "Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

13LP-123-F-2013I – This stream runs through a wooded area between two commercial/ industrial sites. A stormwater pond near Larkin Road drains into the sample segment. It is a B4 channel dominated by gravel substrate. The land use in this 1,555-acre drainage area is somewhat evenly split between forested land use (30%) and commercial/industrial land use (24%). There are also small amounts of land in agriculture, high-density residential development, institutional, low-density residential development, medium-density residential development, open urban land, and transportation land sues. Impervious cover accounts for 24% of the drainage area. The RBP habitat assessment resulted in a score of 64 ("Partially Supporting"); the PHI score was 62.3 ("Degraded"). A total of 13 taxa were present in the benthic macroinvertebrate sample, with only one Plecoptera or Tricoptera taxa present. No Ephemeroptera taxa were present in the sample. None of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 1.33, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

13LP-125-F-2013J – This is a small stream in a very developed residential area. It is a G4 channel dominated by gravel substrate. The land use in this very small 36-acre drainage area is fairly evenly split between medium-density residential development (55%) and agricultural land use (42%). There is also a small amount of land in low-density residential development. Impervious cover accounts for 22% of the drainage area. The RBP habitat assessment resulted in a score of 50 ("Non-Supporting"), the lowest in the watershed; the PHI score was also the lowest in the subwatershed at 44.6 ("Severely Degraded"). A total of 16 taxa were present in the benthic macroinvertebrate sample, with only two Plecoptera or Tricoptera taxa present. No Ephemeroptera taxa were present in the sample. None of the individuals identified were intolerant to urban stressors. The site's overall BIBI score was 1.67, corresponding to a "Very Poor" biological classification. Water quality parameters were all within acceptable COMAR standards.

4 DISCUSSION AND COMPARISON

4.1 DISCUSSION OF 2013 ASSESSMENT RESULTS

Bioassessment – Biological results for 2013 in the Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent subwatersheds indicate areas that are in poor to very poor condition. Fifteen of the sites sampled received overall BIBI ratings of "Poor" and 11 sites received ratings of "Very Poor." Only three sites, all located in the Upper Little Patuxent subwatershed received "Good" ratings. 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 "Partially Supporting" in all of the Upper Little Patuxent and Lower Little Patuxent subwatersheds. Average RBP habitat conditions are "Non-Supporting" in the Middle Little Patuxent subwatershed. None of the sites sampled in any of the three sub-watersheds were "Comparable to Reference" (as defined as > 90% of the maximum score). Only two sites, one in the Upper Little Patuxent and one in the Lower Little Patuxent, were "Supporting." Sixteen sites were "Partially Supporting" and eleven were "Non-Supporting" (eight of which were in the Middle Little Patuxent subwatershed).

The PHI results indicate average subwatershed physical habitat conditions that are "Degraded" in all three subwatersheds sampled in 2013. No sites were "Minimally Degraded." Six sites were "Partially Degraded." Sixteen sites were "Degraded" and seven were "Severely Degraded" (2 in Upper Little Patuxent, 4 in Middle Little Patuxent, and 1 in Lower Little Patuxent).

Appendix D contains details concerning the physical habitat analyses.

Water Quality – Two sites in the Upper Little Patuxent subwatershed were below the minimum COMAR pH standard of 6.5. All other sites sampled 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. Some of the channels sampled throughout the subwatersheds were classified as stable type B, C, and E channels; however, more than half of the channels were classified as unstable, incised F and G channels. Gravel is the dominant substrate type in almost all 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 Little Patuxent subwatershed is 12%. Twenty-four percent of the land in the upstream catchments in the Middle Little Patuxent and 21% of the land in the Lower Little

Patuxent subwatershed is impervious surface. Imperviousness in the areas draining to each sampling site ranges from less than 5% to 41% (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.

Regression Relationships – Regression analysis is a statistical technique for estimating the relationships among variables. It helps one to understand how the typical value of the one variable changes when another variable is varied. It allows a user to use measured data to predict future results. The result of a regression analysis is an R-squared value that ranges from 0 to 1.0. A higher number is indicative of a stronger relationship between the variables.

Land use, habitat, and water chemistry parameters were regressed against the benthic macroinvertebrate IBI scores for each site in order to examine the relationship of those parameters to the biological health of the stream. 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.

The relationship of BIBI scores to impervious surface in the catchments upstream of the sample site was significant (Figure 4-1; R2= 0.22, p = 0.009). Generally, as impervious surface increased, the BIBI scores decreased. Although there were only three sites sampled in 2013 that received a BIBI score greater than 3.00, those three sites were all in catchments with less than 10% impervious surface, consistent with the notion that overall biological condition is likely being affected by the amount of development (i.e., imperviousness) in the watershed.

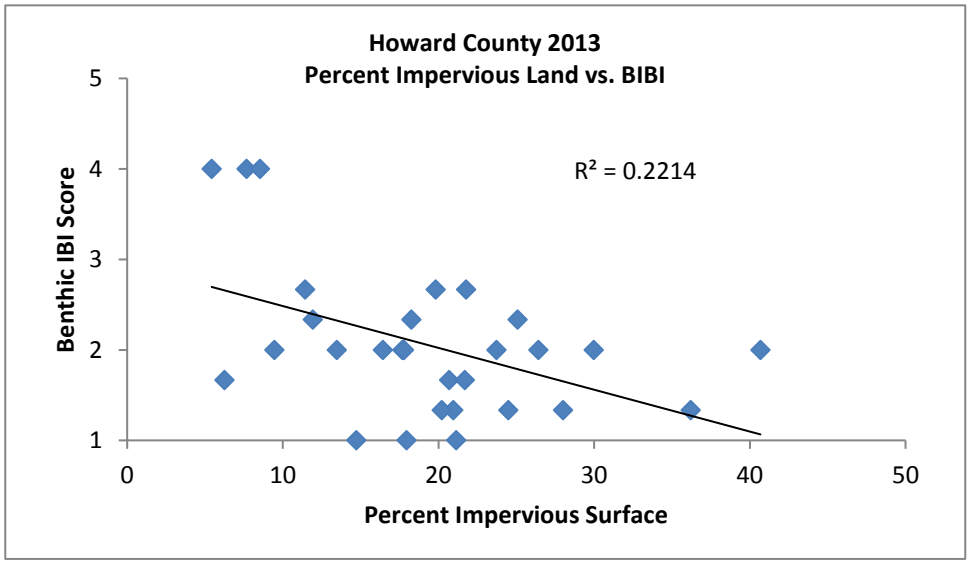

Figure 4-1. Regression relationships between the Benthic Index of Biotic Integrity (BIBI) and impervious surface in upstream catchments during 2013 Howard County Biological Monitoring

Although not very strong, there are significant positive relationships between the BIBI and both the RBP habitat assessment score and the PHI score (R2= 0.15, p = 0.04, for both parameters). As the habitat scores increase, so does the BIBI (see Figure 4-2). This suggests that physical habitat conditions directly affect the biological condition of a stream.

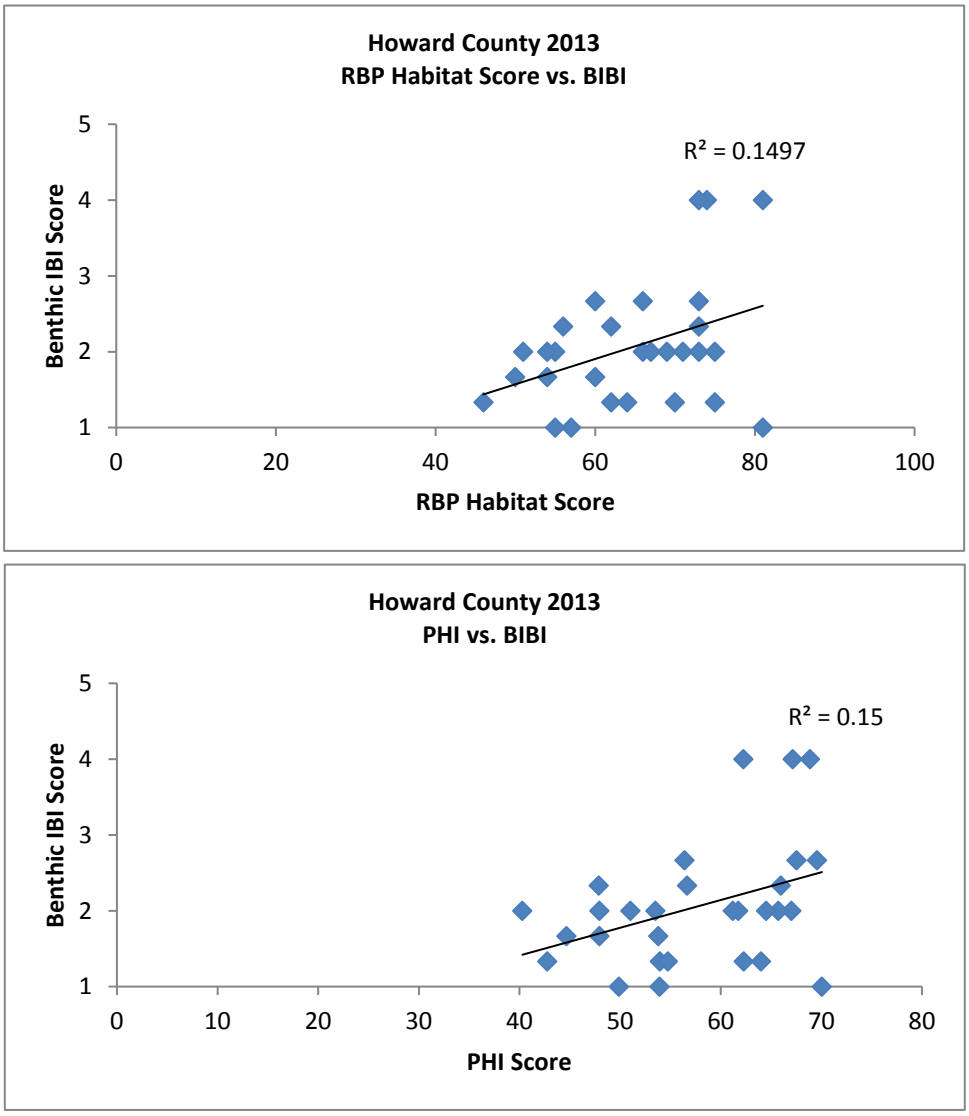

Figure 4-2. Regression relationships between the Benthic Index of Biotic Integrity (BIBI) and both RBP Habitat Assessment Score and Physical Habitat Indicator (PHI) for sites sampled in the 2013 Howard County Biological Monitoring.

Water quality parameters (temperature, dissolved oxygen, pH, conductivity, and turbidity) were also regressed against the BIBI score. None of the results showed significant relationships, although a general trend showed that as dissolved oxygen increased and conductivity decreased, the BIBI scores improved.

4.2 COMPARISON OF 2001, 2006, AND 2013 BIOASSESSMENT DATA

BIBI - Table 4-1 summarizes the 2001, 2006, and 2013 biological index data, and Figure 4-3 is a box plot comparing BIBI scores for each subwatershed (current BIBI calculations were used for all rounds).

In the Upper Little Patuxent subwatershed, the Round 1 assessment (2001) indicated that the subwatershed was in "Poor" biological condition overall, according to the updated BIBI scores (BIBI = 2.45 ± 0.89). Round 2 results (2006) showed "Very Poor" biological condition (BIBI = 1.80 ± 0.39). Round 3 results (2013) show an average "Poor" biological condition (BIBI = 2.70 ± 1.07). The ANOVA test for differences amongst the years showed that the biological condition in Round 2 was significantly different from that in Round 1 and Round 3, but that the condition in Round 1 was not significantly different from that in Round 3.

In the Middle Little Patuxent subwatershed, the Round 1 biological condition was "Very Poor" overall (BIBI=1.56 ± 0.69). Round 2 results show an increase in biological condition, as the subwatershed received a "Poor" rating (BIBI=2.46 ± 1.04). In Round 3, the biological condition decreased again to "Very Poor" (BIBI=1.79 ± 0.50). The ANOVA test showed that the biological condition in Rounds 1 and 2 were significantly different from each other, but neither was significantly different from Round 3.

In the Lower Middle Patuxent subwatershed, the biological condition in all three rounds was "Very Poor" (BIBI=1.69 ± 0.54, BIBI=1.87 ± 0.61, and BIBI=1.73 ± 0.49; respectively). The ANOVA test also showed that the difference in BIBI scores in this subwatershed was not significant.

RBP Physical Habitat Assessment – Table 4-3 summarizes the 2001, 2006, and 2013 RBP comparability scores, and Figure 4-4 is a box plot illustrating RBP comparability scores. Results of the Round 1 (2001) assessment indicate that the Upper Patuxent River subwatershed rated "Non-Supporting" (RBP score of 54.8 ± 14.5). Round 2 (2006) and Round 3 (2013) assessments indicate that the physical habitat condition in this subwatershed increased to "Partially Supporting" (RBP scores of 73.8 ± 9.6 and 68.2 ± 8.7, respectively). For this subwatershed, Round 2 and Round 3 habitat assessment scores were not significantly different from each other, but the Round 1 score was significantly less than both Round 1 and Round 2.

In the Middle Patuxent River subwatershed, results of Round 1 of the assessments indicated that the subwatershed rated "Non-Supporting" (RBP score of 48.1 ± 12.1). In Round 2, physical habitat quality in this subwatershed improved to a "Partially Supporting" (RBP score of 72.6 ± 12.4). Physical habitat quality decreased again to "Non-Supporting" in Round 3 (RBP score of 59.9 ± 8.3). In this subwatershed, the habitat scores in all three Rounds were significantly different from one another.

In the Lower Little Patuxent subwatershed, the Round 1 assessment indicated that the subwatershed rated "Non-Supporting" (RBP score of 51.3± 10.6). The habitat comparability score increased in Rounds 2 and 3 to a rating of "Partially Supporting" (RBP scores of 73.3 ± 8.3 and 66.0 ± 10.4, respectively). In this subwatershed, habitat assessment scores in Rounds 2 and

3 were not significantly different from each other, but the score in Round 1 was significantly lower than both Rounds 2 and 3.

Table 4-1. Comparison of 2001, 2006, and 2013 BIBI data								
Sampling Year		**Number of Sites Sampled**	**Min BIBI Score**	**Max BIBI Score**	**Median BIBI Score**	**Mean BIBI Score**	**Narrative Rating**	**Standard Deviation**
2001	Upper Little Patuxent	11	1.00	2.67	1.33	1.63	Very Poor	0.54
	Middle Little Patuxent	10	1.00	3.00	1.33	1.57	Very Poor	0.69
	Lower Little Patuxent	9	1.00	2.67	1.33	1.63	Very Poor	0.54
2006	Upper Little Patuxent	10	1.33	2.33	1.67	1.80	Very Poor	0.39
	Middle Little Patuxent	10	1.00	4.00	2.50	2.47	Poor	1.04
	Lower Little Patuxent	10	1.00	3.00	1.83	1.87	Very Poor	0.61
2013	Upper Little Patuxent	9	1.00	4.00	2.33	2.70	Poor	1.07
	Middle Little Patuxent	10	1.00	2.67	1.83	1.80	Very Poor	0.50
	Lower Little Patuxent	10	1.00	2.67	1.83	1.73	Very Poor	0.49

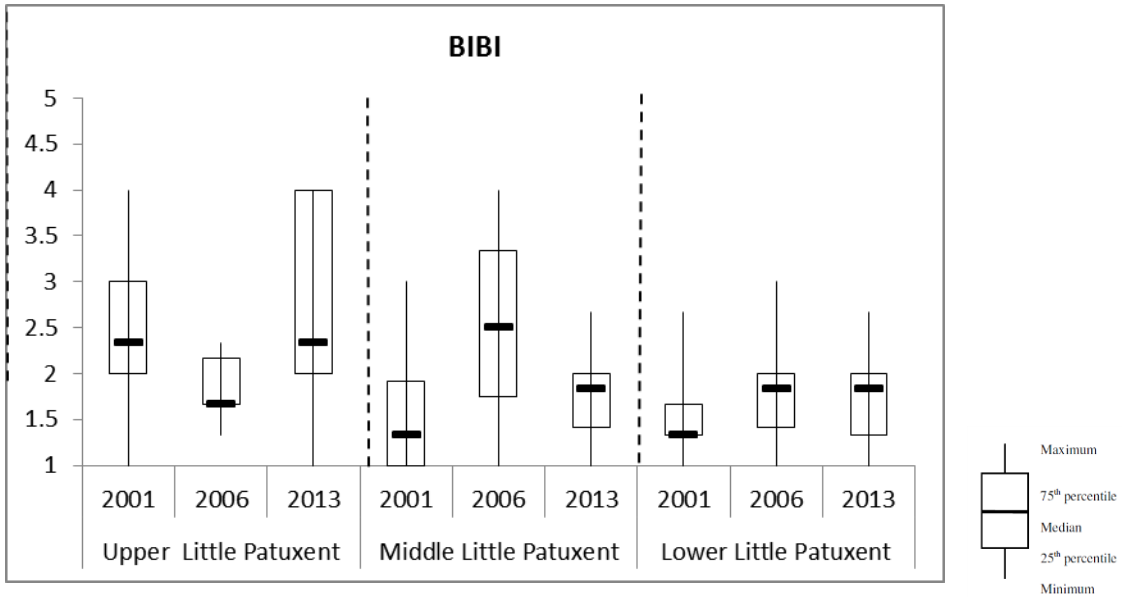

Figure 4-3. Comparison of 2001, 2006, and 2013 BIBI scores

Table 4-2. Comparison of 2001, 2006, and 2013 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 Little Patuxent	11	20.00	74.00	59.00	54.80	Non-Supporting	14.54
	Middle Little Patuxent	10	28.00	69.00	47.00	48.10	Non-Supporting	12.06
	Lower Little Patuxent	6	37.00	65.00	49.00	51.33	Non-Supporting	10.61
2006	Upper Little Patuxent	10	56.00	86.00	74.50	73.80	Partially Supporting	9.61
	Middle Little Patuxent	10	52.00	90.00	76.00	72.60	Partially Supporting	12.40
	Lower Little Patuxent	9	63.00	89.00	72.00	73.33	Partially Supporting	8.31
2013	Upper Little Patuxent	9	55.00	81.00	73.00	68.22	Partially Supporting	8.73
	Middle Little Patuxent	10	46.00	71.00	58.00	59.90	Non-Supporting	8.27
	Lower Little Patuxent	10	50.00	81.00	66.50	66.00	Partially Supporting	10.45

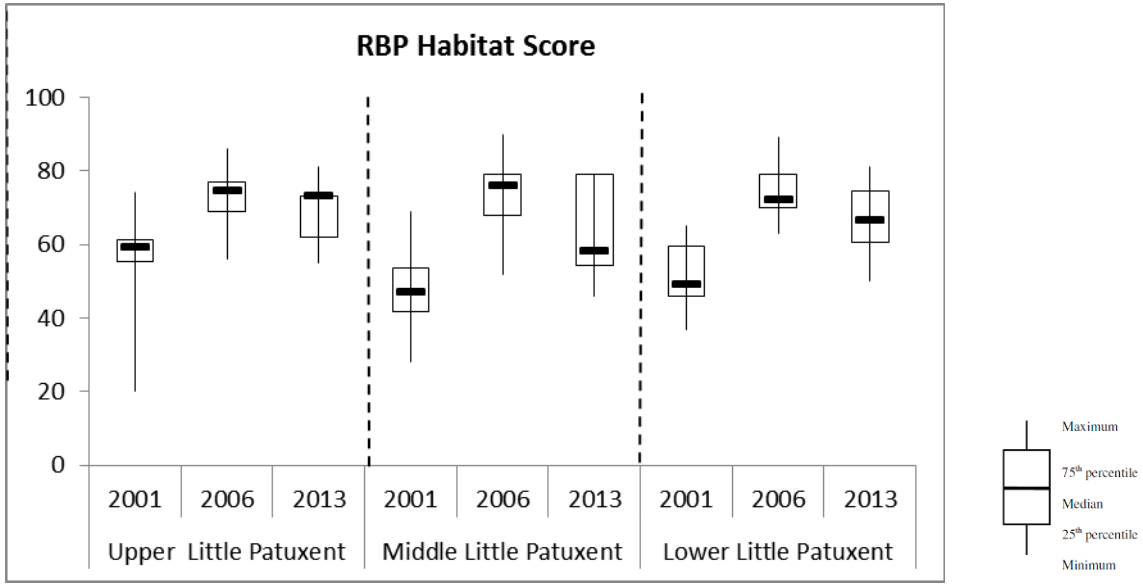

Figure 4-4. Comparison of 2001, 2006, and 2013 RBP assessment scores

5 CONCLUSIONS AND RECOMMENDATIONS

This report is the second 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 most of the water quality parameters measured were within 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 the 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 in stormwater runoff. 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 (beginning of Round 3) 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 collected in Round 3 and previous rounds. The PHI showed a strong significant relationship to the RBP physical habitat assessment ($R^2 = 0.62$ with a p-value of < 0.001), indicating that the PHI score did not improve the overall assessment of the subwatersheds or individual sites significantly. 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 Maryland 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., stream 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 2013 sampling conducted for this project, Versar's field-crew 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.

Recently, Howard County completed a Phase I Countywide Implementation Strategy (CIS) that identifies 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 Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent subwatersheds (and other subwatersheds sampled in Round 3) will help target areas with the greatest restoration potential.

The CIS also includes a proposed 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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