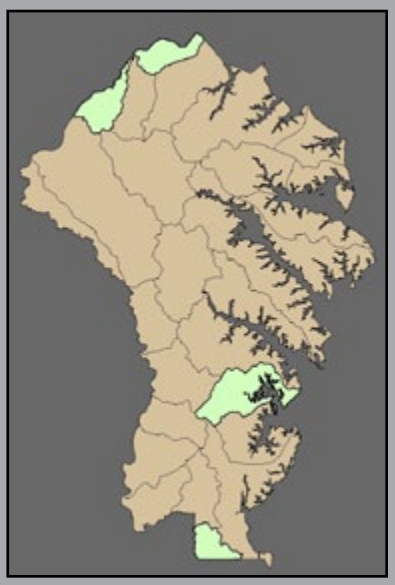


Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2012

Anne Arundel County, Maryland
Department of Public Works
Watershed, Ecosystem, and Restoration Services

Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2012 Round Two—Year Four

November 2012 - FINAL

Prepared for:

Anne Arundel County
Department of Public Works
Watershed, Ecosystem, and Restoration Services
Ecological Assessment Program

2662 Riva Road, P.O. Box 6675
Annapolis, Maryland 21401

Prepared by:

KCI Technologies, Inc.
936 Ridgebrook Road
Sparks, Maryland 21152

Abstract

The Anne Arundel County Department of Public Works' Watershed, Ecosystem, and Restoration Services Program assesses water resource quality using a comprehensive countywide biological monitoring and assessment program. The primary goals of the program are to document and track the ecological health of County streams and watersheds, identify the primary stressors on ecological health, and support natural resource management decision making as it relates to the intended uses of County waterbodies and State regulations. One intended use of all water bodies is the support of aquatic life. Assessment of the ability of a stream to support aquatic life can be accomplished for the entire County through probabilistic (random) site selection, sampling of biological specimens, and observations of the physical habitat and water quality. The County's assessment program was continued in 2012 with sampling in four primary sampling units; Hall Creek, Lower Patapsco, Piney Run, and Rhode River. The indicators used to assess the aquatic life in streams include the Maryland DNR Benthic Index of Biological Integrity (BIBI), the USEPA Rapid Bioassessment Protocol (RBP) physical habitat assessment, and five water quality measures (temperature, dissolved oxygen, specific conductance, pH, and turbidity), as well as a detailed geomorphic assessment and classification using methods developed by Rosgen (1996). Each of these indicators was compared to established thresholds to determine narrative condition ratings. All four sampling units had mean BIBI values that resulted in 'Poor' biological condition ratings. Lower Patapsco was the only sampling unit with physical habitat conditions rated 'Non Supporting' by the RBP method, with the remaining four sampling units rated as 'Partially Supporting.' Using the PHI, all but one sampling unit had 'Partially Degraded' physical habitat conditions; Piney Run had 'Degraded' physical habitat conditions. The majority of reaches (58 percent) were incised F or G type streams (33 percent and 25 percent, respectively). Generally, water quality measurements were within COMAR standards for dissolved oxygen and there were no exceedances for temperature or turbidity. Six of the sites sampled, spanning three of the four sampling units, recorded pH values that fell below state standards of 6.5 standard units. Elevated conductivity values were observed at over half of the sites sampled in 2012 (23 sites), throughout all sampling units. Comparisons of 2012 BIBI data to Round One data did not result in a statistically significant difference between sampling units. Comparisons of physical habitat data showed a statistically significant increase in the average RBP score for Piney Run and Rhode River and a statistically significant decrease in Lower Patapsco. Comparisons of 2012 PHI scores to Round One data did not result in a statistically significant difference between sampling units.

Acknowledgements

The principal authors of this document were Megan Crunkleton, Colin Hill, and Michael Pieper, all of KCI Technologies, Inc. They were assisted by KCI staff including Susanna Brellis and Courtney Hugo. Environmental Services and Consulting completed benthic macroinvertebrate sample sorting and identification. County staff instrumental in program management and quality assurance are Janis Markusic and Christopher Victoria in the Department of Public Works, Watershed, Ecosystem, and Restoration Services. The appropriate citation for this report is:

Crunkleton, M.C., C. R.Hill, and M.J. Pieper. 2012. Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2012. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland. 50 pp., plus Appendices.

For more information about this report, please contact:

Christopher Victoria
Watershed, Ecosystem, and Restoration Services
Department of Public Works
Anne Arundel County
2662 Riva Road / MS 7301
Annapolis, Maryland 21401
410.222.4240
pwvict16@aacounty.org

Table of Contents

List of Tables

List of Figures

1 Introduction

Anne Arundel County, Maryland is bordered on the north by the Patapsco River, to the west by the Patuxent River, and to the east by the Chesapeake Bay. Anne Arundel County has approximately 1,500 miles of streams and rivers within its borders, all of which drain either directly or indirectly into the Chesapeake Bay. With a drainage area of 64,000 square miles, the Chesapeake Bay is the largest estuary in the United States (USEPA, 2004). The Chesapeake Bay provides habitat for many animal and plant species and is an important economic and recreational resource for more than 15 million people who live in the drainage basin. Increasing populations and development in the basin are intensifying point and nonpoint sources of pollutants and multiple other stressors sources that affect environmental conditions.

In order to protect these important resources – not only the streams and rivers of the County but ultimately the Chesapeake Bay – basic information about the overall conditions must be collected and analyzed. To better understand the condition of its watershed and stream resources, a Biological Monitoring and Assessment Program was initiated in the spring of 2004 by the Anne Arundel County Office of Environmental and Cultural Resources (now the Watershed, Ecosystem and Restoration Services Group of the Department of Public Works). The sampling program involves monitoring the biological health and physical condition of the County's water resources to assess the status and trends at the stream level, the watershed level, and ultimately at the County level.

The County initiated the program, in part, to establish a baseline ecological stream condition for all of the County's watersheds and to track changes in condition over time. The program is designed on a five-year rotating basis such that each of the County's 24 watersheds or primary sampling units (PSU) will be sampled once every five years. In general, four to five PSUs are sampled each year with 10 sites sampled in each PSU. Table 1 illustrates the progress made to date within the countywide biological monitoring program. The first sampling rotation, Round 1, was completed in five years (2004-2008). Sampling efforts in 2012 mark the fourth year of Round 2 sampling with 40 randomly selected sites sampled throughout four sampling units (i.e., 10 per PSU).

Table 1 - Summary of Bioassessment Progress

Year	Number of Sites	Primary Sampling Unit (code and name)		
Round 1				
2004	50	03-Lower Patapsco 09-Severn Run	10-Severn River 18-Middle Patuxent	21-Ferry Branch
2005	50	11-Upper North River 12-Lower North River	15-Herring Bay 19-Stocketts Run	22-Lyons Creek
2006	40	05-Marley Creek 06-Bodkin Creek	07-Upper Magothy 24-Hall Creek	
2007	50	01-Piney Run 02-Stony Run	08-Lower Magothy 16-Upper Patuxent	17-Little Patuxent
2008	50	04-Sawmill Creek 13-Rhode River	14-West River 20-Rock Branch	23-Cabin Branch
Round 2				
2009	50	05-Marley Creek 12-Lower North River	14-West River 17-Little Patuxent	20-Rock Branch
2010	50	02-Stony Run 04-Sawmill Creek	15-Herring Bay 18-Middle Patuxent	21-Ferry Branch
2011	50	06-Bodkin Creek 07-Upper Magothy	09-Severn Run 11-Upper North River	16-Upper Patuxent
2012	40	01-Piney Run 03-Lower Patapsco	13-Rhode River 24-Hall Creek	

1.1 Purpose of Biological and Physical Habitat Assessment

The use of benthic macroinvertebrates as the basis of biological assessments offers many considerable advantages over other biological assemblages (e.g., fish, periphyton, herpetofauna). For instance, benthic macroinvertebrates are relatively sedentary and easy to sample in large numbers, they respond to cumulative effects of physical habitat alteration, point source pollution and nonpoint source contaminants, and different aspects of the benthic assemblage change in response to degraded conditions (Barbour et al. 1999).

Physical habitat is also visually assessed at each sampling location to reflect current conditions of physical complexity of the stream channel, the capacity of the stream to support a healthy biota, and the potential of the channel to maintain normal rates of erosion and other hydrogeomorphic functions. Physical habitat of the stream channel can be affected by farming operations, increased housing density, and other urban-suburban developments; all of which may cause sedimentation, degradation of riparian vegetation, and bank instability, leading to reduced overall habitat quality (Richards et al. 1996).

Geomorphic assessments are performed to obtain quantitative information regarding the stream's morphology. The morphological characteristics of a stream channel can provide insight into the impacts of past and present land use on stream stability and/or erosion potential, which can influence the resident biota.

In situ water chemistry parameters are measured at every site to supplement biological and physical data. Water chemistry data, while limited in the number of parameters tested, provides a general indication of the chemical conditions of a waterbody and may indicate the presence of water quality stressors.

The combined use of biological, physical, and chemical data is beneficial for detecting impairment and providing insight into the potential types of stressors and stressor sources. This allows prioritization of more detailed, diagnostic investigations based on the severity of observed biological responses.

2 Methods

2.1 Network Design

2.1.1 Summary of Sampling Design

Details of the overall sampling program design, including the approach for the selection of sampling locations, can be found in *Design of the Biological Monitoring and Assessment Program for Anne Arundel County, Maryland* (Hill and Stribling, 2004). Stream assessment protocols including documented standard operating procedures (SOPs) for data collection, sample processing, taxonomic identification, and data management, the technical rationale behind the procedures, and the series of activities and reporting procedures that are used to document and communicate data quality are included in *Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan* (Anne Arundel County, 2011). Documentation of data quality and method performance characteristics, including measurement and data quality objectives (MQOs and DQOs), are presented in Hill and Pieper (2011a).

2.1.2 Site Selection

The county was separated into 24 primary sampling units (PSUs) in which ten sites are randomly selected for sampling. The number of sampling sites within each of the first through third order channel types, as defined by Strahler (1957), was proportional to the percentage of the total PSU stream length that each type comprised. The National Hydrologic Dataset (NHD) 1:100,000-scale stream layer was used in the selection. Final selection and placement of sampling sites was random and stratified by subwatershed and stream order. Four to five PSUs are sampled each year, so that all sampling units are assessed over a five-year period.

For 2012, ten randomly selected sites were chosen from each of the following PSUs (with PSU code); Piney Run (01), Lower Patapsco (03), Rhode River (13), and Hall Creek (24). Figure 1 shows the geographic distribution of PSUs assessed during this sampling period. A single site within each PSU was selected to conduct duplicate sampling for quality assurance/quality control purposes. Duplicate sampling reaches, or QC sites, were located immediately upstream of their paired sampling sites, and were first selected in the office and then assessed in the field to ensure that they had similar habitat characteristics and were not impacted by road crossings, confluences, or other unique stressors not present at the original sampling reach. Biological sampling, habitat assessments, and water quality measurements were repeated at the duplicate sites.

Sites were located in the field using a Trimble Pathfinder ProXT GPS unit coupled with a Panasonic Toughbook® field computer running ESRI's ArcPad mapping software and loaded with recent (2007), high-resolution aerial orthophotography layers and the same NHD stream layer that was used in the site selection process to ensure that the appropriate stream reach was sampled and surveyed. Since the targeted stream layer is based on coarse 1:100,000-scale mapping, pre-selected site coordinates are often several meters away from the stream channels. Consequently, the position of the reach mid-point was collected with a Trimble® GPS unit capable of sub-meter accuracy to ensure accurate positioning of sampling locations. GPS data were recorded in the Maryland State Plane, NAD 1983 Feet coordinate system. The procedures performed at each site are described in detail in Section 2.2.

2.1.3 Alternate Sites

In addition to the primary sites, ten secondary (alternate) sites were also chosen at random for each subwatershed in case a primary sampling site was proven to be unsampleable (e.g. permission denied by landowner, no defined channel present, or channel is too deep or unsafe to sample). A total of ten alternate sites were sampled during this sampling period (Table 2).

2.2 Field and Laboratory Procedures

2.2.1 Benthic Macroinvertebrate Sampling and Processing

Benthic macroinvertebrate samples were collected during the Spring Index Period (March 1st to May 1st) following the sampling protocols in the Quality Assurance Project Plan (QAPP), which closely mirrors MBSS procedures (DNR, 2010). The approach was used to sample a range of the most productive habitat types within the reach. In this multi-habitat sampling approach, a total of twenty jabs are distributed among the most productive habitats present within the 75-meter reach and sampled in proportion to their dominance within the segment using a D-frame net. The most productive stream habitats are riffles followed by, rootwads, rootmats and woody debris and associated snag habitat; leaf packs; submerged macrophytes and associated substrate; and undercut banks. Less preferred habitats include gravel, broken peat, and clay lumps located within moving water and detrital or sand areas in runs.

Figure 1 - 2012 Sampling Units

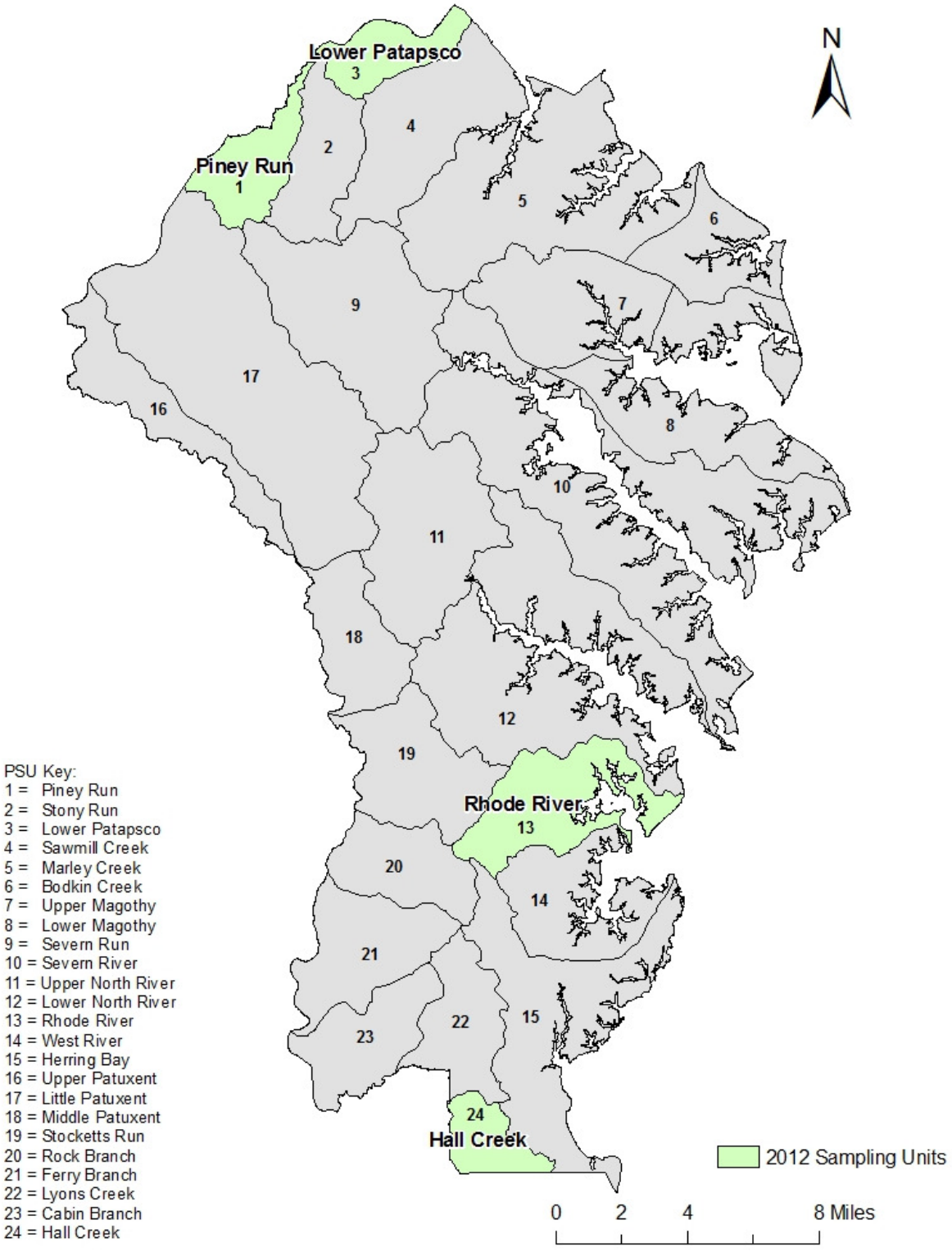


Table 2 - Field Sampling - Alternate Sites Chosen

Original Site	Alternate Site	Reason
R2-03-01	R2-03-11A	Dry, ephemeral channel
R2-03-09	R2-03-15A	Completely within storm sewer system
R2-13-02	R2-13-11A	Permission denied
R2-13-06	R2-13-12A	Permission denied
R2-13-07	R2-13-13A	Permission denied
R2-13-09	R2-13-17A	Permission denied
R2-13-10	R2-13-22A	Permission denied
R2-24-01	R2-24-11A	Permission denied
R2-24-02	R2-24-12A	Permission denied
R2-24-07	R2-24-13A	Permission denied

All sorting and identification of the subsampled specimens was conducted by Environmental Services and Consulting, LLC[1]. Benthic macroinvertebrate samples were processed and subsampled according to the County QAPP and based on the methods described by Caton (1991). 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 (30 total grids) and each grid is picked clean of organisms until a minimum count of 100 is reached. If the initial count exceeds 120 organisms, the sample is further subsampled using a gridded petri dish until the final count is between 100 and 120 organisms. Any samples containing greater than 120 organisms after taxonomic identification and enumeration, a post-processing subsampling procedure was conducted using an Excel spreadsheet application (Tetra Tech, 2006). This post-processing application is designed to randomly subsample all identified organisms within a given sample to a desired target number. Each taxon is subsampled based on its original proportion to the entire sample. In this case, the desired sample size selected was 110 individuals. This allows for a final sample size of approximately 110 individuals (±20 percent) but keeps the total number of individuals below the 120 maximum.

Taxa were primarily identified to the genus level for most organisms. Groups including Oligochaeta and Nematomorpha were identified to the family level while Nematoda was left at phylum. Individuals of early instars or those that may be damaged were identified to the lowest possible level. Chironomidae were further subsampled depending on the number of individuals in the sample and the numbers in each subfamily or tribe. Most taxa were identified using a stereoscope. Temporary slide mounts were used to identify Oligochaeta to family with a compound scope. Chironomid sorting to subfamily and tribe was also conducted using temporary slide mounts. Permanent slide mounts were then used for final genus level identification. Results were logged on a bench sheet and entered into a spreadsheet for data analysis.

2.2.2 Stream Physical Habitat Assessment

Each biological monitoring site was characterized based on visual observation of physical characteristics and various habitat parameters. Both the EPA's Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al., 1999) and the Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI; Paul et al., 2003) were used to visually assess the physical habitat at each

[1] Address: 101 Professional Park Drive, STE 303, Blacksburg, VA

site. Both assessment techniques rely on subjective scoring of selected habitat parameters. To reduce individual sampler bias, both assessments were completed as a team with discussion and agreement of the scoring for each parameter. In addition to the visual assessments, photo-documentation of the condition of each assessment reach was performed. Photographs were taken from three locations within the sampling reach (downstream end, mid-point, and upstream end) facing in the upstream and downstream direction, and also facing in the upstream, downstream, left bank, and right bank directions at the cross-section location, for a total of ten photographs per site. Additional photographs were occasionally taken to document important or unusual site features.

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health. Each parameter is given a numerical score from 0-20 (20=best, 0=worst), or 0-10 (10=best, 0=worst) for individual bank parameters, and a categorical rating of optimal, suboptimal, marginal or poor. Overall habitat quality typically increases as the total score for each site increases. The RBP parameters assessed for low gradient streams are listed in Table 3.

Table 3 - RBP Low Gradient Habitat Parameters

Parameters Assessed	
Epifaunal substrate/available cover	Channel alteration
Pool substrate characterization	Channel sinuosity
Pool variability	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian vegetation zone width

Source: Barbour et al. 1999

The PHI incorporates the results of a series of habitat parameters selected for Coastal Plain, Piedmont and Highlands regions. While all parameters are rated during the field assessment, the Coastal Plain parameters are used to develop the PHI score. In developing the PHI, MBSS identified six parameters that have the most discriminatory power for the coastal plain streams (Table 4). Each habitat parameter is given an assessment score ranging from 0-20, with the exception of shading (percentage) and woody debris and rootwads (total count).

Table 4 - PHI Habitat Parameters

Parameters Assessed	
Remoteness	Instream Habitat
Shading	Woody Debris and Rootwads
Epibenthic Substrate	Bank Stability

Source: Paul et al. 2003

2.2.3 Water Quality Measurement

To assess general water quality conditions, several water chemistry parameters were measured *in situ* at each site. Field measured water chemistry parameters include pH, specific conductivity, dissolved oxygen, temperature, and turbidity. With the exception of turbidity, which was measured at a single point in the upstream end of the site, all measurements were collected from three locations within each sampling reach (upstream end, mid-point, and downstream end) and results were averaged to minimize variability and better represent water quality conditions throughout the entire sampling reach. Most *in situ* parameters (i.e., temperature, pH, conductivity, and dissolved oxygen) were measured with a YSI

Professional Plus series multiprobe, while turbidity was measured with a Hach 2100 Turbidimeter. Water quality meters were regularly inspected, maintained and calibrated to ensure proper usage and accuracy of the readings. Calibration logs were kept by field crew leaders and checked by the project manager regularly.

2.2.4 Geomorphic Assessment

Geomorphic assessments, which included a simplified longitudinal profile survey, cross section survey and modified Wolman pebble count, were conducted within each 75-meter sampling reach. Data were directly entered into the Ohio Department of Natural Resources (ODNR) Reference Reach Spreadsheet Version 4.3L (Mecklenburg, 2006) in the field using a field computer loaded with Microsoft Excel software. Data collected from the assessments were primarily used to determine the morphological stream type of each sampling reach according to the Rosgen Stream Classification (Rosgen, 1994, 1996). Assessment methods followed the standard operating procedures (SOPs) described in the QAPP, and are described briefly below.

Permanent cross sections were established on a representative transitional reach, typically in a riffle feature, and monumented with iron reinforcement bars topped with yellow plastic survey marker caps. The location of each monument was recorded using a Trimble Pathfinder ProXT GPS unit capable of sub-meter accuracy. Cross sections were surveyed using a laser level, calibrated stadia rod, and measuring tape. The surveys captured features of the floodplain, monuments, and all pertinent channel features including:

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

Bankfull elevation was determined in the field using appropriate bankfull indicators as described in Rosgen (1996) and with the assistance of the Maryland Coastal Plain (MCP) regional relationships of bankfull channel geometry (McCandless, 2003). Using the drainage areas delineated to each monitoring location, as described in section 2.3.6 *Land Use Analysis and Impervious Surface*, the approximate bankfull cross sectional areas were derived from the MCP curve and field crews verified bankfull elevations while in the field.

Sinuosity was determined based on the length of the survey reach following the thalweg thread (i.e., 75-meters) and the straight-line distance between the upstream and downstream extent of the channel. If the stream was not incised, the floodprone width was measured at the cross section using an elevation of two times the bankfull depth.

Survey points were taken near the upstream, midpoint, and downstream end of the sampling reach to obtain the water surface slope and elevation of the bankfull discharge. Survey points for slope calculations were typically taken at top of riffle features, although this was not always possible due to available instream features. In the absence of riffle features, the best available feature (e.g., run, glide) was used ensuring that the same bed feature was used in the upstream and downstream extents of the reach.

The channel bed materials were characterized throughout each survey reach using a proportional pebble count procedure adapted from Harrelson et al. (1994), which stratifies the reach by the proportion of pool, riffle, run, and glide features within the entire reach. The pebble count technique, modified from Wolman (1954), was conducted at each site to determine the composition of channel materials and the median particle size (i.e., D_{50}) within each survey reach. The pebble count was conducted at 10 transects positioned throughout the entire reach based on the proportion of bed features, and 10 particles (spaced as evenly as possible) were measured across the bankfull channel of each transect, resulting in a total of 100 particles. Particles were chosen without visual bias by reaching forth with an extended finger into the stream bed while looking away and choosing the first particle that comes in contact with the sampler's finger. All particles are then measured to the nearest millimeter across the intermediate axis using a ruler. For channels comprised entirely of fine sediments (e.g., sand, silt, or clay) with no distinct variation in material size, only two transects were performed and the results were extrapolated to the remainder of the reach.

2.3 Data Analysis

2.3.1 Data Structure

Benthic macroinvertebrate, physical habitat, water chemistry, geomorphic, land cover, land use, and impervious data were entered into an ESRI personal geodatabase. This relational database allows for the input and management of field collected data including physical habitat and water chemistry parameters, as well as taxonomic data, calculated metric and index scores, geomorphic and land use parameters, and other metadata. Furthermore, the data are geospatially linked to each site and drainage area for enhanced mapping and spatial analysis capabilities. Benthic macroinvertebrate index (BIBI) scores and physical habitat index (RBP and PHI) scores were calculated using controlled and verified Microsoft Excel spreadsheets. Final index values and scores for each site were imported into the geodatabase.

2.3.2 Physical Habitat

The individual RBP habitat parameters for each reach were summed to obtain an overall RBP assessment score. The total score, with a maximum possible score of 200, was then placed into one of four categories based on their percent comparability to reference conditions (Table 5). Since adequate reference condition scores do not currently exist for Anne Arundel County, the categories used in this report were adapted from Plafkin et al. (1989) and are based on western coastal plain reference conditions obtained from Prince George's County streams (Stribling et al., 1999).

Using the raw habitat values recorded in the field, a scaled PHI score (ranging from 0-100) for each parameter is calculated following the methods described in Paul et al. (2003). Several of the parameters (i.e., epifaunal substrate, instream habitat, and woody debris and rootwads) have been found to be drainage area dependent and are scaled according to the drainage area to each site. A detailed description of the procedure used to delineate site-specific drainage areas is included in section 2.3.6 *Land Use Analysis and Impervious Surface*. Calculated metric scores are then combined and averaged to obtain the overall PHI index score, and a corresponding narrative rating of the physical habitat condition is applied (Table 6).

Table 5 - EPA RBP Scoring

Score	Narrative
151 +	Comparable
126-150	Supporting
101-125	Partially Supporting
0-100	Non Supporting

Source: Stribling et al. 1999

Table 6 - MBSS PHI Scoring

Score	Narrative
81-100	Minimally Degraded
66-80.9	Partially Degraded
51-65.9	Degraded
0-50.9	Severely Degraded

Source: Paul et al. 2003

2.3.3 Biological Index Rating

Benthic macroinvertebrate 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/or habitat impairment. The metrics selected fall into five major groups including taxa richness, composition measures, tolerance to perturbation, trophic classification, and habit measures.

Raw values from each metric are given a score of one (1), three (3) or five (5) based on ranges of values developed for each metric, as shown in Table 7. The scored metrics are combined and averaged into a scaled BIBI score ranging from 1.0 to 5.0, and a corresponding narrative biological condition rating is assigned (Table 8). Three sets of metric calculations have been developed for Maryland streams based on broad physiographic regions, which include the coastal plain, piedmont and combined highlands regions. Anne Arundel County is located entirely within the coastal plain region; therefore, the metrics selected and calibrated specifically for Maryland coastal plain streams were used for the BIBI scoring and include:

1) *Total Number of Taxa* – Equals the richness of the community in terms of the total number of genera 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.

2) *Number of EPT Taxa* – Equals the number of genera that classify as Ephemeroptera (mayflies), Plecoptera (stoneflies), and/or Trichoptera (caddisflies) in the sample. EPT taxa are generally considered pollution sensitive, thus higher levels of EPT taxa would be indicative of higher water quality.

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

4) *Percent Intolerant Urban* – Percentage of sample considered intolerant to urbanization. Equals the percentage of individuals in the sample with a tolerance value of 0-3. As impairment increases, the percent of intolerant taxa decreases.

5) *Percent Ephemeroptera* – Equals the percent of Ephemeroptera individuals in the sample. Ephemeroptera are generally considered pollution sensitive, thus communities dominated by Ephemeroptera usually indicate lower disturbances in water quality.

6) *Number Scraper Taxa* – Equals the number of scraper taxa in the sample. Individuals in these taxa scrape food from the substrate. As the levels of stressors or pollution rise, there is an expected decrease in the numbers of Scraper taxa.

7) *Percent Climbers* – Equals the percentage of the total number of individuals who are adapted to living on stem type surfaces. Higher percentages of climbers typically represent a decrease in stressors and overall better water quality.

Information on functional feeding group, habit, and tolerance values for each organism were derived primarily from Southerland et al. (2005), which is based heavily on information compiled from Merritt and Cummins (1996) and Bressler et al. (2004). Secondary sources, primarily EPA's RBP document (Barbour et al. 1999), were used only when a particular organism was not included in Southerland et al. (2005).

Table 7 - MBSS Coastal Plain BIBI Metric Scoring

Metric	Score		
	5	3	1
Total Number of Taxa	≥22	14-21	<14
Number of EPT Taxa	≥5	2-4	<2
Number of Ephemeroptera Taxa	≥2	1-1	<1
Percent Intolerant Urban	≥28	10-27	<10
Percent Ephemeroptera	≥11.0	0.8-10.9	<0.8
Number of Scraper Taxa	≥2	1-1	<1
Percent Climbers	≥8.0	0.9-7.9	<0.9

Source: Southerland et al. 2005

Table 8 - MBSS Biological Condition Rating

BIBI Score	Narrative Rating	Characteristics
4.0 – 5.0	Good	Comparable to reference streams considered to be minimally impacted.
3.0 – 3.9	Fair	Comparable to reference conditions, but some aspects of biological integrity may not resemble minimally impacted streams.
2.0 – 2.9	Poor	Significant deviation from reference conditions, indicating some degradation.
1.0 – 1.9	Very Poor	Strong deviation from reference conditions, with most aspects of biological integrity not resembling minimally impacted streams indicating severe degradation.

2.3.4 Water Quality

The Maryland Department of the Environment (MDE) has established acceptable standards for several of the water chemistry parameters measured in this study for each designated Stream Use Classification. Water quality data were compared to acceptable standards for Use I streams listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality* (Table 9). Specific designated uses for Use I streams include water contact sports, fishing, the growth and propagation of fish, and agricultural, and industrial water supply. Currently, there are no standards available for conductivity. However, Morgan et al., (2007) identified a critical threshold between 'Fair' and 'Poor' stream quality for Maryland streams at 247 µS/cm.

Table 9 - Maryland COMAR Standards for Use I Waters

Parameter	Standard
pH (SU)	6.5 to 8.5
Dissolved Oxygen (mg/L)	Minimum of 5 mg/L
Conductivity (µS/cm)	No State standard
Turbidity (NTU)	Maximum of 150 Nephelometric Turbidity Units (NTU's) and maximum monthly average of 50 NTU
Temperature (°C)	Maximum of 32°C (90°F) or ambient temperature of the surface water, whichever is greater

Source: Code of Maryland Regulations (COMAR) 26.08.02.03-3 – Water Quality

2.3.5 Geomorphic Assessment

Geomorphic assessment data were managed using ODNR's Reference Reach Spreadsheet Version 4.3L (Mecklenburg, 2006). This program was used to compile and plot field data and to analyze geometry, profile, and channel material characteristics of each assessment reach. In addition, the following values and/or ratios were calculated:

- Bankfull height, width & area
- Mean bankfull depth
- Width/depth ratio
- Entrenchment ratio
- Floodprone width
- Sinuosity
- Water surface slope
- D_{50}

Data from the geomorphic assessments were used to determine the stream type of each reach as categorized by the Rosgen Stream Classification (Rosgen, 1996). In this classification method, streams are categorized based on their measured values of entrenchment ratio, width/depth ratio, sinuosity, water surface slope, and channel materials. General descriptions for each major stream type (A, G, F, B, E, C, D and DA) and delineative criteria for broad-level (Level I) classification are provided in Table 10. Rosgen Level II characterization incorporates a numeric code (1 – 6) for dominant bed materials and a slope range modifier (a+, a, b, c, or c-) to provide a more detailed morphological description. For instance, a G type stream with gravel dominated bed and a water surface slope of less than 2 percent would be classified as a G4c stream.

Table 10 - Rosgen Channel Type Description and Delineative Criteria for Level I Classification.

Channel Type	General Description	Entr. Ratio	W/D Ratio	Sinuosity	Slope	Landform/Soils/Features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	<1.4	<12	1.0-1.1	>10%	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, confined, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0-1.2	4% - 10%	High relief. Erosional or depositional and bedrock forms; Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in step/pool bed morphology.
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.	1.4 - 2.2	>12	>1.2	2%-3.9%	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate with scour pools.
C	Low gradient, meandering, slightly entrenched, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.	>2.2	>12	>1.2	<2%	Broad valleys w/ terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks. Active lateral adjustment, high bedload and bank erosion.	n/a	>40	n/a	<4%	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment w/abundance of sediment supply. Convergence/divergence bed features, aggradational processes, 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 stream banks.	>2.2	variable	variable	<0.5%	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Anastamosed geologic control creating fine deposition w/well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.
E	Low gradient, Highly sinuous, riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander/width ratio.	>2.2	<12	>1.5	<2%	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratios
F	Entrenched, meandering riffle/pool channel on low gradients with high width/depth ratio and high bank erosion rates.	<1.4	>12	>1.2	<2%	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering, laterally unstable w/ high bank erosion rates. Riffle/pool morphology.
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.	<1.4	<12	>1.2	2%-3.9%	Gullies, step/pool morphology w/ moderate slopes and low W/D ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials. Unstable w/ grade control problems and high bank erosion rates.

Source: Rosgen, 1996

Since the primary goal of the geomorphic assessment component is to supplement biological assessments, the survey reach was constrained to within the randomly selected 75-meter sampling reach and a limited suite of geomorphic parameters was collected. Therefore, the data have certain limitations that should be noted:

- Stream classifications, slopes, and channel materials are only representative of the 75-meter reach in which they were evaluated. In some cases, these data are representative of shorter reaches, depending on site conditions. In other cases, a survey reach is located at a transition point between two different stream types and may contain more than one classification. Since only one cross sectional survey is performed per reach, the transitional portion of the reach without the cross sectional data is classified using best professional judgment. This classification is based primarily on the degree of incision and width/depth ratio in comparison to the surveyed cross section.
- Typically, stream classification using the Rosgen methodology is best performed on riffle or step cross sections. Some of the 75-meter survey reaches assessed in this study did not contain riffle or step features.
- Pebble count data were collected for stream classification purposes only and are not appropriate for use in hydraulic calculations of bankfull velocity and discharge. This is particularly the case for the many sand bed channels in the study area, where data on the dune height would be used instead of the 84th percentile particle size, or D_{84}, in hydraulic calculations. Dune height data were not collected for this study.
- No detailed analyses of stream stability were performed for this study. Statements referring to stream stability are based solely on observations and assumptions, which are founded on fundamental geomorphic principles. Conclusive evidence of the stability of the sampling units assessed could only be obtained after detailed watershed and stream stability assessments were performed.

2.3.6 Land Use Analysis and Impervious Surface

All geospatial analysis was performed using Countywide GIS coverages in ArcGIS 9.3. Land use analysis was completed with the use of the County's 2007 Land Cover GIS layer. Original land cover categories were combined into four primary land use classes to better summarize the conditions in the sampling units (Table 11). The County's 2007 impervious layer was used to assess imperviousness to each site. Site specific land use and impervious surface analysis was completed using drainage areas delineated to each sampling point. The drainage area to each point was delineated using a countywide 3-meter raster grid digital elevation model (DEM) from the United States Department of Agriculture (USDA) Forest Service dataset. The DEM was used to produce a stream, flow accumulation and flow direction grid using the Arc Hydro extension toolset. Bioassessment sampling points were snapped to the closest point on the new stream grid generated from the DEM; then, batch sub-watersheds were generated using these three files. Subwatersheds were then summed where necessary to generate the appropriate drainage area to each bioassessment site.

Five sites in the Piney Run sampling unit (R2-01-02, R2-01-07, R2-01-08, R2-01-09, and R2-01-10) include drainage areas that extend into Howard County. To calculate imperviousness and land use for those five sampling locations, Howard County's vector polygon dataset of impervious land cover and land use from 2006 was used in addition to the Anne Arundel County dataset.

Table 11 - Combined Land Use Classes

Land Use Class	Anne Arundel County Land Cover Type	Howard County Land Cover Type
Developed	Airport, Commercial, Industrial, Transportation, Utility, Residential (1/8-ac., ¼-ac., ½-ac., 1-ac., and 2-ac.)	Commercial, Industrial, Institutional, Transportation, Residential (Low-Density, Medium-Density, and High-Density)
Forested	Forested wetland, Residential woods, Woods	Deciduous forest, Evergreen forest, Mixed forest, Brush, Large lot forest
Agriculture	Pasture/hay, Row crops	Cropland, Pasture, Large lot agriculture
Open Space	Open space, Open wetland, Water	Open urban land, Bare ground

3 Results and Discussion

This section first discusses the overall results across all sampling units, and is then followed by a more detailed discussion on results specific to each sampling unit. Appendix B includes a thorough discussion on the data quality of the biological results. A listing of all taxa identified and their characteristics (i.e., functional feeding group, habit, tolerance value) is included as Appendix C.

3.1 Comparisons among Sampling Units

Biological, physical and water quality conditions, as well as geomorphic assessment results, are discussed for all of the sampling units assessed in 2012. Comparisons primarily focus on mean results for each sampling unit, which due to the random nature of the site selection process, are considered representative of the typical condition of streams contained within, even for stream reaches where no data were directly collected. Table 12 summarizes overall biological and habitat conditions for each sampling unit.

Table 12 - Summary of BIBI and habitat scores across sampling units (n = 10 for each sampling unit)

Sampling Unit	Average BIBI Score ±SD / Condition Narrative	Average PHI Habitat Score ±SD / Condition Narrative	Average RBP Habitat Score ±SD / Condition Narrative
Hall Creek	2.20 ± 0.81 Poor	68.2 ± 10.1 Partially Degraded	108.5 ± 12.1 Partially Supporting
Lower Patapsco	2.43 ± 0.74 Poor	66.3 ± 14.9 Partially Degraded	98.1 ± 27.1 Non Supporting
Piney Run	2.69 ± 0.90 Poor	64.5 ± 13.1 Degraded	124.2 ± 17.1 Partially Supporting
Rhode River	2.17 ± 0.45 Poor	68.4 ± 10.3 Partially Degraded	124.7 ± 19.3 Partially Supporting

3.1.1 Biological and Habitat Assessment Summary

Overall, the majority of BIBI scores throughout the sampling units were split between a rating of 'Poor' (43 percent) and 'Very Poor' (38 percent) with a small proportion of sites rated as 'Fair' (17 percent) and only one site rated as 'Good' (two percent; Figure 2). All sampling units had mean BIBI values that resulted in 'Poor' biological condition ratings (Table 12). There were no sampling units rated as 'Good,' 'Fair,' or 'Very Poor' for biological condition.

Physical habitat assessment results indicate that three of the four sampling units, as determined by the sampling unit mean, received ratings of 'Partially Supporting' (RBP; Table 12). Approximately half (53

percent) of the total sites sampled resulted in a RBP rating of 'Partially Supporting' and one-fourth of the samples (25 percent) resulted in a 'Non Supporting' rating (Figure 3). Only a small proportion of sites were rated as either 'Supporting' (17 percent) or 'Comparable to Reference' (five percent). Three of the four sampling units received PHI ratings of 'Partially Degraded' as determined by the sampling unit mean. Half of the total sites sampled resulted in a PHI rating of 'Partially Degraded', approximately one-third of the total sites received 'Degraded' ratings (32 percent), 13 percent resulted in 'Severely Degraded' ratings, and a very small percentage of sites received 'Minimally Degraded' ratings (five percent).

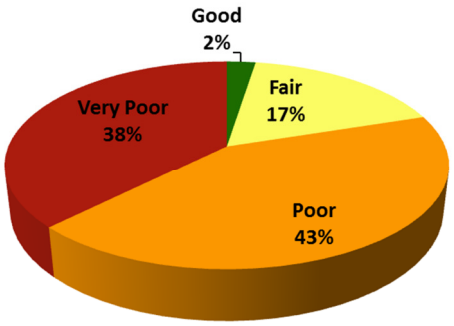


Figure 2 - Summary of Biological Conditions for Sites Assessed in 2012 (n=40)

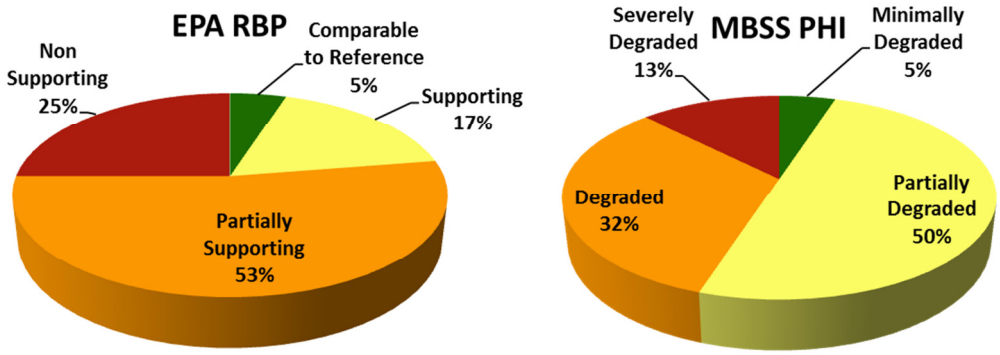


Figure 3 - Summary of Physical Habitat Conditions for Sites Assessed in 2012 (n=40)

3.1.2 Water Quality Assessment Summary

Water quality measurements were within COMAR standards for temperature and turbidity at all sites. Dissolved oxygen was below state standards (<5 mg/L) at one site in the Lower Patapsco sampling unit. In addition, low pH values which were outside the acceptable range of values set forth by COMAR (i.e., 6.5 – 8.5 SU) were recorded at six of the sites sampled and spanning three of the four PSUs sampled in 2012. The pH values ranged from 5.55 – 6.40 for the six sites that did not meet COMAR standards for water quality. Over half of the sites sampled in 2012 (23 sites) showed conductivity levels exceeding 247 µS/cm, which is the critical threshold between 'Fair' and 'Poor' stream quality determined for Maryland streams (Morgan et al., 2007). While there are currently no COMAR standards for conductivity, elevated levels are commonly associated with increased impervious surface upstream in the watershed and often attributed to runoff from roadways, particularly during winter roadway de-icing periods.

3.1.3 Geomorphic Assessment Summary

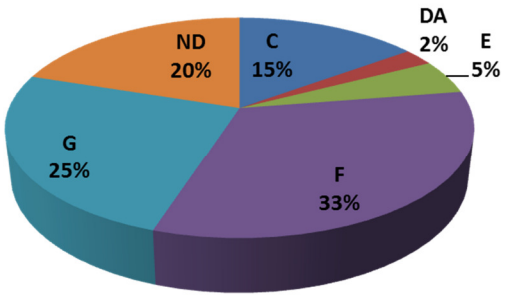


Figure 4 - Distribution of Rosgen Stream Types for Sites Assessed in 2012 (n=40)

Stream types throughout the sampling units were highly variable, with the largest portion of the sites being entrenched F or G channels (33 and 25 percent, respectively; Figure 4). At least one-third of sites in each sampling unit were entrenched. Fifteen percent of the sites were classified as C channels, the majority of which were located in the Piney Run and Rhode River sampling units. Comprising seven percent, E type channels and anastomosed DA type channels (five and two percent, respectively) were found only in Rhode River. The remaining 20 percent of sites were placed into the 'ND' (Not Determined) category due to considerable anthropogenic modification (i.e., channel alteration, hardened banks) or due to natural influences which inhibit channel classification (i.e., beaver dams). A major assumption of the Rosgen characterization is that the stream channel has the ability to adjust its dimensions naturally. Thus, reaches that have been heavily channelized or unnaturally modified violate this assumption and the channel dimensions may not be representative of natural conditions.

Nearly one-half of sites sampled in 2012 (45 percent) had channel substrates composed primarily of sand. Gravel dominated streams comprised just over one-third (38 percent) of the total sites. The remaining 18 percent of sites had predominantly silt/clay channel substrates. With the exception of Lower Patapsco sampling unit, stream slopes in the assessment reaches were generally low (i.e., below one percent). The average slope of all reaches assessed was 0.68 percent. Average slopes for the sampling units ranged from 0.35 percent in Rhode River to 1.37 percent in Lower Patapsco.

3.1.4 Land Use Analysis and Impervious Surface Summary

Approximately two-thirds of the sites sampled in 2012 had forested land as the dominant land use (62.5 percent), while the remaining sites were dominated by developed land (32.5 percent) and agriculture (five percent). At the sampling unit scale, Lower Patapsco had the highest percentage of developed land at 59.7 percent of the total acreage, which was followed by Piney Run at 39.6 percent (Table 13). With over 50 percent of the drainage area comprised of developed land, Lower Patapsco can be considered an urbanized subwatershed. In contrast, Rhode River was the least developed, with 24.7 percent of the sampling unit attributed to developed land. Developed land was also low in Hall Creek (27.2 percent), which collectively with Rhode River can be considered rural subwatersheds. Rhode River had the highest proportion of forested land at 56.5 percent, while Lower Patapsco had the lowest proportion (28.7 percent). The highest proportion of agricultural land use occurred in Hall Creek (21.1 percent), followed by Rhode River at 11.9 percent. In contrast, agricultural land use was not present in Lower Patapsco and Piney Run. Figure 5 shows land use for the entire County based on the County's 2007 Land Cover GIS layer. The sampling unit with the highest percentage of impervious surface was Lower Patapsco (32.2 percent) while Hall Creek had the lowest percentage of impervious surface (4.3 percent). Figure 6 shows impervious surface for the entire County based on the County's 2007 Impervious GIS layer.

Figure 5 - Summarized Land Use in Anne Arundel County (2007)

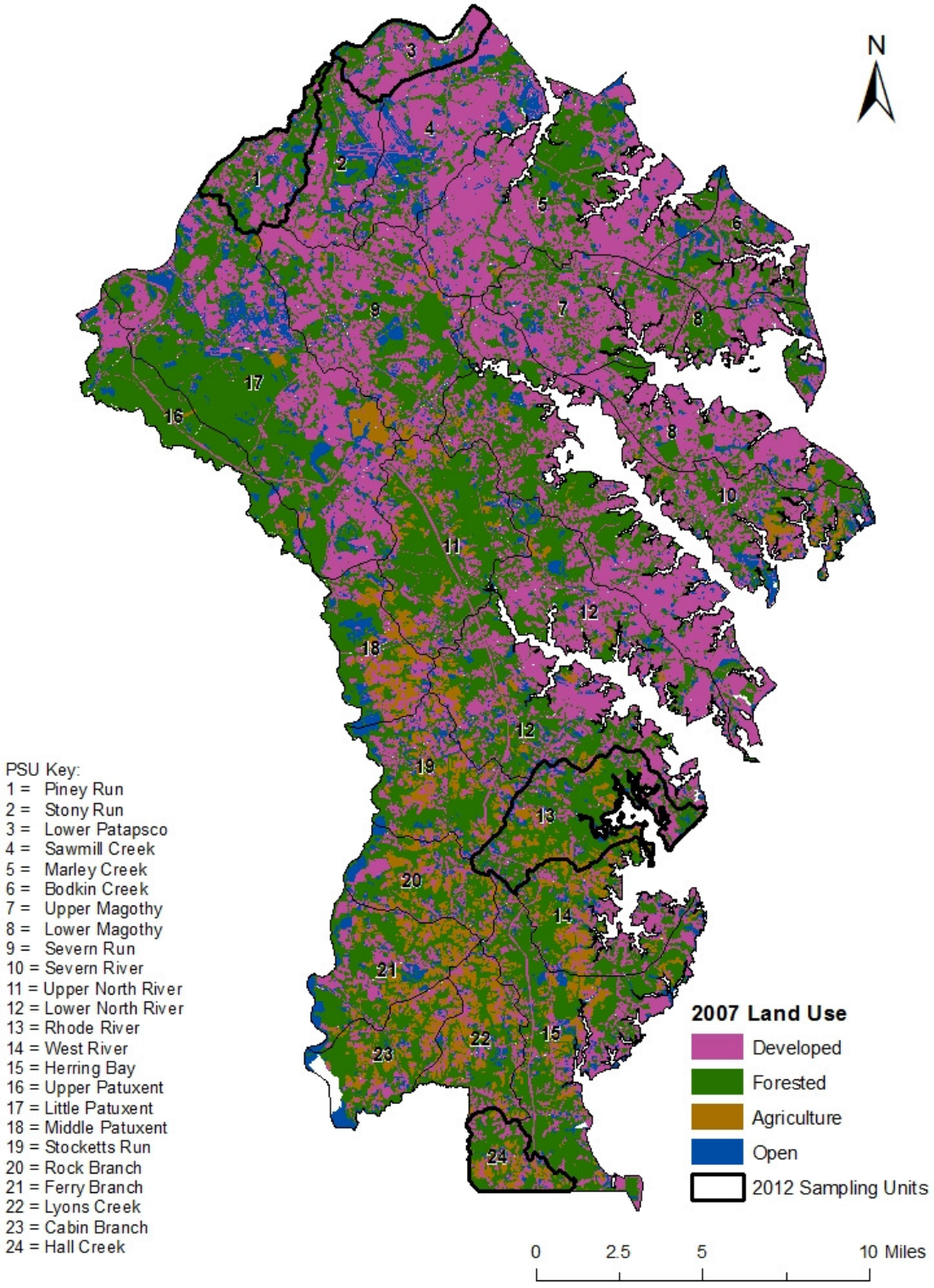


Figure 6 - Impervious Surface in Anne Arundel County (2007)

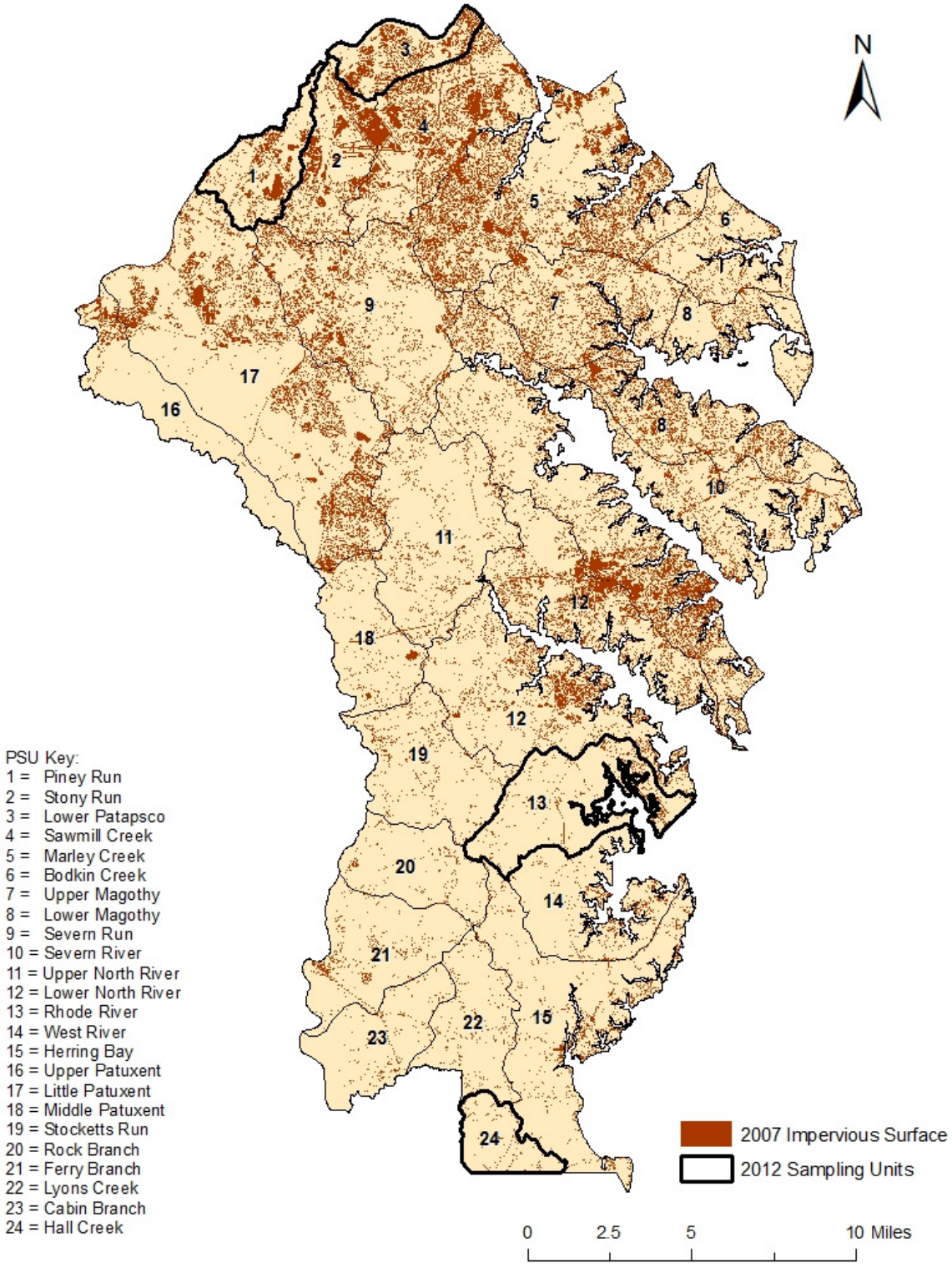


Table 13 - Summary of land use and impervious surface across sampling units

Sampling Unit	Total Acreage	% Impervious	Land Use			
			% Developed	% Forested	% Agriculture	% Open
Hall Creek	3,168	4.3	27.2	48.0	21.1	3.7
Lower Patapsco	4,040	32.2	59.7	28.7	0.0	11.5
Piney Run	4,868	20.4	39.6	49.9	0.0	10.4
Rhode River	8,737	6.1	24.7	56.5	11.9	6.9

4 Individual Sampling Unit Discussions

The following section summarizes the conditions within each of the four sampling units assessed. Site-specific data and assessment results can be found in Appendix D.

4.1 Hall Creek

The Hall Creek sampling unit, located in the southern tip of the County, has a total drainage area of 3,168 acres (Figure 1). The ten sampling sites (eight 1st order and two 2nd order) have drainage areas ranging from 85 to 1,488 acres (Figure 9). The dominant land use for the Hall Creek sampling unit is forested land (48 percent), followed by developed land (27 percent) and agriculture (21 percent). Forested land is the dominant land use for 60 percent of the sites sampled, while the remaining 40 percent of sites are split equally between developed land and agriculture. Impervious surfaces comprise only 4.3 percent of the overall Hall Creek sampling unit, with individual sites ranging from 3.2 to 10.2 percent impervious surface.

4.1.1 Physical Habitat

The majority of the sites sampled in the Hall Creek sampling unit (70 percent) received a 'Partially Supporting' narrative RBP rating, while the remaining 30 percent of sites received a 'Non Supporting' rating (Figure 7). The average RBP score was 108.5 ± 12.1 resulting in a 'Partially Supporting' habitat condition for the sampling unit. Overall RBP scores for individual sites ranged from 89 ('Non Supporting') to 123 ('Partially Supporting'). The PHI rated 60 percent of the sites as 'Partially Degraded' and 40 percent as 'Degraded.' The average PHI score for the sampling unit was 68.2 ± 10.1 with a habitat condition rating of 'Partially Degraded.'

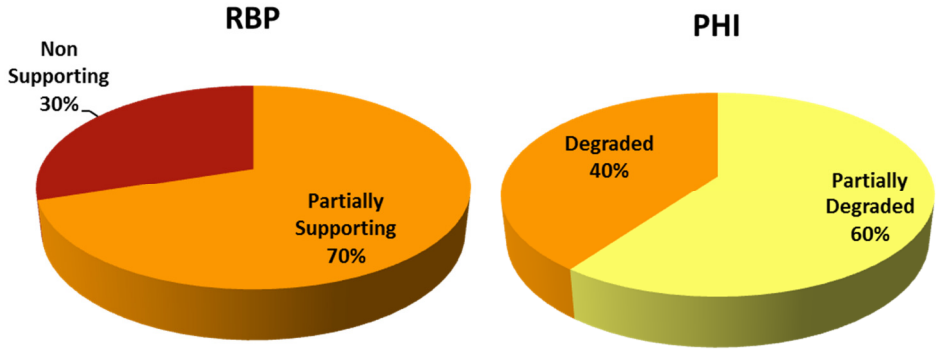


Figure 7 – Hall Creek Physical Habitat Conditions (n=10)

Individual site scores for PHI ranged from a minimum of 53.0 ('Degraded') to a maximum of 78.4 ('Partially Degraded'). The majority of sites received marginal scores for instream habitat and epifaunal substrate. With the exception of R2-24-10, R2-24-11A, and R2-24-13A, sites received marginal to sub-optimal scores for bank stability. Instream woody debris, percent shading, and remoteness were variable between reaches.

4.1.2 Benthic Macroinvertebrates

Of the ten sites sampled in Hall Creek, half of sites received a BIBI rating of 'Very Poor' while 30 percent of the sites were 'Poor' and the remaining 20 percent of sites received a 'Fair' biological condition rating (Figure 8). The average BIBI score for the Hall Creek sampling unit is 2.20 ± 0.81, with an average biological condition of 'Poor' (Table 12). Individual BIBI scores ranged from 1.00 ('Very Poor') to 3.57 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

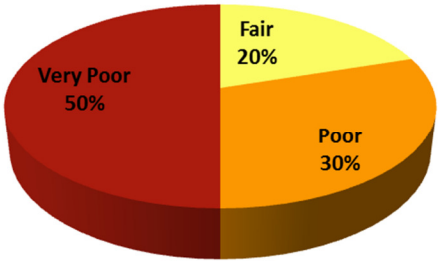


Figure 8 – Hall Creek Biological Conditions

Site R2-24-11A, located 450 meters east of Old Solomons Island Road near Trent Hall Farms (Figure 9), received the lowest BIBI score of all sites sampled in 2012 with a score of 1.00 and a biological rating of 'Very Poor.' This stream reach is deeply incised and had the lowest number of total taxa (seven taxa), which lacked EPT taxa, Ephemeroptera taxa, and scraper taxa. At 75 percent of the sample, amphipods (including *Gammarus,* tolerance value [TV] = 6.7) dominated the macroinvertebrate assemblage. Less than one percent of the macroinvertebrates identified were considered to be intolerant to urban stressors and less than one percent of the sample consisted of climber taxa. Four additional sites received 'Very Poor' biological ratings: R2-24-04, R2-24-06, R2-24-12A, and R2-24-13A. Site R2-24-09 received the highest BIBI score of 3.57 with a 'Fair' biological rating despite the fact that the lower 22 meters of the site was located within the culvert under Chesapeake Beach Road. This site had a high number of total taxa (19) including four EPT taxa, two Ephemeroptera taxa, and four scraper taxa. Not surprisingly, this site also had the largest drainage area (1488 acres) in the Hall Creek PSU.

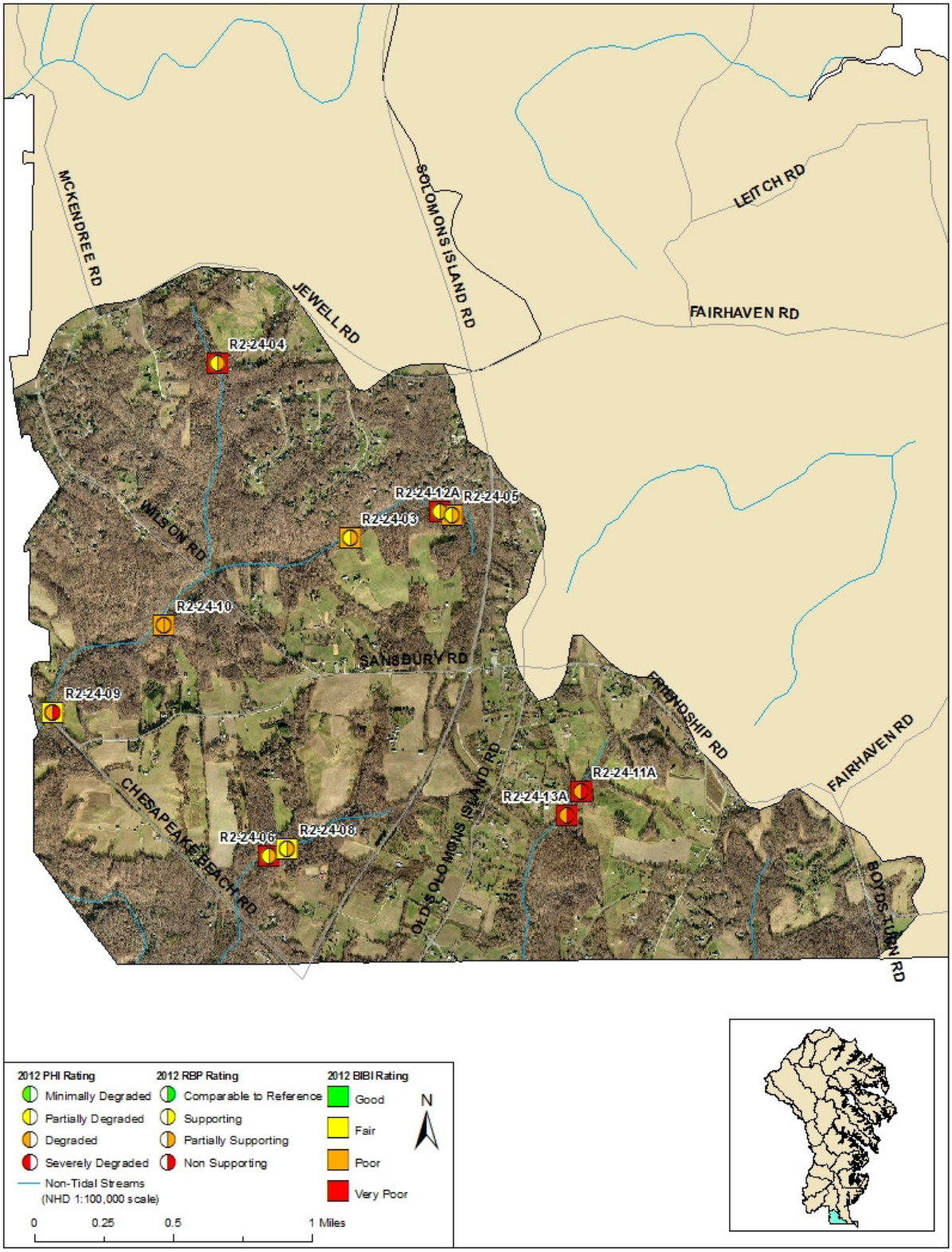
4.1.3 Water Quality

Average water quality values for the Hall Creek sites are provided in Table 14. All of the sites sampled met COMAR standards for water quality.

Table 14 - Average water quality values – Hall Creek (n = 10)

Value ± Standard Deviation				
Temperature (°C)	DO (mg/L)	pH (Units)	Conductance (µS/cm)	Turbidity (NTU)
11.46 ± 2.64	10.54 ± 1.29	7.05 ± 0.33	246.3 ± 56.2	12.92 ± 6.58

Figure 9 – Hall Creek Sampling Sites



Water temperature ranged from 7.67 to 15.50 °C; dissolved oxygen ranged from 8.21 to 12.27 mg/L; pH ranged from 6.77 to 7.87; specific conductance ranged from 174.0 to 336.9 µS/cm; and, turbidity ranged from 4.55 to 25.80 NTU. However, it should be noted that four sites (R2-24-03, R2-24-05, R2-24-09, and R2-24-12A) showed conductivity levels exceeding 247 µS/cm. Three of the four sites with elevated conductivity, which is often attributed to runoff from roadways, drain a portion of Solomons Island Road (Maryland Route 2).

4.1.4 Geomorphic Assessment

Site-specific geomorphic assessment results can be found in Appendix A. The majority of the sites assessed (70 percent) were G type streams (Figure 10). The remaining sites were 'ND' (20 percent), or F type (10 percent) channels. Rosgen stream types were not determined (ND) for sites R2-24-09 and R2-24-10. Site R2-24-09 contained a large double barrel culvert under Route 260 in the lower portion of the reach, while site R2-24-10 was altered by a large beaver dam resulting in two discrete channels, one of which was severely downcut due to the recent disturbance.

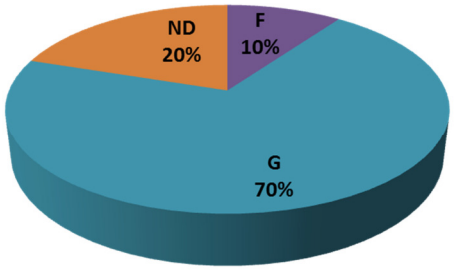


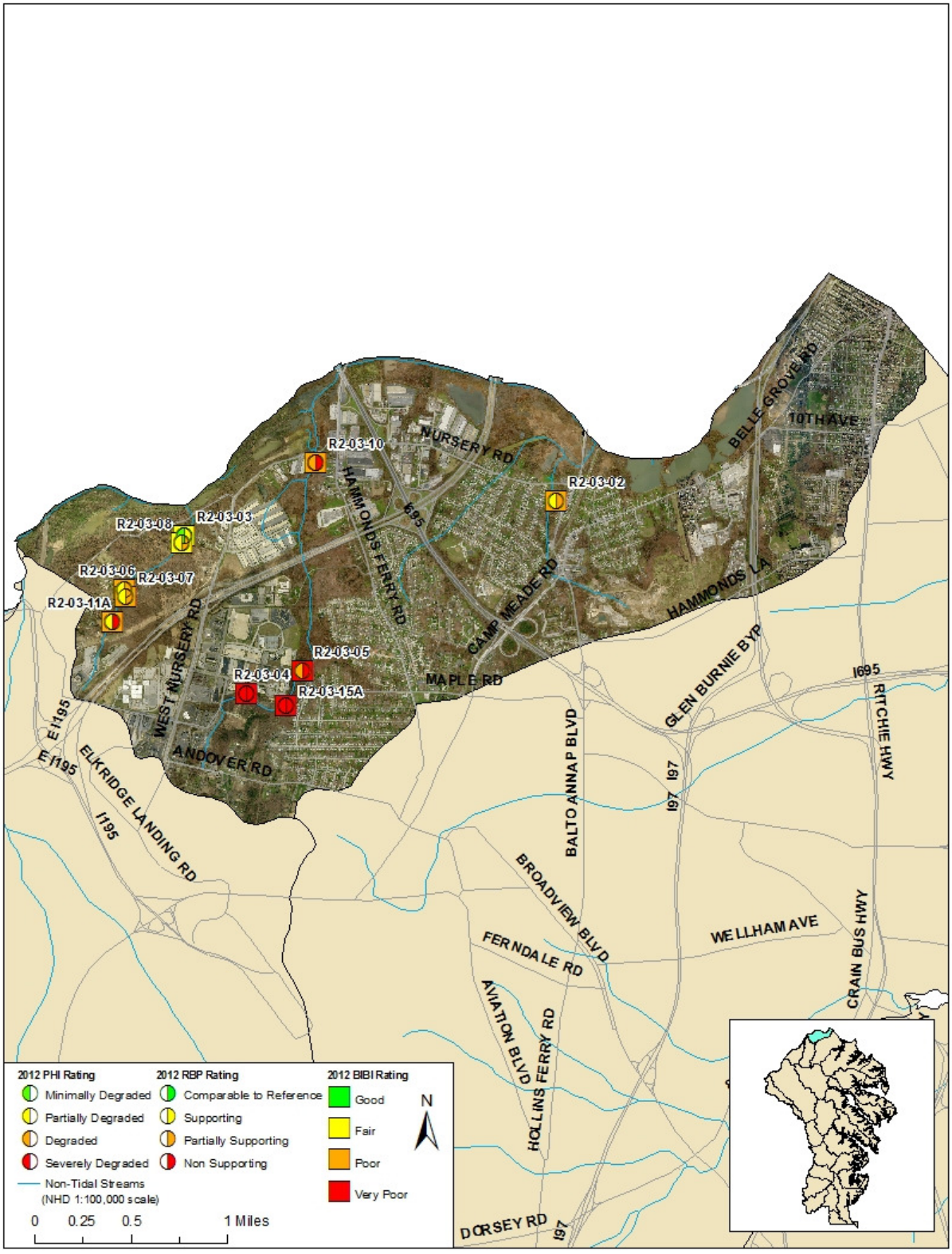
Figure 10 - Rosgen Stream Types Observed in Hall Creek (n = 10)

Streams in this sampling unit were predominantly sand bottom channels (90 percent), although a small percentage of sites were dominated by silt/clay (10 percent). The median D_{50} was 0.15 mm (fine sand material). Individual slopes ranged from 0.07 percent to 0.67 percent, with an average slope of 0.43 percent.

4.2 Lower Patapsco

The Lower Patapsco sampling unit is located on the northern edge of the County, due north of Baltimore/Washington International Thurgood Marshall Airport (Figure 1), and has a drainage area of 4,040 acres. The ten sampling sites, all 1st order streams, have drainage areas ranging from 52 to 993 acres (Figure 11). With 32 percent of the Lower Patapsco sampling unit comprised of impervious surface, this was the most developed sampling unit assessed in 2012. Several major transportation corridors cross through the watershed including Maryland State Highway 295 (Baltimore–Washington Parkway), Interstate 695 (Baltimore Beltway), and Interstate 895 (Harbor Tunnel Thruway). Site-specific drainage areas ranged from 17.1 to 51.4 percent impervious, which is the highest percentage for all sites sampled in 2012. Developed land comprised 60 percent of the total land use, including numerous industrial parks and business parks. Forested land comprised only 29 percent of the land cover, the lowest proportion of all sampling units assessed in 2012.

Figure 11 – Lower Patapsco Sampling Sites



4.2.1 Physical Habitat

Based on the RBP scores, one-half of the Lower Patapsco sites received a rating of 'Non Supporting,' 40 percent received a 'Partially Supporting' rating, and the remaining 10 percent of sites received a rating of 'Supporting' (Figure 12). Overall, the Lower Patapsco sampling unit received the lowest average RBP score (98.1 ± 27.1) and was the only sampling unit to receive an average condition rating of 'Non Supporting.' Individual RBP scores ranged from a minimum of 54 ('Non Supporting'), which was the lowest scoring site in 2012, to a maximum of 130 ('Supporting'). However, it should be noted, that two sites with very low scores (i.e., <75) skewed the average, and the median value for this PSU would be 104 ('Partially Supporting').

One-half of sites assessed received a PHI rating of 'Partially Degraded,' while 20 percent received a 'Degraded' rating, 20 percent received a 'Severely Degraded' rating, and the remaining 10 percent received a rating of 'Minimally Degraded.' The average PHI rating was 66.3 ± 14.9 ('Partially Degraded') with individual sites ranging from 42.2 ('Severely Degraded'), which was the lowest scoring site in 2012, to 85.4 ('Minimally Degraded'), which was one of the highest scoring sites in 2012. Half of the sites received poor to marginal instream physical habitat and epifaunal substrate scores in addition to having marginal bank stability. Vegetative bank protection, sediment deposition, pool variability, and remoteness were also variable between the reaches assessed.

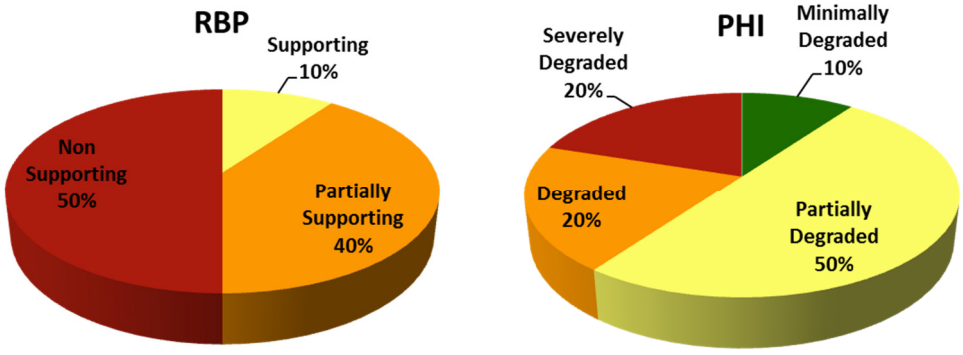


Figure 12 – Lower Patapsco Physical Habitat Conditions (n=10)

4.2.2 Benthic Macroinvertebrates

The Lower Patapsco sampling unit received a BIBI narrative rating of 'Poor' with an average score of 2.43 ± 0.74 (Table 12). Half of the individual sites received a biological condition rating of 'Poor', 30 percent received a 'Very Poor' rating, and the remaining 20 percent of sites received a 'Fair' rating (Figure 13). Individual BIBI scores ranged from 1.57 ('Very Poor') to 3.86 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

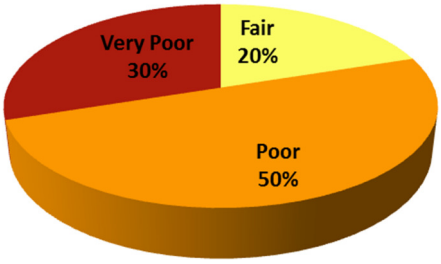


Figure 13 – Lower Patapsco Biological Conditions (n=10)

Site R2-03-05, located behind Hoch Business Park (Figure 11), received the lowest BIBI score of 1.57 with a narrative rating of 'Very Poor.' This site had poor taxa diversity (eight taxa) with no EPT or Ephemeroptera taxa, one scraper taxa, and consisted of less than one percent of intolerant taxa. The macroinvertebrate sample was dominated by worms of the Naididae and Tubificidae families (TV = 8.5

and TV = 8.4, respectively). This site is an intermittent stream that is severely impacted by a beaver dam in the middle of the reach. Two additional sites received a 'Very Poor' biological rating: R2-03-04 and R2-03-15A. Located along the boundary of Patapsco Valley State Park, site R2-03-08 received the highest BIBI score (3.86; 'Fair') in the Lower Patapsco sampling unit. For R2-03-08, five EPT taxa were identified from a total of 18 taxa, including two Ephemeroptera taxa as well as three scraper taxa.

4.2.3 Water Quality

Average water quality values for the Lower Patapsco sites are provided in Table 15. Three of ten sites sampled did not meet COMAR standards for water quality. Two sites (R2-03-07 and R2-03-11A) measured outside the acceptable COMAR range for pH (6.5-8.5), with values ranging from 6.11-6.21. Both sites drain commercial property. One site, R2-03-15A, measured below COMAR for DO (3.79 mg/L) which is largely attributed to mostly standing water present in the stream during the sampling visit. All measurements for water temperature and turbidity were within COMAR standards. Water temperature ranged from 11.17 to 17.00 °C; dissolved oxygen ranged from 3.79 to 11.88 mg/L; pH ranged from 6.11 to 8.10; specific conductance ranged from 194.4 to 630.3 µS/cm; and, turbidity ranged from 0.94 to 24.60 NTU. It should also be noted that eight sites (R2-03-02, R2-03-03, R2-03-04, R2-03-05, R2-03-08, R2-03-10, R2-03-11A, and R2-03-15A) showed elevated conductivity levels exceeding 247 µS/cm, which are commonly associated with increased impervious surface upstream in the watershed.

Table 15 - Average water quality values – Lower Patapsco (n = 10)

Value ± Standard Deviation				
Temperature (°C)	DO (mg/L)	pH (Units)	Conductance (µS/cm)	Turbidity (NTU)
13.79 ± 2.02	8.47 ± 2.41	6.97 ± 0.64	360.4 ± 147.8	7.09 ± 7.26

4.2.4 Geomorphic Assessment

Site-specific geomorphic assessment results are presented in Appendix A. The entrenched F stream type was observed at 70 percent of the sites in the Lower Patapsco sampling unit (Figure 14). The remaining 30 percent of sites were classified as either 'ND' (20 percent) or less entrenched and generally more stable C type (10 percent) streams. The stream type could not be determined at two sites, R2-03-04 and R2-03-05. Site R2-03-04 is an ephemeral channel that was recently stabilized with large cobble/boulder grade control structures, while R2-03-05 is an intermittent channel altered by a large beaver dam in the middle of the reach.

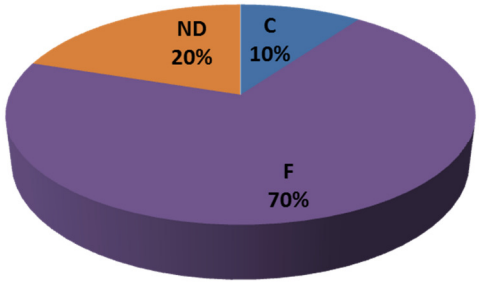


Figure 14 - Rosgen Stream Types Observed in Lower Patapsco (n = 10)

The majority of sites in Lower Patapsco were gravel bed channels (90 percent) with one site dominated by silt/clay (10 percent). The median D_{50} was 17 mm (coarse gravel). Streams in this sampling unit had an average slope of 1.37 percent, with individual slopes ranging from 0.75 percent to 2.50 percent. All but two sites (R2-03-02 and R2-03-03) had slopes that were greater than one percent.

4.3 Piney Run

The Piney Run sampling unit is located in the northwestern portion of the County along the border with Howard County (Figure 1), and has a total drainage area of 4,868 acres. Maryland State Highway 295 (Baltimore Washington Parkway) runs through the entire extent of the sampling unit. Of the 10 sites assessed, five were located on 1st order streams, four on 3rd order streams, and one on a 2nd order stream. Drainage areas to sampling sites ranged from 134 to 12,681 acres (Figure 16). Five sites in the Piney Run sampling unit (R2-01-02, R2-01-07, R2-01-08, R2-01-09, and R2-01-10) include drainage areas that extend into Howard County. Land use in the Piney Run sampling unit is comprised primarily of forested land (50 percent) followed by developed land (40 percent). One-half of the sites have developed land as the dominant land use, while the remaining sites are dominated by forested land cover. Impervious surfaces account for 20.4 percent of the Piney Run sampling unit, with individual sites ranging from 6.8 to 25.0 percent imperviousness.

4.3.1 Physical Habitat

The majority of sites in Piney Run (60 percent) were rated 'Partially Supporting' with two sites (20 percent) rated as 'Supporting,' one site (10 percent) rated as 'Comparable to Reference,' and one site (10 percent) rated as 'Non Supporting' by the RBP habitat index (Figure 15). The average RBP score for the sampling unit was 124.2 ± 17.1 and the corresponding narrative rating was 'Partially Supporting.' Individual site scores ranged from 94 ('Non Supporting') to 152 ('Comparable to Reference'), which was one of the highest scoring sites in 2012.

According to the PHI, the majority of sites were rated as either 'Degraded' (40 percent) or 'Partially Degraded' (30 percent), while 20 percent received a rating of 'Severely Degraded' and the remaining 10 percent of sites received a 'Minimally Degraded' rating. With an average PHI score of 64.5 ± 13.1 and a narrative rating of 'Degraded,' this sampling unit received the lowest average PHI score. Individual site scores ranged from 46.2 ('Severely Degraded') to 85.8 ('Minimally Degraded'), which was one of the highest scoring sites in 2012. The majority of reaches received marginal scores for instream physical habitat and epifaunal substrate. Bank stability, instream woody debris, and vegetative bank protection were variable between reaches. However, all sites received suboptimal to optimal scores for riparian vegetative width.

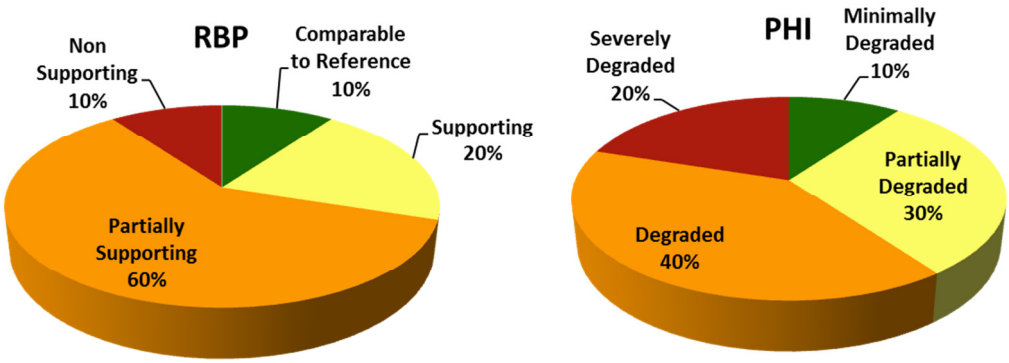
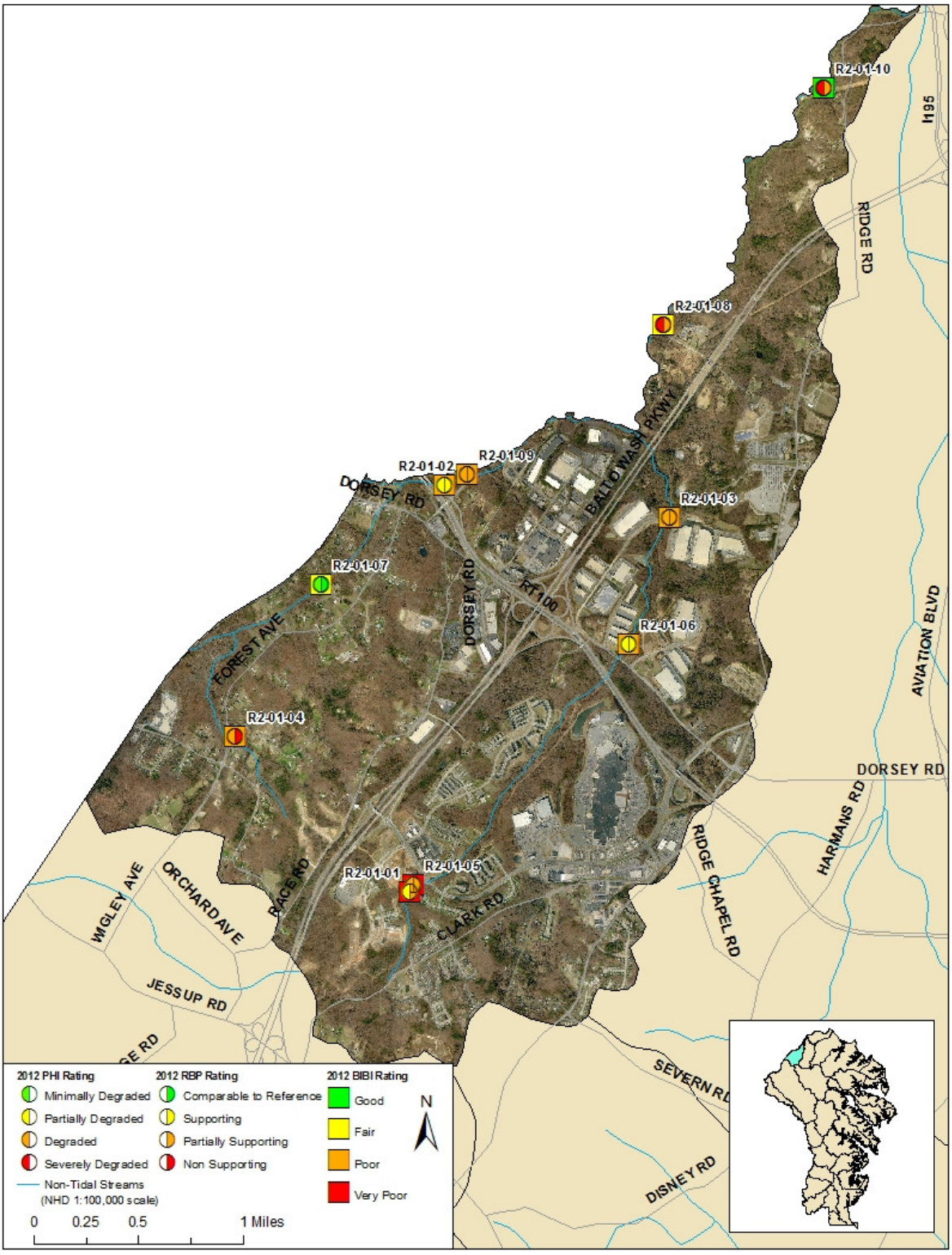


Figure 15 – Piney Run Physical Habitat Conditions (n=10)

Figure 16 – Piney Run Sampling Sites



4.3.2 Benthic Macroinvertebrates

The average BIBI rating for the Piney Run sampling unit is 'Poor' with an average BIBI score of 2.69 ± 0.90 (Table 12), and individual sites ranging from a low of 1.57 ('Very Poor') to 4.43 ('Good'). Half of the sites received a BIBI rating of 'Poor' (50 percent), 40 percent of the sites were split equally between 'Fair' and 'Very Poor' ratings, and the remaining site received a 'Good' rating (10 percent; Figure 17). Site-specific data and assessment results can be found in Appendix D.

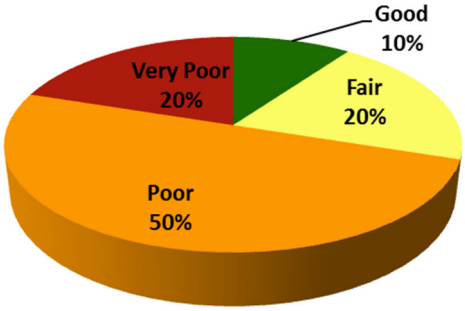


Figure 17 – Piney Run Biological Conditions (n=10)

Site R2-01-01 received the lowest score of 1.57 with a 'Very Poor' narrative rating in the Piney Run sampling unit (Figure 16). Located behind The Hotel at Arundel Preserve near Arundel Mills Boulevard, this site had low taxa diversity (eight taxa) and completely lacked EPT and Ephemeroptera taxa. Site R2-01-01 did not contain any taxa intolerant to urban stressors and was dominated by tolerant midges (*Eukiefferiella*, TV = 6.1). Site R2-01-05 also received a 'Very Poor' rating. In contrast, site R2-01-10 received the highest BIBI score of all sites sampled in 2012 (4.43) and was the only site to receive a 'Good' biological condition rating. This site had a high number of total taxa (29), with six EPT taxa including two Ephemeroptera, the presence of four scraper taxa, and a high percentage of climber taxa (14.2 percent). Additionally, this site also had the largest drainage area (12,680 acres) in the Piney Run PSU.

4.3.3 Water Quality

Average water quality values for the Piney Run sites are provided in Table 16. Of the ten sites sampled, only one site did not meet COMAR standards for water quality. Site R2-01-04 measured outside the acceptable COMAR range for pH (6.5-8.5), with a value of 5.55. All other water quality parameters were within acceptable ranges. Water temperature ranged from 7.87 to 17.30 °C; dissolved oxygen ranged from 8.09 to 11.83 mg/L; pH ranged from 5.55 to 7.72; specific conductance ranged from 98.7 to 697.7 µS/cm; and, turbidity ranged from 2.77 to 19.20 NTU. However, it should be noted that all sites, with the exception of site R2-01-04, had elevated conductivity levels exceeding the impairment threshold of 247 µS/cm, which are commonly associated with increased impervious surface upstream in the watershed.

Table 16 - Average water quality values – Piney Run (n = 10)

Value ± Standard Deviation				
Temperature (°C)	DO (mg/L)	pH (Units)	Conductance (µS/cm)	Turbidity (NTU)
11.93 ± 3.25	10.36 ± 0.98	7.13 ± 0.60	482.9 ± 170.5	7.40 ± 5.44

4.3.4 Geomorphic Assessment

The majority of sites assessed in the Piney Run sampling unit were classified as either F or C type channels, at 40 and 30 percent, respectively. One site was classified as an anastamosed DA type channel (Figure 18). The stream type of two sites could not be determined. Site R2-01-03 is located on Piney Run immediately downstream of a road crossing with evidence of recent bank stabilization. Site R2-01-09, located on Deep Run, is partially under a large bridge crossing, altering morphology. Site-specific geomorphic assessment results can be found in Appendix A.

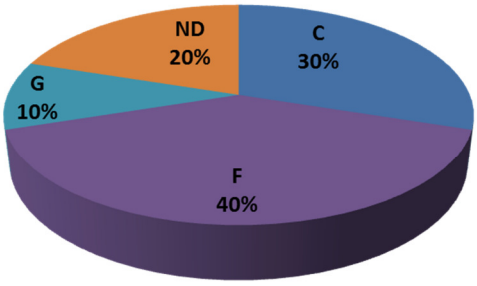


Figure 18 - Rosgen Stream Types Observed in Piney Run (n = 10)

The majority of streams in this sampling unit had predominantly gravel substrate (60 percent) with the remaining sites dominated by sand or silt/clay substrates (30 and 10 percent, respectively). The median D_{50} for the sampling unit was 11.5 mm (medium gravel material). With the exception of one site, slopes were fairly gradual ranging from 0.01 percent to 1.2 percent. Site R2-01-03, was atypical because of a grade control structure in the lower portion of the reach by the road crossing, resulting in a reach wide slope of 1.2 percent.

4.4 Rhode River

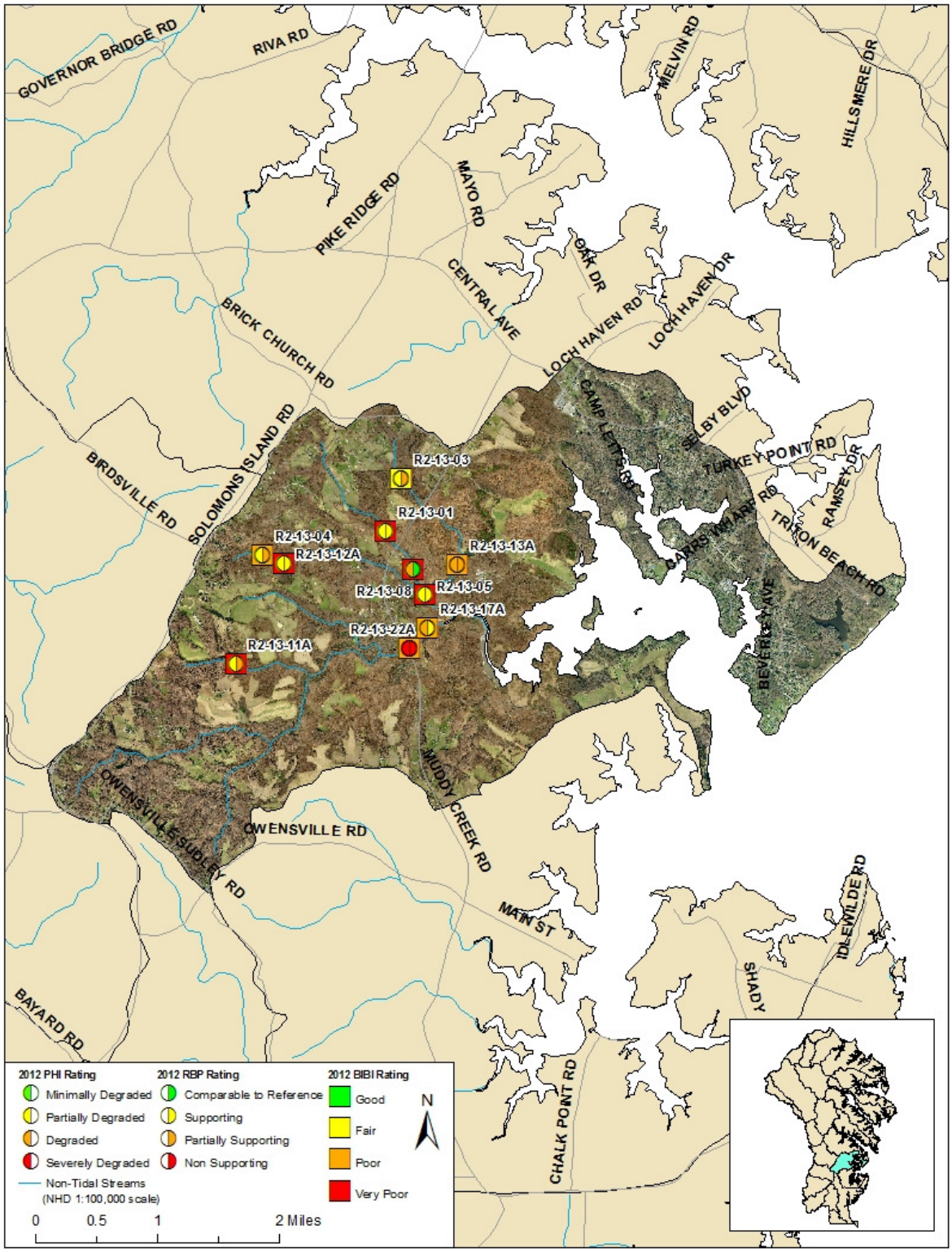
The Rhode River sampling unit is located in the southeastern part of the County south of Edgewater (Figure 1) and has a drainage area of 8,737 acres. A large portion of the Smithsonian Environmental Research Center is located within the Rhode River sampling unit. The ten sampling sites (eight 1st order and two 2nd order streams) have drainage areas ranging from 168 to 2,961 acres (Figure 19). Land use in the Rhode River sampling unit is primarily comprised of forested land (57 percent), followed by developed land (25 percent) and agriculture (12 percent). All sites sampled in the Rhode River sampling unit have predominantly forested land cover. Impervious surfaces comprise just 6.1 percent of the overall sampling unit, with individual sites ranging from 3.0 percent, which is the lowest percentage of imperviousness for all sites sampled in 2012, to 6.8 percent.

4.4.1 Physical Habitat

Physical habitat conditions were fairly variable for this sampling unit (Figure 20). Based on the RBP index, the majority of sites were rated as either 'Supporting' (40 percent) or 'Partially Supporting' (40 percent). Only one site received a rating of 'Comparable to Reference' (10 percent), and one site received a 'Non Supporting' rating (10 percent). With an average RBP score of 124.7 ± 19.3 and a narrative rating of 'Partially Supporting,' this sampling unit received the highest average RBP score in 2012. Individual RBP scores ranged from a minimum of 100 ('Non Supporting') to a maximum of 157 ('Comparable to Reference'), which is the highest score recorded in 2012.

The PHI rated 60 percent of sites as 'Partially Degraded,' 30 percent as 'Degraded,' and the remaining 10 percent as 'Severely Degraded'. The average PHI rating was 'Partially Degraded' with a score of 68.4 ± 10.3. Individual PHI scores ranged from 47.1 ('Severely Degraded') to 79.0 ('Partially Degraded'). The majority of sites received marginal scores for instream habitat, epifaunal substrate, pool substrate characterization, and pool variability. Close to one-half of the sites received poor to marginal scores for bank stability and vegetative protection. Riparian vegetative zone width was optimal at most sites.

Figure 19 – Rhode River Sampling Sites



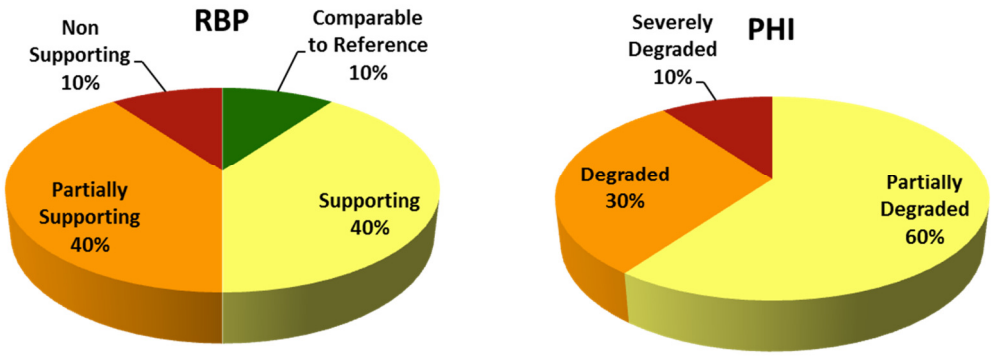


Figure 20 – Rhode River Physical Habitat Conditions (n=10)

4.4.2 Benthic Macroinvertebrates

Half of sites sampled within the Rhode River sampling unit received 'Poor' BIBI ratings, 40 percent received a 'Very Poor' rating while the remaining 10 percent of sites received a 'Fair' rating (Figure 21). The average BIBI score for the sampling unit was 2.17 ± 0.45 resulting in a 'Poor' biological condition rating (Table 12). Individual BIBI scores ranged from 1.57 ('Very Poor') to 3.00 ('Fair'). Individual site data and assessment results can be found in Appendix D.

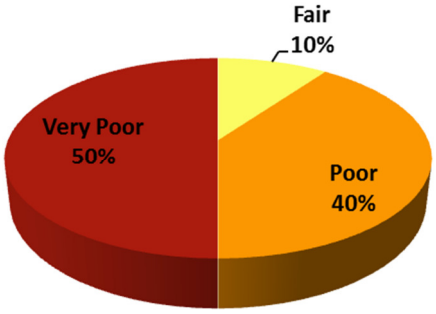


Figure 21 – Rhode River Biological Conditions (n=10)

Located on Bluejay Branch, site R2-13-01 (Figure 19) received the lowest BIBI score of 1.57 with a 'Very Poor' rating. Eight taxa were present in this sample, which was predominantly comprised of midges including *Polypedilum* (TV = 6.3), which accounted for 69 percent of the sample. Although this site received a high score for percent climbers (65 percent), this sample did not contain EPT, Ephemeroptera, scraper taxa, or taxa intolerant to urban stressors. Four additional sites received a 'Very Poor' biological rating: R2-13-05, R2-13-08, R2-13-11A, and R2-13-12A. Located on North Fork Muddy Creek approximately 400 meters upstream of Muddy Creek Road (Route 468), site R2-13-03 received the highest BIBI score of 3.00, resulting in a 'Fair' biological condition rating. Of the 19 taxa identified in this sample, four were EPT including one Ephemeroptera taxa. This site also scored high for percent climbers (10 percent).

4.4.3 Water Quality

Average water quality values for the Rhode River sites are provided in Table 17. Three sites did not meet COMAR standards for water quality. Sites R2-13-03, R2-13-11A, and R2-13-13A measured outside the acceptable COMAR range for pH (6.5-8.5), with values ranging from 6.15 to 6.40. All other water quality parameters were within acceptable ranges. Water temperature ranged from 7.87 to 16.23 °C; dissolved oxygen ranged from 8.44 to 11.98 mg/L; pH ranged from 6.15 to 7.46; specific conductance ranged from 157.5 to 320.4 µS/cm; and, turbidity ranged from 6.16 to 19.80 NTU. Two sites (R2-13-04 and R2-13-12A) recorded elevated conductivity levels exceeding 247 µS/cm. Both sites drain portions of Solomons Island Road (MD Route 2).

Table 17 - Average water quality values – Rhode River (n = 10)

Value ± Standard Deviation				
Temperature (°C)	DO (mg/L)	pH (Units)	Conductance (µS/cm)	Turbidity (NTU)
11.99 ± 2.75	10.42 ± 1.20	6.73 ± 0.45	220.5 ± 55.4	12.46 ± 5.32

4.4.4 Geomorphic Assessment

Site-specific geomorphic assessment results can be found in Appendix A. A variety of stream types were present in the Rhode River sampling unit (Figure 22). Sixty percent of the sites assessed were equally split between C, E, or G type streams (20 percent each) while remaining sites were either DA or F type streams (each presenting 10 percent of sites), or not determined (20 percent). Site R2-13-03, located on North Fork Muddy Creek, was not determined due to the presence of a footbridge and headcut in the middle of the reach as well as atypical channel dimensions suggesting past alteration, which hinder Rosgen classification. Site R2-13-22A, located on Muddy Creek, was not determined because the channel dimensions are constrained by a large box culvert at the upstream end of the reach.

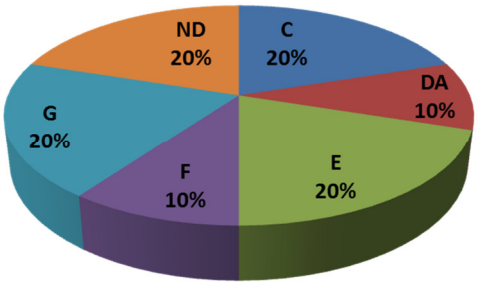


Figure 22 - Rosgen Stream Types Observed in Rhode River (n=10)

The majority of streams in this sampling unit had either sand (60 percent) or silt/clay (40 percent) dominated substrates. The median D_{50} for the sampling unit was 0.08 mm (very fine sand material). With the exception of one site (R2-13-03), slopes were gradual, with an average slope of 0.35 percent, and individual reaches falling in the range from 0.01 percent to 1.00 percent. Site R2-13-03 was an atypical due to a headcut located in the middle of the reach, which resulted in a reach wide slope of 1.0 percent.

5 Comparison of Round 1 and Round 2 Results

This section presents a brief comparison of the biological and physical habitat assessment results from Round 1 and Round 2 for each of the four primary sampling units assessed in 2012. Refer to Figure 23 for box plots comparing average BIBI, RBP, and PHI results from Round 1 and Round 2 in the Hall Creek, Lower Patapsco, Piney Run, and Rhode River sampling units.

To compare statistical differences between mean index values from two time periods (e.g., Round One and Round Two), this report uses the method recommended by Schenker and Gentleman (2001). This is the same method used by the MBSS to evaluate changes in condition over time, and is considered a more robust test than the commonly used method, which examines the overlap between the associated confidence intervals around two means (Roseberry Lincoln et al., 2007). In this method, the 90% confidence interval for the difference in mean values $Q_1 - Q_2$ is estimated using the following formula:

$$(Q_1 - Q_2) \pm 1.645[SE_1^2 + SE_2^2]^{1/2}$$

where Q_1 and Q_2 are two independent estimates of the mean of a variable (i.e., BIBI, RBP, PHI) and SE_1 and SE_2 are the associated standard errors. The null hypothesis that $(Q_1 - Q_2)$ is equal to zero was tested (at the 10% nominal level) by examining whether the 90% confidence interval contains zero. The null hypothesis that the two means are equal was rejected if and only if the interval did not contain zero (Schenker and Gentleman, 2001), resulting in a statistically significant difference between those two values.

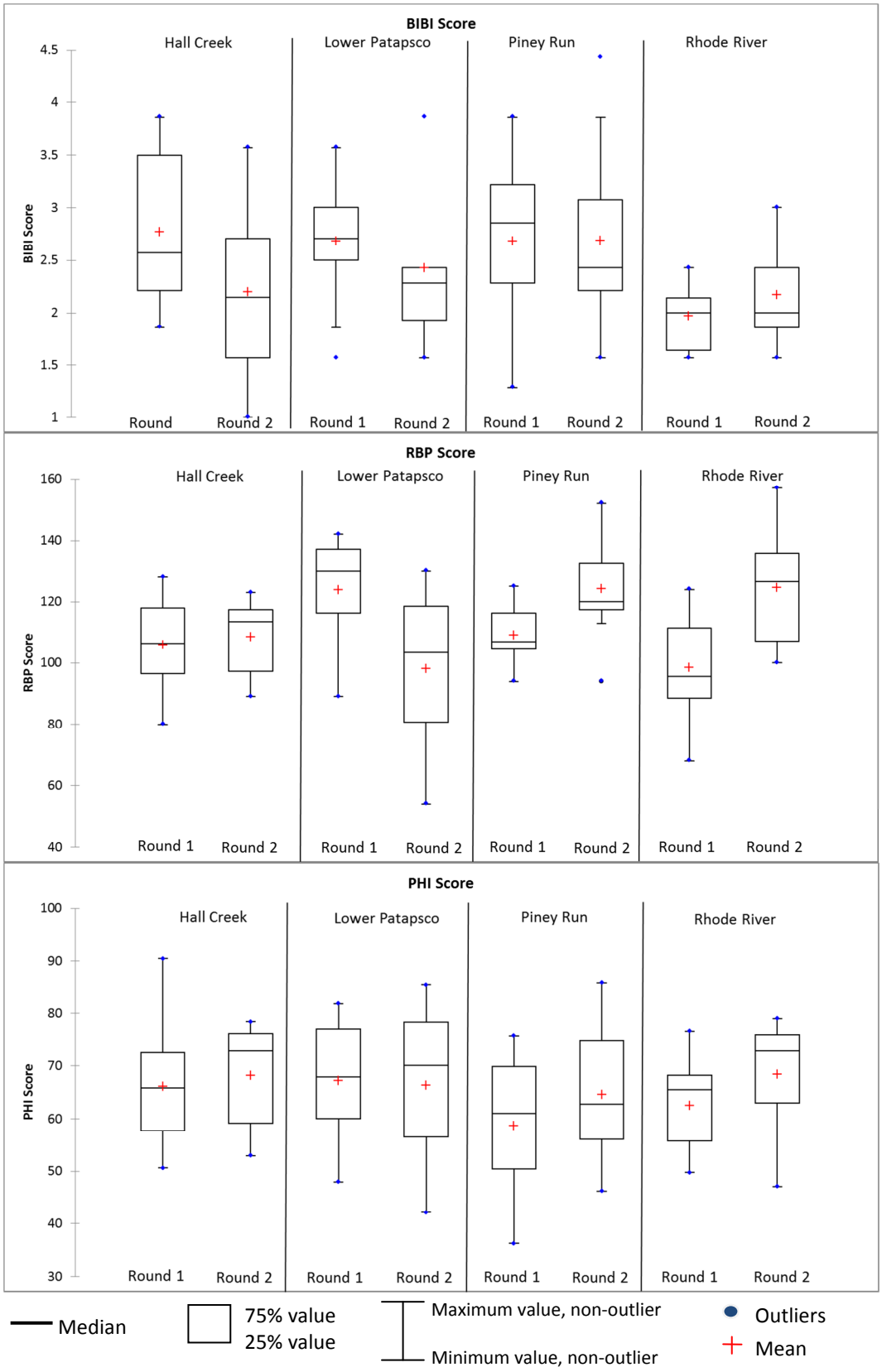


Figure 23 - Box plots comparing mean BIBI, RBP, and PHI scores between Round 1 and Round 2

5.1 Biological Conditions

A comparison of mean BIBI scores between Round One and Round Two showed no significant changes between sampling rounds (Table 18). While average BIBI scores may have increased or decreased slightly, overall biological condition ratings did not change for any of the sampling units assessed in 2012.

Table 18 - Differences in BIBI measures between Rounds One and Two

PSU	Round 2		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean IBI	SE	Mean IBI	SE			
Hall Creek	2.20	0.26	2.77	0.24	1.25	-0.11	No
Lower Patapsco	2.43	0.23	2.69	0.19	0.85	-0.34	No
Piney Run	2.69	0.28	2.69	0.25	0.75	-0.75	No
Rhode River	2.17	0.14	1.97	0.11	0.15	-0.55	No

5.2 Physical Habitat Conditions

Comparisons of physical habitat conditions between Rounds One and Two for the RBP and PHI indices are shown in Table 19 and Table 20, respectively. According to the RBP index, physical habitat conditions were observed to be significantly different during these two time periods for three of the four sampling units (i.e., Lower Patapsco, Piney Run, and Rhode River). Round One RBP data collected in 2004 rated Lower Patapsco as 'Partially Supporting'; however, the 2012 RBP mean habitat score decreased significantly with a condition rating of 'Non Supporting.' Even though the RBP rating remained as 'Partially Supporting', there was a significant increase in RBP score for Piney Run between Round One (2007) and Round Two sampling. Rhode River received a Round One RBP habitat rating of 'Non Supporting' in 2008, which increased significantly to a rating of 'Partially Supporting' in 2012.

In contrast, no significant changes in mean PHI scores occurred between Round One and Round Two. Although the Rhode River PSU increased from a 2008 habitat rating of 'Degraded' to a rating of 'Partially Degraded' in 2012, the change in PHI scores was not statistically significant. Average habitat conditions did not change in Hall Creek between 2006 and 2012 using either PHI or RBP indexes. PHI habitat conditions remain unchanged in Lower Patapsco between 2004 and 2012, as well as in Piney Run between 2007 and 2012.

Table 19 - Differences in RBP measures between Rounds One and Two

PSU	Round 2		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean RBP	SE	Mean RBP	SE			
Hall Creek	108.5	3.82	106.0	5.10	9.99	-14.99	No
Lower Patapsco	98.1	8.57	123.8	5.62	45.79	5.61	Yes (Decrease)
Piney Run	124.2	5.41	109.1	3.15	-2.84	-27.36	Yes (Increase)
Rhode River	124.7	6.09	98.5	5.34	-10.32	-42.08	Yes (Increase)

Table 20 - Differences in PHI measures between Rounds One and Two

PSU	Round 2		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean PHI	SE	Mean PHI	SE			
Hall Creek	68.17	3.20	66.04	3.85	7.68	-11.94	No
Lower Patapsco	66.27	4.71	67.14	3.73	12.63	-10.90	No
Piney Run	64.52	4.14	58.72	4.43	6.07	-17.69	No
Rhode River	68.39	3.26	62.54	3.00	2.83	-14.53	No

6 Conclusions and Recommendations

Biological communities respond to a combination of environmental factors, commonly referred to as stressors. Stressors can be organized according to the five major determinants of biological integrity in aquatic ecosystems, which include water chemistry, energy source, habitat structure, flow regime, and biotic interactions (Karr et al., 1986; Angermeier and Karr, 1994; Karr and Chu, 1998). The cumulative effects of human activities within the County's sampling units often results in an alteration of at least one, if not several, of these factors with detrimental consequences for the aquatic biota. Determining which specific stressors are responsible for the observed degradation within a stream or PSU is a challenging task, given that many stressors co-exist and synergistic effects can occur. Furthermore, an added challenge in identifying the stressors affecting stream biota is that the water quality and physical habitat data collected by the County's monitoring program are not comprehensive (i.e., they do not include many possible stressors). For instance, virtually no data are available regarding biotic interactions and energy sources and only limited data regarding flow regime variables, such as land use and impervious cover, are included. Stressor relationships with stream biotic components, and their derived indices (i.e., BIBI), are often difficult to partition from complex temporal–spatial data sets primarily due to the potential array of multiple stressors working at the reach to landscape scale in small streams (Helms et al. 2005; Miltner et al., 2004; Morgan and Cushman, 2005; Volstad et al., 2003; Morgan et al., 2007). Therefore, it should be noted that the current level of analysis cannot identify all stressors for the impaired watersheds, nor will the stressors identified include all of the stressors present.

6.1 Biological and Physical Habitat Conditions

Results of the 2012 assessment indicate impaired biological conditions in all four sampling units. The observed differences between Round 1 and Round 2 results were variable for each sampling unit. While not significant, average BIBI scores decreased between Round 1 and Round 2 for all but one PSU. Rhode River saw a slight increase in the average BIBI score, moving it from the Very Poor category to the Poor category., although the difference was not deemed to be statistically significant. It is also worth pointing out that a statistically significant increase in RBP scores was also observed for the Rhode River PSU, suggesting that better physical habitat conditions bolstered BIBI scores in 2012. Piney Run also saw a statistically significant increase in RBP scores, although no change was observed in mean BIBI scores. In contrast, Lower Patapsco saw a statistically significant decrease in RBP scores as well as a decrease in mean BIBI scores. These results suggest that physical habitat conditions as measured by the RBP index, are an important driver of biological conditions at the PSU scale.

Overall, both physical habitat assessment methods yielded scores that did not correspond well with predicted BIBI scores. A comparison of narrative biological condition ratings to RBP habitat condition

ratings for each site is shown in Table 21. Similarly, Table 22 compares biological condition ratings to PHI habitat ratings. These results are similar to those found by Roberts et al. (2006) and Stribling et al. 2008, and suggest that BIBI scores are not singularly affected by habitat conditions alone and additional stressors are likely present in these systems. Results from the RBP method showed the majority of sites with 'Partially Supporting' or 'Non Supporting' physical habitat conditions (78 percent); however, approximately half of these sites (48 percent) actually resulted in biological conditions that matched the predicted outcome (Table 21). Similar to the RBP method, results from the PHI method showed the majority of sites with a 'Partially Degraded' or 'Degraded' rating (83 percent) with only 30 percent of sites actually resulting in biological conditions that match the predicted outcome (Table 22).

Table 21 - Comparison of biological condition ratings to EPA RBP habitat condition ratings.

EPA RBP Habitat Rating	BIBI Rating			
	Good	Fair	Poor	Very Poor
Comparable to Reference		R2-01-07		**R2-13-08**
Supporting		R2-03-03	R2-01-02 R2-01-06 R2-13-17A	**R2-13-01** **R2-13-05** **R2-13-12A**
Partially Supporting	**R2-01-10**	R2-01-08 R2-03-08 R2-13-03 R2-24-08	R2-01-03 R2-01-09 R2-03-02 R2-03-06 R2-03-07 R2-13-04 R2-13-13A R2-24-03 R2-24-05 R2-24-10	R2-01-01 R2-01-05 R2-13-11A R2-24-04 R2-24-06 R2-24-12A
Non-Supporting		**R2-24-09**	R2-01-04 R2-03-10 R2-03-11A R2-13-22A	R2-03-04 R2-03-05 R2-03-15A R2-24-11A R2-24-13A

Green cells: stations where the biological community was less impaired than the habitat scores would predict.
Yellow cells: stations where biological community matched available habitat.
Pink cells: stations where the biological community was more impaired than the habitat scores would predict.
Bold type stations have biological conditions that differ by at least two qualitative habitat categories.

Table 22 - Comparison of biological condition ratings to MBSS PHI habitat condition ratings.

MBSS PHI Habitat Rating	BIBI Rating			
	Good	Fair	Poor	Very Poor
Minimally Degraded		R2-01-07 R2-03-03		
Partially Degraded		R2-03-08 R2-13-03 R2-24-08	R2-01-02 R2-01-06 R2-03-02 R2-03-06 R2-03-07 R2-03-11A R2-13-04 R2-24-03 R2-24-05	**R2-01-01** **R2-13-01** **R2-13-05** **R2-13-11A** **R2-13-12A** **R2-24-04** **R2-24-06** **R2-24-12A**
Degraded		R2-24-09	R2-01-03 R2-01-04 R2-01-09 R2-03-10 R2-13-13A R2-13-17A R2-24-10	R2-01-05 R2-03-05 R2-13-08 R2-24-11A R2-24-13A
Severely Degraded	**R2-01-10**	**R2-01-08**	R2-13-22A	R2-03-04 R2-03-15A

Green cells: stations where the biological community was less impaired than the habitat scores would predict.
Yellow cells: stations where biological community matched available habitat.
Pink cells: stations where the biological community was more impaired than the habitat scores would predict.
Bold type stations have biological conditions that differ by at least two qualitative habitat categories.

Although physical habitat conditions were generally degraded in all four watersheds, degraded habitat alone cannot explain the observed biological conditions in these sampling units. Because habitat conditions did not correspond well to predicted biological conditions at many sites, additional stressors are likely influencing the benthic macroinvertebrate assemblages in these streams.

In developed sampling units with a higher percentage of impervious surfaces, such as Lower Patapsco and Piney Run, water quality stressors are likely responsible for impaired biological conditions. Elevated conductivity values (i.e., >247 µS/cm) were observed at sites in all sampling units, with a slight trend (R^2=0.33) toward increased conductivity with increased impervious surfaces. This relationship between conductivity and imperviousness is consistent with patterns observed throughout Anne Arundel County (Hill and Pieper, 2011b). These findings suggest that de-icing chemicals, road salts and other inorganic ions such as sulfate, phosphate and iron may be a predominant water quality stressor responsible for the observed biological impairment in these streams, especially where physical habitat is adequate for supporting healthy benthic macroinvertebrate assemblages. However, additional water quality data would be necessary to determine the constituent (or constituents) responsible for the increased conductivity (e.g., metals, salts, nutrients), and whether there are any known acute or chronic effects to aquatic biota. Nonetheless, data from Round One indicate that BIBI scores are negatively correlated with conductivity values, and conductivity can be a useful predictor of urban runoff in receiving waters (Hill and Pieper, 2011b).

Identifying additional stressors in the rural sampling units, such as Hall Creek and Rhode River, is much more challenging given the available data. According to the PHI, over half of the sites in both Hall Creek and Rhode River sampling units had worse biological conditions than the physical habitat conditions predicted (seven and six sites, respectively). However, one site in both sampling units had better biological conditions than the physical habitat conditions which may suggest some degree of nutrient enrichment in this sampling unit, especially considering the higher proportion of agricultural land use in these sampling units (21 percent of Hall Creek and 12 percent of Rhode River) when compared to the other sampling units.

It is also plausible that the biological condition of these sampling units is impaired by stressors related to past land use, commonly referred to as legacy effects, which are the consequences of past disturbances that continue to influence environmental conditions long after the initial appearance of the disturbance (Allan, 2004). Historically, nearly all of Anne Arundel County has experienced deforestation, followed by intensive agriculture, which significantly altered the landscape (Schneider, 1996). These drastic land use changes likely altered the structure and function of the stream ecosystems to a considerable extent, some of which have yet to fully recover. This notion is supported by Harding and others (1998), who found that that past land use activity, in particular agriculture, may result in long-term modifications to and reductions in aquatic diversity, regardless of reforestation of riparian zones. What is not clear, however, is how long these legacy effects will persist in these subwatersheds, and consequently, what can be done to improve the biological condition of these streams.

Drainage area may influence biological community composition with larger drainage areas providing an increased potential for full colonization by benthic macroinvertebrate communities (Hill and Pieper, 2011b). Using data from 2012 sites, drainage area is significantly correlated with BIBI score ($p<0.001$), with a trend ($R^2=0.32$) of increased BIBI score with increased drainage area. This relationship is consistent with patterns observed throughout Anne Arundel County (Hill and Pieper, 2011b). The drainage area effect was also observed during a concurrent study in West and Rhode Rivers watersheds where the drainage area was significantly correlated with BIBI score ($p = 0.010$; Crunkleton et al., 2012). The results of the comparison of biological condition ratings using the MBSS PHI shown in Table 22 may also be skewed because of a drainage area effect. Habitat ratings seem to be inflated for sites with smaller drainage areas ('Partially Degraded') and deflated for sites with larger drainage areas ('Degraded' or 'Severely Degraded'). For example, all sites that have biological conditions that are worse than the habitat scores would predict by at least two qualitative PHI habitat categories have relatively small drainage areas ranging from 86 to 673 acres (median = 272 acres; n = 8). Conversely, all sites where the biological community was less impaired than the habitat scores would predict have large drainage areas ranging from 1,488 to 12,631 acres (median = 7,325 acres; n = 4).

Climate and seasonal variation may have an effect on biological community composition as well as available habitat. For example, above average precipitation was recorded for this area in 2011, which may have disturbed stream habitat. It is also important to note that sites were sampled during an abnormally warm and dry spring, which may also have an effect on the biological community composition. A warmer spring may accelerate the life cycle progression of benthic macroinvertebrates causing earlier emergence and affecting pupa populations. According to the National Climatic Data Center (NCDC), March and April 2012 recorded below average for precipitation and March recorded above average for temperature at Baltimore-Washington International Thurgood Marshall Airport (BWI; Table 23).

Table 23 - BWI average monthly precipitation and temperature data

Year	Precipitation (inches)		Temperature (°F)	
	March	April	March	April
2012	1.76	1.99	53.7	55.3
Historical average (1871-2010)	3.90	3.19	43.6	53.7

6.2 Geomorphologic Conditions

The geomorphic assessment field data were compared to the Maryland Coastal Plain (MCP) regional relationships of bankfull channel geometry (McCandless, 2003) in order to determine how channel dimensions observed in the field compare to those predicted for rural/suburban subwatersheds. Comparisons of bankfull width, mean bankfull depth, and bankfull cross-sectional area, stratified by Rosgen Level I stream type, are shown in Figures 24, 25, and 26, respectively. Since only one DA channel was identified during the current sampling period, trendlines for DA type channels could not be generated for comparison to the MCP curve.

A comparison of bankfull width values show the trendline for G channels (R^2 = 0.88) as the closest matching the MCP curve (Figure 24). Trendlines from C (R^2 = 0.87) and F (R^2 = 0.73) channels contained more variability, with data points scattered mostly above the MCP curve. This suggests that C and F type channels assessed in 2012 are generally wider than the streams used to derive the MCP regional relationships. On the other hand, the trendline for E type channels was below the MCP curve, indicating narrower channels than predicted by the regional curve. These results are somewhat expected given that C and F type channels tend to have greater width/depth ratios as compared to E and G type channels. Mean bankfull depth values showed the trendline for G type channels (R^2 = 0.77) closely matching the MCP curve, with the exception of a few outliers above the curve (Figure 25). F type channels exhibited the highest degree of variability (R^2 = 0.61), with points scattered on either side of the curve, but mostly showing depths that were shallower than predicted by the MCP. All C channels fell below the MCP curve, suggesting much shallower channels than the MCP would predict. As with bankfull width, the channel types follow the expected mean bankfull depth relationship. For the same drainage area, E channels were the deepest followed by G, F, C, and DA.

Comparisons of bankfull cross-sectional area values show the trendlines for C type (R^2 = 0.94), G type (R^2 = 0.87), and E type (R^2 = 1.00) channels closely matching the MCP curve (Figure 26). The trendline for F type streams was a good fit to the data (R^2 = 0.85), although it deviated from the MCP curve, generally having larger cross-sectional areas compared to the MCP curve.

The results of the comparison are not surprising considering that the streams used to derive the MCP curves were E type C type streams, which explains why these stream types typically show a good fit to the MCP predictions of channel dimensions, primarily cross-sectional area. Conversely, this also helps to explain why F, G, and DA channels often deviate from the predictions, since the curve was created exclusively from C and E type channels. Although it should also be noted, that F, G, and DA streams in the data set were typically confined to drainage areas of two square miles or less.

Channel instability, sediment deposition, and bank erosion are likely significant stressors impacting the benthic macroinvertebrate communities in these sampling units; however, the extent of these impacts is not well understood. Typically, reaches classified as unstable G and F type streams would be expected to have more impaired biological communities than reaches classified as more stable stream types, such as E, C, and B channels. However, geomorphic and biological results from this sampling period, as well as those from Round One do not support this notion. An analysis of the Round One data set found that geomorphic variables did not correlate well with biological variables (Hill and Pieper, 2011b). Furthermore, land use characteristics, while significantly correlated with variables such as entrenchment ratio and flood-prone width, showed relationships that were the opposite of what would have be expected (i.e., positively correlated with percent developed land and negatively correlated with percent agriculture), suggesting a more complex interaction between land use and geomorphic characteristics (Hill and Pieper, 2011b). The pace and age of development may be influencing channel evolution and the types of stream channels found in these sampling units, as suggested by Stribling et al. (2008). However, it is also possible that some of the "stable" E and C type streams are experiencing an aggradation phase of channel evolution whereby an increased sediment supply from bank erosion begins to fill the channel, decreasing stream depth and increasing floodplain connectivity. However, these hypotheses were not tested as part of this study, and further data would be necessary to determine the dominant geomorphological processes in each of these sampling units.

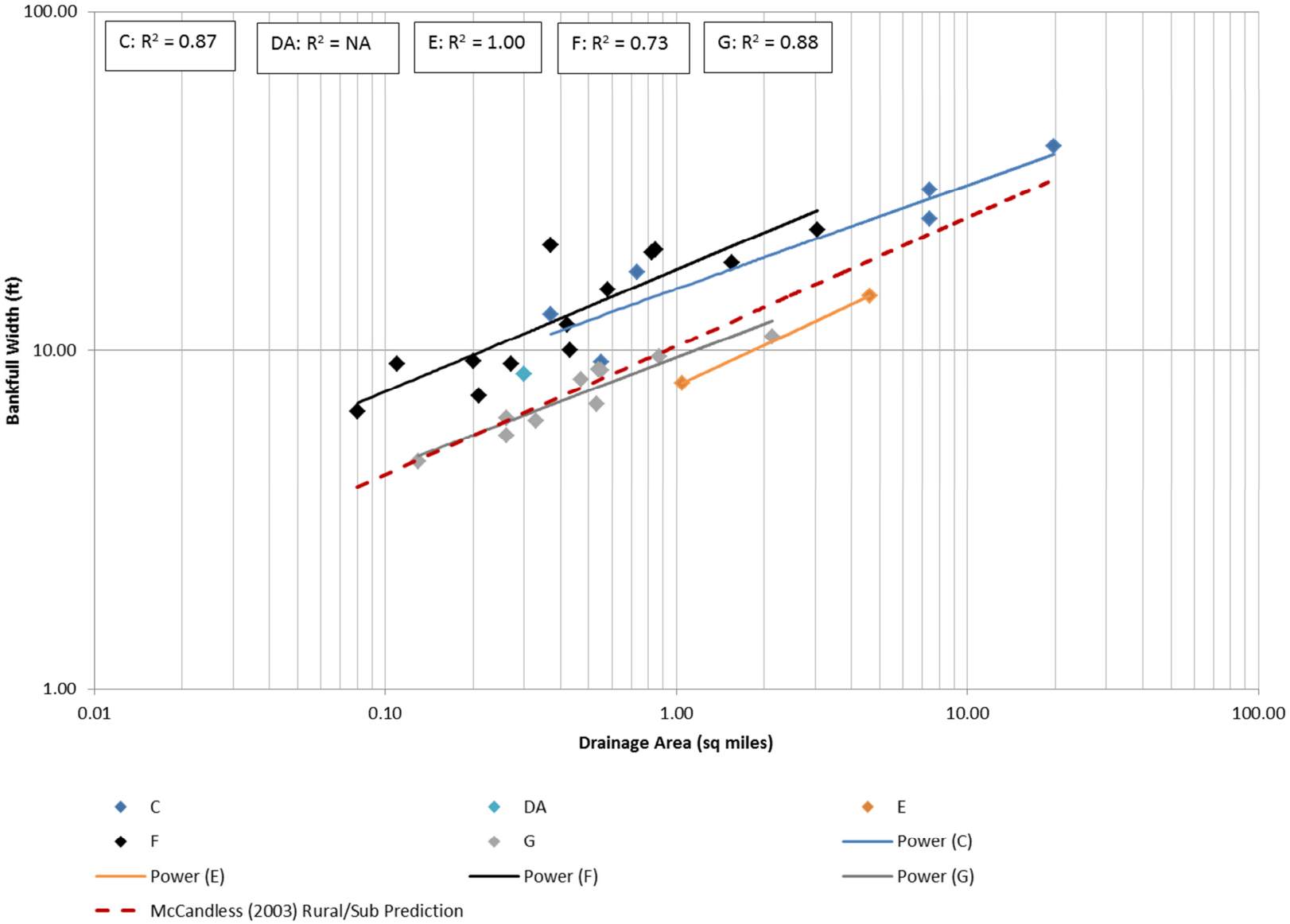


Figure 24 - Comparison of the Bankfull Width - Drainage Area Relationship between Field Data and Regional Relationship Curve Data

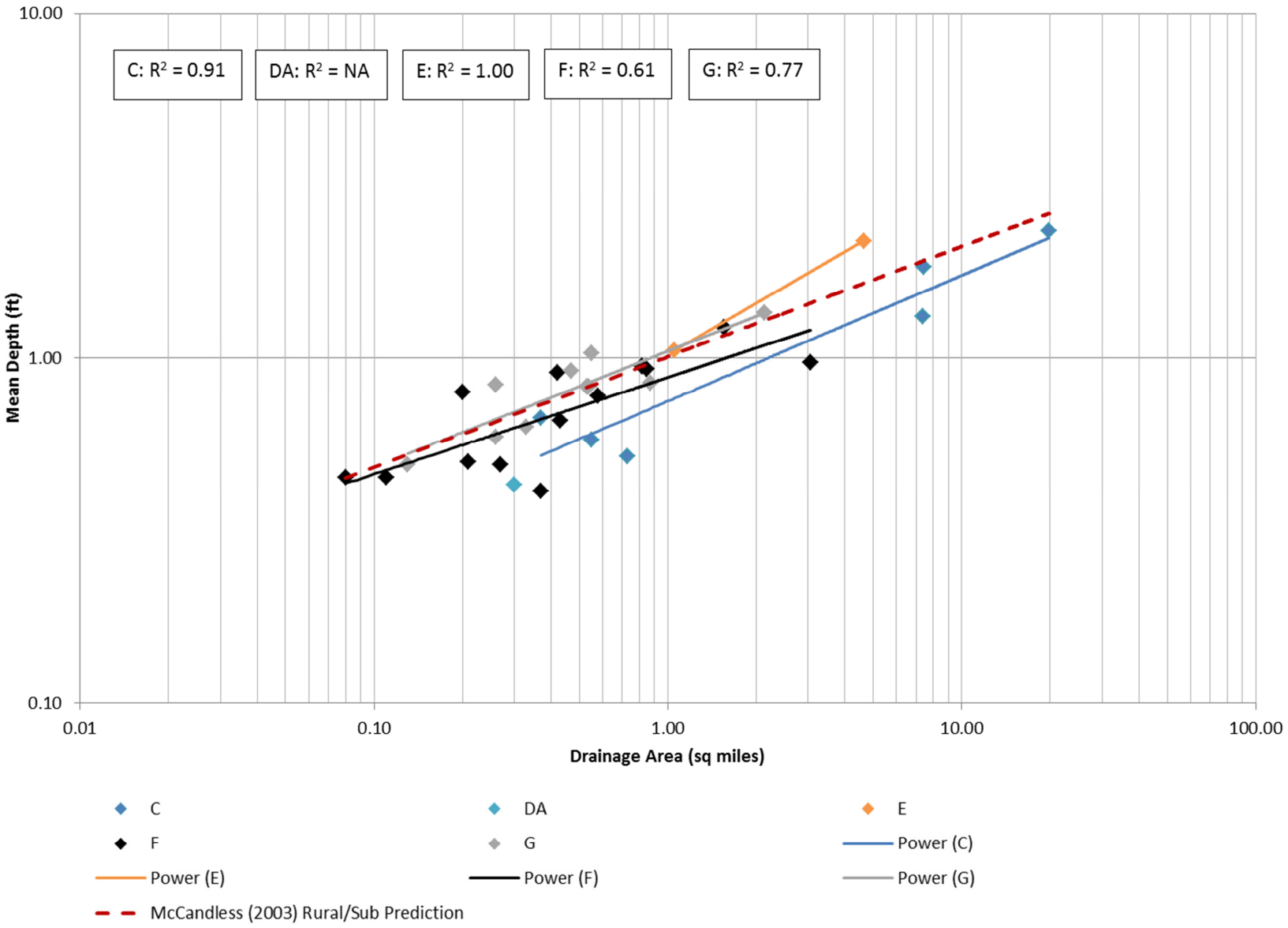


Figure 25 - Comparison of the Mean Bankfull Depth - Drainage Area Relationship between Field Data and Regional Relationship Curve Data

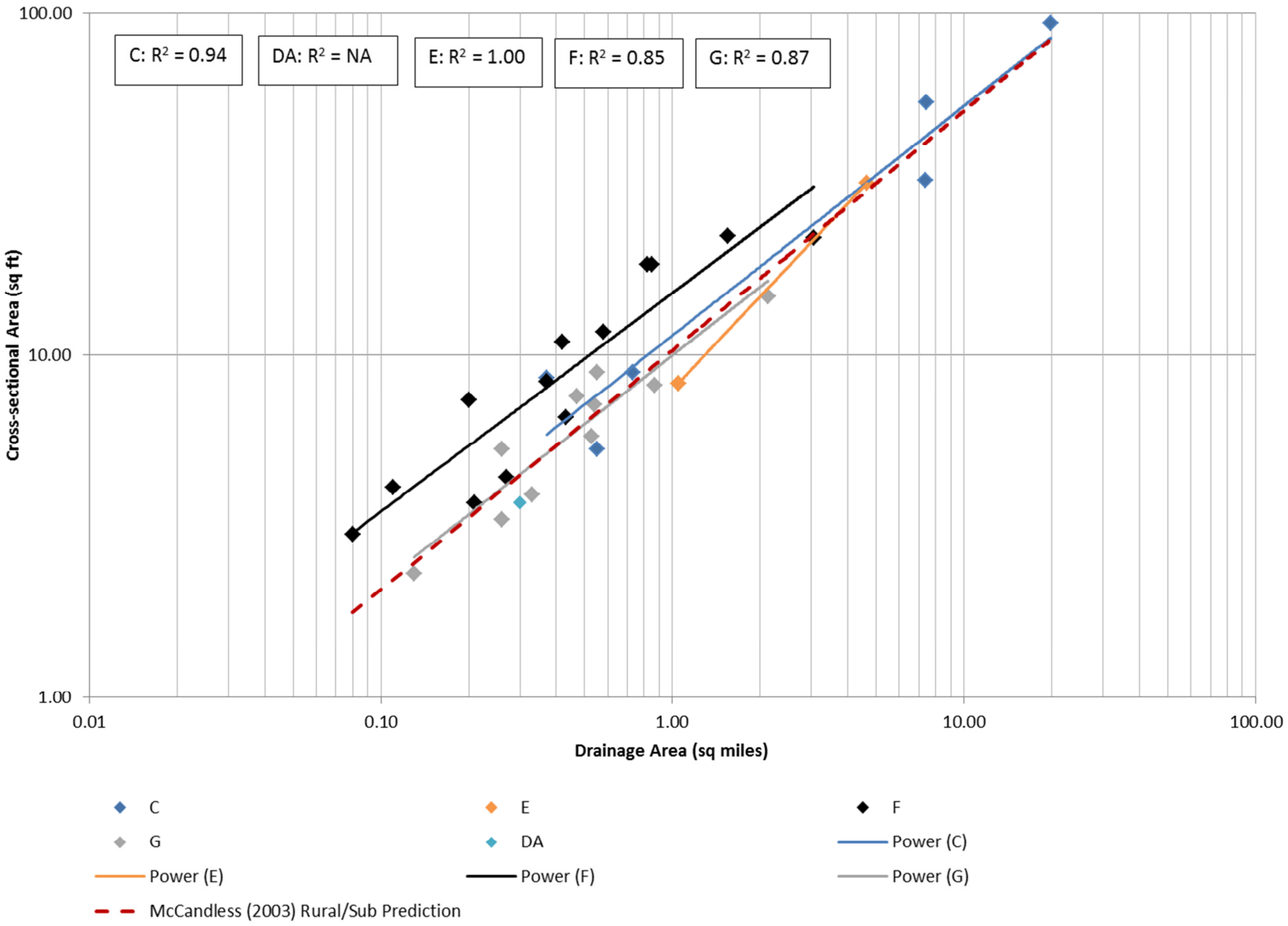


Figure 26 - Comparison of the Bankfull Cross-Sectional Area - Drainage Area Relationship between Field Data and Regional Relationship Curve Data

6.3 Recommendations

Based upon the conclusions discussed in the previous section, the following recommendations are made for these sampling units:

Stream Channel Evolution and Trajectory

Based on the analysis of Round One data, it was shown that many geomorphic variables such as bankfull channel dimensions, dimensionless ratios, and water surface slope were not significantly correlated with BIBI scores (Hill and Pieper, 2011b). Sinuosity and D_{50} were the only geomorphic variables correlated with the overall BIBI score (0.05 level). As a result, it is recommended that subsequent assessment efforts should focus more on the dominant geomorphologic processes or channel evolution stage, since these processes are more likely influencing the benthic macroinvertebrate communities than basic channel dimensions and stream type as classified by the Rosgen approach. In a study relating stream geomorphic state to ecological integrity, Sullivan et al. (2004) recommend that stream channels be evaluated in terms of dynamic stability and adjustment rather than simply categorized as stable or unstable. Sites assessed in Rounds One and Two, or at least a subset of sites, should be re-visited and cross sections re-surveyed after a specified period of time (e.g., 5 years, 10 years) so that changes in channel dimensions can be quantified and determinations made regarding the dominant process occurring in each stream. This would help to validate stability assumptions, providing the County with a better understanding of how land use changes impact streams over time, which may ultimately allow for fine tuning zoning and development regulations toward maximum protection of stream channel stability.

Water Quality Sampling

Because identifying stressors is critical to the development of management actions that can restore or protect the desired condition of streams, it is recommended that the County consider the addition of water quality grab sampling during subsequent sampling efforts to better understand and document chemical stressors affecting the biota. Water quality sampling should evaluate additional parameters such as nutrients, chloride, and metals, which may potentially be of concern. While this would add considerable costs to the monitoring program, the added benefit would greatly enhance the County's ability to identify predominant water quality stressors and sources. Additionally the program would be positioned well to monitor changes in water chemistry as it relates to tracking progress towards meeting total maximum daily load (TMDL) requirements, both for specific impaired water bodies and for the Chesapeake Bay-wide TMDL.

Stressor Identification Studies

While it is assumed that water quality stressors are impacting biota in some of these streams, a more focused stressor identification technique such as the U.S. Environmental Protection Agency's Stressor Identification (SI) process (USEPA, 2000), is necessary to correctly associate biological impacts with their most probable causes. This typically involves the collection of additional data (e.g., water quality grab sampling, storm sampling), which can be both costly and time consuming on a large scale. Therefore, in an effort to optimize the use of limited resources it is recommended that the County prioritize which streams and/or subwatersheds require a more detailed analysis of stressors and sources, whether the goal is for protection, preservation, or enhancement.

Best Management Practices

Stormwater Management

Two of the sampling units, Lower Patapsco and Piney Run, have been developed extensively and could benefit from retrofitting existing development and/or increasing stormwater best management practices (BMPs) to treat larger volumes of stormwater runoff. It is recommended that the County consider improving existing BMPs and/or installing new BMPs, wherever practical and feasible, in these subwatersheds, given that they appear to be widely impacted by urban stormwater runoff.

Agricultural Lands

While Hall Creek and Rhode River sampling units contained less developed land, overall BIBI scores were still poor. These subwatersheds may be impacted by current agricultural land use and may benefit from increasing BMPs to treat agricultural runoff. It is recommended that the County consider working with current landowners to improve existing agricultural BMPs and/or initiate new BMPs, wherever practical and feasible, in the Hall Creek and Rhode River subwatersheds.

7 References

Allan, J.D. 2004. Landscapes and Riverscapes: The influence of land use on stream ecosystems. Annual Review of Ecology and Evolutionary Systems 35:257-284.

Angermeier, P.L., and J.R. Karr. 1994. Biological integrity versus biological diversity as policy directives. Bioscience 44:690-697.

Anne Arundel County. 2011. Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan. Revised May 2011. Prepared by KCI Technologies, Inc. for Anne Arundel County Department of Public Works, Watershed Ecosystem and Restoration Services. Annapolis, MD. For additional information, contact Mr. Chris Victoria (410-222-4240, <PWVICT16@aacounty.org>)

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water; Washington D.C.

Bressler, D. W., M. J. Paul, and J. B. Stribling. 2004. Development of tolerance values for benthic macroinvertebrates in Maryland. Draft by Tetra Tech, Inc., for Versar, Inc., and Maryland Department of Natural Resources, Annapolis. April.

Caton, L.W. 1991. Improved sub-sampling methods for the EPA 'Rapid Bioassessment' benthic protocols. Bulletin of the North American Benthological Society 8(3):317-319.

Crunkleton, M.C., C.R. Hill, and M.J. Pieper. 2012. Targeted Biological Assessment of Streams in the West River and Rhode River Watersheds, Anne Arundel County, Maryland: 2012. Prepared by KCI Technologies, Sparks, MD for Anne Arundel County, Department of Public Works, Watershed, Ecosystem, and Restoration Services. Annapolis, MD.

Harding, J.S., E.F. Benfield, P.V. Bolstad, G.S. Helfman and E.B.D. Jones, III. 1998. Stream biodiversity: the ghost of land use past. Proc. Natl. Acad. Sci. 95: 14843-14847.

Harrelson, C. C., C. L., Rawlins, C. L., and J. P., Potyondy. 1994. Stream channel reference sites: An illustrated guide to field technique. Gen. Tech. Rep. RM-245. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Helms B.S., Feminella J.W., and S. Pan. 2005. Detection of biotic responses to urbanization using fish assemblages from small streams of western Georgia, USA. Urban Ecosystems 8:39–57

Hill, C. and J.B. Stribling. 2004. Design of the Biological Monitoring and Assessment Program for Anne Arundel County, Maryland. Prepared by Tetra Tech, Inc., Owings Mills, Maryland, for the Anne Arundel County Office of Environmental & Cultural Resources, Annapolis, Maryland.

Hill, C.R., and M. J. Pieper. 2011a. Documentation of Method Performance Characteristics for the Anne Arundel County Biological Monitoring Program. Revised, August 2011. Prepared by KCI Technologies, Sparks, MD for Anne Arundel County, Department of Public Works, Watershed, Ecosystem, and Restoration Services. Annapolis, MD.

Hill, C. R., and M.J. Pieper. 2011b. Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: Round One 2004 – 2008. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland.

Karr, J.R. and E.W. Chu. 1998. Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washington, DC.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey Special Publication 5. Champaign, Illinois.

Maryland Department of the Environment. Code of Maryland Regulations (COMAR). Continuously updated. Code of Maryland Regulations, Title 26- Department of the Environment. 26.08.02.03- Water Quality.

Maryland Department of Natural Resources (DNR). 2010. Maryland Biological Stream Survey Sampling Manual: Field Protocols. Publication # 12-2162007-190. Revised January 2010. Maryland Department of Natural Resources, Annapolis, MD. CBWP-MANTA-EA-07-01.

McCandless, T.L. 2003. Maryland stream survey: Bankfull discharge and channel characteristics of streams in the Coastal Plain hydrologic region. U.S. Fish and Wildlife Service, Annapolis, MD. CBFO-S03-02.

Mecklenburg, Dan. 2006. The Reference Reach Spreadsheet. Version 4.3L. Ohio Department of Natural Resources.

Merritt, R.W. and Cummins, K.W. 1996 An Introduction to the Aquatic Insects of North America, 3rd edition, Kendall / Hunt Publishing Company.

Miltner R.J., White D., and C. Yoder. 2004. The biotic integrity of streams in urban and suburbanizing landscapes. Landscape and Urban Planning 69:87–100

Morgan R.P., and S.F. Cushman. 2005. Urbanization effects on stream fish assemblages in Maryland, USA. Journal of the North American Benthological Society 24:643–655

Morgan R.P., K.M. Kline, and S.F. Cushman. 2007. Relationships among nutrients, chloride, and biological indicies in urban Maryland streams. Urban Ecosystems 10:153-177

National Climatic Data Center (NCDC). 2012. Baltimore/Washington: Unique Local Climate Data. National Weather Service Forecast Office. http://www.ncdc.noaa.gov/

Paul, M.J., J.B. Stribling, R.J. Klauda, P. F. Kayzak, M.T. Southerland, and N. E. Roth. 2003. A Physical Habitat Index for Wadeable Streams Maryland. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD. CBWP-MANTA-EA-03-4.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

Richards, C., L. B. Johnson, and G. E. Host. 1996. Landscape-scale influences on stream habitats and biota. Canadian Journal of Fisheries Aquatic Science 53: 295-311.

Roberts, M. C. Smith, and C, Victoria. 2006. Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2005. Anne Arundel County, Office of Environmental and Cultural Resources, Annapolis, Maryland.

Roseberry Lincoln, A., R. Klauda, and E.K. Barnum. 2007. Maryland Biological Stream Survey 2000-2004, Volume 12: Changes in Condition. DNR-12-0305-0103. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD. CBWP-MANTA-EA-05-9.

Rosgen, D.L. 1994. A Classification of Natural Rivers. Catena 22:169-199.

Rosgen, D.L. 1996. Applied River Morphology (Second Edition). Wildland Hydrology. Pagosa Springs, CO.

Schenker, N. and J. F. Gentleman. 2001. On Judging the Significance of Differences by Examining the Overlap Between Confidence Intervals. The American Statistician 55(3):182–186.

Schneider, D.W. 1996. Effects of European settlement and land use on regional patterns of similarity among Chesapeake forests. Bulletin of the Torrey Botanical Club 123(3):223-239.

Southerland, M.T., G.M. Rogers, M.J. Kline, R.P. Morgan, D.M. Boward, P.F. Kazyak, R.J. Klauda, S.A. Stranko. 2005. New Biological Indicators to Better Assess the Condition of Maryland Streams. DNR-12-0305-0100. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD.

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. American Geophysical Union Transactions 38:913-920.

Stribling, J.B., E.W. Leppo, and C. Daley. 1999. Biological Assessment of the Streams and Watersheds of Prince George's County, Maryland. Spring Index Period 1999. PGDER Report No 99-1. Prince George's County, Dept. of Env. Rsrs., Programs and Planning Division, Largo, MD

Stribling, J.B., B. Jessup, and C.J. Victoria. 2008. Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2006. Anne Arundel County, Department of Public Works, Watershed, Ecosystem, and Restoration Services. Annapolis, MD.

Sullivan, S.M.P., M.C. Watzin and W.C. Hession. 2004. Understanding stream geomorphic state in relation to ecological integrity: evidence using habitat assessments and macroinvertebrates. Environmental Management. 34(5): 669-683.

Tetra Tech, Inc. 2006. Random subsample routine spreadsheet. Developed by Erik W. Leppo of Tetra Tech, Inc., Owings Mills, MD

U.S. Environmental Protection Agency (USEPA). 2000. Stressor Identification Guidance Document. EPA 822-B-00-025. U.S. Environmental Protection Agency, Office of Water, Office of Research and Development, Washington, D.C.

USEPA. 2004. Chesapeake Bay: Introduction to an Ecosystem. Produced by the Chesapeake Bay Program, Annapolis, MD. EPA 903-R-04-003. 34 pp.

Volstad J.H., Roth N.E., Mercurio G., Southerland M.T., and D.E. Strebel. 2003. Using environmental stressor information to predict the ecological status of Maryland non-tidal streams as measured by biological indicators. Environmental Monitoring and Assessment 84:219–242

Wolman, M.G. 1954. A Method of Sampling Coarse River-bed Material. Transactions of American Geophysical Union 35: 951-956.

Appendix A: Geomorphic Assessment Results

Site	Drainage Area (mi^2)	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Floodprone Width (ft)	Entrench-ment Ratio	Width to Depth Ratio	Cross Sectional Area (ft^2)	Slope (%)	Sinuosity	D50 (mm)	Rosgen Stream Type	Comments
R2-01-01	0.42	11.9	0.9	13.9	1.2	13.1	10.9	0.8	1.3	10.0	F4/5	Bimodal distribution of substrate (gravel/sand)
R2-01-02	7.39	24.4	1.3	133.0	5.4	18.4	32.4	0.4	1.2	20.0	C4	
R2-01-03	3.44	22.9	1.1	27.1	1.2	20.2	25.9	1.2	1.1	19.0	ND	Immediately downstream of road crossing, with evidence of recent bank stabilization.
R2-01-04	0.21	7.3	0.5	8.8	1.2	14.7	3.7	0.9	1.3	0.062	F6	
R2-01-05	0.85	19.8	0.9	25.1	1.3	21.2	18.4	0.7	1.1	13.0	F4	
R2-01-06	3.05	22.7	1.0	31.9	1.4	23.4	22.0	0.7	1.3	15.0	F4	
R2-01-07	2.13	11.0	1.4	15.7	1.4	8.1	14.9	0.7	1.0	22.0	G4c	
R2-01-08	18.41	44.9	2.0	160.0	3.6	22.6	89.1	0.0	1.0	0.45	ND	Reach partially under bridge crossing, altering morphology.
R2-01-09	7.41	29.8	1.8	250.0	8.4	16.3	54.8	0.3	1.1	1.7	C4/5	Bimodal distribution of substrate (gravel/sand)
R2-01-10	19.81	40.1	2.3	290.0	7.2	17.2	93.7	0.0	1.1	0.69	C5c-	
R2-03-02	0.82	19.4	1.0	25.4	1.3	20.4	18.4	0.8	1.2	8.3	F4/5	Bimodal distribution of substrate (gravel/sand)
R2-03-03	0.37	12.8	0.7	34.0	2.7	19.1	8.6	1.0	1.1	5.5	C4/5	Bimodal distribution of substrate (gravel/sand)
R2-03-04	0.27	8.0	0.5	9.6	1.2	16.6	3.9	1.5	1.0	21.0	ND	Ephemeral channel, recently stabilized with large cobble/boulder grade control structures.
R2-03-05	0.65	11.6	0.9	11.6	1.0	12.4	10.8	1.3	1.1	0.062	ND	Intermittent channel impacted by large beaver dam in middle of reach.
R2-03-06	0.2	9.3	0.8	10.7	1.2	11.6	7.4	2.0	1.3	40.0	F4b	Adjusted WD +0.4 to fit F type.
R2-03-07	0.11	9.1	0.5	10.9	1.2	20.0	4.1	1.4	1.1	35.0	F4	
R2-03-08	0.37	20.4	0.4	26.4	1.3	49.9	8.4	1.0	1.3	15.0	F4/5	Bimodal distribution of substrate (gravel/sand)
R2-03-10	1.55	18.1	1.2	24.9	1.4	14.6	22.3	1.0	1.3	19.0	F4	
R2-03-11A	0.08	6.6	0.5	8.2	1.2	14.9	3.0	2.5	1.3	35.0	F4/5b	Bimodal distribution of substrate (gravel/sand)
R2-03-15a	0.58	15.1	0.8	20.1	1.3	19.5	11.7	1.3	1.1	8.7	F4/5	Bimodal distribution of substrate (gravel/sand)
R2-13-01	0.55	9.2	0.6	195.0	21.1	16.0	5.3	0.2	1.1	0.088	C5	
R2-13-03	0.32	3.4	0.9	6.9	2.0	4.0	2.9	1.0	1.1	0.15	ND	Presence of footbridge and headcut in middle of reach, as well as unusual channel dimensions hinder Rosgen classification.
R2-13-04	0.26	6.3	0.8	8.7	1.4	7.5	5.3	0.2	1.1	0.062	G6c	
R2-13-05	1.05	8.0	1.1	200.0	25.1	7.6	8.3	0.5	1.2	0.097	E5	
R2-13-08	0.73	17.0	0.5	165.0	9.7	32.6	8.9	0.3	1.2	0.062	C6	
R2-13-11A	0.43	10.0	0.7	11.0	1.1	15.1	6.6	0.8	1.2	0.15	F5	
R2-13-12A	0.3	8.5	0.4	200.0	23.6	19.6	3.7	0.6	1.3	0.062	DA6	
R2-13-13A	0.87	9.6	0.9	12.4	1.3	11.3	8.2	0.0	1.4	0.067	G5/6c	Biomodal distribution of substrate (sand/clay)
R2-13-17A	4.63	14.5	2.2	170.0	11.7	6.6	31.8	0.0	1.1	0.18	E5	
R2-13-22A	4.48	13.3	1.6	21.4	1.6	8.3	21.3	0.0	1.0	0.062	ND	Channel altered by large box culvert in upstream end of reach.
R2-24-03	0.53	6.9	0.8	9.7	1.4	8.3	5.8	0.3	1.1	0.16	G5c	
R2-24-04	0.13	4.7	0.5	7.2	1.5	9.5	2.3	0.7	1.1	0.11	G5c	Adjusted ER - 0.1 to fit G type.
R2-24-05	0.26	5.6	0.6	8.1	1.4	9.5	3.3	0.5	1.3	0.18	G5c	
R2-24-06	0.55	8.7	1.0	12.6	1.4	8.5	8.9	0.3	1.1	0.15	G5c	
R2-24-08	0.54	8.8	0.8	11.3	1.3	10.6	7.2	0.5	1.3	0.18	G5c	
R2-24-09	2.33	22.0	1.2	25.4	1.2	17.9	26.9	0.1	1.0	0.11	ND	Double barrel culvert present in lower portion of reach. Channel slope and dimensions likely influenced by culvert.
R2-24-10	1.8	7.1	1.1	12.3	1.7	6.6	7.6	0.5	1.1	0.062	ND	Channel altered by large beaver dam upstream resulting in two threads, one severely downcut.
R2-24-11a	0.33	6.2	0.6	9.9	1.6	9.8	3.9	0.6	1.1	0.22	G4/6c	Adjusted ER -0.2 to fit G type. Bimodal distribution of substrate (gravel/clay).
R2-24-12a	0.27	9.1	0.5	13.0	1.4	18.8	4.4	0.3	1.0	0.13	F5	
R2-24-13A	0.47	8.2	0.9	10.4	1.3	9.0	7.6	0.5	1.1	0.15	G5c	

Appendix B: Quality Control Summary

Appendix B: Quality Assurance/Quality Control Procedures and Results

A quality assurance and quality control analysis was completed for the assessment work conducted in the Countywide Aquatic Biological Assessment following the methods described by Hill and Pieper (2011). This analysis included performance characteristics of precision, accuracy, bias, sensitivity, and completeness, with comparisons to MQOs. Performance measures include:

- Precision (consistency) of field sampling and overall site assessments using intra-team site duplication
  - median relative percent difference (mRPD)
  - root mean square error (RMSE)
  - coefficient of variability (CV)
- Sensitivity of overall site assessments
  - 90% confidence interval (CI)
- Bias of sample sorting and subsampling
  - percent sorting efficiency (PSE)
- Precision of taxonomic identification and enumeration
  - percent taxonomic disagreement (PTD)
  - percent difference in enumeration (PDE)

Data that do not meet performance or acceptable criteria are re-evaluated to correct any problems or investigated further to determine the reason behind the results.

Field Sampling

All field crew leaders were recently trained in MBSS Spring Sampling protocols prior to the start of field sampling. In addition, benthic macroinvertebrate sampling was conducted only by crew members certified in MBSS benthic macroinvertebrate sampling (Megan Crunkleton and Susanna Brellis).

All subjective scoring of physical habitat parameters was completed with the input of all team members at the sampling site to reduce individual sampler bias. To ensure consistency with MBSS protocols, a representative from DNR conducted a field audit. The results of the field audit are included as an addendum to this Appendix.

Field water quality measurements were collected *in situ* at all monitoring sites according to methods in the County QAPP. All *in situ* parameters were measured with an YSI Professional Plus series multiprobe except turbidity which was measured with a Hach 2100 Turbidimeter. Water quality equipment was regularly inspected, maintained and calibrated to ensure proper usage and accuracy of the readings. Calibration logs were kept by field crew leaders and checked by the project manager regularly.

Sample buckets contained both internal and external labels. All chain-of-custody procedures were followed for transfer of the samples between the field and the identification lab.

Replicate (duplicate) samples were taken at ten percent of the overall sites (four sites), one within each sampling unit. QC samples were collected just upstream of the original sampling location to determine the consistency and repeatability of the sampling procedures and the intra-team adherence to those protocols. The QC site was field-selected rather than randomly selected to ensure that the QC sites maintained similar habitat conditions to the original site, and no additional stressors or unusual conditions were present that may affect the biota. Duplicate samples included collection and analysis of the benthic macroinvertebrate

community, completion of the RBP and the PHI habitat assessments, and measurement of *in situ* water chemistry. Photographs were also taken at duplicate sites. Duplicate samples were collected at one site for each of the four primary sampling units (PSUs) sampled in 2012.

Precision

Performance characteristics calculated for the consistency of field sampling and overall site assessments using intra-team site duplication were:

- Relative Percent Difference (RPD)
- Root Mean Square Error (RMSE)
- Coefficient of Variability (CV)

Acceptable measurement quality objectives are listed in Table 1. DNR's MBSS protocols were used for the collection and analysis of macroinvertebrate data.

Table 1 – Measurement quality objectives for metric and index scores

Attribute	MQO[1]		
	Median RPD	RMSE	CV
Total Number of Taxa	20	4.3	20
Number of EPT Taxa	30	1.7	50
Number of Ephemeroptera Taxa	30	2.8	100
Percent Intolerant Urban	80	15.9	80
Percent Ephemeroptera	30	0.5	100
Number of Scraper Taxa	30	0.9	100
Percent Climber	30	6.9	70
B-IBI	20	0.6	22

[1]Values derived from Hill and Pieper, 2011

Results of performance characteristics using individual metric values are presented in Table 2. Results are shown for sites where a duplicate sample (i.e., sample pair) was collected and analyzed.

Both metric values and index scores were compared to MQOs to determine exceedances. Three metrics, EPT Taxa, Scraper Taxa, and Percent Climbers, exceeded the MQO for mRPD. The high RPD value for EPT Taxa and Scraper Taxa was due to relatively few EPT and scraper taxa present in the samples which tend to skew RPD values upward when comparing small values as compared to large values. The high mRPD for Percent Climbers was likely due to the variability within this metric between sites sampled in which values range from 0.0 percent to 40.2 percent for the sites analyzed for QC. In addition to exceeding the MQO for mRPD, the EPT Taxa and Percent Climbers metrics also exceeded the MQO for CV; which is also due to the comparison of small values and a wide range of percentages between sites. Two additional metrics, Percent Ephemeroptera and Ephemeroptera Taxa, exceeded the MQO for CV, but passed for mRPD and RMSE. This was primarily due to a single outlier sample (R2-24-08), which had one Ephemeroptera taxa present while all other samples did not contain Ephemeroptera. EPT Taxa also exceeded the MQO for CV, which is again attributed to the comparison of small values. All other values were within acceptable ranges.

Table 2 – Individual Metric Values and Related Measures of Precision. Bold values exceed MQOs.

Site	Total Taxa	EPT Taxa	% Ephem	Ephem Taxa	% Intol Urban	Scraper Taxa	% Climbers	BIBI	Rating
R2-01-09	18	0	0.0	0	3.6	2	15.5	2.43	Poor
R2-01-09 QC	18	1	0.0	0	2.8	2	9.3	2.43	Poor
R2-03-02	21	3	0.0	0	1.9	2	1.9	2.43	Poor
R2-03-02 QC	20	4	0.0	0	1.8	2	0.0	2.14	Poor
R2-13-04	19	2	0.0	0	8.9	1	21.4	2.43	Poor
R2-13-04 QC	14	1	0.0	0	3.5	0	21.9	1.86	Very Poor
R2-24-08	15	4	0.9	1	4.7	1	40.2	3.00	Fair
R2-24-08 QC	11	0	0.0	0	4.5	0	22.3	1.57	Very Poor
Median RPD	17.6	**133.3**	0.0	0.0	15.2	**100.0**	**53.6**	19.6	-
RMSE	1.7	**2.1**	0.5	0.6	3.0	0.0	**9.2**	0.2	-
CV	9.9	**111.4**	**480.7**	**480.7**	76.8	0.0	55.4	9.6	-

Laboratory Sorting and Subsampling

Bias

All sorting was completed following the SOPs described in the QAPP. For these samples, approximately 13 percent (eight samples) underwent quality control procedures for sorting, above the ten percent requirement. Average percent sorting efficiency was 95.5% (n=8). All samples sorted by laboratory personnel in training (i.e., not consistently achieving >90% sorting efficiency) were checked, while ten percent of samples sorted by experienced laboratory personnel were also checked. When a failed sample was recorded, additional samples, sorted before and/or after the randomly selected failing sample by the same technician, were selected in descending/ascending order to be QC'd until a passing sample was found in either direction. Additionally, trained sorters found to have failed sort QC, were placed back on tray checks until they could produce five consecutive passing squares. This procedure ensures that all sorted samples either initially exceed the MQO of >90% for PSE, or will exceed the MQO following QC checks by experienced sorters.

Taxonomic Identification and Enumeration

Four samples (R2-01-03, R2-01-04, R2-03-04, and R2-24-08QC) were randomly selected for QC identification and enumeration by an independent lab. Original identification was completed by Environmental Services and Consulting, LLC[1] (ESC). Re-identification of the randomly selected sites was done by Aquatic Resources Center[2]. Each sample was identified to the genus level where possible. Individuals that were not able to be identified to genus level were identified to the lowest possible level, usually family, but in some cases order. For Chironomidae, individuals not identifiable to genus may have been identified to subfamily or tribe level.

[1] Address: 101 Professional Park Drive, STE 303, Blacksburg, VA
[2] Address: 545 Cathy Jo Circle, Nashville, TN

Precision

Measures of precision were calculated for the identification consistency for the samples selected at random. These include percent difference in enumeration (PDE) and percent taxonomic disagreement (PTD).

The PDE compares the final specimen counts between the two taxonomy labs, whereas PTD compares the number of agreements in final specimen identifications between the two taxonomic labs. To meet required MQOs set by the QAPP, the PDE for each sample must be equal to or less than 5%, and the PTD must be equal to or less than 15%. Results for the taxonomic comparison and resulting values for PDE and PTD for all four samples are found in Tables 4-7. Dashes shown in the '# of agreements' column signify hierarchical disagreements.

The PDE was below the MQO value of 5% for all verification samples. Following re-identification by the secondary laboratory, the initial PTD of three samples exceeded the acceptable MQO value of 15% (17.1% for R2-01-03, 40.9% for R2-01-04, and 20.7% for R2-03-04). For sample R2-01-03, there was a minor discrepancy between laboratories concerning Orthocladiinae identifications. The second laboratory originally included 12 additional pupae counts due to a lab bench sheet data entry error. Upon review, the second laboratory verified and agreed with the original laboratory's identifications. For sample R2-03-04, there were discrepancies between laboratories concerning Haplotaxida identifications. These discrepancies were largely due to a number of Tubificidae fragments that appeared to be re-growing anterior and posterior ends. The original laboratory counted the fragments growing anterior ends as specimens while the secondary laboratory regarded these as fragments and did not include them in the sample. After discussing this discrepancy, both laboratories agreed not to count budding organisms and the original lab re-counted Tubificidae specimens. Upon closer inspection by both the secondary and primary laboratories, there were enough agreements to reduce the PTD for both samples to an acceptable value of 8.1% (R2-01-03) and 4.1% (R2-03-04), respectively.

For sample R2-01-04, there were several hierarchical disagreements between both laboratories due to the small size and damaged condition of several specimens including Ceratopogonidae, Chironomidae, Dytiscidae, and Asellidae. Although the original laboratory and secondary laboratory both reviewed this sample a second time, there were not enough agreements to reduce the PTD to meet MQO standards. Because this sample still did not pass, the sample was sent to a third laboratory (Maryland Department of Natural Resources[3]) for review of some of the major taxonomic groups (i.e., Ceratopogonidae, Chironomidae, and Dytiscidae). Results of the third party re-identification of selected specimens are presented in Table 5. The final PTD value for this sample, after the third-party review, is 33.9%; which does not pass MQO standards. Some of the discrepancies that could not be resolved include: Ceratopogonidae vs. *Bezzia*/*Palpomyia* and *Culicoides*; *Chaetocladius* vs. *Hydrobaenus*; and, Dytiscidae vs. *Agabus*, Hydroporinae, and *Neoporus*. While this site did not meet the MQO for PTD, the overall average PTD for the year was less than 15%.

[3] Address: Tawes State Office Building C2, 580 Taylor Avenue, Annapolis, MD

Summary

A summary of QC results for this sampling period, as compared to established MQOs, for each activity in the biological sampling process is displayed below in Table 3. Results indicate that all MQOs were met during the 2012 sampling period, and subsequently, all data are of acceptable quality as specified by the QAPP. Results of field audits by both DNR and the County (attached) indicate adherence to the sampling and assessment protocols.

Table 3. Summary comparison of QC results and measurement quality objectives[1].

Activity	Performance Indicator	Measure	MQO	2012 Results
Field Sampling	Precision	mRPD (BIBI)	<20	19.6
		RMSE (BIBI)	<0.6	0.2
Laboratory Sorting/Subsampling	Bias	PSE	>90	95.5
Taxonomic Identification	Precision	PDE	<5	2.0
		PTD	<15	14.5
Site Assessment	Sensitivity	90% CI (BIBI)	≤0.96	0.36

[1] MQOs are derived from Hill and Pieper, 2011

Table 4 - Taxonomic Identification and Enumeration Results: R2-01-03

Order	Family	Tribe	Sample ID	R2-01-03 Taxonomist 1	R2-01-03 Taxonomist 2	R2-01-03 # of agreements
Diptera	Chironomidae	-	Chironomidae	4	0	0
	Chironomidae	-	Cricotopus/Orthocladius	16	48	47
	Chironomidae	-	Orthocladius	31	0	0
	Chironomidae	-	Eukiefferiella	2	2	2
	Chironomidae	-	Hydrobaenus	5	3	3
	Chironomidae	-	Orthocladiinae	5	1	1
	Chironomidae	-	Parakiefferiella	1	0	0
	Chironomidae	-	Rheocricotopus	1	1	1
	Chironomidae	-	Thienemannimyia group	4	4	4
	Chironomidae	-	Tvetenia	1	1	1
	Chironomidae	Chironomini	Polypedilum	10	9	9
	Chironomidae	Diamesini	Diamesa	1	2	1
	Chironomidae	Diamesini	Potthastia	1	1	1
	Chironomidae	Tanytarsini	Micropsectra	0	1	0
	Chironomidae	Tanytarsini	Rheotanytarsus	1	2	1
	Chironomidae	Tanytarsini	Tanytarsini	1	0	0
	Chironomidae	Tanytarsini	Tanytarsus	1	1	1
	Empididae	-	Empididae	1	0	0
	Empididae	-	Neoplasta	0	1	0
	Simuliidae	-	Simuliidae	2	0	0
	Simuliidae	Simuliini	Simulium	2	4	2
Amphipoda	not identified	-	Amphipoda	1	0	0
	Crangonyctidae	-	Synurella	0	1	0
Coleoptera	Elmidae	-	Ancyronyx	1	1	1
	Elmidae	-	Macronychus	1	1	1
	Elmidae	-	Stenelmis	7	7	7
Ephemeroptera	Baetidae	-	Plauditus/Heterocloeon	0	1	-
	Baetidae		Plauditus	1	0	1
Haplotaxida	Naididae	-	Naididae	5	0	5

Order	Family	Tribe	Sample ID	R2-01-03 Taxonomist 1	Taxonomist 2	# of agreements
	Naididae	-	Nais	0	5	-
Lepidoptera	Noctuidae	-	Noctuidae	1	1	1
Odonata	Aeshnidae	-	Boyeria	1	1	1
	Calopterygidae	-	Calopteryx	2	2	2
Trichoptera	Hydropsychidae	-	Cheumatopsyche	9	10	9
	Hydropsychidae	-	Hydropsychidae	1	0	0
			Total	120	111	102
			PDE			3.90
			PTD			8.11

Table 5 - Taxonomic Identification and Enumeration Results: R2-01-04

Order	Family	Tribe	Sample ID	R2-01-04 Taxonomist 1	Taxonomist 2	# of agreements	Taxonomist 3[1]
Diptera	Ceratopogonidae	-	Ceratopogonidae	4	0	-	0
	Ceratopogonidae	-	Bezzia/Palpomyia	0	1	0	1
	Ceratopogonidae	-	Culicoides	0	3	0	3
	Chironomidae	-	Chironomidae	4	0	-	3
	Chironomidae	-	Chaetocladius	0	13	0	9
	Chironomidae	Chironomini	Chironomini	0	2	-	0
	Chironomidae	Chironomini	Chironomus	1	1	1	1
	Chironomidae	-	Cricotopus/Orthocladius	6	6	6	5
	Chironomidae	Chironomini	Cryptochironomus	1	1	1	1
	Chironomidae	-	Diplocladius	2	2	2	1
	Chironomidae	-	Hydrobaenus	13	0	0	0
	Chironomidae	-	Limnophyes	1	1	1	1
	Chironomidae	Chironomini	Microtendipes	0	1	0	1
	Chironomidae	Natarsiini	Natarsia	1	1	1	1
	Chironomidae	-	Orthocladiinae	2	3	2	6

Order	Family	Tribe	Sample ID	R2-01-04 Taxonomist 1	R2-01-04 Taxonomist 2	R2-01-04 # of agreements	R2-01-04 Taxonomist 3[1]
	Chironomidae	-	Paraphaenocladius	0	1	0	0
	Chironomidae	-	Rheocricotopus	1	1	1	1
	Chironomidae	Tanytarsini	Sublettea	0	1	0	1
	Chironomidae	Tanytarsini	Tanytarsus	1	0	0	
	Chironomidae	-	Thienemannimyia group	3	3	3	3
	Culicidae	-	Culicidae	2	0	0	
	Culicidae	Culicini	Aedes	3	5	3	
	Tipulidae	-	Tipulidae	1	0	-	
	Tipulidae	-	Pseudolimnophila	0	1	-	
Amphipoda	not identified	-	Amphipoda	1	0	-	
	Crangonyctidae	-	Crangonyctidae	1	2	1	
Coleoptera	Dytiscidae	-	Dytiscidae	3	0	-	3
	Dytiscidae	-	Agabus	0	3	0	1
	Dytiscidae	-	Hydroporinae	2	1	1	0
	Dytiscidae	-	Neoporus	0	1	0	1
Haplotaxida	Naididae	-	Naididae	1	0	1	
	Naididae	-	Slavina	0	1	-	
	Tubificidae	-	Tubificidae	9	0	9	
	Tubificidae	-	Bothrioneurum	0	1	-	
	Tubificidae	-	Limnodrilus	0	6	-	
	Tubificidae	-	Spirosperma	0	1	-	
	Tubificidae	-	Tubificinae	0	1	-	
Isopoda	Asellidae	-	Asellidae	7	0	-	
	Asellidae	-	Caecidotea	33	41	33	
Trichoptera	Limnephilidae	-	Limnephilidae	1	1	1	
Veneroida	Pisidiidae	-	Pisidium	9	9	9	
			Total	113	115	82	
			PDE			0.88	
			PTD			33.91	

[1]Only specimens in the Ceratopogonidae, Chironomidae, and Dytiscidae families were re-identified by the third laboratory

Table 6 - Taxonomic Identification and Enumeration Results: R2-03-04

Order	Family	Tribe	Sample ID	R2-03-04 Taxonomist 1	R2-03-04 Taxonomist 2	R2-03-04 # of agreements
Diptera	Cecidomyiidae	-	Cecidomyiidae	0	1	0
	Ceratopogonidae	-	Dasyhelea	0	1	0
	Chironomidae	-	Chironomidae	3	0	0
	Chironomidae	-	Cricotopus/Orthocladius	10	9	8
	Chironomidae	-	Orthocladius	3	0	0
	Chironomidae	-	Orthocladiinae	1	1	1
	Tipulidae	-	Dicranota	1	0	0
	Tipulidae	-	Limonia	0	1	0
Basommatophora	Lymnaeidae	-	Stagnicola	2	2	2
	Physidae	-	Physa	4	5	4
Coleoptera	Hydrophilidae	-	Enochrus	1	1	1
Haplotaxida	Lumbricidae	-	Lumbricidae	0	1	0
	Naididae	-	Naididae	43	0	43
	Naididae	-	Nais	0	43	-
	not identified	-	Tubificina	1	0	0
	Tubificidae	-	Tubificidae	82	0	80
	Tubificidae	-	Bothrioneurum	0	16	-
	Tubificidae	-	Limnodrilus	0	19	-
	Tubificidae	-	Quistadrilus	0	1	-
	Tubificidae	-	Tubifex	0	4	-
	Tubificidae	-	Tubificinae	0	33	-
	Tubificidae	-	Tubificinae	0	7	-
Lumbricina	not identified	-	Lumbricina	1	0	0
			Total	152	145	139
			PDE			2.36
			PTD			4.14

Table 7 - Taxonomic Identification and Enumeration Results: R2-24-08QC

Order	Family	Tribe	Sample ID	R2-24-08QC Taxonomist 1	R2-24-08QC Taxonomist 2	R2-24-08QC # of agreements
Diptera	Ceratopogonidae	-	Bezzia/Palpomyia	0	1	0
	Ceratopogonidae	-	Probezzia	1	0	0
	Chironomidae	-	Chironomidae	1	0	0
	Chironomidae	-	Cricotopus/Orthocladius	17	41	41
	Chironomidae	-	Orthocladius	24	0	-
	Chironomidae	-	Parametriocnemus	4	4	4
	Chironomidae	Chironomini	Chironomini	1	0	0
	Chironomidae	Chironomini	Polypedilum	28	29	28
	Chironomidae	Pentaneurini	Zavrelimyia	2	2	2
	Chironomidae	Tanytarsini	Paratanytarsus	0	1	0
	Chironomidae	Tanytarsini	Tanytarsini	1	0	0
	Dixidae	-	Dixa	1	1	1
	Simuliidae	Simuliini	Simulium	1	1	1
	Tipulidae	-	Dicranota	4	4	4
Amphipoda	not identified	-	Amphipoda	11	0	0
	Gammaridae	-	Gammarus	9	20	9
Haplotaxida	Tubificidae	-	Tubificidae	15	0	14
	Tubificidae	-	Tubificinae	0	11	-
	Tubificidae	-	Aulodrilus	0	1	-
	Tubificidae	-	Limnodrilus	0	2	-
Lumbriculida	Lumbriculidae	-	Lumbriculidae	1	1	1
			Total	121	119	105
			PDE			0.83
			PTD			11.76

References

Hill, C.R., and M. J. Pieper. 2011. Documentation of Method Performance Characteristics for the Anne Arundel County Biological Monitoring Program. Revised, June 2010. Prepared by KCI Technologies, Sparks, MD for Anne Arundel County, Department of Public Works, Watershed, Ecosystem, and Restoration Services. Annapolis, MD.

Quality Control Field Audit of KCI Technologies, Inc., Performance in the Geomorphological Assessment Work as part of the Countywide Biological Monitoring Program

Prepared by: Christopher Victoria, DPW, WERS

Date: 27 March 2012

On 27 March 2012, I evaluated the field activities of KCI Technologies, Inc., (KCI) personnel as they collected the required geomorphological data as part of Year Four of Round Two of the Countywide Biological Monitoring Program. Work at one site (R2-01-01) was evaluated. This short report describes my findings.

OFFICE WORK. The drainage area was determined before going to the field. The crew had the information with them in the field and used it to assist in their determination of the bankfull indicator. The survey instrument was a self-leveling laser level type instrument, owned by KCI, which had been calibrated recently. A minor technique issue was observed in that a rod level was not used to ensure the survey rod was held plumb and square to the instrument during measurements, but was not thought to significantly compromise the data. The matter was not discussed with the crew.

The field supervisor had Level II training while one crew member had Level I training. The third crew members did not have formal Rosgen assessment method training, but was experienced in performing a variety of habitat assessment methodologies and had performed survey work on streams in the performance of other projects.

REACH RECONNAISSANCE. At the site, the cross section was co-located with the bioassessment reach and was correctly placed in the approximate midpoint of the reach. The bioassessment reach showed a high level of disturbance likely due to the high level of development upstream. The channel was entrenched, making the bankfull call somewhat challenging.

CROSS SECTION MEASUREMENT. The zero point was set on the left bank / down stream. The survey instrument was properly set up. Monuments were properly installed and marked. A GPS was taken and the location was properly characterized within the limits of the digital datasheet format. Adequate photos were taken at the cross section. All necessary measurements were made on the cross section, although there was no strong bankfull indicator in the cross section itself. Data were properly recorded on the appropriate data sheets. Floodprone width calculations were made in the field using survey data collected by the Trimble unit operated by the field supervisor.

PEBBLE COUNT. A full pebble count was performed. The transects were properly distributed by feature prevalence in the reach, which was determined by the field

supervisor using best professional judgment. Particles, when found, were properly measured along the intermediate axis. Particle selection was properly distributed along all transects. Data were properly recorded on the data sheet.

REACH SLOPE MEASUREMENT. The measurement was collected over the entire reach. The survey instrument was set up properly. A feature-to-feature measurement was made. All required features (i.e.—bankfull, water surface, thalweg, etc.) were surveyed.

OVERALL COMMENTS. The geomorphic data collection activities are being properly executed according to published SOPs and should result in the collection of satisfactory data.

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Maryland Biological Stream Survey
TRAINING AND CERTIFICATION CHECK LIST

BENTHIC MACROINVERTEBRATE SAMPLING

Applicant Name: Megan Crunkleton

Name of DNR staff Person(s) Completing Form: Dan Boward

Element Evaluated	Pass	Fail	Comments	DNR Initials
Attended indoor (Power Point) benthic macroinvertebrate sampling portion of training Training site: Baltimore County Agriculture Center Training date: February 22, 2012	✓			DB
Attended field portion of benthic macroinvertebrate sampling training Training site: Baltimore County Agriculture Center Training date: February 22, 2012	✓			DB
Completed written benthic macroinvertebrate sampling test Training site: Baltimore County Agriculture Center Training date: February 22, 2012 Score = 100% (90% reqd.)	✓			DB
Completed field audit DNR auditor: Dan Boward Audit site: Church Creek UT Audit date: March 5, 2012	✓			DB
DNR duplicate sample lab analysis DNR lab manager: Ellen Friedman Lab work completed: March 6, 2012	✓		Applicant BIBI: 1.6 Auditor BIBI: 1.6	DB

Certification Results

The Applicant HAS / HAS NOT (circle one) successfully met all requirements for MBSS Benthic Macroinvertebrate Sampling Certification

Daniel V Boward — **Signature of DNR Staff Person**

April 19, 2012 — **Date**

Applicant DOES / DOES NOT want his/her name listed on DNR's Certification Registry website

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Maryland Biological Stream Survey
TRAINING AND CERTIFICATION CHECK LIST

BENTHIC MACROINVERTEBRATE SAMPLING

Applicant Name: Susanna Breillis

Name of DNR staff Person(s) Completing Form: Dan Boward

Element Evaluated	Pass	Fail	Comments	DNR Initials
Attended indoor (Power Point) benthic macroinvertebrate sampling portion of training Training site: Baltimore County Agriculture Center Training date: February 22, 2012	✓			DB
Attended field portion of benthic macroinvertebrate sampling training Training site: Baltimore County Agriculture Center Training date: February 22, 2012	✓			DB
Completed written benthic macroinvertebrate sampling test Training site: Baltimore County Agriculture Center Training date: February 22, 2012 Score = 95% (90% reqd.)	✓			DB
Completed field audit DNR auditor: Dan Boward Audit site: Church Creek Audit date: March 5, 2012	✓			DB
DNR duplicate sample lab analysis DNR lab manager: Ellen Friedman Lab work completed: March 6, 2012	✓		Applicant BIBI: 2.4 Auditor BIBI: 2.1	DB

Certification Results

The Applicant HAS / HAS NOT (circle one) successfully met all requirements for MBSS Benthic Macroinvertebrate Sampling Certification

Daniel Boward
Signature of DNR Staff Person

April 18, 2012
Date

Applicant DOES / DOES NOT want his/her name listed on DNR's Certification Registry website

Appendix C: Master Taxa List

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	% of total number of organisms	% of sites
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3	10.95	80.00
Amphipoda	not identified	not identified	Amphipoda	0	sp	6.0	6.90	55.00
Tubificida	Tubificidae	not identified	Tubificidae	Collector	cn	8.4	6.79	72.50
Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	Shredder	0	7.7	6.74	95.00
Diptera	Chironomidae	Orthocladius	Orthocladius	Collector	sp, bu	9.2	6.41	85.00
Haplotaxida	Naididae	not identified	Naididae	Collector	bu	8.5	5.97	47.50
Amphipoda	Gammaridae	Gammarus	Gammarus	Shredder	sp	6.7	5.71	35.00
Diptera	Chironomidae	not identified	Orthocladiinae	Collector	0	7.6	4.68	87.50
Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	Collector	sp	6.1	4.59	40.00
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6	2.78	37.50
Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	Collector	sp	6.2	2.55	57.50
Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	Scraper	sp	7.2	2.20	57.50
Plecoptera	Nemouridae	Amphinemura	Amphinemura	Shredder	sp, cn	3.0	1.87	32.50
Diptera	Chironomidae	Chironomini	Chironomini	0	0	5.9	1.75	55.00
Isopoda	Asellidae	not identified	Asellidae	0	0	3.3	1.68	30.00
Diptera	Chironomidae	Tvetenia	Tvetenia	Collector	sp	5.1	1.52	27.50
Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	Filterer	cn	6.5	1.50	30.00
Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	Collector	sp	4.6	1.50	55.00
Coleoptera	Elmidae	Stenelmis	Stenelmis	Scraper	cn	7.1	1.36	17.50
Diptera	Simuliidae	Simulium	Simulium	Filterer	cn	5.7	1.26	37.50
Diptera	Chironomidae	Chironomus	Chironomus	Collector	bu	4.6	1.03	32.50
Diptera	Chironomidae	not identified	Chironomidae	0	0	6.6	0.98	62.50
Diptera	Simuliidae	Stegopterna	Stegopterna	Filterer	cn	2.4	0.87	25.00
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7.0	0.84	20.00
Diptera	Chironomidae	Cricotopus	Cricotopus	Shredder	cn, bu	9.6	0.82	15.00
Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia group	Predator	sp	8.2	0.82	50.00
Coleoptera	Dytiscidae	not identified	Dytiscidae	Predator	sw, dv	5.4	0.77	30.00
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7	0.75	17.50
Diptera	Chironomidae	not identified	Tanytarsini	Collector	0	3.5	0.75	30.00
Diptera	Chironomidae	Tanytarsus	Tanytarsus	Filterer	cb, cn	4.9	0.58	20.00
Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	Predator	sp	5.3	0.58	22.50
Diptera	Chironomidae	Potthastia	Potthastia	Collector	sp	0.0	0.56	20.00
Diptera	Chironomidae	Thienemanniella	Thienemanniella	Collector	sp	5.1	0.54	35.00
Diptera	Tipulidae	Tipula	Tipula	Shredder	bu	6.7	0.51	20.00
Diptera	Tipulidae	Dicranota	Dicranota	Predator	sp, bu	1.1	0.49	15.00
Diptera	Simuliidae	not identified	Simuliidae	Filterer	cn	3.2	0.49	30.00
Diptera	Chironomidae	Micropsectra	Micropsectra	Collector	cb, sp	2.1	0.47	15.00
Diptera	Chironomidae	not identified	Chironominae	Collector	0	6.6	0.44	20.00
Amphipoda	Crangonyctidae	not identified	Crangonyctidae	Collector	sp	6.5	0.37	15.00
Plecoptera	not identified	not identified	Plecoptera	0	0	2.4	0.35	17.50
not identified	not identified	not identified	Bivalvia	0	0	na	0.33	10.00
Coleoptera	Dytiscidae	Neoporus	Neoporus	Predator	0	na	0.33	12.50
Coleoptera	Elmidae	Ancyronyx	Ancyronyx	Scraper	cn, sp	7.8	0.28	17.50
Odonata	Calopterygidae	Calopteryx	Calopteryx	Predator	cb	8.3	0.28	25.00
Trichoptera	Limnephilidae	Ironoquia	Ironoquia	Shredder	sp	4.9	0.28	15.00
Ephemeroptera	Caenidae	Caenis	Caenis	Collector	sp	2.1	0.23	10.00
Diptera	Chironomidae	Diplocladius	Diplocladius	Collector	sp	5.9	0.23	20.00
Coleoptera	Elmidae	not identified	Elmidae	Collector	cn	4.8	0.21	5.00
Trichoptera	Hydropsychidae	not identified	Hydropsychidae	Filterer	cn	5.7	0.19	17.50
Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	Filterer	cn	7.2	0.19	12.50
Hemiptera	Saldidae	not identified	Saldidae	Predator	0	6.0	0.19	15.00
Diptera	Chironomidae	Tanypodinae	Tanypodinae	Predator	0	7.5	0.19	15.00
Diptera	Ceratopogonidae	not identified	Ceratopogonidae	Predator	sp, bu	3.6	0.16	10.00
Diptera	Chironomidae	Conchapelopia	Conchapelopia	Predator	sp	6.1	0.16	12.50
Trichoptera	Uenoidae	Neophylax	Neophylax	Scraper	cn	2.7	0.16	7.50
Ephemeroptera	Baetidae	not identified	Baetidae	Collector	sw, cn	2.3	0.14	7.50
Diptera	Chironomidae	Brillia	Brillia	Shredder	bu, sp	7.4	0.14	12.50
Diptera	Chironomidae	Diamesa	Diamesa	Collector	sp	8.5	0.14	7.50
Diptera	Chironomidae	Limnophyes	Limnophyes	Collector	sp	8.6	0.14	7.50
Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	Collector	sp	7.7	0.14	7.50
Plecoptera	Perlidae	Perlesta	Perlesta	Predator	cn	1.6	0.14	2.50
Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	Filterer	cn	1.1	0.14	5.00
Haplotaxida	not identified	not identified	Tubificina	0	0	na	0.14	7.50
Coleoptera	Elmidae	Dubiraphia	Dubiraphia	Scraper	cn, cb	5.7	0.12	10.00
Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	Filterer	cn	7.5	0.12	7.50
Trichoptera	Limnephilidae	not identified	Limnephilidae	Shredder	cb, sp, cn	3.4	0.12	7.50
Lumbricina	not identified	not identified	Lumbricina	Collector	bu	na	0.12	12.50
Coleoptera	Elmidae	Oulimnius	Oulimnius	Scraper	cn	2.7	0.12	7.50
Diptera	Tipulidae	not identified	Tipulidae	Predator	bu, sp	4.8	0.12	12.50
Odonata	Coenagrionidae	not identified	Coenagrionidae	Predator	cb	9.0	0.09	7.50
Diptera	Chironomidae	Corynoneura	Corynoneura	Collector	sp	4.1	0.09	7.50
Haplotaxida	not identified	not identified	Diplectrona	0	0	na	0.09	7.50
Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	Collector	bu	9.1	0.09	10.00
Lepidoptera	not identified	not identified	Lepidoptera	0	0	6.7	0.09	10.00
Diptera	Chironomidae	Odontomesa	Odontomesa	Collector	sp	6.6	0.09	5.00
Diptera	Chironomidae	Phaenopsectra/Tribelos	Phaenopsectra/Tribelos	Collector	0	na	0.09	7.50

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	% of total number of organisms	% of sites
Diptera	Ceratopogonidae	Probezzia	Probezzia	Predator	bu	3.0	0.09	10.00
Diptera	Culicidae	Aedes	Aedes	Filterer	sw	8.0	0.07	2.50
Diptera	Ceratopogonidae	Bezzia	Bezzia	Predator	bu	3.3	0.07	2.50
Diptera	not identified	not identified	Diptera	0	0	6.0	0.07	7.50
not identified	Hirudinea	not identified	Hirudinea	Predator	sp	na	0.07	5.00
Basommatophora	Planorbidae	Menetus	Menetus	Scraper	cb	7.6	0.07	5.00
Diptera	Chironomidae	Microtendipes	Microtendipes	Filterer	cn	4.9	0.07	5.00
Diptera	Chironomidae	Stenochironomus	Stenochironomus	Shredder	bu	7.9	0.07	5.00
Trichoptera	not identified	not identified	Trichoptera	0	0	4.6	0.07	7.50
Diptera	Chironomidae	Ablabesmyia	Ablabesmyia	Predator	sp	8.1	0.05	5.00
Ephemeroptera	Ameletidae	Ameletus	Ameletus	Collector	sw, cb	2.6	0.05	5.00
Odonata	Aeshnidae	Boyeria	Boyeria	Predator	cb, sp	6.3	0.05	5.00
Diptera	Ceratopogonidae	Ceratopogon	Ceratopogon	Predator	sp, bu	2.7	0.05	5.00
Trichoptera	Philopotamidae	Chimarra	Chimarra	Filterer	cn	4.4	0.05	5.00
Odonata	Cordulegastridae	Cordulegaster	Cordulegaster	Predator	bu	2.4	0.05	2.50
Diptera	Culicidae	not identified	Culicidae	0	0	8.0	0.05	2.50
Odonata	Gomphidae	Hagenius	Hagenius	Predator	sp	2.2	0.05	5.00
Diptera	Chironomidae	Nanocladius	Nanocladius	Collector	sp	7.6	0.05	5.00
not identified	not identified	not identified	Nemata	0	0	na	0.05	5.00
Coleoptera	Elmidae	Optioservus	Optioservus	Scraper	cn	5.4	0.05	2.50
Diptera	Chironomidae	Parakiefferiella	Parakiefferiella	Collector	sp	2.1	0.05	5.00
Diptera	Chironomidae	Paratendipes	Paratendipes	Collector	bu	6.6	0.05	5.00
Basommatophora	Planorbidae	not identified	Planorbidae	Scraper	cb	7.6	0.05	5.00
Trichoptera	Phryganeidae	Ptilostomis	Ptilostomis	Shredder	cb	4.3	0.05	5.00
Diptera	Tabanidae	not identified	Tabanidae	Predator	0	2.8	0.05	5.00
Hemiptera	Corixidae	Trichocorixa	Trichocorixa	Predator	sw, cb	5.6	0.05	2.50
Coleoptera	Dytiscidae	Agabus	Agabus	Predator	sw, dv	5.4	0.02	2.50
Odonata	Gomphidae	Arigomphus	Arigomphus	Predator	bu	2.2	0.02	2.50
Hemiptera	Corixidae	not identified	Corixidae	Predator	sw	5.6	0.02	2.50
Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	Predator	sp, bu	7.6	0.02	2.50
Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	Collector	bu	9.0	0.02	2.50
Diptera	Dixidae	Dixa	Dixa	Predator	sw, cb	5.8	0.02	2.50
Trichoptera	Philopotamidae	Dolophilodes	Dolophilodes	Filterer	cn	1.7	0.02	2.50
Coleoptera	Hydrophilidae	Enochrus	Enochrus	Collector	bu, sp	4.1	0.02	2.50
Odonata	Corduliidae	Epitheca	Epitheca	Predator	0	4.0	0.02	2.50
Odonata	Gomphidae	not identified	Gomphidae	Predator	bu	2.2	0.02	2.50
Coleoptera	Dryopidae	Helichus	Helichus	Scraper	cn	6.4	0.02	2.50
Hemiptera	not identified	not identified	Hemiptera	0	0	na	0.02	2.50
Plecoptera	Perlodidae	Isoperla	Isoperla	Predator	cn, sp	2.4	0.02	2.50
Trichoptera	Lepidostomatidae	Lepidostoma	Lepidostoma	Shredder	cb, sp, cn	0.0	0.02	2.50
Trichoptera	Leptoceridae	not identified	Leptoceridae	Collector	0	4.1	0.02	2.50
Ephemeroptera	Leptophlebiidae	Leptophlebia	Leptophlebia	Collector	sw, cn, sp	1.8	0.02	2.50
Plecoptera	Leuctridae	Leuctra	Leuctra	Shredder	cn	0.4	0.02	2.50
Hemiptera	not identified	not identified	Lumbriculidae	0	0	na	0.02	2.50
Trichoptera	Psychomyiidae	Lype	Lype	Scraper	cn	4.7	0.02	2.50
Ephemeroptera	Heptageniidae	Maccaffertium	Maccaffertium	Scraper	cn	3.0	0.02	2.50
Coleoptera	Elmidae	Macronychus	Macronychus	Scraper	cn	6.8	0.02	2.50
Diptera	Chironomidae	Natarsia	Natarsia	Predator	sp	6.6	0.02	2.50
Diptera	Empididae	Neoplasta	Neoplasta	Predator	0	na	0.02	2.50
Lepidoptera	Noctuidae	not identified	Noctuidae	Shredder	bu	6.7	0.02	2.50
Odonata	not identified	not identified	Odonata	Predator	0	6.6	0.02	2.50
Decapoda	Cambaridae	Orconectes	Orconectes	Shredder	sp	2.8	0.02	2.50
Diptera	Chironomidae	Parachaetocladius	Parachaetocladius	Collector	sp	3.3	0.02	2.50
Diptera	Chironomidae	Parachironomus	Parachironomus	Predator	sp	6.6	0.02	2.50
Diptera	Chironomidae	Paracladopelma	Paracladopelma	Collector	sp	6.6	0.02	2.50
Diptera	Tipulidae	Pilaria	Pilaria	Predator	bu	4.8	0.02	2.50
Tricladida	Planariidae	not identified	Planariidae	Predator	sp	8.4	0.02	2.50
Ephemeroptera	Baetidae	Plauditus	Plauditus	0	0	na	0.02	2.50
Coleoptera	Psephenidae	Psephenus	Psephenus	Scraper	cn	4.4	0.02	2.50
Coleoptera	Ptilodactylidae	not identified	Ptilodactylidae	0	0	4.0	0.02	2.50
Trichoptera	Limnephilidae	Pycnopsyche	Pycnopsyche	Shredder	sp, cb, cn	3.1	0.02	2.50
Basommatophora	Lymnaeidae	Stagnicola	Stagnicola	Scraper	cb	7.8	0.02	2.50
Coleoptera	Staphylinidae	not identified	Staphylinidae	Predator	cn	na	0.02	2.50
Diptera	Chironomidae	Tanypus	Tanypus	Predator	0	6.6	0.02	2.50
Trichoptera	Leptoceridae	Triaenodes	Triaenodes	Shredder	sw, cb	5.0	0.02	2.50

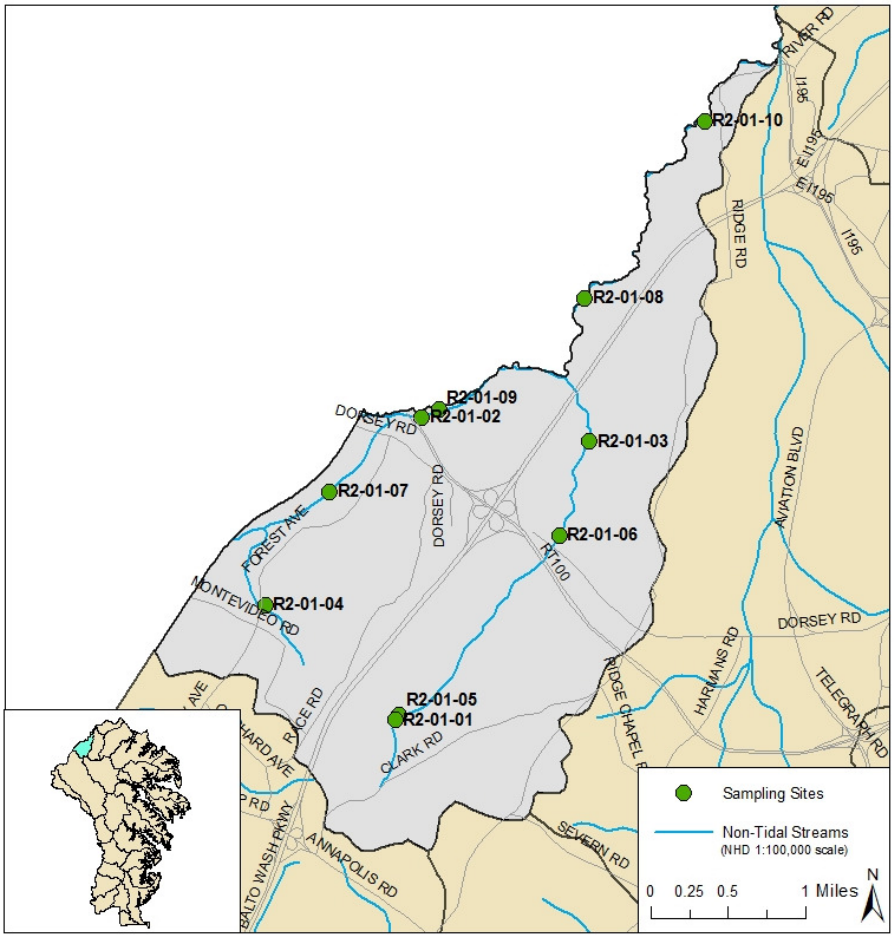
[1] Primary habit or form of locomotion includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; [2] Tolerance values based on Hilsenhoff, modified for Maryland; 0 or na indicates information for the particular taxa was not available.

Appendix D: Individual Site Summaries

Piney Run Sampling Unit

Site Condition Summary

Site	Drainage Area (acres)	Drainage Area (mi^2)	Percent Impervious	Percent Developed	Percent Forested	Percent Agriculture	Percent Open	BIBI Narrative Rating	PHI Narrative Rating	RBP Narrative Rating	Rosgen Stream Type - L1
R2-01-01	265.7	0.42	17.3	46.7	48.5	0.0	4.9	Very Poor	Partially Degraded	Partially Supporting	F
R2-01-02	4728.2	7.39	22.1	57.0	32.6	5.9	4.5	Poor	Partially Degraded	Supporting	C
R2-01-03	2200.6	3.44	24.7	43.2	43.8	0.0	13.1	Poor	Degraded	Partially Supporting	ND
R2-01-04	134.0	0.21	6.8	39.1	53.5	0.0	7.4	Poor	Degraded	Non Supporting	F
R2-01-05	542.6	0.85	13.4	30.0	56.8	0.0	13.2	Very Poor	Degraded	Partially Supporting	F
R2-01-06	1954.8	3.05	25.0	45.4	42.4	0.0	12.2	Poor	Partially Degraded	Supporting	F
R2-01-07	1361.3	2.13	15.1	44.0	51.8	0.1	4.1	Fair	Minimally Degraded	Comparable to Reference	G
R2-01-08	11784.3	18.41	24.1	55.8	32.9	2.8	8.5	Fair	Severely Degraded	Partially Supporting	ND
R2-01-09	4741.5	7.41	22.0	56.9	32.8	5.9	4.5	Poor	Degraded	Partially Supporting	C
R2-01-10	12680.9	19.81	23.0	54.7	34.7	2.7	8.0	Good	Severely Degraded	Partially Supporting	C



R2-01-01 Piney Run Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.1507082431 **Longitude:** -76.7425391632

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**265.73**
Cover	**Acres**	**% Area**
Developed Land	**123.95**	**46.65**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	25.31	9.52
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	83.85	31.56
Residential 2-Acre	9.09	3.42
Transportation	5.7	2.15
Utility	0	0
Forest Land	**128.74**	**48.45**
Forested Wetland	0	0
Residential Woods	0	0
Woods	128.74	48.45
Open Land	**13.03**	**4.9**
Open Space	13.03	4.9
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	46	17.3

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Midges, including Eukiefferiella and Orthocladiinae, dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Sub-optimal instream habitat and epibenthic substrate with abundant woody debris. Moderately stable banks with good riparian width.
- Bimodal distribution of substrate (gravel/sand).

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.
- Because habitat is partially supporting and biological condition is very poor, look for problems with water quality and correct, if possible.
- Consider trash cleanup for this reach.

R2-01-01 Piney Run Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	8
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	0
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	6

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	3
BIBI Score	**1.57**
BIBI Narrative Rating	**Very Poor**

Taxa	**Count**
Ancyronyx	2
Chironomidae	1
Chironomini	3
Cricotopus/Orthocladius	5
Eukiefferiella	74
Orthocladiinae	14
Orthocladius	6
Polypedilum	7
Thienemannimyia group	1
Tubificidae	1
Tvetenia	2
TOTAL:	**116**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	4	Pool Variability	10
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	19	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	10	Sediment Deposition	7
Channel Sinuosity	12	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	10		
RBP Habitat Score			**117**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	11	59.24	Instream Wood Debris	11	91.05
Shading	90	91.34	Instream Habitat	11	84.59
Epifaunal Substrate	11	83.75	Bank Stability	8	63.25
PHI Score					**78.87**
PHI Narrative Rating					**Partially Degraded**

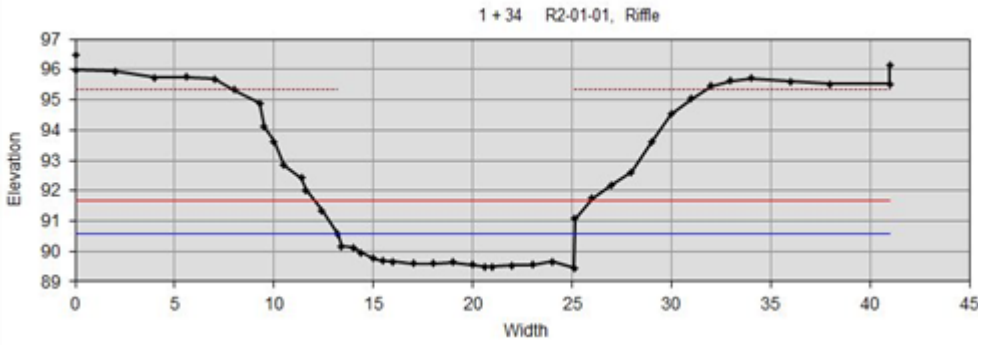
Water Chemistry

Dissolved Oxygen (mg/L)	10.78	pH (SU)	7.25
Turbidity (NTU)	11.5	Specific Conductivity (µS/cm)	697.7
Temperature (°C)	8.7		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.42	Cross Sectional Area (ft^2)	10.9
Bankfull Width (ft)	11.9	Water Surface Slope (%)	0.8
Mean Bankfull Depth (ft)	0.91	Sinuosity	1.3
Floodprone Width (ft)	13.9	D50 (mm)	10
Entrenchment Ratio	1.2	Adjustments?	None
Width to Depth Ratio	13.1	**Rosgen Stream Type**	**F4/5**



R2-01-02 Piney Run Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.1790027415 **Longitude:** -76.7392946785

Land Use/Land Cover Analysis:

*For individual land cover categories only Anne Arundel County land use data is presented below; however, total acreage and percent area land cover values (listed in bold) and impervious land include both Anne Arundel County and Howard County data.

Total Drainage Area (acres)		**4728.18**
Cover	**Acres**	**% Area**
Developed Land	**2686.33**	**56.97**
Airport	0	0
Commercial	9.37	0.2
Industrial	22.89	0.49
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	31.59	0.67
Residential 1-Acre	84.63	1.79
Residential 2-Acre	239.6	5.08
Transportation	46.9	0.99
Utility	0	0
Forest Land	**1538.41**	**32.63**
Forested Wetland	0	0
Residential Woods	0	0
Woods	638.54	13.54
Open Land	**210.6**	**4.47**
Open Space	46.04	0.98
Open Wetland	0	0
Water	0.24	0.01
Agricultural Land	**279.66**	**5.93**
Pasture/Hay	1.77	0.04
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	1042.8	22.1

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Midges, including Cricotopus/Orthocladius and Polypedilum, dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Good velocity/depth diversity and mix of habitats. Abundance of woody debris. Good riparian width but refuse present in moderate amounts.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is supporting and biological condition is poor, look for problems with water quality and correct, if possible.
- Consider trash cleanup for this reach.

R2-01-02 Piney Run Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	20
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	3.6
%Ephemeroptera	0
Scraper Taxa	4
% Climbers	18.9

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	5
% Climbers	5
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Cheumatopsyche	1
Chironomidae	1
Chironomini	1
Cricotopus	5
Cricotopus/Orthocladius	19
Diamesa	1
Dubiraphia	1
Eukiefferiella	1
Hagenius	1
Hydrobaenus	1
Naididae	1
Orthocladiinae	3
Orthocladius	33
Oulimnius	1
Parametriocnemus	1
Polypedilum	16
Potthastia	2
Rheocricotopus	6
Rheotanytarsus	1
Simuliidae	1
Simulium	3
Stenelmis	2
Tanytarsini	2
Tanytarsus	4
Tipula	1
Trichoptera	1
Tvetenia	1
TOTAL:	**111**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	7	Pool Variability	14
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	13	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	14	Sediment Deposition	12
Channel Sinuosity	12	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	14	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	13		
RBP Habitat Score			**136**
RBP Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	7	37.7	Instream Wood Debris	18	79.17
Shading	50	49.95	Instream Habitat	14	71.77
Epifaunal Substrate	14	82.42	Bank Stability	14	83.67
PHI Score					**67.45**
PHI Narrative Rating					**Partially Degraded**

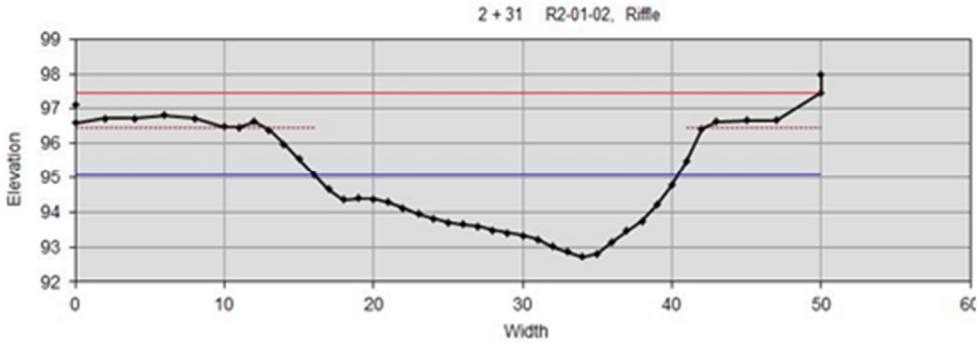
Water Chemistry

Dissolved Oxygen (mg/L)	10.86	pH (SU)	7.72
Turbidity (NTU)	3.06	Specific Conductivity (µS/cm)	473.9
Temperature (°C)	17.3		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	7.39	Cross Sectional Area (ft^2)	32.4
Bankfull Width (ft)	24.4	Water Surface Slope (%)	0.43
Mean Bankfull Depth (ft)	1.32	Sinuosity	1.2
Floodprone Width (ft)	133	D50 (mm)	20
Entrenchment Ratio	5.4	Adjustments?	None
Width to Depth Ratio	18.4	**Rosgen Stream Type**	**C4**



R2-01-03 Piney Run Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.1766954883 **Longitude:** -76.7191840218

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**2200.58**
Cover	**Acres**	**% Area**
Developed Land	**949.88**	**43.16**
Airport	0	0
Commercial	224.28	10.19
Industrial	59.25	2.69
Residential 1/8-acre	147.09	6.68
Residential 1/4-acre	80.69	3.67
Residential 1/2-acre	8.34	0.38
Residential 1-Acre	193.66	8.8
Residential 2-Acre	55.44	2.52
Transportation	181.12	8.23
Utility	0	0
Forest Land	**962.74**	**43.75**
Forested Wetland	0	0
Residential Woods	0	0
Woods	962.74	43.75
Open Land	**287.96**	**13.09**
Open Space	276.77	12.58
Open Wetland	0	0
Water	11.19	0.51
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	544.2	24.7

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Degraded"*
- Midges, including Cricotopus/Orthocladius and Polypedilum, dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Sub-optimal instream habitat and epibenthic substrate but with minimal instream woody debris.
- Stream type not determined due to effects from road crossing and recent bank stabilization.

Recommendations:

- Buffer enhancement.
- Consider trash cleanup for this reach.

R2-01-03 Piney Run Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	20
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	2
%Ephemeroptera	0
Scraper Taxa	4
% Climbers	10.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	5
% Climbers	5
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Amphipoda	1
Ancyronyx	1
Boyeria	1
Calopteryx	2
Cheumatopsyche	6
Chironomidae	4
Cricotopus/Orthocladius	12
Diamesa	1
Eukiefferiella	2
Hydrobaenus	4
Hydropsychidae	1
Macronychus	1
Naididae	5
Noctuidae	1
Orthocladiinae	3
Orthocladius	28
Parakiefferiella	1
Polypedilum	8
Potthastia	1
Rheocricotopus	1
Simuliidae	1
Simulium	2
Stenelmis	9
Tanytarsini	1
Thienemannimyia group	4
Tvetenia	1
TOTAL:	**102**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	7	Pool Variability	12
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	5
Channel Alteration	10	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	15	Sediment Deposition	10
Channel Sinuosity	9	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	13	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	12		
RBP Habitat Score			**120**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	5	26.93	Instream Wood Debris	5	49.37
Shading	45	45.47	Instream Habitat	13	74.05
Epifaunal Substrate	14	87.4	Bank Stability	14	83.67
PHI Score					**61.15**
PHI Narrative Rating					**Degraded**

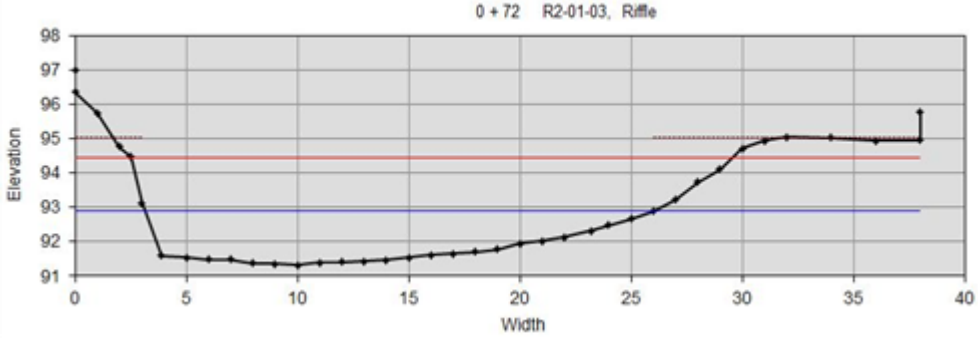
Water Chemistry

Dissolved Oxygen (mg/L)	9.73	pH (SU)	7.41
Turbidity (NTU)	6.07	Specific Conductivity (µS/cm)	428
Temperature (°C)	12		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	3.44	Cross Sectional Area (ft^2)	25.9
Bankfull Width (ft)	22.9	Water Surface Slope (%)	1.2
Mean Bankfull Depth (ft)	1.13	Sinuosity	1.1
Floodprone Width (ft)	27.1	D50 (mm)	19
Entrenchment Ratio	1.2	Adjustments?	None
Width to Depth Ratio	20.2	**Rosgen Stream Type**	**ND**



R2-01-04 Piney Run Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.1615422597 **Longitude:** -76.7580818149

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**134**
Cover	**Acres**	**% Area**
Developed Land	**52.39**	**39.1**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	3.64	2.72
Residential 2-Acre	43.72	32.62
Transportation	5.03	3.75
Utility	0	0
Forest Land	**71.69**	**53.5**
Forested Wetland	0	0
Residential Woods	0	0
Woods	71.69	53.5
Open Land	**9.93**	**7.41**
Open Space	9.93	7.41
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	9.2	6.8

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Non Supporting"* and *"Degraded"*
- Isopods (Caecidotea) and midges (Hydrobaenus) dominated the sample.
- Measured below COMAR standards for pH.
- Intermittent reach with very little flow, mostly draining wetland. Very little habitat due to lack of flow. Good bank stability.

Recommendations:

- Buffer enhancement.

R2-01-04 Piney Run Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	19
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	24.8
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	1.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	3
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	3
BIBI Score	**2.14**
BIBI Narrative Rating	**Poor**

Taxa	Count
Aedes	3
Amphipoda	2
Asellidae	10
Caecidotea	27
Ceratopogonidae	4
Chironomidae	3
Chironominae	1
Chironomus	1
Cricotopus/Orthocladius	6
Cryptochironomus	1
Culicidae	2
Diplocladius	1
Dytiscidae	5
Hydrobaenus	11
Limnephilidae	1
Naididae	1
Natarsia	1
Orthocladiinae	5
Pisidium	9
Rheocricotopus	1
Tanytarsus	1
Thienemannimyia group	3
Tipulidae	1
Tubificidae	9
TOTAL:	**109**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	8	Pool Variability	3
Bank Stability- Right Bank	9	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	12	Riparian Vegetative Zone Width- Right Bank	3
Channel Flow Status	4	Sediment Deposition	13
Channel Sinuosity	13	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	3	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	3		
RBP Habitat Score			**94**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	1	5.39	Instream Wood Debris	2	72.18
Shading	75	73.32	Instream Habitat	2	41.66
Epifaunal Substrate	3	41.73	Bank Stability	17	92.2
PHI Score					**54.41**
PHI Narrative Rating					**Degraded**

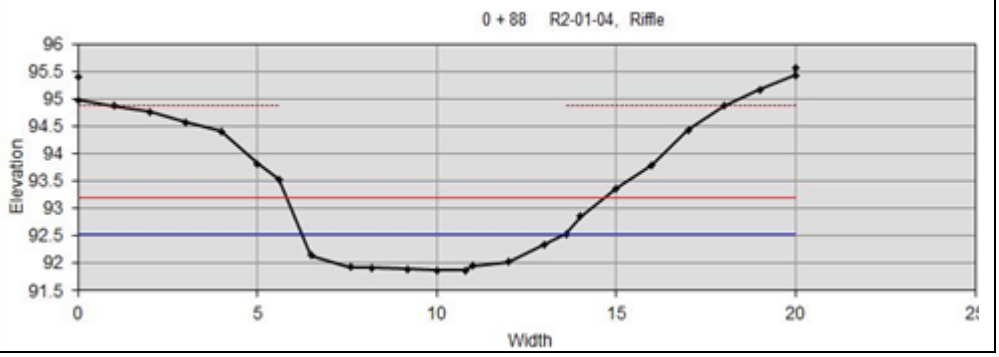
Water Chemistry

Dissolved Oxygen (mg/L)	8.09	pH (SU)	5.55
Turbidity (NTU)	19.2	Specific Conductivity (µS/cm)	98.7
Temperature (°C)	15.5		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.21	Cross Sectional Area (ft^2)	3.7
Bankfull Width (ft)	7.3	Water Surface Slope (%)	0.87
Mean Bankfull Depth (ft)	0.5	Sinuosity	1.3
Floodprone Width (ft)	8.8	D50 (mm)	0.062
Entrenchment Ratio	1.2	Adjustments?	None
Width to Depth Ratio	14.7	**Rosgen Stream Type**	**F6**



R2-01-05 Piney Run Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.1512190199 **Longitude:** -76.7421955816

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**542.62**
Cover	**Acres**	**% Area**
Developed Land	**162.55**	**29.96**
Airport	0	0
Commercial	0.16	0.03
Industrial	0.79	0.15
Residential 1/8-acre	25.31	4.66
Residential 1/4-acre	0	0
Residential 1/2-acre	0.83	0.15
Residential 1-Acre	85.2	15.7
Residential 2-Acre	19.96	3.68
Transportation	30.29	5.58
Utility	0	0
Forest Land	**308.26**	**56.81**
Forested Wetland	0	0
Residential Woods	0	0
Woods	308.26	56.81
Open Land	**71.8**	**13.23**
Open Space	71.32	13.14
Open Wetland	0	0
Water	0.48	0.09
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	72.7	13.4

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Partially Supporting"* and *"Degraded"*
- Midges, including Cricotopus/Orthocladius, Eukiefferiella, and Polypedilum, dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Channel overwidened and incised with numerous point bars. Marginal instream habitat and epibenthic substrate.

Recommendations:

- Buffer enhancement.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.
- Because habitat is partially supporting and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-01-05 Piney Run Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	11
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	5.5
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	18.3

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	5
BIBI Score	**1.86**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Brillia	1
Cheumatopsyche	9
Chironomidae	2
Cricotopus/Orthocladius	23
Eukiefferiella	29
Hydrobaenus	1
Hydropsychidae	1
Micropsectra	5
Orconectes	1
Orthocladiinae	1
Orthocladius	14
Polypedilum	15
Rheocricotopus	1
Thienemannimyia group	1
Tvetenia	5
TOTAL:	**109**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	5	Pool Variability	10
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	6
Channel Alteration	14	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	11	Sediment Deposition	8
Channel Sinuosity	11	Vegetative Protection - Left Bank	4
Epifaunal Substrate/Available Cover	9	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	10		
RBP Habitat Score			**113**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	6	32.31	Instream Wood Debris	5	65.22
Shading	65	63.55	Instream Habitat	9	66.19
Epifaunal Substrate	10	73.29	Bank Stability	13	80.63
PHI Score					**63.53**
PHI Narrative Rating					**Degraded**

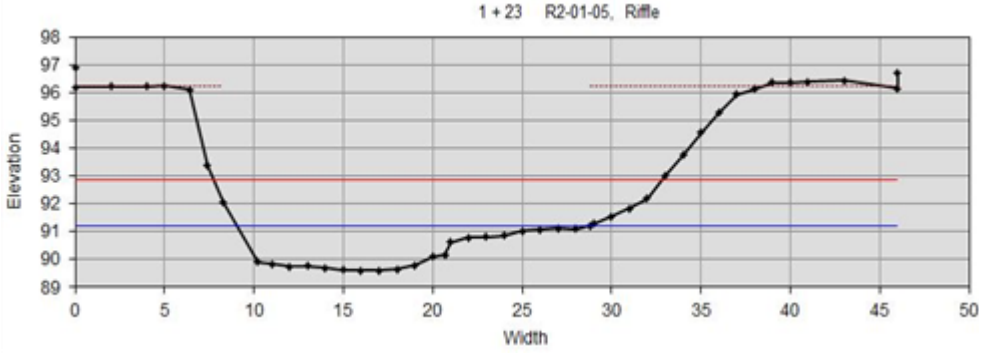
Water Chemistry

Dissolved Oxygen (mg/L)	10.85	pH (SU)	6.92
Turbidity (NTU)	13	Specific Conductivity (µS/cm)	603.3
Temperature (°C)	7.9		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.85	Cross Sectional Area (ft^2)	18.4
Bankfull Width (ft)	19.8	Water Surface Slope (%)	0.7
Mean Bankfull Depth (ft)	0.93	Sinuosity	1.1
Floodprone Width (ft)	25.1	D50 (mm)	13
Entrenchment Ratio	1.3	Adjustments?	None
Width to Depth Ratio	21.2	**Rosgen Stream Type**	**F4**



R2-01-06 Piney Run Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.1679079006 **Longitude:** -76.7228536407

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**1954.75**
Cover	**Acres**	**% Area**
Developed Land	**888.22**	**45.44**
Airport	0	0
Commercial	218.46	11.18
Industrial	10.17	0.52
Residential 1/8-acre	147.09	7.52
Residential 1/4-acre	80.69	4.13
Residential 1/2-acre	8.34	0.43
Residential 1-Acre	193.19	9.88
Residential 2-Acre	55.44	2.84
Transportation	174.84	8.94
Utility	0	0
Forest Land	**827.82**	**42.35**
Forested Wetland	0	0
Residential Woods	0	0
Woods	827.82	42.35
Open Land	**238.7**	**12.21**
Open Space	228.57	11.69
Open Wetland	0	0
Water	10.13	0.52
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	488.7	25

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Caddisflies (Cheumatopsyche) and beetles (Stenelmis) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Meandering reach with good depth in pools. Sub-optimal instream habitat and epibenthic substrate with abundant instream woody debris and rootwads. Good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.
- Because habitat is supporting and biological condition is poor, look for problems with water quality and correct, if possible.

R2-01-06 Piney Run Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	19
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	9.2
%Ephemeroptera	0
Scraper Taxa	5
% Climbers	14.7

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	5
% Climbers	5
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Ancyronyx	2
Calopteryx	1
Cheumatopsyche	21
Chironomidae	1
Chironomini	2
Chironomus	1
Conchapelopia	2
Crangonyctidae	2
Cricotopus/Orthocladius	4
Dubiraphia	1
Elmidae	2
Eukiefferiella	4
Hydrobaenus	1
Hydropsychidae	1
Micropsectra	5
Naididae	4
Orthocladiinae	7
Orthocladius	10
Oulimnius	2
Polypedilum	9
Potthastia	3
Ptilodactylidae	1
Simulium	2
Stenelmis	19
Thienemannimyia group	2
TOTAL:	**109**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	7	Pool Variability	14
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	13	Sediment Deposition	9
Channel Sinuosity	15	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	14	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	14		
RBP Habitat Score			**148**
RBP Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	12	64.62	Instream Wood Debris	15	80.29
Shading	65	63.55	Instream Habitat	14	80.81
Epifaunal Substrate	14	88.18	Bank Stability	15	86.61
PHI Score					**77.34**
PHI Narrative Rating					**Partially Degraded**

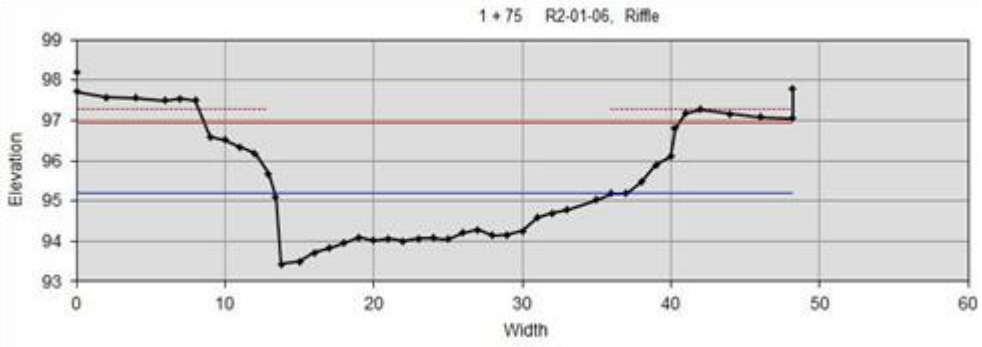
Water Chemistry

Dissolved Oxygen (mg/L)	10.23	pH (SU)	7.28
Turbidity (NTU)	6.31	Specific Conductivity (µS/cm)	440.9
Temperature (°C)	12.8		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	3.05	Cross Sectional Area (ft^2)	22
Bankfull Width (ft)	22.7	Water Surface Slope (%)	0.66
Mean Bankfull Depth (ft)	0.97	Sinuosity	1.3
Floodprone Width (ft)	31.9	D50 (mm)	15
Entrenchment Ratio	1.4	Adjustments?	None
Width to Depth Ratio	23.4	**Rosgen Stream Type**	**F4**



R2-01-07 Piney Run Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.1721033747 **Longitude:** -76.7503501423

Land Use/Land Cover Analysis:

*For individual land cover categories only Anne Arundel County land use data is presented below; however, total acreage and percent area land cover values (listed in bold) and impervious land include both Anne Arundel County and Howard County data.

Total Drainage Area (acres)		**1361.34**
Cover	**Acres**	**% Area**
Developed Land	**596.85**	**43.95**
Airport	0	0
Commercial	3.82	0.28
Industrial	17.99	1.32
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	27.33	2.01
Residential 1-Acre	48.99	3.61
Residential 2-Acre	181.57	13.37
Transportation	32.84	2.42
Utility	0	0
Forest Land	**703.83**	**51.83**
Forested Wetland	0	0
Residential Woods	0	0
Woods	451.17	33.22
Open Land	**55.5**	**4.09**
Open Space	34.7	2.55
Open Wetland	0	0
Water	0.24	0.02
Agricultural Land	**1.77**	**0.13**
Pasture/Hay	1.77	0.13
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	205.7	15.1

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Comparable to Reference"* and *"Minimally Degraded"*
- Caddisflies (Cheumatopsyche) and beetles (Stenelmis) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Very straight channel, but with excellent bank stability and vegetative protection. Excellent mix of stable habitat for benthos. Refuse present in moderate amounts.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is comparable to reference and biological condition is fair, look for problems with water quality and correct, if possible.
- Consider trash cleanup for this reach.

R2-01-07 Piney Run Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	25
EPT Taxa	7
Ephemeroptera Taxa	0
%Intolerant Urban	9.3
%Ephemeroptera	0
Scraper Taxa	4
% Climbers	10.2

Calculated Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	5
% Climbers	5
BIBI Score	**3.29**
BIBI Narrative Rating	**Fair**

Taxa	Count
Amphinemura	5
Ancyronyx	3
Asellidae	1
Calopteryx	1
Cheumatopsyche	17
Chimarra	1
Chironomidae	1
Coenagrionidae	1
Cricotopus/Orthocladius	8
Elmidae	7
Eukiefferiella	1
Gomphidae	1
Hydrobaenus	2
Hydropsyche	3
Hydropsychidae	2
Leuctra	1
Optioservus	2
Orthocladiinae	1
Orthocladius	3
Parametriocnemus	2
Polycentropus	2
Polypedilum	8
Potthastia	1
Ptilostomis	1
Rheocricotopus	1
Rheotanytarsus	4
Simuliidae	1
Stenelmis	21
Tipulidae	1
Tvetenia	5
TOTAL:	**108**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	9	Pool Variability	14
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	9
Channel Alteration	16	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	18	Sediment Deposition	13
Channel Sinuosity	10	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	16	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	13		
RBP Habitat Score			**152**
RBP Narrative Rating			**Comparable to Reference**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	6	32.31	Instream Wood Debris	22	100
Shading	95	99.94	Instream Habitat	15	90.06
Epifaunal Substrate	16	100	Bank Stability	17	92.2
PHI Score					**85.75**
PHI Narrative Rating					**Minimally Degraded**

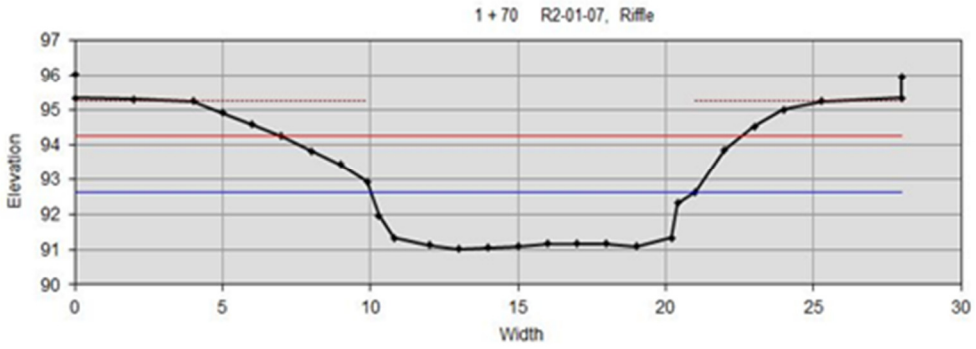
Water Chemistry

Dissolved Oxygen (mg/L)	11.83	pH (SU)	7.18
Turbidity (NTU)	3.91	Specific Conductivity (µS/cm)	349.1
Temperature (°C)	10		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	2.13	Cross Sectional Area (ft^2)	14.9
Bankfull Width (ft)	11	Water Surface Slope (%)	0.67
Mean Bankfull Depth (ft)	1.35	Sinuosity	1
Floodprone Width (ft)	15.7	D50 (mm)	22
Entrenchment Ratio	1.4	Adjustments?	None
Width to Depth Ratio	8.1	**Rosgen Stream Type**	**G4c**



R2-01-08 Piney Run Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.1901007097 **Longitude:** -76.719691201

Land Use/Land Cover Analysis:

*For individual land cover categories only Anne Arundel County land use data is presented below; however, total acreage and percent area land cover values (listed in bold) and impervious land include both Anne Arundel County and Howard County data.

Total Drainage Area (acres)		**11784.31**
Cover	**Acres**	**% Area**
Developed Land	**6564.5**	**55.8**
Airport	0	0
Commercial	241.51	2.05
Industrial	341.5	2.9
Residential 1/8-acre	148.34	1.26
Residential 1/4-acre	80.69	0.69
Residential 1/2-acre	42.21	0.36
Residential 1-Acre	302.1	2.57
Residential 2-Acre	346.92	2.95
Transportation	319.13	2.71
Utility	0	0
Forest Land	**3871.4**	**32.91**
Forested Wetland	0	0
Residential Woods	0	0
Woods	2102.6	17.87
Open Land	**997.15**	**8.48**
Open Space	479.94	4.08
Open Wetland	0	0
Water	13.01	0.11
Agricultural Land	**331.31**	**2.82**
Pasture/Hay	1.77	0.02
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	2840.4	24.1

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Partially Supporting"* and *"Severely Degraded"*
- Midges, including Hydrobaenus and Polypedilum, dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Very straight reach with mostly pool habitat. Sub-optimal instream habitat and epibenthic substrate. Good bank stability.
- Stream type not determined due to bridge crossing altering morphology.

Recommendations:

- Buffer enhancement.

R2-01-08 Piney Run Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	25
EPT Taxa	3
Ephemeroptera Taxa	1
%Intolerant Urban	10.2
%Ephemeroptera	1.9
Scraper Taxa	6
% Climbers	21.3

Calculated Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	3
%Intolerant Urban	3
%Ephemeroptera	3
Scraper Taxa	5
% Climbers	5
BIBI Score	**3.86**
BIBI Narrative Rating	**Fair**

Taxa	Count
Amphipoda	2
Ancyronyx	1
Baetidae	2
Brillia	1
Calopteryx	2
Cheumatopsyche	2
Chironomidae	1
Chironomini	3
Chironomus	2
Coenagrionidae	2
Cricotopus	1
Cricotopus/Orthocladius	8
Dubiraphia	1
Dytiscidae	1
Eukiefferiella	1
Hydrobaenus	19
Hydropsychidae	1
Orthocladiinae	10
Orthocladius	7
Oulimnius	2
Polycentropus	4
Polypedilum	16
Potthastia	3
Psephenus	1
Rheocricotopus	1
Simulium	1
Stenelmis	1
Tanytarsini	4
Tanytarsus	2
Tubificidae	5
Tvetenia	1
TOTAL:	**108**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	9	Pool Variability	11
Bank Stability- Right Bank	9	Riparian Vegetative Zone Width- Left Bank	6
Channel Alteration	9	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	19	Sediment Deposition	10
Channel Sinuosity	5	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	12		
RBP Habitat Score			**123**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	1	5.39	Instream Wood Debris	12	51.08
Shading	20	21.22	Instream Habitat	11	45.78
Epifaunal Substrate	11	59.04	Bank Stability	18	94.87
PHI Score					**46.23**
PHI Narrative Rating					**Severely Degraded**

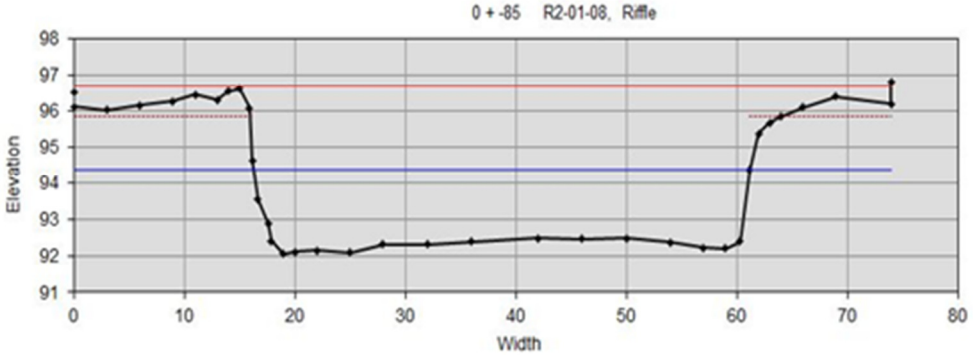
Water Chemistry

Dissolved Oxygen (mg/L)	10.47	pH (SU)	7.42
Turbidity (NTU)	2.77	Specific Conductivity (µS/cm)	618.3
Temperature (°C)	10.1		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	18.41	Cross Sectional Area (ft^2)	89.1
Bankfull Width (ft)	44.9	Water Surface Slope (%)	0.03
Mean Bankfull Depth (ft)	1.98	Sinuosity	1
Floodprone Width (ft)	160	D50 (mm)	0.45
Entrenchment Ratio	3.6	Adjustments?	None
Width to Depth Ratio	22.6	**Rosgen Stream Type**	**ND**



R2-01-09 Piney Run Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.1797787961 **Longitude:** -76.7372559546

Land Use/Land Cover Analysis:

*For individual land cover categories only Anne Arundel County land use data is presented below; however, total acreage and percent area land cover values (listed in bold) and impervious land include both Anne Arundel County and Howard County data.

Total Drainage Area (acres)		**4741.49**
Cover	**Acres**	**% Area**
Developed Land	**2687.89**	**56.86**
Airport	0	0
Commercial	9.37	0.2
Industrial	22.89	0.48
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	31.59	0.67
Residential 1-Acre	84.63	1.79
Residential 2-Acre	239.6	5.07
Transportation	48.15	1.02
Utility	0	0
Forest Land	**1549.25**	**32.77**
Forested Wetland	0	0
Residential Woods	0	0
Woods	646.87	13.68
Open Land	**210.62**	**4.46**
Open Space	46.05	0.97
Open Wetland	0	0
Water	0.24	0.01
Agricultural Land	**279.66**	**5.92**
Pasture/Hay	1.77	0.04
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	1044	22

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Degraded"*
- Midges (Polypedilum and Cricotopus/Orthocladius) and worms (Naididae) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Sub-optimal habitat diversity. Poor remoteness score due to close proximity to Coca Cola Drive.
- Bimodal distribution of substrate (gravel/sand).

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.
- Consider trash cleanup for this reach.

R2-01-09 Piney Run Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	18
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	3.6
%Ephemeroptera	0
Scraper Taxa	2
% Climbers	15.5

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	5
% Climbers	5
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Ancyronyx	1
Brillia	1
Calopteryx	1
Chironomidae	2
Chironominae	3
Cricotopus/Orthocladius	12
Enchytraeidae	1
Eukiefferiella	3
Hydrobaenus	5
Lumbricina	1
Micropsectra	1
Naididae	17
Orthocladiinae	9
Orthocladius	9
Polypedilum	13
Potthastia	3
Rheocricotopus	2
Simuliidae	3
Simulium	3
Stenochironomus	2
Tanytarsini	4
Tanytarsus	2
Thienemannimyia group	1
Tubificidae	11
TOTAL:	**110**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	6	Pool Variability	10
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	7
Channel Alteration	10	Riparian Vegetative Zone Width- Right Bank	9
Channel Flow Status	15	Sediment Deposition	12
Channel Sinuosity	9	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	11		
RBP Habitat Score			**119**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	1	5.39	Instream Wood Debris	13	64.35
Shading	85	84.56	Instream Habitat	13	66.19
Epifaunal Substrate	12	70.78	Bank Stability	13	80.63
PHI Score					**61.98**
PHI Narrative Rating					**Degraded**

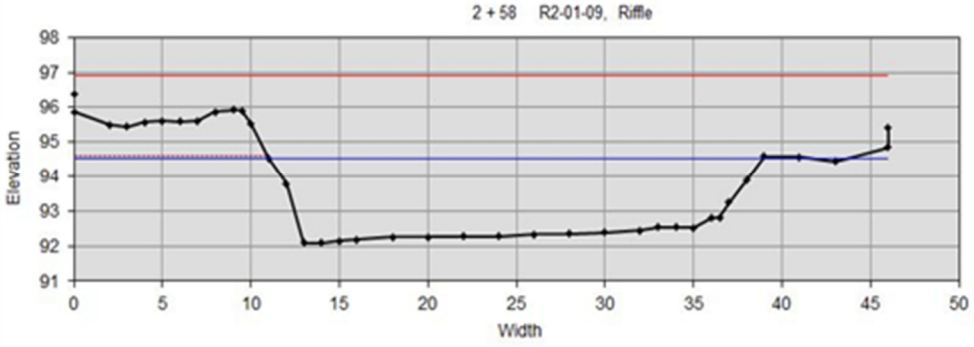
Water Chemistry

Dissolved Oxygen (mg/L)	10.75	pH (SU)	7.55
Turbidity (NTU)	3.19	Specific Conductivity (µS/cm)	540
Temperature (°C)	15.5		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	7.41	Cross Sectional Area (ft^2)	54.8
Bankfull Width (ft)	29.8	Water Surface Slope (%)	0.31
Mean Bankfull Depth (ft)	1.84	Sinuosity	1.1
Floodprone Width (ft)	250	D50 (mm)	1.7
Entrenchment Ratio	8.4	Adjustments?	None
Width to Depth Ratio	16.3	**Rosgen Stream Type**	**C4/5**



R2-01-10 Piney Run Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2065850729 **Longitude:** -76.7052480742

Land Use/Land Cover Analysis:

*For individual land cover categories only Anne Arundel County land use data is presented below; however, total acreage and percent area land cover values (listed in bold) and impervious land include both Anne Arundel County and Howard County data.

Total Drainage Area (acres)		**12680.87**
Cover	**Acres**	**% Area**
Developed Land	**6918.44**	**54.66**
Airport	0	0
Commercial	244.8	1.93
Industrial	341.86	2.7
Residential 1/8-acre	148.34	1.17
Residential 1/4-acre	80.69	0.64
Residential 1/2-acre	42.21	0.33
Residential 1-Acre	302.1	2.39
Residential 2-Acre	414.25	3.27
Transportation	333.48	2.63
Utility	1.55	0.01
Forest Land	**4389.92**	**34.69**
Forested Wetland	0	0
Residential Woods	0	0
Woods	2384.13	18.84
Open Land	**1006.22**	**7.95**
Open Space	489.01	3.86
Open Wetland	0	0
Water	13.01	0.1
Agricultural Land	**341.77**	**2.7**
Pasture/Hay	1.77	0.01
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	2914.3	23

Summary Results:

- Biological condition – *"Good"*
- Habitat scores *"Partially Supporting"* and *"Severely Degraded"*
- Midges, including Cricotopus/Orthocladius, Rheocricotopus, and Tanytarsus, dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Limited benthic habitat with minimal instream woody debris. Good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-01-10 Piney Run Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	29
EPT Taxa	6
Ephemeroptera Taxa	2
%Intolerant Urban	10.6
%Ephemeroptera	4.4
Scraper Taxa	4
% Climbers	14.2

Calculated Metric Scores

Total Taxa	5
EPT Taxa	5
Ephemeroptera Taxa	5
%Intolerant Urban	3
%Ephemeroptera	3
Scraper Taxa	5
% Climbers	5
BIBI Score	**4.43**
BIBI Narrative Rating	**Good**

Taxa	Count
Ancyronyx	2
Arigomphus	1
Baetidae	3
Brillia	1
Caenis	2
Calopteryx	1
Cheumatopsyche	1
Chironomidae	1
Chironomini	10
Cricotopus/Orthocladius	11
Dubiraphia	2
Enchytraeidae	1
Hagenius	1
Hydrobaenus	2
Hydropsyche	1
Lumbricina	1
Naididae	2
Orthocladiinae	11
Orthocladius	6
Parakiefferiella	1
Parametriocnemus	1
Paratanytarsus	1
Plecoptera	1
Polypedilum	4
Potthastia	3
Rheocricotopus	10
Simulium	2
Stenelmis	5
Stenochironomus	1
Tanytarsini	10
Tanytarsus	8
Thienemannimyia group	1
Triaenodes	1
Trichoptera	1
Tubificina	1
Tvetenia	2
TOTAL:	**113**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	7	Pool Variability	11
Bank Stability- Right Bank	2	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	9
Channel Flow Status	15	Sediment Deposition	8
Channel Sinuosity	10	Vegetative Protection - Left Bank	3
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	2
Pool Substrate Characterization	12		
RBP Habitat Score			**120**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	10	53.85	Instream Wood Debris	5	29.54
Shading	30	31.57	Instream Habitat	12	50.58
Epifaunal Substrate	11	58.57	Bank Stability	9	67.08
PHI Score					**48.53**
PHI Narrative Rating					**Severely Degraded**

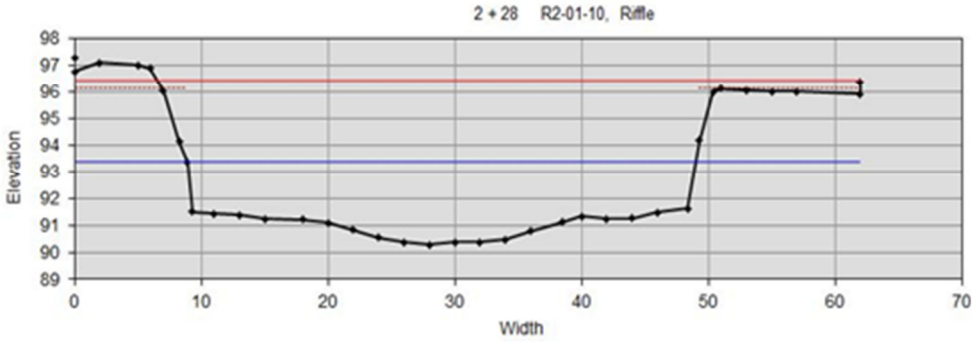
Water Chemistry

Dissolved Oxygen (mg/L)	10.04	pH (SU)	6.99
Turbidity (NTU)	4.94	Specific Conductivity (µS/cm)	578.7
Temperature (°C)	9.5		

Geomorphic Assessment

Rosgen Level II Classification Data

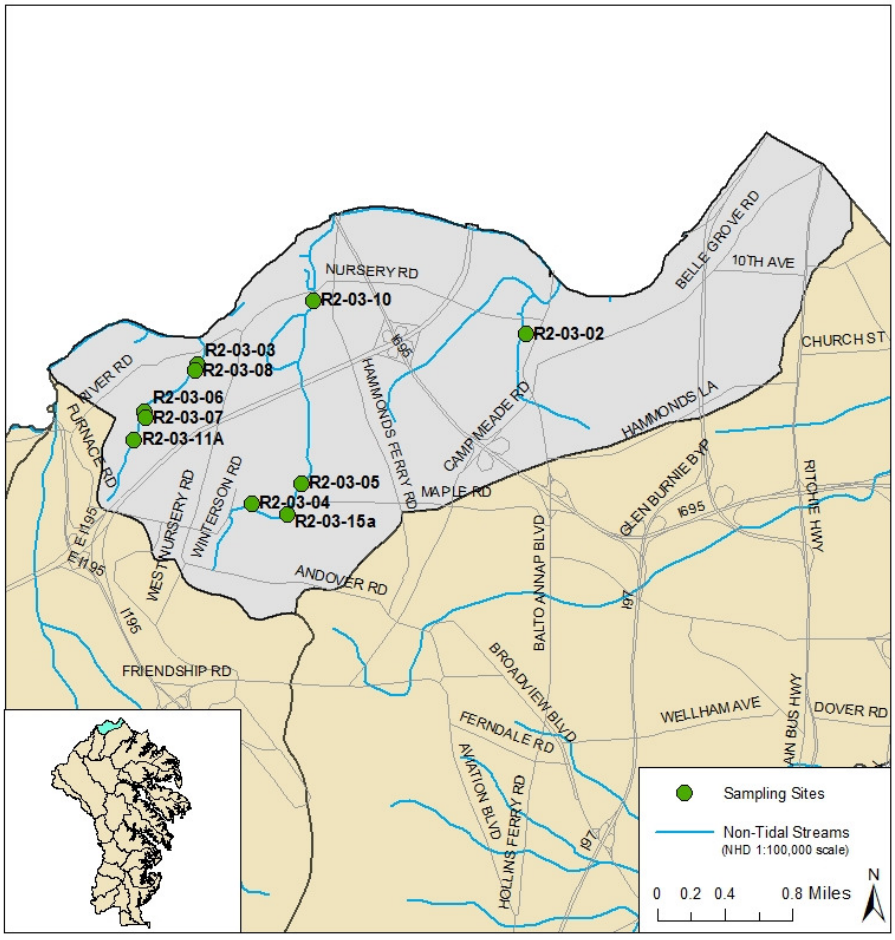
Drainage Area (mi^2)	19.81	Cross Sectional Area (ft^2)	93.7
Bankfull Width (ft)	40.1	Water Surface Slope (%)	0.012
Mean Bankfull Depth (ft)	2.34	Sinuosity	1.1
Floodprone Width (ft)	290	D50 (mm)	0.69
Entrenchment Ratio	7.2	Adjustments?	None
Width to Depth Ratio	17.2	**Rosgen Stream Type**	**C5c-**



Lower Patapsco Sampling Unit

Site Condition Summary

Site	Drainage Area (acres)	Drainage Area (mi^2)	Percent Impervious	Percent Developed	Percent Forested	Percent Agriculture	Percent Open	BIBI Narrative Rating	PHI Narrative Rating	RBP Narrative Rating	Rosgen Stream Type - L1
R2-03-02	527.1	0.82	32.5	66.6	19.4	0.0	14.0	Poor	Partially Degraded	Partially Supporting	F
R2-03-03	237.6	0.37	17.1	32.5	59.3	0.0	8.2	Fair	Minimally Degraded	Supporting	C
R2-03-04	172.3	0.27	51.4	76.8	18.7	0.0	4.6	Very Poor	Severely Degraded	Non Supporting	ND
R2-03-05	415.5	0.65	40.1	71.2	23.9	0.0	4.9	Very Poor	Degraded	Non Supporting	ND
R2-03-06	125.7	0.20	22.2	40.6	49.6	0.0	9.8	Poor	Partially Degraded	Partially Supporting	F
R2-03-07	72.0	0.11	25.1	48.6	49.7	0.0	1.7	Poor	Partially Degraded	Partially Supporting	F
R2-03-08	234.9	0.37	17.3	32.8	58.9	0.0	8.3	Fair	Partially Degraded	Partially Supporting	F
R2-03-10	992.7	1.55	37.6	70.8	24.3	0.0	4.9	Poor	Degraded	Non Supporting	F
R2-03-11A	51.5	0.08	34.2	60.5	37.2	0.0	2.3	Poor	Partially Degraded	Non Supporting	F
R2-03-15A	368.1	0.58	40.9	70.7	24.4	0.0	5.0	Very Poor	Severely Degraded	Non Supporting	F



R2-03-02 Lower Patapsco Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2199175578 **Longitude:** -76.6443296366

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**527.09**
Cover	**Acres**	**% Area**
Developed Land	**351.03**	**66.6**
Airport	0	0
Commercial	33.02	6.26
Industrial	4.62	0.88
Residential 1/8-acre	82.19	15.59
Residential 1/4-acre	178.05	33.78
Residential 1/2-acre	12.59	2.39
Residential 1-Acre	0	0
Residential 2-Acre	0	0
Transportation	40.57	7.7
Utility	0	0
Forest Land	**102.21**	**19.39**
Forested Wetland	0	0
Residential Woods	13.16	2.5
Woods	89.06	16.9
Open Land	**73.85**	**14.01**
Open Space	73.22	13.89
Open Wetland	0	0
Water	0.63	0.12
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	171.5	32.5

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Tvetenia (midge) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Gravel riffles providing mostly stable habitat but channel appears overwidened. Good riparian width. Refuse present in moderate amounts.
- Bimodal distribution of substrate (gravel/sand).

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.
- Investigate potential water quality impacts from residential land uses.
- Consider trash cleanup for this reach.

R2-03-02 Lower Patapsco Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	21
EPT Taxa	3
Ephemeroptera Taxa	0
%Intolerant Urban	1.9
%Ephemeroptera	0
Scraper Taxa	2
% Climbers	1.9

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	5
% Climbers	3
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Brillia	2
Cheumatopsyche	3
Chironomidae	1
Cricotopus	5
Cricotopus/Orthocladius	11
Dolophilodes	1
Eukiefferiella	3
Gammarus	1
Hydrobaenus	3
Hydropsyche	1
Lepidoptera	1
Limnophyes	3
Lumbricina	1
Micropsectra	1
Naididae	3
Orthocladiinae	9
Orthocladius	7
Parametriocnemus	1
Phaenopsectra/Tribelos	2
Physa	1
Simuliidae	1
Thienemannimyia group	2
Tubificidae	2
Tvetenia	41
TOTAL:	**106**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	6	Pool Variability	9
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	18	Riparian Vegetative Zone Width- Right Bank	9
Channel Flow Status	9	Sediment Deposition	6
Channel Sinuosity	10	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	12	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	11		
RBP Habitat Score			**117**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	10	53.85	Instream Wood Debris	7	71.47
Shading	85	84.56	Instream Habitat	11	77.58
Epifaunal Substrate	12	85.1	Bank Stability	13	80.63
PHI Score					**75.53**
PHI Narrative Rating					**Partially Degraded**

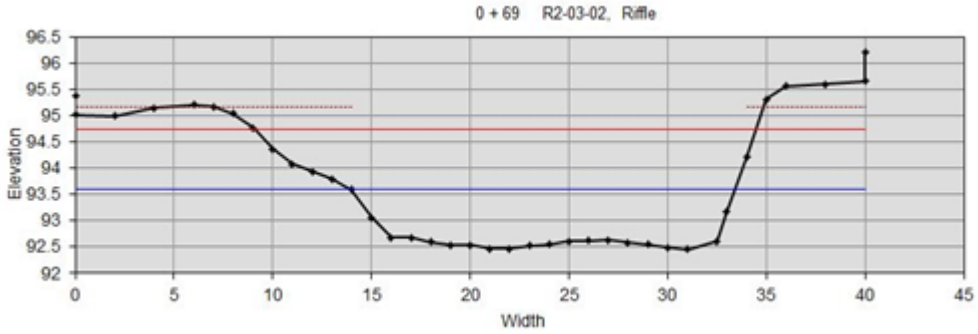
Water Chemistry

Dissolved Oxygen (mg/L)	11.88	pH (SU)	6.86
Turbidity (NTU)	0.94	Specific Conductivity (µS/cm)	550
Temperature (°C)	13.13		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.82	Cross Sectional Area (ft^2)	18.4
Bankfull Width (ft)	19.4	Water Surface Slope (%)	0.75
Mean Bankfull Depth (ft)	0.95	Sinuosity	1.2
Floodprone Width (ft)	25.4	D50 (mm)	8.3
Entrenchment Ratio	1.3	Adjustments?	None
Width to Depth Ratio	20.4	**Rosgen Stream Type**	**F4/5**



R2-03-03 Lower Patapsco Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2174286036 **Longitude:** -76.6804809438

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**237.55**
Cover	**Acres**	**% Area**
Developed Land	**77.31**	**32.54**
Airport	0	0
Commercial	26.18	11.02
Industrial	2.64	1.11
Residential 1/8-acre	0	0
Residential 1/4-acre	0.22	0.09
Residential 1/2-acre	0	0
Residential 1-Acre	6.22	2.62
Residential 2-Acre	15.51	6.53
Transportation	15.43	6.5
Utility	11.11	4.68
Forest Land	**140.81**	**59.28**
Forested Wetland	0	0
Residential Woods	0	0
Woods	140.81	59.28
Open Land	**19.43**	**8.18**
Open Space	19.43	8.18
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	40.6	17.1

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Supporting"* and *"Minimally Degraded"*
- Worms (Naididae) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Sub-optimal instream habitat and epibenthic substrate with abundant instream woody debris. Good bank stability and riparian width.
- Bimodal distribution of substrate (gravel/sand).

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-03-03 Lower Patapsco Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	22
EPT Taxa	4
Ephemeroptera Taxa	1
%Intolerant Urban	15.4
%Ephemeroptera	0.9
Scraper Taxa	3
% Climbers	9.4

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	3
%Intolerant Urban	3
%Ephemeroptera	3
Scraper Taxa	5
% Climbers	5
BIBI Score	**3.57**
BIBI Narrative Rating	**Fair**

Taxa	Count
Ameletus	1
Calopteryx	1
Chironomidae	2
Chironomini	1
Epitheca	1
Hydrobaenus	5
Lepidostoma	1
Naididae	50
Neophylax	3
Orthocladiinae	5
Parametriocnemus	6
Paratendipes	1
Phaenopsectra/Tribelos	1
Physa	2
Plecoptera	3
Polypedilum	6
Saldidae	1
Simuliidae	2
Simulium	1
Staphylinidae	1
Stegopterna	10
Tanypodinae	1
Tanytarsini	1
Thienemanniella	1
Thienemannimyia group	1
Tipula	4
Tubificidae	3
Tvetenia	2
TOTAL:	**117**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	9	Pool Variability	13
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	19	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	9	Sediment Deposition	6
Channel Sinuosity	11	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	12	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	11		
RBP Habitat Score			**130**
RBP Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	12	64.62	Instream Wood Debris	12	95.28
Shading	80	78.67	Instream Habitat	12	91.29
Epifaunal Substrate	12	90.29	Bank Stability	17	92.2
PHI Score					**85.39**
PHI Narrative Rating					**Minimally Degraded**

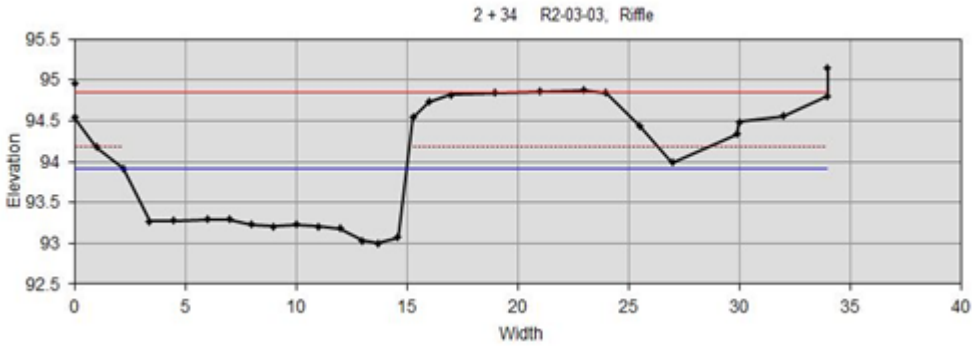
Water Chemistry

Dissolved Oxygen (mg/L)	9.84	pH (SU)	6.77
Turbidity (NTU)	2.5	Specific Conductivity (µS/cm)	277.77
Temperature (°C)	11.17		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.37	Cross Sectional Area (ft^2)	8.6
Bankfull Width (ft)	12.8	Water Surface Slope (%)	0.97
Mean Bankfull Depth (ft)	0.67	Sinuosity	1.1
Floodprone Width (ft)	34	D50 (mm)	5.5
Entrenchment Ratio	2.7	Adjustments?	None
Width to Depth Ratio	19.1	**Rosgen Stream Type**	**C4/5**



R2-03-04 Lower Patapsco Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2054925483 **Longitude:** -76.674546763

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**172.28**
Cover	**Acres**	**% Area**
Developed Land	**132.28**	**76.78**
Airport	0	0
Commercial	86.52	50.22
Industrial	2.52	1.46
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	23.91	13.88
Residential 2-Acre	3.47	2.02
Transportation	15.85	9.2
Utility	0	0
Forest Land	**32.14**	**18.65**
Forested Wetland	0	0
Residential Woods	0	0
Woods	32.14	18.65
Open Land	**7.87**	**4.57**
Open Space	7.87	4.57
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	88.5	51.4

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Non Supporting"* and *"Severely Degraded"*
- Worms (Tubificidae and Naididae) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Ephemeral channel with only standing water in pools and no visible flow. Very poor habitat for benthos and moderately unstable banks with poor vegetative protection. Refuse present in moderate amounts.
- Ephemeral channel, recently stabilized with large cobble/boulder grade control structures. Stream type indeterminate.

Recommendations:

- Buffer enhancement.
- Consider trash cleanup for this reach.

R2-03-04 Lower Patapsco Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	8
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	1
%Ephemeroptera	0
Scraper Taxa	2
% Climbers	2.9

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	5
% Climbers	3
BIBI Score	**1.86**
BIBI Narrative Rating	**Very Poor**

Taxa	**Count**
Chironomidae	1
Cricotopus/Orthocladius	4
Dicranota	1
Enochrus	1
Lumbricina	1
Naididae	10
Orthocladiinae	1
Orthocladius	2
Physa	2
Stagnicola	1
Tubificidae	80
Tubificina	1
TOTAL:	**105**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	4	Pool Variability	6
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	2
Channel Alteration	5	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	4	Sediment Deposition	9
Channel Sinuosity	5	Vegetative Protection - Left Bank	2
Epifaunal Substrate/Available Cover	2	Vegetative Protection - Right Bank	2
Pool Substrate Characterization	5		
RBP Habitat Score			**58**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	5	26.93	Instream Wood Debris	0	63.42
Shading	30	31.57	Instream Habitat	1	33.54
Epifaunal Substrate	2	34.29	Bank Stability	8	63.25
PHI Score					**42.17**
PHI Narrative Rating					**Severely Degraded**

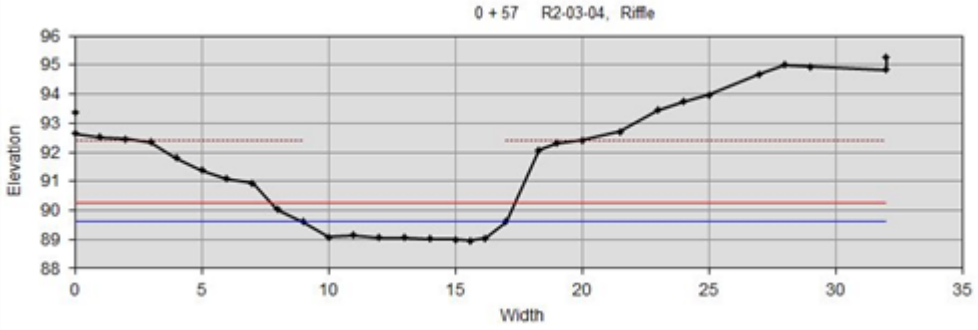
Water Chemistry

Dissolved Oxygen (mg/L)	8.57	pH (SU)	8.1
Turbidity (NTU)	5.1	Specific Conductivity (µS/cm)	326.27
Temperature (°C)	16.77		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.27	Cross Sectional Area (ft^2)	3.9
Bankfull Width (ft)	8	Water Surface Slope (%)	1.5
Mean Bankfull Depth (ft)	0.48	Sinuosity	1
Floodprone Width (ft)	9.6	D50 (mm)	21
Entrenchment Ratio	1.2	Adjustments?	None
Width to Depth Ratio	16.6	**Rosgen Stream Type**	**ND**



R2-03-05 Lower Patapsco Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2071768429 **Longitude:** -76.6690797061

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**415.49**
Cover	**Acres**	**% Area**
Developed Land	**295.84**	**71.2**
Airport	0	0
Commercial	100.2	24.12
Industrial	40.68	9.79
Residential 1/8-acre	0	0
Residential 1/4-acre	72.57	17.47
Residential 1/2-acre	0	0
Residential 1-Acre	35.96	8.65
Residential 2-Acre	22.7	5.46
Transportation	23.73	5.71
Utility	0	0
Forest Land	**99.19**	**23.87**
Forested Wetland	0	0
Residential Woods	0	0
Woods	99.19	23.87
Open Land	**20.47**	**4.93**
Open Space	20.47	4.93
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	166.5	40.1

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Non Supporting"* and *"Degraded"*
- Worms (Tubificidae and Naididae) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Very poor benthic habitat. Marginal riparian width.
- Intermittent stream severely impacted by beaver dam in middle of reach. Stream type indeterminate.

Recommendations:

- Buffer enhancement.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-03-05 Lower Patapsco Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	8
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	0.9
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	6.9

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	3
BIBI Score	**1.57**
BIBI Narrative Rating	**Very Poor**

Taxa	**Count**
Cricotopus/Orthocladius	18
Enchytraeidae	1
Hirudinea	2
Naididae	24
Orthocladiinae	6
Orthocladius	19
Physa	8
Pisidium	13
Probezzia	1
Tubificidae	24
TOTAL:	**116**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	4	Pool Variability	5
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	3
Channel Alteration	14	Riparian Vegetative Zone Width- Right Bank	7
Channel Flow Status	3	Sediment Deposition	10
Channel Sinuosity	12	Vegetative Protection - Left Bank	3
Epifaunal Substrate/Available Cover	2	Vegetative Protection - Right Bank	3
Pool Substrate Characterization	5		
RBP Habitat Score			**75**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	5	26.93	Instream Wood Debris	20	100
Shading	90	91.34	Instream Habitat	1	24.53
Epifaunal Substrate	3	34.36	Bank Stability	8	63.25
PHI Score					**56.73**
PHI Narrative Rating					**Degraded**

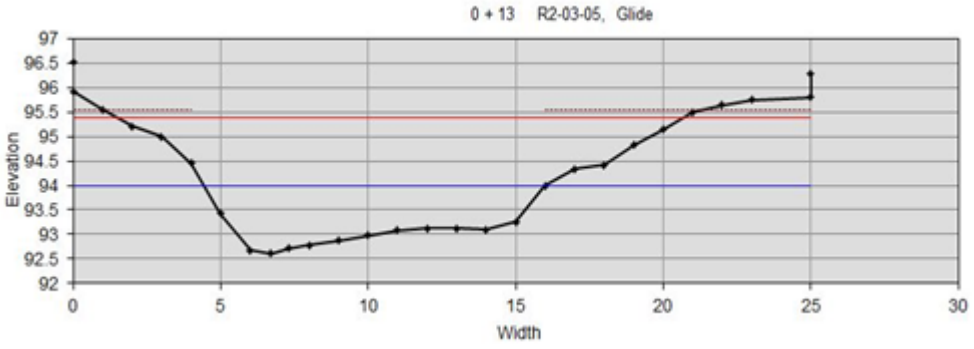
Water Chemistry

Dissolved Oxygen (mg/L)	5.02	pH (SU)	7.08
Turbidity (NTU)	10.4	Specific Conductivity (µS/cm)	443.3
Temperature (°C)	17		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.65	Cross Sectional Area (ft^2)	10.8
Bankfull Width (ft)	11.6	Water Surface Slope (%)	1.3
Mean Bankfull Depth (ft)	0.93	Sinuosity	1.1
Floodprone Width (ft)	19.3	D50 (mm)	0.062
Entrenchment Ratio	1.7	Adjustments?	None
Width to Depth Ratio	12.4	**Rosgen Stream Type**	**ND**



R2-03-06 Lower Patapsco Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2133609398 **Longitude:** -76.6862937888

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**125.74**
Cover	**Acres**	**% Area**
Developed Land	**51.09**	**40.63**
Airport	0	0
Commercial	26.17	20.82
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	5.59	4.44
Residential 2-Acre	7.3	5.81
Transportation	4.66	3.71
Utility	7.36	5.85
Forest Land	**62.34**	**49.58**
Forested Wetland	0	0
Residential Woods	0	0
Woods	62.34	49.58
Open Land	**12.31**	**9.79**
Open Space	12.31	9.79
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	28	22.2

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Worms (Naididae) dominated the sample.
- Water quality values within COMAR standards.
- Channel appears incised and overwidened with mostly shallow riffles and pools. Poor remoteness score due to close proximity to Furnace Road.
- Adjusted WD +0.4 to fit F type.

Recommendations:

- Buffer enhancement.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-03-06 Lower Patapsco Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	14
EPT Taxa	4
Ephemeroptera Taxa	0
%Intolerant Urban	8.6
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	1.9

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	3
BIBI Score	**2.14**
BIBI Narrative Rating	**Poor**

Taxa	Count
Cheumatopsyche	1
Chironomidae	2
Cricotopus/Orthocladius	5
Diplectrona	2
Dytiscidae	1
Eukiefferiella	12
Ironoquia	1
Naididae	41
Orthocladiinae	17
Parametriocnemus	1
Physa	1
Plecoptera	4
Polypedilum	1
Simuliidae	1
Stegopterna	3
Thienemannimyia group	1
Tipula	4
Tubificidae	3
Tubificina	4
TOTAL:	**105**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	6	Pool Variability	9
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	8
Channel Alteration	12	Riparian Vegetative Zone Width- Right Bank	3
Channel Flow Status	10	Sediment Deposition	12
Channel Sinuosity	11	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	10	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	11		
RBP Habitat Score			**108**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	1	5.39	Instream Wood Debris	4	78.82
Shading	75	73.32	Instream Habitat	8	75.6
Epifaunal Substrate	11	88.62	Bank Stability	12	77.46
PHI Score					**66.54**
PHI Narrative Rating					**Partially Degraded**

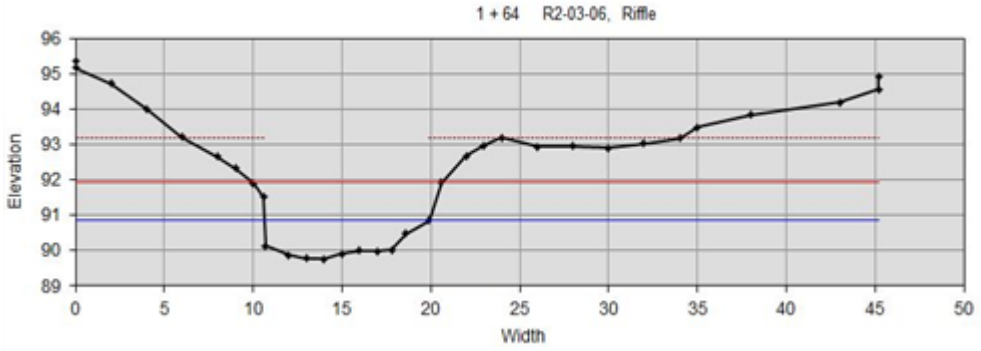
Water Chemistry

Dissolved Oxygen (mg/L)	9.21	pH (SU)	6.94
Turbidity (NTU)	3.48	Specific Conductivity (µS/cm)	205.5
Temperature (°C)	12.83		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.2	Cross Sectional Area (ft^2)	7.4
Bankfull Width (ft)	9.3	Water Surface Slope (%)	2
Mean Bankfull Depth (ft)	0.8	Sinuosity	1.3
Floodprone Width (ft)	10.7	D50 (mm)	40
Entrenchment Ratio	1.2	Adjustments?	Yes, WD +0.4
Width to Depth Ratio	11.6	**Rosgen Stream Type**	**F4b**



R2-03-07 Lower Patapsco Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2128485935 **Longitude:** -76.6861831343

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**71.96**
Cover	**Acres**	**% Area**
Developed Land	**34.99**	**48.62**
Airport	0	0
Commercial	18.28	25.4
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	3.42	4.75
Residential 2-Acre	7.08	9.83
Transportation	1.41	1.96
Utility	4.81	6.68
Forest Land	**35.76**	**49.7**
Forested Wetland	0	0
Residential Woods	0	0
Woods	35.76	49.7
Open Land	**1.21**	**1.68**
Open Space	1.21	1.68
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	18.1	25.1

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Worms (Tubificidae and Naididae) and midges (Eukiefferiella) dominated the sample.
- Measured below COMAR standards for pH.
- Marginal instream habitat and epibenthic substrate. Channel overwidened with numerous point bars and low flow. Good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.

R2-03-07 Lower Patapsco Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	17
EPT Taxa	4
Ephemeroptera Taxa	0
%Intolerant Urban	4.6
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	2.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	3
BIBI Score	**2.14**
BIBI Narrative Rating	**Poor**

Taxa	Count
Amphipoda	1
Cheumatopsyche	1
Chironomidae	1
Cricotopus/Orthocladius	2
Diplectrona	1
Diplocladius	2
Dytiscidae	2
Eukiefferiella	26
Hydrobaenus	4
Limnephilidae	1
Naididae	10
Orthocladiinae	2
Orthocladius	5
Parametriocnemus	1
Plecoptera	3
Polypedilum	2
Simuliidae	1
Stegopterna	1
Tanypodinae	1
Thienemannimyia group	3
Tipula	2
Tubificidae	36
TOTAL:	**108**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	7	Pool Variability	8
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	18	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	9	Sediment Deposition	11
Channel Sinuosity	9	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	10	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	10		
RBP Habitat Score			**123**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	6	32.31	Instream Wood Debris	6	91.05
Shading	95	99.94	Instream Habitat	9	86.86
Epifaunal Substrate	10	86.45	Bank Stability	14	83.67
PHI Score					**80.05**
PHI Narrative Rating					**Partially Degraded**

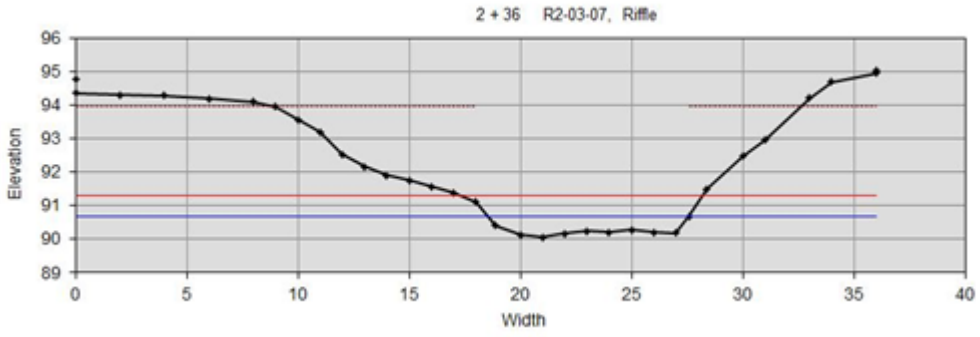
Water Chemistry

Dissolved Oxygen (mg/L)	8.98	pH (SU)	6.21
Turbidity (NTU)	4.61	Specific Conductivity (µS/cm)	194.4
Temperature (°C)	13.3		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.11	Cross Sectional Area (ft^2)	4.1
Bankfull Width (ft)	9.1	Water Surface Slope (%)	1.4
Mean Bankfull Depth (ft)	0.45	Sinuosity	1.1
Floodprone Width (ft)	10.9	D50 (mm)	35
Entrenchment Ratio	1.2	Adjustments?	None
Width to Depth Ratio	20	**Rosgen Stream Type**	**F4**



R2-03-08 Lower Patapsco Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2168826591 **Longitude:** -76.680730789

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**234.85**
Cover	**Acres**	**% Area**
Developed Land	**77.09**	**32.83**
Airport	0	0
Commercial	26.18	11.15
Industrial	2.64	1.13
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	6.22	2.65
Residential 2-Acre	15.51	6.6
Transportation	15.43	6.57
Utility	11.11	4.73
Forest Land	**138.33**	**58.9**
Forested Wetland	0	0
Residential Woods	0	0
Woods	138.33	58.9
Open Land	**19.43**	**8.27**
Open Space	19.43	8.27
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	40.6	17.3

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Worms (Naididae) and midges (Stegopterna) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Marginal instream habitat and epibenthic substrate but abundant instream woody debris. Good bank stability.
- Bimodal distribution of substrate (gravel/sand).

Recommendations:

- Buffer enhancement.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-03-08 Lower Patapsco Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	18
EPT Taxa	5
Ephemeroptera Taxa	2
%Intolerant Urban	15.4
%Ephemeroptera	1.9
Scraper Taxa	3
% Climbers	4.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	5
Ephemeroptera Taxa	5
%Intolerant Urban	3
%Ephemeroptera	3
Scraper Taxa	5
% Climbers	3
BIBI Score	**3.86**
BIBI Narrative Rating	**Fair**

Taxa	Count
Ameletus	1
Amphinemura	2
Caenis	1
Cheumatopsyche	1
Chironomidae	3
Cricotopus	1
Cricotopus/Orthocladius	3
Hydrobaenus	3
Hydropsychidae	1
Lumbricina	1
Naididae	39
Neophylax	1
Orthocladiinae	4
Orthocladius	6
Parametriocnemus	6
Plecoptera	1
Polypedilum	4
Simuliidae	1
Stegopterna	10
Stenelmis	1
Thienemanniella	2
Tipula	6
Trichoptera	1
Tubificidae	2
Tvetenia	3
TOTAL:	**104**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	8	Pool Variability	10
Bank Stability- Right Bank	9	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	16	Riparian Vegetative Zone Width- Right Bank	4
Channel Flow Status	9	Sediment Deposition	7
Channel Sinuosity	14	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	10	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	10		
RBP Habitat Score			**119**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	13	70.01	Instream Wood Debris	10	89.49
Shading	60	58.94	Instream Habitat	10	80.31
Epifaunal Substrate	11	84.55	Bank Stability	17	92.2
PHI Score					**79.25**
PHI Narrative Rating					**Partially Degraded**

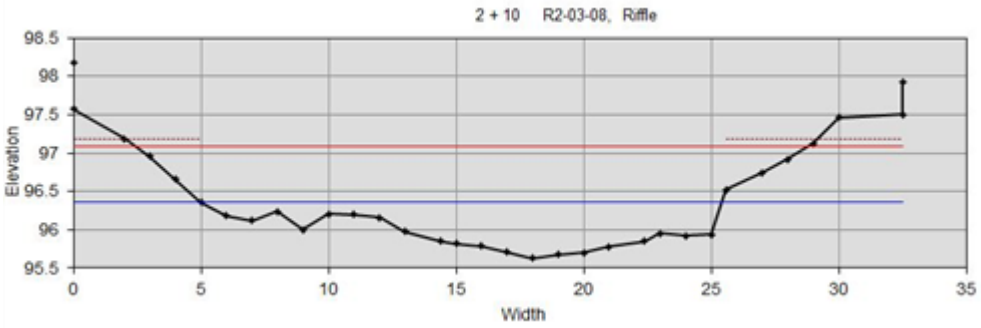
Water Chemistry

Dissolved Oxygen (mg/L)	10.39	pH (SU)	7.17
Turbidity (NTU)	13.3	Specific Conductivity (µS/cm)	271.53
Temperature (°C)	11.23		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.37	Cross Sectional Area (ft^2)	8.4
Bankfull Width (ft)	20.4	Water Surface Slope (%)	1
Mean Bankfull Depth (ft)	0.41	Sinuosity	1.3
Floodprone Width (ft)	26.4	D50 (mm)	15
Entrenchment Ratio	1.3	Adjustments?	None
Width to Depth Ratio	49.9	**Rosgen Stream Type**	**F4/5**



R2-03-10 Lower Patapsco Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2228732232 **Longitude:** -76.6676779645

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**992.74**
Cover	**Acres**	**% Area**
Developed Land	**702.88**	**70.8**
Airport	0	0
Commercial	128.99	12.99
Industrial	131.48	13.24
Residential 1/8-acre	0	0
Residential 1/4-acre	299.31	30.15
Residential 1/2-acre	0	0
Residential 1-Acre	49.05	4.94
Residential 2-Acre	24.53	2.47
Transportation	58.7	5.91
Utility	10.81	1.09
Forest Land	**240.83**	**24.26**
Forested Wetland	0	0
Residential Woods	0	0
Woods	240.83	24.26
Open Land	**49.03**	**4.94**
Open Space	47.77	4.81
Open Wetland	0	0
Water	1.26	0.13
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	373.3	37.6

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Non Supporting"* and *"Degraded"*
- Midges, including Polypedilum, Eukiefferiella, and Cricotopus/Orthocladius, dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Gravel riffles abundant but poor quality with heavy deposition in channel and moderate bank stability. Good riparian width. Refuse present in moderate amounts.

Recommendations:

- Maintain the protection of the riparian areas.
- Investigate potential water quality impacts from residential land uses.
- Consider trash cleanup for this reach.

R2-03-10 Lower Patapsco Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	18
EPT Taxa	2
Ephemeroptera Taxa	0
%Intolerant Urban	9.9
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	22.5

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	5
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Ceratopogon	1
Cheumatopsyche	1
Chimarra	1
Chironomini	8
Crangonyctidae	3
Cricotopus/Orthocladius	11
Diamesa	4
Diptera	1
Eukiefferiella	12
Hydrobaenus	6
Micropsectra	2
Naididae	5
Orthocladiinae	11
Orthocladius	4
Parametriocnemus	2
Polypedilum	22
Potthastia	8
Rheotanytarsus	1
Simulium	2
Tanytarsini	2
Tanytarsus	1
Thienemanniella	1
Tvetenia	2
TOTAL:	**111**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	3	Pool Variability	9
Bank Stability- Right Bank	5	Riparian Vegetative Zone Width- Left Bank	8
Channel Alteration	16	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	8	Sediment Deposition	6
Channel Sinuosity	11	Vegetative Protection - Left Bank	3
Epifaunal Substrate/Available Cover	8	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	7		
RBP Habitat Score			**99**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	6	32.31	Instream Wood Debris	8	67.26
Shading	65	63.55	Instream Habitat	8	54.46
Epifaunal Substrate	8	57.73	Bank Stability	8	63.25
PHI Score					**56.43**
PHI Narrative Rating					**Degraded**

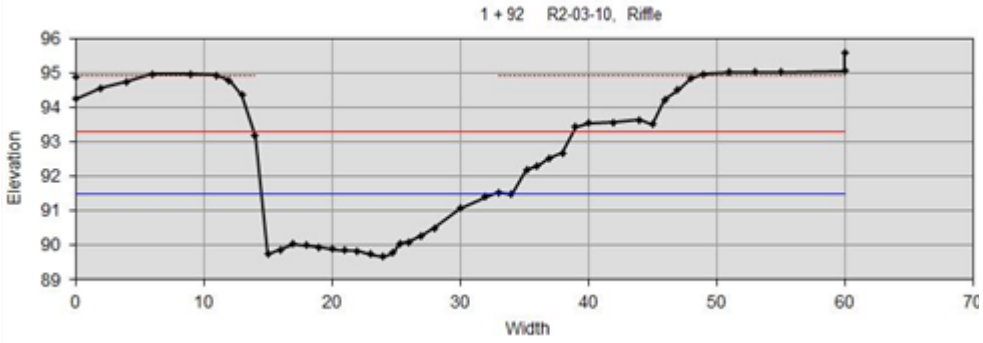
Water Chemistry

Dissolved Oxygen (mg/L)	8.92	pH (SU)	6.63
Turbidity (NTU)	1.94	Specific Conductivity (µS/cm)	434.23
Temperature (°C)	13.9		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	1.55	Cross Sectional Area (ft^2)	22.3
Bankfull Width (ft)	18.1	Water Surface Slope (%)	1
Mean Bankfull Depth (ft)	1.23	Sinuosity	1.3
Floodprone Width (ft)	24.9	D50 (mm)	19
Entrenchment Ratio	1.4	Adjustments?	None
Width to Depth Ratio	14.6	**Rosgen Stream Type**	**F4**



R2-03-11A Lower Patapsco Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2109716751 **Longitude:** -76.6875083138

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**51.53**
Cover	**Acres**	**% Area**
Developed Land	**31.16**	**60.47**
Airport	0	0
Commercial	18.28	35.47
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	0.93	1.81
Residential 2-Acre	7.08	13.73
Transportation	1.41	2.74
Utility	3.47	6.73
Forest Land	**19.16**	**37.19**
Forested Wetland	0	0
Residential Woods	0	0
Woods	19.16	37.19
Open Land	**1.21**	**2.34**
Open Space	1.21	2.34
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	17.6	34.2

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Non Supporting"* and *"Partially Degraded"*
- Midges, including Eukiefferiella and Orthocladiinae, dominated the sample.
- Measured below COMAR standards for pH and conductivity elevated.
- Channel deeply incised and overwidened with very little visible flow. Benthic habitat severely lacking. Good riparian width.
- Bimodal distribution of substrate (gravel/sand).

Recommendations:

- Maintain the protection of the riparian areas.

R2-03-11A Lower Patapsco Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	15
EPT Taxa	4
Ephemeroptera Taxa	0
%Intolerant Urban	9.6
%Ephemeroptera	0
Scraper Taxa	3
% Climbers	4.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	5
% Climbers	3
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Chironomidae	1
Cricotopus/Orthocladius	3
Diplectrona	1
Dytiscidae	6
Eukiefferiella	24
Hydrobaenus	6
Limnephilidae	3
Limnophyes	2
Naididae	2
Neophylax	3
Neoporus	3
Orthocladiinae	11
Orthocladius	5
Physa	1
Pisidium	1
Plecoptera	1
Saldidae	1
Stegopterna	3
Tubificidae	6
TOTAL:	**83**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	4	Pool Variability	4
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	19	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	2	Sediment Deposition	12
Channel Sinuosity	12	Vegetative Protection - Left Bank	5
Epifaunal Substrate/Available Cover	5	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	6		
RBP Habitat Score			**98**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	14	75.39	Instream Wood Debris	1	80.04
Shading	100	100	Instream Habitat	4	62.54
Epifaunal Substrate	5	59.58	Bank Stability	8	63.25
PHI Score					**73.47**
PHI Narrative Rating					**Partially Degraded**

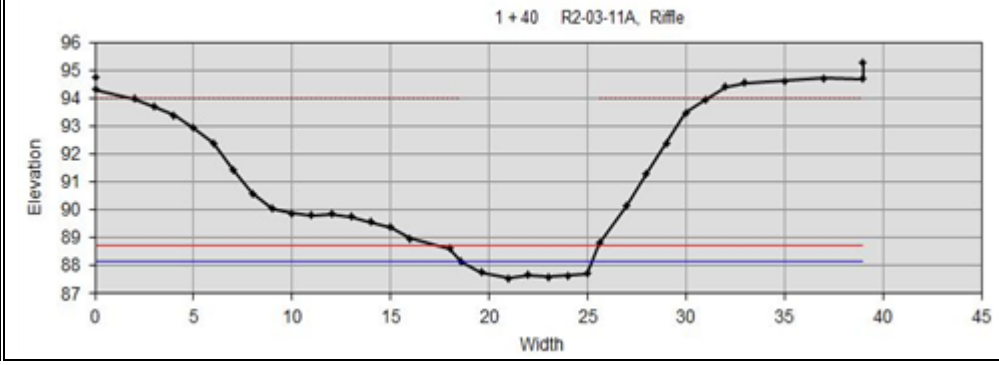
Water Chemistry

Dissolved Oxygen (mg/L)	8.11	pH (SU)	6.11
Turbidity (NTU)	4.05	Specific Conductivity (µS/cm)	270.47
Temperature (°C)	15.27		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.08	Cross Sectional Area (ft^2)	3
Bankfull Width (ft)	6.6	Water Surface Slope (%)	2.5
Mean Bankfull Depth (ft)	0.45	Sinuosity	1.3
Floodprone Width (ft)	8.2	D50 (mm)	35
Entrenchment Ratio	1.2	Adjustments?	None
Width to Depth Ratio	14.9	**Rosgen Stream Type**	**F4/5b**



R2-03-15A Lower Patapsco Sampling Unit

Upstream View:

Downstream View:

Latitude: 39.2045823212 **Longitude:** -76.6706435577

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**368.14**
Cover	**Acres**	**% Area**
Developed Land	**260.11**	**70.66**
Airport	0	0
Commercial	100.2	27.22
Industrial	32.14	8.73
Residential 1/8-acre	0	0
Residential 1/4-acre	45.41	12.33
Residential 1/2-acre	0	0
Residential 1-Acre	35.96	9.77
Residential 2-Acre	22.7	6.17
Transportation	23.7	6.44
Utility	0	0
Forest Land	**89.64**	**24.35**
Forested Wetland	0	0
Residential Woods	0	0
Woods	89.64	24.35
Open Land	**18.38**	**4.99**
Open Space	18.38	4.99
Open Wetland	0	0
Water	0	0
Agricultural Land	**0**	**0**
Pasture/Hay	0	0
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	150.4	40.9

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Non Supporting"* and *"Severely Degraded"*
- Worms (Naididae and Tubificidae) dominated the sample.
- Measured below COMAR standards for dissolved oxygen and conductivity elevated.
- Very poor benthic habitat because channel mostly dry immediate downstream of stormwater outfall. Refuse present in moderate amounts.
- Bimodal distribution of substrate (gravel/sand).

Recommendations:

- Buffer enhancement.
- Consider trash cleanup for this reach.

R2-03-15A Lower Patapsco Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	4
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	0
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	19.8

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	5
BIBI Score	**1.86**
BIBI Narrative Rating	**Very Poor**

Taxa	**Count**
Naididae	37
Orthocladiinae	1
Orthocladius	1
Physa	19
Tubificidae	38
TOTAL:	**96**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	5	Pool Variability	2
Bank Stability- Right Bank	5	Riparian Vegetative Zone Width- Left Bank	6
Channel Alteration	5	Riparian Vegetative Zone Width- Right Bank	5
Channel Flow Status	1	Sediment Deposition	5
Channel Sinuosity	5	Vegetative Protection - Left Bank	4
Epifaunal Substrate/Available Cover	2	Vegetative Protection - Right Bank	4
Pool Substrate Characterization	5		
RBP Habitat Score			**54**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	7	37.7	Instream Wood Debris	2	60.74
Shading	60	58.94	Instream Habitat	1	25.77
Epifaunal Substrate	2	29.34	Bank Stability	10	70.71
PHI Score					**47.2**
PHI Narrative Rating					**Severely Degraded**

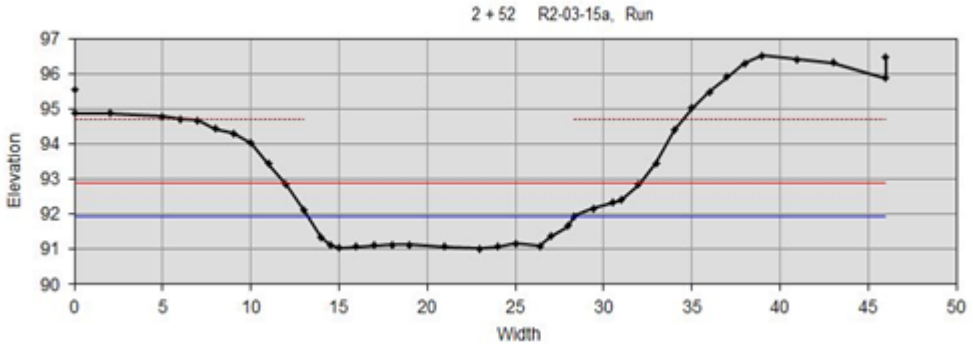
Water Chemistry

Dissolved Oxygen (mg/L)	3.79	pH (SU)	7.88
Turbidity (NTU)	24.6	Specific Conductivity (µS/cm)	630.33
Temperature (°C)	13.27		

Geomorphic Assessment

Rosgen Level II Classification Data

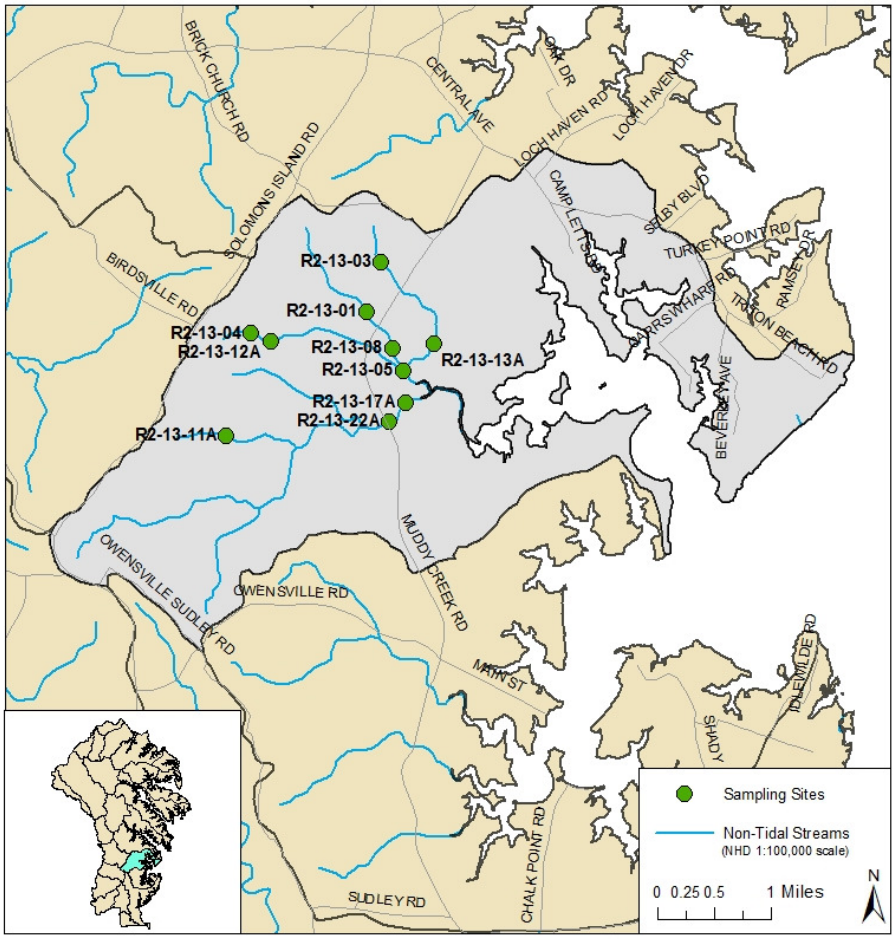
Drainage Area (mi^2)	0.58	Cross Sectional Area (ft^2)	11.7
Bankfull Width (ft)	15.1	Water Surface Slope (%)	1.3
Mean Bankfull Depth (ft)	0.78	Sinuosity	1.1
Floodprone Width (ft)	20.1	D50 (mm)	8.7
Entrenchment Ratio	1.3	Adjustments?	None
Width to Depth Ratio	19.5	**Rosgen Stream Type**	**F4/5**



Rhode River Sampling Unit

Site Condition Summary

Site	Drainage Area (acres)	Drainage Area (mi^2)	Percent Impervious	Percent Developed	Percent Forested	Percent Agriculture	Percent Open	BIBI Narrative Rating	PHI Narrative Rating	RBP Narrative Rating	Rosgen Stream Type - L1
R2-13-01	349.6	0.55	4.7	33.9	44.3	10.2	11.6	Very Poor	Partially Degraded	Supporting	C
R2-13-03	203.7	0.32	6.0	34.8	40.0	6.3	18.9	Fair	Partially Degraded	Partially Supporting	ND
R2-13-04	167.6	0.26	6.8	33.1	56.2	0.4	10.4	Poor	Partially Degraded	Partially Supporting	G
R2-13-05	673.4	1.05	5.0	28.3	60.9	3.5	7.3	Very Poor	Partially Degraded	Supporting	E
R2-13-08	464.2	0.73	4.7	29.3	53.5	7.7	9.6	Very Poor	Degraded	Comparable to Reference	C
R2-13-11A	278.4	0.43	3.0	16.4	51.8	14.7	17.1	Very Poor	Partially Degraded	Partially Supporting	F
R2-13-12A	191.1	0.3	6.4	31.3	59.3	0.4	9.1	Very Poor	Partially Degraded	Supporting	DA
R2-13-13A	554.5	0.87	4.8	22.2	62.7	2.4	12.7	Poor	Degraded	Partially Supporting	G
R2-13-17A	2961.2	4.63	3.4	19.5	58.3	17.0	5.2	Poor	Degraded	Supporting	E
R2-13-22A	2866.4	4.48	3.5	19.9	57.2	17.6	5.4	Poor	Severely Degraded	Non Supporting	ND



R2-13-01 Rhode River Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.8937839582 **Longitude:** -76.5689603405

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**349.55**
Cover	**Acres**	**% Area**
Developed Land	**118.46**	**33.89**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0.81	0.23
Residential 1-Acre	0	0
Residential 2-Acre	114.24	32.68
Transportation	3.41	0.98
Utility	0	0
Forest Land	**154.89**	**44.31**
Forested Wetland	0	0
Residential Woods	0	0
Woods	154.89	44.31
Open Land	**40.41**	**11.56**
Open Space	39.16	11.2
Open Wetland	0	0
Water	1.25	0.36
Agricultural Land	**35.79**	**10.24**
Pasture/Hay	1.9	0.54
Row Crops	33.9	9.7
Impervious Surface	**Acres**	**% Area**
Impervious Land	16.4	4.7

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Polypedilum (midge) dominated the sample.
- Water quality values within COMAR standards.
- Low gradient, silt/clay dominated channel with good woody substrates, but habitat diversity limited. Good bank stability and riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is supporting and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-13-01 Rhode River Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	8
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	0
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	64.5

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	1
% Climbers	5
BIBI Score	**1.57**
BIBI Narrative Rating	**Very Poor**

Taxa	**Count**
Bivalvia	2
Chironomidae	1
Chironominae	2
Chironomini	10
Chironomus	11
Cricotopus/Orthocladius	1
Orthocladiinae	1
Orthocladius	1
Polypedilum	69
Rheocricotopus	3
Tipulidae	1
Tubificidae	4
Zavrelimyia	1
TOTAL:	**107**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	8	Pool Variability	7
Bank Stability- Right Bank	8	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	18	Riparian Vegetative Zone Width- Right Bank	9
Channel Flow Status	16	Sediment Deposition	12
Channel Sinuosity	10	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	8	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	9		
RBP Habitat Score			**131**
RBP Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	7	37.7	Instream Wood Debris	13	93.87
Shading	85	84.56	Instream Habitat	8	65.14
Epifaunal Substrate	8	64.53	Bank Stability	16	89.45
PHI Score					**72.54**
PHI Narrative Rating					**Partially Degraded**

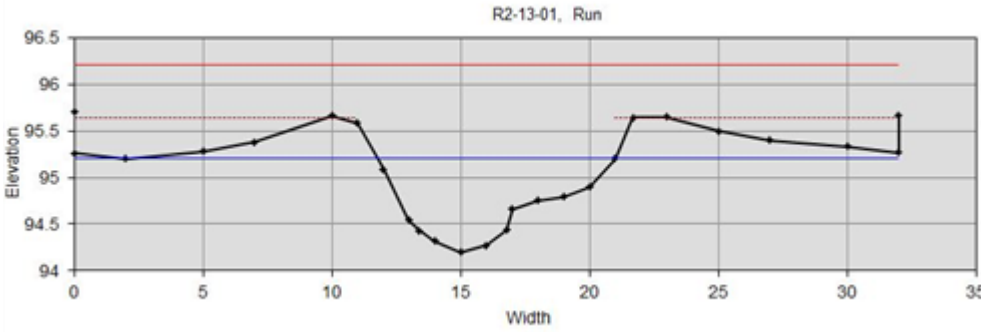
Water Chemistry

Dissolved Oxygen (mg/L)	11.18	pH (SU)	7.42
Turbidity (NTU)	6.16	Specific Conductivity (µS/cm)	234.5
Temperature (°C)	8.7		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.55	Cross Sectional Area (ft^2)	5.3
Bankfull Width (ft)	9.2	Water Surface Slope (%)	0.18
Mean Bankfull Depth (ft)	0.58	Sinuosity	1.1
Floodprone Width (ft)	195	D50 (mm)	0.088
Entrenchment Ratio	21.1	Adjustments?	None
Width to Depth Ratio	16	**Rosgen Stream Type**	**C5**



R2-13-03 Rhode River Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.9001599673 **Longitude:** -76.5665690317

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**203.7**
Cover	**Acres**	**% Area**
Developed Land	**70.89**	**34.8**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	4	1.96
Residential 1-Acre	3.73	1.83
Residential 2-Acre	58.7	28.81
Transportation	4.46	2.19
Utility	0	0
Forest Land	**81.43**	**39.97**
Forested Wetland	0	0
Residential Woods	0	0
Woods	81.43	39.97
Open Land	**38.54**	**18.92**
Open Space	37.43	18.38
Open Wetland	0	0
Water	1.11	0.54
Agricultural Land	**12.85**	**6.31**
Pasture/Hay	12.82	6.29
Row Crops	0.03	0.01
Impervious Surface	**Acres**	**% Area**
Impervious Land	12.2	6

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Amphipods and isopods (Caecidotea) dominated the sample.
- Measured below COMAR standards for pH.
- Incised gully with eroding banks throughout. Marginal instream habitat and epibenthic substrate. Poor vegetative protection.
- Stream type not determined due to effects from footbridge and headcut in middle of reach.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-13-03 Rhode River Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	19
EPT Taxa	4
Ephemeroptera Taxa	1
%Intolerant Urban	19.6
%Ephemeroptera	0.9
Scraper Taxa	0
% Climbers	9.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	3
%Intolerant Urban	3
%Ephemeroptera	3
Scraper Taxa	1
% Climbers	5
BIBI Score	**3**
BIBI Narrative Rating	**Fair**

Taxa	Count
Amphinemura	2
Amphipoda	44
Asellidae	7
Caecidotea	15
Caenis	1
Coenagrionidae	1
Crangonyctidae	5
Cricotopus/Orthocladius	1
Ironoquia	2
Lumbriculidae	1
Parametriocnemus	9
Polypedilum	9
Probezzia	1
Ptilostomis	1
Rheocricotopus	2
Rheotanytarsus	1
Saldidae	1
Simulium	1
Stegopterna	3
Thienemannimyia group	2
Tipula	3
TOTAL:	**112**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	3	Pool Variability	11
Bank Stability- Right Bank	3	Riparian Vegetative Zone Width- Left Bank	8
Channel Alteration	15	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	19	Sediment Deposition	12
Channel Sinuosity	9	Vegetative Protection - Left Bank	2
Epifaunal Substrate/Available Cover	10	Vegetative Protection - Right Bank	2
Pool Substrate Characterization	9		
RBP Habitat Score			**111**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	10	53.85	Instream Wood Debris	14	100
Shading	75	73.32	Instream Habitat	10	81.76
Epifaunal Substrate	9	73.86	Bank Stability	6	54.77
PHI Score					**72.93**
PHI Narrative Rating					**Partially Degraded**

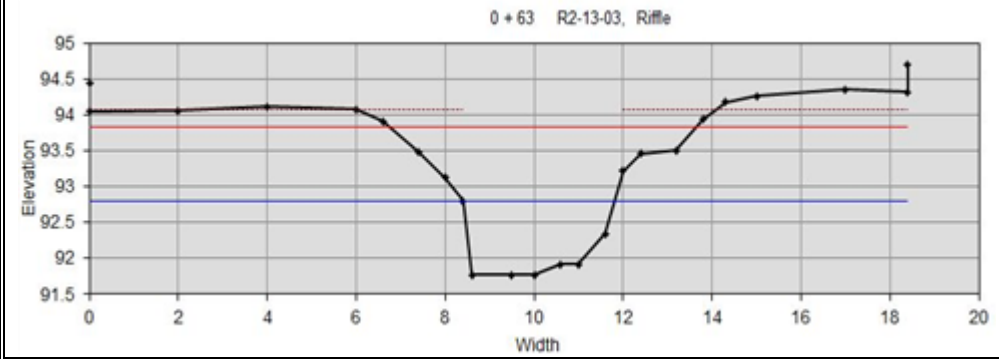
Water Chemistry

Dissolved Oxygen (mg/L)	9.79	pH (SU)	6.15
Turbidity (NTU)	6.57	Specific Conductivity (µS/cm)	190.1
Temperature (°C)	14.1		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.32	Cross Sectional Area (ft^2)	2.9
Bankfull Width (ft)	3.4	Water Surface Slope (%)	1
Mean Bankfull Depth (ft)	0.86	Sinuosity	1.1
Floodprone Width (ft)	6.9	D50 (mm)	0.15
Entrenchment Ratio	2	Adjustments?	None
Width to Depth Ratio	4	**Rosgen Stream Type**	**ND**



R2-13-04 Rhode River Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.89110207 **Longitude:** -76.5877889632

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**167.58**
Cover	**Acres**	**% Area**
Developed Land	**55.41**	**33.07**
Airport	0	0
Commercial	0.33	0.2
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	11.34	6.77
Residential 2-Acre	37.71	22.5
Transportation	6.03	3.6
Utility	0	0
Forest Land	**94.12**	**56.17**
Forested Wetland	0	0
Residential Woods	0	0
Woods	94.12	56.17
Open Land	**17.39**	**10.37**
Open Space	16.47	9.83
Open Wetland	0	0
Water	0.92	0.55
Agricultural Land	**0.66**	**0.39**
Pasture/Hay	0.66	0.39
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	11.3	6.8

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Amphipods (Gammarus) and midges (Polypedilum) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Deeply incised channel with silt/clay dominated substrate and low flow velocities. Stable benthic habitat lacking. Good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-13-04 Rhode River Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	19
EPT Taxa	2
Ephemeroptera Taxa	0
%Intolerant Urban	8.9
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	21.4

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	5
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Amphipoda	10
Asellidae	3
Caecidotea	4
Calopteryx	1
Chironominae	2
Chironomini	2
Chironomus	2
Cricotopus/Orthocladius	1
Dixa	1
Dytiscidae	2
Gammarus	37
Helichus	1
Ironoquia	4
Lepidoptera	1
Micropsectra	6
Neoporus	1
Orthocladius	1
Parametriocnemus	1
Paratendipes	1
Polypedilum	15
Pycnopsyche	1
Rheocricotopus	5
Tanypodinae	2
Tanytarsini	2
Tubificidae	1
Zavrelimyia	5
TOTAL:	**112**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	4	Pool Variability	7
Bank Stability- Right Bank	4	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	16	Sediment Deposition	5
Channel Sinuosity	9	Vegetative Protection - Left Bank	4
Epifaunal Substrate/Available Cover	7	Vegetative Protection - Right Bank	4
Pool Substrate Characterization	6		
RBP Habitat Score			**106**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	15	80.78	Instream Wood Debris	10	93.31
Shading	98	100	Instream Habitat	7	67.11
Epifaunal Substrate	7	63.51	Bank Stability	8	63.25
PHI Score					**77.99**
PHI Narrative Rating					**Partially Degraded**

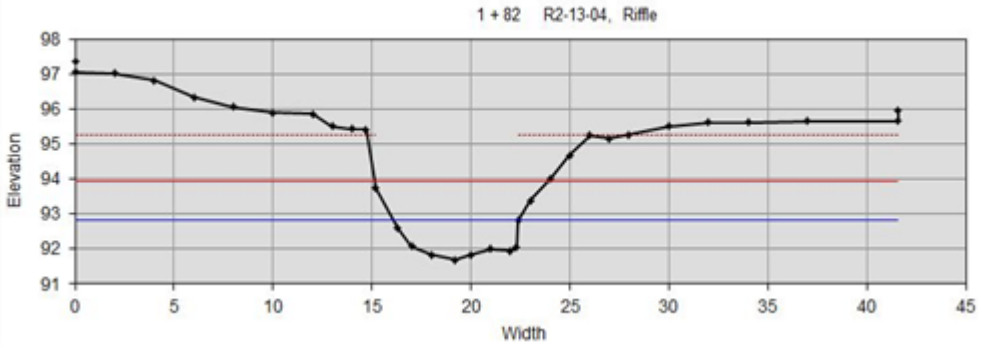
Water Chemistry

Dissolved Oxygen (mg/L)	9.68	pH (SU)	6.93
Turbidity (NTU)	18.8	Specific Conductivity (µS/cm)	320.4
Temperature (°C)	13		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.26	Cross Sectional Area (ft^2)	5.3
Bankfull Width (ft)	6.3	Water Surface Slope (%)	0.17
Mean Bankfull Depth (ft)	0.84	Sinuosity	1.1
Floodprone Width (ft)	8.7	D50 (mm)	0.062
Entrenchment Ratio	1.4	Adjustments?	None
Width to Depth Ratio	7.5	**Rosgen Stream Type**	**G6c**



R2-13-05 Rhode River Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.8862720197 **Longitude:** -76.5630647039

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**673.41**
Cover	**Acres**	**% Area**
Developed Land	**190.7**	**28.32**
Airport	0	0
Commercial	2.88	0.43
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	9.61	1.43
Residential 1-Acre	24.56	3.65
Residential 2-Acre	133.79	19.87
Transportation	19.87	2.95
Utility	0	0
Forest Land	**410.31**	**60.93**
Forested Wetland	0	0
Residential Woods	0	0
Woods	410.31	60.93
Open Land	**49.14**	**7.3**
Open Space	48.22	7.16
Open Wetland	0	0
Water	0.92	0.14
Agricultural Land	**23.26**	**3.45**
Pasture/Hay	19.79	2.94
Row Crops	3.47	0.51
Impervious Surface	**Acres**	**% Area**
Impervious Land	33.4	5

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Amphipods (Gammarus) and midges (Polypedilum) dominated the sample.
- Water quality values within COMAR standards.
- Low gradient stream with abundance of woody debris. Habitat complexity lacking but good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is supporting and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-13-05 Rhode River Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	15
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	9.8
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	25.9

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	1
% Climbers	5
BIBI Score	**1.86**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Amphinemura	9
Amphipoda	9
Asellidae	7
Caecidotea	1
Chironomidae	1
Chironomini	6
Chironomus	1
Cricotopus/Orthocladius	6
Diptera	1
Dytiscidae	1
Gammarus	24
Nanocladius	1
Orthocladiinae	1
Orthocladius	5
Parametriocnemus	1
Pisidium	1
Polypedilum	29
Rheocricotopus	3
Saldidae	1
Stegopterna	1
Thienemanniella	1
Tubificidae	2
TOTAL:	**112**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	8	Pool Variability	8
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	9
Channel Flow Status	18	Sediment Deposition	14
Channel Sinuosity	13	Vegetative Protection - Left Bank	8
Epifaunal Substrate/Available Cover	9	Vegetative Protection - Right Bank	6
Pool Substrate Characterization	8		
RBP Habitat Score			**137**
RBP Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	11	59.24	Instream Wood Debris	13	86.44
Shading	80	78.67	Instream Habitat	9	63.98
Epifaunal Substrate	9	66.07	Bank Stability	14	83.67
PHI Score					**73.01**
PHI Narrative Rating					**Partially Degraded**

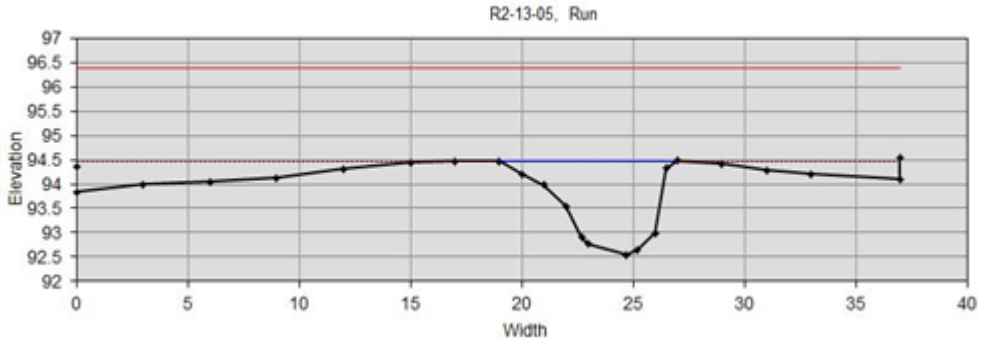
Water Chemistry

Dissolved Oxygen (mg/L)	9.92	pH (SU)	7.46
Turbidity (NTU)	8.63	Specific Conductivity (µS/cm)	216.6
Temperature (°C)	10.5		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	1.05	Cross Sectional Area (ft^2)	8.3
Bankfull Width (ft)	8	Water Surface Slope (%)	0.48
Mean Bankfull Depth (ft)	1.05	Sinuosity	1.2
Floodprone Width (ft)	200	D50 (mm)	0.097
Entrenchment Ratio	25.1	Adjustments?	None
Width to Depth Ratio	7.6	**Rosgen Stream Type**	**E5**



R2-13-08 Rhode River Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.8892010029 **Longitude:** -76.5647899307

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**464.24**
Cover	**Acres**	**% Area**
Developed Land	**135.89**	**29.27**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0.81	0.17
Residential 1-Acre	4.59	0.99
Residential 2-Acre	124.69	26.86
Transportation	5.8	1.25
Utility	0	0
Forest Land	**248.12**	**53.45**
Forested Wetland	0	0
Residential Woods	0	0
Woods	248.12	53.45
Open Land	**44.39**	**9.56**
Open Space	43.14	9.29
Open Wetland	0	0
Water	1.25	0.27
Agricultural Land	**35.84**	**7.72**
Pasture/Hay	1.95	0.42
Row Crops	33.9	7.3
Impervious Surface	**Acres**	**% Area**
Impervious Land	21.9	4.7

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Comparable to Reference"* and *"Degraded"*
- Isopods (Caecidotea) and midges (Polypedilum) dominated the sample.
- Water quality values within COMAR standards.
- Benthic habitat limited to vegetation and small woody debris. Good bank stability and riparian width. Excellent vegetative protection.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.
- Because habitat is comparable to reference and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-13-08 Rhode River Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	10
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	16.5
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	35

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	3
%Ephemeroptera	1
Scraper Taxa	1
% Climbers	5
BIBI Score	**1.86**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Asellidae	20
Bivalvia	3
Caecidotea	17
Ceratopogonidae	1
Chironomidae	1
Chironomini	4
Chironomus	2
Cricotopus/Orthocladius	4
Orthocladius	2
Phaenopsectra/Tribelos	1
Pisidium	4
Polypedilum	36
Rheocricotopus	5
Thienemanniella	1
Thienemannimyia group	1
Tubificidae	1
TOTAL:	**103**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	10	Pool Variability	10
Bank Stability- Right Bank	10	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	20	Sediment Deposition	15
Channel Sinuosity	12	Vegetative Protection - Left Bank	10
Epifaunal Substrate/Available Cover	7	Vegetative Protection - Right Bank	10
Pool Substrate Characterization	13		
RBP Habitat Score			**157**
RBP Narrative Rating			**Comparable to Reference**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	10	53.85	Instream Wood Debris	5	66.99
Shading	40	40.96	Instream Habitat	7	56.69
Epifaunal Substrate	7	56.88	Bank Stability	20	100
PHI Score					**62.56**
PHI Narrative Rating					**Degraded**

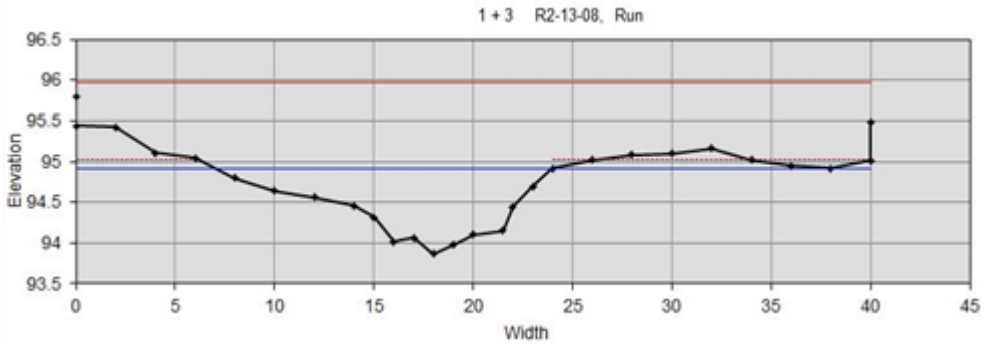
Water Chemistry

Dissolved Oxygen (mg/L)	10.81	pH (SU)	6.56
Turbidity (NTU)	6.62	Specific Conductivity (µS/cm)	225.8
Temperature (°C)	15.2		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.73	Cross Sectional Area (ft^2)	8.9
Bankfull Width (ft)	17	Water Surface Slope (%)	0.25
Mean Bankfull Depth (ft)	0.52	Sinuosity	1.2
Floodprone Width (ft)	165	D50 (mm)	0.062
Entrenchment Ratio	9.7	Adjustments?	None
Width to Depth Ratio	32.6	**Rosgen Stream Type**	**C6**



R2-13-11A Rhode River Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.8781670652 **Longitude:** -76.5918250166

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**278.37**
Cover	**Acres**	**% Area**
Developed Land	**45.67**	**16.41**
Airport	0	0
Commercial	5.73	2.06
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	2.33	0.84
Residential 1-Acre	18.47	6.63
Residential 2-Acre	16.88	6.06
Transportation	2.27	0.82
Utility	0	0
Forest Land	**144.26**	**51.82**
Forested Wetland	0	0
Residential Woods	0	0
Woods	144.26	51.82
Open Land	**47.45**	**17.05**
Open Space	47.45	17.05
Open Wetland	0	0
Water	0	0
Agricultural Land	**40.98**	**14.72**
Pasture/Hay	35.8	12.86
Row Crops	5.19	1.86
Impervious Surface	**Acres**	**% Area**
Impervious Land	8.4	3

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Gammarus (amphipod), Amphinemura (stonefly), and Polypedilum (midge) dominated the sample.
- Measured below COMAR standards for pH.
- Deeply incised channel with severe bank erosion. Numerous gravel riffles and large woody debris provide stable benthic habitat. Good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.
- Because habitat is partially supporting and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-13-11A Rhode River Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	9
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	21.3
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	25.9

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	3
%Ephemeroptera	1
Scraper Taxa	1
% Climbers	5
BIBI Score	**1.86**
BIBI Narrative Rating	**Very Poor**

Taxa	**Count**
Amphinemura	17
Amphipoda	23
Asellidae	1
Caecidotea	2
Chironomidae	3
Chironominae	3
Chironomini	2
Cricotopus/Orthocladius	1
Dicranota	4
Gammarus	20
Polypedilum	28
Thienemanniella	2
Tipula	1
Zavrelimyia	1
TOTAL:	**108**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	2	Pool Variability	12
Bank Stability- Right Bank	2	Riparian Vegetative Zone Width- Left Bank	8
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	15	Sediment Deposition	10
Channel Sinuosity	13	Vegetative Protection - Left Bank	4
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	4
Pool Substrate Characterization	11		
RBP Habitat Score			**122**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	14	75.39	Instream Wood Debris	10	87.57
Shading	90	91.34	Instream Habitat	10	78.57
Epifaunal Substrate	11	83.45	Bank Stability	4	44.72
PHI Score					**76.84**
PHI Narrative Rating					**Partially Degraded**

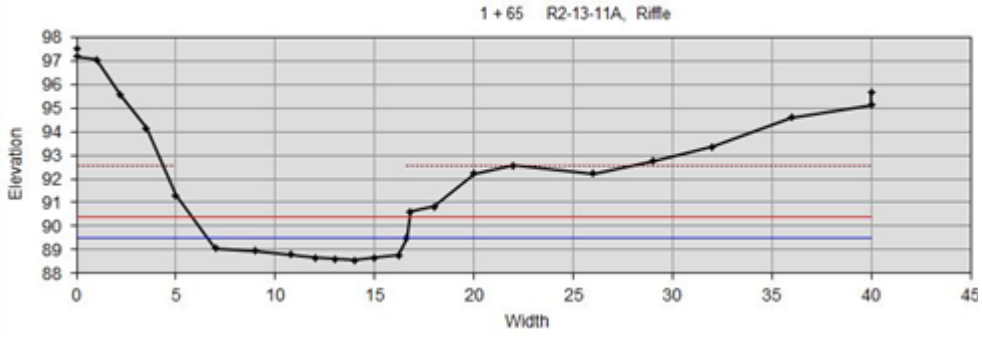
Water Chemistry

Dissolved Oxygen (mg/L)	11.98	pH (SU)	6.4
Turbidity (NTU)	10.6	Specific Conductivity (µS/cm)	157.5
Temperature (°C)	7.9		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.43	Cross Sectional Area (ft^2)	6.6
Bankfull Width (ft)	10	Water Surface Slope (%)	0.8
Mean Bankfull Depth (ft)	0.66	Sinuosity	1.2
Floodprone Width (ft)	11	D50 (mm)	0.15
Entrenchment Ratio	1.1	Adjustments?	None
Width to Depth Ratio	15.1	**Rosgen Stream Type**	**F5**



R2-13-12A Rhode River Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.8901001826 **Longitude:** -76.5845191406

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**191.07**
Cover	**Acres**	**% Area**
Developed Land	**59.78**	**31.29**
Airport	0	0
Commercial	0.33	0.17
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	11.34	5.93
Residential 2-Acre	42.08	22.02
Transportation	6.03	3.16
Utility	0	0
Forest Land	**113.24**	**59.27**
Forested Wetland	0	0
Residential Woods	0	0
Woods	113.24	59.27
Open Land	**17.39**	**9.1**
Open Space	16.47	8.62
Open Wetland	0	0
Water	0.92	0.48
Agricultural Land	**0.66**	**0.35**
Pasture/Hay	0.66	0.35
Row Crops	0	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	12.2	6.4

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Supporting"* and *"Partially Degraded"*
- Amphipods and midges (Polypedilum and Parametriocnemus) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Marginal instream habitat and epibenthic substrate. Good bank stability and riparian width. Excellent vegetative protection.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is supporting and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-13-12A Rhode River Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	15
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	4.2
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	11.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	1
% Climbers	5
BIBI Score	**1.86**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Amphipoda	40
Asellidae	10
Bivalvia	1
Caecidotea	5
Crangonyctidae	2
Cricotopus/Orthocladius	1
Dytiscidae	2
Gammarus	1
Limnophyes	1
Neoporus	1
Orthocladiinae	1
Orthocladius	1
Parametriocnemus	12
Pisidium	2
Planariidae	1
Polypedilum	14
Rheocricotopus	8
Thienemanniella	1
Thienemannimyia group	2
Tubificidae	7
Zavrelimyia	6
TOTAL:	**119**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	10	Pool Variability	8
Bank Stability- Right Bank	10	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	15	Sediment Deposition	16
Channel Sinuosity	14	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	8	Vegetative Protection - Right Bank	9
Pool Substrate Characterization	7		
RBP Habitat Score			**146**
RBP Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	14	75.39	Instream Wood Debris	6	80
Shading	85	84.56	Instream Habitat	7	65.77
Epifaunal Substrate	8	68.47	Bank Stability	20	100
PHI Score					**79.03**
PHI Narrative Rating					**Partially Degraded**

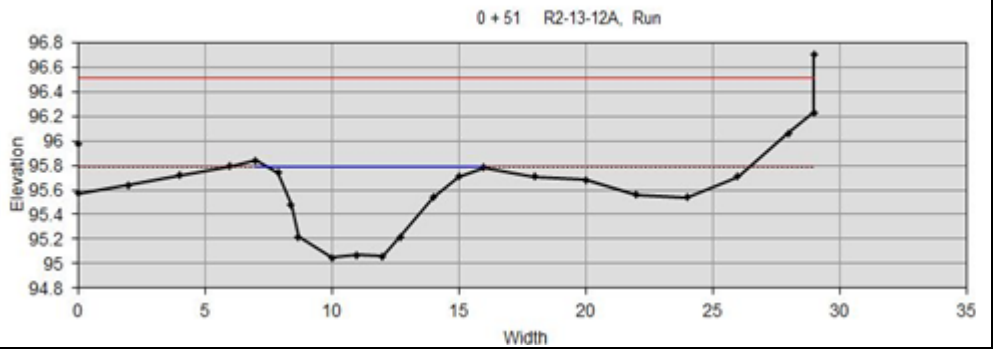
Water Chemistry

Dissolved Oxygen (mg/L)	8.44	pH (SU)	6.56
Turbidity (NTU)	19.8	Specific Conductivity (µS/cm)	311.1
Temperature (°C)	10.3		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.3	Cross Sectional Area (ft^2)	3.7
Bankfull Width (ft)	8.5	Water Surface Slope (%)	0.56
Mean Bankfull Depth (ft)	0.43	Sinuosity	1.3
Floodprone Width (ft)	200	D50 (mm)	0.062
Entrenchment Ratio	23.6	Adjustments?	None
Width to Depth Ratio	19.6	**Rosgen Stream Type**	**DA6**



R2-13-13A Rhode River Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.8897591319 **Longitude:** -76.5580259801

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**554.53**
Cover	**Acres**	**% Area**
Developed Land	**123.21**	**22.22**
Airport	0	0
Commercial	3.19	0.58
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	9.56	1.72
Residential 1-Acre	11.01	1.98
Residential 2-Acre	85.29	15.38
Transportation	14.16	2.55
Utility	0	0
Forest Land	**347.49**	**62.66**
Forested Wetland	0	0
Residential Woods	0	0
Woods	347.49	62.66
Open Land	**70.42**	**12.7**
Open Space	66.99	12.08
Open Wetland	0	0
Water	3.43	0.62
Agricultural Land	**13.41**	**2.42**
Pasture/Hay	13.39	2.41
Row Crops	0.03	0
Impervious Surface	**Acres**	**% Area**
Impervious Land	26.5	4.8

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Degraded"*
- Midges (Chironomus and Orthocladius) and black flies (Simulium) dominated the sample.
- Measured below COMAR standards for pH.
- Deeply incised channel with heavily eroded banks. Marginal instream habitat and epibenthic substrate but good riparian width.
- Biomodal distribution of substrate (sand/clay).

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-13-13A Rhode River Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	21
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	9.4
%Ephemeroptera	6.3
Scraper Taxa	2
% Climbers	5.2

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	3
%Intolerant Urban	1
%Ephemeroptera	3
Scraper Taxa	5
% Climbers	3
BIBI Score	**2.71**
BIBI Narrative Rating	**Poor**

Taxa	Count
Amphipoda	4
Asellidae	3
Bezzia	3
Bivalvia	8
Caecidotea	3
Caenis	6
Ceratopogonidae	1
Chironomini	3
Chironomus	11
Crangonyctidae	3
Cricotopus/Orthocladius	1
Diptera	1
Eukiefferiella	1
Hirudinea	1
Hydrobaenus	3
Neoporus	5
Orthocladiinae	3
Orthocladius	6
Parachironomus	1
Parametriocnemus	1
Pisidium	2
Planorbidae	1
Polypedilum	3
Simuliidae	4
Simulium	7
Tanypus	1
Tanytarsini	1
Tanytarsus	1
Thienemannimyia group	4
Tipula	1
Tubificidae	3
TOTAL:	**96**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	1	Pool Variability	7
Bank Stability- Right Bank	2	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	14	Sediment Deposition	9
Channel Sinuosity	14	Vegetative Protection - Left Bank	2
Epifaunal Substrate/Available Cover	6	Vegetative Protection - Right Bank	3
Pool Substrate Characterization	6		
RBP Habitat Score			**104**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	11	59.24	Instream Wood Debris	7	70.89
Shading	80	78.67	Instream Habitat	6	49.32
Epifaunal Substrate	6	49.91	Bank Stability	3	38.73
PHI Score					**57.79**
PHI Narrative Rating					**Degraded**

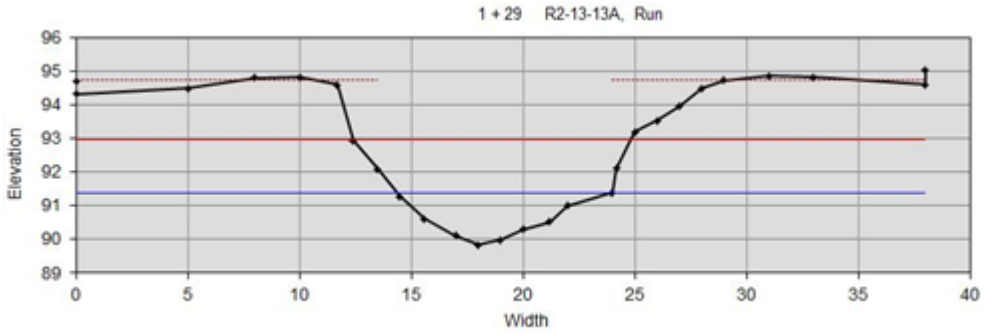
Water Chemistry

Dissolved Oxygen (mg/L)	9.15	pH (SU)	6.3
Turbidity (NTU)	15.5	Specific Conductivity (µS/cm)	190.8
Temperature (°C)	16.2		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.87	Cross Sectional Area (ft^2)	8.2
Bankfull Width (ft)	9.6	Water Surface Slope (%)	0.025
Mean Bankfull Depth (ft)	0.85	Sinuosity	1.4
Floodprone Width (ft)	12.4	D50 (mm)	0.067
Entrenchment Ratio	1.3	Adjustments?	None
Width to Depth Ratio	11.3	**Rosgen Stream Type**	**G5/6c**



R2-13-17A Rhode River Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.8822032186 **Longitude:** -76.5626588803

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**2961.2**
Cover	**Acres**	**% Area**
Developed Land	**578.01**	**19.52**
Airport	0	0
Commercial	16.93	0.57
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	12.57	0.42
Residential 1-Acre	123.45	4.17
Residential 2-Acre	318.77	10.77
Transportation	44.61	1.51
Utility	61.68	2.08
Forest Land	**1725.65**	**58.28**
Forested Wetland	0	0
Residential Woods	0	0
Woods	1725.65	58.28
Open Land	**154.21**	**5.21**
Open Space	152.43	5.15
Open Wetland	0	0
Water	1.77	0.06
Agricultural Land	**503.32**	**17**
Pasture/Hay	190.8	6.44
Row Crops	312.52	10.55
Impervious Surface	**Acres**	**% Area**
Impervious Land	100.7	3.4

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Supporting"* and *"Degraded"*
- Amphipods (Gammarus) and midges (Cricotopus/Orthocladius and Polypedilum) dominated the sample.
- Water quality values within COMAR standards.
- Sub-optimal instream habitat and epibenthic substrate. Marginal vegetative protection due to extensive presence of invasive phragmites along banks. Good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is supporting and biological condition is poor, look for problems with water quality and correct, if possible.

R2-13-17A Rhode River Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	15
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	2.9
%Ephemeroptera	0
Scraper Taxa	2
% Climbers	7.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	5
% Climbers	3
BIBI Score	**2.14**
BIBI Narrative Rating	**Poor**

Taxa	Count
Amphipoda	18
Caecidotea	3
Ceratopogonidae	1
Chironomini	4
Chironomus	4
Cricotopus	8
Cricotopus/Orthocladius	10
Diplocladius	1
Gammarus	19
Hydrobaenus	5
Menetus	1
Microtendipes	1
Orthocladiinae	4
Orthocladius	1
Paratanytarsus	3
Polypedilum	7
Tanytarsini	2
Thienemanniella	1
Thienemannimyia group	1
Tubificidae	8
TOTAL:	**102**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	3	Pool Variability	11
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	20	Sediment Deposition	10
Channel Sinuosity	12	Vegetative Protection - Left Bank	3
Epifaunal Substrate/Available Cover	12	Vegetative Protection - Right Bank	3
Pool Substrate Characterization	12		
RBP Habitat Score			**133**
RBP Narrative Rating			**Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	16	86.16	Instream Wood Debris	16	78.55
Shading	15	15.33	Instream Habitat	12	65.46
Epifaunal Substrate	11	68.04	Bank Stability	10	70.71
PHI Score					**64.04**
PHI Narrative Rating					**Degraded**

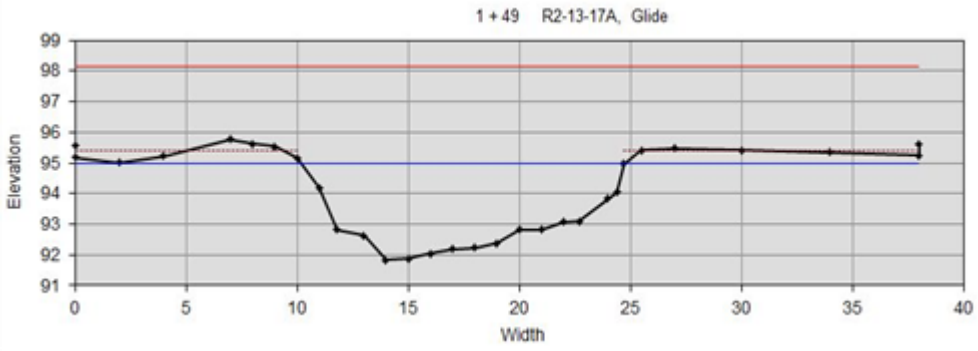
Water Chemistry

Dissolved Oxygen (mg/L)	11.39	pH (SU)	6.91
Turbidity (NTU)	15.8	Specific Conductivity (µS/cm)	177.7
Temperature (°C)	13		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	4.63	Cross Sectional Area (ft^2)	31.8
Bankfull Width (ft)	14.5	Water Surface Slope (%)	0.013
Mean Bankfull Depth (ft)	2.19	Sinuosity	1.1
Floodprone Width (ft)	170	D50 (mm)	0.18
Entrenchment Ratio	11.7	Adjustments?	None
Width to Depth Ratio	6.6	**Rosgen Stream Type**	**E5**



R2-13-22A Rhode River Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.8798645727 **Longitude:** -76.5653323167

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**2866.38**
Cover	**Acres**	**% Area**
Developed Land	**569.39**	**19.86**
Airport	0	0
Commercial	16.93	0.59
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	12.57	0.44
Residential 1-Acre	120.61	4.21
Residential 2-Acre	314.32	10.97
Transportation	43.28	1.51
Utility	61.68	2.15
Forest Land	**1639.45**	**57.2**
Forested Wetland	0	0
Residential Woods	0	0
Woods	1639.45	57.2
Open Land	**154.22**	**5.38**
Open Space	152.44	5.32
Open Wetland	0	0
Water	1.77	0.06
Agricultural Land	**503.32**	**17.56**
Pasture/Hay	190.8	6.66
Row Crops	312.52	10.9
Impervious Surface	**Acres**	**% Area**
Impervious Land	98.9	3.5

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Non Supporting"* and *"Severely Degraded"*
- Midges, including Polypedilum and Cricotopus/Orthocladius, dominated the sample.
- Water quality values within COMAR standards.
- Moderately stable banks throughout reach with minimal instream woody debris and marginal benthic habitat. Channel appears incised and mostly scoured to clay bottom with poor vegetative protection.
- Stream type not determined due to effects from large box culvert in upstream end of reach.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-13-22A Rhode River Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	18
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	17.4
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	22.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	3
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	5
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Ablabesmyia	1
Amphinemura	6
Amphipoda	3
Caecidotea	10
Calopteryx	1
Chironomini	1
Conchapelopia	1
Cricotopus	15
Cricotopus/Orthocladius	10
Eukiefferiella	1
Hydrobaenus	1
Microtendipes	2
Orthocladiinae	8
Parametriocnemus	1
Paratanytarsus	2
Polypedilum	20
Rheocricotopus	1
Tanytarsini	2
Thienemanniella	3
Thienemannimyia group	1
Tubificidae	1
Zavrelimyia	1
TOTAL:	**92**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	3	Pool Variability	9
Bank Stability- Right Bank	3	Riparian Vegetative Zone Width- Left Bank	8
Channel Alteration	11	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	19	Sediment Deposition	12
Channel Sinuosity	7	Vegetative Protection - Left Bank	2
Epifaunal Substrate/Available Cover	8	Vegetative Protection - Right Bank	2
Pool Substrate Characterization	8		
RBP Habitat Score			**100**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	0	0	Instream Wood Debris	4	43.42
Shading	85	84.56	Instream Habitat	9	49.15
Epifaunal Substrate	8	50.83	Bank Stability	6	54.77
PHI Score					**47.12**
PHI Narrative Rating					**Severely Degraded**

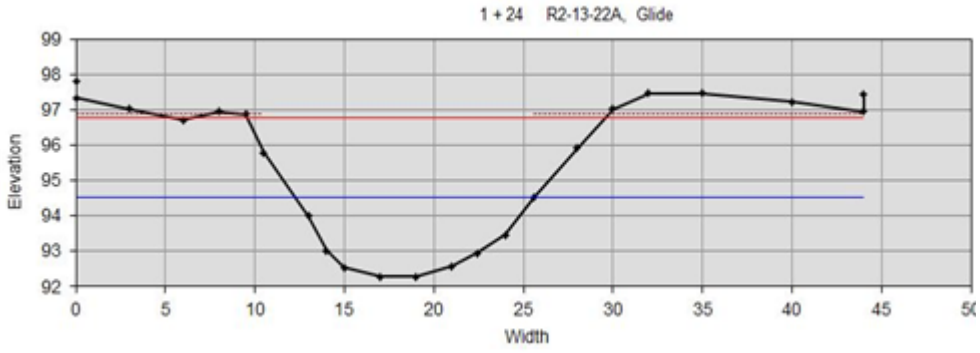
Water Chemistry

Dissolved Oxygen (mg/L)	11.85	pH (SU)	6.56
Turbidity (NTU)	16.1	Specific Conductivity (µS/cm)	180.5
Temperature (°C)	11		

Geomorphic Assessment

Rosgen Level II Classification Data

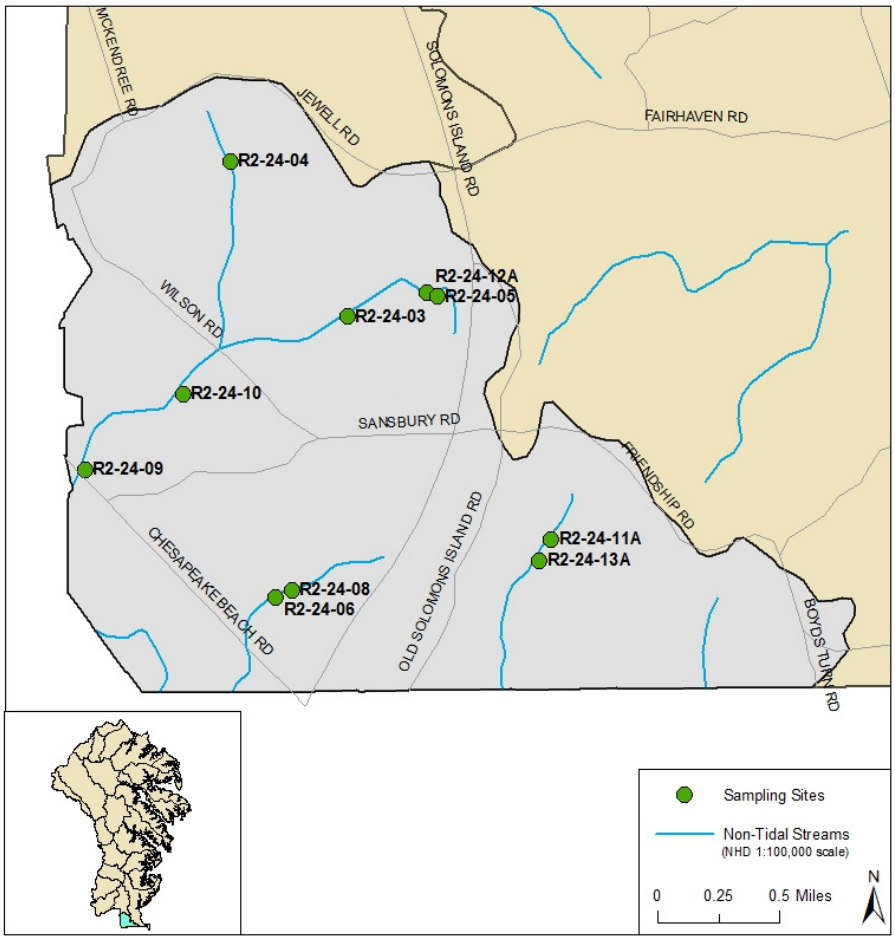
Drainage Area (mi^2)	4.48	Cross Sectional Area (ft^2)	21.3
Bankfull Width (ft)	13.3	Water Surface Slope (%)	0.046
Mean Bankfull Depth (ft)	1.6	Sinuosity	1
Floodprone Width (ft)	21.4	D50 (mm)	0.062
Entrenchment Ratio	1.6	Adjustments?	None
Width to Depth Ratio	8.3	**Rosgen Stream Type**	**ND**



Hall Creek Sampling Unit

Site Condition Summary

Site	Drainage Area (acres)	Drainage Area (mi^2)	Percent Impervious	Percent Developed	Percent Forested	Percent Agriculture	Percent Open	BIBI Narrative Rating	PHI Narrative Rating	RBP Narrative Rating	Rosgen Stream Type - L1
R2-24-03	339.6	0.53	8.0	42.1	47.8	9.3	0.9	Poor	Partially Degraded	Partially Supporting	G
R2-24-04	85.5	0.13	5.7	34.7	51.6	13.7	0.0	Very Poor	Partially Degraded	Partially Supporting	G
R2-24-05	168.4	0.26	10.2	44.2	47.9	6.8	1.1	Poor	Partially Degraded	Partially Supporting	G
R2-24-06	351.9	0.55	3.2	18.4	35.4	43.7	2.4	Very Poor	Partially Degraded	Partially Supporting	G
R2-24-08	342.5	0.54	3.3	18.9	34.4	44.2	2.5	Fair	Partially Degraded	Partially Supporting	G
R2-24-09	1488.1	2.33	4.5	30.6	56.5	10.1	2.9	Fair	Degraded	Non Supporting	ND
R2-24-10	1152.3	1.80	5.3	33.3	53.9	9.9	2.8	Poor	Degraded	Partially Supporting	ND
R2-24-11A	213.3	0.33	4.7	36.4	21.4	34.9	7.3	Very Poor	Degraded	Non Supporting	G
R2-24-12A	171.6	0.27	10.0	43.5	48.7	6.8	1.1	Very Poor	Partially Degraded	Partially Supporting	F
R2-24-13A	302.0	0.47	6.8	39.7	20.5	31.1	8.8	Very Poor	Degraded	Non Supporting	G



R2-24-03 Hall Creek Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.7434412553 **Longitude:** -76.601651423

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**339.57**
Cover	**Acres**	**% Area**
Developed Land	**142.82**	**42.06**
Airport	0	0
Commercial	7.06	2.08
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	2.6	0.77
Residential 2-Acre	121.51	35.78
Transportation	11.64	3.43
Utility	0	0
Forest Land	**162.21**	**47.77**
Forested Wetland	0	0
Residential Woods	0	0
Woods	162.21	47.77
Open Land	**3.02**	**0.89**
Open Space	3.02	0.89
Open Wetland	0	0
Water	0	0
Agricultural Land	**31.52**	**9.28**
Pasture/Hay	19.43	5.72
Row Crops	12.09	3.56
Impervious Surface	**Acres**	**% Area**
Impervious Land	27.2	8

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Midges, including Cricotopus/Orthocladius, Rheocricotopus, and Polypedilum, dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Channel with heavy deposition of fines reducing bed feature diversity. Mostly run/glide habitat with pool habitat lacking. Good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-24-03 Hall Creek Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	24
EPT Taxa	2
Ephemeroptera Taxa	0
%Intolerant Urban	6.3
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	10.7

Calculated Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	5
BIBI Score	**2.71**
BIBI Narrative Rating	**Poor**

Taxa	Count
Amphinemura	5
Amphipoda	9
Caecidotea	1
Chironomidae	1
Chironomini	1
Chironomus	1
Conchapelopia	1
Corynoneura	1
Cricotopus/Orthocladius	19
Diplocladius	1
Gammarus	1
Hemiptera	1
Hydrobaenus	1
Hydropsychidae	1
Naididae	1
Nemata	1
Odonata	1
Odontomesa	2
Orthocladiinae	3
Orthocladius	15
Parametriocnemus	3
Polypedilum	12
Rheocricotopus	15
Saldidae	2
Simuliidae	1
Simulium	1
Stegopterna	1
Tipulidae	1
Tubificidae	6
Zavrelimyia	3
TOTAL:	**112**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	7	Pool Variability	2
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	16	Sediment Deposition	5
Channel Sinuosity	10	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	7	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	8		
RBP Habitat Score			**113**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	12	64.62	Instream Wood Debris	9	82.36
Shading	80	78.67	Instream Habitat	6	54.34
Epifaunal Substrate	7	58.91	Bank Stability	13	80.63
PHI Score					**69.92**
PHI Narrative Rating					**Partially Degraded**

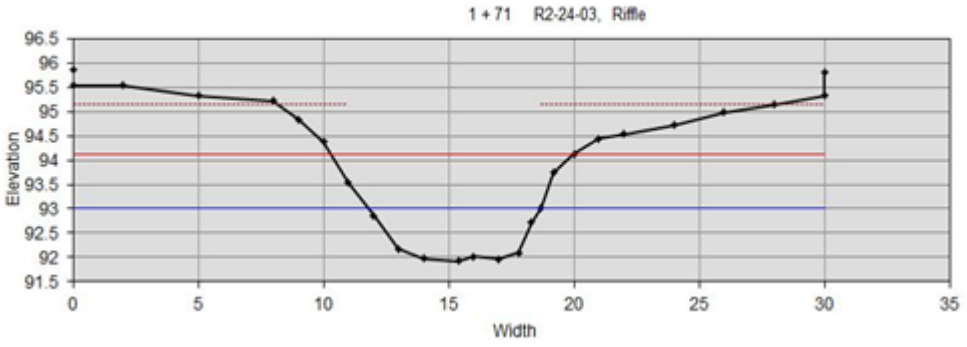
Water Chemistry

Dissolved Oxygen (mg/L)	9.1	pH (SU)	7.87
Turbidity (NTU)	12	Specific Conductivity (µS/cm)	262.9
Temperature (°C)	13.3		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.53	Cross Sectional Area (ft^2)	5.8
Bankfull Width (ft)	6.9	Water Surface Slope (%)	0.27
Mean Bankfull Depth (ft)	0.83	Sinuosity	1.1
Floodprone Width (ft)	9.7	D50 (mm)	0.16
Entrenchment Ratio	1.4	Adjustments?	None
Width to Depth Ratio	8.3	**Rosgen Stream Type**	**G5c**



R2-24-04 Hall Creek Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.7526387397 **Longitude:** -76.6104641449

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**85.47**
Cover	**Acres**	**% Area**
Developed Land	**29.67**	**34.72**
Airport	0	0
Commercial	0.51	0.59
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	12.56	14.69
Residential 2-Acre	14.78	17.29
Transportation	1.83	2.14
Utility	0	0
Forest Land	**44.13**	**51.63**
Forested Wetland	0	0
Residential Woods	0	0
Woods	44.13	51.63
Open Land	**0**	**0**
Open Space	0	0
Open Wetland	0	0
Water	0	0
Agricultural Land	**11.67**	**13.65**
Pasture/Hay	2.5	2.93
Row Crops	9.17	10.72
Impervious Surface	**Acres**	**% Area**
Impervious Land	4.9	5.7

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Gammarus (amphipod) and Amphinemura (stonefly) dominated the sample.
- Water quality values within COMAR standards.
- Small incised channel with heavy sediment deposition, which limits bed features. Mostly run/glide feature, pools lacking. Benthic habitat lacking but good riparian width.
- Adjusted ER - 0.1 to fit G type.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is partially supporting and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-24-04 Hall Creek Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	12
EPT Taxa	2
Ephemeroptera Taxa	0
%Intolerant Urban	25.3
%Ephemeroptera	0
Scraper Taxa	1
% Climbers	0

Calculated Metric Scores

Total Taxa	1
EPT Taxa	3
Ephemeroptera Taxa	1
%Intolerant Urban	3
%Ephemeroptera	1
Scraper Taxa	3
% Climbers	1
BIBI Score	**1.86**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Amphinemura	12
Amphipoda	24
Asellidae	3
Caecidotea	7
Ceratopogon	1
Chironomidae	1
Cordulegaster	2
Cricotopus/Orthocladius	5
Diplocladius	1
Gammarus	10
Hydrobaenus	5
Ironoquia	2
Lepidoptera	1
Orthocladiinae	5
Orthocladius	3
Thienemanniella	1
Tubificidae	4
TOTAL:	**87**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	5	Pool Variability	2
Bank Stability- Right Bank	5	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	13	Sediment Deposition	5
Channel Sinuosity	10	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	5	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	5		
RBP Habitat Score			**104**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	15	80.78	Instream Wood Debris	11	100
Shading	90	91.34	Instream Habitat	4	57.36
Epifaunal Substrate	5	56.28	Bank Stability	10	70.71
PHI Score					**76.08**
PHI Narrative Rating					**Partially Degraded**

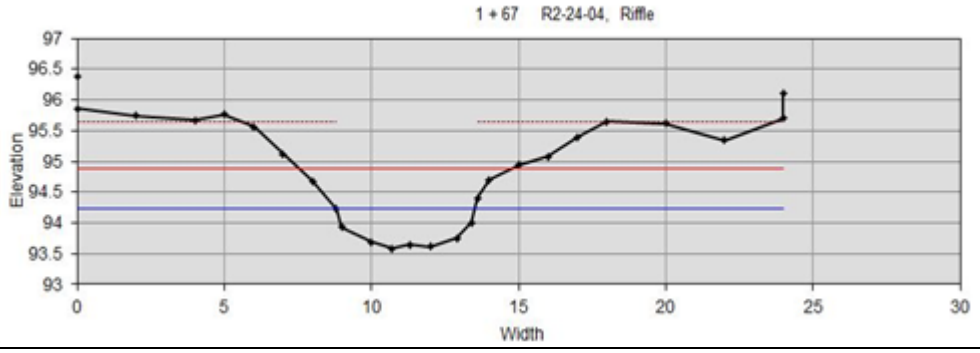
Water Chemistry

Dissolved Oxygen (mg/L)	11.05	pH (SU)	6.77
Turbidity (NTU)	16.8	Specific Conductivity (µS/cm)	174.6
Temperature (°C)	10		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.13	Cross Sectional Area (ft^2)	2.3
Bankfull Width (ft)	4.7	Water Surface Slope (%)	0.67
Mean Bankfull Depth (ft)	0.49	Sinuosity	1.1
Floodprone Width (ft)	7.2	D50 (mm)	0.11
Entrenchment Ratio	1.5	Adjustments?	Yes, ER -0.1
Width to Depth Ratio	9.5	**Rosgen Stream Type**	**G5c**



R2-24-05 Hall Creek Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.7446068478 **Longitude:** -76.5948744361

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**168.42**
Cover	**Acres**	**% Area**
Developed Land	**74.49**	**44.23**
Airport	0	0
Commercial	4.86	2.89
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	2.6	1.55
Residential 2-Acre	56.99	33.84
Transportation	10.03	5.96
Utility	0	0
Forest Land	**80.71**	**47.92**
Forested Wetland	0	0
Residential Woods	0	0
Woods	80.71	47.92
Open Land	**1.85**	**1.1**
Open Space	1.85	1.1
Open Wetland	0	0
Water	0	0
Agricultural Land	**11.37**	**6.75**
Pasture/Hay	10.16	6.03
Row Crops	1.21	0.72
Impervious Surface	**Acres**	**% Area**
Impervious Land	17.2	10.2

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Crane flies (Dicranota), amphipods, and midges (Orthocladius) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Channel appears mostly incised with heavy sediment deposition. Some woody debris providing stable substrate for benthos. Good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.

R2-24-05 Hall Creek Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	22
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	20
%Ephemeroptera	0
Scraper Taxa	2
% Climbers	2.9

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	3
%Ephemeroptera	1
Scraper Taxa	5
% Climbers	3
BIBI Score	**2.43**
BIBI Narrative Rating	**Poor**

Taxa	Count
Agabus	1
Amphinemura	3
Amphipoda	12
Caecidotea	1
Chironomus	3
Corynoneura	2
Cricotopus/Orthocladius	7
Dicranota	12
Diplocladius	2
Dytiscidae	5
Gammarus	2
Hydrobaenus	3
Neoporus	4
Odontomesa	2
Orthocladiinae	6
Orthocladius	10
Parametriocnemus	1
Physa	2
Polypedilum	1
Rheocricotopus	6
Simulium	1
Stegopterna	4
Tabanidae	1
Thienemanniella	2
Tubificidae	6
Zavrelimyia	6
TOTAL:	**105**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	5	Pool Variability	9
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	10	Sediment Deposition	6
Channel Sinuosity	12	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	8	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	8		
RBP Habitat Score			**119**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	11	59.24	Instream Wood Debris	6	81.42
Shading	95	99.94	Instream Habitat	8	72.61
Epifaunal Substrate	8	69.29	Bank Stability	11	74.16
PHI Score					**76.11**
PHI Narrative Rating					**Partially Degraded**

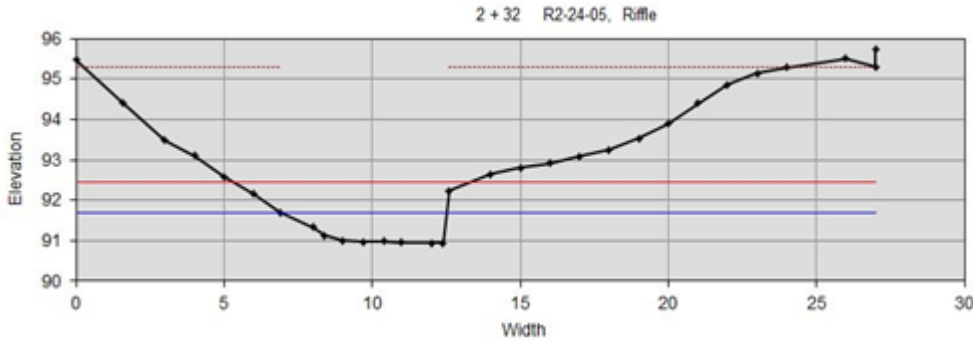
Water Chemistry

Dissolved Oxygen (mg/L)	12.27	pH (SU)	6.93
Turbidity (NTU)	4.55	Specific Conductivity (µS/cm)	330.3
Temperature (°C)	9.6		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.26	Cross Sectional Area (ft^2)	3.3
Bankfull Width (ft)	5.6	Water Surface Slope (%)	0.5
Mean Bankfull Depth (ft)	0.59	Sinuosity	1.3
Floodprone Width (ft)	8.1	D50 (mm)	0.18
Entrenchment Ratio	1.4	Adjustments?	None
Width to Depth Ratio	9.5	**Rosgen Stream Type**	**G5c**



R2-24-06 Hall Creek Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.7268528625 **Longitude:** -76.6071412793

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**351.89**
Cover	**Acres**	**% Area**
Developed Land	**64.82**	**18.42**
Airport	0	0
Commercial	6.53	1.86
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	9.47	2.69
Residential 2-Acre	37.46	10.65
Transportation	11.35	3.23
Utility	0	0
Forest Land	**124.72**	**35.44**
Forested Wetland	0	0
Residential Woods	0	0
Woods	124.72	35.44
Open Land	**8.45**	**2.4**
Open Space	8.18	2.32
Open Wetland	0	0
Water	0.27	0.08
Agricultural Land	**153.9**	**43.74**
Pasture/Hay	57.13	16.24
Row Crops	96.77	27.5
Impervious Surface	**Acres**	**% Area**
Impervious Land	11.2	3.2

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Gammarus (amphipod) and Polypedilum (midge) dominated the sample.
- Water quality values within COMAR standards.
- Heavy sediment deposition in channel has severely limited benthic habitat and minimized presence of pools. Channel incised and overwidened. Banks mostly stable and well vegetated. Good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-24-06 Hall Creek Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	13
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	6.3
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	34.2

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	1
% Climbers	5
BIBI Score	**1.57**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Amphinemura	7
Amphipoda	19
Calopteryx	1
Chironomidae	3
Chironomini	3
Conchapelopia	1
Cricotopus/Orthocladius	5
Gammarus	16
Naididae	1
Orthocladiinae	2
Orthocladius	5
Parametriocnemus	3
Polypedilum	37
Rheocricotopus	1
Rheotanytarsus	1
Simulium	1
Tanypodinae	2
Tipulidae	1
Tubificidae	2
TOTAL:	**111**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	6	Pool Variability	7
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	15	Sediment Deposition	5
Channel Sinuosity	7	Vegetative Protection - Left Bank	7
Epifaunal Substrate/Available Cover	6	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	6		
RBP Habitat Score			**114**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	16	86.16	Instream Wood Debris	14	96.75
Shading	100	100	Instream Habitat	6	53.97
Epifaunal Substrate	6	52.87	Bank Stability	13	80.63
PHI Score					**78.4**
PHI Narrative Rating					**Partially Degraded**

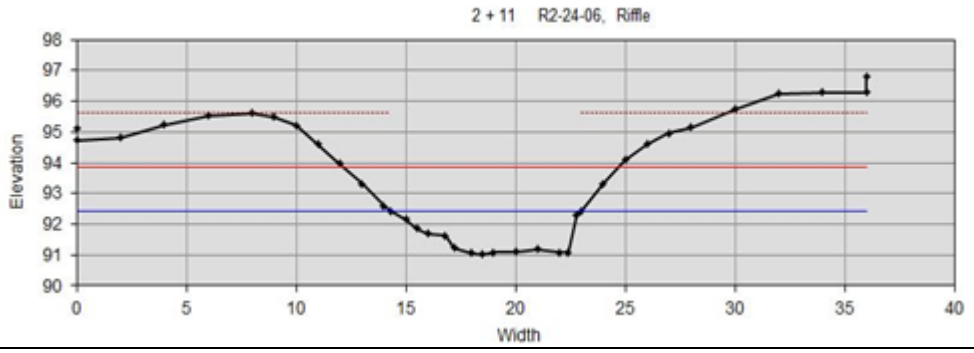
Water Chemistry

Dissolved Oxygen (mg/L)	11.4	pH (SU)	7
Turbidity (NTU)	10.4	Specific Conductivity (µS/cm)	227.4
Temperature (°C)	8.6		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.55	Cross Sectional Area (ft^2)	8.9
Bankfull Width (ft)	8.7	Water Surface Slope (%)	0.31
Mean Bankfull Depth (ft)	1.03	Sinuosity	1.1
Floodprone Width (ft)	12.6	D50 (mm)	0.15
Entrenchment Ratio	1.4	Adjustments?	None
Width to Depth Ratio	8.5	**Rosgen Stream Type**	**G5c**



R2-24-08 Hall Creek Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.7272717683 **Longitude:** -76.6059417669

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**342.46**
Cover	**Acres**	**% Area**
Developed Land	**64.82**	**18.93**
Airport	0	0
Commercial	6.53	1.91
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	9.47	2.77
Residential 2-Acre	37.46	10.94
Transportation	11.35	3.32
Utility	0	0
Forest Land	**117.83**	**34.41**
Forested Wetland	0	0
Residential Woods	0	0
Woods	117.83	34.41
Open Land	**8.45**	**2.47**
Open Space	8.18	2.39
Open Wetland	0	0
Water	0.27	0.08
Agricultural Land	**151.36**	**44.2**
Pasture/Hay	57.13	16.68
Row Crops	94.23	27.52
Impervious Surface	**Acres**	**% Area**
Impervious Land	11.2	3.3

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Polypedilum (midge) dominated the sample.
- Water quality values within COMAR standards.
- Heavy sediment deposition in channel, minimizing benthic substrate and bed feature diversity. Channel incised and overwidened, with some notably undercut banks. Good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Because habitat is partially supporting and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-24-08 Hall Creek Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	15
EPT Taxa	4
Ephemeroptera Taxa	1
%Intolerant Urban	4.7
%Ephemeroptera	0.9
Scraper Taxa	1
% Climbers	40.2

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	3
%Intolerant Urban	1
%Ephemeroptera	3
Scraper Taxa	3
% Climbers	5
BIBI Score	**3**
BIBI Narrative Rating	**Fair**

Taxa	Count
Amphinemura	2
Amphipoda	7
Boyeria	1
Chironominae	1
Chironomini	2
Cricotopus/Orthocladius	8
Dicranota	1
Gammarus	19
Hydrobaenus	1
Ironoquia	2
Isoperla	1
Orthocladius	11
Parametriocnemus	2
Plauditus	1
Polypedilum	42
Probezzia	1
Rheocricotopus	1
Tanypodinae	1
Thienemannimyia group	1
Tubificidae	2
TOTAL:	**107**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	5	Pool Variability	7
Bank Stability- Right Bank	6	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	14	Sediment Deposition	5
Channel Sinuosity	11	Vegetative Protection - Left Bank	6
Epifaunal Substrate/Available Cover	8	Vegetative Protection - Right Bank	7
Pool Substrate Characterization	9		
RBP Habitat Score			**118**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	16	86.16	Instream Wood Debris	9	82.26
Shading	95	99.94	Instream Habitat	7	59.8
Epifaunal Substrate	8	64.67	Bank Stability	11	74.16
PHI Score					**77.83**
PHI Narrative Rating					**Partially Degraded**

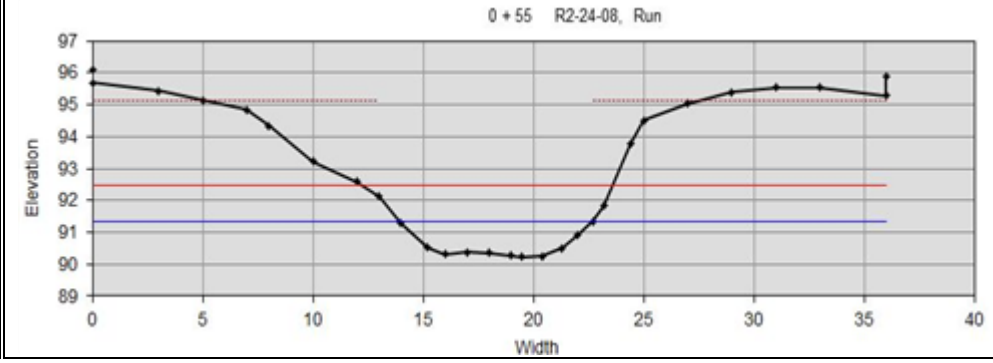
Water Chemistry

Dissolved Oxygen (mg/L)	11.14	pH (SU)	7
Turbidity (NTU)	7.4	Specific Conductivity (µS/cm)	239
Temperature (°C)	9.7		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.54	Cross Sectional Area (ft^2)	7.2
Bankfull Width (ft)	8.8	Water Surface Slope (%)	0.5
Mean Bankfull Depth (ft)	0.83	Sinuosity	1.3
Floodprone Width (ft)	11.3	D50 (mm)	0.18
Entrenchment Ratio	1.3	Adjustments?	None
Width to Depth Ratio	10.6	**Rosgen Stream Type**	**G5c**



R2-24-09 Hall Creek Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.7344378771 **Longitude:** -76.6215310803

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**1488.09**
Cover	**Acres**	**% Area**
Developed Land	**436.86**	**30.55**
Airport	0	0
Commercial	10.9	0.76
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	31.77	2.22
Residential 2-Acre	366.38	25.62
Transportation	27.81	1.94
Utility	0	0
Forest Land	**807.72**	**56.49**
Forested Wetland	0	0
Residential Woods	0	0
Woods	807.72	56.49
Open Land	**41.54**	**2.9**
Open Space	40.45	2.83
Open Wetland	0	0
Water	1.08	0.08
Agricultural Land	**143.83**	**10.06**
Pasture/Hay	72.07	5.04
Row Crops	71.77	5.02
Impervious Surface	**Acres**	**% Area**
Impervious Land	67.7	4.5

Summary Results:

- Biological condition – *"Fair"*
- Habitat scores *"Non Supporting"* and *"Degraded"*
- Midges, including Rheocricotopus, Orthocladiinae, and Cricotopus/Orthocladius, dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Lower 22 meters of reach within culvert. Mostly pool habitat, very low gradient with poor sinuosity. Incised channel with sand/silt substrate.
- Stream type not determined due to effect from double barrel culvert present in lower portion of reach.

Recommendations:

- Maintain the protection of the riparian areas.

R2-24-09 Hall Creek Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	19
EPT Taxa	4
Ephemeroptera Taxa	2
%Intolerant Urban	1.9
%Ephemeroptera	1.9
Scraper Taxa	4
% Climbers	15.5

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	5
%Intolerant Urban	1
%Ephemeroptera	3
Scraper Taxa	5
% Climbers	5
BIBI Score	**3.57**
BIBI Narrative Rating	**Fair**

Taxa	Count
Ablabesmyia	1
Amphipoda	3
Chironomidae	3
Chironominae	6
Chironomini	4
Chironomus	3
Crangonyctidae	1
Cricotopus/Orthocladius	7
Dicrotendipes	1
Diplocladius	1
Dytiscidae	4
Hydrobaenus	2
Leptoceridae	1
Leptophlebia	1
Lype	1
Maccaffertium	1
Menetus	2
Orthocladiinae	18
Orthocladius	3
Paracladopelma	1
Parametriocnemus	1
Planorbidae	1
Polypedilum	7
Rheocricotopus	20
Tanytarsini	1
Tanytarsus	6
Tubificidae	3
TOTAL:	**103**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	6	Pool Variability	10
Bank Stability- Right Bank	3	Riparian Vegetative Zone Width- Left Bank	7
Channel Alteration	6	Riparian Vegetative Zone Width- Right Bank	7
Channel Flow Status	16	Sediment Deposition	8
Channel Sinuosity	8	Vegetative Protection - Left Bank	3
Epifaunal Substrate/Available Cover	8	Vegetative Protection - Right Bank	5
Pool Substrate Characterization	8		
RBP Habitat Score			**95**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	1	5.39	Instream Wood Debris	10	68.59
Shading	95	99.94	Instream Habitat	9	55.86
Epifaunal Substrate	8	55.1	Bank Stability	9	67.08
PHI Score					**58.66**
PHI Narrative Rating					**Degraded**

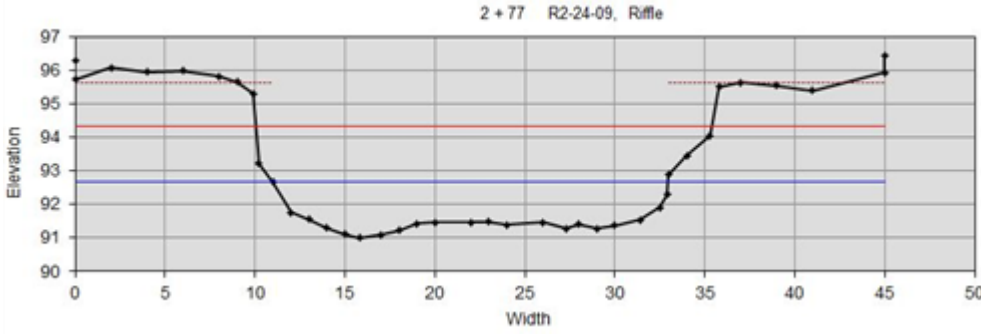
Water Chemistry

Dissolved Oxygen (mg/L)	10.35	pH (SU)	6.84
Turbidity (NTU)	18.3	Specific Conductivity (µS/cm)	268.7
Temperature (°C)	13.9		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	2.33	Cross Sectional Area (ft^2)	26.9
Bankfull Width (ft)	22	Water Surface Slope (%)	0.07
Mean Bankfull Depth (ft)	1.22	Sinuosity	1
Floodprone Width (ft)	25.4	D50 (mm)	0.11
Entrenchment Ratio	1.2	Adjustments?	None
Width to Depth Ratio	17.9	**Rosgen Stream Type**	**ND**



R2-24-10 Hall Creek Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.738928843 **Longitude:** -76.6140750071

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**1152.26**
Cover	**Acres**	**% Area**
Developed Land	**384.11**	**33.34**
Airport	0	0
Commercial	10.2	0.89
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	28.28	2.45
Residential 2-Acre	320.16	27.79
Transportation	25.47	2.21
Utility	0	0
Forest Land	**621.52**	**53.94**
Forested Wetland	0	0
Residential Woods	0	0
Woods	621.52	53.94
Open Land	**32.24**	**2.8**
Open Space	32.24	2.8
Open Wetland	0	0
Water	0	0
Agricultural Land	**114.4**	**9.93**
Pasture/Hay	57.52	4.99
Row Crops	56.88	4.94
Impervious Surface	**Acres**	**% Area**
Impervious Land	60.9	5.3

Summary Results:

- Biological condition – *"Poor"*
- Habitat scores *"Partially Supporting"* and *"Degraded"*
- Black flies (Simulium) and isopods (Caecidotea) dominated the sample.
- Water quality values within COMAR standards.
- Incised gully with very poor bank stability approximately 50 meters downstream of active headcut and large beaver dam. Good riparian width but poor vegetative protection.
- Channel altered by large beaver dam upstream resulting in two threads, one severely downcut. Stream type indeterminate.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-24-10 Hall Creek Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	19
EPT Taxa	2
Ephemeroptera Taxa	1
%Intolerant Urban	25.9
%Ephemeroptera	0.9
Scraper Taxa	0
% Climbers	2.8

Calculated Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	3
%Intolerant Urban	3
%Ephemeroptera	3
Scraper Taxa	1
% Climbers	3
BIBI Score	**2.71**
BIBI Narrative Rating	**Poor**

Taxa	Count
Amphipoda	6
Asellidae	6
Baetidae	1
Caecidotea	21
Chironomini	1
Conchapelopia	2
Cricotopus/Orthocladius	7
Dytiscidae	1
Eukiefferiella	2
Nanocladius	1
Neoplasta	1
Orthocladiinae	3
Orthocladius	5
Parachaetocladius	1
Perlesta	6
Polypedilum	1
Rheocricotopus	6
Simuliidae	4
Simulium	26
Thienemanniella	2
Thienemannimyia group	1
Trichocorixa	2
Tubificidae	1
Zavrelimyia	1
TOTAL:	**108**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	0	Pool Variability	12
Bank Stability- Right Bank	0	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	20	Sediment Deposition	14
Channel Sinuosity	10	Vegetative Protection - Left Bank	1
Epifaunal Substrate/Available Cover	11	Vegetative Protection - Right Bank	1
Pool Substrate Characterization	14		
RBP Habitat Score			**123**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	18	96.93	Instream Wood Debris	9	68.53
Shading	10	8.55	Instream Habitat	11	69.58
Epifaunal Substrate	11	74.19	Bank Stability	0	0
PHI Score					**52.96**
PHI Narrative Rating					**Degraded**

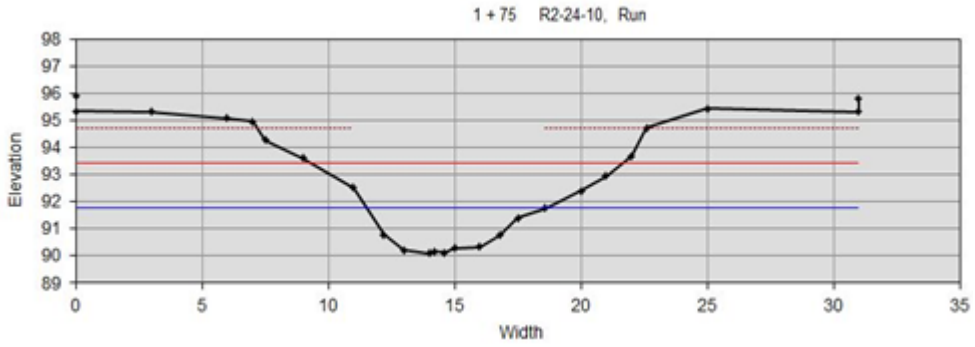
Water Chemistry

Dissolved Oxygen (mg/L)	8.21	pH (SU)	6.82
Turbidity (NTU)	25.8	Specific Conductivity (µS/cm)	243.3
Temperature (°C)	12.8		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	1.8	Cross Sectional Area (ft^2)	7.6
Bankfull Width (ft)	7.1	Water Surface Slope (%)	0.51
Mean Bankfull Depth (ft)	1.08	Sinuosity	1.1
Floodprone Width (ft)	12.3	D50 (mm)	0.062
Entrenchment Ratio	1.7	Adjustments?	None
Width to Depth Ratio	6.6	**Rosgen Stream Type**	**ND**



R2-24-11A Hall Creek Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.7302060959 **Longitude:** -76.5863603976

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**213.31**
Cover	**Acres**	**% Area**
Developed Land	**77.61**	**36.38**
Airport	0	0
Commercial	0	0
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	8.37	3.92
Residential 2-Acre	46.86	21.97
Transportation	6.52	3.06
Utility	15.86	7.43
Forest Land	**45.66**	**21.41**
Forested Wetland	0	0
Residential Woods	0	0
Woods	45.66	21.41
Open Land	**15.52**	**7.27**
Open Space	14.94	7.01
Open Wetland	0	0
Water	0.57	0.27
Agricultural Land	**74.52**	**34.93**
Pasture/Hay	41.41	19.41
Row Crops	33.11	15.52
Impervious Surface	**Acres**	**% Area**
Impervious Land	10.1	4.7

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Non Supporting"* and *"Degraded"*
- Amphipods (Gammarus) dominated the sample.
- Water quality values within COMAR standards.
- Deeply incised channel with heavily undercut banks. Channel scoured to clay bottom. Marginal instream habitat and epibenthic substrate with poor vegetative protection but good riparian width.
- Adjusted ER -0.2 to fit G type. Bimodal distribution of substrate (gravel/clay).

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-24-11A Hall Creek Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	7
EPT Taxa	0
Ephemeroptera Taxa	0
%Intolerant Urban	0.9
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	0.9

Calculated Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	1
% Climbers	1
BIBI Score	**1**
BIBI Narrative Rating	**Very Poor**

Taxa	**Count**
Amphipoda	34
Cricotopus/Orthocladius	6
Gammarus	51
Lepidoptera	1
Orthocladiinae	3
Orthocladius	9
Parametriocnemus	4
Polypedilum	1
Tabanidae	1
Thienemanniella	3
TOTAL:	**113**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	0	Pool Variability	6
Bank Stability- Right Bank	0	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	19	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	12	Sediment Deposition	13
Channel Sinuosity	9	Vegetative Protection - Left Bank	1
Epifaunal Substrate/Available Cover	7	Vegetative Protection - Right Bank	1
Pool Substrate Characterization	8		
RBP Habitat Score			**94**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	10	53.85	Instream Wood Debris	0	61
Shading	90	91.34	Instream Habitat	7	64.65
Epifaunal Substrate	7	61.94	Bank Stability	0	0
PHI Score					**55.46**
PHI Narrative Rating					**Degraded**

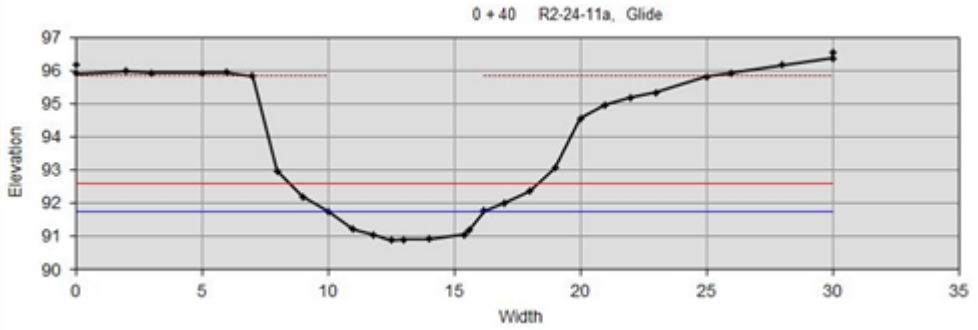
Water Chemistry

Dissolved Oxygen (mg/L)	10.88	pH (SU)	7.12
Turbidity (NTU)	15.3	Specific Conductivity (µS/cm)	174
Temperature (°C)	13.4		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.33	Cross Sectional Area (ft^2)	3.9
Bankfull Width (ft)	6.2	Water Surface Slope (%)	0.59
Mean Bankfull Depth (ft)	0.63	Sinuosity	1.1
Floodprone Width (ft)	9.9	D50 (mm)	0.22
Entrenchment Ratio	1.6	Adjustments?	Yes, ER -0.2
Width to Depth Ratio	9.8	**Rosgen Stream Type**	**G4/6c**



R2-24-12A Hall Creek Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.744839003 **Longitude:** -76.5956263407

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**171.59**
Cover	**Acres**	**% Area**
Developed Land	**74.67**	**43.52**
Airport	0	0
Commercial	4.86	2.83
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	0	0
Residential 1-Acre	2.6	1.52
Residential 2-Acre	57.18	33.32
Transportation	10.03	5.85
Utility	0	0
Forest Land	**83.47**	**48.65**
Forested Wetland	0	0
Residential Woods	0	0
Woods	83.47	48.65
Open Land	**1.85**	**1.08**
Open Space	1.85	1.08
Open Wetland	0	0
Water	0	0
Agricultural Land	**11.59**	**6.76**
Pasture/Hay	10.38	6.05
Row Crops	1.21	0.71
Impervious Surface	**Acres**	**% Area**
Impervious Land	17.2	10

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Partially Supporting"* and *"Partially Degraded"*
- Amphipods (Gammarus) and worms (Tubificidae) dominated the sample.
- Water quality values within COMAR standards but conductivity elevated.
- Incised channel with heavy sediment deposition and minimal variation in bed features. Good bank stability and riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.
- Because habitat is partially supporting and biological condition is very poor, look for problems with water quality and correct, if possible.

R2-24-12A Hall Creek Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	21
EPT Taxa	1
Ephemeroptera Taxa	0
%Intolerant Urban	11
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	0

Calculated Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
%Intolerant Urban	3
%Ephemeroptera	1
Scraper Taxa	1
% Climbers	1
BIBI Score	**1.57**
BIBI Narrative Rating	**Very Poor**

Taxa	Count
Amphinemura	4
Amphipoda	15
Caecidotea	2
Chironominae	1
Chironomini	2
Chironomus	2
Corixidae	1
Corynoneura	1
Cricotopus/Orthocladius	3
Dicranota	2
Diplocladius	1
Dytiscidae	3
Enchytraeidae	1
Gammarus	13
Naididae	2
Orthocladiinae	9
Orthocladius	4
Parametriocnemus	4
Pilaria	1
Plecoptera	2
Probezzia	1
Rheocricotopus	9
Saldidae	2
Stegopterna	1
Tanypodinae	1
Thienemanniella	2
Tubificidae	19
Zavrelimyia	1
TOTAL:	**109**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	9	Pool Variability	7
Bank Stability- Right Bank	7	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	20	Riparian Vegetative Zone Width- Right Bank	10
Channel Flow Status	9	Sediment Deposition	6
Channel Sinuosity	7	Vegetative Protection - Left Bank	9
Epifaunal Substrate/Available Cover	7	Vegetative Protection - Right Bank	8
Pool Substrate Characterization	7		
RBP Habitat Score			**116**
RBP Narrative Rating			**Partially Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	11	59.24	Instream Wood Debris	4	75.3
Shading	95	99.94	Instream Habitat	7	66.87
Epifaunal Substrate	7	63.36	Bank Stability	16	89.45
PHI Score					**75.69**
PHI Narrative Rating					**Partially Degraded**

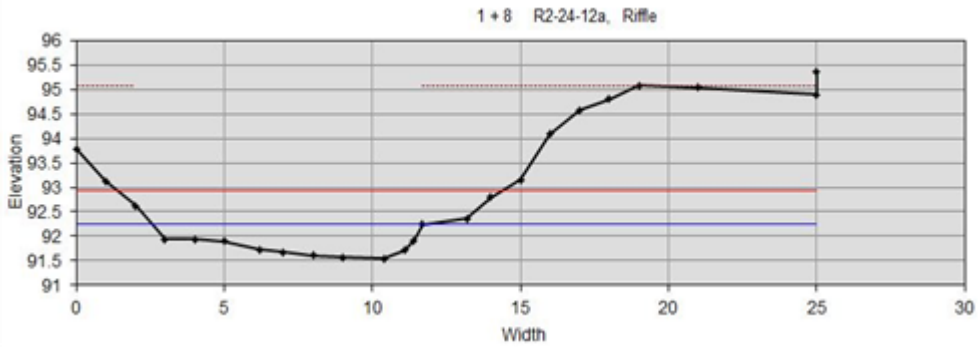
Water Chemistry

Dissolved Oxygen (mg/L)	11.74	pH (SU)	6.83
Turbidity (NTU)	4.81	Specific Conductivity (µS/cm)	336.9
Temperature (°C)	7.7		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.27	Cross Sectional Area (ft^2)	4.4
Bankfull Width (ft)	9.1	Water Surface Slope (%)	0.34
Mean Bankfull Depth (ft)	0.49	Sinuosity	1
Floodprone Width (ft)	13	D50 (mm)	0.13
Entrenchment Ratio	1.4	Adjustments?	None
Width to Depth Ratio	18.8	**Rosgen Stream Type**	**F5**



R2-24-13A Hall Creek Sampling Unit

Upstream View:

Downstream View:

Latitude: 38.7289586341 **Longitude:** -76.5872649252

Land Use/Land Cover Analysis:

Total Drainage Area (acres)		**301.99**
Cover	**Acres**	**% Area**
Developed Land	**119.87**	**39.69**
Airport	0	0
Commercial	5.64	1.87
Industrial	0	0
Residential 1/8-acre	0	0
Residential 1/4-acre	0	0
Residential 1/2-acre	1.5	0.5
Residential 1-Acre	9.91	3.28
Residential 2-Acre	75.97	25.16
Transportation	10.5	3.48
Utility	16.34	5.41
Forest Land	**61.85**	**20.48**
Forested Wetland	0	0
Residential Woods	0	0
Woods	61.85	20.48
Open Land	**26.42**	**8.75**
Open Space	25.85	8.56
Open Wetland	0	0
Water	0.57	0.19
Agricultural Land	**93.86**	**31.08**
Pasture/Hay	41.41	13.71
Row Crops	52.45	17.37
Impervious Surface	**Acres**	**% Area**
Impervious Land	20.5	6.8

Summary Results:

- Biological condition – *"Very Poor"*
- Habitat scores *"Non Supporting"* and *"Degraded"*
- Midges (Cricotopus/Orthocladius) and amphipods (Gammarus) dominated the sample.
- Water quality values within COMAR standards.
- Channel deeply incised with poor complexity of bed features and unstable banks. Pools lacking due to heavy bed deposition. Marginal benthic habitat and poor vegetative protection, but good riparian width.

Recommendations:

- Maintain the protection of the riparian areas.
- Determine causes of instability observed in this reach and evaluate potential for stabilization.

R2-24-13A Hall Creek Sampling Unit

Biological Assessment

Raw Metric Values

Total Taxa	11
EPT Taxa	2
Ephemeroptera Taxa	0
%Intolerant Urban	6.4
%Ephemeroptera	0
Scraper Taxa	0
% Climbers	5.5

Calculated Metric Scores

Total Taxa	1
EPT Taxa	3
Ephemeroptera Taxa	1
%Intolerant Urban	1
%Ephemeroptera	1
Scraper Taxa	1
% Climbers	3
BIBI Score	**1.57**
BIBI Narrative Rating	**Very Poor**

Taxa	**Count**
Amphinemura	6
Amphipoda	9
Asellidae	1
Chironomini	2
Cricotopus/Orthocladius	20
Dicranota	1
Gammarus	30
Ironoquia	1
Nemata	1
Orthocladiinae	2
Orthocladius	27
Polypedilum	6
Rheocricotopus	1
Simulium	1
Thienemannimyia group	2
TOTAL:	**110**

Physical Habitat Assessment

EPA Rapid Bioassessment Protocol

	Score		Score
Bank Stability- Left Bank	1	Pool Variability	5
Bank Stability- Right Bank	1	Riparian Vegetative Zone Width- Left Bank	10
Channel Alteration	19	Riparian Vegetative Zone Width- Right Bank	8
Channel Flow Status	15	Sediment Deposition	5
Channel Sinuosity	9	Vegetative Protection - Left Bank	2
Epifaunal Substrate/Available Cover	6	Vegetative Protection - Right Bank	2
Pool Substrate Characterization	6		
RBP Habitat Score			**89**
RBP Narrative Rating			**Non Supporting**

MBSS Physical Habitat Index

	Value	Score		Value	Score
Remoteness	11	59.24	Instream Wood Debris	4	68.9
Shading	98	100	Instream Habitat	5	49.99
Epifaunal Substrate	6	53.87	Bank Stability	2	31.62
PHI Score					**60.6**
PHI Narrative Rating					**Degraded**

Water Chemistry

Dissolved Oxygen (mg/L)	9.3	pH (SU)	7.28
Turbidity (NTU)	13.8	Specific Conductivity (µS/cm)	206.3
Temperature (°C)	15.5		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi^2)	0.47	Cross Sectional Area (ft^2)	7.6
Bankfull Width (ft)	8.2	Water Surface Slope (%)	0.49
Mean Bankfull Depth (ft)	0.92	Sinuosity	1.1
Floodprone Width (ft)	10.4	D50 (mm)	0.15
Entrenchment Ratio	1.3	Adjustments?	None
Width to Depth Ratio	9	**Rosgen Stream Type**	**G5c**