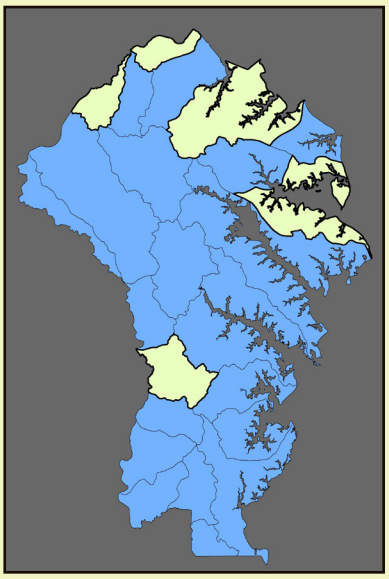

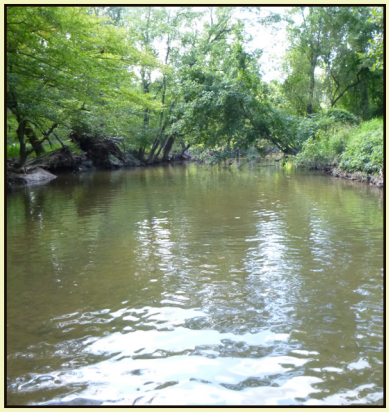

Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2018

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

Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2018 Round Three—Year Two

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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 Protection and Restoration 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. A stream's ability to support aquatic life is assessed for the entire County through probabilistic (random) site selection, surveying of biological communities, and observations of the physical habitat and water quality.

The County's assessment Program was continued in 2018 with sampling in five primary sampling units; Lower Magothy River, Lower Patapsco River, Marley Creek, Piney Run, and Stocketts Run. Sampling consisted of a 50/50 split between newly selected random sites, and repeat sites from Round One and Round Two. The indicators used to assess the aquatic life and habitat in Anne Arundel County streams include the Maryland Biological Stream Survey (MBSS) Benthic Index of Biological Integrity (BIBI), Fish Index of Biotic Integrity (FIBI), the USEPA Rapid Bioassessment Protocol (RBP) physical habitat assessment, the MBSS Physical Habitat Index (PHI), five physio-chemical water quality measures (temperature, dissolved oxygen, specific conductance, pH, and turbidity), seventeen water quality parameters measured from grab sample, as well as a detailed geomorphic assessment and classification using methods developed by Rosgen (1996).

Each of the biological and physical habitat indicators was compared to established thresholds to determine narrative condition ratings. Four of the five sampling units had mean BIBI values that resulted in 'Poor' biological condition ratings and one rated 'Fair'. Four of the five sampling units had mean FIBI values that resulted in 'Poor' biological condition ratings, and one sampling unit had a mean FIBI value that resulted in 'Fair' rating. Three of the five sampling units had mean physical habitat conditions rated as 'Partially Supporting' by the RBP method from spring sampling, one had a mean rating of 'Supporting', and one had a mean rating of 'Non-Supporting'. Using the PHI from summer sampling, two sampling units had 'Partially Degraded' mean physical habitat conditions, and the remaining three sampling unit had a mean habitat condition of 'Degraded'.

More than one-half of reaches were either entrenched F channels (30 percent) or entrenched G channels (25 percent). Approximately 20 percent of the sites classified as E channels. Water quality measurements exceeded COMAR standards for average monthly turbidity (i.e., <50 NTU) at one site in the spring and three sites during the summer. Five of 40 sites in the spring and 0 of 40 sites in the summer had recorded pH values that fell below state standards of 6.5 standard units. For dissolved oxygen, one of 40 sites in the spring and four of 40 sites in the summer had measured DO concentrations below the 5.0 mg/L standard. Thirty-two of 40 sites in the spring and 24 of 40 sites in the summer had conductivity values that exceeded 247 µS/cm threshold of BIBI impairment developed from MBSS data.

On average, BIBI scores improved in Marley Creek from Round 2 to Round 3, and remained the same in all other sampling units from Round One and Two to Round Three. In addition, a weak negative trend was detected between changes in BIBI scores and increase in cross-sectional area.

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For more information about this report, please contact:

Christopher Victoria
Ecological Assessment and Evaluation Program
Watershed Protection and Restoration Program
Department of Public Works
Anne Arundel County
2662 Riva Road / MS 7409
Annapolis, Maryland 21401
410.222.0545
pwvict16@aacounty.org

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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 human population and development in the basin are intensifying point and nonpoint sources of pollutants and multiple other stressors that affect environmental conditions.

In order to protect these important resources and inform management decisions – not only for the streams and rivers of the County but ultimately for the Chesapeake Bay – basic information regarding overall conditions must be understood. To more fully assess the condition of its watershed and stream resources, a Countywide Biological Monitoring and Assessment Program (Program) was initiated in the spring of 2004 by the Anne Arundel County Office of Environmental and Cultural Resources (now the Watershed Protection and Restoration Program 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. During Rounds 1 and 2, 10 sites were sampled in each PSU. However, beginning in Round Three the sampling approach was revised to allow for sampling eight sites per PSU. Table 1 illustrates the progress made to date within the Program. The first sampling rotation, Round One, was completed from 2004-2008, while Round Two was completed from 2009-2013. Sampling efforts in 2018 mark the second year of Round Three sampling with 40 randomly selected sites sampled throughout five sampling units (i.e., 8 per PSU).

Prior to the start of Round Three, the County commissioned a review of the Program which was completed in 2016 (Southland et al, 2016). Based on this review the County added several new sampling components to the Program. These new components of the Program were collected for the first time in 2017 and will continue through the completion of Round Three. A water quality grab sample is now collected at each of the sites and is analyzed for nutrients, sediment, metals, and other parameters. A complete discussion of the water quality grab sample methods are available in section 2.2.4. To complement the benthic macroinvertebrate community data and Benthic Index of Biotic Integrity (BIBI) collected by the Program, a fish community assessment was added to each site to allow for the calculation of the Fish Index of Biotic Integrity (FIBI). The fish sampling follows closely the two-pass electrofishing method developed by the MBSS and is explained in detail in section 2.2.3. Each site is now visited two times, once in the spring and once in the summer. The addition of the second summer visit allows the collection of an additional set of habitat data. The Rapid Bioassessment Protocol (RBP) and MBSS Physical Habitat Index (PHI) habitat assessments are now collected a second time during the summer visit. Both the RBP and PHI habitat assessments are described in detail in section 2.2.1. For the purpose of this annual monitoring summary report, the BIBI data are reported with the spring-collected RBP habitat assessment and the FIBI data are reported with the summer-collected PHI habitat assessment.

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	
2013	50	08-Lower Magothy 10-Severn River	19-Stocketts Run 22-Lyons Creek	23-Cabin Branch
Round 3				
2017	40	06-Bodkin Creek 09-Severn Run	10-Severn River 11-Upper North River	13-Rhode River
2018	40	01-Piney Run 03-Lower Patapsco River	05-Marley Creek 08-Lower Magothy River	19-Stocketts Run

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).

As detailed in the Round 3 Program design update (Southerland et al, 2016), fish communities have been found to respond to different environmental stressors as compared to benthic macroinvertebrates, therefore the addition of fish as a biological parameter provides a more complete picture of stream health. Fish sampling provides data on stream habitat connectivity and barriers, invasive species, recreational fisheries, and migratory species.

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.

Water chemistry parameters are measured *In situ* and grab samples are collected for laboratory analysis at every site to supplement biological and physical data. Water chemistry data provides a general indication of the chemical constituents 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

The sampling design uses a stratified random sampling approach, stratified by stream order. 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 (Southerland et al, 2016; 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 (QAPP) (Anne Arundel County, 2017). 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 sites are randomly selected for sampling based on stream order stratification. In this approach, 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. Four to five PSUs are sampled each year, so that all sampling units are assessed over a five-year period.

For 2018, sites were randomly selected from each of the following PSUs (with PSU code); Lower Magothy River (08), Lower Patapsco River (03), Marley Creek (05), Piney Run (01), and Stocketts Run (19). Figure 1 shows the geographic distribution of PSUs assessed during this sampling period. Sampling was conducted at eight sites in each of the five PSUs during 2018. A single site within each PSU was selected to conduct duplicate sampling for quality assurance/quality control (QA/QC) 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 reviewed 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. Habitat assessments, biological sampling, and water quality measurements were repeated at the duplicate sites.

Sites were located in the field using a Trimble R1 GNSS GPS unit coupled with a Microsoft Surface tablet running ESRI's ArcPad mapping software and loaded with recent (2016), 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 actual 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 final 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.

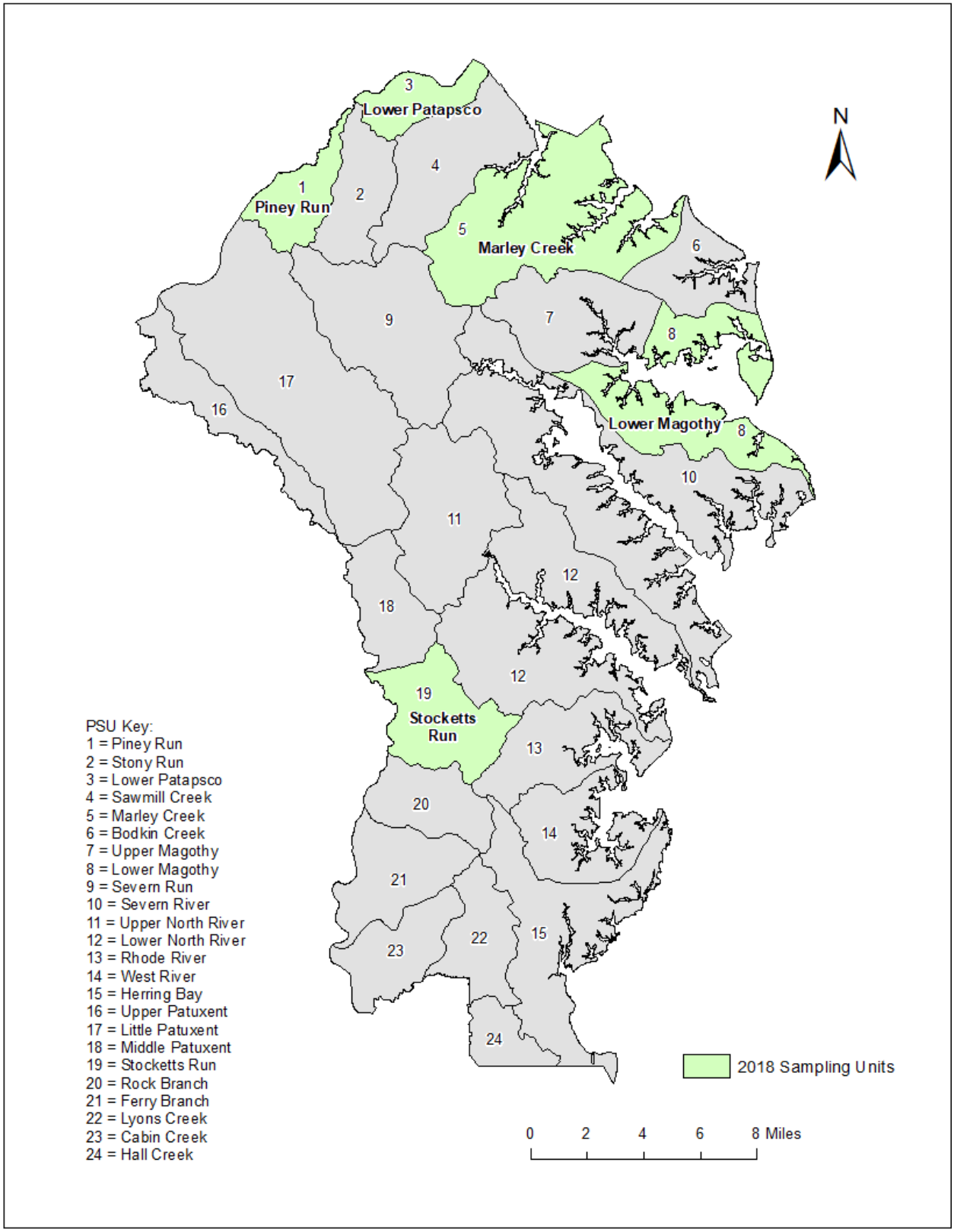


Figure 1 - 2018 Sampling Units

2.2 Field and Laboratory Procedures

2.2.1 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 site. Both physical habitat assessment methods were completed during the Spring and Summer assessments. 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 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 to document general reach conditions. Four additional photographs were taken at the cross section location facing in the upstream, downstream, left bank, and right bank directions, documenting the channel conditions at the cross section 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 2.

Table 2 - 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 3). 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 3 - PHI Habitat Parameters

Parameters Assessed	
Remoteness	Instream habitat
Shading	Woody debris and rootwads
Epifaunal substrate	Bank stability

Source: Paul et al. 2003

2.2.2 Benthic Macroinvertebrate Sampling and Processing

Benthic macroinvertebrate samples were collected during the Spring Index Period (March 1 through April 30) following the sampling protocols in the QAPP, which closely mirrors MBSS procedures (Stranko et al. 2017). 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 sampling approximately 1 square foot of habitat per jab 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.

All sorting and identification of the subsampled specimens was conducted by EcoAnalysts, Inc., which currently holds certification for laboratory sorting by the MBSS and employs taxonomists who hold taxonomic identification certification from the Society for Freshwater Science. 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. If there were 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.

During the Spring Index Period, the crew searched for vernal pools in the 50-meter wide buffer zone (each side) perpendicular to the 75-meter study reach. Vernal pools are defined by MBSS as “small, temporary bodies of water that provide vitally important habitat for many amphibians and aquatic invertebrates”, typically being less than one acre (as small as one square meter) and not directly connected to a flowing stream. If encountered, information on the location and size of vernal pools as well as fish or amphibian species found in or immediately adjacent to the pool were recorded for each site.

2.2.3 Fish Sampling

The fish community was sampled at each of the 40 sites during the Summer Index Period, June 1 through September 30, according to methods described in Maryland Biological Stream Survey: Round Four Field Sampling Manual (Stranko et al. 2017). In general, the approach uses two-pass electrofishing of the entire 75-meter study reach. Block nets were placed at the upstream and downstream ends of the reach, as well as at tributaries or outfall channels, to obstruct fish movement into or out of the study reach. Two passes were completed along the reach to ensure the segment was adequately sampled. The time in seconds for each pass was recorded and the level of effort for each pass was similar. Captured fish were identified to species and enumerated following MBSS protocols (Stranko et al. 2017) by crew members holding MBSS certification in fish taxonomy. A total fish biomass for each electrofishing pass was measured. Unusual anomalies such as fin erosion, tumors, etc. were recorded. Photographic vouchers were taken in lieu of physical voucher specimens.

Herpetofauna (i.e., reptiles and amphibians) were surveyed at each site using methods following MBSS protocols (Stranko et al. 2017). A search of likely herpetofauna habitats was performed during both spring and summer visits at each site sampled. An intensive stream salamander survey was not performed. All collected individuals were identified to species level and released. Photographic vouchers were collected if a specimen could not be positively identified in the field. Herpetofauna data collection occurs primarily to assist MBSS with supplementing their inventory of biodiversity in Maryland's streams. Currently, MBSS has not developed any indexes of biotic integrity for herpetofauna, and therefore, they were not used to evaluate the biological integrity of sampling sites throughout this study. Rather, the data are provided to help document existing conditions.

Each site was surveyed for crayfish using MBSS protocols (Stranko et al. 2017). All crayfish observed while electrofishing were captured and retained until the end of each electrofishing pass. Captured crayfish were identified to species and counted before release back into the stream outside of the 75-meter sampling reach. Any crayfish encountered outside of the electrofishing effort were identified and noted on the datasheet as an incidental observation. Any crayfish burrows observed in and around the sampling site were excavated and an attempt made to capture the burrowing crayfish.

A survey of freshwater mussels was conducted at each site using MBSS protocols (Stranko et al. 2017). Any live individuals encountered were identified, photographed, and then returned back to the stream as closely as possible to where they were collected. Any dead shells encountered were retained as voucher specimens.

A survey of invasive plants was performed at each site during the Summer Index Period following MBSS protocols (Stranko et al. 2017). The common name and relative abundance of invasive plants (i.e., present or extensive) within view of the study reach and within the 5-meter riparian vegetative zone parallel the stream channel were recorded. Invasive plant data collection occurs to assist MBSS with supplementing their inventory of biodiversity. The data are provided to help document existing conditions at each site.

2.2.4 Water Quality Sampling

Water quality grab samples for laboratory analysis were collected at each site during the spring sampling visit following the sampling protocols in the QAPP, which closely mirrors MBSS procedures (Stranko et al. 2017). Samples were collected in triple-rinsed bottles from a suitable location along the thalweg with sufficient depth to submerge the bottle without disturbing the bottom sediments. Bottles were labeled prior to sampling with sample ID, date, time, and parameters for analysis. Samples were preserved on ice

immediately after collection and transported to the lab within 48 hours. In addition, a duplicate sample was collected from each PSU for quality assurance purposes. All grab samples were analyzed by UMCES – Appalachian Laboratory. The laboratory methods are consistent with Analytical Laboratory Standard Operating Procedures for the Maryland Biological Stream Survey (Kline and Morgan, 2006). A complete list of analytical parameters and methods, including method detection limits, is presented in Table 4 below.

Table 4 - Water Quality Parameters

Parameter	Method Detection Limit*	Method Number
Turbidity	0.1 NTU	APHA 2130B
Total Nitrogen	0.022	APHA 4500-N C
Total Phosphorus	0.004	APHA 4500-P H
Ammonia-N	0.003	USGS (1993) NWQL I-2525
TKN (calculated)	0.022	NA
Nitrate-Nitrogen	0.050	APHA 4500-NO3 E
Nitrite-Nitrogen	0.002	APHA 4500-NO2 B
Dissolved Organic Carbon	0.067	APHA 5310 C
Orthophosphate	0.003	APHA 4500-P G
Total Organic Carbon	0.067	APHA 5310 C
Total Copper	0.008 µg/L	APHA 3125
Total Lead	0.006 µg/L	APHA 3125
Total Zinc	0.078 µg/L	APHA 3125
Chloride	0.003	APHA 4110B
Total Hardness	0.78	APHA 2340B

*All values in mg/L, except as noted.

To supplement the water quality grab sampling, *in situ* water quality measurements were taken at each site during both the spring and summer sampling visits. Field measured water chemistry parameters include pH, specific conductivity, dissolved oxygen, temperature, and turbidity. All measurements were collected from the upstream end of the site, prior to any other sampling activites to ensure that measurements were not influenced by sampling activities within the stream. *In situ* parameters (i.e., temperature, pH, specific conductivity, and dissolved oxygen, turbidity) were measured with either a YSI ProDSS or a YSI Professional Plus series multiprobe. At some sites, however, 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.

2.2.5 Geomorphic Assessment

Geomorphic assessments, which included a cross section survey, a simplified longitudinal profile survey for measurement of channel slope, and a 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 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.

Bed materials were characterized in each 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 reach.

2.3 Data Analysis

2.3.1 Data Structure

Physical habitat, benthic macroinvertebrate, fish, 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. Physical habitat index (RBP and PHI) scores, benthic macroinvertebrate index (BIBI) scores, and fish index (FIBI) 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 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 using a score 168 (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 2.3.7 *Land Use Analysis and Impervious Surface*. Calculated metric scores are then 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 1.00 to 5.00, 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 of 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
4.00 – 5.00	Good	Comparable to reference streams considered to be minimally impacted.
3.00 – 3.99	Fair	Comparable to reference conditions, but some aspects of biological integrity may not resemble minimally impacted streams.
2.00 – 2.99	Poor	Significant deviation from reference conditions, indicating some degradation.
1.00 – 1.99	Very Poor	Strong deviation from reference conditions, with most aspects of biological integrity not resembling minimally impacted streams indicating severe degradation.

2.3.4 Fish Index Analysis

Fish data for all sites 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 IBI approach involves statistical analysis using metrics that have a predictable response to water quality and/or habitat impairment. Raw values from each metric were assigned a score of one (1), three (3) or five (5) based on ranges of values developed for each metric. The results were combined into a scaled FIBI score, ranging from 1.00 to 5.00, and a corresponding narrative rating of 'Good', 'Fair', 'Poor' or 'Very Poor' was applied, again in accordance with standard practice.

Four sets of FIBI metric calculations have been developed for Maryland streams. Like the BIBI, these metrics were developed for Maryland's streams based on physiographic region and include the Coastal Plain, Eastern Piedmont, and warmwater and coldwater Highlands. As all sites were located in the Coastal Plain region the following metrics listed in Table 9 were used for the FIBI scoring and analysis and then given the condition ratings as shown in Table 10. The individual FIBI metrics are defined below:

1) Abundance per Square Meter-- The total number of fish found per square meter of assessed reach. Overall fish numbers tend to decrease as impairment increases.

2) Number of Benthic Species--The number of fish species found that inhabit stream bottom substrates. These species tend to decrease as levels of impairment increase.

3) Percent Tolerant--The percentage of individuals collected at a site considered tolerant to disturbance. This percentage increases as disturbance increases.

4) Percent Generalists, Omnivores, Invertivores--Fishes found in these trophic guilds are less sensitive to watershed disturbance, so a higher percentage of these fish in a sample indicate a more disturbed site.

5) Percent Round Bodied Suckers--These types of suckers tend to live in less disturbed streams, so a lower observed percentage is indicative of higher levels of watershed development.

6) Percent Abundance of Dominant Taxon—The more one species dominates a sample, the less diverse the overall fish community. Less diversity is generally considered a sign of impairment, so a higher score for this metric indicates higher levels of watershed impairment or disturbance.

Table 9 – Fish Metric Scoring for the Coastal Plain FIBI

Metric	Score		
	5	3	1
Abundance per Square Meter	≥ 0.72	0.45 – 0.71	< 0.45
Number of Benthic species *	≥ 0.22	0.01 – 0.21	0
% Tolerant	≤ 68	69 – 97	> 97
% Generalist, Omnivores, Invertivores	≤ 92	93 – 99	100
% Round Bodied Suckers	≥ 2	1	0
% Abundance of Dominant Taxon	≤ 40	41 - 69	> 69

*Adjusted for catchment size

Table 10 – MBSS FIBI Condition Ratings

IBI Score	Narrative Rating
4.00 – 5.00	Good
3.00 – 3.99	Fair
2.00 – 2.99	Poor
1.00 – 1.99	Very Poor

2.3.5 Water Quality

The water quality grab sample parameters were compared against published acute and chronic water quality criteria for aquatic life and criteria for toxic substances in surface waters (Table 11) for each corresponding parameter. MBSS has established water quality ranges for nutrients from the distribution of concentrations from the MBSS dataset and published in Southerland et al. (2005), which are listed in Table 12. 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. All sites sampled during 2018 were located on streams listed as Use Class I in *Code of Maryland Regulations (COMAR) 26.08.02.08 – Stream Segment Designations.* Water quality data were compared to acceptable standards for the appropriate designated use listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality* (Table 13). 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 specific conductivity. However, Morgan et al. (2007) identified a critical threshold of impairment of BIBI scores for Maryland streams at 247 µS/cm. Furthermore, Morgan et al. (2012) identified a critical threshold of 469 µS/cm for fish within the Coastal Plain physiographic region.

Table 11 - Water Quality Criteria

Parameter	Criteria	
	Acute	Chronic
Chloride (mg/L)**	860	230
Total Kjehldal Nitrogen (mg/L)	none	none
Dissolved Organic Carbon (mg/L)	none	none
Total Organic Carbon (mg/L)	none	none
Magnesium (mg/L)	none	none
Calcium (mg/L)	none	none
Hardness (mg equivalent $CaCO_3$/L)	none	none
Total Copper (µg/L)***	13	9
Total Zinc (µg/L)***	120	120
Total Lead (µg/L)***	65	2.5
Turbidity (NTU)***	150	50

** EPA National Recommended Water Quality Criteria for Aquatic Life

*** COMAR 26.08.02.03-2: Numerical Criteria for Toxic Substances in Surface Waters

Table 12 - MBSS Water Quality Ranges for Nutrients

Parameter*	Low	Moderate	High
Nitrate (NO3)	< 1.0	1.0 – 5.0	> 5.0
Nitrite (NO2)	< 0.0025	0.0025 – 0.01	> 0.01
Ammonia (NH3)	< 0.03	0.03 – 0.07	> 0.07
TN	< 1.5	1.5 – 7.0	>7.0
TP	< 0.025	0.025 – 0.070	> 0.070
Ortho-PO4	< 0.008	0.008 – 0.03	> 0.03

* All values in mg/L

Table 13 - Maryland COMAR Standards

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)	Use I - Maximum of 32°C (90°F) or ambient temperature of the surface water, whichever is greater; Use III - Maximum of 20°C (68°F) or ambient temperature of the surface water, whichever is greater; Use IV - Maximum of 23.9°C (75°F) or ambient temperature of the surface water, whichever is greater

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

2.3.6 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, and area
- Mean bankfull depth
- Width/depth ratio
- Entrenchment ratio
- Floodprone width
- Sinuosity
- Water surface slope
- Median channel bed particle size - 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 (i.e., A, G, F, B, E, C, D and DA) and delineative criteria for broad level (Level I) classification are provided in Table 14. Rosgen Level II characterization incorporates a numeric code (1 – 6) for dominant bed materials and a slope range modifier (i.e., 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 two percent would be classified as a G4c stream.

Table 14 - Rosgen Channel Type Description and Delineative Criteria for Level I Classification.

Channel Type	General Description	Entr. Ratio	W/D Ratio	Sinu-osity	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.

2.3.7 Land Use Analysis and Impervious Surface

All geospatial analysis was performed using Countywide GIS coverages in ArcGIS 10.5.1. Land use analysis was completed with the use of the County's 2014 Land Cover GIS layer and Howard County's 2013 Land Cover GIS layer, to account for drainage areas beyond County boundaries (i.e., Piney Run). Original land cover categories were combined into four primary land use classes to better summarize the conditions in the sampling units (Table 15). The County's 2014 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 Anne Arundel County's raster grid digital elevation model (DEM) and flow accumulation grid using ESRI's ArcMap 10.3.1. 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.

Table 15 - Combined Land Use Classes

Land Use Class	Land Cover Type
Developed	Airport, Commercial, Industrial, Transportation, Utility, Residential (1/8-ac., ¼-ac., ½-ac., 1-ac., and 2-ac.)
Forested	Forested wetland, Residential woods, Woods
Agriculture	Pasture/hay, Row crops
Open Space	Open space, Open wetland, Water

3 Results and Discussion

This section first discusses the overall results across the 2018 sampling units, and is then followed by a more detailed discussion on results specific to each sampling unit. Appendix A includes a summary of the geomorphic assessment results. Appendix B includes a thorough discussion on the data QA/QC results. A listing of all taxa identified and their characteristics (i.e., functional feeding group, habit, tolerance value) is included as Appendix C, summaries for each site are in Appendix D, and water quality data are presented in Appendix E.

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 2018. 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 each PSU, even for stream reaches where no data were directly collected. Table 16 summarizes overall biological and habitat conditions for each sampling unit.

Table 16 - Summary of habitat, BIBI, and FIBI scores across sampling units (n=8 for each sampling unit unless noted)

Sampling Unit	Average PHI Summer Habitat Score ± SD / Condition Narrative	Average RBP Spring Habitat Score ± SD / Condition Narrative	Average BIBI Score ± SD / Condition Narrative	Average FIBI Score ± SD / Condition Narrative
Lower Magothy River	69.18 ± 5.75 Partially Degraded	131.38 ± 11.26 Supporting	2.14 ± 0.53 Poor	2.38 ± 0.40* Poor
Lower Patapsco River	55.78 ± 8.12 Degraded	93.75 ± 22.47 Non-Supporting	2.14 ± 0.98 Poor	2.29 ± 0.74 Poor
Marley Creek	61.75 ± 8.71 Degraded	111.8 ± 16.93 Partially Supporting	2.64 ± 0.48 Poor	2.63 ± 0.92 Poor
Piney Run	59.59 ± 9.46 Degraded	100.9 ± 22.62 Partially Supporting	2.61 ± 0.43 Poor	3.25 ± 1.12 Fair
Stocketts Run	71.77 ± 6.26 Partially Degraded	123.6 ± 19.08 Partially Supporting	3.11 ± 1.18 Fair	2.67 ± 1.50 Poor

*n=7 for FIBI

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' (16 of 40; 40.0 percent) and 'Very Poor' (11 of 40; 27.5 percent), with approximately a quarter of sites

rated as 'Fair' (11 of 40; 27.5 percent) and only two sites rated as 'Good' (five percent; Figure 2). Four of the five sampling units had mean BIBI values that equate to 'Poor' biological condition ratings (Lower Magothy River, Lower Patapsco River, Marley Creek, Piney Run) and the fifth sampling unit had a mean BIBI value rating 'Fair' condition (Stocketts Run; Table 16).

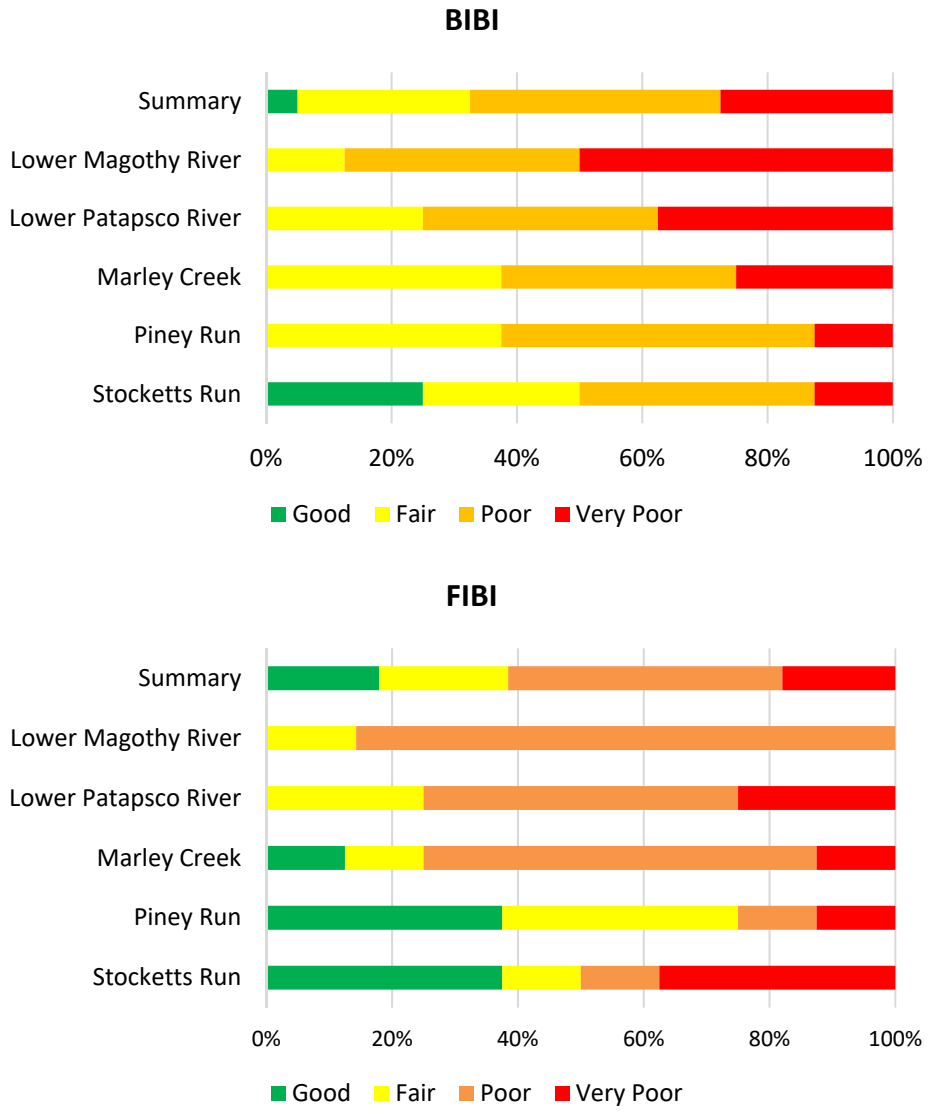


Figure 2 - Summary of biological conditions for sites assessed in 2018 (BIBI n=40, FIBI n=39)

The vast majority of sites sampled during 2018 had FIBI condition ratings of 'Poor' (17 of 39; 43.6%) or 'Fair' (8 of 39; 20.5%). The remaining sites were split evenly and rated 'Good' (7 of 39; 17.9%) or 'Very Poor' (17.9%; Figure 2). Four sampling units (Lower Magothy River, Lower Patapsco River, Marley Creek, Stocketts Run) had mean FIBI scores equating to a 'Poor' biological condition rating and one had mean FIBI rating 'Fair' (Piney Run; Table 16). Lower Patapsco River was the sampling unit with the lowest mean FIBI score (2.29) equating to a 'Poor' condition rating. Piney Run had the highest mean FIBI rating of the

sampling units from 2018, with a 3.25 mean equating to a 'Fair' biological condition rating. No sites visited during the summer of 2018 were dry but three sites had no fish observed during the summer visit.

Physical habitat conditions were assessed twice in 2018 through the utilization of the RBP method during the spring season, and the PHI method during the summer season. Spring physical habitat assessment results indicate that three of the five sampling units, as determined by the sampling unit mean, received ratings of 'Partially Supporting', one received 'Supporting', and one received 'Non-Supporting' (RBP; Table 16). Approximately half (19 of 40; 47.5 percent) of the total sites sampled resulted in a RBP rating of 'Partially Supporting,' and one-quarter of the sites (10 of 40; 25 percent) resulted in a 'Supporting', and another one-quarter of the sites (10 of 40; 25 percent) resulted in a 'Non-Supporting' rating (Figure 3). Only one site was rated as 'Comparable to Reference' (2.5 percent).

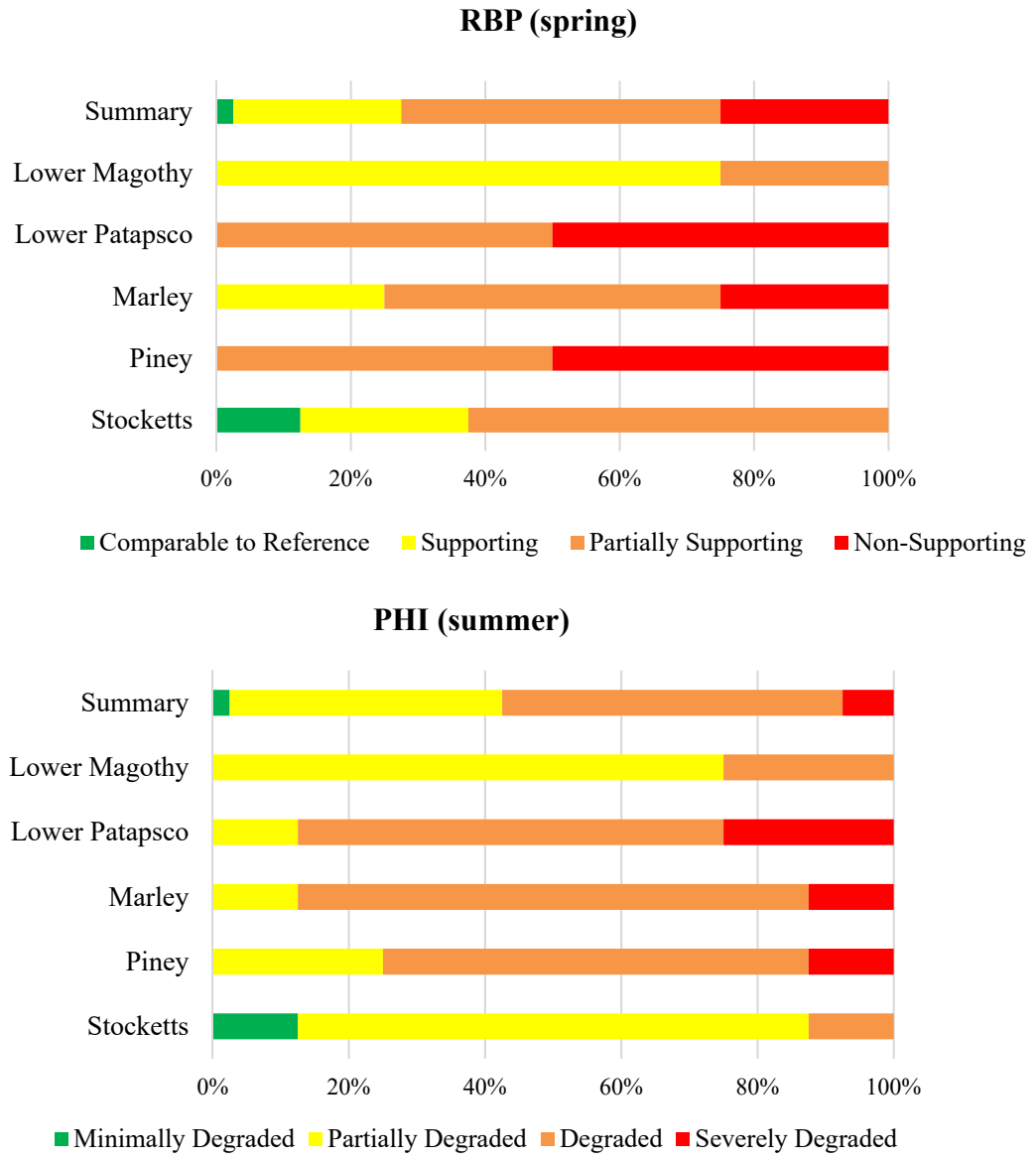


Figure 3- Summary of physical habitat conditions for sites assessed in 2018 (RBP n=40; PHI n=40)

Two sampling units assessed during the summer season received a PHI rating of 'Partially Degraded', as determined by the sampling unit mean. The three remaining sampling units received a rating of 'Degraded' (Table 16). Half of the total sites sampled resulted in a PHI rating of 'Degraded' (50.0 percent), two fifths of the sites received 'Partially Degraded' ratings (16 of 40; 40.0 percent), 7.5% (3 of 40) resulted in 'Severely Degraded' ratings, and 2.5 percent (1 of 40) resulted in 'Minimally Degraded' ratings (Figure 3).

3.1.2 Water Quality Assessment Summary

In situ water quality measurements of instantaneous turbidity exceeded COMAR standards for average monthly turbidity (i.e., <50 NTU) at one site in the spring and three sites in two of the five sampling units in the summer. Although the average monthly turbidity criteria was exceeded, turbidity measurements from a single point in time do not provide sufficient data on average monthly turbidity. In the Marley Creek sampling unit, site 05-R3M-02-18 had a value of 63.2 NTU in the spring, and sites 05-R3M-02-18 and 05-R3M-06-18 had values greater than 99.9 NTU in the summer. The >99.9 reading is possibly a result of a malfunctioning turbidity meter, but both sites were very turbid and appeared to the eye to be the most turbid sites visited during summer of 2018. One site in the Piney Run sampling unit, site 01-L2M-01-18, exceeded the average monthly turbidity criteria in the summer, with a value of 85.9 NTU. 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 five sites spanning two of the five sampling units in the spring. The pH values ranged from 5.93 to 6.47, for the sites that did not meet COMAR standards for water quality. All sites in each of the five sampling units met COMAR standards for pH in the summer. Low DO values, which were outside the acceptable range of values set forth by COMAR (i.e., >5 mg/L), were recorded at one site in the spring and four sites spanning three of the five sampling units in the summer. The DO value was 3.39 mg/L in the spring and values ranged from 2.26 to 3.88 mg/L in the summer, for the sites that did not meet COMAR criteria. For conductivity, the critical threshold between 'Fair' and 'Poor' stream quality determined for urban Maryland streams is 247 µS/cm, based on BIBI scores (Morgan et al., 2007). Conductivity values that exceeded 247 µS/cm were recorded at eight sites spanning four of the five sampling units in the spring and 16 sites spanning all five sampling units in the summer. All Use I streams were within their designated criteria for temperature in 2018 (i.e., <32 °C).

With the exception of one sampling unit, all chloride values met EPA standards for acute (i.e., <860 mg/L) and chronic (i.e., <230 mg/L) exposure. In the Lower Patapsco sampling unit, site 03-R3M-05-18 did not meet EPA standards for chronic chloride concentration, with a value of 653.60 mg/L. Sites 03-R3M-01-18 and 03-R3M-04-18 did not meet EPA standards for both chronic and acute (i.e., <860 mg/L) chloride concentration with values of 924.30 and 1,262.64 mg/L, respectively. However, chloride concentration measurements from a single point in time do not provide sufficient data on chronic exposure levels. In the four remaining sampling units that met EPA standards in 2018, chloride values ranged from 8.48 to 216.84 mg/L.

Based on spring grab samples, all 2018 sites met COMAR or EPA standards for heavy metal concentrations and only one site exceeded COMAR criteria for turbidity. In the Marley Creek sampling unit, site 05-R3M-02-18 met COMAR criteria for instantaneous turbidity, but exceeded the acceptable COMAR range for average monthly turbidity (i.e., <50 NTU), with a value of 64.6 NTU. Turbidity at site 05-R3M-02-18 exceeded COMAR criteria for average monthly turbidity in both the spring and summer; however, two instantaneous turbidity measurements do not provide sufficient data on average monthly turbidity. For total nitrogen and nitrate, all 2018 sites fell in the low or moderate categories used by MBSS. Over 22 percent of sites sampled in 2018 fell in the high category used by MBSS for total phosphorus (i.e., >0.07

mg/L), with values ranging from 0.077 to 0.576 mg/L. The majority of these sites were located in the Stocketts Run sampling unit. Only one site fell in the high category used by MBSS for orthophosphate concentration (i.e., >0.03 mg/L). This site was located in the Piney Run sampling unit and had a value of 0.415 mg/L. Over 22 percent of sites sampled in 2018 fell in the high category used by MBSS for total ammonia (i.e., >0.07 mg/L), with values ranging from 0.103 to 5.447 mg/L. The majority of these sites were located in the Lower Magothy sampling unit. Over 17 percent of sites sampled in 2018 fell in the high category used by MBSS for nitrite (i.e., >0.01 mg/L) with values ranging from 0.013 to 0.046 mg/L. Nitrite levels fell in the moderate to high category in over 87 percent of all sites across all sampling units. No state or national water quality standards exist for dissolved organic carbon (DOC), total organic carbon (TOC), magnesium, calcium, or hardness. Average values for these parameters ranged from 0.51 to 12.46 mg/L for DOC, 0.54 to 13.60 mg/L for TOC, 2.10 to 11.25 mg/L for magnesium, 8.09 to 76.47 mg/L for calcium, and 31.16 to 237.27 mg/L for hardness, across all sampling units.

3.1.3 Geomorphic Assessment Summary

There was high variability in stream types throughout the sampling units in 2018. The largest portion of the sites were entrenched F and G type channels (30 and 25 percent, respectively; Figure 4), which comprised a large portion of the sites in the Marley Creek, Piney Run, and Stocketts Run sampling units. Across all sampling units, approximately 20 percent of the sites were classified as E type channels. The slightly entrenched E type channels were most frequent in the Lower Magothy sampling unit. Approximately 12.5 percent of sites were classified as C type channels, with most of these slightly entrenched channels occurring in the Piney Run sampling unit. Across all sampling units, 7.5 percent of sites were classified as moderately entrenched B type channels, which only occurred in the Lower Patapsco and Marley Creek sampling units. The remaining 5 percent of sites were placed into the 'Not Determined' category due to considerable anthropogenic modification (i.e., channel alteration, hardened banks) or due to natural influences that inhibit channel classification (i.e., beaver dams). A major assumption of the Rosgen characterization system 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. None of the sites assessed in 2018 were classified as 'Transitional'.

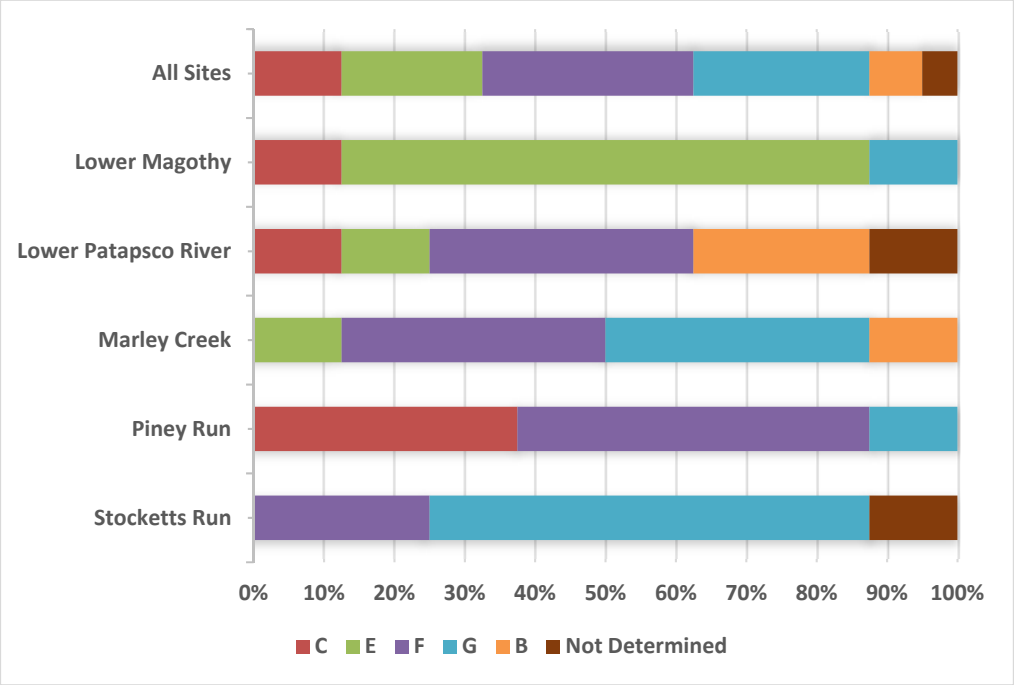


Figure 4 - Distribution of Rosgen stream types for sites assessed in 2018 (n=40)

Half of sites sampled in 2018 had channel substrate composed primarily of sand. Gravel dominated streams comprised 22.5 percent of all sites, while gravel/sand sites comprised 12.5 percent of sites. The remaining 15 percent of sites had predominantly silt/clay channel substrates (7.5 percent), with sand/silt/clay, gravel/silt, and cobble rounding out the remaining sites assessed in 2018 (2.5 percent each).

Stream slopes in the reaches assessed in 2018 were generally low (i.e., below one percent). The average slope of all reaches assessed was 0.65 percent. Average slopes for the sampling units ranged from 0.35 percent in the Piney Run sampling unit to 1.07 percent in the Lower Patapsco sampling unit.

3.1.4 Land Use Analysis and Impervious Surface Summary

A summary of land use and impervious surface across each sampling unit assessed in 2018 is presented in Table 17.

Table 17 - Summary of land use and impervious surface across sampling units

Sampling Unit	Total Acreage	% Impervious	Land Use			
			% Developed	% Forested	% Agriculture	% Open
Lower Magothy River	12,697	19.9	64.8	27.4	1.1	6.7
Lower Patapsco River	4,040	31.5	64.9	23.7	0.0	11.4
Marley Creek	19,425	28.4	65.4	26.4	0.4	7.8
Piney Run	4,868	23.5	46.6	41.4	0.2	11.7
Stocketts Run	8,714	5.8	35.3	39.4	19.7	5.6

The vast majority of sites sampled in 2018 had developed land as the dominant land use (87.5 percent), while the remaining sites were dominated by forested land (12.5 percent). At the sampling unit scale, Marley Creek had the highest percentage of developed land at 65.4 percent of the total acreage, followed closely by the Lower Patapsco at 64.9 percent and the Lower Magothy at 64.8 percent (Table 17). Piney Run is also largely developed, with developed land comprising 46.6 percent of the sampling unit. In contrast, Stocketts Run was the least developed, with 35.3 percent of the sampling unit attributed to developed land. Piney Run and Stocketts Run had the highest proportion of forested land at 41.4 and 39.4 percent, respectively, while Lower Magothy, Marley Creek, and Lower Patapsco had the lowest proportion of forested land (27.4, 26.4, and 23.7 percent, respectively). The highest proportion of agricultural land use occurred in Stocketts Run at 19.7 percent, followed by the Lower Magothy at 1.1 percent. Agricultural land uses comprised less than one percent for all other 2018 sampling units. Figure 5 shows land use for the entire County based on the County's 2014 Land Cover GIS layer. The sampling units with the highest percentage of impervious surface were Lower Patapsco (31.5 percent) and Marley Creek (28.4 percent), while Stocketts Run had the lowest percentage of impervious surface (5.8 percent). Figure 6 shows impervious surface for the entire County based on the County's 2014 Impervious GIS layer.

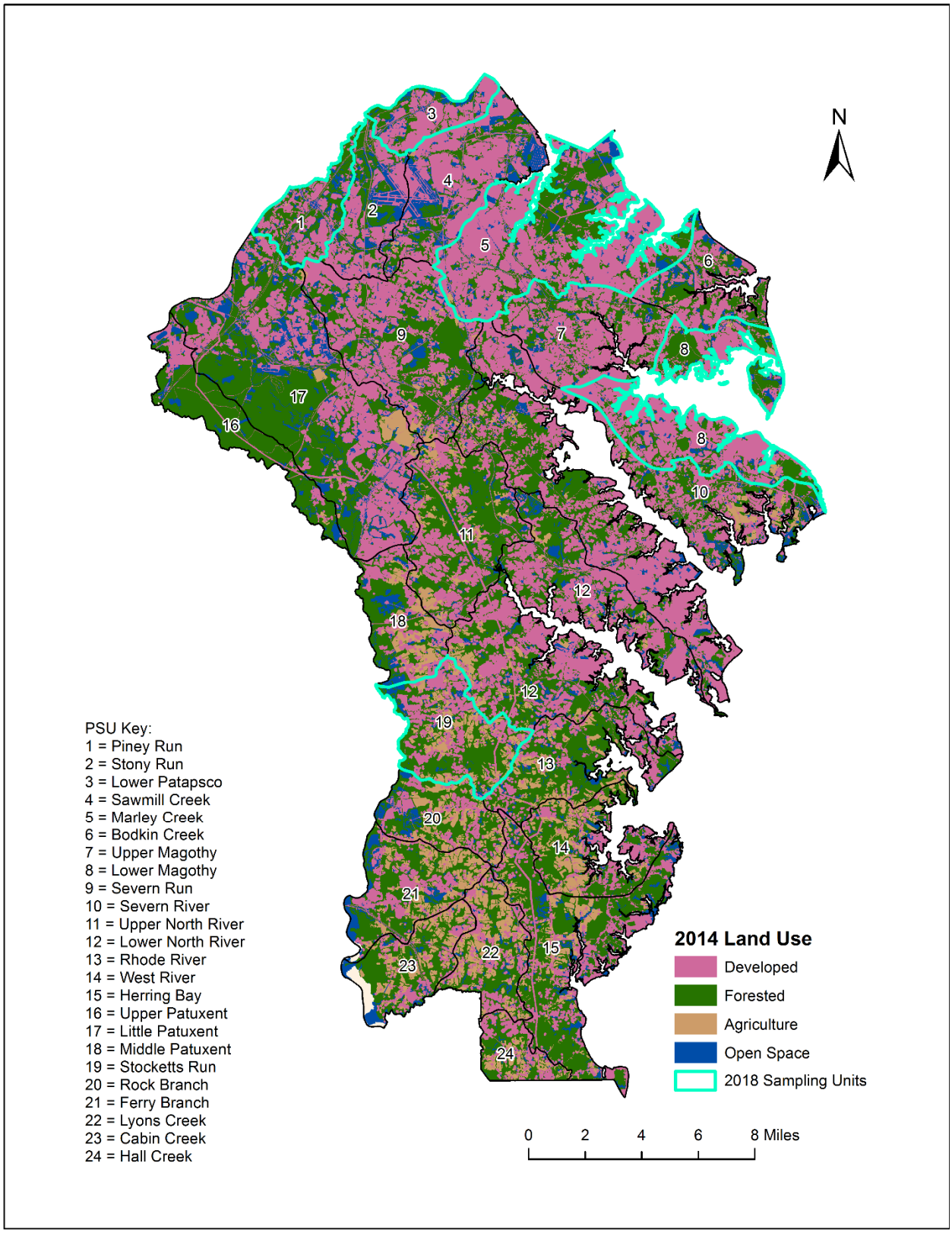


Figure 5 - Summarized land use in Anne Arundel County (2014)

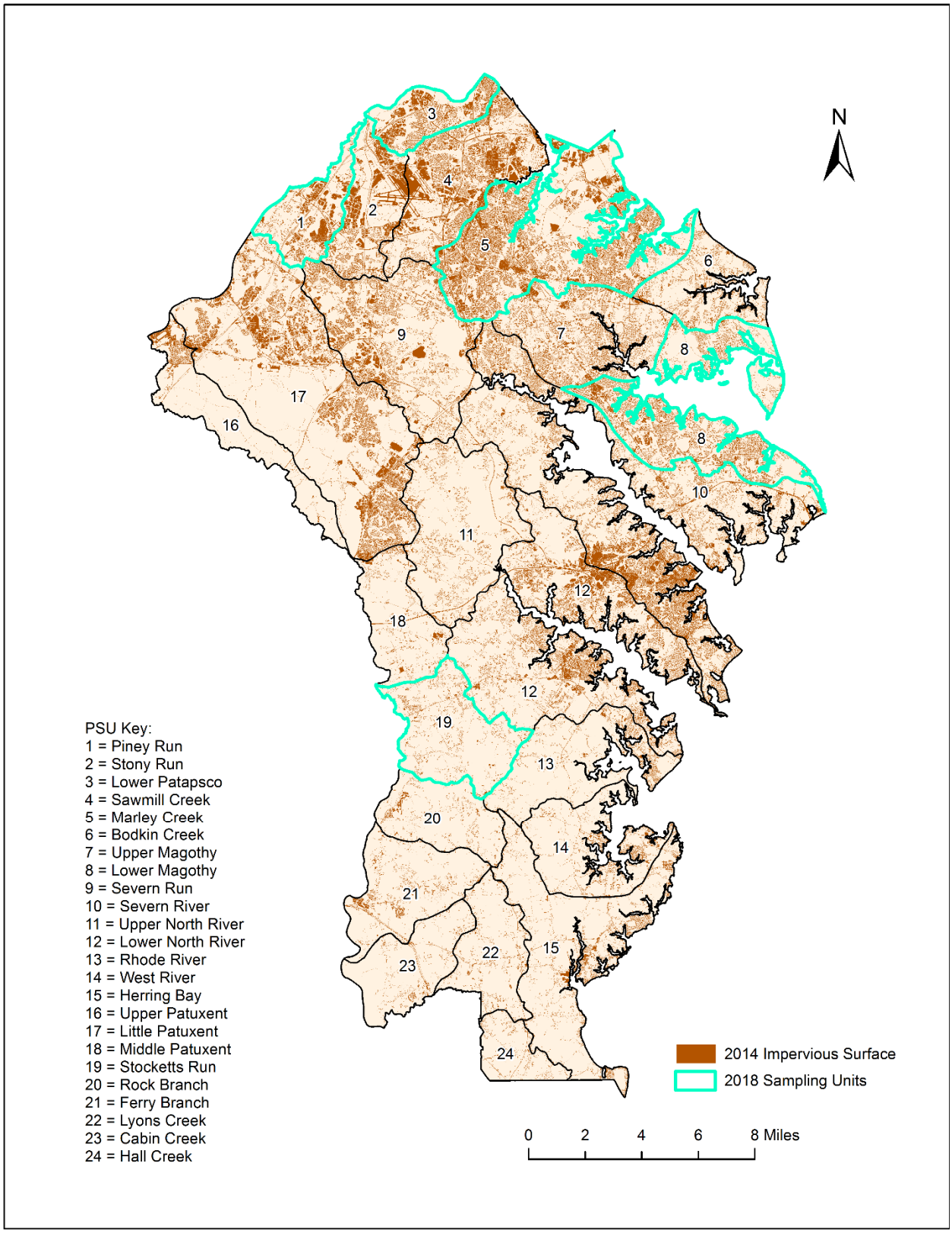


Figure 6 - Impervious surface in Anne Arundel County (2014)

4 Individual Sampling Unit Discussions

The following section summarizes the conditions within each of the five sampling units assessed during 2018. Site-specific data and assessment results can be found in Appendix D.

4.1 Lower Magothy River

The Lower Magothy sampling unit is located along the eastern edge of the County (Figure 1). The Lower Magothy has a total drainage area of 12,697 acres and drains directly into the Magothy River before draining into the Chesapeake Bay just north of the Chesapeake Bay Bridge. The eight sampling sites, all 1st order streams (Figure 10), have drainage areas ranging from 108 to 649 acres.

4.1.1 Land Use

The dominant land use for the Lower Magothy sampling unit is developed land (65 percent), followed by forested land (27 percent), open land (7 percent), and agriculture (1 percent) (Table 17). The land use distribution within the sampling unit was similar to the average land use among sampling sites. Developed land dominated all sampling sites and seven of the eight sites followed the same composition as the overall sampling unit (Figure 7). On average, land use among the eight sampling sites was comprised of 70 percent developed land, 21 percent forested land, 9 percent open space, and less than 1 percent agriculture. However, at one site, 08-R3M-05-18, open space comprised a larger portion than forested area. Impervious surfaces comprise 19.9 percent of the overall Lower Magothy sampling unit (Table 17), with individual sites ranging from 19.7 percent to 29.3 percent impervious surface.

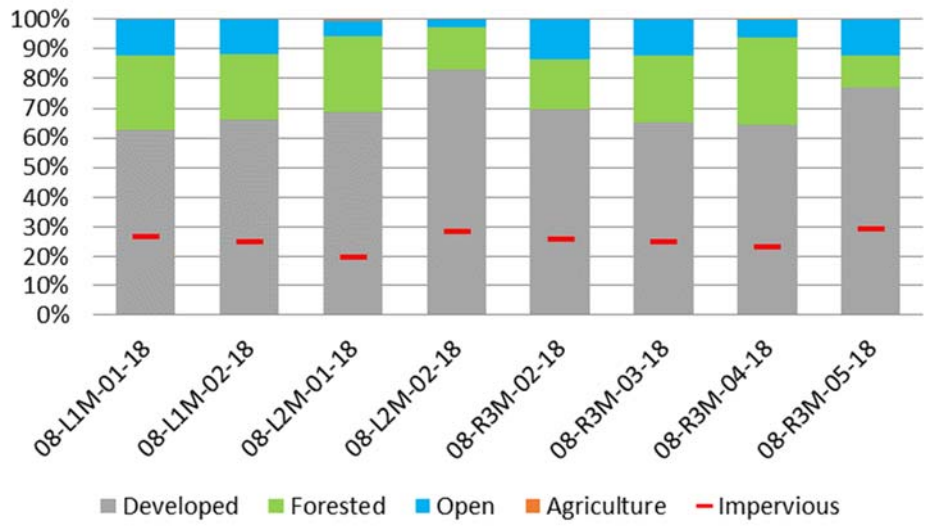


Figure 7 – Lower Magothy River land use (n=8)

4.1.2 Physical Habitat

Physical habitat conditions were relatively consistent for this sampling unit during the spring season. Based on the RBP scores, 75.0 percent of the Lower Magothy River sites received a rating of 'Supporting,' and 25.0 percent of sites received a 'Partially Supporting' (Figure 8). The average RBP score for the Lower Magothy River sampling unit was 131.38 ± 11.26, and the corresponding narrative rating was 'Supporting'. Individual site scores ranged from 116 ('Partially Supporting') to 150 ('Supporting'), which was the second

highest scoring site in 2018 and one point away from the highest rating category. Lower Magothy River had the highest mean score for the spring RBP habitat assessment and the second highest mean score for the summer PHI habitat assessment.

According to the PHI assessment (summer season), 75.0 percent of the Lower Magothy sites were rated as 'Partially Degraded', and 25.0 percent were rated as 'Degraded' (Figure 8). The average PHI rating was 'Partially Degraded' with a score of 69.18 ± 5.75. Individual site scores ranged from 60.49 ('Degraded') to 76.21 ('Partially Degraded'). Instream habitat and epifaunal substrate scored in the 'Marginal' and 'Poor' categories; high-quality habitat for fish and benthic macroinvertebrates was lacking at all Lower Magothy River sites. The scaled metric for number of rootwads and woody debris scored 89.42% at one site and 100% at the remaining seven sites. Percent shading scored 85% or 90% at six of the sites with one site scoring 70% and one site scoring 10%. Embeddedness was 75% at one site and 100% for the other seven Lower Magothy River sites.

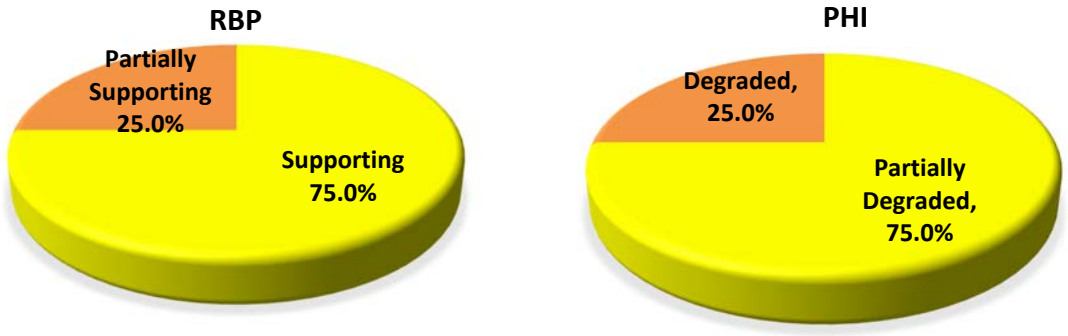


Figure 8 – Lower Magothy River Physical Habitat Conditions (RBP n=8; PHI n=8)

4.1.3 Benthic Macroinvertebrates

Of the eight sites sampled in Lower Magothy River, 50.0 percent of sites received a BIBI rating of 'Very Poor' while 37.5 percent of the sites were 'Poor,' and the remaining 12.5 percent were rated as 'Fair' (Figure 9). The average BIBI score for the Lower Magothy River sampling unit is 2.14 ± 0.53, with an average biological condition of 'Poor'. This sampling unit had the lowest mean BIBI score and the highest proportion of sites in the 'Very Poor' category. Individual BIBI scores ranged from 1.57 ('Very Poor') to 3.00 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

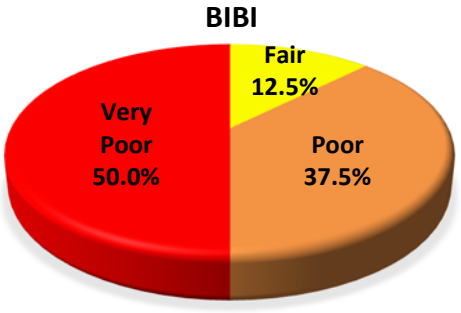


Figure 9 – Lower Magothy River BIBI Conditions (n=8)

Two sites (Figure 10) received the second lowest BIBI score of 2018 at 1.57 and two sites scored 1.86. These four sites received a biological rating of 'Very Poor' and RBP ratings of 'Supporting' or 'Partially Supporting.' The low scoring sites all shared similar BIBI metric scores with zero or one EPT taxa, low diversity with between 12 and 16 taxa, and very few intolerant organisms. The higher scoring sites had

more taxa (18-30), more scraper taxa, and higher proportion of climbers. The only 'Fair' site in this sampling unit, 08-R3M-03-18 received the highest BIBI score of 3.00. This site had a highest number of total taxa (30), highest number of EPT taxa (3), highest number of scraper taxa (3), and 25 percent of the sample consisted of individuals considered climber taxa. All sites in the Lower Magothy River sampling unit lacked Ephemeroptera taxa and had few if any individuals intolerant to urbanization with the max percentage of any sample at 7.4%.

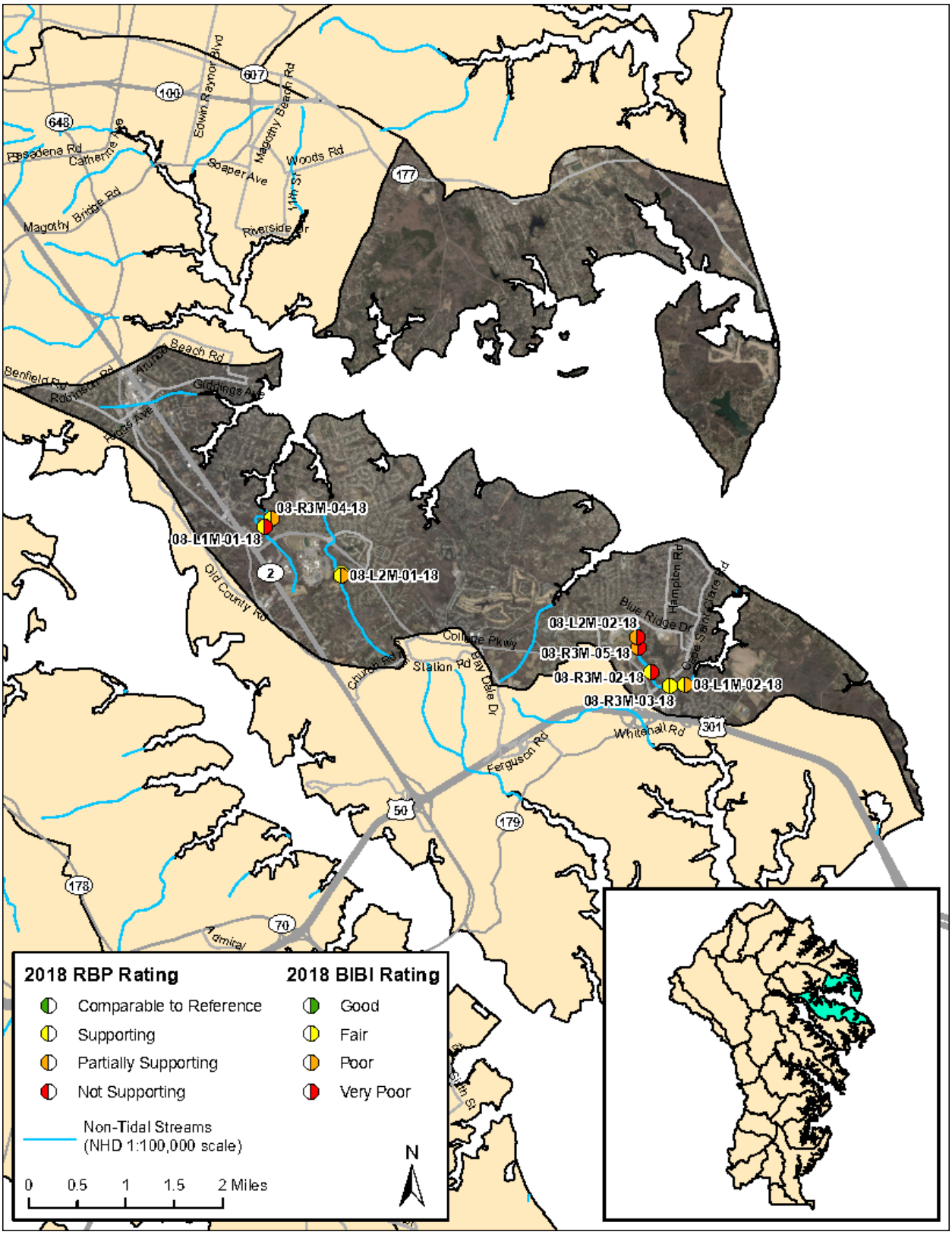


Figure 10 – Lower Magothy River Sampling Sites (BIBI and RBP)

4.1.4 Fish

The Lower Magothy River sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.38 ± 0.40. The majority of the sites in this sampling unit received a biological condition rating of 'Poor' (85.7%), and 14.3 percent received a 'Fair' rating (Figure 11). Individual FIBI scores ranged from 2.00 ('Poor') to 3.00 ('Fair'). One site was visited several times during the summer of 2018, and each time was found to be approximately 80 meters wide and more like a wetland-stream complex. This site was sampled qualitatively and no FIBI is available. Site-specific data and assessment results can be found in Appendix D.

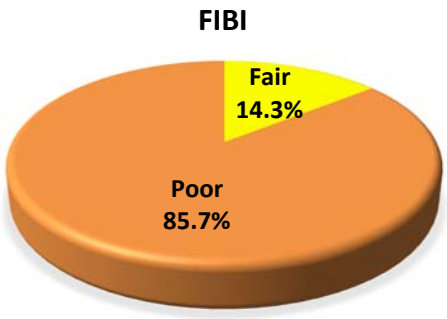


Figure 11 – Lower Magothy River FIBI Conditions (n=7)

Three sites, 08-L1M-01-18, 08-L2M-01-18, and 08-R3M-04-18, received the lowest FIBI scores of Lower Magothy Creek sites (2.00) with a narrative rating of 'Poor.' These sites scored in the lowest category (1) for all metrics except percent tolerant, and percent abundance of dominant taxon. Site 08-R3M-03-18 received the highest FIBI score (3.00; 'Fair') in the Lower Magothy River sampling unit. Both sites scored in the highest category for abundance per square meter and percent tolerant; in the middle category for both percent abundance of dominate taxon and percent generalist, omnivores, and invertivores; and in the lowest category for both adjusted number of benthic species and percent round-bodied suckers. This site had the highest diversity in the sampling unit with seven species observed.

Eastern Mudminnow (*Umbra pygmaea*) and American Eel (*Anguilla rostrata*) were the most widely distributed species in the sampling unit, present at each of the eight sites. Eastern Mosquitofish (*Gambusia holbrooki*) were found at seven of the eight sites. The least common species in this sampling unit were Chain Pickerel (*Esox niger*; found at a single site), Brown Bullhead (*Ameiurus nebulosus*; found at two sites), and Mummichog (*Fundulus heteroclitus*; found at two sites). Ten species were observed in the sampling unit with one non-native species (Bluegill (*Lepomis macrochirus*)), and nine native species (American Eel, Golden Shiner (*Notemigonus crysoleucas*), Brown Bullhead, Chain Pickerel, Eastern Mudminnow, Banded Killifish (*Fundulus diaphanus*), Mummichog, Eastern Mosquitofish, Pumpkinseed (*Lepomis gibbosus*). No round-bodied suckers, benthic fishes, nor any species considered intolerant to pollution were observed in this sampling unit.

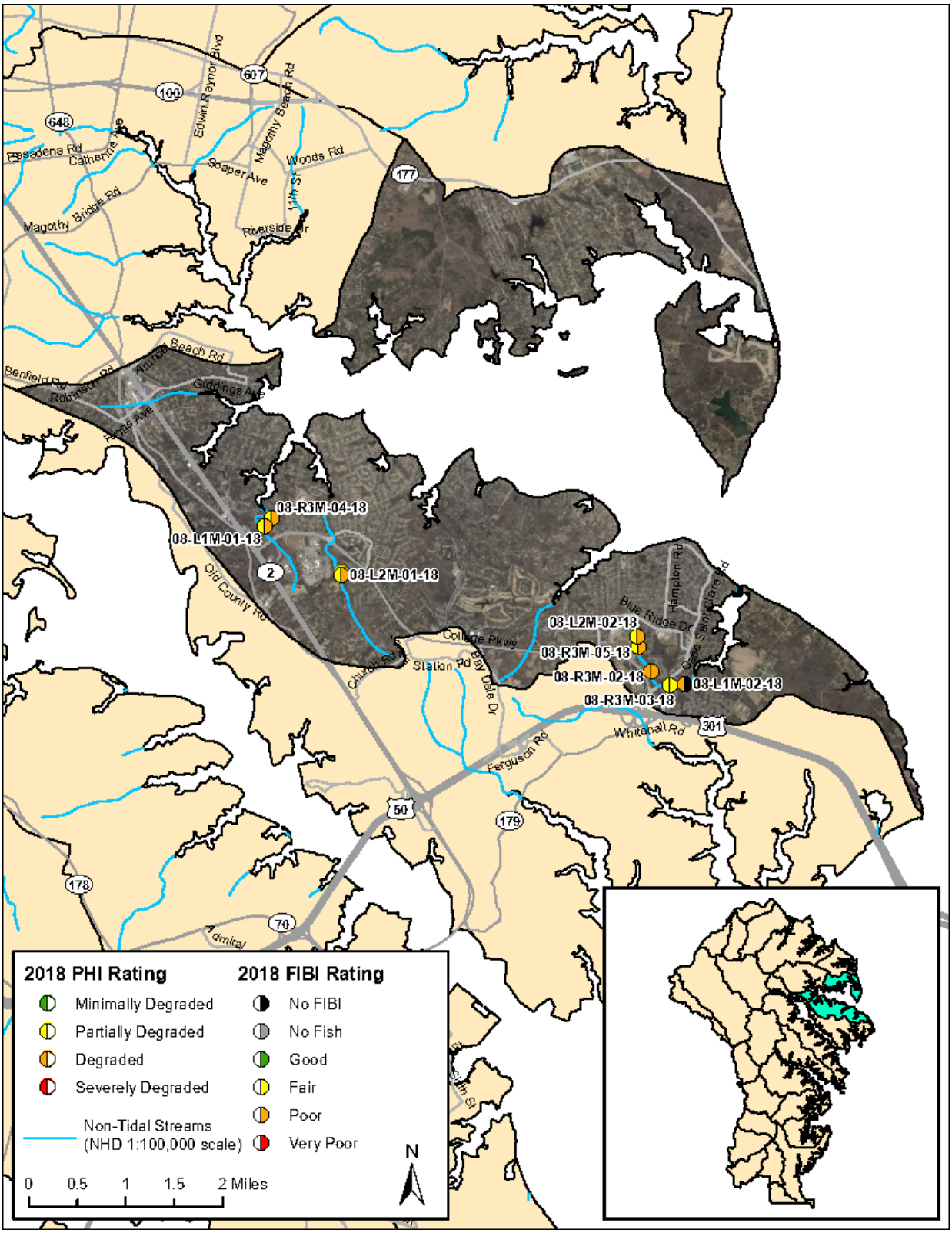


Figure 12 – Lower Magothy River (FIBI and PHI)

4.1.5 Water Quality

Average spring and summer *in situ* water quality values for the Lower Magothy sites are provided in Table 18. Of the eight sites sampled, one site did not meet COMAR standards for water quality in the spring. Site 08-R3M-03-18 measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with a value of 5.93. All other sites sampled met COMAR standards for water quality. In the spring, water temperature ranged from 3.70 to 11.30 °C; DO ranged from 7.06 to 12.92 mg/L; pH ranged from 5.93 to 7.05; specific conductance ranged from 174.0 to 531.0 µS/cm; and turbidity ranged from 0.90 to 9.90 NTU.

In the summer, all eight Lower Magothy sites were sampleable; however, two sites did not meet COMAR standards for water quality. Sites 08-R3M-05-18 and 08-L2M-02-18 measured outside the acceptable COMAR range for DO (i.e., >5.0 mg/L), with values of 3.70 and 3.88 mg/L, respectively. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 20.60 to 24.60 °C; DO ranged from 3.70 to 8.40 mg/L; pH ranged from 6.73 to 7.61; specific conductance ranged from 87.0 to 390.0 µS/cm; and, turbidity ranged from 4.60 to 10.40 NTU

Table 18 - Average in situ water quality values – Lower Magothy River

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	7.13 ± 2.19	10.80 ± 1.93	6.65 ± 0.34	319.8 ± 125.9	3.91 ± 2.74
Summer	22.43 ± 1.45	6.28 ± 1.81	7.04 ± 0.32	232.6 ± 111.6	6.51 ± 2.08

The average spring grab sample water quality values for the Lower Magothy sites are provided in Table 19. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, lead, and turbidity. For total nitrogen, orthophosphate, nitrite, and nitrate, all values at Lower Magothy sites fell in the low or moderate categories used by MBSS. For total phosphorus, site 08-R3M-05-18 fell in the high category used by MBSS (i.e., >0.07 mg/L), with a value of 0.132 mg/L. For total ammonia, sites 08-R3M-04-18, 08-L1M-01-18, 08-L2M-01-18, and 08-L2M-02-18 fell in the high category used by MBSS (i.e., >0.07 mg/L), with values of 0.228, 0.237, 0.103, and 0.167 mg/L, respectively. All other Lower Magothy sites fell in the low to moderate categories used by MBSS for total phosphorus and total ammonia. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 0.51 to 7.56 mg/L; TOC ranged from 0.54 to 7.95 mg/L; magnesium ranged from 2.10 to 7.64 mg/L; calcium ranged from 11.17 to 36.01 mg/L; and, hardness ranged from 37.68 to 121.37 mg/L.

Table 19 - Average grab sample water quality values – Lower Magothy River

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)
57.99 ± 40.01	0.035 ± 0.041	1.064 ± 0.379	0.004 ± 0.002	0.106 ± 0.093	0.005 ± 0.002	0.660 ± 0.496	2.383 ± 2.335
Value ± Standard Deviation							
Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
2.508 ± 2.431	5.267 ± 2.212	18.11 ± 7.73	66.91 ± 26.35	0.934 ± 0.877	17.58 ± 3.96	0.176 ± 0.156	9.4 ± 4.2

4.1.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. The majority of sites (75 percent) assessed in the Lower Magothy sampling unit were slightly entrenched E type channels (75 percent; Figure 13). The remaining sites were slightly entrenched C type channels (12.5 percent) and entrenched G type channels (12.5 percent).

The majority of the streams in this sampling unit were sand bottom channels (62.5 percent) with the remainder of the sites being silt/clay bottoms (37.5). The average D50 was 0.09 mm (very fine sand). Individual site slopes ranged from 0.05 percent to 1.10 percent, with an average slope of 0.66 percent.

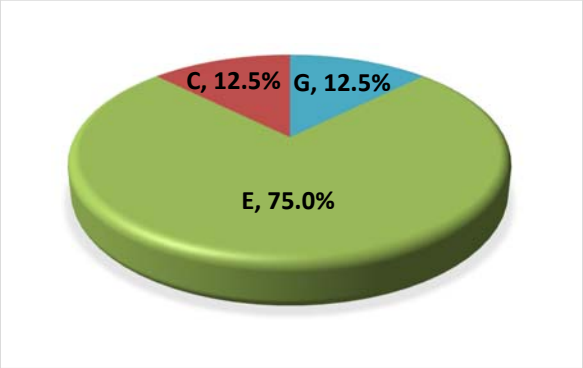


Figure 13 - Rosgen stream types observed in Lower Magothy River (n=8)

4.2 Lower Patapsco River

The Lower Patapsco sampling unit, which drains directly to the Patapsco River, is located at the northern edge of the County (Figure 1), and has a drainage area of 4,040 acres. The eight sampling sites, all 1st order streams (Figure 17) have drainage areas ranging from 138 to 735 acres.

4.2.1 Land Use

Land use in the Lower Patapsco sampling unit is primarily comprised of developed land (65 percent), followed by forested land (24 percent) and open space (11 percent) (Table 17), which is almost identical to the average land use observed among sampling sites. The majority of sites sampled in the Lower Patapsco sampling unit have predominantly developed land cover (68 percent), followed by forested land cover (23 percent) and open space (9 percent) (Figure 14). Impervious surfaces comprise 31.5 percent of

the Lower Patapsco, the largest percentage out of the 2018 sampling units, with individual sites ranging from 27 percent to 45 percent.

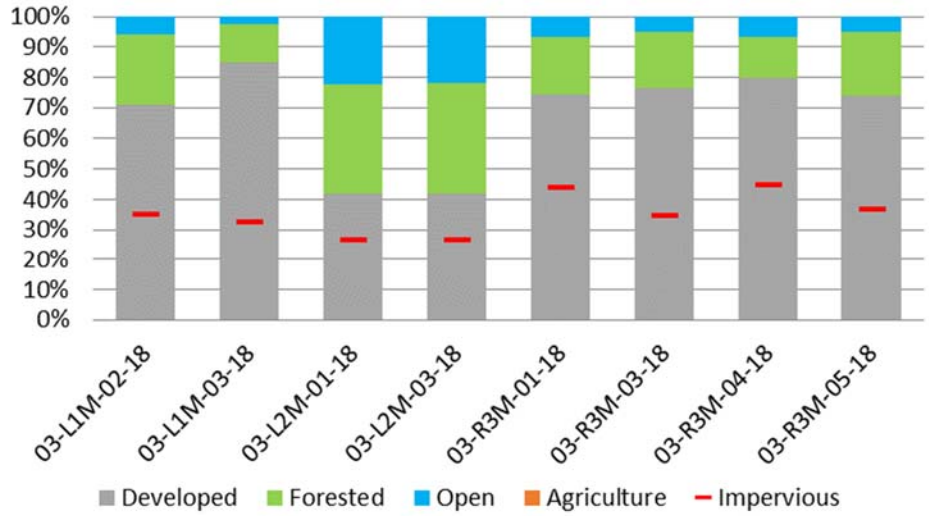


Figure 14 – Lower Patapsco River land use (n=8)

4.2.2 Physical Habitat

Physical habitat conditions during the spring season were fairly poor for this sampling unit. Based on the RBP scores, 50.0 percent of the Lower Patapsco River sites received a rating of 'Partially Supporting,' and 50.0 percent received a 'Non-Supporting' rating (Figure 15). The average RBP score for the Lower Patapsco River sampling unit was 93.75 ± 22.47 (Table 16), and the corresponding narrative rating was 'Non-Supporting.' Individual site scores ranged from 119 ('Partially Supporting') to 62 ('Non-Supporting'). Lower Patapsco River had the lowest mean scores for both the RBP spring and the PHI summer habitat assessments.

According to the PHI (summer), 12.5 percent of the Lower Patapsco River sites were rated as 'Partially Degraded', 62.5 percent received a rating of 'Degraded', and 25.0 percent were rated as 'Severely Degraded' (Figure 15). The average PHI rating was 'Degraded' with a score of 55.78 ± 8.12. Individual site scores ranged from 42.08 ('Severely Degraded') to 66.15 ('Partially Degraded'). Lower Patapsco River had two of the three sites scoring in the lowest 'Severely Degraded' category. Instream habitat and epifaunal substrate scored in the 'Marginal' and 'Poor' categories; high-quality habitat for fish and benthic macroinvertebrates was lacking at all Lower Patapsco River sites. Remoteness was mostly in the 'Marginal' category with two sites in the 'Poor' category. Bank stability at sites in Lower Patapsco River varied the most in this sampling unit when compared to the other four, with scores ranging from the lowest possible 0 to the highest possible 20. Only one site from 2018 sampling scored a 0 for bank stability and only two sites scored a 20. Embeddedness was variable across sites, ranging from 20% to 100% and scoring in the 'Marginal' category for sediment deposition.

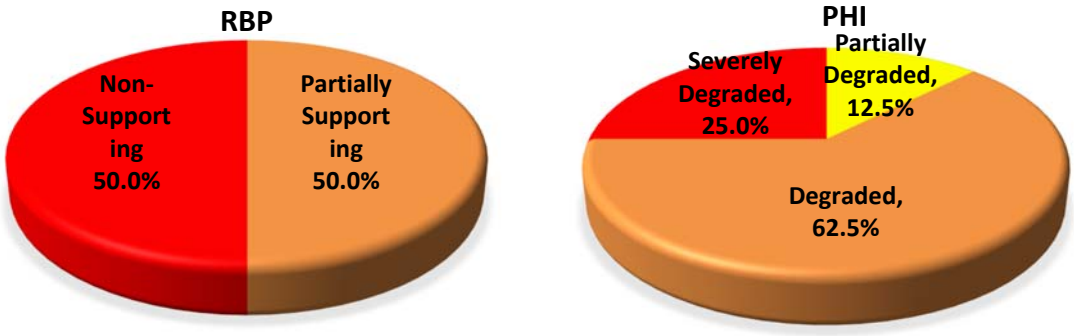


Figure 15 – Lower Patapsco River Physical Habitat Conditions (RBP n=8; PHI n=5)

4.2.3 Benthic Macroinvertebrates

The Lower Patapsco River sampling unit received a BIBI narrative rating of 'Poor' with an average score of 2.14 ± 0.98 (Table 16). Twenty-five percent of the individual sites received a biological condition rating of 'Fair', 37.5 percent received a 'Poor' rating, and the remaining 37.5 percent of sites were rated as 'Very Poor' (Figure 16). Individual BIBI scores ranged from 1.00 ('Very Poor') to 3.86 ('Fair'). This sampling unit had the lowest mean BIBI score and both of the lowest scoring sites at a 1.00. Site-specific data and assessment results can be found in Appendix D.

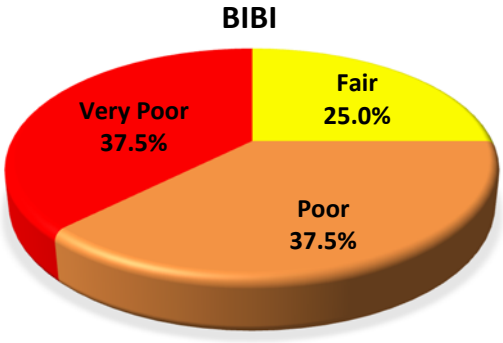


Figure 16 – Lower Patapsco River BIBI Conditions (n=8)

Sites 03-R3M-04-18 and 03-R3M-05-18 received the lowest BIBI score of all Lower Patapsco River sites (1.00) with a narrative rating of 'Very Poor' (Figure 17). Both of these sites had less than 60 organisms in the sample, low taxa diversity (1 and 11 total taxa) with a complete absence of EPT, Ephemeroptera, and intolerant organisms. Site 03-R3M-04-18 had only a single organism in the sample, a worm in the Order Lumbricina. Site 03-R3M-05-18 had Oligochaete worms comprise over 54% of the sample. One additional site received a 'Very Poor' biological rating (03-L1M-02-18) where no Ephemeroptera, scraper, or intolerant taxa were present. Sites 03-L2M-01-18 and 03-L2M-03-18 received the highest BIBI scores (3.00 and 3.86; 'Fair') in the Lower Patapsco River sampling unit. For 03-L2M-01-18, four EPT taxa and three scraper taxa were identified from a total of 28 taxa, with 33.9 percent of the sample consisting of climber taxa. For 03-L2M-03-18, seven EPT and four scraper taxa were present, with 25.2 percent of the sample consisting of climber taxa.

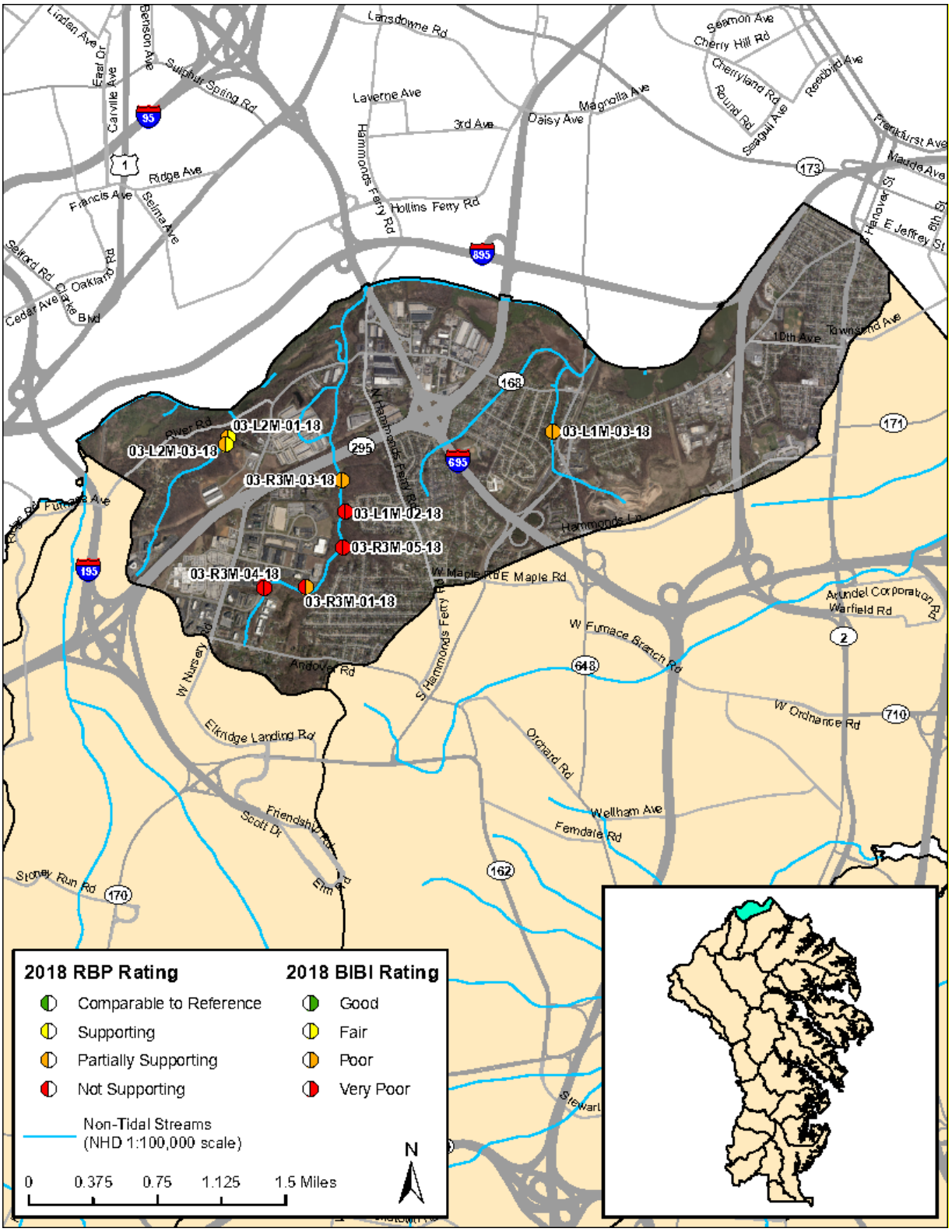


Figure 17 – Lower Patapsco River Sampling Sites (BIBI and RBP)

4.2.4 Fish

The Lower Patapsco River sampling unit received the lowest mean FIBI score among all sampling units sampled during 2018. The Lower Patapsco River received a FIBI narrative rating of 'Poor' with an average score of 2.29 ± 0.74 (Table 16). Fifty percent of the individual sites sampled in this unit received a biological condition rating of 'Poor', 25.0 percent received a 'Fair' rating, and the remaining 25.0 percent of sites were rated as 'Very Poor' (Figure 18). Individual FIBI scores ranged from 1.00 ('Very Poor') to 3.33 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

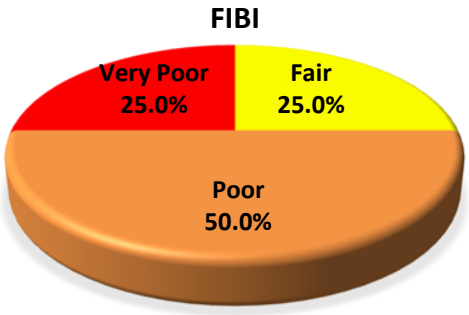


Figure 18 – Lower Patapsco River FIBI Conditions (n=8)

Site 03-R3M-04-18 received the lowest FIBI score of all Lower Patapsco River sites (1.00) with a narrative rating of 'Very Poor.' This site scored a 1.00 because the stream was flowing at the time of sampling but no fish were encountered during either electrofishing pass. MBSS scores sites as 1.00 where no fish were encountered during sampling even though there was water in the stream channel. Site 03-R3M-03-18 (3.33; 'Fair') received the highest FIBI score of sites sampled during 2018 in the Lower Patapsco River sampling unit. This site scored in the highest category for abundance per square meter and adjusted number of benthic species; in the middle category for percent tolerant, percent generalist, omnivores, and invertivores, and percent abundance of dominant taxon; and in the lowest category for percent round bodied suckers. This site, along with 03-L2M-03-18 had the highest diversity in the sampling unit with seven species observed.

Creek Chub (*Semotilus atromaculatus)* was the most widely distributed species in the sampling unit, present at seven of the eight sites. American Eel and Blacknose Dace (*Rhinichthys atratulus)* were both found at six of the eight sites. The least common species in this sampling unit, only present at one site, were Longnose Dace (*Rhinichthys cataractae),* Yellow Bullhead (*Ameiurus natalis*), Swallowtail Shiner (*Notropis procne)*, and Largemouth Bass (*Mictopterus salmoides*). Eleven species were observed in the sampling unit with two non-native species (Largemouth Bass, Green Sunfish (*Lepomis cyanellus))*, and nine native species (American Eel, Yellow Bullhead, Central Stoneroller (*Campostoma anomalum)*, Swallowtail Shiner, Creek Chub, Blacknose Dace, Longnose Dace, Eastern Mosquitofish, and Tessellated Darter (*Etheostoma olmstedi*)). No round-bodied suckers were present at this sampling unit, while Tessellated Darter was the only benthic species observed along with a single intolerant to urban stressors species, Central Stoneroller.

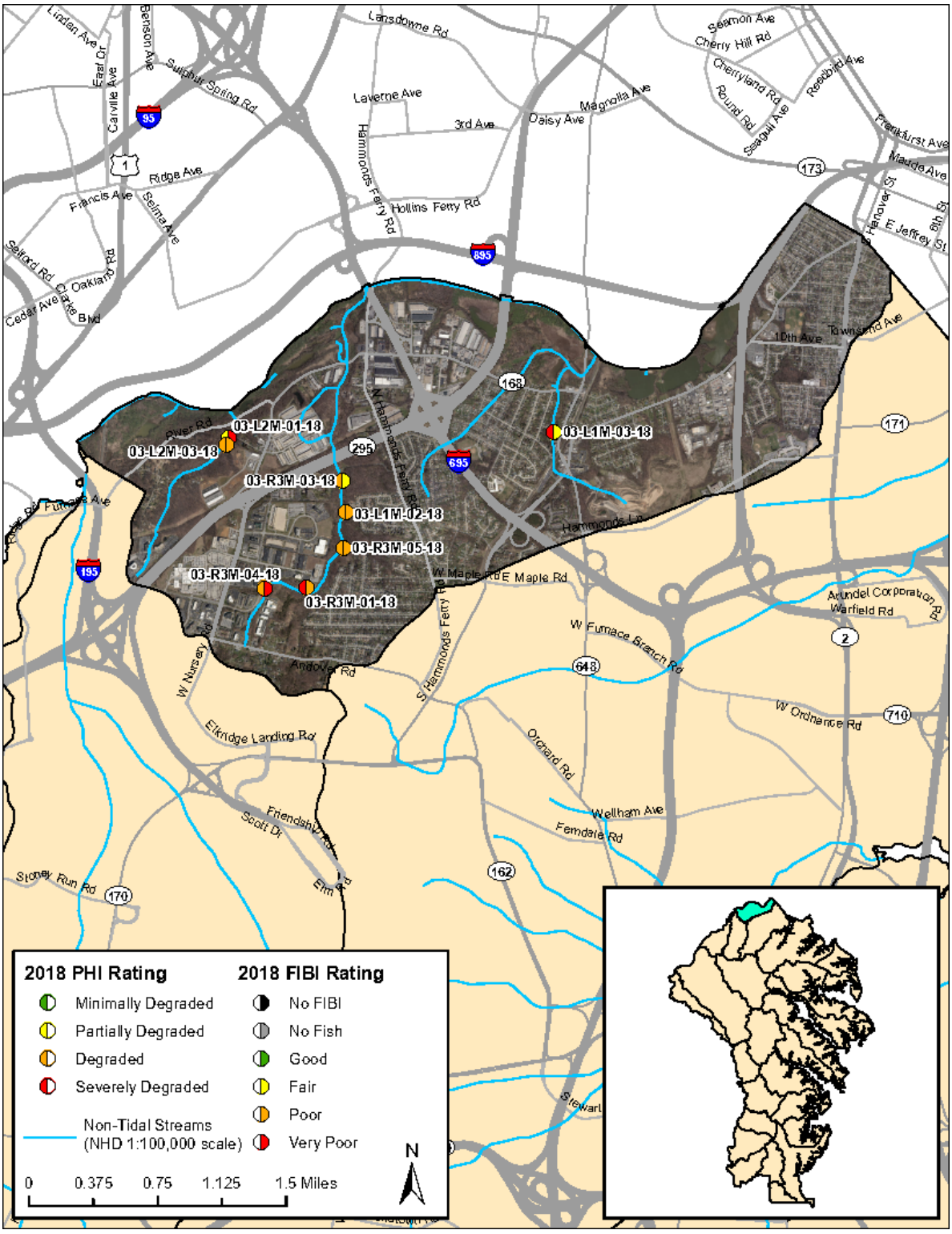


Figure 19 – Lower Patapsco River Sampling Sites (FIBI and PHI)

4.2.5 Water Quality

Average spring and summer *in situ* water quality values for the Lower Patapsco sites are provided in Table 20. Of the eight sites sampled, one site did not meet COMAR standards for water quality in the spring. Site 03-R3M-05-18 measured outside the acceptable COMAR range for DO (i.e., >5.0 mg/L), with a value of 3.39 mg/L. All other sites sampled met COMAR standards for water quality. In the spring, water temperature ranged from 5.80 to 14.80 °C; DO ranged from 3.39 to 12.37 mg/L; pH ranged from 6.61 to 7.71; specific conductance ranged from 447.8 to 4111.0 µS/cm; and, turbidity ranged from 3.05 to 31.30 NTU.

In the summer, all eight Lower Patapsco sites were sampleable. The only site that did not meet COMAR standards for water quality in the summer was site 03-R3M-05-18, which measured outside of the acceptable COMAR range for DO (i.e., >5.0 mg/L), with a value of 2.65 mg/L. This low DO value was likely due to the lack of flow and presence of standing pools that were noted during the sampling event. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 20.00 to 23.20 °C; DO ranged from 2.65 to 7.66 mg/L; pH ranged from 6.66 to 8.03; specific conductance ranged from 238.0 to 557.0 µS/cm; and, turbidity ranged from 1.80 to 18.60 NTU.

Table 20 - Average in-situ water quality values – Lower Patapsco River

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	9.09 ± 2.82	10.19 ± 3.00	7.14 ± 0.43	1434.3 ± 1348.1	12.85 ± 11.59
Summer	21.64 ± 0.96	6.39 ± 1.75	7.46 ± 0.49	359.3 ± 106.8	8.83 ± 5.92

Average spring grab sample water quality values for the Lower Patapsco sites are provided in Table 21. Site 03-R3M-05-18 did not meet EPA standards for chronic chloride concentration (i.e., <230 mg/L), with a value of 653.60 mg/L. Sites 03-R3M-01-18 and 03-R3M-04-18 did not meet EPA standards for both acute and chronic chloride concentration (i.e., <860 mg/L) with values of 924.30 and 1,262.64 mg/L, respectively. All other Lower Patapsco sites sampled met EPA standards for chloride concentration. For copper, zinc, lead, and turbidity, all eight sites sampled met COMAR standards. For total phosphorus, total nitrogen, orthophosphate, and nitrate, all values for Lower Patapsco sites fell in the low to moderate categories used by MBSS. For total ammonia, site 03-LIM-03-18 fell in the high category used by MBSS (i.e., >0.07 mg/L), with a value of 0.104 mg/L. For nitrite, sites 03-R3M-01-18 and 03-L1M-03-18 fell in the high category used by MBSS (i.e., >0.01 mg/L) with values of 0.016 and 0.034 mg/L, respectively. All other Lower Patapsco sites fell in the low to moderate categories used by MBSS for total ammonia and nitrite. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 0.63 to 3.37 mg/L; TOC ranged from 0.64 to 3.35 mg/L; magnesium ranged from 3.64 to 11.25 mg/L; calcium ranged from 15.45 to 76.47 mg/L; and, hardness ranged from 61.37 to 237.27 mg/L.

Table 21 - Average grab sample water quality values – Lower Patapsco River

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)
427.58 ± 460.17	0.023 ± 0.015	1.597 ± 1.018	0.004 ± 0.002	0.033 ± 0.038	0.011 ± 0.010	1.265 ± 1.082	1.606 ± 1.114
Value ± Standard Deviation							
Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
1.621 ± 1.094	7.113 ± 2.601	34.38 ± 20.47	115.12 ± 58.23	2.378 ± 1.325	7.80 ± 4.71	0.289 ± 0.193	8.2 ± 9.5

4.2.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results are presented in Appendix A. The majority of sites in the Lower Patapsco sampling unit were entrenched and classified as F type channels (37.5 percent; Figure 20). Moderately entrenched B type channels comprised 25 percent of the sites, while slightly entrenched C and E type channels each comprised 12.5 percent of the sites. Channel type at the remaining 12.5 percent of sites was not determined 'ND', as the sites did not meet criteria for any single stream type category.

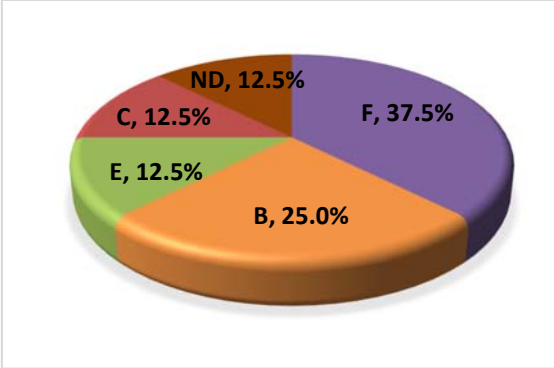


Figure 20- Rosgen stream types observed in Lower Patapsco River (n=8)

Half of the sites in the Lower Patapsco sampling unit were gravel bed channels and the substrate at 25 percent of sites was dominated by a gravel and sand mix. The substrate at 12.5 percent of sites was dominated by a sand and cobble mix. The average D50 within the Lower Patapsco sampling unit was 9.15 mm (medium gravel). Streams in this sampling unit had an average slope of 1.07 percent, with individual slopes ranging from 0.74 percent to 1.61 percent. The Lower Patapsco sampling unit had the largest average D50 and steepest average slope observed among the 2018 sampling units.

4.3 Marley Creek

The Marley Creek sampling unit is located on the eastern edge of the County, primarily draining Glen Burnie and the surrounding area (Figure 1). The sampling unit has a total drainage area of 19,424 acres, which eventually drains into the Patapsco River downstream of the Francis Scott Key Bridge. Of the eight sites assessed, seven were located on 1st order streams and one on a 2nd order stream as shown in Figure 24. Drainage areas to sampling sites ranged from 178 to 1,044 acres.

4.3.1 Land Use

Land use in the Marley Creek sampling unit is comprised primarily of developed land (65 percent), followed by forested land (26 percent) and open space (8 percent), with agriculture comprising less than one percent (Table 17). All eight sampling sites were dominated by developed land (Figure 21). On average, land use among the eight sites was similar to that of the sampling unit: 72 percent developed, 22 percent forested, 5 percent open space, and less than 1 percent agriculture. Impervious surfaces account for 28.4 percent of the Marley Creek sampling unit, the second highest percentage of the 2018 sampling units, with individual sites ranging from 15 to 42 percent imperviousness.

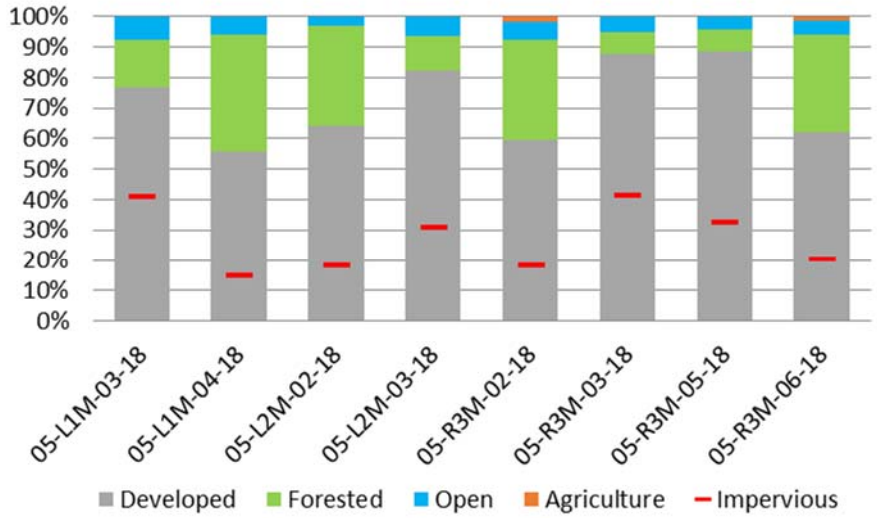


Figure 21 – Marley Creek land use (n=8)

4.3.2 Physical Habitat

Based on the RBP scores, 50.0 percent of the Marley Creek sites received a rating of 'Partially Supporting,' 25.0 percent received a 'Supporting' rating, and the remaining 25.0 percent of sites were classified as 'Non-Supporting' (Figure 22). The average RBP score for the Marley Creek sampling unit was 111.75 ± 16.93, and the corresponding narrative rating was 'Partially Supporting.' Individual site scores ranged from 81 ('Non-Supporting') to 132 ('Supporting'). This sampling unit had mean scores for both spring RBP and summer PHI in the middle of the five sampling units from 2018.

According to the PHI (summer), 75.0 percent of the Marley Creek sites were rated as 'Degraded', 12.5 percent were rated as 'Severely Degraded', and 12.5 percent were rated as 'Partially Degraded' (Figure 22). The average PHI rating was 'Degraded' with a score of 61.75 ± 8.71. Individual site scores ranged from 43.54 ('Severely Degraded') to 73.37 ('Partially Degraded'). All of the sites sampled received 'Marginal' to 'Poor' scores for instream habitat and epifaunal substrate. Bank stability, scored in the 'Marginal' and 'Sub-Optimal' categories for most sites, with one site scoring in the 'Poor' and one in the 'Optimal' categories. Embeddedness scored greater than 90% at seven of the eight sites, and 40% at the remaining site.

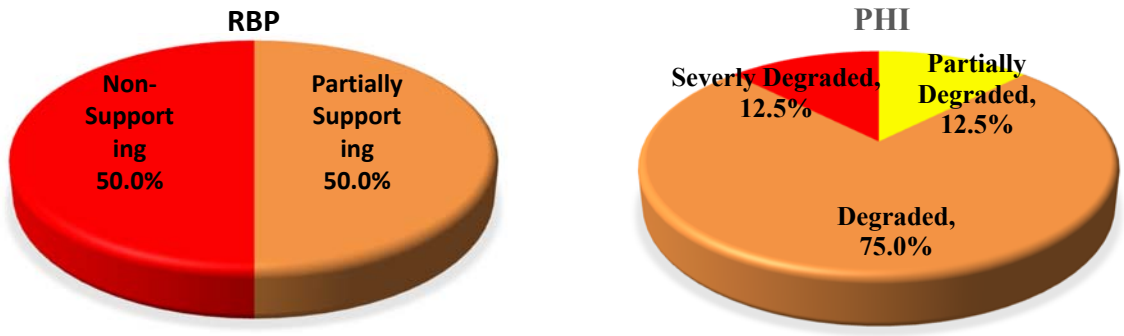


Figure 22 – Marley Creek Physical Habitat Conditions (RBP n=8; PHI n=8)

4.3.3 Benthic Macroinvertebrates

The average BIBI rating for the Marley Creek sampling unit is 'Poor' with an average BIBI score of 2.64 ± 0.48 (Table 16), and individual sites ranging from a low of 1.86 ('Very Poor') to 3.29 ('Fair'). Approximately a third of sites (37.5 percent) received a BIBI rating of 'Fair', another 37.5 percent of the sites were rated as 'Poor', and the remaining sites received a 'Very Poor' rating (25.0 percent; Figure 23). Marley Creek was the sampling unit with the second highest mean BIBI score. Site-specific data and assessment results can be found in Appendix D.

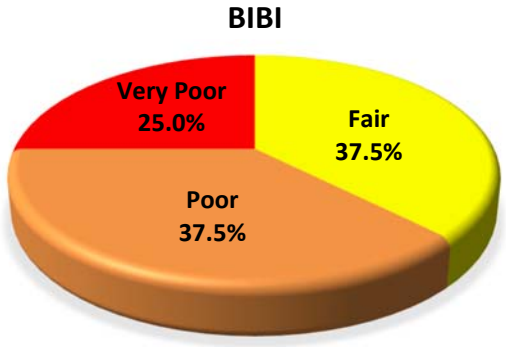


Figure 23 – Marley Creek BIBI Conditions (n=8)

Site 05-L2M-03-18 received the lowest score in the Marley Creek sampling unit of 1.86 with a 'Very Poor' narrative rating (Figure 24). The site had relatively low taxa diversity (11 taxa), only had one EPT taxa and completely lacked both Ephemeroptera and taxa intolerant to urban. In contrast, site 05-L1M-04-18 received the highest BIBI score of 3.29 due to its relatively high number of total taxa (23), having two EPT taxa, five scraper taxa, and 18.6% of the sample consisted of climbers; however, no Ephemeroptera taxa were present.

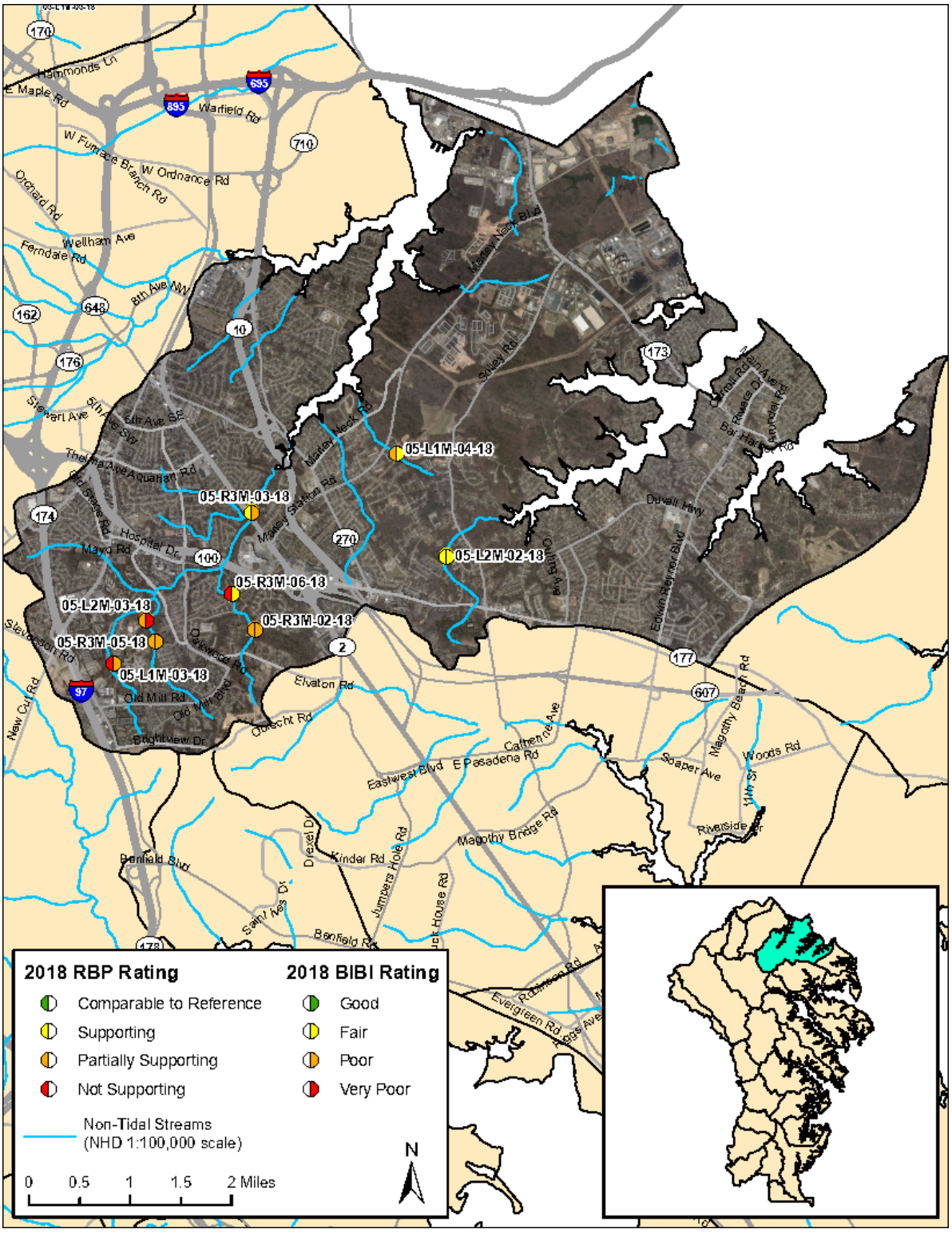


Figure 24 – Marley Creek Sampling Sites (BIBI and RBP)

4.3.4 Fish

The Marley Creek sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.63 ± 0.92 (Table 16). The majority of the sites in this sampling unit received a biological condition rating of 'Poor' (62.7%), and 12.5 percent received a 'Good', 'Fair', and 'Very Poor' rating (Figure 25). Individual FIBI scores ranged from 1.67 ('Very Poor') to 4.33 ('Good'). Site-specific data and assessment results can be found in Appendix D.

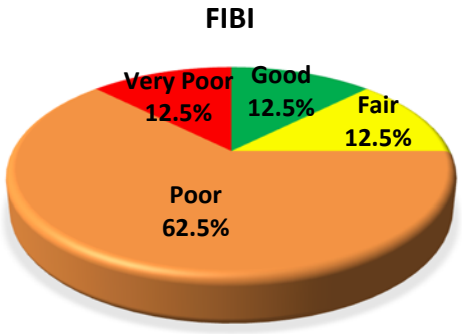


Figure 25 – Marley Creek FIBI Conditions (n=8)

Site 05-L2M-02-18 received the lowest FIBI scores of Marley Creek sites (1.67) with a narrative rating of 'Very Poor.' This site scored in the lowest category (1) for all metrics except percent tolerant (5). Site 05-R3M-03-18 received the highest FIBI score (4.33; 'Good') in the Marley Creek sampling unit. This site scored in the highest category (5) for all metrics except percent generalist, omnivores, and invertivores (1). This site had the highest diversity in the sampling unit with sixteen species observed.

Blacknose Dace and Eastern Mudminnow were the most widely distributed species in the sampling unit, present at each of the six sites. Tessellated Darter were found at five of the eight sites. The least common species in this sampling unit were Goldfish (*Carassius auratus*), Spottail Shiner (*Notropis hudsonius*), and Warmouth (*Lepomis gulosus*) found at a single site. Seventeen species were observed in the sampling unit with two non-native species (Goldfish and Bluegill), and fifteen native species (American Eel, Brown Bullhead, Creek Chubsucker (*Erimyzon oblongus*), White Sucker (*Catostomus commersonii*), Golden Shiner, Spottail Shiner, Blacknose Dace, Eastern Mudminnow, Banded Killifsh, Mummichog, Eastern Mosquitofish, Tessellated Darter, Warmouth, Redbreast Sunfish (*Lepomis auritus*), and Pumpkinseed). One round-bodied sucker (Creek Chubsucker) was present, along with one benthic fish (Tessellated Darter), and one species considered intolerant to pollution (Spottail Shiner) were observed in this sampling unit.

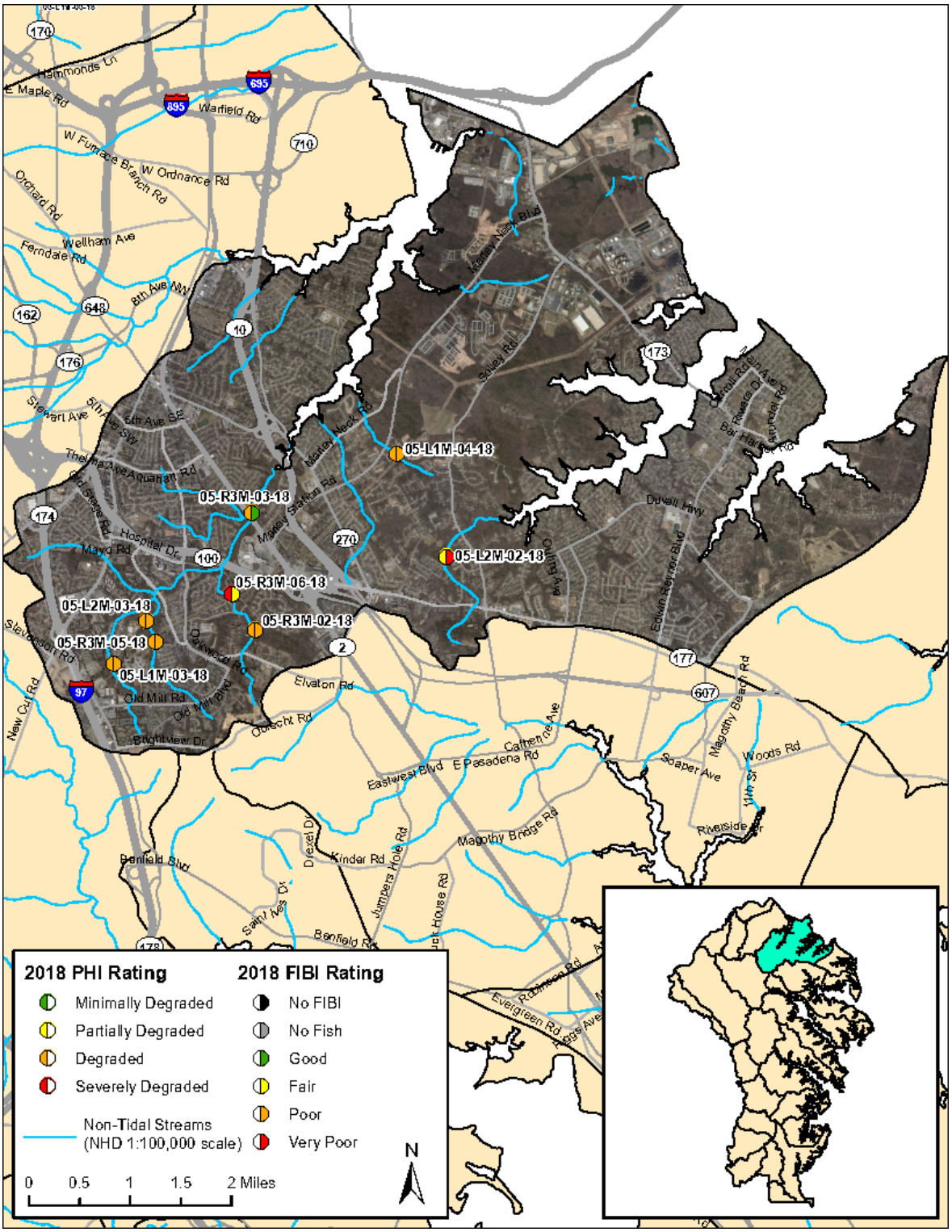


Figure 26 – Marley Creek Sampling Sites (FIBI and PHI)

4.3.5 Water Quality

Average spring and summer *in situ* water quality values for the Marley Creek sites are provided in Table 22. Of the eight sites sampled, one site did not meet COMAR standards for water quality in the spring. Site 05-R3M-02-18 measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5 SU) and average monthly turbidity (i.e., <50 NTU), with values of 6.02 and 63.2, respectively. All other sites sampled met COMAR standards for water quality. In the spring, water temperature ranged from 2.10 to 9.60 °C; DO ranged from 7.03 to 13.83 mg/L; pH ranged from 6.02 to 7.48; specific conductance ranged from 245.7 to 873.0 µS/cm; and, turbidity ranged from 2.60 to 63.20 NTU.

In the summer, all eight Marley Creek sites were sampleable and six of the eight sites met COMAR standards for water quality. Sites 05-R3M-02-18 and 05-R3M-06-18 exceeded COMAR standards for average monthly turbidity in the summer, with values exceeding 99.9 NTU. Because the maximum detection limit of the turbidimeter was 99.9 NTU, it is unknown if these readings also exceeded COMAR standards for instantaneous turbidity (i.e., <150 NTU). In the summer, water temperature ranged from 19.30 to 25.30 °C; DO ranged from 5.36 to 8.48 mg/L; pH ranged from 6.93 to 7.61; specific conductance ranged from 208.0 to 495.0 µS/cm; and, turbidity ranged from 2.40 to 99.90 NTU.

Table 22 - Average in-situ water quality values – Marley Creek

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	7.18 ± 2.58	11.43 ± 2.24	6.99 ± 0.49	373.2 ± 207.6	16.95 ± 22.03
Summer	22.20 ± 1.78	7.28 ± 0.99	7.33 ± 0.27	344.0 ± 109.6	34.64 ± 40.63

Average spring grab sample water quality values for the Marley Creek sites are provided in Table 23. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, and lead. Site 05-R3M-02-18 met COMAR criteria for acute turbidity, but exceeded the acceptable COMAR range for average monthly turbidity (i.e., <50 NTU), with a value of 64.6 NTU. For total phosphorus, total nitrogen, orthophosphate, and nitrate, all values at the Marley Creek sites fell in the low or moderate categories used by MBSS. For total ammonia, site 05-R3M-03-18 fell in the high category used by MBSS (i.e., >0.07 mg/L) with a value of 0.134 mg/L. For nitrite, site 05-R3M-03-18 fell in the high category used by MBSS (i.e., >0.01 mg/L) with a value of 0.026 mg/L. All other Marley Creek sites fell in the low or moderate categories used by MBSS for total ammonia and nitrite. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 3.92 to 12.46 mg/L; TOC ranged from 3.95 to 13.60 mg/L; magnesium ranged from 2.63 to 5.36 mg/L; calcium ranged from 17.80 to 39.96 mg/L; and, hardness ranged from 57.49 to 121.86 mg/L.

Table 23 - Average grab sample water quality values – Marley Creek

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)
67.02 ± 56.44	0.024 ± 0.016	1.175 ± 0.509	0.004 ± 0.001	0.031 ± 0.042	0.007 ± 0.008	0.793 ± 0.549	6.898 ± 2.927
Value ± Standard Deviation							
Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
7.139 ± 3.224	3.547 ± 0.896	23.33 ± 7.1	72.85 ± 20.51	2.655 ± 1.122	20.22 ± 21.66	0.401 ± 0.207	16.5 ± 21.2

4.3.6 Geomorphic Assessment

Site-specific geomorphic assessment results can be found in Appendix A. A variety of stream types were present in the Marley Creek sampling unit (Figure 27). Seventy-five percent of sites were entrenched G or F type channels (37.5 percent each). Slightly entrenched E type channels made up 12.5 percent of the sites. The remaining 12.5 percent of sites were moderately entrenched B type channels. Site-specific geomorphic assessment results can be found in Appendix A.

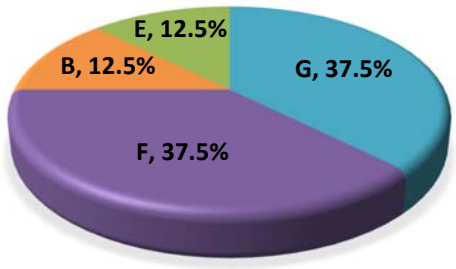


Figure 27 - Rosgen stream types observed in Severn River (n=8)

The majority of streams in this sampling unit had predominantly sand substrate (75 percent) with the remaining sites dominated by either a gravel/silt/clay mix (12.5 percent) or a gravel/sand mix (12.5 percent). The average D50 for the Marley Creek sampling unit was 0.44 mm (medium sand). With the exception of one site, slopes were less than one percent, with average slope of 0.54 percent, ranging from 0.01 percent to 2.20 percent.

4.4 Piney Run

With a drainage area of 4,868 acres, the Piney Run sampling unit is located at the northwestern edge of the County (Figure 1) and drains directly into the Patapsco River. Some of the sampling sites also drain large areas in Howard County, resulting in site drainage areas greater than that of the sampling unit. The eight sampling sites (four 1st order, one 2nd order, and three 3rd order streams) shown in Figure 31 have drainage areas ranging from 134 to 11,512 acres.

4.4.1 Land Use

The Piney Run sampling unit is comprised of 23.5 percent impervious surfaces, and developed (47 percent) and forested (41) land comprise the majority of the sampling unit (Table 17). Site-specific drainage areas ranged from 7 to 30 percent impervious surfaces and were dominated by developed land, on average (Figure 28). Only one site, 01-L2M-01-18, was comprised of approximately equal proportions of developed (43 percent) and forested (48 percent) land uses. Developed land comprised the majority of the drainage areas for the other seven sites.

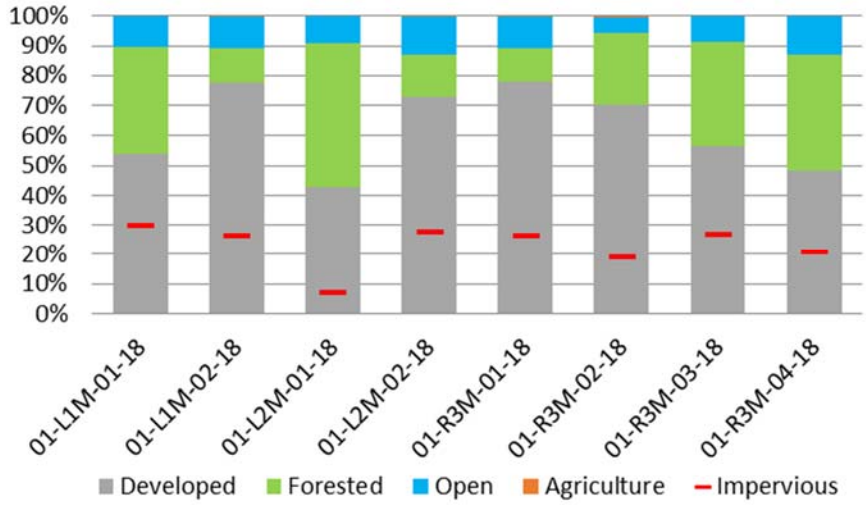


Figure 28 - Piney Run land use (n=8)

4.4.2 Physical Habitat

Based on the RBP index assessed during the spring season, half of the sites were rated as 'Supporting' (50.0 percent), and the remaining half were rated as 'Partially Supporting' (50.0 percent; Figure 29). With an average RBP score of 100.88 ± 22.62 and a narrative rating of 'Partially Supporting', Piney Run had the second lowest mean RBP score. Individual RBP scores ranged from a minimum of 75 ('Non-Supporting') to a maximum of 124 ('Partially Supporting').

The PHI (summer season) rated 62.5 percent of sites as 'Degraded', 25.0 percent of sites as 'Partially Degraded', and 12.5 percent as 'Severely Degraded' (Figure 29). The average PHI rating was 'Degraded' with a score of 59.59 ± 9.46 and was the second lowest mean PHI rating of the PSUs sampled during 2018. Individual PHI scores ranged from 42.51 ('Severely Degraded') to 71.79 ('Partially Degraded'). The majority of sites assessed received 'Marginal' to 'Suboptimal' scores for instream habitat, epifaunal substrate, pool/glide/eddy quality, and velocity depth diversity. Embeddedness was generally lower at the Piney Run sites, with most sites scoring between 45% and 65%.

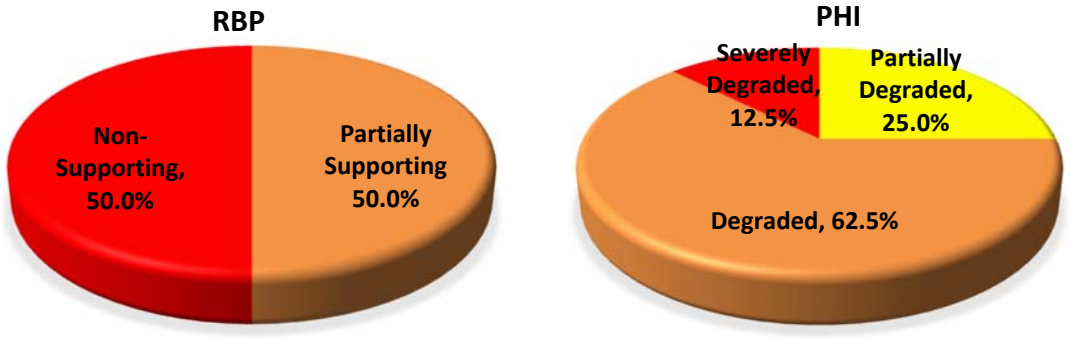


Figure 29 – Piney Run Physical Habitat Conditions (RBP n=8; PHI n=8)

4.4.3 Benthic Macroinvertebrates

Among the Piney Run sampling unit sites, 50.0 percent of the sites received 'Poor' BIBI ratings, 37.5 percent were rated as 'Fair', while the remaining 12.5 percent of sites received a 'Very Poor' rating (Figure 30). The average BIBI score for the sampling unit was 2.61 ± 0.43, resulting in a 'Poor' biological condition rating (Table 16). This sampling unit had the second highest mean BIBI of all PSUs evaluated in 2018. Individual BIBI scores ranged from 1.86 ('Very Poor') to 3.00 ('Fair'). Individual site data and assessment results can be found in Appendix D.

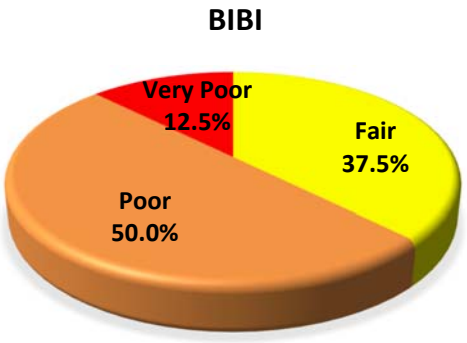


Figure 30 – Piney Run BIBI Conditions (n=8)

Site 01-R3M-04-18 received the lowest BIBI score of 1.86 with a 'Very Poor' rating. A total of thirteen taxa were present in this sample, which was predominantly comprised of Chironomidae which accounted for over 79 percent of the sample. This sample did not contain any scraper taxa or taxa intolerant to urban stressors. Three sites, (01-L1M-02-18, 01-L2M-02-18, and 01-R3M-01-18) received the highest BIBI score for this sampling unit of 3.00, resulting in a 'Fair' biological condition rating. These sites had relatively high diversity (22 or 26 taxa), high number of EPT taxa (2-4), high number of scraper taxa (3), and relatively high percentage of climbers in the sample (19.8% - 37.6%). All sites sampled during 2018 in the Piney Run sampling unit lacked any Ephemeroptera taxa and all sites received the lowest score for both the metrics 'Number of Ephemeroptera Taxa' and 'Percent Ephemeroptera'.

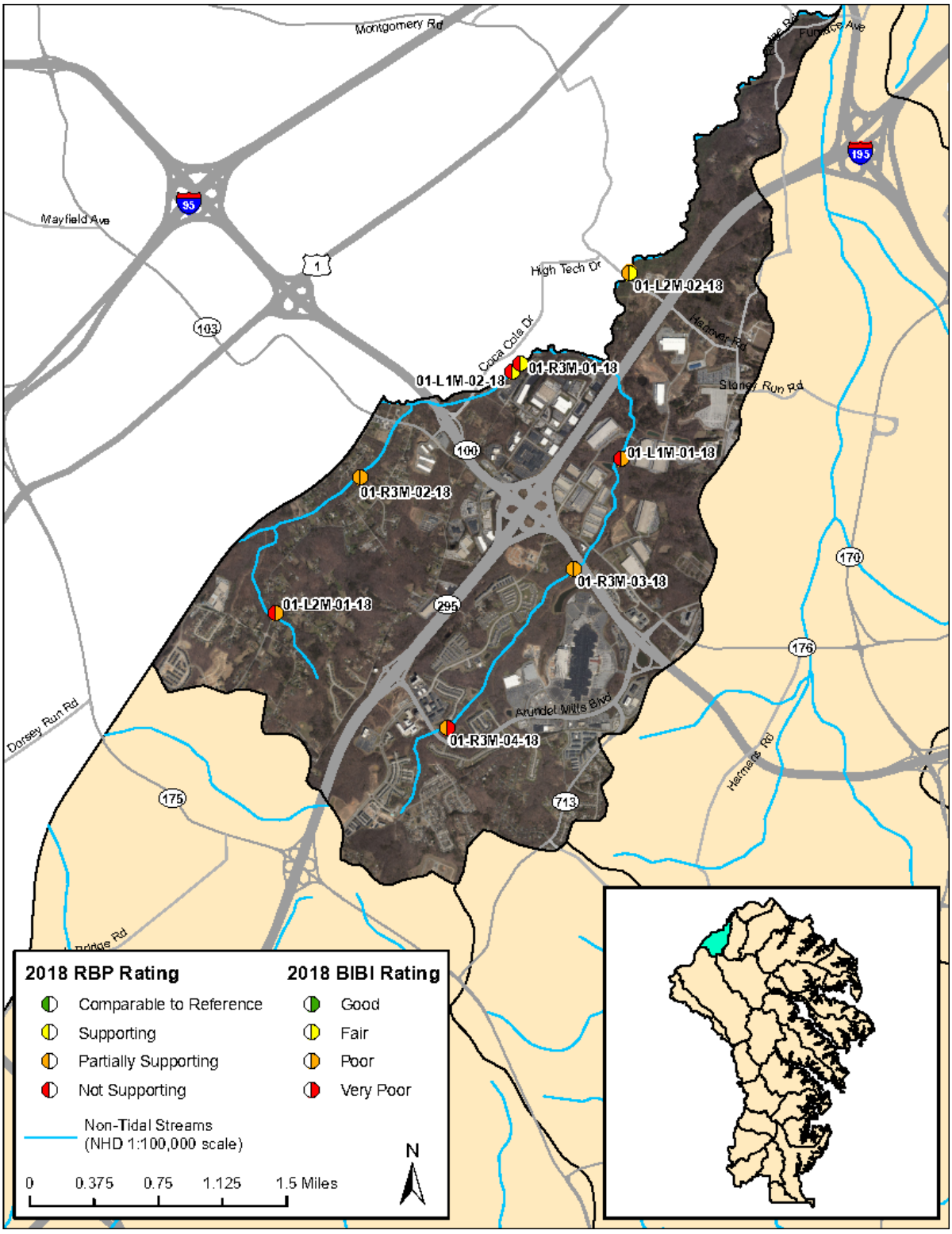


Figure 31 - Piney Run Sampling Sites (BIBI and RBP)

4.4.4 Fish

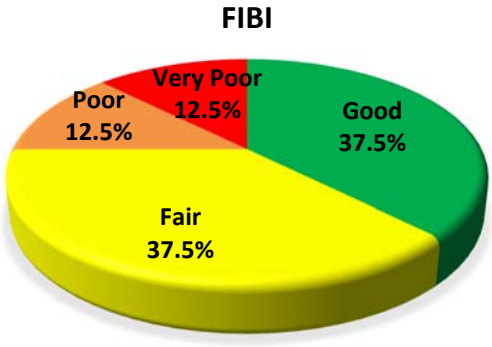


Figure 32 – Piney Run FIBI Conditions (n=8)

The Piney Run sampling unit received a FIBI narrative rating of 'Fair' with an average score of 3.25 ±1.12 (Table 16). A biological condition rating of 'Good' or 'Fair' was given to 75 percent of the sites while the other 25 percent received either 'Poor' or 'Very Poor' ratings (Figure 32). Individual FIBI scores ranged from 1.00 ('Very Poor') to 4.33 ('Good'). Site-specific data and assessment results can be found in Appendix D.

Sites 01-L1M-01-18 and 01-R3M-01-18 each received the highest FIBI score (4.33; 'Good') in the Piney Run sampling unit. These sites scored in the highest category (5) for all metrics except percent round-bodied suckers (1). These sites had the highest diversity in the sampling unit with 22 and 23 species observed, respectively. Site 01-L2M-01-18 received the lowest FIBI score of Piney Run sites (1.00) with a narrative rating of 'Very Poor.' This site scored a 1.00 because the stream was flowing at the time of sampling but no fish were encountered during either electrofishing pass. MBSS scores sites as 1.00 where no fish were encountered during sampling even though there was water in the stream channel.

American Eel, Yellow Bullhead, Swallowtail Shiner, Satinfin Shiner (*Cyprinella analostana*), Creek Chub, and Tessellated Darter were the most widely distributed species in the sampling unit, present at seven of the eight sites. The least common species in this sampling unit were Fathead Minnow (*Pimephales promelas;* found at one site), Smallmouth Bass (*Micropterus dolomieu;* found at two sites), and Warmouth (found at two sites). Twenty-seven species were observed in the sampling unit with five non-native species (Fathead Minnow, Smallmouth Bass, Largemouth Bass, Green Sunfish and Bluegill), and twenty-two native species (Least Brook Lamprey (*Lampetra aepyptera)*, Sea Lamprey (*Petromyzon* marinus), American Eel, Yellow Bullhead, Northern Hogsucker (*Hypentelium nigricans)*, White Sucker, Central Stoneroller, Cutlip Minnow (*Exoglossum maxillingua)*, Bluntnose Minnow (*Pimephales notatus)*, Satinfin Shiner, Swallowtail Shiner, Rosyside Dace (*Clinostomus funduloides)*, Fallfish (*Semotilus corporalis)*, Creek Chub, Blacknose Dace, Longnose Dace, Eastern Mosquitofish, Blue Ridge Sculpin (*Cottus caeruleomentum*), Tessellated Darter, Warmouth, Redbreast Sunfish, Pumpkinseed. One round-bodied sucker (Northern Hogsucker) was present, along with three benthic fish (Least Brook Lamprey, Sea Lamprey, andTessellated Darter), and six species considered intolerant to pollution (Sea Lamprey, Northern Hogsucker, Central Stoneroller, Satinfin Shiner, Fallfish, and Blue Ridge Sculpin) were observed in this sampling unit.

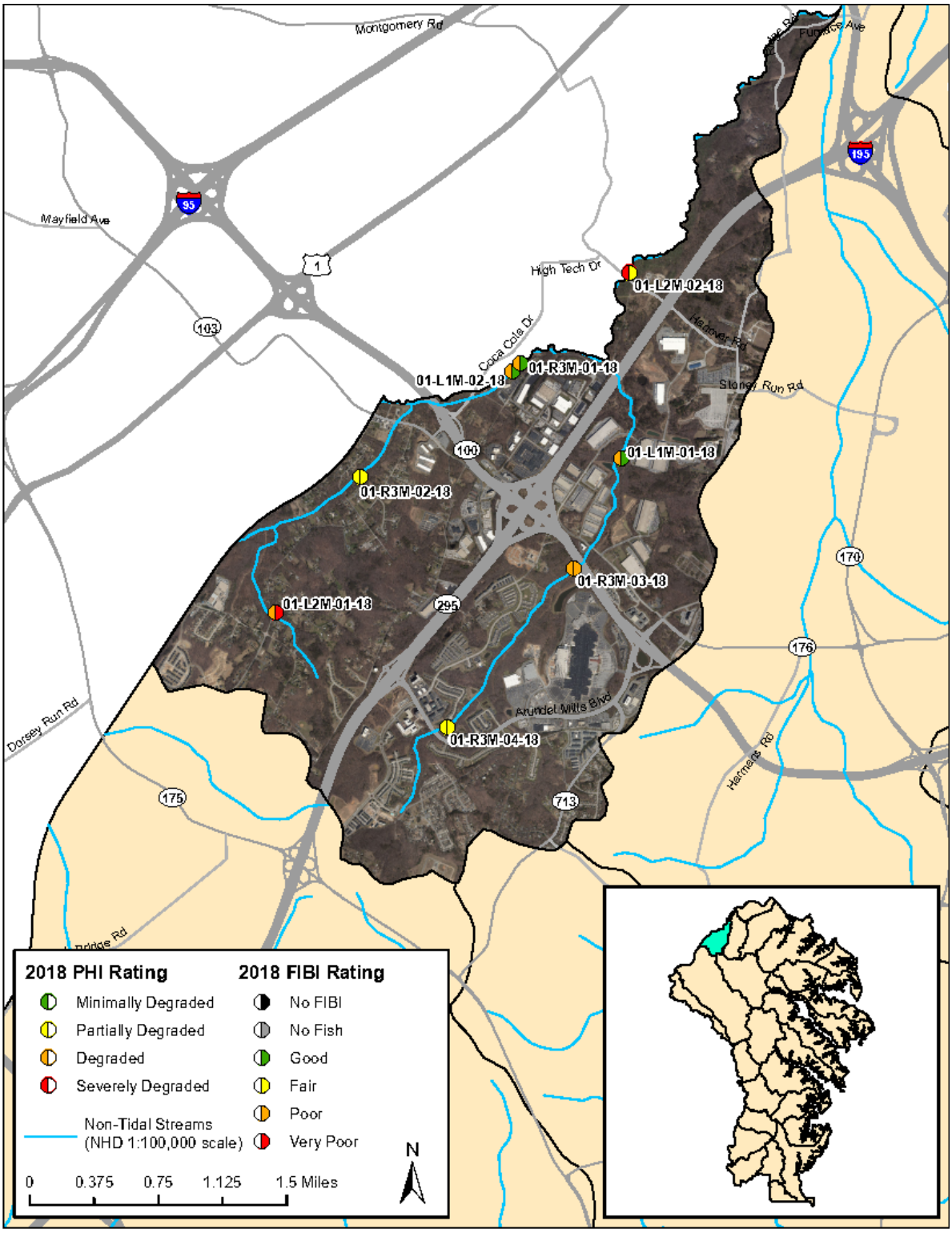


Figure 33 – Piney Run Sampling Sites (FIBI and PHI)

4.4.5 Water Quality

Average spring and summer *in situ* water quality values for the Piney Run sites are provided in Table 24. All eight sites sampled met COMAR standards for water quality in the spring. Water temperature ranged from 6.50 to 11.80 °C; DO ranged from 7.72 to 12.75 mg/L; pH ranged from 6.92 to 7.82; specific conductance ranged from 202.9 to 943.0 µS/cm; and, turbidity ranged from 4.50 to 12.60 NTU.

In the summer, all eight Piney Run sites were sampleable with one site not meeting COMAR standards for water quality. Site 01-L2M-01-18 measured outside the acceptable COMAR range for DO (i.e., >5.0 mg/L) and average monthly turbidity (i.e., <50 NTU), with values of 2.26 mg/L and 85.9, respectively. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 18.90 to 25.40 °C; DO ranged from 2.26 to 8.53 mg/L; pH ranged from 6.50 to 7.96; specific conductance ranged from 156.5 to 595.0 µS/cm; and, turbidity ranged from 4.80 to 85.90 NTU.

Table 24 - Average *in situ* water quality values – Piney Run

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	9.00 ± 1.89	10.96 ± 1.56	7.31 ± 0.35	688.4 ± 253.8	6.78 ± 2.58
Summer	22.65 ± 2.31	6.61 ± 1.90	7.24 ± 0.53	434.8 ± 167.5	26.38 ± 28.36

The average spring grab sample water quality values for the Piney Run sites are provided in Table 25. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, lead, and turbidity. For total nitrogen and nitrate, all values at Piney Run sites fell in the low or moderate categories used by MBSS. For total phosphorus, site 01-R3M-04-18 fell in the high category used by MBSS (i.e., >0.07 mg/L), with a value of 0.576 mg/L. For orthophosphate, site 01-R3M-04-18 fell in the high category used by MBSS (i.e., >0.03 mg/L), with a value of 0.415 mg/L. For total ammonia, sites 01-R3M-04-18 and 01-LIM-01-18 fell in the high category used by MBSS (i.e., >0.07 mg/L), with values of 5.447 and 0.650 mg/L, respectively. For nitrite, sites 01-R3M-03-18, 01-R3M-04-18, and 01-L1M-01-18 fell in the high category used by MBSS (i.e., >0.01 mg/L) with values of 0.013, 0.046, and 0.022 mg/L, respectively. All other Piney Run sites fell in the low or moderate categories used by MBSS for total phosphorus, orthophosphate, total ammonia, and nitrite. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 1.21 to 2.89 mg/L; TOC ranged from 1.22 to 3.04 mg/L; magnesium ranged from 2.66 to 10.58 mg/L; calcium ranged from 8.09 to 44.26 mg/L; and, hardness ranged from 31.16 to 153.59 mg/L.

Table 25 - Average grab samples water quality values - Piney Run

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)
150.26 ± 60.29	0.092 ± 0.196	1.654 ± 1.981	0.055 ± 0.146	0.775 ± 1.901	0.013 ± 0.015	0.624 ± 0.366	1.780 ± 0.557
Value ± Standard Deviation							
Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
1.825 ± 0.595	6.723 ± 2.683	27.85 ± 11.10	97.24 ± 37.37	1.676 ± 0.783	12.56 ± 7.16	0.122 ± 0.059	4.9 ± 1.3

4.4.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. Fifty percent of sites assessed in the Piney Run sampling unit were classified as entrenched F type channels (Figure 34). Entrenched G channels made up 12.5 percent of sites. The remaining 37.5 percent of the sites assessed were slightly entrenched C type channels.

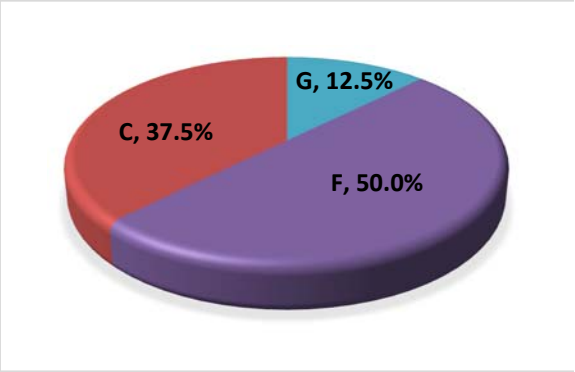


Figure 34 - Rosgen stream types observed in Piney Run (n=8)

The majority of streams in this sampling unit had a sand (50 percent) dominated substrate. The remaining sites were split between sites dominated by gravel (37.5 percent) and sand/silt/clay mix (12.5 percent). The average D50 for the sampling unit was 3.9 mm (very fine gravel) and slopes ranged from 0.01 to 0.75 percent, with an average slope of 0.35 percent. All of the Piney Run sites assessed in 2018 had a slope of less than 1 percent.

4.5 Stocketts Run

The Stocketts Run sampling unit, which drains directly to the Patuxent River, is located in the south-central portion of the County, along the western border (Figure 1).). Overall, the sampling unit has a drainage area of 8,714 acres. The eight sampling sites (six 1st order and two 2nd order streams) shown in Figure 38 have drainage areas ranging from 68 to 3,685 acres.

4.5.1 Land Use

Land use in the Stocketts Run sampling unit is primarily comprised of forested (39 percent) and developed (35 percent) land, followed by agricultural land (20 percent) (Table 17). This is substantially more forest cover than the other 2018 sampling units. On average, individual site drainage areas were comprised of developed (42 percent), forested (28 percent), and agricultural (26 percent) land uses (Figure 35). Within Stocketts Run, dominant land use varied by site. Sites 19-L1M-01-18, 19-L1M-03-18, 19-L2M-01-18, and 19-R3M-07-18 were dominated by forested land, whereas the remainder of sites were dominated by developed land (Figure 35). Impervious surfaces comprise only 5.8 percent of the overall sampling unit, with individual sites ranging from 4 percent to 15 percent. Site 19-L1M-03-17 in this sampling unit had the lowest percentage of imperviousness of any sites visited in 2018.

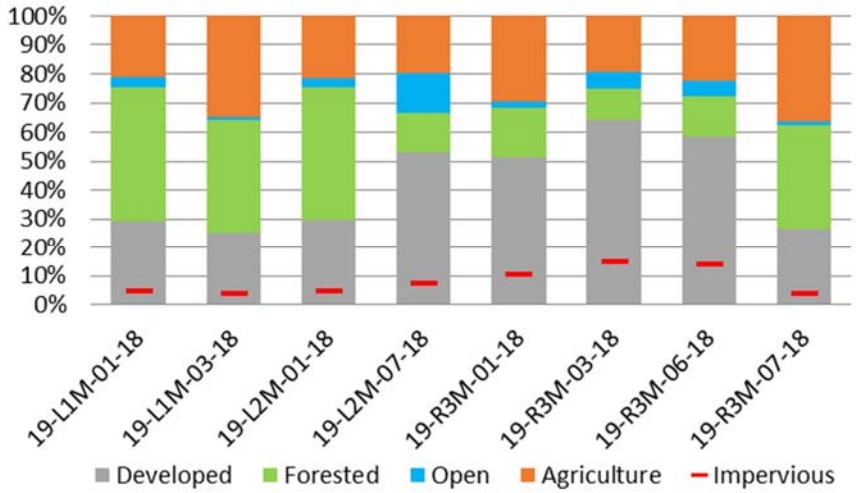


Figure 35 – Stocketts Run land use (n=8)

4.5.2 Physical Habitat

Nearly a third of the sites sampled during the spring season in the Stocketts Run sampling unit (62.5 percent) received a 'Partially Supporting' narrative RBP rating, while 25.0 percent of the sites received a 'Supporting' rating, and the remaining 12.5 percent received a RBP rating of 'Comparable to Reference' (Figure 36). The average RBP score for the sampling unit was 123.63 ± 19.08, and the corresponding narrative rating was 'Partially Supporting.' Individual RBP scores ranged from a minimum of 103 ('Partially Supporting') to a maximum of 155 ('Comparable to Reference'). This sampling unit had the highest scoring site in 2018 and had the second highest mean RBP score of all PSUs assessed this year.

The PHI (summer season) rated 12.5 percent of sites as 'Minimally Degraded', 75.0 percent as 'Partially Degraded', and 12.5 percent as 'Degraded' (Figure 36). The average PHI rating was 'Partially Degraded' with a score of 71.77 ± 6.26. Individual PHI scores ranged from 68.41 ('Degraded') to 81.18 ('Minimally Degraded'). The Stocketts Run sampling unit had the only site scoring as 'Minimally Degraded' for the summer PHI and had the highest mean PHI score of the sampling units from 2018. The majority of sites received 'Marginal' and 'Poor' scores for instream habitat, and epifaunal substrate. The scaled scores for bank stability, shading, and remoteness were relatively high, helping raise the overall PHI score for sites.

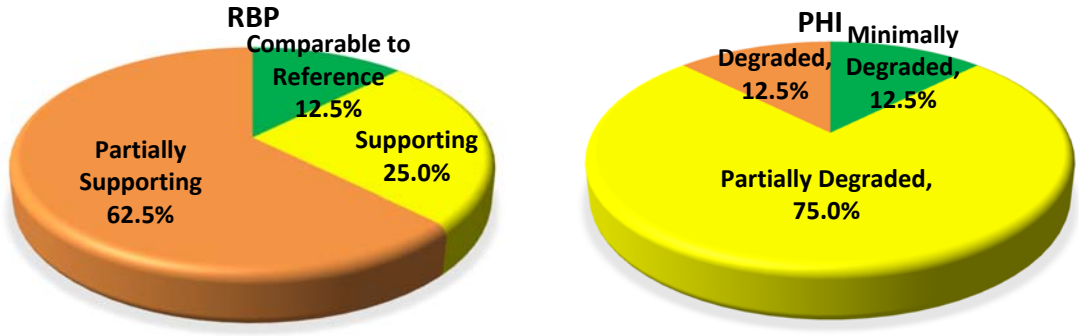


Figure 36 – Stocketts Run Physical Habitat Conditions (RBP n=8; PHI n=8)

4.5.3 Benthic Macroinvertebrates

One quarter of the sites sampled within the Stocketts Run sampling unit received 'Good' BIBI ratings, another quarter received a 'Fair' rating, while 37.5 percent of sites received 'Poor' ratings, and the remaining 12.5 percent of sites were rated as 'Very Poor' (Figure 37). The average BIBI score for the sampling unit was 3.11 ± 1.18 resulting in a 'Fair' biological condition rating (Table 16). Individual BIBI scores ranged from 1.57 ('Very Poor') to 4.71 ('Good'). This sampling unit had the highest mean BIBI score, and the only two sites scoring in the 'Good' range for 2018. Individual site data and assessment results can be found in Appendix D.

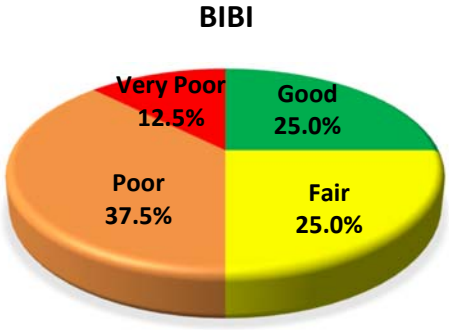


Figure 37 – Stocketts Run BIBI Conditions (n= 8)

Located close to Maryland Route 2, site 19-R3M-03-18 received the lowest BIBI score of 1.57 with a 'Very Poor' rating (Figure 38). Seventeen taxa were present in this sample, which contained 5.5 percent of climber taxa; however, the sample did not contain any EPT, Ephemeroptera or scraper taxa. Sites 19-L1M-03-18 and 19-L2M-01-18 received the highest scores in Stocketts Run (4.71 and 4.43), resulting in a biological condition rating of 'Good.' Both of these sites had a high number of taxa (25 and 22), a high number of EPT taxa (8 and 6), two Ephemeroptera taxa, greater than 19.3% intolerant organisms, a high number of scraper taxa (4 and 5), and greater than 29.4% of sample comprised of climbers. Site 19-L2M-01-18 had a RBP habitat score that placed it in the highest 'Comparable to Reference' category, making this site a "perfect" site with both the BIBI and RBP habitat in the highest category. All of the sites scoring either 'Good' or 'Fair' in this sampling unit had at least one Ephemeroptera taxa in the sample.

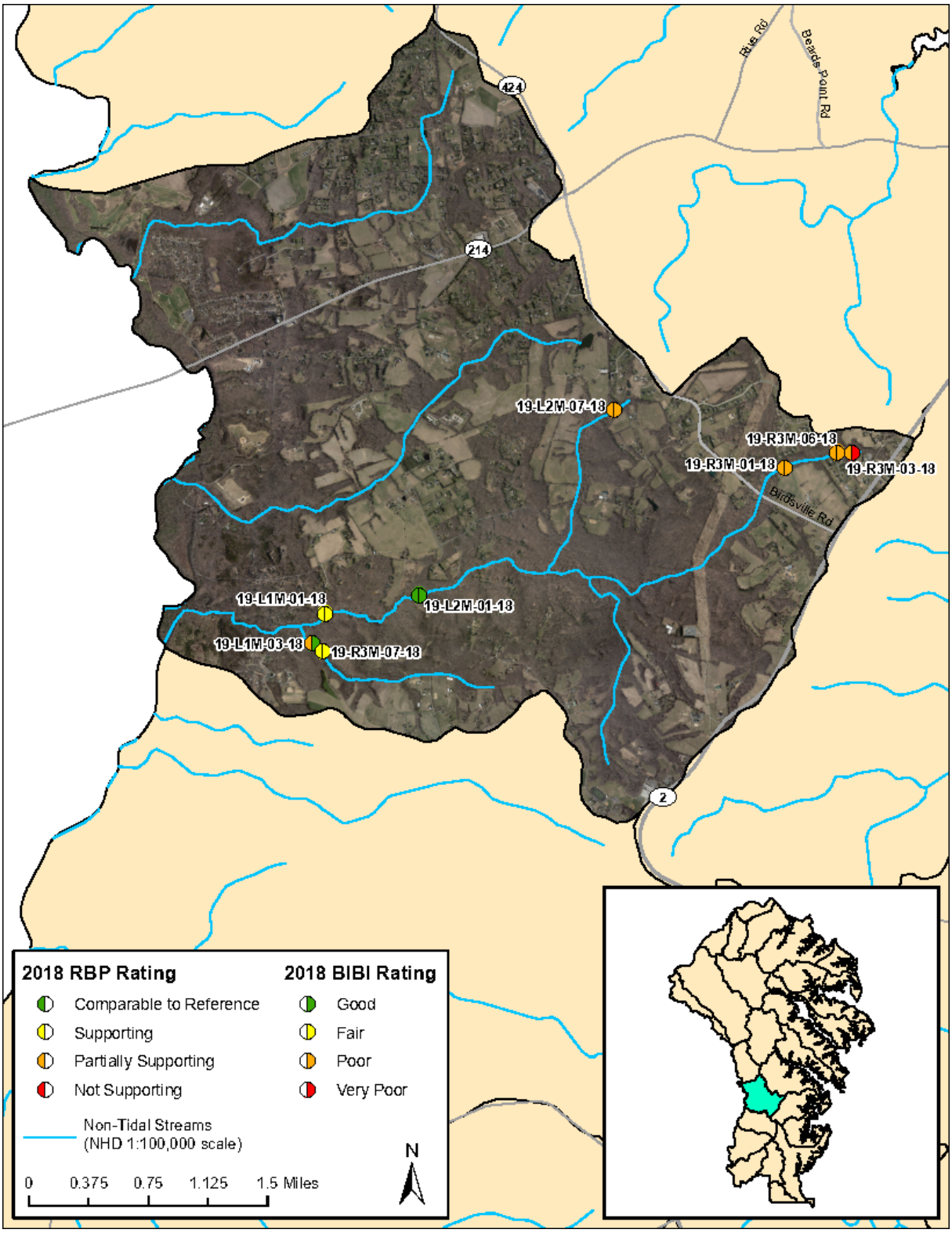


Figure 38 – Stocketts Run Sampling Sites (BIBI and RBP)

4.5.4 Fish

The Stocketts Run sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.67 ± 1.50 (Table 16). Twenty-five percent of the sites in this sampling unit received a biological condition rating of 'Fair' or 'Poor', while 37.5 percent of the sites each received a 'Good' or 'Very Poor' rating (Figure 39). Individual FIBI scores ranged from 1.00 ('Very Poor') to 4.33 ('Good'). Site-specific data and assessment results can be found in Appendix D.

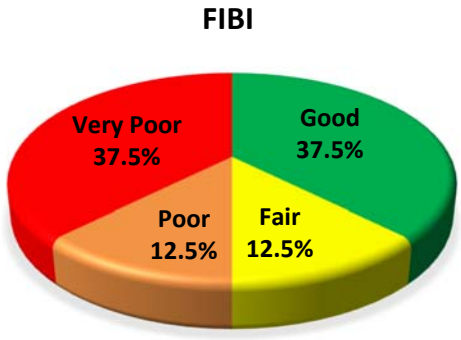


Figure 39 – Stocketts Run FIBI Condition (n=8)

Site 19-R3M-03-18 the lowest FIBI scores of Stocketts Run sites (1.00) with a narrative rating of 'Very Poor.' This site scored a 1.00 because the stream was flowing at the time of sampling but no fish were encountered during either electrofishing pass. MBSS scores sites as 1.00 where no fish were encountered during sampling even though there was water in the stream channel. Sites 19-L1M-01-18 and 19-L2M-01-18 received the highest FIBI scores of Stocketts Run sites (4.33) with a narrative rating of 'Good'. These sites scored in the highest metric category (5) for all metrics except percent round-bodied suckers (1). These sites had the highest diversity in the sampling unit with 15 and 14 species observed, respectively.

Blacknose Dace was the most widely distributed species in the sampling unit, present at seven of the eight sites. Tessellated Darter was also prevalent in the sampling unit and found at five sites. The least common species in this sampling unit were Spottail Shiner, Eastern Mudminnow, and Glassy Darter (*Etheostoma vitreum)* found at only a single site. Sixteen species were observed in the sampling unit with three non-native species (Largemouth Bass, Green Sunfish and Bluegill), and thirteen native species (Least Brook Lamprey, Sea Lamprey, American Eel, Creek Chubsucker, White Sucker, Spottail Shiner, Swallowtail Shiner, Rosyside Dace, Fallfish, Blacknose Dace, Eastern Mudminnow, Glassy Darter and Tessellated Darter). One round-bodied sucker (Creek Chubsucker) was present, along with three benthic fish (Least Brook Lamprey, Glassy Darter, and Tessellated Darter), and three species considered intolerant to pollution (Sea Lampreym, Spottail Shiner, and Fallfish) were observed in this sampling unit. The only State-listed rare, threatened, or endangered fish species observed in 2018 was found in the Stocketts Run sampling unit. That species is the Glassy Darter, listed as threatened in Maryland (DNR, 2016).

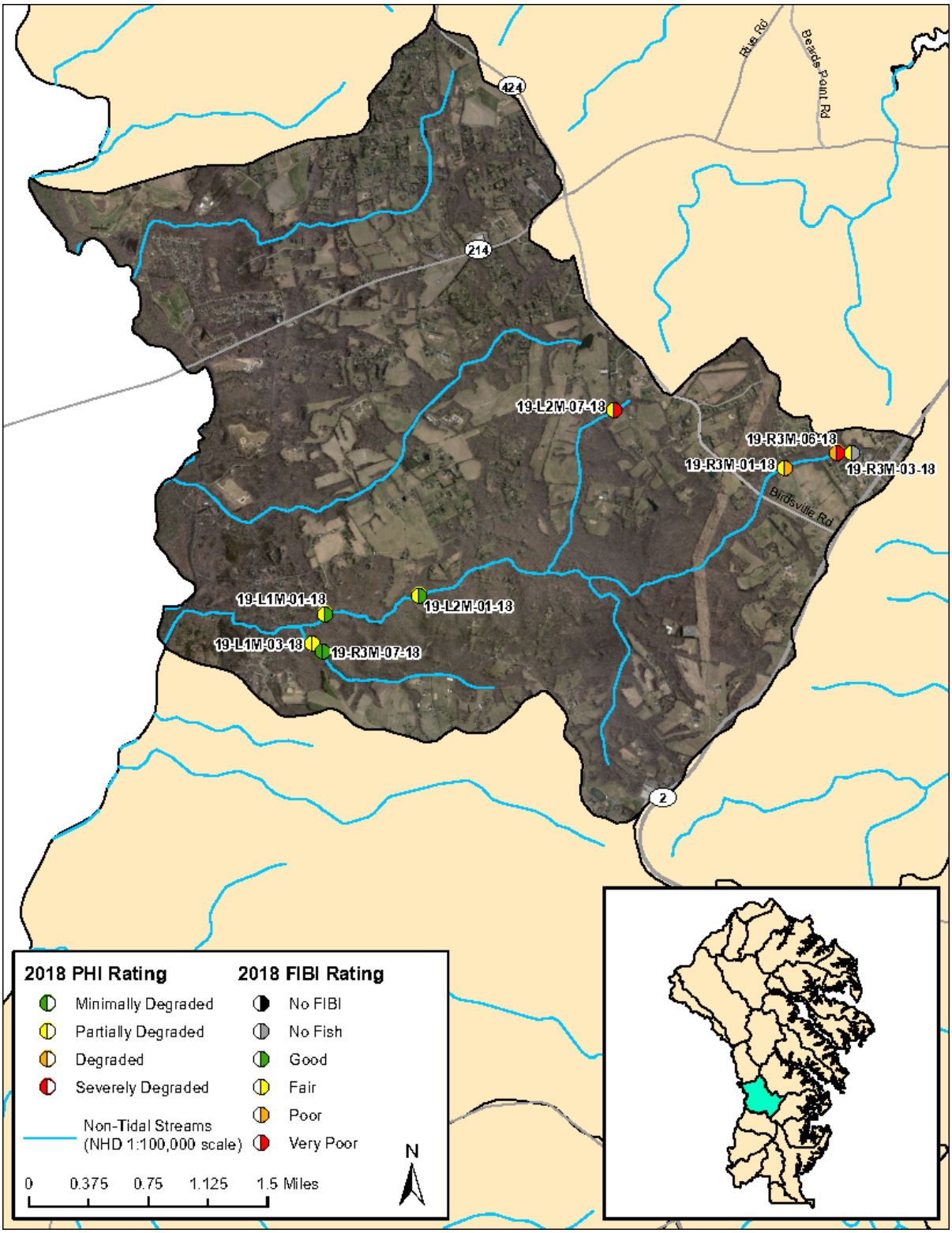


Figure 40 – Stocketts Run Sampling Sites (FIBI and PHI)

4.5.5 Water Quality

Average spring and summer *in situ* water quality values for the Stocketts Run sites are provided in Table 26. Of the eight sites sampled, three sites did not meet COMAR standards for water quality in the spring. Sites 19-R3M-01-18, 19-R3M-06-18, and 19-L2M-01-18 all measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with values of 6.46, 6.47, and 6.06, respectively. All other sites sampled met COMAR standards for water quality. In the spring, water temperature ranged from 2.40 to 12.10 °C; DO ranged from 10.92 to 12.99 mg/L; pH ranged from 6.06 to 7.41; specific conductance ranged from 185.0 to 462.0 µS/cm; and, turbidity ranged from 1.70 to 8.90 NTU.

In the summer, all eight sites in Stocketts Run met COMAR standards for water quality. Water temperature ranged from 17.90 to 22.10 °C; DO ranged from 7.55 to 8.69 mg/L; pH ranged from 6.81 to 8.02; specific conductance ranged from 118.0 to 475.0 µS/cm; and, turbidity ranged from 1.70 to 14.90 NTU.

Table 26 - Average *in situ* water quality values – Stocketts Run

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	7.95 ± 3.10	12.06 ± 0.77	6.70 ± 0.41	293.0 ± 109.0	4.60 ± 2.85
Summer	20.38 ± 1.27	8.18 ± 0.35	7.22 ± 0.41	272.8 ± 127.4	5.70 ± 4.31

Average spring grab sample water quality values for the Stocketts Run sites are provided in Table 27. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, lead, and turbidity. For total nitrogen, orthophosphate, and nitrate, all values at Stocketts Run sites fell in the low or moderate categories used by MBSS. For total phosphorus, sites 19-R3M-01-18, 19-R3M-06-18, 19-R3M-07-18, 19-L1M-01-18, 19-L1M-03-18, 19-L2M-01-18, and 19-L2M-07-18 fell in the high category used by MBSS (i.e., >0.07 mg/L) with values ranging from 0.077 to 0.156 mg/L. For total ammonia, site 19-L2M-07-18 fell in the high category used by MBSS (i.e., >0.07 mg/L) with a value of 0.153 mg/L, and for nitrite, site 19-L2M-07-18 fell in the high category used by MBSS (i.e., >0.01 mg/L) with a value of 0.013 mg/L. All other Stocketts Run sites fell in the low or moderate categories used by MBSS for total phosphorus, total ammonia, and nitrite. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 1.27 to 3.26 mg/L; TOC ranged from 1.28 to 3.39 mg/L; magnesium ranged from 2.78 to 3.63 mg/L; calcium ranged from 17.33 to 24.93 mg/L; and, hardness ranged from 55.40 to 79.63 mg/L.

Table 27 - Average grab sample water quality values – Stocketts Run

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)
53.77 ± 32.64	0.093 ± 0.029	1.358 ± 0.613	0.016 ± 0.007	0.041 ± 0.048	0.005 ± 0.003	1.121 ± 0.635	1.989 ± 0.677
Value ± Standard Deviation							
Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
2.057 ± 0.707	3.435 ± 0.559	20.48 ± 3.38	65.29 ± 10.28	0.366 ± 0.079	12.89 ± 5.91	0.133 ± 0.098	5.4 ± 2.5

4.5.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. The majority of sites in the Stocketts Run sampling unit were classified as entrenched G and F type channels (62.5 and 25 percent, respectively; Figure 41). The remaining 12.5 percent of sites were not determined (ND).

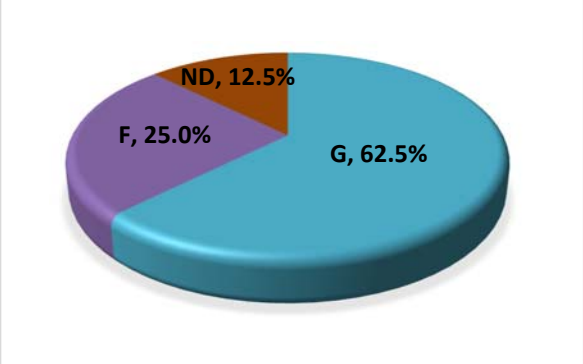


Figure 41 - Rosgen stream types observed in Stocketts Run (n=8)

The majority of sites were sand dominated (50 percent), while the remaining 50 percent of sites were split between gravel and gravel/sand substrates (25 and 12.5 percent, respectively). The average D50 for the sampling unit was 0.48 mm (medium sand). The average slope within Stocketts Run was 0.63 percent, with individual reach slopes ranging from 0.22 to 1.60 percent.

5 Round Comparisons for Repeated Sites

In Round 3, a subset of sites from Round One and Two (i.e., two sites from each previous round) were reestablished and resampled in order to track changes through time at individual sites within each sampling unit. For these sites, cross-sectional area, Rosgen classification, substrate distribution, and BIBI scores were compared across sampling years (Table 28). In order to allow for comparisons at revisited sites, Round One and Two bankfull elevations were adjusted at select sites in order to match the bankfull discharge in 2018. These bankfull adjustments were performed for sites that did not match the regional curve. From Round One and Two to Round Three, substrate coarsened in the Marley Creek, Piney Run, and Stocketts Run sampling units and remained unchanged in the Lower Magothy and Lower Patapsco sampling units, based on the average D_{50}. Substrate size increased from very fine sand to medium sand in the Marley Creek sampling unit, fine gravel to medium gravel in the Piney Run sampling unit, and coarse sand to very fine gravel in the Stocketts Run sampling unit.

Trends in BIBI scores at revisit sites also varied by sampling unit. On average, BIBI scores remained the same in Lower Magothy, improved in Marley Creek and Stocketts Run, and declined in Lower Patapsco. Overall, no clear trend was observed between changes in BIBI scores and changes substrate distribution. Although trends were weak and based on few data points, BIBI score generally decreased with an increase in cross-sectional area in the Lower Magothy. Typically, an increase in cross-sectional area is the result of over widening and excessive erosion due to anthropogenic effects at the watershed scale (e.g., an increase in impervious surface within the watershed). This type of channel trajectory is known to potentially degrade aquatic habitat to varying degrees. No other trends in BIBI scores and cross-sectional area were apparent in other 2018 sampling units.

Cross-section overlays of sites in the Lower Magothy sampling unit that were resampled in Round Three indicated varying, site-specific trends, with respect to cross-sectional area. On average, cross-sectional area decreased by 3.5 percent from Round One and Two to Round Three. At sites 08-L1M-01-18 and 08-L2M-01-18, cross-sectional area increased by 20.7 and 6.7 percent, respectively; however, at sites 08-L1M-02-18 and 08-L2M-02-18, cross-sectional area decreased by 15.7 and 25.5 percent, respectively. In Round Three, all Lower Magothy sites were classified as E type channels and had D_{50} classifications of medium sand or finer (Table 28). Site 08-L1M-01-18 was the only site with a change in Rosgen stream classification between sampling rounds (C5 in Round One to E5 in Round Three). A representative cross-sectional overlay can be found in Figure 42. Individual site cross-sectional overlays can be found in Appendix D: Individual Site Summaries.

On average, BIBI scores at Lower Magothy revisit sites were similar during previous rounds and Round Three, with BIBI scores receiving a 'Poor' biological rating (Table 28). No change in BIBI score was observed at sites 08-L1M-02-18 and 08-L2M-01-18. The BIBI score at site 08-L1M-01-18 decreased slightly from Round One ('Poor' rating) to Round Three ('Very Poor' rating), which also corresponds with an increase in cross-sectional area. At site 08-L2M-02-18, the BIBI score increased slightly from Round Two to Round Three, but received a 'Very Poor' rating in both rounds. This slight increase in BIBI score coincided with a decrease in cross-sectional area between rounds.

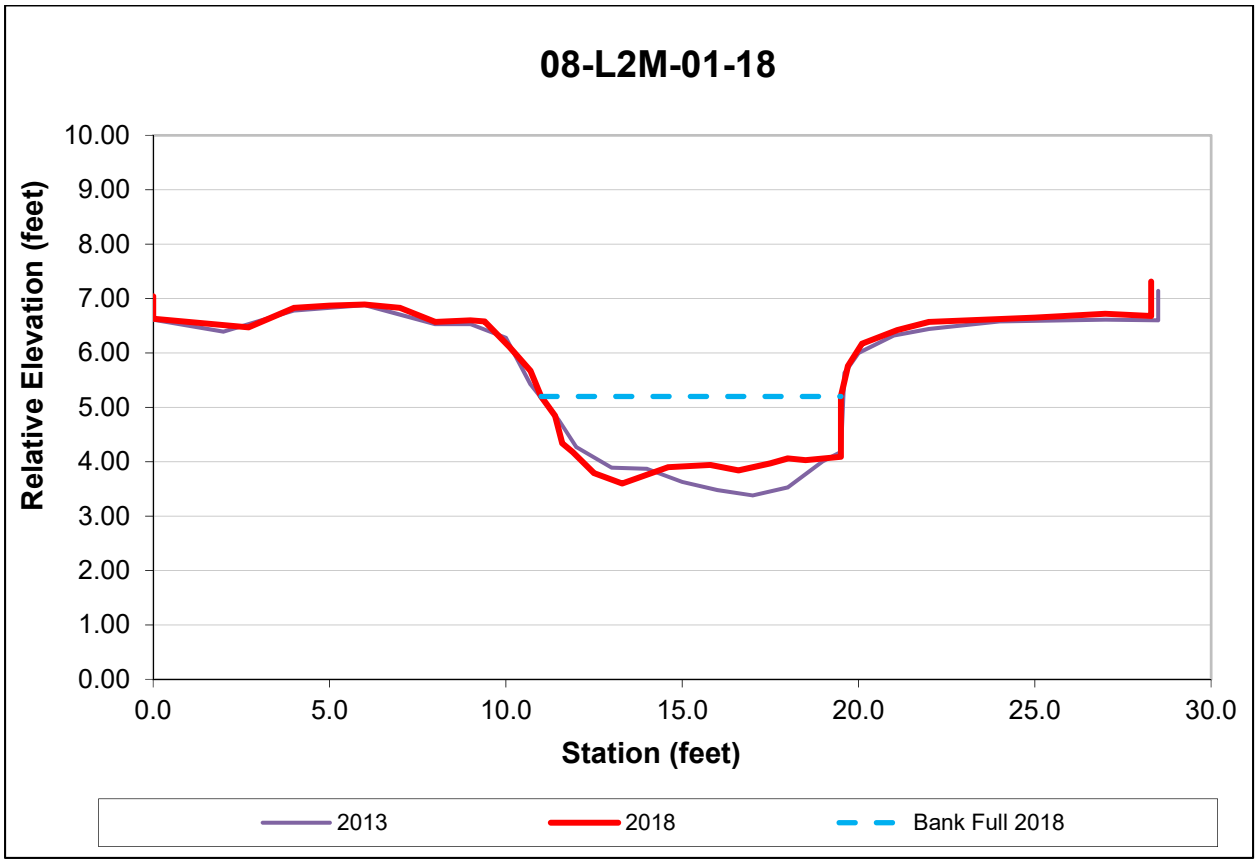


Figure 42- Representative cross-section overlay in Lower Magothy River

Table 28 - Comparison of Round One and Round Two (2004 - 2013) with Round Three (2018) geomorphological and biological data

2018 Site Name	Year First Sampled	Cross-Sectional Area (ft^2)			D_{50} Substrate Classification (Size in mm)		Rosgen Classification		BIBI Narrative Ranking (Score)	
		R1/R2	R3	%Δ	R1/R2	R3	R1/R2	R3	R1/R2	R3
08-L1M-01-18	2007	5.3	6.4	20.7	medium sand (0.25)	very fine sand (0.12)	C5	E5	Poor (2.14)	Very Poor (1.86)
08-L1M-02-18	2007	8[1]	6.7	-15.7	fine sand (0.13)	very fine sand (0.062)	E5	E6	Poor (2.14)	Poor (2.14)
08-L2M-01-18	2013	9.7[1]	10.4	6.7	fine sand (0.15)	medium sand (0.41)	E5	E5	Poor (2.71)	Poor (2.71)
08-L2M-02-18	2013	2.8	2.1	-25.5	very fine sand (0.062)	very fine sand (0.062)	ND	E6	Very Poor (1.57)	Very Poor (1.86)
Lower Magothy Average		6.5	6.4	-3.5	fine sand (0.15)	fine sand (0.16)	--	--	Poor (2.14)	Poor (2.14)
03-L1M-02-18	2004	--[2]	7.7	--[2]	--[2]	medium gravel (10)	--[2]	B4c	Poor (2.71)	Very Poor (1.57)
03-L1M-03-18	2004	--[2]	8.5	--[2]	--[2]	medium gravel (8.3)	--[2]	F4/5	Poor (2.71)	Poor (2.43)
03-L2M-01-18	2012	11.7	9.9	-15.3	fine gravel (5.5)	coarse gravel (18)	C4/5	C4	Fair (3.57)	Fair (3.00)
03-L2M-03-18	2012	8.4	4.7	---[4]	medium gravel (15)	coarse gravel (24)	F4/5	F4	Fair (3.86)	Fair (3.86)
Lower Patapsco Average		10.1	7.7	-29.5	medium gravel (10.3)	medium gravel (15.1)	--	--	Fair (3.21)	Poor (2.72)
05-L1M-03-18	2006	4.4	6.2	41.4[3]	--[5]	medium sand (0.25)	--[5]	F5	Poor (2.43)	Poor (2.43)
05-L1M-04-18	2006	13.4[1]	11.4	-14.6	very fine sand (0.062)	fine sand (0.14)	C6	G5c	Poor (2.43)	Fair (3.29)
05-L2M-02-18	2009	6.4[1]	8.8	37.0	very fine sand (0.067)	coarse sand (0.54)	E6	E5	Poor (2.14)	Fair (3.00)
05-L2M-03-18	2009	9.8	14.3	45.9	fine sand (0.21)	medium sand (0.34)	E5	G5	Poor (2.14)	Very Poor (1.86)
Marley Creek Average		8.5	10.2	27.4	very fine sand (0.11)	medium sand (0.32)	--	--	Poor (2.29)	Poor (2.65)
01-L1M-01-18	2007	8.9[1]	32.1	--[6]	very coarse sand (1)	coarse gravel (22)	E5	F4	Fair (3.00)	Poor (2.14)
01-L1M-02-18	2007	35.1[1]	50.5	43.8	fine gravel (6)	medium gravel (9.9)	C4	C4	Poor (2.71)	Fair (3.00)
01-L2M-01-18	2012	3.7	3.7	-0.3	very fine sand (0.062)	very fine sand (0.088)	F6	G5c	Poor (2.14)	Poor (2.43)
01-L2M-02-18	2012	89.1	97.1	9.0	medium sand (0.45)	medium sand (0.43)	ND	F5	Fair (3.86)	Fair (3.00)
Piney Run Average		34.2	45.9	17.5	fine gravel 7.5	medium gravel 8.1	--	--	Poor (2.93)	Poor (2.64)
19-L1M-01-18	2005	36.4[1]	33.5	-7.9	--[5]	fine gravel (7.1)	--[5]	G4c	Good (4.71)	Fair 3.86
19-L1M-03-18	2005	26.6	10.9	--[6]	--[5]	very fine gravel (2)	--[5]	F4/5	Fair (3.00)	Good 4.71
19-L2M-01-18	2013	36.1	86.6	139.9	very coarse sand (1.3)	medium sand (0.34)	F4/5	ND	Poor (2.43)	Good 4.43
19-L2M-07-18	2013	3.2	2.7	-15.3	very fine sand (0.062)	coarse sand (0.73)	G6c	G5c	Very Poor (1.57)	Poor 2.14
Stocketts Run Average		25.6	33.4	116.7	coarse sand (0.7)	very fine gravel (2.5)	--	--	Poor (2.93)	Fair (3.79)

*[1]Bankfull elevation adjusted to match 2018 bankfull discharge for comparison, [2]Geomorph survey not performed in 2004, [3]Only one existing XS pin was found in R3 but cross sections were determined to be consistent enough for comparison, [4]Only one existing XS pin was found in R3 and cross sections were not determined to be consistent enough for comparison , [5]Not reported in R1/R2, [6]R1/R2 XS pins were not found in R3, re-established XS, comparison could not be made between the rounds, R1 - Round One; R2 - Round Two; R3 - Round Three; %Δ = ((R3 cross-sectional area - R1 or R2 cross-sectional area)/ R1 or R2 cross-sectional area) * 100*

Cross-section surveys were not completed in the first year of Round One (2004), so geomorphological comparisons could only be made with Round Two revisit sites within the Lower Patapsco sampling unit. During the Round Three resurvey at site 03-L2M-03-18, the field crew was only able to locate one cross-section endpin and the survey results were not consistent enough for a comparison, therefore, an overlay was not completed for this site. Site 03-L2M-01-18 exhibited a 15.3 percent decrease in cross-sectional area from Round Two to Round Three (Table 28). This decrease was likely the result of considerable down cutting within the cross-section, which has created a slightly more confined channel. Both Round Two sites that were revisited in Round Three had coarser substrate according to the D_{50} classification, increasing from fine or medium gravel in Round Two to coarse gravel in Round Three. Rosgen stream classifications did not change for either of the Lower Patapsco revisit sites.

On average, BIBI scores from Round Three at Lower Patapsco revisit sites declined from a 'Fair' to 'Poor' biological rating (Table 28). All but one site (03-L2M-03-18) resampled in 2018 had biological ratings that decreased from the initial sampling in Round One or Two to Round Three. Site 03-L2M-03-18 maintained the same biological rating observed in Round Two ('Fair' rating). Due to the lack of Round One geomorphological data, no trends were evident between changes in BIBI score and changes in cross-sectional area or substrate size.

Cross-section overlays at Marley Creek sites indicate varying changes since the initial assessments in Round One and Two. On average, revisit sites experienced an increase in cross-sectional area of about 27.4 percent (Table 28). Cross sectional area increased for all Marley Creek sites, except for site 05-L1M-04-18. A decrease in cross-sectional area occurred at this site, which corresponds with the change in the stream classification from a C channel to a further entrenched G channel. This change was due to increased erosion and observed streambed scour. Site 05-L2M-03-18 transitioned from a C channel to an entrenched G channel as the stream widened due to erosion. Overall, the substrate at all of the Marley Creek revisit sites became coarser in Round Three, while still having D_{50} classifications of various sand types. During the Round Three survey, only one existing cross-section endpin was found at site 05-L1M-03-18. The endpin was re-established at a location that provided similar cross-section width for comparisons with Round One data.

On average, BIBI scores at Marley Creek revisit sites improved slightly from previous rounds but remained in the 'Poor' category (Table 28). For sites 05-L1M-04-18 and 05-L2M-02-18, BIBI scores improved in biological rating from 'Poor' to 'Fair'. BIBI score remained the same at site 05-L1M-03-18 and declined slightly from 'Poor' to 'Very Poor' at site 05-L2M-03-18. No trends were evident between changes in BIBI score and changes in cross-sectional area or substrate size.

On average, cross-section overlays at Piney Run sites indicated an increase in cross-sectional area (17.5 percent) from previous rounds to Round Three (Table 28). The cross-section at site 01-L1M-01-18 was re-established after both endpins were unable to be located; therefore, no comparison overlay was completed. The cross-sectional area at site 01-L1M-02-18 changed the most (43.8 percent increase) due to erosion occurring on both banks and some streambed scour. Site 01-L2M-01-18 remained relatively stable from Round Two to Round Three, only decreasing by 0.3 percent in cross-sectional area and staying within the same D_{50} classification (very fine sand). Site 01-L2M-02-18 remained mostly stable as well, only increasing in cross-sectional area by 9 percent, due to slight widening and down cutting, and staying within the same D_{50} classification (medium sand).

On average, BIBI scores at Piney Run revisit sites were similar from previous rounds to Round Three ('Poor' rating; Table 28). Scores at sites 01-L1M-01-18 and 01-L2M-02-18 declined from previous rounds sampling. The remaining two sites that were resampled in 2018, 01-L1M-02-18 and 01-L2M-01-18, both improved slightly from previous rounds to Round Three. No trends were evident between changes in BIBI score and changes in cross-sectional area or substrate size.

Cross-section overlays for Stocketts Run revisit sites indicate that two sites, 19-L1M-01-18 and 19-L2M-07-18, decreased in cross-sectional area (7.9 percent and 15.3 percent, respectively) from previous rounds to Round Three (Table 28). The cross section overlay for site 19-L1M-01-18 indicates an obvious shift in the thalweg to the face of the right bank, with deposition on the left bank and bank erosion on the right bank. The cross-section overlay for site 19-L2M-07-18 does not indicate notable change between sampling rounds. Site 19-L2M-01-18 increased in cross-sectional area substantially from the Round Two survey (139.9 percent). This was due to erosion on the left bank and the shifting of the stream to create a depositional bench feature acting as the channel's floodplain. This caused the stream classification to change from an entrenched F channel to a less entrenched C channel. During the Round Three cross-section survey at site 19-L1M-03-18, one of the original endpins was unable to be located. The cross-section was re-established and surveyed for future comparison; however, no overlay was completed for site 19-L1M-03-18. For the two revisit sites with previous round substrate data (19-L2M-01-18 and 19-L2M-07-18) both sites remained in the sand classification.

On average, BIBI scores at Stocketts Run were 'Fair' in Round One, 'Poor' in Round Two, and 'Fair' in Round Three. BIBI scores improved at all sites resampled in Round Three, with the exception of site 19-L1M-01-18. The BIBI score at site 19-L1M-01-18 declined from 'Good' to 'Fair'. The largest biological improvement seen across all sampling units assessed in 2018 was observed at site 19-L2M-01-18, where the BIBI score improved from 'Poor' to Good'. Within the Stocketts Run sampling unit, a weak relationship between change in BIBI score and change in cross-sectional area was observed. In general, an increase in BIBI score corresponded with an increase in area, however, this relationship was driven heavily by a single site (19-L2M-01-18) and is not a reliable trend.

6 Comparison of Results with Previous Rounds

This section presents a brief comparison of the biological and physical habitat assessment results collected as part of Round Three, with results from Round One and Round Two for each of the five PSUs assessed in 2018. Refer to Figure 43 for box plots comparing mean BIBI, RBP, and PHI results from Rounds One, Two and Three in the Lower Magothy River, Lower Patapsco River, Marley Creek, Piney Run, and Stocketts Run 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 95% confidence interval for the difference in mean values $Q_1 - Q_2$ is estimated using the following formula:

$$(Q_1 - Q_2) \pm 1.96[SE_1^2 + SE_2^2]^{1/2}$$

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 95% 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.

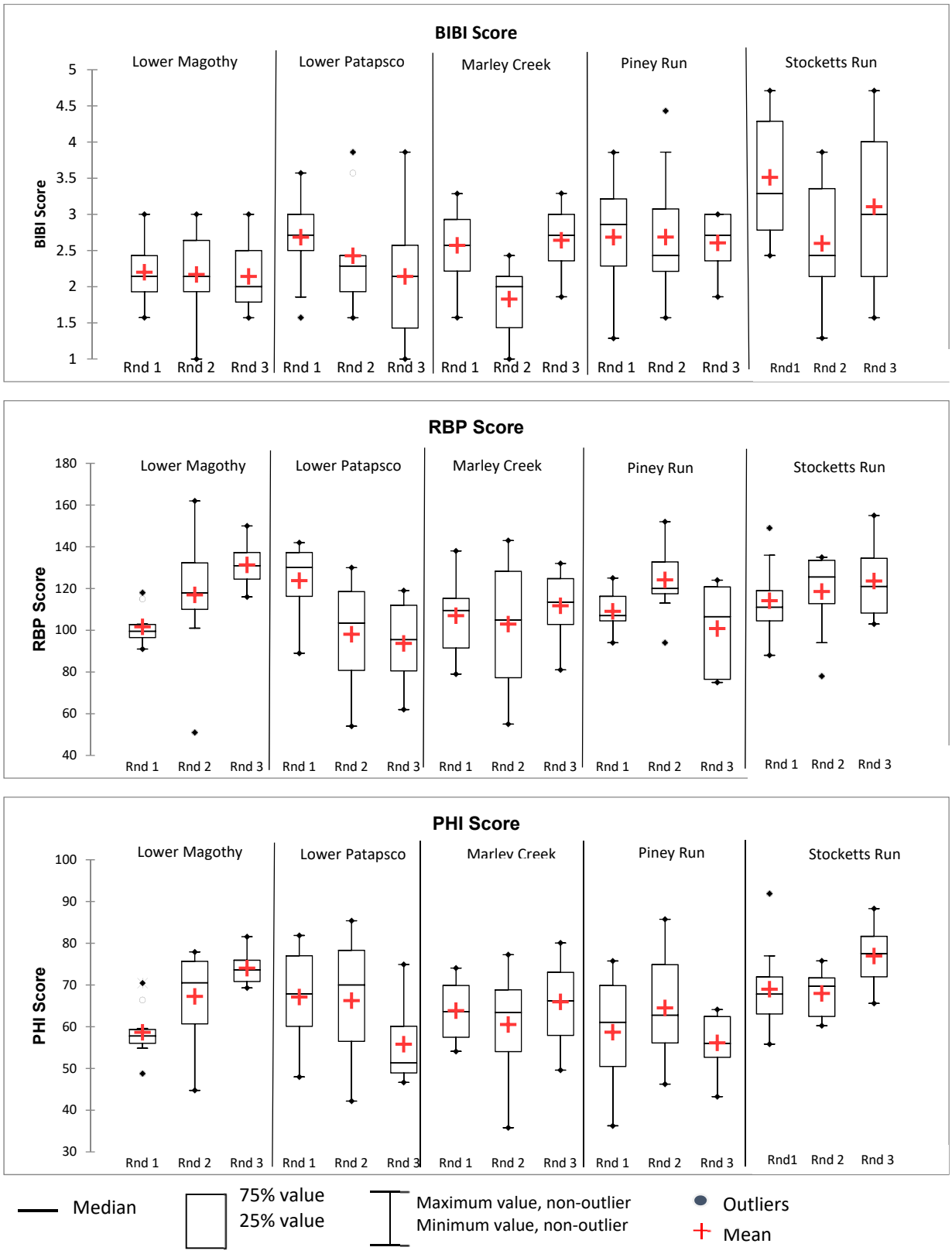


Figure 43 - Box plots comparing mean BIBI, RBP and PHI scores between Rounds One, Two and Three

6.1 Biological Conditions

A comparison of mean BIBI scores between Round Two and Round Three showed a significant increase in the Marley Creek PSU between sampling rounds from 1.85 ±0.15 and a biological condition rating of 'Very Poor' to 2.64 ±0.17 and a rating of 'Poor' (Table 29). No significant changes in mean BIBI scores were observed between Round One and Round Three (Table 30).

Table 29 - Difference in BIBI measures between Rounds Two and Three

PSU	Round 3		Round 2		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean IBI	SE	Mean IBI	SE			
Lower Magothy	2.14	0.19	2.17	0.19	0.55	-0.49	No
Lower Patapsco	2.14	0.35	2.43	0.23	1.10	-0.53	No
Marley Creek	2.64	0.17	1.83	0.15	-0.37	-1.26	Yes (Increase)
Piney Run	2.61	0.15	2.69	0.28	0.71	-0.55	No
Stocketts Run	3.11	0.42	2.60	0.29	0.49	-1.50	No

Table 30 - Differences in BIBI measures between Rounds One and Three

PSU	Round 3		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean IBI	SE	Mean IBI	SE			
Lower Magothy	2.14	0.19	2.20	0.15	0.52	-0.41	No
Lower Patapsco	2.14	0.35	2.69	0.19	1.32	-0.23	No
Marley Creek	2.64	0.17	2.57	0.17	0.40	-0.54	No
Piney Run	2.61	0.15	2.69	0.25	0.66	-0.50	No
Stocketts Run	3.11	0.42	3.51	0.28	1.39	-0.57	No

6.2 Physical Habitat Conditions

Comparisons of physical habitat conditions between Rounds Two and Three and Rounds One and Three for the RBP are shown in Table 31 and Table 32, respectively. There were one PSU, Piney Run, that saw a significant decrease in RBP habitat conditions between sampling Round Two (124.2 ±5.41) and Round Three (100.9 ±5.41). Comparisons between Round One and Three showed a significant increase in Lower Magothy, with the mean RBP score increasing from 101.7 ±2.71 in Round One to 131.4 ±3.98 in Round Three, and a significant decrease in Lower Patapsco with the mean RBP score decreasing from 123.8 ±5.62 in Round One to 93.8 ±7.94 in Round Three.

Table 31 - Differences in RBP measures between Rounds Two and Three

PSU	Round 3		Round 2		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean RBP	SE	Mean RBP	SE			
Lower Magothy	131.4	3.98	117.0	9.12	5.13	-33.88	No
Lower Patapsco	93.8	7.94	98.1	8.57	27.26	-18.56	No
Marley Creek	111.8	5.99	103.0	9.54	13.32	-30.82	No
Piney Run	100.9	8.00	124.2	5.41	42.25	4.40	Yes (Decrease)
Stocketts Run	123.6	6.75	118.6	6.12	12.83	-22.88	No

Table 32 - Differences in RBP measures between Rounds One and Three

PSU	Round 3		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean RBP	SE	Mean RBP	SE			
Lower Magothy	131.4	3.98	101.7	2.71	-20.24	-39.11	Yes (Increase)
Lower Patapsco	93.8	7.94	123.8	5.62	49.12	10.98	Yes (Decrease)
Marley Creek	111.8	5.99	107.0	5.81	11.60	-21.10	No
Piney Run	100.9	8.00	109.1	3.15	25.07	-8.62	No
Stocketts Run	123.6	6.75	114.2	5.55	7.70	-26.55	No

Comparisons of physical habitat conditions between Rounds Two and Three and Rounds One and Three for the PHI are shown in Table 33 and Table 34, respectively. Only one PSU, Stocketts Run, showed significant changes in PHI habitat conditions between sampling Rounds Two and Three. The mean PHI score increased from 68.00 ±1.78 in Round Two to 76.97 ±2.79 in Round 3. Two PSUs, Lower Magothy and Lower Patapsco, saw significant changes in PHI scores between Round One and Round Three. Lower Magothy increased from 58.67 ±1.90 and a rating of "Degraded" in Round One to 74.04 ±1.43 and a rating of "Partially Degraded" in Round 3. Lower Patapsco, on the other hand, saw a decrease from 67.14 ±3.73 and a rating of "Partially Degraded" in Round One to 55.83 ±3.66 and a rating of "Degraded" in Round Three.

Table 33 - Differences in PHI measures between Rounds Two and Three

PSU	Round 3		Round 2		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean PHI	SE	Mean PHI	SE			
Lower Magothy	74.04	1.43	67.29	3.37	0.43	-13.92	No
Lower Patapsco	55.83	3.66	66.28	4.71	22.14	-1.25	No
Marley Creek	65.98	3.78	60.55	3.78	5.06	-15.92	No
Piney Run	56.14	2.54	64.52	4.14	17.90	-1.13	No
Stocketts Run	76.97	2.79	68.00	1.78	-2.49	-15.45	Yes (Increase)

Table 34 - Differences in PHI measures between Rounds One and Three

PSU	Round 3		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean PHI	SE	Mean PHI	SE			
Lower Magothy	74.04	1.43	58.67	1.90	-10.69	-20.03	Yes (Increase)
Lower Patapsco	55.83	3.66	67.14	3.73	21.56	1.06	Yes (Decrease)
Marley Creek	65.98	3.78	63.88	2.37	6.65	-10.84	No
Piney Run	56.14	2.54	58.72	4.43	12.59	-7.43	No
Stocketts Run	76.97	2.79	68.99	3.20	0.33	-16.29	No

7 Conclusions

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 and are poorly understood. 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 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, FIBI), 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.

7.1 Biological and Physical Habitat Conditions

Results of the 2018 assessment indicate impaired biological conditions in all five sampling units. Four of the five sampling units had mean BIBI scores in the 'Poor' category, with one (Stocketts Run) in the low end of the 'Fair' category. Four of the five had mean FIBI scores in the 'Poor' category, and one sampling unit (Piney Run) had mean FIBI of 'Fair'. Changes in mean BIBI scores for sampling units were not significant between Rounds 1 and 3, and only Marley Creek showed a significant positive difference of mean BIBI scores between Rounds 2 and 3, the other four sampling units had no significant change in BIBI scores between these same Rounds. There were no discernable trends in PHI habitat data at two of the five sampling units. Piney Run showed a statistically significant increase in mean PHI scores between Round 2 and Round 3 and between Round 2 and Round 3. Lower Patapsco River showed a significant decrease in mean PHI scores between Rounds 1 and 3. Mean scores for RBP between Rounds 2 and 3 for this sampling unit showed no significant trend. Lower Magothy River showed a significant increase in mean PHI scores between Rounds 1 and 3. Mean scores for RBP between Rounds 2 and 3 for this sampling unit showed no significant trend. Marley Creek and Stocketts Run showed no significant trends in mean RBP scores between either Round 3 and Round 2, or Round 3 and Round 1.

Overall, both physical habitat assessment methods yielded scores that did not correspond well with predicted BIBI nor FIBI scores. A comparison of narrative BIBI ratings to spring-collected RBP habitat condition ratings for each site is shown in Table 35. Similarly, Table 36 compares FIBI ratings to summer-collected 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. It is likely that holds true for FIBI scores as well. Results from the RBP method showed the majority of sites with 'Supporting' or 'Partially Supporting' physical habitat conditions (72.5 percent); however, more than one-third of these sites (37.9 percent) actually resulted in biological conditions that were lower than the habitat category may suggest is possible

(Table 35). Similar to the RBP method, results from the PHI method showed the majority of sites with a 'Partially Degraded' or 'Degraded' rating (87.2 percent), with more than 38 percent of those sites resulting in biological conditions that were lower than the habitat category may suggest is possible (Table 36).

Table 35 - Comparison of BIBI to spring-collected EPA RBP habitat condition ratings.

EPA RBP Habitat Rating	BIBI Rating			
	Good	Fair	Poor	Very Poor
Comparable to Reference	19-L2M-01-18			
Supporting		05-L2M-02-18 08-R3M-03-18 19-L1M-01-18 19-R3M-07-18	05-R3M-03-18 08-L1M-02-18 08-L2M-01-18 08-R3M-04-18	**08-L1M-01-18** **08-R3M-02-18**
Partially Supporting	**19-L1M-03-18**	01-L2M-02-18 03-L2M-01-18 03-L2M-03-18 05-L1M-04-18	01-R3M-02-18 01-R3M-03-18 03-L1M-03-18 03-R3M-03-18 05-R3M-02-18 05-R3M-05-18 19-L2M-07-18 19-R3M-01-18 19-R3M-06-18	01-R3M-04-18 05-L2M-03-18 08-L2M-02-18 08-R3M-05-18 19-R3M-03-18
Non-Supporting		**01-L1M-02-18** **01-R3M-01-18** **05-R3M-06-18**	01-L1M-01-18 01-L2M-01-18 03-R3M-01-18 05-L1M-03-18	03-L1M-02-18 03-R3M-04-18 03-R3M-05-18

Blue cells: stations where the biological community was less impaired than the habitat scores would predict.
Gray cells: stations where biological community matched available habitat.
Orange 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.
n=40

Table 36 - Comparison of FIBI to summer-collected MBSS PHI habitat condition ratings.

MBSS PHI Habitat Rating	FIBI Rating			
	Good	Fair	Poor	Very Poor
Minimally Degraded	19-R3M-07-18			
Partially Degraded	19-L1M-01-18 19-L2M-01-18	01-R3M-02-18 01-R3M-04-18 08-R3M-03-18 19-L1M-03-18	08-L1M-01-18 08-L2M-01-18 08-L2M-02-18 08-R3M-04-18 08-R3M-05-18 19-R3M-01-18	**03-L2M-01-18** **05-L2M-02-18** **19-L2M-07-18** **19-R3M-03-18**
Degraded	**01-L1M-01-18** **01-L1M-02-18** **01-R3M-01-18** **05-R3M-03-18**	03-R3M-03-18	01-R3M-03-18 03-L1M-02-18 03-L2M-03-18 03-R3M-05-18 05-L1M-03-18 05-L1M-04-18 05-L2M-03-18 05-R3M-02-18 05-R3M-05-18 08-R3M-02-18	01-L2M-01-18 03-R3M-04-18 19-R3M-06-18
Severely Degraded		**01-L2M-02-18** **03-L1M-03-18** **05-R3M-06-18**	03-R3M-01-18	

Blue cells: stations where the biological community was less impaired than the habitat scores would predict.
Gray cells: stations where biological community matched available habitat.
Orange 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.
n=39; 1 site qualitatively sampled

Although physical habitat conditions were generally degraded in all five watersheds, degraded habitat alone cannot explain the observed biological conditions in these sampling units. Because habitat conditions did not correspond well to 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 Magothy River, Lower Patapsco River, Marley Creek, and Piney Run, water quality stressors are likely strong contributors to impaired biological conditions. Elevated conductivity values (i.e., >247 µS/cm) were observed at 32 of 40 sites in the spring and 24 of 40 sites in the summer had conductivity values that exceeded the 247 µS/cm threshold of BIBI impairment developed from MBSS data. The expected pattern of increased imperviousness leading to increased conductivity measurements was not evident in 2017 data but was observed with 2018 spring and summer data. There was a significant trend (R^2=0.32; p=0.0002) toward increased springtime conductivity with increased impervious surfaces for the sites sampled in 2018. There was a weaker trend (R^2=0.11; p=0.04) between summertime conductivity and impervious surfaces for these sites. The PSU with the largest amount of imperviousness, Lower Patapsco River (31.5 percent) had the highest mean conductivity (1434.3 µS/cm) of the spring measurements and Piney Run had the third largest amount of imperviousness (23.5 percent) and the highest mean (434.8 µS/cm) summer measurement. Also, Lower Patapsco River had the highest two spring conductivity measurements of 4,111 µS/cm taken at 03-R3M-04-18 and 2,263 at 03-R3M-05-18. The PSU with the lowest amount of imperviousness, Stocketts Run (5.8 percent), had the lowest mean conductivity measurement in the spring (293 µS/cm) and Lower Magothy River, which had the second highest

imperviousness (28.4 percent), had the lowest summer mean conductivity (232.6 µS/cm). There was a significant negative trend between spring conductivity and BIBI score (R^2=0.16; p=0.009) but no trend between summer conductivity and FIBI scores (R^2=0.02; p=0.39). Continued sampling across all sampling units within the County will help create a larger dataset to investigate further the effects of conductivity on the ecological condition of the County's streams.

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 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.

Previous years of this study have shown 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 2018 sites, drainage area has a non-significant weak positive effect on BIBI score (R^2=0.09; p=0.06) with increased drainage area. With the addition of fish data in Round 3, similar correlation can be investigated for the drainage area effect on the FIBI in Anne Arundel County. Similar to results from 2017, data from 2018 sampling shows a significant correlation between increasing drainage area and FIBI score (R^2=0.23; p=0.002). This relationship is consistent with patterns observed throughout Maryland by the MBSS (Southerland et al, 2005).

Precipitation during 2018 was anomalously high. Maryland's official precipitation station is in Anne Arundel County at the Baltimore-Washington Thurgood Marshall International Airport. An average year's precipitation is approximately 42". On November 15th of 2018 the calendar year precipitation record of 62.66" was broken. July 2018 was the wettest July on record, with 16.73" of precipitation, exceeding the previous record of 11.03" from 1889 by more than 5.5 inches. For the 2018 summer index period June 1 – September 30, 34.53" of precipitation fell, approximately 82% of an average annual precipitation for Maryland. MBSS has noted effects of below average or above average precipitation on ecological condition at long-term Sentinel Sites (Saville et al, 2014). The effects of precipitation on IBI scores at Sentinel Sites is somewhat easier to observe since Sentinel Sites are sampled annually. The possible effects of the unusually wet 2018 on ecological condition of Anne Arundel Countywide sites from 2018 are harder to determine as these sites are a one-time snapshot. Analysis of the MBSS Sentinel Sites by MD DNR or by Anne Arundel County at the end of Round 3 may help determine what effects on ecological condition, if any, are observed in Anne Arundel Countywide data.

7.2 Geomorphologic Conditions

The geomorphic assessment field data were compared to the MCP regional relationships of bankfull channel geometry versus drainage area (McCandless, 2003), which were derived from E type and C type streams, 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 Figure 44, Figure 45, and Figure 46, respectively. Channels where Rosgen classifications could not be determined (ND, two sites) or were considered transitional were not included in these analyses.

Comparisons of bankfull width values show the trendline for E (R^2 = 0.51) and G (R^2 = 0.77) channels as the closest to matching the MCP curve (Figure 44). Trendlines for F (R^2 = 0.93) and C (R^2 = 0.79) channels contained the least variability, with data points scattered mostly above the MCP curve. This suggests that C and F type channels assessed in 2018 were generally wider than the streams used to derive the MCP regional relationships. On the other hand, the trendlines for E (R^2 = 0.51) and G (R^2 = 0.77) type channels was at or below the MCP curve, indicating narrower channels than predicted by the regional curve. These results are somewhat expected given that F type channels tend to have greater width/depth ratios as compared to E and G type channels (Rosgen, 1996).

Mean bankfull depth values showed the trendline for C type channels (R^2 = 0.82) closely matching the MCP curve, with the exception of a few outliers above and below the curve (Figure 45). For F type channels (R^2 = 0.75), points were scattered below the curve, indicating that mean bankfull depths were shallower than predicted by the MCP. The two ND (Not Determined) channels fell above the MCP curve, nearest to the G type channel trendline. As with bankfull width, the channel types follow the expected mean bankfull depth relationship (Rosgen, 1996). Overall, with the exception of F type channels, most sites sampled in 2018 were fairly close to the predicted MCP curve for mean bankfull depth.

Comparisons of bankfull cross-sectional area values show the trendlines for F type (R^2 = 0.94) and E type (R^2 = 0.83) channels closely matching the MCP curve (Figure 46). The trendlines for G (R^2 = 0.80), C (R^2 = 0.81) and B (R^2 = 0.53) type channels were approximately parallel to the MCP curve, but slightly higher. The two ND (Not Determined) channels type fell well above the MCP curve. Very few channel cross-sectional areas, mainly F type channels, fell below the MCP curve. As expected, E type channels fell very close to the MCP curve although C channels did not and were generally larger than predicted.

Sediment deposition as a result of bank erosion and channel instability may be a significant stressor on the benthic macroinvertebrate communities in these sampling units; however, the extent of these impacts was not clear in Rounds One and Two. 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 Rounds One and Two, do not support this notion as degraded stream types do not necessarily result in degraded biological conditions. For example, of the sites classified as F type and G type channels in 2018 (n=20), four sites (20.0 percent) received a 'Very Poor' biological rating, 11 sites (55.0 percent) received a 'Poor' rating, four sites (20.0 percent) received a 'Fair' rating, and the remaining site (5.0 percent) received a 'Good' rating. This breakdown is similar to the overall distribution of BIBI scores across all channel types sampled in 2018 (25.0 percent 'Very Poor'; 42.5 percent 'Very Poor'; 27.5 percent 'Fair'; and five percent 'Good'), which were comprised of approximately equal proportions of C, E, F, and G type channels (20-25 percent each), as well as a few B type channels.

An analysis of the Round One data set found that many geomorphic variables did not correlate strongly with biological variables (Hill and Pieper, 2011b). Conversely, the Round Two data showed highly significant ($p < 0.001$), positive correlations between mean depth, bankfull area, and estimated bankfull discharge and the overall BIBI score (Hill et al., 2014). Round Two geomorphic variables such as width,

depth, and estimated discharge were likely potential drivers of the drainage area effect observed with benthic macroinvertebrate metrics and the BIBI score (i.e., sites with larger drainage areas typically had higher BIBI scores). 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; Hill et al., 2014). In general, variability in channel evolution was observed within all sampling units, whereas some sites are stable, some are actively degrading, and some are stabilizing. In many cases, each of these states are occurring within specific sampling units, indicating a range of stream conditions in a given watershed. Depending on the individual site, aggradation, deposition, and erosion are all occurring throughout the 2018 sampling units. Floodplain access is improving at some sites, while becoming more limited at others. This range of stability and channel evolution can be attributed to changes in site-specific watershed characteristics, as there is no overall trend applicable to the small set of revisit sites.

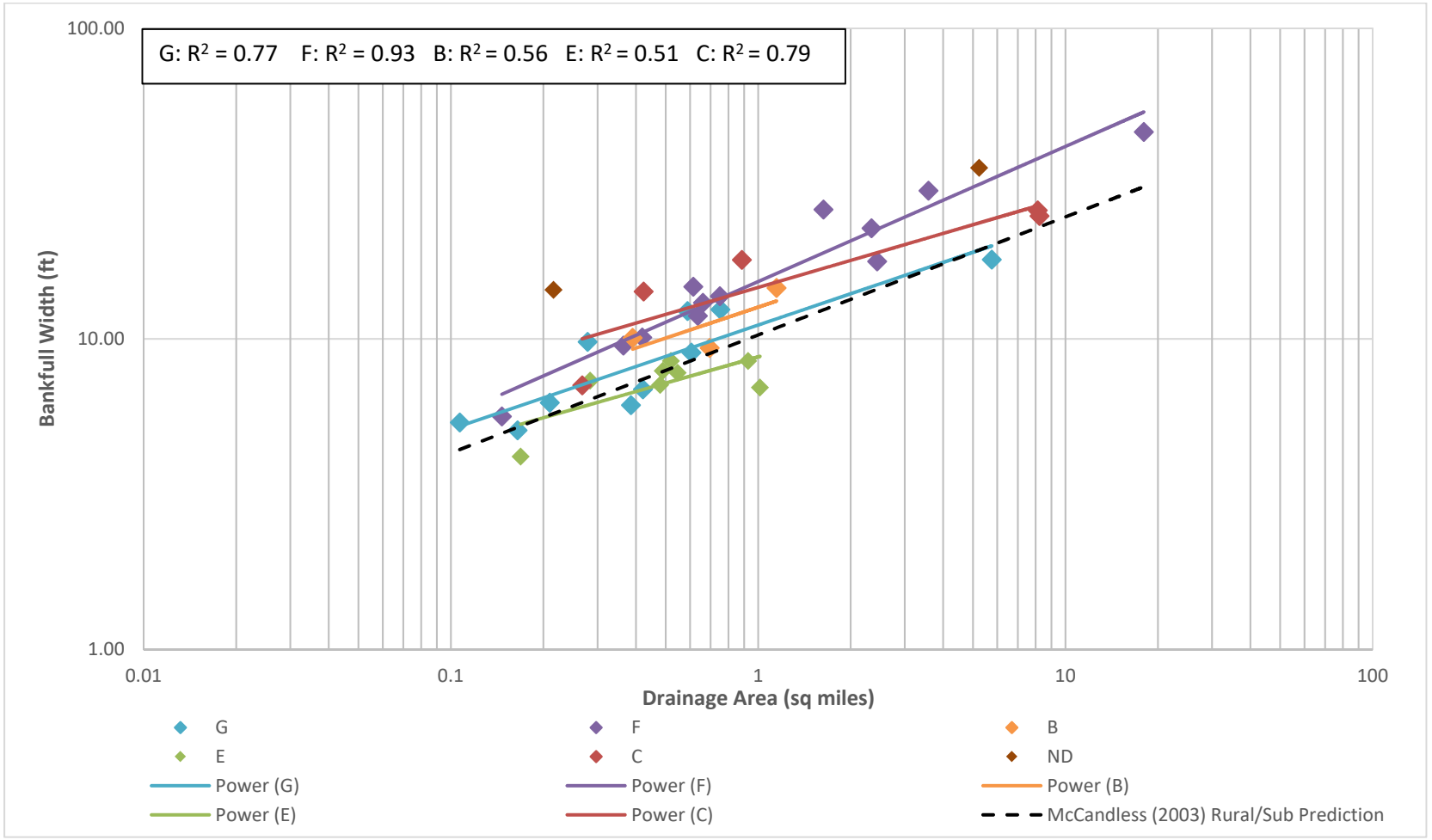


Figure 44- Comparison of bankfull width - Drainage area relationship between field data and regional curve data

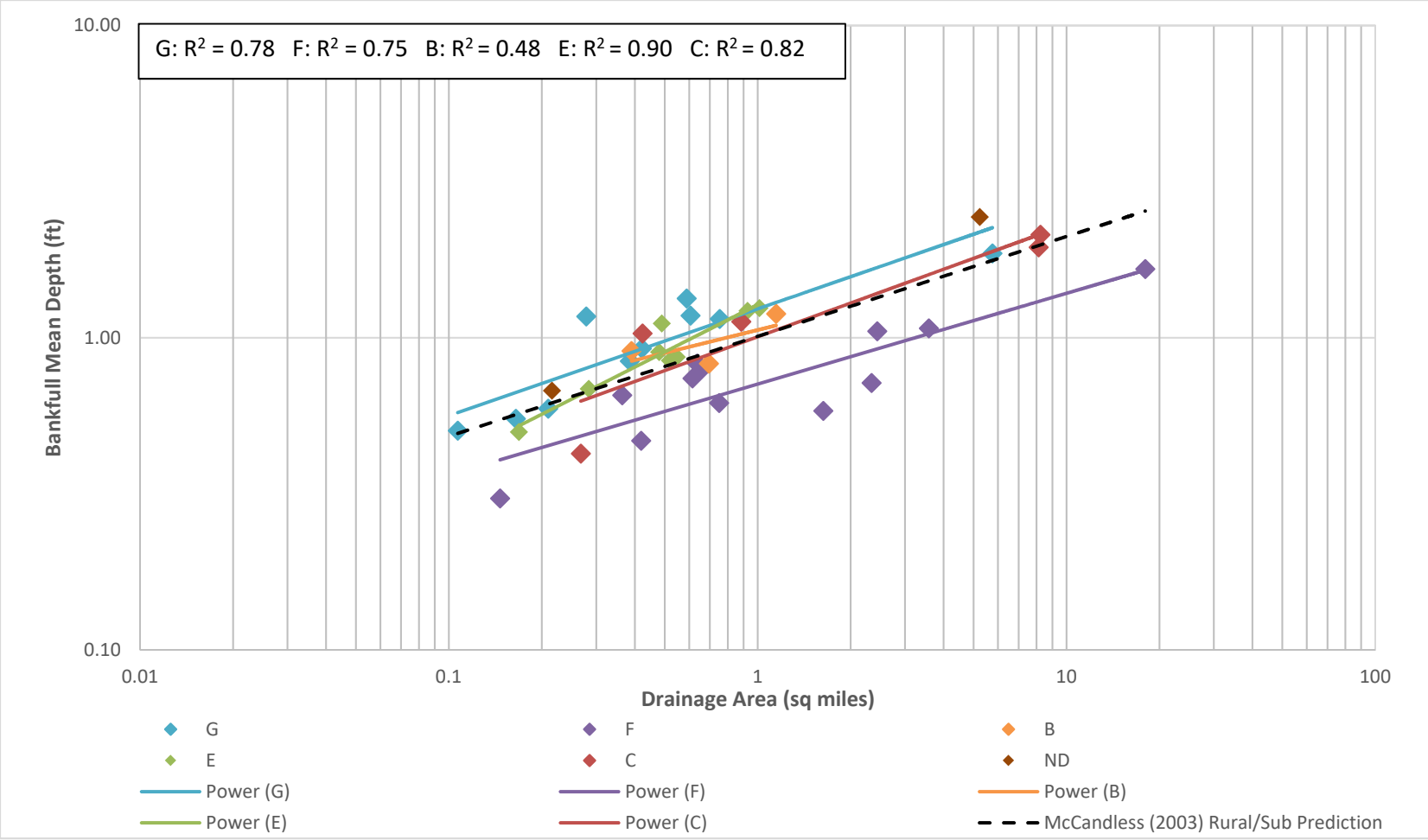


Figure 45 - Comparison of mean bankfull depth - Drainage area relationship between field data and regional curve data

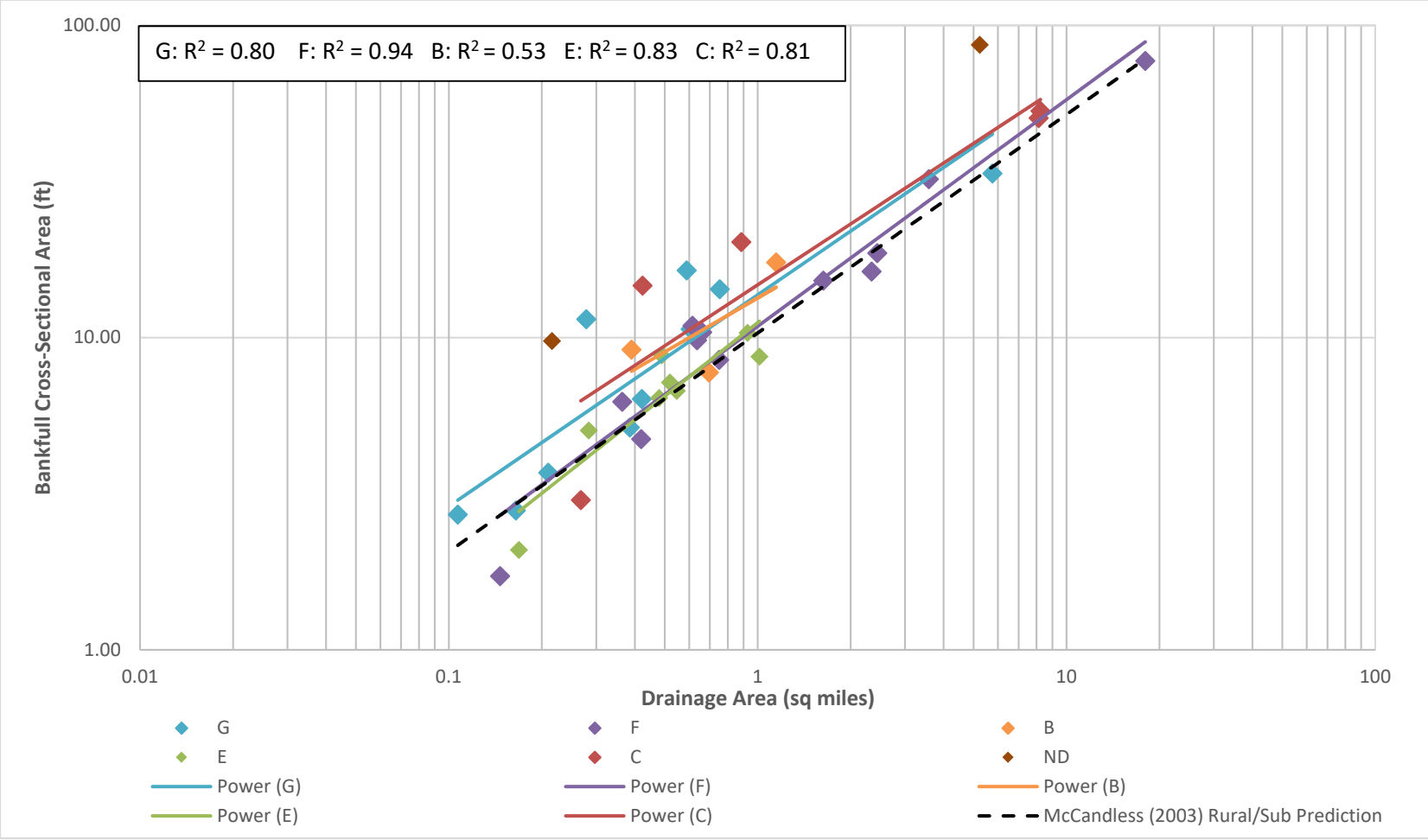


Figure 46 - Comparison of the bankfull cross-sectional area - Drainage area relationship between field data and regional curve data

7.3 Water Quality Conditions

In situ water quality measurements were within COMAR standards for temperature at all sites during both the spring and summer monitoring periods. High turbidity values, which exceeded the acceptable COMAR standards for average monthly turbidity (i.e., <50 NTU) were recorded at one site in the spring and over seven percent of sites spanning two of the five sampling units in the summer. Although the average monthly turbidity criteria was exceeded at these sites, turbidity measurements from a single point in time do not provide sufficient data on average monthly turbidity. One site in the Marley Creek watershed, site 05-R3M-02-18, had elevated turbidity values in the spring and summer. At three additional site visits to this site in the summer, visual observations of turbid water were also noted. Additionally, a site downstream of 05-R3M-02-18, site 05-R3M-06-18 had elevated turbidity in the summer, indicating a potential issue with high suspended sediment loads in this area of the Marley Creek sampling unit. 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 approximately 13 percent of the sites spanning three of the five sampling units in the spring. All sites in all five sampling units met COMAR standards for pH in the summer. Low pH values are likely the result of soils within the 2018 sampling units being generally strongly to very strongly acidic (NRCS 2018). Low DO values, which were outside the acceptable range of values set forth by COMAR (i.e., >5 mg/L), were recorded at one site in the spring and 10 percent of the sites spanning three of the five sampling units in the summer. Approximately 20 percent of the sites spanning three of the five sampling units in the spring and 40 percent of the sites spanning all five of the sampling units in the summer had conductivity values that exceeded 247 µS/cm, which is the critical threshold between 'Fair' and 'Poor' stream quality determined for urban Maryland streams, based on BIBI scores (Morgan et al., 2007). Elevated conductivity levels in the majority of sites sampled in 2018 may be impacting the benthic macroinvertebrate communities in these PSUs, there was a significant negative trend between conductivity and BIBI scores. There was no trend observed between conductivity and FIBI scores in 2018 data. Analysis of the entire Round 3 data set after 2021 will help clarify the relationship between conductivity and stream ecological condition in Anne Arundel County.

With the exception of one site, all 2018 sites met COMAR or EPA standards based on grab sample parameters. In the Marley Creek sampling unit, site 05-R3M-02-18 exceeded the acceptable COMAR range for average monthly turbidity (i.e., <50 NTU), with a value of 64.6 NTU, which was one of the same sites to exceed COMAR standards for average monthly turbidity based on *in situ* readings. For total nitrogen and nitrate, all 2018 sites fell in the low or moderate categories used by MBSS, suggesting low to moderate anthropogenic stress based on these parameters. Over twenty-two percent of sites sampled in 2018 fell in the high category used by MBSS for total phosphorus (i.e., >0.07 mg/L), the majority of which fell in the Stocketts Run sampling unit. Agricultural land use is high in the Stocketts Run sampling unit when compared to all other sampling units and fertilizer applications can be a major source of phosphorus. Only one site fell in the high category used by MBSS for orthophosphate concentration (i.e., >0.03 mg/L), which was located in the Piney Run sampling unit. Over twenty-two percent of sites sampled in 2018 fell in the high category used by MBSS for total ammonia (i.e., >0.07 mg/L), the majority of which fell in the Lower Magothy sampling unit. Point source discharge and nutrient enrichment are both common sources of elevated ammonia in surface waters (USEPA, 2000). Because pH levels were generally acidic or neutral in the Lower Magothy sampling unit, un-ionized ammonia was likely not found in high concentrations. The un-ionized form of ammonia is largely toxic to aquatic biota. Finally, over seventeen percent of sites sampled in 2018 fell in the high category used by MBSS for nitrite (i.e., >0.01 mg/L).

With the exception of one sampling unit, all chloride values met EPA standards for acute (i.e., <230 mg/L) and chronic (i.e., <860 mg/L) exposure in 2018. In the Lower Patapsco sampling unit, one site did not meet EPA standards for chronic chloride concentration (i.e., <230 mg/L), with a value of 653.60 mg/L, and two sites did not meet EPA standards for acute or chronic (i.e., <860 mg/L) chloride concentration with values of 924.30 and 1,262.64 mg/L, respectively. There was a strong positive correlation between conductivity and chloride concentration for all sampling units sampled in 2018 (R^2=0.97; Figure 47). Elevated levels of chloride and magnesium are commonly associated with either runoff from roadways, particularly following winter roadway de-icing periods, or runoff carrying fertilizers (Williams 2001; Stranko et al. 2013). Data from the National Weather Service (NOAA) indicates that the Lower Patapsco watershed received over four inches of snow just eight days prior to the spring sampling events at the three Lower Patapsco sites with elevated chloride levels (NOAA 2018). The week following the snowfall event, higher temperatures and rainfall occurred, indicating that snow melt and runoff containing road salt and brine may be the cause for elevated chloride levels.

Based on the negligible (Spearman's rank correlation coefficients generally <0.5; Piney Run, Marley Creek, and Lower Magothy) and negative (Lower Patapsco) correlations between chlorides and nutrients across all sampling units except for Stocketts Run, elevated chloride levels may be the result of runoff following road salt and brine applications and/or underlying geology. In the Stocketts Run sampling unit, however, chloride concentrations were positively correlated with total nitrogen and total nitrate (Spearman's rank correlation coefficient >0.6). Although this correlation wasn't extremely strong, elevated chloride and nutrient levels in Stocketts Run may be influenced by fertilizer applications within the watershed.

No state or federal water quality criteria exist for dissolved organic carbon (DOC), however, DOC concentrations can be used to characterize different stream types. Blackwater streams are characterized by sluggish flow, low pH, high DOC levels, and low DO levels, and are identified as key wildlife habitats based on information from Maryland DNR (DNR 2016). Although two sites in the Marley Creek sampling unit had DOC values that met blackwater stream criteria (i.e., DOC >8 mg/L), no other required criteria were met. Additionally, low pH was observed throughout all sampling units and is likely the result of strongly to very strongly acidic soils dominating drainage areas within the 2018 sampling units (NRCS 2018).

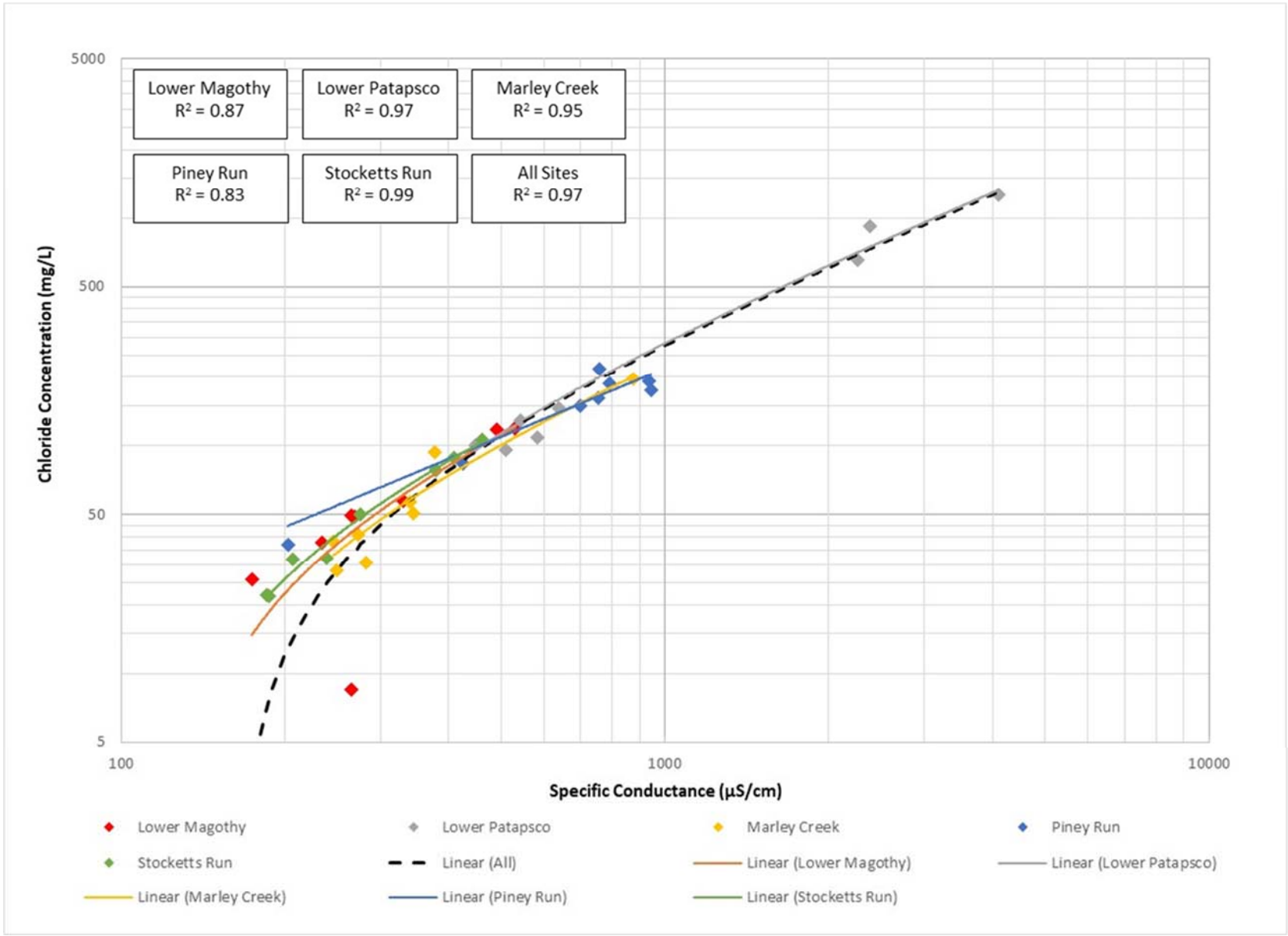


Figure 47 – Relationship between Specific Conductivity and Chloride concentration for each PSU

7.4 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). However, some geomorphic variables correlated significantly with individual metrics of the BIBI, most notably bankfull area correlated with the percent intolerant metric. Sinuosity and D50 were the only geomorphic variables correlated with the overall BIBI score (0.05 level). On the other hand, the Round Two data showed highly significant ($p < 0.001$) correlations between mean depth, bankfull area, and estimated bankfull discharge and the overall BIBI score, although this was primarily attributed to the positive correlation between drainage area and the BIBI score (Hill et al., 2014). 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 merely 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. Round Three includes revisits of a subset of sites assessed in Rounds One and Two, which allows for evaluating changes in dimensions and adjustments over time along with the response of the biological communities. At the completion of Round Three, the revisit site data set should be analyzed to look for trends and relationships between channel evolution and biological response to determine if patterns exist throughout the County or within various sampling units. This would help to validate stability assumptions and corresponding biological responses, providing the County with a better understanding of how land use changes impact streams and biological communities over time. Ultimately, this may allow for fine tuning of zoning and development regulations toward maximum protection of stream channel stability.

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

Four of the sampling units, Lower Magothy River, Lower Patapsco River, Marley Creek, and Piney Run have been developed extensively (46% - 65% developed land use) 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 Stocketts Run sampling unit contained less developed land, individual BIBI scores still show signs of impairment. This subwatershed may be impacted by current and historical 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 Rhode River subwatersheds.

8 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. 2017. Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan. Revised May 2017. 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.

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. R., Crunkleton, M.D. and M.J. Pieper. 2014. Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: Round Two 2009 – 2013. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland.

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.

Kline, K.M. and Morgan, R.P. 2006. Analytical Laboratory Standard Operating Procedures for the Maryland Biological Stream Survey. University of Maryland Center for Environmental Science, Appalachian Laboratory. Frostburg, MD.

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 the Environment. Code of Maryland Regulations (COMAR). Continuously updated. Code of Maryland Regulations, Title 26- Department of the Environment. 26.08.02.08- Stream Segment Designations.

Maryland Department of Natural Resources (DNR). 2016. Maryland State Wildlife Action Plan. Annapolis, Maryland.

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 indices in urban Maryland streams. Urban Ecosystems 10:153-177

Morgan R.P., Kline, K.M., Kline, M.J., Cushman, S.F., Sell, M.T., Weitzell, R.E. and J.B. Churchill. 2012. Stream conductivity: Relationships to land use, chloride, and fishes in Maryland streams. North American Journal of Fisheries Management 32:941-952

National Oceanic and Atmospheric Administration (NOAA). Preliminary Snowfall Map. Available online at https://www.weather.gov/lwx/pnsmap?type=snow&date=20180321&option=snow. Accessed 11/20/2018.

NRCS, Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at https://websoilsurvey.nrcs.usda.gov/. Accessed 12/18/2017.

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.

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.

Saville, J., M.T. Kashiwagi, A.J. Becker, and P.H. Graves. 2014. A Multi-Year Update (2011-2014) to Maryland Biological Stream Survey's Sentinel Site Network. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD.

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., G. Rogers, N. Roth and D. Zaveta. 2016. Design Update of the Anne Arundel County Biological Monitoring Program. Prepared for the Anne Arundel County Department of Public Works, Watershed Protection and Restoration Program, Annapolis, Maryland. Prepared by Versar, Inc., Columbia, Maryland, and AKRF, Inc., Hanover, Maryland. 37pp.

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.

Stranko, S., R. Bourquin, J. Zimmerman, M. Kashiwagi, M. McGinty, and R. Klauda. 2013. Do Road Salts Cause Environmental Impacts? Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division, Resources Assessment Service. Annapolis, MD.

Stranko, S., D. Boward, J. Kilian, A. Becker, M. Ashton, M. Southerland, B. Franks, W. Harbold, and J. Cessna. 2015. Maryland Biological Stream Survey: Round Four Field Sampling Manual. Revised January 2017. Published by the Maryland Department of Natural Resources, Annapolis, MD. Publication # 12-Resource Assessment Service-3142014-700.

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

Williams, W.D. 2001. Anthropogenic salinization of inland waters. Hydrobiologia, 466:329-337.

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
01-L1M-01-18	3.58	30.0	1.1	34.4	1.1	28.0	32.1	0.39	1.3	22	F4	Could not locate R1 xs pins. Relatively recent sewer line construction, possibly between visits. Revised bankfull elevation to better match regional and field photos.
01-L1M-02-18	8.13	25.9	1.9	71.0	2.7	13.3	50.5	0.75	1.3	9.9	C4	Found R1 cross section. 50m upstream of 01-R3M-01-18. Top end of site crossed by sewer protected by riprap.
01-L2M-01-18	0.21	6.2	0.6	9.7	1.5	10.5	3.7	0.49	1.5	0.088	G5c	Adjusted ENT -0.2. Found left bank pin. Reinstalled right pin. No bed features, one long shallow pool.
01-L2M-02-18	17.99	46.4	1.7	63.0	1.4	28.0	76.9	0.0053	1.0	0.43	F5	Reach just below bridge crossing, altering morphology. All pool feature, but riffle surveyed for XS 25ft DS of 0m mark. Overflow channel present on right bank near midpoint providing access to floodplain.
01-R3M-01-18	8.24	24.9	2.1	178.0	7.2	11.6	53.2	0.21	1.0	22	C4	Adjusted W/D +1.0. Top of right bank is an old earthen berm. Heavily impacted urban stream.
01-R3M-02-18	2.34	22.7	0.7	23.0	1.0	31.7	16.3	0.12	1.1	0.36	F5	---
01-R3M-03-18	2.44	17.8	1.0	20.3	1.1	16.9	18.6	0.46	1.4	7.3	F4/5	---
01-R3M-04-18	0.89	18.0	1.1	57.5	3.2	16.0	20.2	0.41	1.9	0.45	C5	Incised channel. Lots of new development upstream of site.
03-L1M-02-18	0.69	9.4	0.8	15.2	1.6	11.3	7.7	0.96	1.5	10	B4c	Adjusted W/D +1.0. Urban stream that appears to be changing/eroding actively. In Maritime Blvd stream restoration reach. Could not lcate R1 pins.
03-L1M-03-18	0.75	13.7	0.6	14.5	1.1	22.2	8.5	1.2	1.2	8.3	F4/5	---
03-L2M-01-18	0.42	14.2	1.0	35.5	2.5	13.8	14.7	1.1	1.1	18	C4	Resurveyed original cross-section
03-L2M-03-18	0.42	10.1	0.5	15.3	1.5	21.6	4.7	1.61	1.3	24	F4	Adjusted ER -0.1.
03-R3M-01-18	0.28	7.3	0.7	200.1	27.2	10.7	5.0	0.74	1.1	0.31	E5	Site in stormwater facility. Small channel in SWM. No real defined bed features in channel.
03-R3M-03-18	1.15	14.6	1.2	23.6	1.6	12.2	17.4	1.4	1.3	52	B4/3c	In Maritime Boulevard stream restoration reach. Heavily impacted urban stream.
03-R3M-04-18	0.22	14.4	0.7	21.3	1.5	21.3	9.7	0.79	1.0	0.062	ND	Upper half of site is in road culvert. Most of stream bottom gabion. Rip rap channel enters site on RB upstream of cross section. Heavily impacted site, not natural channel.
03-R3M-05-18	0.66	13.1	0.8	15.0	1.2	16.4	10.4	0.75	1.1	0.63	F4/5	standing pools, riffles dry
05-L1M-03-18	0.36	9.5	0.7	11.1	1.2	14.6	6.2	0.16	1.4	0.25	F5	Round 1 revisit site 05-13A. Calibration site (KCI & CRI)
05-L1M-04-18	0.28	9.8	1.2	15.8	1.6	8.4	11.4	0.35	1.2	0.14	G5c	R1 revisit 05-11A. Found XS. Restored trib enters LB just DS of XS. Restoration includes a boulder/cobble riffle at the confluence with the restored trib. This riffleand another DS of 0m are backwatering the entire reach except for the riffle. No pebble counts done in placed riprap. Stream has vertical eroded outside meanders but had consistent BKF indicator. (MARL-204-O-2018)

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
05-L2M-02-18	0.49	7.9	1.1	39.0	4.9	7.1	8.8	0.62	1.3	0.54	E5	Round 2 revisit site R2-05-08. Found XS. Soft red/orange clay in eroded outer left bank in one meander bend. Otherwise many banks were near vertical but not badly eroded, had some vegetation. (MARL-212-T-2018)
05-L2M-03-18	0.75	12.4	1.1	14.5	1.2	10.8	14.3	0.3	1.2	0.34	G5	Round 2 revisit R2-05-03. Regional curve predicts a low XS area (~8.4 sq ft). Channel is incised with badly eroded banks in many places, and few BKF indicators are present. Sand deposition on top of both banks indicates that the stream accesses the floodplain. (MARL-213-T-2018). 31% Impervious drainage most likely changed flow regime during storm events.
05-R3M-02-18	0.39	10.1	0.9	15.7	1.6	11.1	9.1	0.58	1.1	4.9	B4/5c	Adjusted W/D +1.0
05-R3M-03-18	1.63	26.1	0.6	30.8	1.2	44.8	15.2	0.0093	1.0	1.4	F5	Wide stream just DS bridge. Few BKF indicators. No riffles. Entire site is backwatered by a riffle about 100 ft DS of site. (MARL-102-L-2018)
05-R3M-05-18	0.64	11.9	0.8	14.0	1.2	14.4	9.8	0.1	1.1	0.22	F5	upstream of a road culvert.
05-R3M-06-18	0.61	9.0	1.2	10.4	1.2	7.7	10.6	2.2	1.0	13	G4/6	UPSTREAM HALF POWERLINE ROW
08-L1M-01-18	0.48	7.1	0.9	130.0	18.3	7.9	6.4	0.9	1.1	0.12	E5	R1 site 08-05. Re-established at original XS pins. US portion of site contains a confluence with a side/overflow channel. A small channel ran parallell within 30 ft for most of the reach, and entered the main channel near the DS end of the reach. It contained mostly standing water and appeared to originate at a wetland on the opposite side of the valley, so this was not considered a braided system. (LOMG-201-O-2018)
08-L1M-02-18	0.55	7.8	0.9	120.0	15.4	9.0	6.7	0.45	1.1	0.062	E6	R1 site 08-15A. Found XS REP (no cap, did not replace), did not find LEP so replaced. All trees on FP dead. A neighbor confirmed that the area was impounded by a beaver dam for 2 years, then the beaver was trapped and removed. FP mucky. (LOMG-202-O-2018)
08-L2M-01-18	0.93	8.5	1.2	160.0	18.8	7.0	10.4	0.046	1.1	0.41	E5	R2 revisit R2-08-10 (LOMG-211-T-2018)
08-L2M-02-18	0.17	4.2	0.5	55.0	13.1	8.4	2.1	1	1.2	0.062	E6	Placed riprap and possibly some gravel. (LOMG-212-T-2018)
08-R3M-02-18	0.42	6.9	0.9	9.3	1.3	7.5	6.4	0.6	1.3	0.29	G5c	Several construction stakes and flagging which may indicate a future restoration.
08-R3M-03-18	0.52	8.5	0.8	115.0	13.5	10.1	7.2	0.44	1.2	0.094	E5	Mostly backwatered conditions, debris jam near the downstream end of the reach causing slight head cut. Vernal pools identified. Green Frog found. One riffle downstream of debris jam. (LOMG-102-L-2018)

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
08-R3M-04-18	1.01	7.0	1.2	84.0	12.0	5.6	8.7	1.1	1.7	0.062	E6	Predominately silt/clay. Reach started at confluence with trib. Not included in DA or any bkfl calls. Minimal bed features, mostly due to debris in channel. (LOMG-103-L-2018)
08-R3M-05-18	0.27	7.1	0.4	27.8	3.9	16.7	3.0	0.78	1.2	0.081	C5	---
19-L1M-01-18	5.76	18.0	1.9	18.0	1.0	9.7	33.5	0.22	1.6	7.1	G4c	R1 site 19-09. Found LEP, reset REP. Large stream with tall sand/gravel bars. Most bars have a thick layer of loose sand on top of more stable gravel, indicating a recent high flow event depositing the sand. Few BKF indicators. Moderately eroded, slumping banks in some outside meanders. Sand deposition on both tops of bank. Likely flashy. (STOC-201-O-2018)
19-L1M-03-18	0.62	14.7	0.7	19.4	1.3	19.9	10.9	0.31	1.2	2	F4/5	Round 1 revisit 19-06. Overwidened and incised channel for the drainage area. Active flow path is narrow. Stream is actively building benches on alternating sides. Severe bank erosion with undercut trees in places. Loose sand in pools and somewhat clean riffles indicate a mobile bed. Did not locate R1 XS pins, reestablished in a riffle. (STOC-203-O-2018)
19-L2M-01-18	5.24	35.6	2.4	236.0	6.6	14.6	86.6	0.33	1.5	0.34	ND	Found both round 2 xs pins (R2-19-07). Trees fallen in cross section, cross section in pool so XS area , width, depth higher than anticipated. To disturbed to classify. (STOC-211-T-2018)
19-L2M-07-18	0.11	5.4	0.5	8.0	1.5	10.7	2.7	0.91	1.2	0.73	G5c	Round 2 site R2-19-10. Found XS pins and resurveyed. (STOC-217-T-2018)
19-R3M-01-18	0.39	6.1	0.8	9.6	1.6	7.3	5.1	0.44	1.1	0.18	G4c	Entrenchment ratio slightly higher than upper threshhold for G type streams, but observations in the fielsd and other bankull dimnesions support G4 stream type. (STOC-100-L-2018)
19-R3M-03-18	0.15	5.6	0.3	6.4	1.1	18.4	1.7	0.87	1.2	0.2	F5	Crossing donwstream of reach is holding grade, may also explain the high amount of fine sediments deposited in the bed. (STOC-102-L-2018)
19-R3M-06-18	0.16	5.1	0.5	7.2	1.4	9.2	2.8	0.36	1.0	0.092	G5c	Downstream of crossing. Crossing causing stream downcutting.
19-R3M-07-18	0.59	12.3	1.3	14.5	1.2	9.2	16.4	1.6	2.6	0.62	G5c	Not far US of STOC-203-O-2018 (R1 revisit). Site is on a large meander bend leading to high sinuosity. Two significant drops (>1ft) are arrested by LWD, but may cause headcutting in the future if LWD washes out. XS is upstream of both drops near 75 m. Most of site has unstable bed and banks, with pools filled with loose sand and only one stable riffle near 0 m. (STOC-106-L-2018)

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 Measurement Quality Objectives 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 and Summer sampling protocols prior to the start of each field sampling season. Benthic macroinvertebrate sampling was conducted only by crew members certified in MBSS benthic macroinvertebrate sampling. Fish sampling was performed under the leadership of a crew member certified as Fish Sampling Crew Leader and fish taxonomic identification was performed only by crew members certified as Fish Taxonomist. In addition, field crew members leading the geomorphic assessments have either completed Rosgen Level II training or completed a previous season of geomorphic assessments.

All subjective scoring of physical habitat assessment parameters was completed with the input of all team members at the sampling site to reduce individual sampler bias.

Field water quality measurements and grab samples were collected at all monitoring sites according to methods in the County QAPP. 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 collected at one site per strata (i.e., large streams, small streams) within each of the five primary sampling units (PSUs) sampled in 2018, for a total of 10 duplicates. These 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 obvious 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, water quality grabs and measurement of *in situ* water chemistry. Photographs were also taken at duplicate sites.

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)

Programmatic measurement quality objectives are listed in Table 1. 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.

Table 1 – Measurement quality objectives for metric values 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

Both metric values and index scores were compared to MQOs to determine exceedances. Four metrics, Total Taxa, Number of EPT Taxa, Percent Intolerant, and Percent Climbers, exceeded the MQO for mRPD. The high RPD value for Number of EPT Taxa was due to relatively few EPT taxa present in the samples which tend to skew RPD values upward when comparing small values as compared to large values. For example, a sample pair with 1 vs 2 taxa yielded an RPD of 67, while a sample pair with 3 vs 4 taxa had an RPD of 29, despite the same difference of only 1 taxon between sample pairs. The high mRPD for Percent Intolerant and Percent Climber metrics was likely due to the variability within these metrics between sites sampled in which values range from 0.0% to 41.6% and 0.0% to 33.3%, respectively, for the sites analyzed for QC.

Scraper Taxa and the BIBI exceeded the MQO for RMSE, but passed for mRPD, while Total Taxa and Percent Climbers exceeded the MQO for RMSE in addition to median RPD. The exceedance for Scraper Taxa was primarily due to a few samples which had 5 or more taxa, while all other samples had only one or two taxa or no scrapers present at all. The BIBI narrowly exceeded the threshold primarily due to one sample pair (19-R3M-07-18 & 19-R3M-07-18QC) with a relatively large difference in BIBI scores of 5.00 and 3.57, respectively. The overall taxonomic composition between samples 19-R3M-07-18 & 19-R3M-07-18QC was quite similar, although the presence of

a few rare Ephemeroptera and Plecoptera taxa skewed the difference considerably. For instance, both samples contained the mayfly *Acerpenna* but the QC site had 24, while the original site had only 9. Since this in an intolerant species, it's higher abundance helped push the Percent Intolerant metric up to '5' compared to the original site that received a '3'. Similarly, the QC site contained two additional Ephemeroptera taxa (only 5 individuals) that also resulted in the Ephemeroptera Taxa receiving a '5'. The presence of three additional Plecoptera Taxa (only total 3 individuals) helped the QC site receive a '5' for EPT Taxa. Lastly, a difference of only one scraper taxa resulted in the QC site receiving a '5' for that metric as well, while the original site received a '3'. The exceedance for Percent Climbers was primarily due to the amount of variation between samples in which the percentages range from 0.0% to 33.3%, percent for sites analyzed for QC. Total Taxa narrowly exceeded the threshold primarily due to a few sample pairs with relatively large differences.

Four metrics and the BIBI exceeded the MQO for CV. Number of Ephemeroptera Taxa was the only metric that exceeded CV only, while the remaining three metrics (Total Taxa, Number of EPT Taxa, Percent Intolerant) and the BIBI had already exceeded either mRPD or RMSE as explained above. This is primarily due to the low overall mean value for Ephemeroptera Taxa (0.35) in the QC data set, which was smaller than the RMSE value of 0.38 and resulted in an elevated CV value of 109.1% and exceeding the threshold of 100%.

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

Site	Total Taxa	EPT Taxa	Ephem Taxa	% Intol	% Ephem	Scraper Taxa	% Climbers	BIBI	Rating
08-R3S-08-18	12	0	0	11.7	0.0	0	0.0	1.29	Very Poor
08-R3S-08-18-QC	15	0	0	12.7	0.0	0	16.4	2.14	Poor
03-L2M-03-18	29	7	1	4.9	1.0	4	25.2	3.86	Fair
03-L2M-03-18 QC	28	5	0	8.7	0.0	1	8.7	3.00	Fair
03-R3S-18-18	13	0	0	3.8	0.0	1	29.1	1.86	Very Poor
03-R3S-18-18 QC	21	2	0	17.0	0.0	1	17.9	2.71	Poor
05-R3S-02-18	7	1	0	0.0	0.0	0	33.3	1.57	Very Poor
05-R3S-02-18 QC	6	0	0	0.0	0.0	0	26.7	1.57	Very Poor
05-L2M-03-18	11	1	0	0.0	0.0	1	10.0	1.86	Very Poor
05-L2M-03-18-QC	18	0	0	0.0	0.0	1	21.1	2.14	Poor
01-R3M-03-18	23	4	0	7.0	0.0	7	2.6	2.71	Poor
01-R3M-03-18 QC	19	3	0	2.0	0.0	6	1.0	2.43	Poor
01-R3S-13-18	19	4	1	41.6	2.7	5	11.5	3.86	Fair
01-R3S-13-18 QC	25	7	1	25.7	8.8	5	19.5	4.14	Good
19-R3M-07-18	23	3	1	10.1	8.3	1	15.6	3.57	Fair
19-R3M-07-18-QC	22	8	3	35.3	25.0	2	20.7	5.00	Good
19-R3S-04-18	15	1	0	20.9	0.0	2	4.5	2.43	Poor
19-R3S-04-18-QC	17	1	0	5.5	0.0	2	8.3	2.43	Poor
08-R3S-08-18	12	0	0	11.7	0.0	0	0.0	1.29	Very Poor
08-R3S-08-18-QC	15	0	0	12.7	0.0	0	16.4	2.14	Poor
Median RPD	**20.6**	**43.9**	0.0	**84.2**	0.0	0.0	**54.7**	18.8	-
RMSE	**4.5**	1.7	0.4	11.6	0.3	**1.2**	**10.6**	**0.6**	-
CV	**24.4**	**70.7**	**109.1**	**112.1**	14.9	57.3	69.1	**23.5**	-

It is important to note that these results show the innate variability that is possible within a given sampling reach and throughout the sample processing and data reduction. Although all samples were collected by a certified benthic macroinvertebrate sampler, variation within a reach (primary site vs. field replicate) is probable due to slight variations in habitat availability (e.g., instream woody debris, quality of leaf packs and riffles) and sample processing and subsampling within the laboratory. It should also be noted that inclusion of small streams into this data set is likely to introduce additional variability in the results given that only larger streams were used to develop the MQOs.

Laboratory Sorting and Subsampling

Bias

All sorting was completed following the SOPs described in the QAPP. For these samples, 52% (46 samples) underwent quality control procedures for sorting, exceeding the ten percent requirement. Average percent sorting efficiency was 96.9% (n=46). 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. 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

Nine samples (19-R3S-19-18, 08-R3M-03-18, 19-L2M-07-18, 05-L2M-03-18, 03-L1M-03-18, 19-R3S-14-18, 01-R3M-01-18, 03-R3M-05-18, 01-R3S-11-18) were randomly selected for QC identification and enumeration by an independent lab. Initial identification was performed by EcoAnalysts[1] (ESC). Re-identification of the randomly selected samples was completed by the Maryland Department of Natural Resources[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.

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 Table 6Table 6 through Table 14. Dashes shown in the '# of agreements' column signify hierarchical disagreements, which counts as an agreement for PTD calculations. For example, if the primary laboratory identified a specimen as Naididae and the secondary laboratory

[1] Address: 1420 S. Blaine St., Suite 14 Moscow, ID 83843
[2] Address: 1919 Lincoln Drive Annapolis, Maryland 21401

identified the same specimen as *Dero* (genus of the family Naididae) this would be considered a hierarchical disagreement.

All but one (1) sample fell below the allowable thresholds for both PDE and PTD measures. Sample 03-R3M-05-18 had only 49 specimens present; therefore, a slight difference of five (5) taxa resulted in a skewed PDE value since there were fewer than 100 organisms present. The average PDE for all samples was 2.4% with a range between 0.4% and 5.4%. The average PTD was 9.9% with a range between 2.8% and 14.9%.

Water Quality Sampling

A QA/QC analysis was completed for the water quality grab sampling following the procedures used for MBSS and described by Mercurio et al. (2003), due to a lack of established MQOs developed specifically for Anne Arundel County. This analysis includes an evaluation of precision (repeatability) of water quality grab sampling.

A total of 16 duplicate water quality grab sample were collected during the spring index period according to methods detailed in the County QAPP. To evaluate the consistency of water quality sampling using duplicate samples, the following performance characteristic was calculated:

- Relative Percent Difference (RPD)

Results of performance characteristics using individual parameter values are presented in Table 3a and Table 3b. Results are shown for sites where a duplicate sample (i.e., sample pair) was collected and analyzed.

In 2018, there were no parameters that exceeded 20% mRPD (median RPD). For individual duplicate sites, five out of eight pairs exceeded 20% RPD for Total Kjehldal Nitrogen. Total Kjehldal Nitrogen values generally differed by <0.1 mg/L at duplicate sites, but because the values were very close to zero the RPD was inflated. One duplicate site pair (08-R3S-08-18 and 08-R3S-08-18QC) had Total Kjehldal Nitrogen that differed by 0.24 mg/L. Similarly, four out of eight samples exceeded 20% RPD, although values generally differed by <0.01 mg/L at duplicate sites. Nonetheless, these results are in line with those reported by MBSS in the 2001 Quality Assurance Report (Mercurio et al. 2003).

Field blanks containing deionized water were also collected at two sites during 2017. Results of individual parameter values for both field blank samples are presented in Table 4. At site 08-L1M-02-18QC, five individual parameters had values slightly above the method detection limit, which include chloride, TN, DOC, TOC and Turbidity. At site 01-R3M-03-18QC, values for TN, DOC and TOC fell slightly above the method detection limit, with all other parameter values falling below. No metals or cations were detected above the detection limits at either site.

Table 3a - Individual Grab Sample Parameter Values and Measures of Precision. Bold values exceed MQOs. All values are in mg/L.

Sample ID	Chloride	Total Phosphorus	Total Nitrogen	Ortho-phosphate	Total Ammonia Nitrogen	Nitrite-N	Nitrate-N	Total Kjehldal Nitrogen	Dissolved Organic Carbon
08-R3S-08-18	17.74	0.062	0.464	0.0031	0.091	0.002	0.004	0.458	4.896
08-R3S-08-18-QC	13.66	0.010	0.225	0.0031	0.039	0.002	0.004	0.219	3.520
03-R3S-18-18	80.51	0.114	0.695	0.0135	0.010	0.004	0.006	0.685	13.807
03-R3S-18-18-QC	80.56	0.138	0.708	0.0143	0.013	0.004	0.007	0.697	13.600
03-L2M-03-18	95.98	0.036	2.026	0.0076	0.011	0.009	1.631	0.385	3.374
03-L2M-03-18-QC	95.83	0.039	1.886	0.0053	0.010	0.009	1.561	0.316	3.366
05-R3S-02-18	92.80	0.006	1.950	0.0033	0.026	0.003	1.801	0.146	1.969
05-R3S-02-18-QC	108.62	0.005	1.749	0.0031	0.030	0.003	1.633	0.113	1.628
05-L2M-03-18	28.29	0.030	0.918	0.0031	0.011	0.007	0.494	0.417	4.803
05-L2M-03-18-QC	28.79	0.018	0.794	0.0031	0.009	0.007	0.576	0.211	4.761
01-R3S-13-18	176.93	0.007	0.768	0.0031	0.030	0.002	0.604	0.162	1.035
01-R3S-13-18-QC	174.76	0.006	0.854	0.0031	0.021	0.002	0.611	0.241	1.077
19-R3M-07-18	22.20	0.083	1.063	0.018	0.010	0.004	0.919	0.140	1.775
19-R3M-07-18-QC	22.43	0.099	1.009	0.0263	0.012	0.005	0.847	0.157	1.919
19-R3S-04-18	76.04	0.092	1.081	0.0149	0.039	0.005	0.822	0.254	1.327
19-R3S-04-18-QC	76.87	0.086	1.042	0.0115	0.056	0.005	0.839	0.198	1.249
Median RPD	1.1	13.0	7.1	0.0	17.0	0.0	1.1	19.8	3.9

BDL signifies “below detection limit”

Table 3b - Individual Sample Parameter Values and Measures of Precision (Continued). All values are in mg/L, unless otherwise noted.

Sample ID	Total Organic Carbon	Magnesium	Calcium	Hardness	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
08-R3S-08-18	6.147	2.482	9.498	33.94	0.718	21.480	0.315	27.0
08-R3S-08-18-QC	3.905	2.031	8.044	28.45	0.635	21.825	0.138	4.3
03-R3S-18-18	14.068	3.911	16.28	56.76	8.06	8.791	1.804	76.3
03-R3S-18-18-QC	13.931	3.871	15.95	55.77	7.879	8.409	1.702	82.9
03-L2M-03-18	3.351	3.64	24.28	75.62	2.977	6.180	0.531	20.8
03-L2M-03-18-QC	3.287	3.623	23.52	73.65	2.952	6.009	0.521	21.6
05-R3S-02-18	1.976	4.938	14.1	55.54	1.212	16.687	0.193	1.1
05-R3S-02-18-QC	1.671	5.036	16.07	60.87	1.012	10.839	0.136	1.0
05-L2M-03-18	4.927	2.629	23.32	69.06	1.526	4.941	0.207	8.8
05-L2M-03-18-QC	4.764	2.613	22.06	65.84	1.345	8.851	0.168	6.2
01-R3S-13-18	1.072	6.697	21.14	80.36	1.834	25.947	0.072	3.6
01-R3S-13-18-QC	1.135	6.846	21.8	82.63	1.919	26.586	0.08	2.0
19-R3M-07-18	1.858	3.373	17.33	57.16	0.325	12.212	0.058	2.6
19-R3M-07-18-QC	1.962	3.317	17.18	56.56	0.356	10.692	0.063	2.8
19-R3S-04-18	1.416	2.794	25.37	74.85	0.19	6.433	0.094	8.3
19-R3S-04-18-QC	1.300	2.806	24.74	73.33	0.248	7.997	0.152	7.2
Median RPD	5.4	1.7	3.1	2.6	4.5	2.4	8.3	9.6

BDL signifies “below detection limit”

Table 4 - Individual Grab Sample Parameter Values for Field Blanks. All Values are in mg/L, unless otherwise noted.

Parameter	08-L1M-02-18QC	01-R3M-03-18QC	Parameter	08-L1M-02-18QC	01-R3M-03-18QC
Chloride	0.0357	BDL	Total Organic Carbon	0.1167	0.1611
Total Phosphorus	BDL	BDL	Magnesium	BDL	BDL
Total Nitrogen	0.025	0.0513	Calcium	BDL	BDL
Orthophosphate	BDL	BDL	Hardness	BDL	BDL
Total Ammonia Nitrogen	BDL	BDL	Total Copper (µg/L)	BDL	BDL
Nitrite-N	BDL	BDL	Total Zinc (µg/L)	BDL	BDL
Nitrate-N	BDL	BDL	Total Lead (µg/L)	BDL	BDL
Total Kjelhal Nitrogen	BDL	BDL	Turbidity (NTU)	0.15	BDL
Dissolved Organic Carbon	0.1652	0.1881			

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 6. Although several individual metrics had exceeded measures for mRPD, RMSE and CV, the overall BIBI was within the proposed MQO limits for mRPD and RMSE demonstrating acceptable precision for field sampling. Laboratory sorting and subsampling measures indicated acceptable levels of bias, while taxonomic identification measures demonstrated acceptable precision. The overall sensitivity of the site assessment was slightly greater than the desired 90% confidence interval for the BIBI, 1.03 compared to the MQO of ≤0.96. One QC site pair, with BIBI scores of 3.87 and 5.00, contributes greatly to the variability of the BIBI. The benthic samples from these sites were very dissimilar, one site requiring a sorting of 100% of the sample to reach 138 organisms, and the other requiring sorting of only 21% of the sample to also reach 138 organisms. When analyzing the QC data without this pair included, the confidence interval decreases to 0.96, within the MQO for the sensitivity of the site assessment.

As mentioned in Hill and Pieper, 2011, there are generally two forms of error: systematic and random. Systematic error is error associated with a particular method, which can to a certain extent, be controlled by using an appropriate quality assurance program. Random error, however, is the error that results from the sample itself of the population from which it is derived and can only partly be controlled through a careful sampling design. What we are seeing when comparing the field replicate and primary samples is a combination of both systematic and random error. As certified samplers, the field crew is taking steps to minimize systematic error by following the exact same procedures at every site. Therefore, the MQO exceedances for Field Sampling and Site Assessment are not likely due to systematic error, and are more likely random error due to the spatial heterogeneity between adjacent reaches. This issue can be addressed in the future by taking a field replicate macroinvertebrate sample within the primary sampling reach and not an adjacent reach upstream, although this approach is difficult at sites where habitat extent is limited.

All remaining MQOs were met during the 2018 sampling period, and subsequently, the data are of acceptable quality as specified by the QAPP.

Table 5 - Summary comparison of QC results and measurement quality objectives[1].

Activity	Performance Indicator	Measure	MQO	2018 Results
Field Sampling	Precision	mRPD (BIBI)	<20	18.8
		RMSE (BIBI)	<0.6	0.6
Laboratory Sorting/Subsampling	Bias	PSE	>90	96.9
Taxonomic Identification	Precision	PDE	<5	2.4
		PTD	<15	9.9
Site Assessment	Sensitivity	90% CI (BIBI)	≤0.96	1.03

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

Table 6 - Taxonomic Identification and Enumeration Results: 08-R3M-03-18

Order	Family	Tribe	Sample ID	08-R3M-03-18		
				Taxonomist 1	Taxonomist 2	# of agreements
		-	Nematoda	1	1	1
Veneroida	Pisidiidae	-	Pisidium	1	0	0
		-	Sphaerium	0	1	0
Haplotaxida	Naididae	-	Naididae	2		2
		-	TUBIFICIDAE		2	-
Basommatophora	Physidae	-	Physa	1	1	1
Coleoptera	Elmidae	-	Ancyronyx	3	3	3
	Elmidae	-	Stenelmis	11	11	11
Diptera	Chironomidae	-	Corynoneura	2	2	2
	Chironomidae	Chironomini	Cryptochironomus	5	4	4
			Chironomini	0	1	0
	Chironomidae	Chironomini	Dicrotendipes	1	0	0
	Chironomidae	-	Diplocladius	1	0	0
	Chironomidae	Chironomini	Microtendipes	1	1	1
	Chironomidae	Chironomini	Paracladopelma	1	1	1
	Chironomidae	-	Parametriocnemus	1	1	1
	Chironomidae	Tanytarsini	Paratanytarsus	7	5	5
	Chironomidae	Chironomini	Polypedilum	20	20	20
	Chironomidae	-	Rheocricotopus	1	1	1
	Chironomidae	Tanytarsini	Rheotanytarsus	26	26	26
	Chironomidae	Chironomini	Stictochironomus	1	1	1
	Chironomidae	Tanytarsini	Tanytarsus	2	2	2
	Chironomidae	-	Thienemannimyia group	1	1	1
	Chironomidae	Chironomini	Tribelos	6	6	6
	Chironomidae	-	Xylotopus	1	1	1
	Empididae	Hemerodromiini	Hemerodromia	2	2	2
	Tipulidae	-	Erioptera	1	0	0
	Tipulidae	-	Tipula	1	1	1
Odonata	Calopterygidae	-	Calopteryx	1	1	1

Order	Family	Tribe	Sample ID		08-R3M-03-18	
				Taxonomist 1	Taxonomist 2	# of agreements
Trichoptera	Dipseudopsidae	-	Phylocentropus	1	0	0
	Hydropsychidae	-	Cheumatopsyche	9	9	9
	Hydropsychidae	-	Hydropsyche	1	0	0
Amphipoda	Gammaridae	-	Gammarus	7	7	7
			Total	119	112	110
			PDE			3.03
			PTD			7.56

Table 7 - Taxonomic Identification and Enumeration Results: 19-L2M-07-18

Order	Family	Tribe	Sample ID	19-L2M-07-18		
				Taxonomist 1	Taxonomist 2	# of agreements
Veneroida	Pisidiidae		Sphaeriidae	2	0	0
	Pisidiidae		Pisidium	2	0	0
			PISIDIIDAE	0	2	0
Haplotaxida	Naididae		Naididae	4	0	4
			TUBIFICIDAE		4	-
Hoplonemertea	Tetrastemmatidae		Prostoma	3	3	3
Basommatophora	Physidae		Physa	7	6	6
Diptera	Ceratopogonidae		Bezzia/Palpomyia	7	1	1
			Probezzia	0	6	0
	Chironomidae	-	Chaetocladius	20	17	17
	Chironomidae	-	Diplocladius	15	15	15
	Chironomidae	-	Orthocladius	5	6	5
	Chironomidae	-	Parametriocnemus	32	31	31
			Orthocladiinae	0	1	0
	Chironomidae	Chironomini	Polypedilum	3	3	3
	Chironomidae	-	Thienemannimyia group	4	4	4
	Chironomidae	Pentaneurini	Zavrelimyia	1	0	0

Order	Family	Tribe	Sample ID	19-L2M-07-18 Taxonomist 1	Taxonomist 2	# of agreements
	Tabanidae	-	Chrysops	2	2	2
	Tipulidae	-	Pilaria	2	0	0
		-	Pseudolimnophila	0	2	0
	Tipulidae	-	Tipula	1	1	1
Trichoptera	Limnephilidae	0	Ironoquia	6	7	6
			Limnephilidae	0	1	0
Amphipoda	Crangonyctidae		Crangonyctidae	2	0	0
	Gammaridae	0	Gammaridae	5	0	5
	Gammaridae	0	Gammarus	13	20	13
			Hyalella	1	0	0
			Total	137	132	116
			PDE			1.86
			PTD			12.12

Table 8 - Taxonomic Identification and Enumeration Results: 01-R3M-01-18

Order	Family	Tribe	Sample ID	01-R3M-01-18 Taxonomist 1	Taxonomist 2	# of agreements
Veneroida	Corbiculidae		Corbicula	1	0	0
Haplotaxida	Naididae		Naididae	3	4	3
Basommatophora	Physidae		Physa	1	1	1
Coleoptera	Elmidae		Ancyronyx	1	0	0
	Elmidae		Stenelmis	1	1	1
Diptera	Ceratopogonidae	-	Ceratopogonidae	1	0	0
	Chironomidae	Pentaneurini	Ablabesmyia	3	3	3
	Chironomidae	-	Cricotopus	19	13	13
	Chironomidae	-	Hydrobaenus	1	0	0

Order	Family	Tribe	Sample ID	01-R3M-01-18 Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	-	Nanocladius	1	0	0
	Chironomidae	-	Orthocladius	10	13	10
			Orthocladiinae		5	0
	Chironomidae	Chironomini	Polypedilum	18	17	17
	Chironomidae	-	Rheocricotopus	12	10	10
	Chironomidae	Tanytarsini	Rheotanytarsus	18	15	15
			Tanytarsini		1	0
	Chironomidae	Chironomini	Saetheria	3	2	2
	Chironomidae	Chironomini	Stenochironomus	1	1	1
	Chironomidae	Tanytarsini	Tanytarsus	21	20	20
			Paratanytarsus		1	1
	Chironomidae	-	Thienemannimyia group	2	1	1
			Tanypodinae		1	1
	Empididae		Neoplasta	1	1	1
Odonata	Aeshnidae		Boyeria	1	1	1
	Calopterygidae		Calopteryx	5	5	5
	Coenagrionidae		Argia	3	3	3
Trichoptera	Hydropsychidae		Hydropsyche	1	1	1
	Philopotamidae		Chimarra	1	1	1
	Polycentropodidae		Polycentropus	1	1	1
			Total	130	122	112
			PDE			3.17
			PTD			13.85

Table 9 - Taxonomic Identification and Enumeration Results: 19-R3S-19-18

Order	Family	Tribe	Sample ID	19-R3S-19-18		
				Taxonomist 1	Taxonomist 2	# of agreements
			Nematoda	1	0	1
			GORDIIDAE		1	-
Veneroida	Pisidiidae		Sphaeriidae	1	0	0
	Pisidiidae		Pisidium	2	0	0
			PISIDIIDAE	0	3	0
Haplotaxida	Naididae		Naididae	1		1
			TUBIFICIDAE		1	-
			Gastropoda	1		1
Basommatophora	Physidae		Physa	3	4	3
Coleoptera	Dytiscidae		Hydroporus	1	0	0
	Elmidae		Stenelmis	1	1	1
Diptera	Ceratopogonidae		Ceratopogoninae	3	0	3
			Bezzia/Palpomyia	0	1	0
			Probezzia sp.	0	2	0
	Chironomidae		Orthocladiinae	1	0	0
	Chironomidae	Tanytarsini	Tanytarsini	1	0	0
	Chironomidae		Diplocladius	1	1	1
	Chironomidae		Hydrobaenus	3	0	0
	Chironomidae		Orthocladius	6	7	6
			Orthocladiinae	0	2	0
	Chironomidae	Chironomini	Paracladopelma	1	0	0
	Chironomidae		Parametriocnemus	20	20	20
	Chironomidae	Chironomini	Polypedilum	54	50	50
			Saetheria	0	1	0
	Chironomidae		Rheocricotopus	2	2	2
	Chironomidae	Tanytarsini	Rheotanytarsus	5	7	5
	Chironomidae	Tanytarsini	Tanytarsus	3	1	1
			Micropsectra	0	1	0
	Chironomidae		Thienemannimyia group	2	2	2

Order	Family	Tribe	Sample ID	19-R3S-19-18 Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	Chironomini	Tribelos	1	1	1
	Tipulidae		Tipula	1	1	1
Plecoptera	not identified		Plecoptera	1	1	1
Trichoptera	Hydropsychidae		Diplectrona	1	1	1
	Limnephilidae		Ironoquia	3	2	2
			LIMNEPHILIDAE	0	1	1
	Uenoidae		Neophylax	3	3	3
Amphipoda	not identified		Amphipoda	5	0	0
	Crangonyctidae		Crangonyctidae	2	0	0
	Gammaridae		Gammaridae	3	0	3
	Gammaridae		Gammarus	6	11	6
			Total	139	128	116
			PDE			4.12
			PTD			9.38

Table 10 - Taxonomic Identification and Enumeration Results: 05-L2M-03-18

Order	Family	Tribe	Sample ID	05-L2M-03-18 Taxonomist 1	Taxonomist 2	# of agreements
Basommatophora	Physidae		Physa	1	1	1
			Nematoda	3	3	3
Diptera	Ceratopogonidae		Dasyhelea	5	4	4
	Chironomidae		Cricotopus	1	0	0
	Chironomidae	Chironomini	Dicrotendipes	1	1	1
	Chironomidae		Hydrobaenus	5	0	0
	Chironomidae		Orthocladius	93	97	93
			Diplocladius	0	2	0

Order	Family	Tribe	Sample ID	05-L2M-03-18 Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	Chironomini	Polypedilum	14	9	9
	Chironomidae		Thienemannimyia group	1	10	1
	Chironomidae	Pentaneurini	Zavrelimyia	1	0	0
	Tipulidae		Tipula	2	2	2
Trichoptera	Hydropsychidae		Cheumatopsyche	1	1	1
			Total	128	130	115
			PDE			0.78
			PTD			10.16

Table 11 - Taxonomic Identification and Enumeration Results: 03-L1M-03-18

Order	Family	Tribe	Sample ID	03-L1M-03-18 Taxonomist 1	Taxonomist 2	# of agreements
Nemata			Nemata	2	3	2
Mollusca			Gastropoda	2	0	0
Basommatophora	Physidae		Physa	2	4	2
Coleoptera	Dytiscidae		Dytiscidae	4	3	3
Diptera	Chironomidae	-	Brillia	1	1	1
	Chironomidae	-	Chaetocladius	8	8	8
	Chironomidae	-	Cricotopus/Orthocladius	3	1	1
	Chironomidae	Chironomini	Cryptochironomus	1	1	1
	Chironomidae	Diamesini	Diamesa	1	1	1
	Chironomidae	-	Eukiefferiella	4	4	4
	Chironomidae	-	Orthocladius	40	42	42
	Chironomidae	-	Parametriocnemus	9	9	9
	Chironomidae	Chironomini	Polypedilum	7	7	7
	Chironomidae	Diamesini	Potthastia	2	2	2
	Chironomidae	Chironomini	Saetheria	1	0	0

Order	Family	Tribe	Sample ID	03-L1M-03-18 Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	-	Thienemannimyia group	2	2	2
	Chironomidae	-	Tvetenia	5	5	5
	Empididae	Hemerodromiini	Hemerodromia	1	1	1
			Roederiodes	1	0	0
	Simuliidae	-	Simuliidae	3	0	3
	Simuliidae	Simuliini	Simulium	16	19	16
Trichoptera	not identified	-	Trichoptera	1		-
			HYDROPSYCHIDAE		1	1
	Hydropsychidae	-	Cheumatopsyche	25	25	25
	Hydropsychidae	-	Hydropsyche	4	5	4
	Philopotamidae	-	Dolophilodes	1	0	0
			Total	146	144	140
			PDE			0.69
			PTD			2.78

Table 12 - Taxonomic Identification and Enumeration Results: 19-R3S-14-18

Order	Family	Tribe	Sample ID	19-R3S-14-18 Taxonomist 1	Taxonomist 2	# of agreements
Veneroida	Pisidiidae		Sphaeriidae	2	0	0
	Pisidiidae		Pisidium	1	0	0
			PISIDIIDAE	0	4	0
Haplotaxida	Naididae		Naididae	15	18	15
Coleoptera	Dytiscidae		Dytiscidae	1	0	0
Diptera	Chironomidae	-	Chaetocladius	1	0	0
	Chironomidae	-	Corynoneura	1	0	0
	Chironomidae	Diamesini	Diamesa	3	1	1
			Diamesinae	0	2	2
	Chironomidae	-	Parametriocnemus	5	5	5

Order	Family	Tribe	Sample ID	19-R3S-14-18 Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	Chironomini	Polypedilum	11	11	11
			Thienemanniella	0	1	0
	Tipulidae	-	Pseudolimnophila	5	4	4
	Tipulidae	-	Tipula	1	1	1
Plecoptera	Capniidae		Capniidae	1	0	-
			Plecoptera		1	1
			Ironoquia	1	1	1
Amphipoda	Gammaridae		Gammaridae	20	0	-
	Gammaridae		Gammarus	61	75	75
			Total	129	124	116
			PDE			1.98
			PTD			6.45

Table 13 - Taxonomic Identification and Enumeration Results: 01-R3S-11-18

Order	Family	Tribe	Sample ID	01-R3S-11-18 Taxonomist 1	Taxonomist 2	# of agreements
			Nemata	1		1
			NEMATODA		1	-
Coleoptera	Elmidae		Oulimnius	2	0	0
			Optioservus	0	2	0
	Elmidae		Stenelmis	3	3	3
Diptera	Chironomidae		Cricotopus/Orthocladius	4	0	0
	Chironomidae	Diamesini	Diamesa	1	-	1
			Diamesinae		1	-
	Chironomidae	-	Diplocladius	10	9	9
	Chironomidae	-	Hydrobaenus	31	20	20
	Chironomidae	-	Nanocladius	1	1	1
	Chironomidae	-	Orthocladius	24	37	24

Order	Family	Tribe	Sample ID	01-R3S-11-18 Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	-	Orthocladius	6	-	6
		-	Orthocladiinae		9	-
	Chironomidae	-	Parametriocnemus	4	4	4
	Chironomidae	Chironomini	Polypedilum	8	8	8
	Chironomidae	-	Rheocricotopus	3	3	3
	Chironomidae	Tanytarsini	Rheotanytarsus	1	0	0
	Chironomidae	Pentaneurini	Zavrelimyia	1	1	1
	Simuliidae	-	Simuliidae	1	1	1
	Simuliidae	Prosimuliini	Prosimulium	1	1	1
	Simuliidae	Prosimuliini	Stegopterna	13	13	13
Plecoptera	not identified		Plecoptera	1	2	1
	Capniidae		Capniidae	1	0	1
Trichoptera	Hydropsychidae		Diplectrona	4	4	4
Amphipoda	not identified		Amphipoda	1	-	1
			Stygobromus		1	-
			Total	122	121	103
			PDE			0.41
			PTD			14.88

Table 14 - Taxonimic Identification and Enumeration Results: 03-R3M-05-18

Order	Family	Tribe	Sample ID	3-R3M-05-18 Taxonomist 1	Taxonomist 2	# of agreements
Haplotaxida	Enchytraeidae		Enchytraeidae	4	4	4
Lumbriculida	Lumbriculidae		Lumbriculidae	4	4	4
Haplotaxida	Naididae		Naididae	10		10
			TUBIFICIDAE		11	-

Order	Family	Tribe	Sample ID	**3-R3M-05-18** Taxonomist 1	Taxonomist 2	# of agreements
Hoplonemertea	Tetrastemmatidae		Prostoma	3	3	3
Basommatophora	Physidae		Physa	6	6	6
COLEOPTERA	DYTISCIDAE		Copelatus	0	1	0
Diptera	Ceratopogonidae	0	Dasyhelea	3	3	3
	Chironomidae	0	Chaetocladius	2	5	2
	Chironomidae	Chironomini	Dicrotendipes	2	2	2
	Chironomidae	0	Orthocladius	8	8	8
	Chironomidae	Tanytarsini	Paratanytarsus	1	1	1
			TABANIDAE	0	1	0
	Stratiomyidae		Hedriodiscus/Odontomyia	1		0
			Total	44	49	43
			PDE			5.38
			PTD			12.24

References

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

Mercurio, G., D. Baxter, J. Volstad, N. Roth, and M. Southerland. 2003. Maryland Biological Stream Survey 2001 Quality Assurance Report. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD. CBWP-MANTA-EA-03-1.

Stribling, J.B., S.R. Moulton, and G.T. Lester. 2003. Determining the quality of taxonomic data. J. N. Am. Benthol. Soc., 2003, 22(4):621–631.

Appendix C: Master Taxa List

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3	487	12.21%	34	85.0%
Diptera	Chironomidae	Orthocladius	Orthocladius	Collector	sp, bu	9.2	348	8.73%	35	87.5%
Haplotaxida	Naididae	not identified	Naididae	Collector	bu	8.5	278	6.97%	27	67.5%
Amphipoda	Gammaridae	Gammarus	Gammarus	Shredder	sp	6.7	149	3.74%	12	30.0%
Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	Scraper	sp	7.2	143	3.59%	14	35.0%
Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	Filterer	cn	7.2	142	3.56%	18	45.0%
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7	134	3.36%	14	35.0%
Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia group	Predator	sp	8.2	126	3.16%	33	82.5%
Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	Collector	sp	4.6	125	3.14%	20	50.0%
Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	Filterer	cn	6.5	121	3.03%	17	42.5%
Diptera	Chironomidae	Tanytarsus	Tanytarsus	Filterer	cb, cn	4.9	104	2.61%	18	45.0%
Coleoptera	Elmidae	Stenelmis	Stenelmis	Scraper	cn	7.1	98	2.46%	12	30.0%
0	0	not identified	Nematoda	0	0	na	91	2.28%	16	40.0%
Diptera	Chironomidae	Cricotopus	Cricotopus	Shredder	cn, bu	9.6	89	2.23%	20	50.0%
Veneroida	Pisidiidae	not identified	Sphaeriidae	Filterer	bu	6.5	89	2.23%	15	37.5%
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7	70	1.76%	19	47.5%
Lumbriculida	Lumbriculidae	not identified	Lumbriculidae	Collector	bu	6.6	67	1.68%	12	30.0%
Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	Shredder	0	7.7	49	1.23%	10	25.0%
Diptera	Chironomidae	Microtendipes	Microtendipes	Filterer	cn	4.9	48	1.20%	9	22.5%
Ephemeroptera	Baetidae	Acerpenna	Acerpenna	Collector	sw, cn	2.6	41	1.03%	4	10.0%
Diptera	Chironomidae	Tvetenia	Tvetenia	Collector	sp	5.1	41	1.03%	16	40.0%
Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	Filterer	cn	7.5	37	0.93%	12	30.0%
Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	Collector	cn	8.7	37	0.93%	14	35.0%
Amphipoda	Gammaridae	not identified	Gammaridae	0	0	6	36	0.90%	7	17.5%
Diptera	Chironomidae	Chaetocladius	Chaetocladius	Collector	sp	7	35	0.88%	10	25.0%
Diptera	Chironomidae	Diplocladius	Diplocladius	Collector	sp	5.9	34	0.85%	11	27.5%
Basommatophora	Lymnaeidae	not identified	Lymnaeidae	Scraper	cb	6.9	33	0.83%	6	15.0%
Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	Collector	sp	6.2	33	0.83%	12	30.0%
Diptera	Chironomidae	Ablabesmyia	Ablabesmyia	Predator	sp	8.1	30	0.75%	7	17.5%
Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	Collector	sp	6.1	29	0.73%	6	15.0%
Diptera	Simuliidae	Simulium	Simulium	Filterer	cn	5.7	28	0.70%	6	15.0%
Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	Collector	bu	9	27	0.68%	10	25.0%
Basommatophora	Planorbidae	Menetus	Menetus	Scraper	cb	7.6	26	0.65%	5	12.5%
Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	Collector	sp	7.7	25	0.63%	12	30.0%
Hoplonemertea	Tetrastemmatidae	Prostoma	Prostoma	Predator	0	7.3	25	0.63%	8	20.0%
Odonata	Calopterygidae	Calopteryx	Calopteryx	Predator	cb	8.3	24	0.60%	13	32.5%
Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	Predator	sp, bu	7.6	23	0.58%	14	35.0%
Diptera	Tipulidae	Tipula	Tipula	Shredder	bu	6.7	23	0.58%	14	35.0%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Veneroida	not identified	not identified	Veneroida	0	0	na	23	0.58%	4	10.0%
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9	22	0.55%	12	30.0%
Trichoptera	Philopotamidae	Chimarra	Chimarra	Filterer	cn	4.4	21	0.53%	7	17.5%
Diptera	Chironomidae	Tribelos	Tribelos	Collector	bu	7	21	0.53%	8	20.0%
Diptera	Chironomidae	Corynoneura	Corynoneura	Collector	sp	4.1	19	0.48%	6	15.0%
Odonata	Coenagrionidae	Argia	Argia	Predator	cn, cb, sp	9.3	17	0.43%	4	10.0%
Trichoptera	Limnephilidae	Ironoquia	Ironoquia	Shredder	sp	4.9	16	0.40%	6	15.0%
not identified	not identified	not identified	Turbellaria	Predator	sp	4	16	0.40%	3	7.5%
Diptera	Ceratopogonidae	not identified	Bezzia/Palpomyia	0	0	na	14	0.35%	5	12.5%
Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	Filterer	cn	2.7	14	0.35%	6	15.0%
Diptera	Chironomidae	Stenochironomus	Stenochironomus	Shredder	bu	7.9	14	0.35%	5	12.5%
Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	Predator	sp	5.3	13	0.33%	8	20.0%
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6	12	0.30%	5	12.5%
Amphipoda	Crangonyctidae	not identified	Crangonyctidae	Collector	sp	6.5	12	0.30%	5	12.5%
Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	Collector	bu	9.1	12	0.30%	8	20.0%
Coleoptera	Elmidae	Macronychus	Macronychus	Scraper	cn	6.8	12	0.30%	7	17.5%
Coleoptera	Elmidae	Oulimnius	Oulimnius	Scraper	cn	2.7	12	0.30%	4	10.0%
Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	Filterer	cn	1.1	12	0.30%	3	7.5%
Diptera	Ceratopogonidae	not identified	Ceratopogoninae	0	0	na	11	0.28%	6	15.0%
Diptera	Ceratopogonidae	Dasyhelea	Dasyhelea	Collector	sp	3.6	11	0.28%	6	15.0%
not identified	not identified	not identified	Gastropoda	0	0	na	11	0.28%	5	12.5%
Lumbricina	not identified	not identified	Lumbricina	Collector	bu	na	11	0.28%	8	20.0%
Ostracoda	not identified	not identified	Ostracoda	Collector	0	8	11	0.28%	2	5.0%
Diptera	Chironomidae	Thienemanniella	Thienemanniella	Collector	sp	5.1	11	0.28%	6	15.0%
Diptera	Chironomidae	Diamesa	Diamesa	Collector	sp	8.5	9	0.23%	7	17.5%
Diptera	Chironomidae	Saetheria	Saetheria	Collector	bu	6.6	9	0.23%	5	12.5%
Diptera	Culicidae	Aedes	Aedes	Filterer	sw	8	8	0.20%	1	2.5%
Trichoptera	Limnephilidae	not identified	Limnephilidae	Shredder	cb, sp, cn	3.4	8	0.20%	4	10.0%
Diptera	Chironomidae	Paracladopelma	Paracladopelma	Collector	sp	6.6	8	0.20%	4	10.0%
Diptera	Simuliidae	Prosimulium	Prosimulium	Filterer	cn	2.4	8	0.20%	2	5.0%
Diptera	Simuliidae	not identified	Simuliidae	Filterer	cn	3.2	8	0.20%	4	10.0%
Amphipoda	Crangonyctidae	Synurella	Synurella	0	0	0.4	8	0.20%	2	5.0%
Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	Collector	sp	6.7	7	0.18%	2	5.0%
Basommatophora	Ancylidae	Ferrissia	Ferrissia	Scraper	cb	7	7	0.18%	4	10.0%
Diptera	Chironomidae	Glyptotendipes	Glyptotendipes	Filterer	bu, cn	6.6	7	0.18%	2	5.0%
Diptera	Chironomidae	Pseudorthocladius	Pseudorthocladius	Collector	sp	6	7	0.18%	3	7.5%
Diptera	Chironomidae	Stictochironomus	Stictochironomus	Collector	bu	9.2	7	0.18%	4	10.0%
Coleoptera	Elmidae	Ancyronyx	Ancyronyx	Scraper	cn, sp	7.8	6	0.15%	4	10.0%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Diptera	Tipulidae	Antocha	Antocha	Collector	cn	8	6	0.15%	4	10.0%
Decapoda	Cambaridae	not identified	Cambaridae	Shredder	sp	2.8	6	0.15%	1	2.5%
Diptera	Ceratopogonidae	not identified	Ceratopogonidae	Predator	sp, bu	3.6	6	0.15%	2	5.0%
Plecoptera	Nemouridae	not identified	Nemouridae	Shredder	sp, cn	2.9	6	0.15%	3	7.5%
Trichoptera	Uenoidae	Neophylax	Neophylax	Scraper	cn	2.7	6	0.15%	3	7.5%
Coleoptera	Elmidae	Optioservus	Optioservus	Scraper	cn	5.4	6	0.15%	3	7.5%
Diptera	Chironomidae	not identified	Orthocladiinae	Collector	0	7.6	6	0.15%	3	7.5%
Plecoptera	Nemouridae	Amphinemura	Amphinemura	Shredder	sp, cn	3	5	0.13%	3	7.5%
Veneroida	Corbiculidae	Corbicula	Corbicula	Filterer	bu	6	5	0.13%	2	5.0%
Diptera	Chironomidae	Odontomesa	Odontomesa	Collector	sp	6.6	5	0.13%	1	2.5%
Diptera	Tipulidae	Pilaria	Pilaria	Predator	bu	4.8	5	0.13%	4	10.0%
Trichoptera	Polycentropodidae	not identified	Polycentropodidae	0	cn	0.2	5	0.13%	3	7.5%
Plecoptera	Capniidae	not identified	Capniidae	Shredder	sp, cn	3.7	4	0.10%	2	5.0%
Diptera	Tabanidae	Chrysops	Chrysops	Predator	sp, bu	2.9	4	0.10%	3	7.5%
Coleoptera	Dytiscidae	not identified	Dytiscidae	Predator	sw, dv	5.4	4	0.10%	1	2.5%
Plecoptera	Perlodidae	Isoperla	Isoperla	Predator	cn, sp	2.4	4	0.10%	3	7.5%
Coleoptera	Psephenidae	Psephenus	Psephenus	Scraper	cn	4.4	4	0.10%	2	5.0%
Odonata	Corduliidae	Somatochlora	Somatochlora	Predator	sp	1	4	0.10%	1	2.5%
Diptera	Chironomidae	not identified	Tanytarsini	Collector	0	3.5	4	0.10%	1	2.5%
Amphipoda	not identified	not identified	Amphipoda	0	sp	6	3	0.08%	2	5.0%
Diptera	Chironomidae	Brillia	Brillia	Shredder	bu, sp	7.4	3	0.08%	3	7.5%
Diptera	not identified	not identified	Diptera	0	0	6	3	0.08%	1	2.5%
Ephemeroptera	Heptageniidae	Maccaffertium	Maccaffertium	Scraper	cn	3	3	0.08%	2	5.0%
Diptera	Chironomidae	Paratendipes	Paratendipes	Collector	bu	6.6	3	0.08%	3	7.5%
Diptera	Tipulidae	Pseudolimnophila	Pseudolimnophila	Predator	bu	2.8	3	0.08%	1	2.5%
Diptera	Simuliidae	Stegopterna	Stegopterna	Filterer	cn	2.4	3	0.08%	3	7.5%
Odonata	Aeshnidae	Boyeria	Boyeria	Predator	cb, sp	6.3	2	0.05%	2	5.0%
Diptera	Chironomidae	Cladotanytarsus	Cladotanytarsus	Filterer	-	6.6	2	0.05%	2	5.0%
Odonata	Coenagrionidae	not identified	Coenagrionidae	Predator	cb	9	2	0.05%	2	5.0%
Megaloptera	Corydalidae	not identified	Corydalidae	Predator	0	1.4	2	0.05%	2	5.0%
Coleoptera	Elmidae	Dubiraphia	Dubiraphia	Scraper	cn, cb	5.7	2	0.05%	2	5.0%
Diptera	Tipulidae	Erioptera	Erioptera	Collector	bu	4.8	2	0.05%	2	5.0%
Hirudinida	Erpobdellidae	Erpodella	Erpobdella	0	0	na	2	0.05%	2	5.0%
Coleoptera	Dryopidae	Helichus	Helichus	Scraper	cn	6.4	2	0.05%	1	2.5%
Trichoptera	Hydropsychidae	not identified	Hydropsychidae	Filterer	cn	5.7	2	0.05%	2	5.0%
Diptera	Chironomidae	Micropsectra	Micropsectra	Collector	cb, sp	2.1	2	0.05%	2	5.0%
Coleoptera	Dytiscidae	Neoporus	Neoporus	Predator	0	na	2	0.05%	2	5.0%
Diptera	Chironomidae	Potthastia	Potthastia	Collector	sp	0.01	2	0.05%	1	2.5%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Diptera	Chironomidae	Prodiamesa	Prodiamesa	Collector	bu, sp	6.6	2	0.05%	2	5.0%
Trichoptera	Phryganeidae	Ptilostomis	Ptilostomis	Shredder	cb	4.3	2	0.05%	2	5.0%
Diptera	Chironomidae	Smittia	Smittia	Collector	lentic	6.6	2	0.05%	2	5.0%
Plecoptera	Taeniopterygidae	Strophopteryx	Strophopteryx	Shredder	sp, cn	3.3	2	0.05%	1	2.5%
Diptera	Tabanidae	not identified	Tabanidae	Predator	0	2.8	2	0.05%	2	5.0%
Trichoptera	not identified	not identified	Trichoptera	0	0	4.6	2	0.05%	2	5.0%
Diptera	Chironomidae	Xylotopus	Xylotopus	Shredder	bu	6.6	2	0.05%	2	5.0%
Ephemeroptera	Ameletidae	Ameletus	Ameletus	Collector	sw, cb	2.6	1	0.03%	1	2.5%
Diptera	Ptychopteridae	Bittacomorpha	Bittacomorpha	Collector	bu	4	1	0.03%	1	2.5%
Diptera	Chironomidae	Chironomini	Chironomini	0	0	5.9	1	0.03%	1	2.5%
Diptera	Chironomidae	Chironomus	Chironomus	Collector	bu	4.6	1	0.03%	1	2.5%
Diptera	Tipulidae	Dicranota	Dicranota	Predator	sp, bu	1.1	1	0.03%	1	2.5%
Trichoptera	Philopotamidae	Dolophilodes	Dolophilodes	Filterer	cn	1.7	1	0.03%	1	2.5%
Diptera	Ceratopogonidae	Forcipomyia	Forcipomyia	Predator	0	na	1	0.03%	1	2.5%
Odonata	Gomphidae	not identified	Gomphidae	Predator	bu	2.2	1	0.03%	1	2.5%
Diptera	Chironomidae	Gymnometriocnemus	Gymnometriocnemus	0	0	na	1	0.03%	1	2.5%
Basommatophora	Planorbidae	Gyraulus	Gyraulus	Scraper	cb	7.6	1	0.03%	1	2.5%
Tubificida	Haplotaxidae	not identified	Haplotaxidae	0	0	na	1	0.03%	1	2.5%
Diptera	Tipulidae	Hexatoma	Hexatoma	Predator	bu, sp	1.5	1	0.03%	1	2.5%
Odonata	Coenagrionidae	Ischnura	Ischnura	Predator	cb	9	1	0.03%	1	2.5%
Diptera	Chironomidae	Krenosmittia	Krenosmittia	Collector	sp	na	1	0.03%	1	2.5%
Ephemeroptera	Leptophlebiidae	not identified	Leptophlebiidae	Collector	sw, cn	1.7	1	0.03%	1	2.5%
Plecoptera	Leuctridae	Leuctra	Leuctra	Shredder	cn	0.4	1	0.03%	1	2.5%
Diptera	Chironomidae	Nanocladius	Nanocladius	Collector	sp	7.6	1	0.03%	1	2.5%
Diptera	Chironomidae	Natarsia	Natarsia	Predator	sp	6.6	1	0.03%	1	2.5%
Megaloptera	Corydalidae	Nigronia	Nigronia	Predator	cn, cb	1.4	1	0.03%	1	2.5%
Diptera	Chironomidae	Paraphaenocladius	Paraphaenocladius	Collector	sp	4	1	0.03%	1	2.5%
Trichoptera	Dipseudopsidae	Phylocentropus	Phylocentropus	Collector	bu	5	1	0.03%	1	2.5%
Basommatophora	Planorbidae	not identified	Planorbidae	Scraper	cb	7.6	1	0.03%	1	2.5%
Coleoptera	Dytiscidae	Platambus	Platambus	0	0	na	1	0.03%	1	2.5%
Trichoptera	Limnephilidae	Pycnopsyche	Pycnopsyche	Shredder	sp, cb, cn	3.1	1	0.03%	1	2.5%
Diptera	Chironomidae	Radotanypus	Radotanypus	0	0	na	1	0.03%	1	2.5%
Diptera	Empididae	Roederiodes	Roederiodes	Predator	cn	na	1	0.03%	1	2.5%
Diptera	Sciomyzidae	not identified	Sciomyzidae	Predator	bu	6	1	0.03%	1	2.5%
Diptera	Stratiomyidae	not identified	Stratiomyidae	Collector	0	na	1	0.03%	1	2.5%
Amphipoda	Crangonyctidae	Stygobromus	Stygobromus	Collector	0	4	1	0.03%	1	2.5%
Diptera	Tipulidae	not identified	Tipulidae	Predator	bu, sp	4.8	1	0.03%	1	2.5%
Odonata	Coenagrionidae	Enallagma	Enallagma	Predator	cb	9	1	0.03%	1	2.5%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Coleoptera	Haliplidae	Peltodytes	Peltodytes	Shredder	cb, cn	8.9	1	0.03%	1	2.5%
Diptera	Chironomidae	not identified	Tanypodinae	Predator	0	7.5	1	0.03%	1	2.5%

1) 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 (Bressler et al., 2004)
An entry of "0" indicates information was not available in the MBSS Master Taxa List

Common Name	Scientific Name	Tolerance	Trophic Status	Lithophilic Spawner	Composition	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Blacknose Dace	*Rhinichthys atratulus*	T	OM	N	NOTYPE	1621	23.2%	25	64%
Eastern Mosquitofish	*Gambusia holbrooki*	NOTYPE	IV	N	NOTYPE	781	11.2%	19	49%
Eastern Mudminnow	*Umbra pygmaea*	T	IV	N	NOTYPE	748	10.7%	14	36%
Swallowtail Shiner	*Notropis procne*	NOTYPE	IV	Y	NOTYPE	464	6.6%	11	28%
Tessellated Darter	*Etheostoma olmstedi*	T	IV	N	B	388	5.6%	19	49%
Creek Chub	*Semotilus atromaculatus*	T	GE	Y	NOTYPE	379	5.4%	14	36%
American Eel	*Anguilla rostrata*	NOTYPE	GE	N	NOTYPE	332	4.8%	26	67%
Bluegill	*Lepomis macrochirus*	T	IV	N	NOTYPE	228	3.3%	16	41%
Rosyside Dace	*Clinostomus funduloides*	NOTYPE	IV	Y	NOTYPE	229	3.3%	8	21%
Pumpkinseed	*Lepomis gibbosus*	T	IV	N	NOTYPE	203	2.9%	9	23%
Satinfin Shiner	*Cyprinella analostana*	I	IV	N	NOTYPE	190	2.7%	7	18%
Fallfish	*Semotilus corporalis*	I	GE	Y	NOTYPE	162	2.3%	10	26%
Mummichog	*Fundulus heteroclitus*	NOTYPE	IV	N	NOTYPE	161	2.3%	3	8%
White Sucker	*Catostomus commersonii*	T	OM	Y	NOTYPE	156	2.2%	12	31%
Green Sunfish	*Lepomis cyanellus*	T	GE	N	NOTYPE	128	1.8%	14	36%
Central Stoneroller	*Campostoma anomalum*	I	AL	Y	NOTYPE	109	1.6%	7	18%
Sea Lamprey	*Petromyzon marinus*	I	FF	N	NOTYPE	112	1.6%	6	15%
Bluntnose Minnow	*Pimephales notatus*	T	OM	N	NOTYPE	97	1.4%	6	15%
Creek Chubsucker	*Erimyzon oblongus*	NOTYPE	IV	N	R	81	1.2%	5	13%
Longnose Dace	*Rhinichthys cataractae*	NOTYPE	OM	N	NOTYPE	78	1.1%	7	18%
Brown Bullhead	*Ameiurus nebulosus*	T	OM	N	NOTYPE	63	0.9%	4	10%
Least brook Lamprey	*Lampetra aepyptera*	NOTYPE	FF	N	B	63	0.9%	6	15%
Redbreast Sunfish	*Lepomis auritus*	NOTYPE	GE	N	NOTYPE	56	0.8%	7	18%
Golden Shiner	*Notemigonus crysoleucas*	T	OM	N	NOTYPE	32	0.5%	6	15%
Yellow Bullhead	*Ameiurus natalis*	NOTYPE	OM	N	NOTYPE	32	0.5%	8	21%
Blue Ridge Sculpin	*Cottus caeruleomentum*	I	IS	Y	B	29	0.4%	5	13%
Banded Killifish	*Fundulus diaphanus*	NOTYPE	IV	N	NOTYPE	16	0.2%	5	13%
Cutlip Minnow	*Exoglossum maxillingua*	NOTYPE	IV	Y	NOTYPE	11	0.2%	3	8%
Largemouth Bass	*Mictopterus salmoides*	T	TP	N	NOTYPE	16	0.2%	11	28%
Northern Hogsucker	*Hypentelium nigricans*	I	IV	Y	R	5	0.1%	4	10%
Chain Pickerel	*Esox niger*	NOTYPE	TP	N	NOTYPE	1	0.0%	1	3%
Fathead Minnow	Pimephales promelas	NOTYPE	OM	N	NOTYPE	1	0.0%	1	3%
Glassy Darter	*Etheostoma vitreum*	NOTYPE	IS	Y	B	2	0.0%	1	3%
Goldfish	*Carassius auratus*	NOTYPE	OM	N	NOTYPE	3	0.0%	1	3%
Smallmouth Bass	*Micropterus dolomieu*	NOTYPE	TP	N	NOTYPE	3	0.0%	2	5%
Spottail Shiner	*Notropis hudsonius*	I	OM	Y	NOTYPE	3	0.0%	2	5%

Common Name	Scientific Name	Tolerance	Trophic Status	Lithophilic Spawner	Composition	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Warmouth	*Lepomis gulosus*	NOTYPE	GE	N	NOTYPE	3	0.0%	3	8%

Note: Total number of sites is 39 as 1 of the 40 sites was sampled qualitatively

Tolerance: I = intolerant, T = tolerant; NOTYPE = no category assigned

Trophic groups: FF = filter feeder, TP = top predator, GE = generalist, IV = invertivore, IS = insectivore, OM = omnivore, AL = algivore, HE = herbivore

Lithophilic spawner: Y = Yes, N = No, NOTYPE = no categopry assigned

Composition: B = Benthic, R = Round-Bodied Sucker, NOTYPE = no category assigned

Crayfish

Common Name	Scientific Name	Total Number of Sites	% of Sites
Devil Crawfish	*Orconectes virilis*	7	18%
Spinycheek Crayfish	*Orconectes limosus*	4	10%
n/a	*Cambarus diogenes*	3	8%
Red Swamp Crawfish	*Procambaris clarkii*	3	8%
n/a	*Procambarus acutus/zonangulus*	2	5%
n/a	*Cambarus acuminatus*	1	3%
Rusty Crayfish	*Orconectes rusticus*	1	3%

Herpetofauna

Common Name	Scientific Name	Total Number of Sites	% of Sites
Northern Green Frog	*Lithobates clamitans*	31	34%
Northern Two-lined Salamander	*Eurycea bislineata*	16	18%
American Bullfrog	*Lithobates catesbeianus*	13	14%
Pickerel Frog	*Lithobates palustris*	4	4%
Northern Spring Peeper	*Pseudacris crucifer*	3	3%
Eastern American Toad	*Anaxyrus americanus*	4	4%
Wood Frog	*Lithobates sylvaticus*	2	2%
Red eared slider	*Trachemys scripta elegans*	2	2%
Northern watersnake	*Nerodia sipedon sipedon*	3	3%
Eastern Spadefoot	*Scaphiopus holbrookii*	1	1%
Eastern Box Turtle	*Terrapene carolina carolina*	1	1%
Eastern Wormsnake	*Carphophis amoenus*	1	1%
Common Five-lined Skink	*Plestiodon fasciatus*	1	1%

Non-native Riparian Plants

Common Name	Scientific Name	Total Number of Sites	% of Sites
Japanese honeysuckle	*Lonicera japonica*	33	83%
Multiflora rose	*Rosa multiflora*	31	78%
Japanese stiltgrass	*Microstegium vimineum*	28	70%
Oriential bittersweet	*Celastrus orbiculatus*	19	48%
English ivy	*Hedera helix*	13	33%
Japanese barberry	*Berberis thunbergii*	11	28%
Mile-a-minute	*Persicaria perfoliata*	11	28%
Porcelain berry	*Ampelopsis brevipedunculata*	7	18%
Garlic mustard	*Alliaria petiolata*	5	13%
Ground ivy	*Glechoma hederacea*	4	10%
Japanese knotweed	*Fallopia japonica*	4	10%
Mimosa	*Albizia julibrissin*	4	10%
Autumn love	*n/a*	3	8%
Beefsteak plant	*Perilla frutescens var. crispa*	3	8%
Rose of Sharon	*Hibiscus syriacus*	3	8%
Chinese lespedeza	*Lespedeza cuneata*	2	5%
Periwinkle	*Vinca*	2	5%
Phragmites	*Phragmites australis*	2	5%
Wineberry	*Rubus phoenicolasius*	2	5%
Winged euonymus	*Euonymus alatus*	2	5%
Asiatic dayflower	*Commelina communis*	1	3%
Bush honeysuckle	*Lonicera maackii*	1	3%
Creeping thistle	*Cirsium arvense*	1	3%
Chinese privet	*Ligustrum sinense*	1	3%
Indian strawberry	*Duchesnea indica*	1	3%
Japanese pachysandra	*Pachysandra terminalis*	1	3%
Lily turf	*Liriope muscari*	1	3%
Mock orange	*Philadelphus sp.*	1	3%
Oriental lady's thumb	*Persicaria longiseta*	1	3%
Hydrangea sp.	*Hydrangea sp.*	1	3%

Freshwater Mussels/Corbicula

Common Name	Scientific Name	Total Number of Sites	% of Sites
Asiatic clam	*Corbicula sp.*	1	1%

Appendix D: Individual Site Summaries

Site ID 01-L1M-01-18

Revist of site R1-01-04

Upstream View - 2018

Downstream View - 2018

Upstream View - 2007

Downstream View - 2007

Summary Results

	2018 Data	2007 Data
Benthic Macroinvertebrate Community	Poor	Fair
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Non-Supporting
MPHI Habitat Condition	Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nutrients	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2294.01

Land Cover	2018 Acres	2007 Acres	2018 % Area	2007 % Area
Developed Land	1237.35	70.53	53.94	47.98
Forested Land	813.29	25.52	35.45	17.36
Open Land	243.37	50.95	10.61	34.66
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2007 Acres	2018 % Area	2007 % Area
Impervious Land	682.76	54.72	29.76	37.22

Site ID 01-L1M-01-18

Revist of site R1-01-04

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2007 Spring
Dissolved Oxygen (mg/L)	10.74	7.78	11.33
Turbidity (NTU)	4.5	36.2	n/a
Temperature (°C)	6.5	21.9	3.61
pH (Standard Units)	7.25	6.81	n/a
Specific Conductivity (µS/cm)	757.5	443	1774

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.041	Chloride (mg/L)	216.842
Total Nitrogen (mg/L)	1.716	Magnesium (mg/L)	6.706
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	27.96
Total Ammonia N (mg/L)	0.650	Total Copper (µg/L)	1.609
Nitrite-N (mg/L)	0.022	Total Zinc (µg/L)	10.466
Nitrate-N (mg/L)	0.784	Total Lead (µg/L)	0.086
Total Kjehldal N (mg/L)	0.910	Turbidity (NTU)	3.9
Dissolved Organic C (mg/L)	1.563		
Total Organic C (mg/L)	1.572		
Hardness (mg eq. $CaCO_3$/L)	97.43		

Geomorphic Assessment

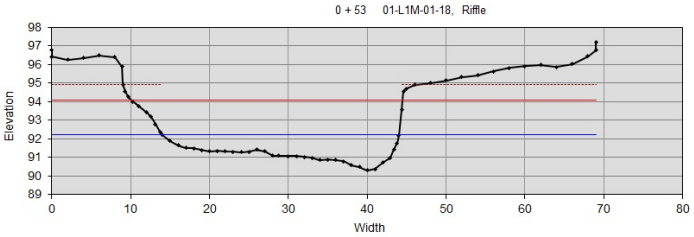
Rosgen Level II Classification Data

	2018	2007		2018	2007
Drainage Area (mi²)	3.58		Sinuosity	1.26	1.10
Bankfull Width (ft)	30.0	6.5	D50 (mm)	22.00	1.00
Mean Bankfull Depth (ft)	1.1	1.0	Adjustments?	None	Sin
Floodprone Width (ft)	34.4	23.9			
Entrenchment Ratio	1.1	3.7			
Width to Depth Ratio	28.0	6.5			
Cross Sectional Area (ft²)	32.1	6.5			
Water Surface Slope (%)	0.390	1.800			

Rosgen Stream Type	
2018	2007
F4	**E5**

Cross-sectional Survey

(R1 XS not located)



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2007 Spring Value	2007 Spring Score
Remoteness	8.81	47.44	8.00	43.08
Shading	60	58.94	95	99.94
Epifaunal Substrate	9	58.09	11	87.61
Instream Habitat	13	73.62	11	90.65
Instream Woody Debris	12	69.61	3	74.09
Bank Stability	13.87	83.27	7.00	59.16

	2018 Score	2007 Score
MPHI Habitat Score	65.16	75.75
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2018 Score	2007 Score		2018 Score	2007 Score
Epifaunal Substrate/Available Cover	5	11	Bank Stability - Right Bank	1	3
Pool Substrate Characterization	11	9	Bank Stability - Left Bank	1	3
Pool Variability	4	8	Vegetative Protection - Right Bank	3	3
Sediment Deposition	5	6	Vegetative Protection - Left Bank	3	3
Channel Flow Status	14	8	Riparian Veg. Zone Width - Right Bank	8	10
Channel Alteration	6	17	Riparian Veg. Zone Width - Left Bank	8	10
Channel Sinuosity	6	8			

	2018 Score	2007 Score
RBP Habitat Score	75	99
RBP Rating	Non-Supporting	Non-Supporting

Site ID 01-L1M-01-18

Revist of site R1-01-04

Biological Assessments

BIBI Metric Values	2018	2007
Total Taxa	15	27
EPT Taxa	3	6
Ephemeroptera Taxa	0	1
% Intolerant to Urban	0.91	3.81
% Ephemeroptera	0.00	0.95
Scraper Taxa	5	0
% Climbers	0.00	4.76

FIBI Metric Values (2018 only)	
Abundance per m²	0.72
Adj. No. of Benthic Species	1.63
% Tolerant	35.59
% Gen., Omni., Invert.	90.39
% Round-bodied Suckers	0.36
% Abund. Dominant Taxon	24.91

BIBI Metric Scores		
Total Taxa	3	5
EPT Taxa	3	5
Ephemeroptera Taxa	1	3
% Intolerant to Urban	1	1
% Ephemeroptera	1	3
Scraper Taxa	5	1
% Climbers	1	3

FIBI Metric Scores (2018 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	2.14	3.00
BIBI Rating	Poor	Fair

FIBI Score	4.33
FIBI Rating	Good

Supplemental Flora and Fauna (2018 only)

Crayfish

Orconectes limosus

Orconectes virilis

Mussels

Corbicula sp.

Herpetofauna

American Bullfrog

Fish Taxa

Fish Taxa	Number
American Eel	27
Blacknose Dace	28
Blue Ridge Sculpin	6
Bluegill	18
Bluntnose Minnow	6
Central Stoneroller	12
Creek Chub	13
Eastern Mosquitofish	1
Fallfish	7
Fathead Minnow	1
Largemouth Bass	1
Least Brook Lamprey	2
Longnose Dace	13
Northern Hogsucker	1
Redbreast Sunfish	5
Satinfin Shiner	23
Sea Lamprey	6
Swallowtail Shiner	70
Tessellated Darter	26
Warmouth	1
White Sucker	8
Yellow Bullhead	6

Benthic Macroinvertebrate Taxa

2018	Number
Cheumatopsyche	7
Chimarra	4
Cricotopus	1
Hemerodromia	8
Hydrobaenus	9
Hydropsyche	11
Lumbricina	1
Macronychus	5
Nematoda	1
Orthocladius	28
Oulimnius	1
Phaenopsectra	1
Psephenus	3
Stenelmis	28
Thienemannimyia group	2

Original Visit	Number
Lumbricidae	1
Limnodrilus	2
Agabus	1
Neoporus	1
Ablabesmyia	1
Chaetocladius	4
Cryptochironomus	1
Eukiefferiella	3
Limnophyes	1
Orthocladius/Cricotopus	10
Parametriocnemus	15
Phaenopsectra	2
Polypedilum	2
Thienemannimyia	29
Tvetenia	2
Xenochironomus	1
Zavrelimyia	12
Chrysops	1
Pilaria	1
Tipula	1
Caenis	1
Calopteryx	2
Allocapnia	2
Cheumatopsyche	1
Diplectrona	2
Limnephilidae	5
Ptilostomis	1

Site ID 01-L1M-02-18

Revist of site R1-01-07

Upstream View - 2018

Downstream View - 2018

Upstream View - 2007

Downstream View - 2007

Summary Results

	2018 Data	2007 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Partially Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 5203.12

Land Cover	2018 Acres	2007 Acres	2018 % Area	2007 % Area
Developed Land	4041.38	2328.99	77.67	43.03
Forested Land	596.47	2736.07	11.46	50.56
Open Land	554.24	343.88	10.65	6.35
Agricultural Land	11.04	3.06	0.21	0.06

Impervious Surface	2018 Acres	2007 Acres	2018 % Area	2007 % Area
Impervious Land	1369.80	262.49	26.33	4.85

Site ID 01-L1M-02-18

Revist of site R1-01-07

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2007 Spring
Dissolved Oxygen (mg/L)	11.8	7.24	14.83
Turbidity (NTU)	7.84	4.8	n/a
Temperature (°C)	10.4	25.4	1.14
pH (Standard Units)	7.82	7.96	n/a
Specific Conductivity (µS/cm)	943	595	1464

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.008	Chloride (mg/L)	174.791
Total Nitrogen (mg/L)	0.739	Magnesium (mg/L)	10.580
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	36.85
Total Ammonia N (mg/L)	0.018	Total Copper (µg/L)	1.175
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	5.609
Nitrate-N (mg/L)	0.519	Total Lead (µg/L)	0.063
Total Kjehldal N (mg/L)	0.214	Turbidity (NTU)	5.3
Dissolved Organic C (mg/L)	1.206		
Total Organic C (mg/L)	1.218		
Hardness (mg eq. $CaCO_3$/L)	135.58		

Geomorphic Assessment

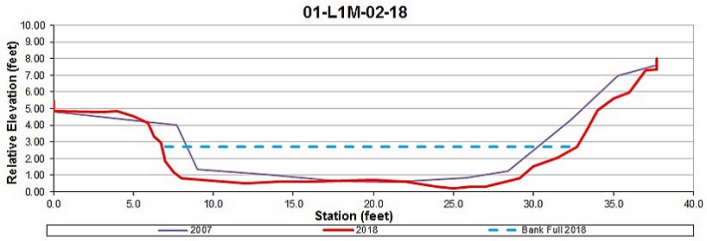
Rosgen Level II Classification Data

	2018	2007		2018	2007
Drainage Area (mi²)	8.13		Sinuosity	1.26	1.00
Bankfull Width (ft)	25.9	24.2	D50 (mm)	9.90	6.00
Mean Bankfull Depth (ft)	1.9	2.8	Adjustments?	None	Sin
Floodprone Width (ft)	71.0	590.0			
Entrenchment Ratio	2.7	24.4			
Width to Depth Ratio	13.3	8.8			
Cross Sectional Area (ft²)	50.5	66.9			
Water Surface Slope (%)	0.750	0.270			

Rosgen Stream Type

2018	2007
C4	**E4**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2007 Spring Value	2007 Spring Score
Remoteness	6.96	37.50	7.00	37.70
Shading	55	54.42	85	84.56
Epifaunal Substrate	11	64.37	11	64.11
Instream Habitat	12	59.69	12	59.29
Instream Woody Debris	15	69.21	6	42.14
Bank Stability	10.20	71.42	7.00	59.16

	2018 Score	2007 Score
MPHI Habitat Score	59.43	57.83
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2018 Score	2007 Score		2018 Score	2007 Score
Epifaunal Substrate/Available Cover	7	12	Bank Stability - Right Bank	2	4
Pool Substrate Characterization	13	9	Bank Stability - Left Bank	1	5
Pool Variability	7	13	Vegetative Protection - Right Bank	3	3
Sediment Deposition	5	10	Vegetative Protection - Left Bank	3	5
Channel Flow Status	9	16	Riparian Veg. Zone Width - Right Bank	8	7
Channel Alteration	5	16	Riparian Veg. Zone Width - Left Bank	6	10
Channel Sinuosity	8	9			

	2018 Score	2007 Score
RBP Habitat Score	77	119
RBP Rating	Non-Supporting	Partially Supporting

Site ID 01-L1M-02-18

Revist of site R1-01-07

Biological Assessments

BIBI Metric Values	2018	2007
Total Taxa	22	27
EPT Taxa	2	2
Ephemeroptera Taxa	0	1
% Intolerant to Urban	2.70	1.79
% Ephemeroptera	0.00	0.89
Scraper Taxa	3	0
% Climbers	22.52	5.36

FIBI Metric Values (2018 only)	
Abundance per m²	0.52
Adj. No. of Benthic Species	0.87
% Tolerant	45.65
% Gen., Omni., Invert.	76.09
% Round-bodied Suckers	0.43
% Abund. Dominant Taxon	20.87

BIBI Metric Scores		
Total Taxa	5	5
EPT Taxa	3	3
Ephemeroptera Taxa	1	3
% Intolerant to Urban	1	1
% Ephemeroptera	1	3
Scraper Taxa	5	1
% Climbers	5	3

FIBI Metric Scores (2018 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.00	2.71
BIBI Rating	Fair	Poor

FIBI Score	4.00
FIBI Rating	Good

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
American Eel	20
Blacknose Dace	37
Blue Ridge Sculpin	5
Bluegill	13
Bluntnose Minnow	6
Central Stoneroller	48
Creek Chub	13
Cutlip Minnow	1
Eastern Mosquitofish	9
Fallfish	10
Green Sunfish	2
Largemouth Bass	2
Longnose Dace	17
Northern Hogsucker	1
Pumpkinseed	3
Redbreast Sunfish	2
Satinfin Shiner	7
Swallowtail Shiner	3
Tessellated Darter	23
White Sucker	6
Yellow bullhead	2

Benthic Macroinvertebrate Taxa

2018	Number
Ablabesmyia	8
Ancyronyx	1
Argia	2
Calopteryx	1
Cheumatopsyche	6
Cricotopus	18
Cricotopus/Orthocladius	2
Dicrotendipes	2
Hydrobaenus	5
Lumbriculidae	3
Macronychus	3
Microtendipes	1
Naididae	2
Nematoda	1
Orthocladius	11
Phaenopsectra	1
Polycentropodidae	3
Polypedilum	7
Rheocricotopus	7
Rheotanytarsus	11
Saetheria	1
Tanytarsus	15

Original Visit	Number
Ablabesmyia	1
Ancyronyx	2
Antocha	1
Argia	2
Baetidae	1
Brillia	1
Cheumatopsyche	6
Dicrotendipes	2
Enchytraeidae	1
Eukiefferiella	1
Hydrobaenus	12
Limnodrilus	1
Macronychus	1
Micropsectra	1
Nais	10
Orthocladius/Cricotopus	16
Parametriocnemus	3
Paratanytarsus	2
Polypedilum	1
Rheotanytarsus	20
Slavina	4
Stenelmis	4
Sympotthastia	2
Tanytarsus	4
Thienemannimyia	3
Tubificinae	9
Tvetenia	1

Site ID 01-L2M-01-18

Revist of site R2-01-04

Upstream View - 2018

Downstream View - 2018

Upstream View - 2012

Downstream View - 2012

Summary Results

	2018 Data	2012 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Non-Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	Within acceptable ranges	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 134.23

Land Cover	2018 Acres	2012 Acres	2018 % Area	2012 % Area
Developed Land	57.37	52.39	42.74	39.10
Forested Land	64.85	71.69	48.31	53.50
Open Land	12.01	9.93	8.94	7.41
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2012 Acres	2018 % Area	2012 % Area
Impervious Land	9.43	9.20	7.02	6.80

Site ID 01-L2M-01-18

Revist of site R2-01-04

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2012 Spring
Dissolved Oxygen (mg/L)	10.12	2.26	8.09
Turbidity (NTU)	6.2	85.9	19.2
Temperature (°C)	11.8	19.8	15.5
pH (Standard Units)	6.92	6.5	5.55
Specific Conductivity (µS/cm)	202.9	156.5	98.7

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.013	Chloride (mg/L)	37.063
Total Nitrogen (mg/L)	0.209	Magnesium (mg/L)	2.660
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	8.09
Total Ammonia N (mg/L)	0.012	Total Copper (µg/L)	1.116
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	12.747
Nitrate-N (mg/L)	0.032	Total Lead (µg/L)	0.197
Total Kjehldal N (mg/L)	0.175	Turbidity (NTU)	4.7
Dissolved Organic C (mg/L)	2.268		
Total Organic C (mg/L)	2.314		
Hardness (mg eq. $CaCO_3$/L)	31.16		

Geomorphic Assessment

Rosgen Level II Classification Data

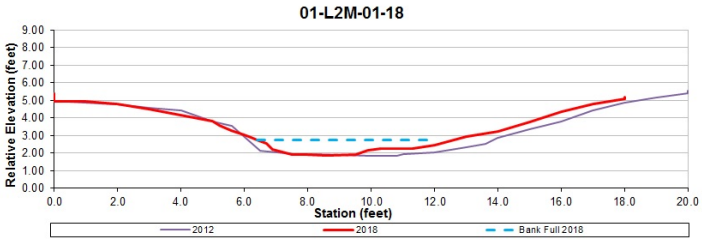
	2018	2012
Drainage Area (mi²)	0.21	
Bankfull Width (ft)	6.2	7.3
Mean Bankfull Depth (ft)	0.6	0.5
Floodprone Width (ft)	9.7	8.8
Entrenchment Ratio	1.5	1.2
Width to Depth Ratio	10.5	14.7
Cross Sectional Area (ft²)	3.7	3.7
Water Surface Slope (%)	0.490	0.870

	2018	2012
Sinuosity	1.54	1.30
D50 (mm)	0.09	0.06
Adjustments?	ENT -0.2	None

Rosgen Stream Type

2018	2012
G5c	**F6**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2012 Spring Value	2012 Spring Score
Remoteness	2.93	15.79	1.00	5.39
Shading	75	73.32	75	73.32
Epifaunal Substrate	1	30.10	3	41.73
Instream Habitat	1	36.09	2	41.66
Instream Woody Debris	1	69.20	2	72.18
Bank Stability	14.53	85.25	17.00	92.20

	2018 Score	2012 Score
MPHI Habitat Score	51.63	54.41
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2018 Score	2012 Score		2018 Score	2012 Score
Epifaunal Substrate/Available Cover	2	3	Bank Stability - Right Bank	2	9
Pool Substrate Characterization	8	3	Bank Stability - Left Bank	2	8
Pool Variability	4	3	Vegetative Protection - Right Bank	8	7
Sediment Deposition	18	13	Vegetative Protection - Left Bank	8	6
Channel Flow Status	7	4	Riparian Veg. Zone Width - Right Bank	2	3
Channel Alteration	15	12	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	10	13			

	2018 Score	2012 Score
RBP Habitat Score	96	94
RBP Rating	Non-Supporting	Non-Supporting

Site ID 01-L2M-01-18

Revist of site R2-01-04

Biological Assessments

BIBI Metric Values	2018	2012
Total Taxa	19	19
EPT Taxa	2	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	7.84	24.80
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	1
% Climbers	21.57	1.80

FIBI Metric Values (2018 only)	
Abundance per m²	No Fish
Adj. No. of Benthic Species	No Fish
% Tolerant	No Fish
% Gen., Omni., Invert.	No Fish
% Round-bodied Suckers	No Fish
% Abund. Dominant Taxon	No Fish

BIBI Metric Scores		
Total Taxa	3	3
EPT Taxa	3	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	3
% Ephemeroptera	1	1
Scraper Taxa	3	3
% Climbers	5	3

FIBI Metric Scores (2018 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43	2.14
BIBI Rating	Poor	Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
NO FISH	

Benthic Macroinvertebrate Taxa

2018	Number
Aedes	8
Caecidotea	7
Ceratopogonidae	5
Chaetocladius	2
Gastropoda	3
Ironoquia	3
Limnephilidae	1
Lumbricina	1
Lymnaeidae	18
Naididae	15
Neoporus	1
Paraphaenocladius	1
Pisidium	16
Polypedilum	2
Prostoma	4
Ptilostomis	1
Rheocricotopus	1
Sciomyzidae	1
Sphaeriidae	6
Stygobromus	1
Tabanidae	1
Veneroida	4

Original Visit	Number
Aedes	3
Amphipoda	2
Asellidae	10
Caecidotea	27
Ceratopogonidae	4
Chironomidae	4
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

Site ID 01-L2M-02-18

Revist of site R2-01-08

Upstream View - 2018

Downstream View - 2018

Upstream View - 2012

Downstream View - 2012

Summary Results

	2018 Data	2012 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Severely Degraded	Severely Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 11512.30

Land Cover	2018 Acres	2012 Acres	2018 % Area	2012 % Area
Developed Land	8405.40	6564.50	73.01	55.80
Forested Land	1608.45	3871.40	13.97	32.91
Open Land	1487.40	997.15	12.92	8.48
Agricultural Land	11.04	331.31	0.10	2.82

Impervious Surface	2018 Acres	2012 Acres	2018 % Area	2012 % Area
Impervious Land	3206.92	2840.40	27.86	24.10

Site ID 01-L2M-02-18

Revist of site R2-01-08

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2012 Spring
Dissolved Oxygen (mg/L)	7.72	6.15	10.47
Turbidity (NTU)	12.6	5.2	2.77
Temperature (°C)	10.6	24.8	10.1
pH (Standard Units)	7.07	7.81	7.42
Specific Conductivity (µS/cm)	754	546	618.3

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.019	Chloride (mg/L)	161.618
Total Nitrogen (mg/L)	0.663	Magnesium (mg/L)	4.764
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	34.60
Total Ammonia N (mg/L)	0.022	Total Copper (µg/L)	1.898
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	6.923
Nitrate-N (mg/L)	0.453	Total Lead (µg/L)	0.191
Total Kjehldal N (mg/L)	0.206	Turbidity (NTU)	7.0
Dissolved Organic C (mg/L)	1.784		
Total Organic C (mg/L)	1.793		
Hardness (mg eq. $CaCO_3$/L)	106.01		

Geomorphic Assessment

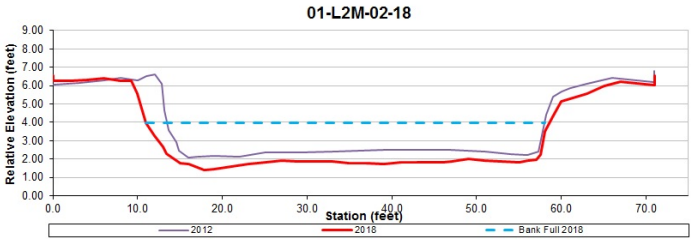
Rosgen Level II Classification Data

	2018	2012		2018	2012
Drainage Area (mi²)	17.99		Sinuosity	1.04	1.00
Bankfull Width (ft)	46.4	44.9	D50 (mm)	0.43	0.45
Mean Bankfull Depth (ft)	1.7	2.0	Adjustments?	None	None
Floodprone Width (ft)	63.0	160.0			
Entrenchment Ratio	1.4	3.6			
Width to Depth Ratio	28.0	22.6			
Cross Sectional Area (ft²)	76.9	89.1			
Water Surface Slope (%)	0.005	0.030			

Rosgen Stream Type

2018	2012
F5	**ND**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2012 Spring Value	2012 Spring Score
Remoteness	4.28	23.05	1.00	5.39
Shading	65	63.55	20	21.22
Epifaunal Substrate	7	35.96	11	59.04
Instream Habitat	8	29.37	11	45.78
Instream Woody Debris	11	48.39	12	51.08
Bank Stability	6.00	54.77	18.00	94.87

	2018 Score	2012 Score
MPHI Habitat Score	42.51	46.23
MPHI Rating	Severely Degraded	Severely Degraded

Rapid Bioassessment Protocol

	2018 Score	2012 Score		2018 Score	2012 Score
Epifaunal Substrate/Available Cover	11	11	Bank Stability - Right Bank	2	9
Pool Substrate Characterization	15	12	Bank Stability - Left Bank	2	9
Pool Variability	13	11	Vegetative Protection - Right Bank	5	8
Sediment Deposition	8	10	Vegetative Protection - Left Bank	6	6
Channel Flow Status	17	19	Riparian Veg. Zone Width - Right Bank	10	8
Channel Alteration	18	9	Riparian Veg. Zone Width - Left Bank	10	6
Channel Sinuosity	6	5			

	2018 Score	2012 Score
RBP Habitat Score	123	123
RBP Rating	Partially Supporting	Partially Supporting

Site ID 01-L2M-02-18

Revist of site R2-01-08

Biological Assessments

BIBI Metric Values	2018	2012
Total Taxa	26	25
EPT Taxa	4	3
Ephemeroptera Taxa	0	1
% Intolerant to Urban	6.90	10.20
% Ephemeroptera	0.00	1.90
Scraper Taxa	3	6
% Climbers	19.83	21.30

FIBI Metric Values (2018 only)	
Abundance per m²	0.28
Adj. No. of Benthic Species	0.37
% Tolerant	50.00
% Gen., Omni., Invert.	96.38
% Round-bodied Suckers	0.33
% Abund. Dominant Taxon	25.66

BIBI Metric Scores		
Total Taxa	5	5
EPT Taxa	3	3
Ephemeroptera Taxa	1	3
% Intolerant to Urban	1	3
% Ephemeroptera	1	3
Scraper Taxa	5	5
% Climbers	5	5

FIBI Metric Scores (2018 only)	
Abundance per m²	1
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.00	3.86
BIBI Rating	Fair	Fair

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Flora and Fauna (2018 only)

Crayfish

Orconectes virilis

Mussels

None Observed

Herpetofauna

American Bullfrog

Fish Taxa

Fish Taxa	Number
American Eel	28
Bluegill	78
Bluntnose Minnow	5
Creek Chub	1
Eastern Mosquitofish	8
Fallfish	10
Green Sunfish	4
Largemouth Bass	3
Northern Hogsucker	1
Pumpkinseed	12
Redbreast Sunfish	33
Satinfin Shiner	48
Sea Lamprey	6
Smallmouth Bass	2
Swallowtail Shiner	7
Tessellated Darter	11
Warmouth	1
White Sucker	38
Yellow Bullhead	8

Benthic Macroinvertebrate Taxa

2018	Number
Ablabesmyia	12
Calopteryx	3
Cheumatopsyche	16
Chimarra	3
Cladotanytarsus	1
Crangonyx	4
Cricotopus	3
Cryptochironomus	2
Dicrotendipes	4
Enallagma	1
Hydrobaenus	3
Hydropsyche	4
Hydropsychidae	1
Lumbriculidae	2
Orthocladiinae	4
Orthocladius	2
Paratendipes	1
Peltodytes	1
Phaenopsectra	1
Polycentropus	8
Polypedilum	6
Psephenus	1
Rheocricotopus	1
Rheotanytarsus	5
Saetheria	3
Stenelmis	4
Tanypodinae	1
Tanytarsini	4
Tanytarsus	12
Thienemannimyia Grou	3

Original Visit	Number
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

Site ID: 01-R3M-01-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Good
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 5270.72

Land Cover

	Acres	% Area
Developed Land	4103.76	77.86
Forested Land	600.66	11.40
Open Land	555.26	10.53
Agricultural Land	11.04	0.21

Impervious Surface

	Acres	% Area
Impervious Land	1389.26	26.36

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.25
Turbidity (NTU)	6.14
Temperature (°C)	9.2
pH (Standard Units)	7.18
Specific Conductivity (µS/cm)	936

Laboratory Measurements

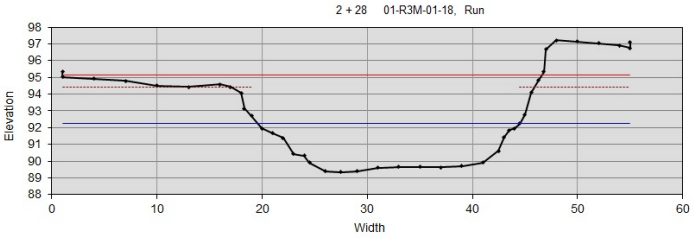
Total Phosphorus (mg/L)	0.009	Chloride (mg/L)	191.506
Total Nitrogen (mg/L)	0.759	Magnesium (mg/L)	10.460
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	44.26
Total Ammonia N (mg/L)	0.020	Total Copper (µg/L)	1.097
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	5.697
Nitrate-N (mg/L)	0.525	Total Lead (µg/L)	0.051
Total Kjehldal N (mg/L)	0.228	Turbidity (NTU)	3.9
Dissolved Organic C (mg/L)	1.249		
Total Organic C (mg/L)	1.287		
Hardness (mg eq. $CaCO_3$/L)	153.59		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	8.24	Sinuosity	1.01
Bankfull Width (ft)	24.9	D50 (mm)	22.00
Mean Bankfull Depth (ft)	2.1	Adjustments?	W/D +1.0
Floodprone Width (ft)	178.0		
Entrenchment Ratio	7.2		
Width to Depth Ratio	11.6	**Rosgen Stream Type**	**C4**
Cross Sectional Area (ft²)	53.2		
Water Surface Slope (%)	0.21		

Cross-sectional Survey



Site ID: 01-R3M-01-18

Biological Assessments

BIBI Metric Values

Total Taxa	22
EPT Taxa	3
Ephemeroptera Taxa	0
% Intolerant to Urban	0.92
% Ephemeroptera	0.00
Scraper Taxa	3
% Climbers	37.61

FIBI Metric Values

Abundance per m²	0.92
Adj. No. of Benthic Species	1.31
% Tolerant	54.93
% Gen., Omni., Invert.	86.55
% Round-bodied Suckers	0.45
% Abund. Dominant Taxon	15.92

BIBI Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	5

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.00
BIBI Rating	Fair

FIBI Score	4.33
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Ablabesmyia	2
Ancyronyx	1
Argia	3
Boyeria	1
Caloptervx	5
Ceratopogoninae	1
Chimarra	1
Corbicula	1
Cricotopus	16
Hydropsyche	1
Naididae	3
Orthocladius	7
Physa	1
Polycentropus	1
Polypedilum	16
Rheocricotopus	12
Rheotanytarsus	15
Saetheria	3
Stenelmis	1
Stenochironomus	1
Tanytarsus	15
Thienemannimyia group	2

Fish Taxa

American Eel	29
Blacknose Dace	57
Blue Ridge Sculpin	11
Bluegill	9
Bluntnose Minnow	71
Central Stoneroller	34
Creek Chub	18
Cutlip Minnow	8
Eastern Mosquitofish	1
Fallfish	13
Green Sunfish	11
Largemouth Bass	1
Least Brook Lamprey	1
Longnose Dace	18
Northern Hogsucker	2
Redbreast Sunfish	1
Rosyside Dace	2
Satinfin Shiner	44
Sea Lamprey	13
Swallowtail Shiner	21
Tessellated Darter	71
White Sucker	7
Yellow Bullhead	3

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	5
Pool Substrate Characterization	11
Pool Variability	4
Sediment Deposition	5
Channel Flow Status	14
Channel Alteration	6
Channel Sinuosity	6
Bank Stability - Right Bank	1
Bank Stability - Left Bank	1
Vegetative Protection - Right Bank	3
Vegetative Protection - Left Bank	3
Riparian Veg. Zone Width - Right Bank	8
Riparian Veg. Zone Width - Left Bank	8

RBP Habitat Score	75
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.95	42.78
Shading	80	78.67
Epifaunal Substrate	9	52.67
Instream Habitat	8	37.37
Instream Woody Debris	10	54.27
Bank Stability	12.20	78.10

MPHI Habitat Score	57.31
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

Orconectes limosus

Orconectes virilis

Herpetofauna

Northern Green Frog

Red eared slider

Mussels

None Observed

Site ID: 01-R3M-02-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Fair
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1496.48

Land Cover

	Acres	% Area
Developed Land	1050.72	70.21
Forested Land	362.57	24.23
Open Land	72.73	4.86
Agricultural Land	10.46	0.70

Impervious Surface

	Acres	% Area
Impervious Land	288.14	19.25

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.94
Turbidity (NTU)	4.6
Temperature (°C)	6.6
pH (Standard Units)	7.62
Specific Conductivity (µS/cm)	424.7

Laboratory Measurements

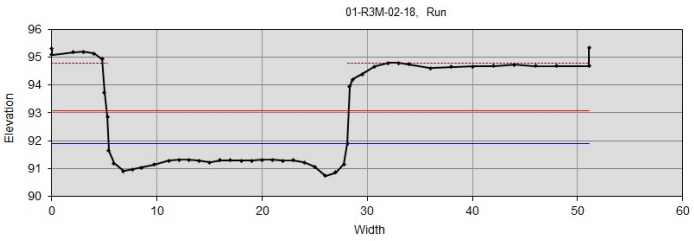
Total Phosphorus (mg/L)	0.008	Chloride (mg/L)	83.620
Total Nitrogen (mg/L)	1.195	Magnesium (mg/L)	6.060
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	23.11
Total Ammonia N (mg/L)	0.020	Total Copper (µg/L)	1.071
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	16.215
Nitrate-N (mg/L)	1.016	Total Lead (µg/L)	0.165
Total Kjehldal N (mg/L)	0.172	Turbidity (NTU)	3.2
Dissolved Organic C (mg/L)	1.651		
Total Organic C (mg/L)	1.664		
Hardness (mg eq. $CaCO_3$/L)	82.66		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	2.34	Sinuosity	1.11
Bankfull Width (ft)	22.7	D50 (mm)	0.36
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	23.0		
Entrenchment Ratio	1.0		
Width to Depth Ratio	31.7	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	16.3		
Water Surface Slope (%)	0.12		

Cross-sectional Survey



Site ID: 01-R3M-02-18

Biological Assessments

BIBI Metric Values

Total Taxa	21
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	4.63
% Ephemeroptera	0.00
Scraper Taxa	6
% Climbers	29.63

FIBI Metric Values

Abundance per m²	0.28
Adj. No. of Benthic Species	1.91
% Tolerant	63.39
% Gen., Omni., Invert.	95.54
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	16.07

BIBI Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	5

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	2.71
BIBI Rating	Poor

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Cheumatopsyche	9
Cricotopus	5
Cricotopus/Orthocladius	8
Hemerodromia	1
Hydrobaenus	11
Macronychus	1
Neophylax	1
Nigronia	1
Optioservus	1
Orthocladius	16
Oulimnius	3
Parametriocnemus	1
Paratendipes	1
Polypedilum	28
Rheocricotopus	5
Rheotanytarsus	3
Simulium	1
Stenelmis	6
Tanytarsus	3
Tribelos	1
Tvetenia	2

Fish Taxa

American Eel	2
Blacknose Dace	8
Blue Ridge Sculpin	1
Bluegill	15
Bluntnose Minnow	8
Central Stoneroller	2
Creek Chub	8
Cutlip Minnow	2
Fallfish	7
Green Sunfish	8
Least Brook Lamprey	1
Longnose Dace	2
Pumpkinseed	3
Redbreast Sunfish	2
Rosyside Dace	4
Satinfin Shiner	12
Smallmouth Bass	1
Swallowtail Shiner	4
Tessellated Darter	3
White Sucker	18
Yellow Bullhead	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	11
Pool Substrate Characterization	13
Pool Variability	10
Sediment Deposition	10
Channel Flow Status	11
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	2
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	7
Vegetative Protection - Left Bank	7
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	120
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.81	47.44
Shading	70	68.32
Epifaunal Substrate	11	72.49
Instream Habitat	15	89.09
Instream Woody Debris	25	100.00
Bank Stability	5.70	53.39

MPHI Habitat Score	71.79
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

Orconectes virilis

Herpetofauna

Northern Two-lined Salamander

Mussels

None Observed

Site ID: 01-R3M-03-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	High conductivity; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1560.61

Land Cover

	Acres	% Area
Developed Land	882.95	56.58
Forested Land	539.39	34.56
Open Land	138.27	8.86
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	420.37	26.94

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.33
Turbidity (NTU)	6.23
Temperature (°C)	8.3
pH (Standard Units)	6.94
Specific Conductivity (µS/cm)	791

Laboratory Measurements

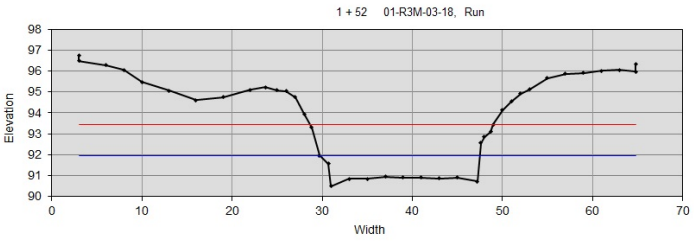
Total Phosphorus (mg/L)	0.064	Chloride (mg/L)	186.696
Total Nitrogen (mg/L)	1.551	Magnesium (mg/L)	6.698
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	27.38
Total Ammonia N (mg/L)	0.012	Total Copper (µg/L)	2.093
Nitrite-N (mg/L)	0.013	Total Zinc (µg/L)	16.050
Nitrate-N (mg/L)	1.200	Total Lead (µg/L)	0.141
Total Kjehldal N (mg/L)	0.339	Turbidity (NTU)	6.4
Dissolved Organic C (mg/L)	1.625		
Total Organic C (mg/L)	1.714		
Hardness (mg eq. $CaCO_3$/L)	95.95		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	2.44	Sinuosity	1.37
Bankfull Width (ft)	17.8	D50 (mm)	7.30
Mean Bankfull Depth (ft)	1.0	Adjustments?	None
Floodprone Width (ft)	20.3		
Entrenchment Ratio	1.1		
Width to Depth Ratio	16.9	**Rosgen Stream Type**	**F4/5**
Cross Sectional Area (ft²)	18.6		
Water Surface Slope (%)	0.46		

Cross-sectional Survey



Site ID: 01-R3M-03-18

Biological Assessments

BIBI Metric Values

Total Taxa	23
EPT Taxa	4
Ephemeroptera Taxa	0
% Intolerant to Urban	6.96
% Ephemeroptera	0.00
Scraper Taxa	7
% Climbers	2.61

FIBI Metric Values

Abundance per m²	0.88
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	7.29

BIBI Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	3

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	2.71
BIBI Rating	Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Ancyronyx	1
Antocha	1
Calopteryx	1
Cheumatopsyche	20
Chimarra	3
Corbicula	4
Cricotopus	1
Cricotopus/Orthocladius	1
Diplectrona	1
Hydrobaenus	9
Hydropsyche	5
Hydropsychidae	1
Macronychus	1
Nematoda	2
Optioservus	3
Orthocladius	1
Oulimnius	7
Parametriocnemus	1
Physa	1
Polypedilum	1
Rheocricotopus	2
Stenelmis	46
Thienemannimyia group	1
Tvetenia	1

Fish Taxa

American Eel	23
Blacknose Dace	18
Blue Ridge Sculpin	6
Bluegill	20
Central Stoneroller	1
Creek Chub	20
Fallfish	1
Green Sunfish	3
Largemouth Bass	1
Least Brook Lamprey	7
Longnose Dace	18
Rosyside Dace	1
Satinfin Shiner	41
Sea Lamprey	9
Swallowtail Shiner	54
Tessellated Darter	13
White Sucker	3
Yellow Bullhead	8

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	11
Pool Substrate Characterization	12
Pool Variability	9
Sediment Deposition	9
Channel Flow Status	12
Channel Alteration	10
Channel Sinuosity	9
Bank Stability - Right Bank	9
Bank Stability - Left Bank	7
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	124
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.05	32.59
Shading	70	68.32
Epifaunal Substrate	7	48.98
Instream Habitat	9	55.37
Instream Woody Debris	9	65.09
Bank Stability	16.10	89.72

MPHI Habitat Score	60.01
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

Orconectes virilis

Herpetofauna

Northern Green Frog

Pickerel Frog

Mussels

None Observed

Site ID: 01-R3M-04-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Fair
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 566.51

Land Cover

	Acres	% Area
Developed Land	272.80	48.15
Forested Land	221.25	39.05
Open Land	72.47	12.79
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	118.75	20.96

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.75
Turbidity (NTU)	6.1
Temperature (°C)	8.6
pH (Standard Units)	7.65
Specific Conductivity (µS/cm)	698.2

Laboratory Measurements

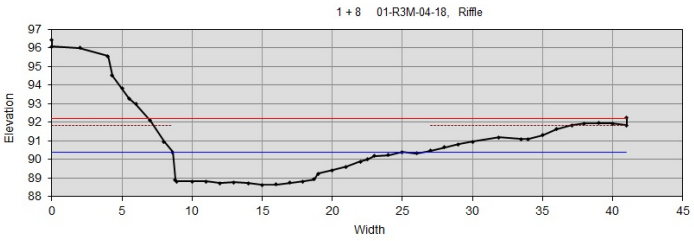
Total Phosphorus (mg/L)	0.576	Chloride (mg/L)	149.909
Total Nitrogen (mg/L)	6.400	Magnesium (mg/L)	5.856
Orthophosphate (mg/L)	0.415	Calcium (mg/L)	20.58
Total Ammonia N (mg/L)	5.447	Total Copper (µg/L)	3.350
Nitrite-N (mg/L)	0.046	Total Zinc (µg/L)	26.767
Nitrate-N (mg/L)	0.462	Total Lead (µg/L)	0.078
Total Kjehldal N (mg/L)	5.892	Turbidity (NTU)	5.1
Dissolved Organic C (mg/L)	2.892		
Total Organic C (mg/L)	3.041		
Hardness (mg eq. $CaCO_3$/L)	75.50		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.89	Sinuosity	1.92
Bankfull Width (ft)	18.0	D50 (mm)	0.50
Mean Bankfull Depth (ft)	1.1	Adjustments?	None
Floodprone Width (ft)	57.5		
Entrenchment Ratio	3.2		
Width to Depth Ratio	16.0	**Rosgen Stream Type**	**C5**
Cross Sectional Area (ft²)	20.2		
Water Surface Slope (%)	0.41		

Cross-sectional Survey



Site ID: 01-R3M-04-18

Biological Assessments

BIBI Metric Values

Total Taxa	13
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	47.66

FIBI Metric Values

Abundance per m²	0.72
Adj. No. of Benthic Species	0.92
% Tolerant	71.62
% Gen., Omni., Invert.	99.32
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	28.38

BIBI Metric Scores

Total Taxa	1
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	5

FIBI Metric Scores

Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	1.86
BIBI Rating	Very Poor

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Cheumatopsyche	14
Cricotopus	1
Cryptochironomus	3
Erpobdella	1
Hemerodromia	1
Hydropsyche	6
Microtendipes	21
Orthocladius	1
Paratanytarsus	1
Polypedilum	47
Rheotanytarsus	1
Tanytarsus	4
Thienemannimyia group	6

Fish Taxa

American Eel	3
Blacknose Dace	20
Bluegill	36
Bluntnose Minnow	1
Creek Chub	42
Green Sunfish	2
Largemouth Bass	1
Longnose Dace	3
Rosyside Dace	3
Satinfin Shiner	15
Swallowtail Shiner	15
Tessellated Darter	4
Yellow Bullhead	3

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	8
Pool Substrate Characterization	9
Pool Variability	6
Sediment Deposition	12
Channel Flow Status	9
Channel Alteration	18
Channel Sinuosity	14
Bank Stability - Right Bank	4
Bank Stability - Left Bank	4
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	9
Riparian Veg. Zone Width - Left Bank	8

RBP Habitat Score	117
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.37	39.70
Shading	60	58.94
Epifaunal Substrate	11	78.82
Instream Habitat	10	71.29
Instream Woody Debris	9	76.57
Bank Stability	15.50	88.04

MPHI Habitat Score	68.89
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Red eared slider

Mussels

None Observed

Site ID 03-L1M-02-18

Revist of site R1-03-04

Upstream View - 2018

Downstream View - 2018

Upstream View - 2004

Downstream View - 2004

Summary Results

	2018 Data	2004 Data
Benthic Macroinvertebrate Community	Very Poor	Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Supporting
MPHI Habitat Condition	Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 444.72

Land Cover	2018 Acres	2004 Acres	2018 % Area	2004 % Area
Developed Land	315.30	395.34	70.90	71.30
Forested Land	104.37	127.53	23.47	23.00
Open Land	25.06	31.61	5.63	5.70
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2004 Acres	2018 % Area	2004 % Area
Impervious Land	156.56	205.16	35.20	37.00

Site ID 03-L1M-02-18

Revist of site R1-03-04

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2004 Spring
Dissolved Oxygen (mg/L)	12.16	7.54	7.39
Turbidity (NTU)	3.05	9.3	6.4
Temperature (°C)	9.3	21.7	15.39
pH (Standard Units)	6.78	6.94	7.7
Specific Conductivity (µS/cm)	447.8	416.2	389.8

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.007	Chloride (mg/L)	100.455
Total Nitrogen (mg/L)	1.453	Magnesium (mg/L)	5.535
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	15.45
Total Ammonia N (mg/L)	0.007	Total Copper (µg/L)	0.653
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	3.072
Nitrate-N (mg/L)	1.379	Total Lead (µg/L)	0.056
Total Kjehldal N (mg/L)	0.071	Turbidity (NTU)	0.6
Dissolved Organic C (mg/L)	0.958		
Total Organic C (mg/L)	0.965		
Hardness (mg eq. $CaCO_3$/L)	61.37		

Geomorphic Assessment

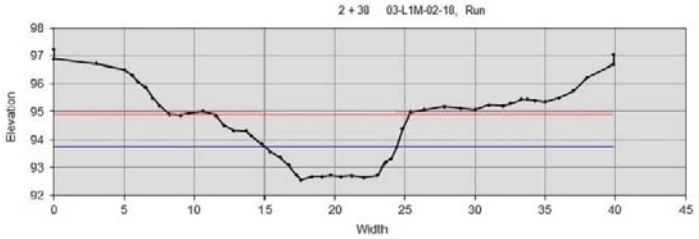
Rosgen Level II Classification Data

	2018	2004		2018	2004
Drainage Area (mi²)	0.69		Sinuosity	1.49	n/a
Bankfull Width (ft)	9.4	n/a	D50 (mm)	10.00	n/a
Mean Bankfull Depth (ft)	0.8	n/a	Adjustments?	W/D +1.0	None
Floodprone Width (ft)	15.2	n/a			
Entrenchment Ratio	1.6	n/a			
Width to Depth Ratio	11.3	n/a			
Cross Sectional Area (ft²)	7.7	n/a			
Water Surface Slope (%)	0.960	n/a			

Rosgen Stream Type	
2018	2004
B4c	**ND**

Cross-sectional Survey

(R1 XS not located)



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2004 Spring Value	2004 Spring Score
Remoteness	6.75	36.34	7.00	37.70
Shading	40	40.96	80	78.67
Epifaunal Substrate	8	62.96	12	84.77
Instream Habitat	9	68.22	11	77.06
Instream Woody Debris	4	64.52	2	56.10
Bank Stability	13.97	83.57	17.00	92.20

	2018 Score	2004 Score
MPHI Habitat Score	59.43	71.08
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2018 Score	2004 Score		2018 Score	2004 Score
Epifaunal Substrate/Available Cover	7	12	Bank Stability - Right Bank	1	8
Pool Substrate Characterization	7	8	Bank Stability - Left Bank	1	9
Pool Variability	4	8	Vegetative Protection - Right Bank	5	8
Sediment Deposition	8	8	Vegetative Protection - Left Bank	3	9
Channel Flow Status	12	14	Riparian Veg. Zone Width - Right Bank	9	10
Channel Alteration	17	20	Riparian Veg. Zone Width - Left Bank	7	10
Channel Sinuosity	8	14			

	2018 Score	2004 Score
RBP Habitat Score	89	138
RBP Rating	Non-Supporting	Supporting

Site ID 03-L1M-02-18

Revist of site R1-03-04

Biological Assessments

BIBI Metric Values	2018	2004
Total Taxa	21	23
EPT Taxa	1	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.00	0.88
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	4
% Climbers	4.35	13.00

FIBI Metric Values (2018 only)	
Abundance per m²	3.82
Adj. No. of Benthic Species	0.00
% Tolerant	99.75
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	62.44

BIBI Metric Scores		
Total Taxa	3	5
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	1	5
% Climbers	3	5

FIBI Metric Scores (2018 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	1.57	2.71
BIBI Rating	Very Poor	Poor

FIBI Score	2.00
FIBI Rating	Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

Orconectes virilis

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Fish Taxa

Fish Taxa	Number
American Eel	1
Blacknose Dace	246
Creek Chub	145
Green Sunfish	2

Benthic Macroinvertebrate Taxa

2018	Number
Ablabesmyia	1
Chaetocladius	2
Chimarra	1
Corynoneura	6
Cricotopus	15
Cricotopus/Orthocladius	21
Cryptochironomus	1
Diamesa	1
Lumbriculidae	1
Microtendipes	5
Naididae	30
Orthocladius	15
Parametriocnemus	1
Paratanytarsus	2
Phaenopsectra	1
Polypedilum	4
Saetheria	1
Tanytarsus	1
Thienemanniella	2
Thienemannimyia group	2
Tvetenia	2

Original Visit	Number
Physidae	1
Sphaeriidae	2
Tubificidae	4
Lumbricidae	14
Amphipoda	1
Caecidotea	1
Helichus	1
Agabus	2
Hoperius	3
Hydroporus	2
Stenelmis	1
Diptera	1
Chironomidae	3
Chironomus	1
Eukiefferiella	9
Hydrobaenus	45
Larsia	2
Orthocladius	9
Parachironomus	1
Tanytarsus	4
Culicidae	1
Simulium	2
Sialis	1
Calopteryx	1
Somatochlora	1

Site ID 03-L1M-03-18

Revist of site R1-03-09

Upstream View - 2018

Downstream View - 2018

Upstream View - 2004

Downstream View - 2004

Summary Results

	2018 Data	2004 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Severely Degraded	Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 480.33

Land Cover	2018 Acres	2004 Acres	2018 % Area	2004 % Area
Developed Land	408.01	383.12	84.94	73.60
Forested Land	60.06	99.95	12.50	19.20
Open Land	12.26	38.00	2.55	7.30
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2004 Acres	2018 % Area	2004 % Area
Impervious Land	156.47	173.34	32.58	33.30

Site ID 03-L1M-03-18

Revist of site R1-03-09

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2004 Spring
Dissolved Oxygen (mg/L)	12.37	7.46	7.64
Turbidity (NTU)	3.2	18.6	8.4
Temperature (°C)	14.8	20	13.59
pH (Standard Units)	7.71	7.42	7.7
Specific Conductivity (µS/cm)	637	557	477.1

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.017	Chloride (mg/L)	146.000
Total Nitrogen (mg/L)	3.642	Magnesium (mg/L)	8.672
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	21.30
Total Ammonia N (mg/L)	0.104	Total Copper (µg/L)	1.600
Nitrite-N (mg/L)	0.034	Total Zinc (µg/L)	5.605
Nitrate-N (mg/L)	3.354	Total Lead (µg/L)	0.302
Total Kjehldal N (mg/L)	0.254	Turbidity (NTU)	1.8
Dissolved Organic C (mg/L)	0.688		
Total Organic C (mg/L)	0.724		
Hardness (mg eq. $CaCO_3$/L)	88.90		

Geomorphic Assessment

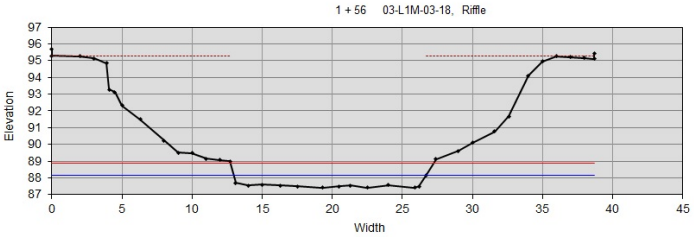
Rosgen Level II Classification Data

	2018	2004		2018	2004
Drainage Area (mi²)	0.75		Sinuosity	1.19	n/a
Bankfull Width (ft)	13.7	n/a	D50 (mm)	8.30	n/a
Mean Bankfull Depth (ft)	0.6	n/a	Adjustments?	None	None
Floodprone Width (ft)	14.5	n/a			
Entrenchment Ratio	1.1	n/a			
Width to Depth Ratio	22.2	n/a			
Cross Sectional Area (ft²)	8.5	n/a			
Water Surface Slope (%)	1.200	n/a			

Rosgen Stream Type	
2018	2004
F4	**ND**

Cross-sectional Survey

(R1 XS not located)



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2004 Spring Value	2004 Spring Score
Remoteness	2.93	15.79	5.00	26.93
Shading	55	54.42	70	68.32
Epifaunal Substrate	6	50.84	12	85.18
Instream Habitat	8	61.89	11	77.71
Instream Woody Debris	6	69.56	4	62.73
Bank Stability	0.00	0.00	9.00	67.08

	2018 Score	2004 Score
MPHI Habitat Score	42.08	64.66
MPHI Rating	Severely Degraded	Degraded

Rapid Bioassessment Protocol

	2018 Score	2004 Score		2018 Score	2004 Score
Epifaunal Substrate/Available Cover	12	12	Bank Stability - Right Bank	2	5
Pool Substrate Characterization	14	8	Bank Stability - Left Bank	2	4
Pool Variability	8	12	Vegetative Protection - Right Bank	7	8
Sediment Deposition	9	9	Vegetative Protection - Left Bank	7	6
Channel Flow Status	13	9	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	17	20	Riparian Veg. Zone Width - Left Bank	10	6
Channel Sinuosity	8	8			

	2018 Score	2004 Score
RBP Habitat Score	119	117
RBP Rating	Partially Supporting	Partially Supporting

Site ID 03-L1M-03-18

Revist of site R1-03-09

Biological Assessments

BIBI Metric Values	2018	2004
Total Taxa	22	15
EPT Taxa	3	4
Ephemeroptera Taxa	0	1
% Intolerant to Urban	2.83	4.00
% Ephemeroptera	0.00	1.00
Scraper Taxa	1	1
% Climbers	6.60	2.00

FIBI Metric Values (2018 only)	
Abundance per m²	0.79
Adj. No. of Benthic Species	0.97
% Tolerant	74.47
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	53.90

BIBI Metric Scores		
Total Taxa	5	3
EPT Taxa	3	3
Ephemeroptera Taxa	1	3
% Intolerant to Urban	1	1
% Ephemeroptera	1	3
Scraper Taxa	3	3
% Climbers	3	3

FIBI Metric Scores (2018 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	2.43	2.71
BIBI Rating	Poor	Poor

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Fish Taxa	Number
American Eel	35
Blacknose Dace	76
Creek Chub	19
Green Sunfish	3
Swallowtail Shiner	1
Tessellated Darter	7

Benthic Macroinvertebrate Taxa

2018	Number
Brillia	1
Chaetocladius	5
Cheumatopsyche	13
Cricotopus/Orthocladius	2
Cryptochironomus	1
Diamesa	1
Dolophilodes	1
Dytiscidae	4
Eukiefferiella	4
Hemerodromia	1
Hydropsyche	4
Nematoda	2
Orthocladius	29
Parametriocnemus	6
Physa	2
Polypedilum	5
Potthastia	2
Roederiodes	1
Saetheria	1
Simuliidae	3
Simulium	11
Thienemannimyia group	2
Trichoptera	1
Tvetenia	4

Original Visit	Number
Lumbricidae	1
Caecidotea	10
Chironomidae	6
Brillia	21
Eukiefferiella	4
Hydrobaenus	13
Orthocladius	43
Parametriocnemus	4
Prodiamesa	1
Tanytarsus	3
Thienemannimyia	11
Simulium	10
Odontomyia	1
Limonia	1
Baetis	1
Cheumatopsyche	1
Hydropsyche	4
Dolophilodes	3

Site ID 03-L2M-01-18

Revist of site R2-03-03

Upstream View - 2018

Downstream View - 2018

Upstream View - 2012

Downstream View - 2012

Summary Results

	2018 Data	2012 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Minimally Degraded
Water Quality Conditions	High conductivity; Elevated nutrients	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 271.34

Land Cover	2018 Acres	2012 Acres	2018 % Area	2012 % Area
Developed Land	113.38	77.31	41.79	32.54
Forested Land	97.96	140.81	36.10	59.28
Open Land	60.00	19.43	22.11	8.18
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2012 Acres	2018 % Area	2012 % Area
Impervious Land	72.55	40.60	26.74	17.10

Site ID 03-L2M-01-18

Revist of site R2-03-03

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2012 Spring
Dissolved Oxygen (mg/L)	12.25	7.51	9.84
Turbidity (NTU)	31.3	14.6	2.5
Temperature (°C)	5.8	22.4	11.17
pH (Standard Units)	7.48	8.03	6.77
Specific Conductivity (µS/cm)	582.6	362.4	277.77

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.038	Chloride (mg/L)	108.419
Total Nitrogen (mg/L)	2.007	Magnesium (mg/L)	4.035
Orthophosphate (mg/L)	0.006	Calcium (mg/L)	29.04
Total Ammonia N (mg/L)	0.066	Total Copper (µg/L)	2.861
Nitrite-N (mg/L)	0.010	Total Zinc (µg/L)	5.966
Nitrate-N (mg/L)	1.609	Total Lead (µg/L)	0.523
Total Kjehldal N (mg/L)	0.389	Turbidity (NTU)	24.4
Dissolved Organic C (mg/L)	3.251		
Total Organic C (mg/L)	3.218		
Hardness (mg eq. $CaCO_3$/L)	89.13		

Geomorphic Assessment

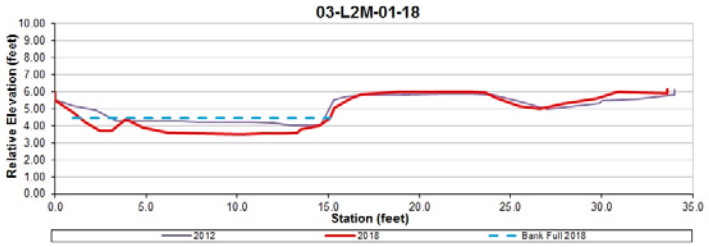
Rosgen Level II Classification Data

	2018	2012		2018	2012
Drainage Area (mi²)	0.42		Sinuosity	1.09	1.10
Bankfull Width (ft)	14.2	12.8	D50 (mm)	18.00	5.50
Mean Bankfull Depth (ft)	1.0	0.7	Adjustments?	None	None
Floodprone Width (ft)	35.5	34.0			
Entrenchment Ratio	2.5	2.7			
Width to Depth Ratio	13.8	19.1			
Cross Sectional Area (ft²)	14.7	8.6			
Water Surface Slope (%)	1.100	0.970			

Rosgen Stream Type

2018	2012
C4	**C4/5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2012 Spring Value	2012 Spring Score
Remoteness	6.52	35.14	12.00	64.62
Shading	90	91.34	80	78.67
Epifaunal Substrate	5	48.75	12	90.29
Instream Habitat	5	51.09	12	91.29
Instream Woody Debris	11	90.82	12	95.28
Bank Stability	12.73	79.79	17.00	92.20

	2018 Score	2012 Score
MPHI Habitat Score	66.15	85.39
MPHI Rating	Partially Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2018 Score	2012 Score		2018 Score	2012 Score
Epifaunal Substrate/Available Cover	11	12	Bank Stability - Right Bank	8	8
Pool Substrate Characterization	10	11	Bank Stability - Left Bank	5	9
Pool Variability	9	13	Vegetative Protection - Right Bank	4	6
Sediment Deposition	7	6	Vegetative Protection - Left Bank	9	6
Channel Flow Status	8	9	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	11			

	2018 Score	2012 Score
RBP Habitat Score	118	130
RBP Rating	Partially Supporting	Supporting

Site ID 03-L2M-01-18

Revist of site R2-03-03

Biological Assessments

BIBI Metric Values	2018	2012
Total Taxa	28	22
EPT Taxa	4	4
Ephemeroptera Taxa	0	1
% Intolerant to Urban	4.72	15.40
% Ephemeroptera	0.00	0.90
Scraper Taxa	3	3
% Climbers	33.96	9.40

FIBI Metric Values (2018 only)	
Abundance per m²	0.55
Adj. No. of Benthic Species	0.00
% Tolerant	94.25
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	87.36

BIBI Metric Scores		
Total Taxa	5	3
EPT Taxa	3	3
Ephemeroptera Taxa	1	3
% Intolerant to Urban	1	3
% Ephemeroptera	1	3
Scraper Taxa	5	5
% Climbers	5	5

FIBI Metric Scores (2018 only)	
Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	3.00	3.57
BIBI Rating	Fair	Fair

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

Orconectes rusticus

Mussels

None Observed

Herpetofauna

Eastern American Toad

Northern Green Frog

Northern Two-lined Salamander

Fish Taxa

Fish Taxa	Number
American Eel	1
Blacknose Dace	76
Creek Chub	6
Eastern Mosquitofish	3
Yellow Bullhead	1

Benthic Macroinvertebrate Taxa

2018	Number
Amphinemura	3
Capniidae	2
Cricotopus	1
Cricotopus/Orthocladius	3
Cryptochironomus	1
Diamesa	2
Diplectrona	1
Eukiefferiella	10
Gammarus	1
Hemerodromia	1
Hydrobaenus	5
Krenosmittia	1
Limnephilidae	1
Lumbricina	1
Micropsectra	1
Microtendipes	2
Naididae	2
Orthocladius	11
Parametriocnemus	4
Physa	5
Polypedilum	28
Simuliidae	1
Simulium	6
Stenelmis	1
Tanytarsus	1
Thienemanniella	1
Tipula	2
Tribelos	1
Tvetenia	7

Original Visit	Number
Ameletus	1
Caloptervx	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

Site ID 03-L2M-03-18

Revist of site R2-03-08

Upstream View - 2018

Downstream View - 2018

Upstream View - 2012

Downstream View - 2012

Summary Results

	2018 Data	2012 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nutrients	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 268.56

Land Cover	2018 Acres	2012 Acres	2018 % Area	2012 % Area
Developed Land	112.91	77.09	42.04	32.83
Forested Land	97.17	138.33	36.18	58.90
Open Land	58.48	19.43	21.78	8.27
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2012 Acres	2018 % Area	2012 % Area
Impervious Land	71.72	40.60	26.70	17.30

Site ID 03-L2M-03-18

Revist of site R2-03-08

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2012 Spring
Dissolved Oxygen (mg/L)	11.59	7.66	10.39
Turbidity (NTU)	28.8	10.7	13.3
Temperature (°C)	7.9	23.2	11.23
pH (Standard Units)	7.55	7.98	7.17
Specific Conductivity (µS/cm)	510.7	310.7	271.53

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.036	Chloride (mg/L)	95.979
Total Nitrogen (mg/L)	2.026	Magnesium (mg/L)	3.640
Orthophosphate (mg/L)	0.008	Calcium (mg/L)	24.28
Total Ammonia N (mg/L)	0.011	Total Copper (µg/L)	2.977
Nitrite-N (mg/L)	0.009	Total Zinc (µg/L)	6.180
Nitrate-N (mg/L)	1.631	Total Lead (µg/L)	0.531
Total Kjehldal N (mg/L)	0.385	Turbidity (NTU)	20.8
Dissolved Organic C (mg/L)	3.374		
Total Organic C (mg/L)	3.351		
Hardness (mg eq. $CaCO_3$/L)	75.62		

Geomorphic Assessment

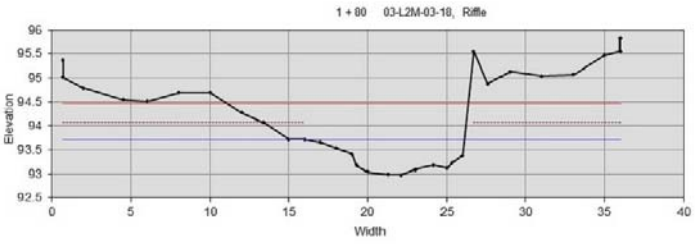
Rosgen Level II Classification Data

	2018	2012		2018	2012
Drainage Area (mi²)	0.42		Sinuosity	1.32	1.30
Bankfull Width (ft)	10.1	20.4	D50 (mm)	24.00	15.00
Mean Bankfull Depth (ft)	0.5	0.4	Adjustments?	ENT -0.1	None
Floodprone Width (ft)	15.3	26.4			
Entrenchment Ratio	1.5	1.3			
Width to Depth Ratio	21.6	49.9			
Cross Sectional Area (ft²)	4.7	8.4			
Water Surface Slope (%)	1.610	1.000			

Rosgen Stream Type	
2018	2012
F4	**F4/5**

Cross-sectional Survey

(R2 XS not located)



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2012 Spring Value	2012 Spring Score
Remoteness	8.30	44.71	13.00	70.01
Shading	60	58.94	60	58.94
Epifaunal Substrate	5	48.82	11	84.55
Instream Habitat	6	56.74	10	80.31
Instream Woody Debris	7	79.10	10	89.49
Bank Stability	18.47	96.09	17.00	92.20

	2018 Score	2012 Score
MPHI Habitat Score	64.07	79.25
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2018 Score	2012 Score		2018 Score	2012 Score
Epifaunal Substrate/Available Cover	10	10	Bank Stability - Right Bank	7	9
Pool Substrate Characterization	7	10	Bank Stability - Left Bank	9	8
Pool Variability	7	10	Vegetative Protection - Right Bank	5	6
Sediment Deposition	8	7	Vegetative Protection - Left Bank	5	6
Channel Flow Status	7	9	Riparian Veg. Zone Width - Right Bank	7	4
Channel Alteration	12	16	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	14			

	2018 Score	2012 Score
RBP Habitat Score	102	119
RBP Rating	Partially Supporting	Partially Supporting

Site ID 03-L2M-03-18

Revist of site R2-03-08

Biological Assessments

BIBI Metric Values	2018	2012
Total Taxa	29	18
EPT Taxa	7	5
Ephemeroptera Taxa	1	2
% Intolerant to Urban	4.85	15.40
% Ephemeroptera	0.97	1.90
Scraper Taxa	4	3
% Climbers	25.24	4.80

FIBI Metric Values (2018 only)	
Abundance per m²	0.63
Adj. No. of Benthic Species	0.00
% Tolerant	92.31
% Gen., Omni., Invert.	95.80
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	57.34

BIBI Metric Scores		
Total Taxa	5	3
EPT Taxa	5	5
Ephemeroptera Taxa	3	5
% Intolerant to Urban	1	3
% Ephemeroptera	3	3
Scraper Taxa	5	5
% Climbers	5	3

FIBI Metric Scores (2018 only)	
Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	3.86	3.86
BIBI Rating	Fair	Fair

FIBI Score	2.33
FIBI Rating	Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

Cambarus acuminatus

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Fish Taxa	Number
American Eel	1
Blacknose Dace	82
Central Stoneroller	4
Creek Chub	2
Eastern Mosquitofish	6
Green Sunfish	46
Largemouth Bass	2

Benthic Macroinvertebrate Taxa

2018	Number
Ameletus	1
Amphinemura	1
Capniidae	2
Chaetocladius	2
Cheumatopsyche	2
Chimarra	1
Corynoneura	1
Cricotopus/Orthocladius	2
Dasyhelea	1
Diamesa	2
Dicrotendipes	1
Eukiefferiella	13
Gastropoda	2
Hemerodromia	3
Hydrobaenus	9
Hydropsyche	1
Lymnaeidae	1
Nematoda	2
Neophylax	3
Orthocladius	16
Physa	6
Polypedilum	16
Prostoma	1
Simulium	2
Stenochironomus	1
Tanytarsus	2
Thienemanniella group	1
Tipula	3
Tvetenia	2
Zavrelimyia	3

Original Visit	Number
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

Site ID: 03-R3M-01-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Severely Degraded
Water Quality Conditions	High conductivity; High chloride; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 181.64

Land Cover

	Acres	% Area
Developed Land	135.00	74.32
Forested Land	34.80	19.16
Open Land	11.84	6.52
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	79.72	43.89

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.88
Turbidity (NTU)	15.2
Temperature (°C)	9.1
pH (Standard Units)	6.7
Specific Conductivity (µS/cm)	2378

Laboratory Measurements

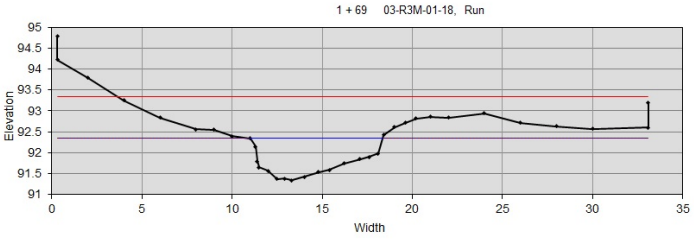
Total Phosphorus (mg/L)	0.044	Chloride (mg/L)	924.304
Total Nitrogen (mg/L)	0.900	Magnesium (mg/L)	8.148
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	50.18
Total Ammonia N (mg/L)	0.007	Total Copper (µg/L)	4.311
Nitrite-N (mg/L)	0.016	Total Zinc (µg/L)	16.429
Nitrate-N (mg/L)	0.225	Total Lead (µg/L)	0.435
Total Kjehldal N (mg/L)	0.659	Turbidity (NTU)	9.7
Dissolved Organic C (mg/L)	1.823		
Total Organic C (mg/L)	1.890		
Hardness (mg eq. $CaCO_3$/L)	158.85		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.28	Sinuosity	1.12
Bankfull Width (ft)	7.3	D50 (mm)	0.31
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	200.1		
Entrenchment Ratio	27.2		
Width to Depth Ratio	10.7	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	5.0		
Water Surface Slope (%)	0.74		

Cross-sectional Survey



Site ID: 03-R3M-01-18

Biological Assessments

BIBI Metric Values

Total Taxa	12
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	0.88
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	10.53

FIBI Metric Values

Abundance per m²	0.52
Adj. No. of Benthic Species	0.00
% Tolerant	0.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	40.00

BIBI Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	5

FIBI Metric Scores

Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	2.67
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Coenagrionidae	1
Cricotopus	1
Cryptochironomus	1
Enchytraeidae	1
Gastropoda	1
Lymnaeidae	10
Naididae	28
Nematoda	67
Orthocladius	1
Physa	1
Smittia	1
Stegopterna	1

Fish Taxa

Creek Chub	14
Eastern Mosquitofish	14
Green Sunfish	7

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	2
Pool Substrate Characterization	2
Pool Variability	4
Sediment Deposition	8
Channel Flow Status	17
Channel Alteration	1
Channel Sinuosity	6
Bank Stability - Right Bank	9
Bank Stability - Left Bank	9
Vegetative Protection - Right Bank	2
Vegetative Protection - Left Bank	1
Riparian Veg. Zone Width - Right Bank	2
Riparian Veg. Zone Width - Left Bank	1

RBP Habitat Score	64
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.05	32.59
Shading	10	8.55
Epifaunal Substrate	3	39.75
Instream Habitat	2	38.55
Instream Woody Debris	0	62.82
Bank Stability	19.67	99.17

MPHI Habitat Score	46.90
MPHI Rating	Severely Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Northern Spring Peeper

Mussels

None Observed

Site ID: 03-R3M-03-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Fair
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 734.65

Land Cover	Acres	% Area
Developed Land	560.78	76.33
Forested Land	138.09	18.80
Open Land	35.77	4.87
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	255.46	34.77

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.84
Turbidity (NTU)	4.06
Temperature (°C)	8.2
pH (Standard Units)	6.61
Specific Conductivity (µS/cm)	543.9

Laboratory Measurements

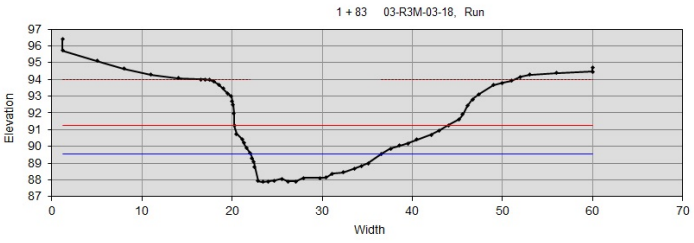
Total Phosphorus (mg/L)	<0.004	Chloride (mg/L)	129.239
Total Nitrogen (mg/L)	1.632	Magnesium (mg/L)	8.742
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	19.20
Total Ammonia N (mg/L)	0.004	Total Copper (µg/L)	0.689
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	8.253
Nitrate-N (mg/L)	1.574	Total Lead (µg/L)	0.047
Total Kjehldal N (mg/L)	0.054	Turbidity (NTU)	0.6
Dissolved Organic C (mg/L)	0.632		
Total Organic C (mg/L)	0.644		
Hardness (mg eq. $CaCO_3$/L)	83.94		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.15	Sinuosity	1.30
Bankfull Width (ft)	14.6	D50 (mm)	51.00
Mean Bankfull Depth (ft)	1.2	Adjustments?	None
Floodprone Width (ft)	23.6		
Entrenchment Ratio	1.6		
Width to Depth Ratio	12.2	**Rosgen Stream Type**	**B4/3c**
Cross Sectional Area (ft²)	17.4		
Water Surface Slope (%)	1.4		

Cross-sectional Survey



Site ID: 03-R3M-03-18

Biological Assessments

BIBI Metric Values

Total Taxa	28
EPT Taxa	3
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	6.67

FIBI Metric Values

Abundance per m²	1.16
Adj. No. of Benthic Species	0.80
% Tolerant	93.41
% Gen., Omni., Invert.	97.07
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	67.03

BIBI Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	3

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Ablabesmyia	1
Antocha	3
Chaetocladius	1
Cheumatopsyche	5
Chimarra	8
Chironomini	1
Crangonyctidae	2
Crangonyx	3
Cricotopus	15
Cricotopus/Orthocladius	7
Cryptochironomus	1
Diamesa	1
Dicrotendipes	9
Hemerodromia	2
Hydropsyche	1
Microtendipes	2
Naididae	2
Nematoda	1
Orthocladius	11
Paracladopelma	1
Parametriocnemus	22
Paratanytarsus	3
Phaenopsectra	1
Polypedilum	7
Prostoma	1
Simuliidae	1
Tanytarsus	1
Thienemanniella	1
Thienemannimyia group	3
Tvetenia	3

Fish Taxa

American Eel	1
Blacknose Dace	183
Central Stoneroller	8
Creek Chub	71
Eastern Mosquitofish	2
Longnose Dace	7
Tessellated Darter	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	8
Pool Substrate Characterization	11
Pool Variability	8
Sediment Deposition	9
Channel Flow Status	8
Channel Alteration	18
Channel Sinuosity	13
Bank Stability - Right Bank	3
Bank Stability - Left Bank	1
Vegetative Protection - Right Bank	6
Vegetative Protection - Left Bank	7
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	8

RBP Habitat Score	110
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.29	33.89
Shading	65	63.55
Epifaunal Substrate	8	59.69
Instream Habitat	8	57.54
Instream Woody Debris	6	64.75
Bank Stability	8.17	63.90

MPHI Habitat Score	57.22
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

Orconectes virilis

Herpetofauna

None Observed

Mussels

None Observed

Site ID: 03-R3M-04-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Very Poor
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	High conductivity; High chloride; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 138.13

Land Cover

	Acres	% Area
Developed Land	110.03	79.66
Forested Land	19.08	13.81
Open Land	9.02	6.53
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	61.74	44.69

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.03
Turbidity (NTU)	12.9
Temperature (°C)	11
pH (Standard Units)	6.94
Specific Conductivity (µS/cm)	4111

Laboratory Measurements

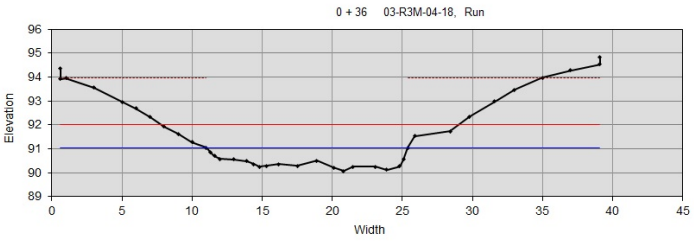
Total Phosphorus (mg/L)	0.023	Chloride (mg/L)	1262.639
Total Nitrogen (mg/L)	0.718	Magnesium (mg/L)	11.250
Orthophosphate (mg/L)	0.004	Calcium (mg/L)	76.47
Total Ammonia N (mg/L)	0.007	Total Copper (µg/L)	3.613
Nitrite-N (mg/L)	0.007	Total Zinc (µg/L)	13.266
Nitrate-N (mg/L)	0.249	Total Lead (µg/L)	0.236
Total Kjehldal N (mg/L)	0.462	Turbidity (NTU)	6.6
Dissolved Organic C (mg/L)	1.026		
Total Organic C (mg/L)	1.050		
Hardness (mg eq. $CaCO_3$/L)	237.27		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.22	Sinuosity	1.03
Bankfull Width (ft)	14.4	D50 (mm)	0.06
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	21.3		
Entrenchment Ratio	1.5		
Width to Depth Ratio	21.3	**Rosgen Stream Type**	**ND**
Cross Sectional Area (ft²)	9.7		
Water Surface Slope (%)	0.79		

Cross-sectional Survey



Site ID: 03-R3M-04-18

Biological Assessments

BIBI Metric Values

Total Taxa	<60 orgs
EPT Taxa	<60 orgs
Ephemeroptera Taxa	<60 orgs
% Intolerant to Urban	<60 orgs
% Ephemeroptera	<60 orgs
Scraper Taxa	<60 orgs
% Climbers	<60 orgs

FIBI Metric Values

Abundance per m²	No Fish
Adj. No. of Benthic Species	No Fish
% Tolerant	No Fish
% Gen., Omni., Invert.	No Fish
% Round-bodied Suckers	No Fish
% Abund. Dominant Taxon	No Fish

BIBI Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	1

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.00
BIBI Rating	Very Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa	
Lumbricina	1

Fish Taxa
NO FISH

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	1
Pool Substrate Characterization	3
Pool Variability	2
Sediment Deposition	9
Channel Flow Status	8
Channel Alteration	0
Channel Sinuosity	6
Bank Stability - Right Bank	7
Bank Stability - Left Bank	6
Vegetative Protection - Right Bank	7
Vegetative Protection - Left Bank	7
Riparian Veg. Zone Width - Right Bank	3
Riparian Veg. Zone Width - Left Bank	3

RBP Habitat Score	62
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	0.62	3.31
Shading	90	91.34
Epifaunal Substrate	1	29.92
Instream Habitat	1	35.80
Instream Woody Debris	1	68.88
Bank Stability	17.80	94.34

MPHI Habitat Score	53.93
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

None Observed

Mussels

None Observed

Site ID: 03-R3M-05-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Poor
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	High conductivity; High chloride; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 422.94

Land Cover

	Acres	% Area
Developed Land	312.10	73.79
Forested Land	88.98	21.04
Open Land	21.86	5.17
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	154.73	36.59

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	3.39
Turbidity (NTU)	4.32
Temperature (°C)	6.6
pH (Standard Units)	7.33
Specific Conductivity (µS/cm)	2263

Laboratory Measurements

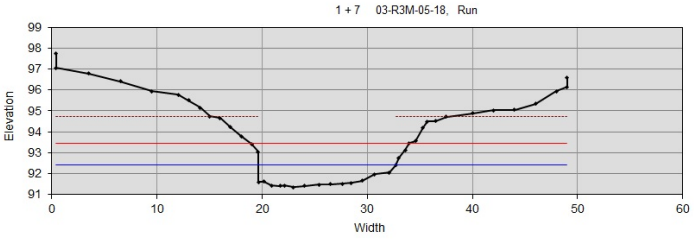
Total Phosphorus (mg/L)	0.018	Chloride (mg/L)	653.603
Total Nitrogen (mg/L)	0.396	Magnesium (mg/L)	6.878
Orthophosphate (mg/L)	0.004	Calcium (mg/L)	39.08
Total Ammonia N (mg/L)	0.061	Total Copper (µg/L)	2.320
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	3.595
Nitrate-N (mg/L)	0.102	Total Lead (µg/L)	0.184
Total Kjehldal N (mg/L)	0.292	Turbidity (NTU)	1.3
Dissolved Organic C (mg/L)	1.098		
Total Organic C (mg/L)	1.122		
Hardness (mg eq. $CaCO_3$/L)	125.91		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.66	Sinuosity	1.08
Bankfull Width (ft)	13.1	D50 (mm)	0.63
Mean Bankfull Depth (ft)	0.8	Adjustments?	None
Floodprone Width (ft)	15.0		
Entrenchment Ratio	1.2		
Width to Depth Ratio	16.4	**Rosgen Stream Type**	**F4/5**
Cross Sectional Area (ft²)	10.4		
Water Surface Slope (%)	0.75		

Cross-sectional Survey



Site ID: 03-R3M-05-18

Biological Assessments

BIBI Metric Values

Total Taxa	<60 orgs
EPT Taxa	<60 orgs
Ephemeroptera Taxa	<60 orgs
% Intolerant to Urban	<60 orgs
% Ephemeroptera	<60 orgs
Scraper Taxa	<60 orgs
% Climbers	<60 orgs

FIBI Metric Values

Abundance per m²	1.16
Adj. No. of Benthic Species	0.00
% Tolerant	78.57
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	50.00

BIBI Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	1

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	1.00
BIBI Rating	Very Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Chaetocladius	2
Dasyhelea	3
Dicrotendipes	2
Enchytraeidae	4
Lumbriculidae	4
Naididae	10
Orthocladius	8
Paratanytarsus	1
Physa	6
Prostoma	3
Stratiomyidae	1

Fish Taxa

American Eel	1
Blacknose Dace	4
Creek Chub	7
Eastern Mosquitofish	2

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	3
Pool Substrate Characterization	11
Pool Variability	5
Sediment Deposition	9
Channel Flow Status	5
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	1
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	2
Vegetative Protection - Left Bank	3
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	8

RBP Habitat Score	86
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.13	49.17
Shading	80	78.67
Epifaunal Substrate	3	34.24
Instream Habitat	3	35.45
Instream Woody Debris	6	71.00
Bank Stability	9.80	70.00

MPHI Habitat Score	56.42
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Northern Spring Peeper

Mussels

None Observed

Site ID 05-L1M-03-18

Revist of site R1-05-13A

Upstream View - 2018

Downstream View - 2018

Upstream View - 2006

Downstream View - 2006

Summary Results

	2018 Data	2006 Data
Benthic Macroinvertebrate Community	Very Poor	Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Non-Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 233.16

Land Cover	2018 Acres	2006 Acres	2018 % Area	2006 % Area
Developed Land	179.10	190.42	76.82	65.57
Forested Land	36.69	50.48	15.73	17.38
Open Land	17.37	27.49	7.45	9.47
Agricultural Land	0.00	22.01	0.00	7.58

Impervious Surface	2018 Acres	2006 Acres	2018 % Area	2006 % Area
Impervious Land	95.92	106.90	41.14	36.81

Site ID 05-L1M-03-18

Revist of site R1-05-13A

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2006 Spring
Dissolved Oxygen (mg/L)	7.03	8.26	8.83
Turbidity (NTU)	4.4	16.3	n/a
Temperature (°C)	2.1	25.3	6.63
pH (Standard Units)	7.03	7.17	6.08
Specific Conductivity (µS/cm)	377.7	422.8	366

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.008	Chloride (mg/L)	93.595
Total Nitrogen (mg/L)	0.531	Magnesium (mg/L)	3.575
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	20.99
Total Ammonia N (mg/L)	0.017	Total Copper (µg/L)	2.656
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	64.454
Nitrate-N (mg/L)	0.210	Total Lead (µg/L)	0.689
Total Kjehldal N (mg/L)	0.318	Turbidity (NTU)	2.9
Dissolved Organic C (mg/L)	4.662		
Total Organic C (mg/L)	4.747		
Hardness (mg eq. $CaCO_3$/L)	67.13		

Geomorphic Assessment

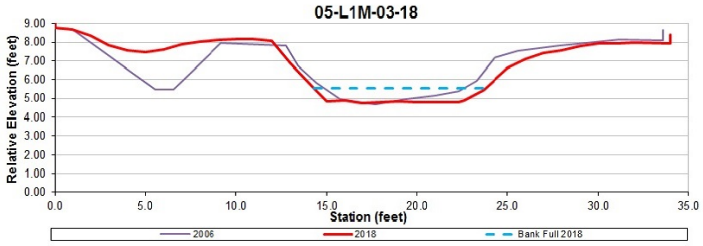
Rosgen Level II Classification Data

	2018	2006		2018	2006
Drainage Area (mi²)	0.36		Sinuosity	1.37	n/a
Bankfull Width (ft)	9.5	9.8	D50 (mm)	0.25	n/a
Mean Bankfull Depth (ft)	0.7	1.5	Adjustments?	None	None
Floodprone Width (ft)	11.1	n/a			
Entrenchment Ratio	1.2	n/a			
Width to Depth Ratio	14.6	6.6			
Cross Sectional Area (ft²)	6.2	14.5			
Water Surface Slope (%)	0.160	n/a			

Rosgen Stream Type

2018	2006
F5	**ND**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2006 Spring Value	2006 Spring Score
Remoteness	5.53	29.79	4.00	21.54
Shading	90	91.34	80	78.67
Epifaunal Substrate	3	38.12	5	48.31
Instream Habitat	3	41.54	4	44.84
Instream Woody Debris	6	77.74	10	87.09
Bank Stability	7.40	60.83	6.00	54.77

	2018 Score	2006 Score
MPHI Habitat Score	56.56	55.87
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2018 Score	2006 Score		2018 Score	2006 Score
Epifaunal Substrate/Available Cover	5	5	Bank Stability - Right Bank	4	3
Pool Substrate Characterization	7	6	Bank Stability - Left Bank	5	3
Pool Variability	3	6	Vegetative Protection - Right Bank	8	5
Sediment Deposition	6	6	Vegetative Protection - Left Bank	8	5
Channel Flow Status	8	9	Riparian Veg. Zone Width - Right Bank	8	4
Channel Alteration	19	14	Riparian Veg. Zone Width - Left Bank	9	4
Channel Sinuosity	9	9			

	2018 Score	2006 Score
RBP Habitat Score	99	79
RBP Rating	Non-Supporting	Non-Supporting

Site ID 05-L1M-03-18

Revist of site R1-05-13A

Biological Assessments

BIBI Metric Values

	2018	2006
Total Taxa	<60 orgs	24
EPT Taxa	<60 orgs	0
Ephemeroptera Taxa	<60 orgs	0
% Intolerant to Urban	<60 orgs	3.26
% Ephemeroptera	<60 orgs	0.00
Scraper Taxa	<60 orgs	1
% Climbers	<60 orgs	10.87

FIBI Metric Values (2018 only)

Abundance per m²	0.17
Adj. No. of Benthic Species	1.54
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	60.00

BIBI Metric Scores

Total Taxa	1	5
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	1	3
% Climbers	1	5

FIBI Metric Scores (2018 only)

Abundance per m²	1
Adj. No. of Benthic Species	5
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	1.00	2.43
BIBI Rating	Very Poor	Poor

FIBI Score	2.00
FIBI Rating	Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

Procambaris clarkii

Procambarus acutus/zonangulus

Procambarus acutus/zonangulus

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa

Fish Taxa	Number
Blacknose dace	1
Eastern mudminnow	12
Golden shiner	2
Pumpkinseed	4
Tessellated darter	1

Benthic Macroinvertebrate Taxa

2018	Number
Antocha	1
Cambaridae	6
Chironomus	1
Lymnaeidae	1
Naididae	1
Thienemannimyia group	1
Zavrelimyia	1

Original Visit	Number
Anax	2
Bittacomorpha	2
Bothrioneurum	7
Calopteryx	1
Culicoides	4
Enchytraeidae	2
Epiphragma	1
Fossaria	1
Hydrobaenus	1
Lubricidae	6
Ormosia	1
Orthocladius/Cricotopus	2
Phaenopsectra	3
Physa	15
Pisidium	15
Polypedilum	7
Pseudolimnophila	1
Pseudosmittia	1
Somatochlora	2
Stygobromus	1
Thienemannimyia	1
Tipula	1
Tubificidae	13
Zavrelimyia	2

Site ID 05-L1M-04-18

Revist of site R1-05-11A

Upstream View - 2018

Downstream View - 2018

Upstream View - 2006

Downstream View - 2006

Summary Results

	2018 Data	2006 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Non-Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	High conductivity	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 178.20

Land Cover	2018 Acres	2006 Acres	2018 % Area	2006 % Area
Developed Land	99.51	76.14	55.84	42.37
Forested Land	68.27	102.11	38.31	56.82
Open Land	10.42	1.45	5.85	0.81
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2006 Acres	2018 % Area	2006 % Area
Impervious Land	26.42	27.25	14.83	15.16

Site ID 05-L1M-04-18

Revist of site R1-05-11A

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2006 Spring
Dissolved Oxygen (mg/L)	10.62	5.36	11.49
Turbidity (NTU)	7.4	21.1	n/a
Temperature (°C)	8.5	22.4	9.2
pH (Standard Units)	7.25	6.93	6.43
Specific Conductivity (µS/cm)	345	473	218

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.014	Chloride (mg/L)	50.715
Total Nitrogen (mg/L)	0.499	Magnesium (mg/L)	4.142
Orthophosphate (mg/L)	0.006	Calcium (mg/L)	21.18
Total Ammonia N (mg/L)	0.011	Total Copper (µg/L)	3.567
Nitrite-N (mg/L)	<0.002	Total Zinc (µg/L)	7.865
Nitrate-N (mg/L)	0.021	Total Lead (µg/L)	0.541
Total Kjehldal N (mg/L)	0.476	Turbidity (NTU)	9.0
Dissolved Organic C (mg/L)	12.457		
Total Organic C (mg/L)	13.604		
Hardness (mg eq. $CaCO_3$/L)	69.94		

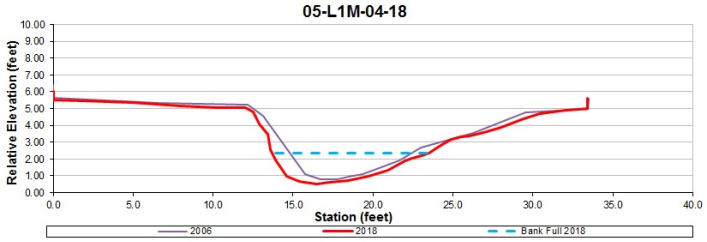
Geomorphic Assessment

Rosgen Level II Classification Data

	2018	2006		2018	2006
Drainage Area (mi²)	0.28		Sinuosity	1.21	1.10
Bankfull Width (ft)	9.8	8.5	D50 (mm)	0.14	0.06
Mean Bankfull Depth (ft)	1.2	1.2	Adjustments?	ENT -0.2	Sin, ER
Floodprone Width (ft)	15.8	16.0			
Entrenchment Ratio	1.6	1.9			
Width to Depth Ratio	8.4	6.8			
Cross Sectional Area (ft²)	11.4	10.5			
Water Surface Slope (%)	0.350	0.245			

Rosgen Stream Type	
2018	2006
G5c	**C6**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2006 Spring Value	2006 Spring Score
Remoteness	8.30	44.71	15.00	80.78
Shading	75	73.32	100	100.00
Epifaunal Substrate	5	51.49	3	39.82
Instream Habitat	6	60.94	3	44.21
Instream Woody Debris	14	100.00	2	68.86
Bank Stability	8.40	64.81	3.00	38.73

	2018 Score	2006 Score
MPHI Habitat Score	65.88	62.07
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2018 Score	2006 Score		2018 Score	2006 Score
Epifaunal Substrate/Available Cover	8	4	Bank Stability - Right Bank	5	1
Pool Substrate Characterization	11	3	Bank Stability - Left Bank	5	1
Pool Variability	9	3	Vegetative Protection - Right Bank	8	10
Sediment Deposition	7	15	Vegetative Protection - Left Bank	6	10
Channel Flow Status	18	10	Riparian Veg. Zone Width - Right Bank	10	1
Channel Alteration	14	19	Riparian Veg. Zone Width - Left Bank	10	1
Channel Sinuosity	7	9			

	2018 Score	2006 Score
RBP Habitat Score	118	87
RBP Rating	Partially Supporting	Non-Supporting

Site ID 05-L1M-04-18

Revist of site R1-05-11A

Biological Assessments

BIBI Metric Values	2018	2006
Total Taxa	23	40
EPT Taxa	2	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	12.86	17.17
% Ephemeroptera	0.00	0.00
Scraper Taxa	5	0
% Climbers	18.57	5.05

FIBI Metric Values (2018 only)	
Abundance per m²	2.97
Adj. No. of Benthic Species	0.00
% Tolerant	89.49
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	8.08
% Abund. Dominant Taxon	83.23

BIBI Metric Scores		
Total Taxa	5	5
EPT Taxa	3	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	3	3
% Ephemeroptera	1	1
Scraper Taxa	5	1
% Climbers	5	3

FIBI Metric Scores (2018 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	5
% Abund. Dominant Taxon	1

BIBI Score	3.29	2.43
BIBI Rating	Fair	Poor

FIBI Score	2.67
FIBI Rating	Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

American Toad

Northern Green Frog

Fish Taxa

Fish Taxa	Number
Banded killifish	2
Blacknose dace	23
Brown bullhead	2
Creek chubsucker	40
Eastern mudminnow	412
Mummichog	10
Pumpkinseed	6

Benthic Macroinvertebrate Taxa

2018	Number
Ceratopogoninae	1
Dasyhelea	1
Diamesa	1
Dicrotendipes	1
Diplocladius	4
Enchytraeidae	1
Ferrissia	3
Hydrobaenus	12
Ironoquia	1
Lumbriculidae	5
Lymnaeidae	2
Menetus	2
Naididae	1
Nematoda	1
Nemouridae	4
Orthocladius	7
Physa	5
Pisidium	7
Polypedilum	1
Rheocricotopus	1
Somatochlora	4
Sphaeriidae	1
Stegopterna	1
Thienemannimyia group	2
Tipula	1

Original Visit	Number
Aulodrilus	10
Bezzia/Palpomyia	1
Ceratopogon	3
Chaetocladius	1
Chaulíodes	1
Culicoides	9
Dasyhelea	1
Dubiraphia	1
Enchtraeidae	1
Gomphidae	2
Gonomyia	1
Helichus	1
Hydrobaenus	2
Ironoquia	1
Limnodrilus	1
Lumbricidae	1
Mesocricotopus	3
Nemouridae	4
Neoporus	2
Orthocladius	2
Parametriocnemus	1
Paraphaenocladius	5
Phaenosectra	2
Physa	8
Pisidium	11
Planorbidae	1
Polypedilum	2
Pseudolimnophila	2
Ptilostomis	3
Rheocricotopus	1
Smittia	1
Somatochlora	1
Stegopterna	2
Stygobromus	1
Synurella	2
Tanypodinae	1
Thienemannimyia	1
Tubificidae	3
Veliidae	2
Zavrelimyia	1

Site ID 05-L2M-02-18

Revist of site R2-05-08

Upstream View - 2018

Downstream View - 2018

Upstream View - 2009

Downstream View - 2009

Summary Results

	2018 Data	2009 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 313.10

Land Cover	2018 Acres	2009 Acres	2018 % Area	2009 % Area
Developed Land	201.18	227.20	64.25	53.31
Forested Land	102.69	199.03	32.80	46.69
Open Land	9.23	0.00	2.95	0.00
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2009 Acres	2018 % Area	2009 % Area
Impervious Land	57.29	67.90	18.30	15.90

Site ID 05-L2M-02-18

Revist of site R2-05-08

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2009 Spring
Dissolved Oxygen (mg/L)	10.84	8.48	10.43
Turbidity (NTU)	2.6	2.4	n/a
Temperature (°C)	9.6	19.3	8.35
pH (Standard Units)	7.21	7.3	6.92
Specific Conductivity (µS/cm)	340	315	322

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.011	Chloride (mg/L)	57.104
Total Nitrogen (mg/L)	1.846	Magnesium (mg/L)	3.803
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	17.80
Total Ammonia N (mg/L)	0.013	Total Copper (µg/L)	1.322
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	16.034
Nitrate-N (mg/L)	1.593	Total Lead (µg/L)	0.232
Total Kjehldal N (mg/L)	0.250	Turbidity (NTU)	1.8
Dissolved Organic C (mg/L)	3.921		
Total Organic C (mg/L)	3.949		
Hardness (mg eq. $CaCO_3$/L)	60.11		

Geomorphic Assessment

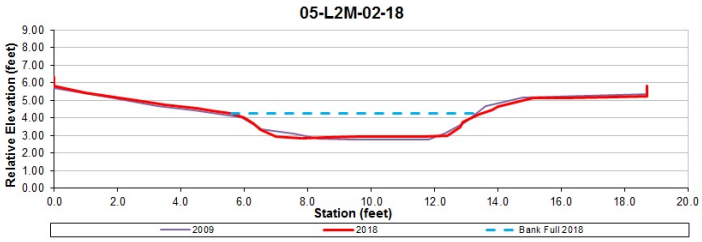
Rosgen Level II Classification Data

	2018	2009		2018	2009
Drainage Area (mi²)	0.49		Sinuosity	1.29	1.50
Bankfull Width (ft)	7.9	9.7	D50 (mm)	0.54	0.07
Mean Bankfull Depth (ft)	1.1	1.2	Adjustments?	None	None
Floodprone Width (ft)	39.0	72.0			
Entrenchment Ratio	4.9	7.4			
Width to Depth Ratio	7.1	8.2			
Cross Sectional Area (ft²)	8.8	11.6			
Water Surface Slope (%)	0.620	0.750			

Rosgen Stream Type

2018	2009
E5	**E6**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2009 Spring Value	2009 Spring Score
Remoteness	6.29	33.89	3.00	16.16
Shading	95	99.94	100	100.00
Epifaunal Substrate	8	65.25	6	51.63
Instream Habitat	9	71.81	14	96.41
Instream Woody Debris	10	86.24	11	85.71
Bank Stability	13.80	83.07	10.00	70.71

	2018 Score	2009 Score
MPHI Habitat Score	73.37	70.10
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2018 Score	2009 Score		2018 Score	2009 Score
Epifaunal Substrate/Available Cover	10	14	Bank Stability - Right Bank	8	5
Pool Substrate Characterization	11	9	Bank Stability - Left Bank	7	5
Pool Variability	9	9	Vegetative Protection - Right Bank	9	5
Sediment Deposition	7	10	Vegetative Protection - Left Bank	9	5
Channel Flow Status	18	13	Riparian Veg. Zone Width - Right Bank	7	7
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	12			

	2018 Score	2009 Score
RBP Habitat Score	132	123
RBP Rating	Supporting	Partially Supporting

Site ID 05-L2M-02-18

Revist of site R2-05-08

Biological Assessments

BIBI Metric Values	2018	2009
Total Taxa	24	27
EPT Taxa	3	2
Ephemeroptera Taxa	0	0
% Intolerant to Urban	11.71	6.19
% Ephemeroptera	0.00	0.00
Scraper Taxa	2	0
% Climbers	2.70	6.19

FIBI Metric Values (2018 only)	
Abundance per m²	0.14
Adj. No. of Benthic Species	0.00
% Tolerant	0.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	100.00

BIBI Metric Scores		
Total Taxa	5	5
EPT Taxa	3	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	3	1
% Ephemeroptera	1	1
Scraper Taxa	5	1
% Climbers	3	3

FIBI Metric Scores (2018 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	3.00	2.14
BIBI Rating	Fair	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
American eel	15

Benthic Macroinvertebrate Taxa

2018	Number
Brillia	1
Calopteryx	1
Diplectrona	5
Enchytraeidae	1
Gammaridae	12
Gammarus	41
Hydropsyche	1
Lumbriculidae	1
Naididae	7
Nanocladius	1
Orthocladiinae	1
Oulimnius	1
Phaenopsectra	2
Pisidium	3
Polycentropodidae	1
Polycentropus	3
Polypedilum	2
Prodiamesa	1
Pseudolimnophila	3
Radotanypus	1
Rheotanytarsus	3
Smittia	1
Sphaeriidae	7
Stenelmis	1
Thienemannimyia group	2
Turbellaria	5
Tvetenia	3

Original Visit	Number
Ancylidae	1
Brillia	1
Cheumatopsyche	1
Crangonyx	10
Diplectrona	4
Enchytraeidae	1
Hemerodromia	1
Heterotrissocladius	1
Lumbriculidae	1
Micropsectra	2
Nais	2
Nemata	1
Cricotopus/Orthocladius	27
Parametriocnemus	16
Paraphaenocladius	2
Paratendipes	1
Phaenopsectra	1
Pisidiidae	5
Polypedilum	3
Pristina	1
Rheocricotopus	2
Stenelmis	5
Tanytarsus	1
Thienemanniella	5
Tribelos	1
Tubificinae	7
Tvetenia	10

Site ID 05-L2M-03-18

Revist of site R2-05-03

Upstream View - 2018

Downstream View - 2018

Upstream View - 2009

Downstream View - 2009

Summary Results

	2018 Data	2009 Data
Benthic Macroinvertebrate Community	Very Poor	Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	High conductivity; Elevated nutrients	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 482.06

Land Cover	2018 Acres	2009 Acres	2018 % Area	2009 % Area
Developed Land	396.80	371.87	82.31	77.51
Forested Land	54.33	71.80	11.27	14.97
Open Land	30.93	36.12	6.42	7.53
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2009 Acres	2018 % Area	2009 % Area
Impervious Land	149.56	152.00	31.03	31.70

Site ID 05-L2M-03-18

Revist of site R2-05-03

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2009 Spring
Dissolved Oxygen (mg/L)	12.93	6.96	10.53
Turbidity (NTU)	5.6	10.7	n/a
Temperature (°C)	8.8	21.8	6.16
pH (Standard Units)	7.39	7.03	7.21
Specific Conductivity (µS/cm)	249	336	562

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.030	Chloride (mg/L)	28.293
Total Nitrogen (mg/L)	0.918	Magnesium (mg/L)	2.629
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	23.32
Total Ammonia N (mg/L)	0.011	Total Copper (µg/L)	1.526
Nitrite-N (mg/L)	0.007	Total Zinc (µg/L)	4.941
Nitrate-N (mg/L)	0.494	Total Lead (µg/L)	0.207
Total Kjehldal N (mg/L)	0.417	Turbidity (NTU)	8.8
Dissolved Organic C (mg/L)	4.803		
Total Organic C (mg/L)	4.927		
Hardness (mg eq. $CaCO_3$/L)	69.06		

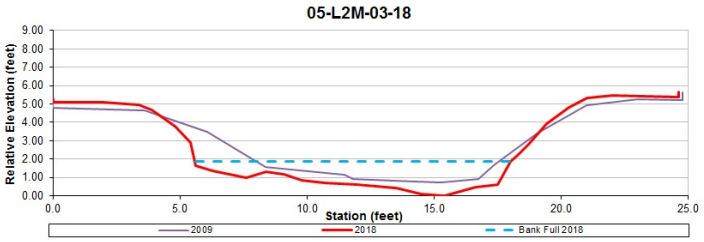
Geomorphic Assessment

Rosgen Level II Classification Data

	2018	2009		2018	2009
Drainage Area (mi²)	0.75		Sinuosity	1.21	1.20
Bankfull Width (ft)	12.4	17.0	D50 (mm)	0.34	0.21
Mean Bankfull Depth (ft)	1.1	2.5	Adjustments?	None	↑Sin
Floodprone Width (ft)	14.5	160.0			
Entrenchment Ratio	1.2	9.4			
Width to Depth Ratio	10.8	6.7			
Cross Sectional Area (ft²)	14.3	43.2			
Water Surface Slope (%)	0.300	0.450			

Rosgen Stream Type	
2018	2009
G5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2009 Spring Value	2009 Spring Score
Remoteness	10.61	57.14	8.00	43.08
Shading	65	63.55	90	91.34
Epifaunal Substrate	4	39.20	3	33.42
Instream Habitat	7	56.30	7	56.34
Instream Woody Debris	24	100.00	12	87.32
Bank Stability	8.80	66.33	12.00	77.46

	2018 Score	2009 Score
MPHI Habitat Score	63.75	64.83
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2018 Score	2009 Score		2018 Score	2009 Score
Epifaunal Substrate/Available Cover	11	7	Bank Stability - Right Bank	6	6
Pool Substrate Characterization	8	8	Bank Stability - Left Bank	4	6
Pool Variability	6	7	Vegetative Protection - Right Bank	8	6
Sediment Deposition	13	4	Vegetative Protection - Left Bank	7	6
Channel Flow Status	13	8	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	8			

	2018 Score	2009 Score
RBP Habitat Score	124	106
RBP Rating	Partially Supporting	Partially Supporting

Site ID 05-L2M-03-18

Revist of site R2-05-03

Biological Assessments

BIBI Metric Values	2018	2009
Total Taxa	11	25
EPT Taxa	1	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.00	0.00
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	10.00	22.12

FIBI Metric Values (2018 only)	
Abundance per m²	0.54
Adj. No. of Benthic Species	1.02
% Tolerant	94.62
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	80.65

BIBI Metric Scores		
Total Taxa	1	5
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	3	1
% Climbers	5	5

FIBI Metric Scores (2018 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.86	2.14
BIBI Rating	Very Poor	Poor

FIBI Score	2.33
FIBI Rating	Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Eastern Wormsnake

Fish Taxa	Number
Blacknose dace	75
Eastern mosquitofish	5
Eastern mudminnow	1
Tessellated darter	5
White sucker	7

Benthic Macroinvertebrate Taxa

2018	Number
Cheumatopsyche	1
Cricotopus	1
Dasyhelea	4
Dicrotendipes	1
Hydrobaenus	5
Nematoda	2
Orthocladius	82
Polypedilum	11
Thienemannimyia group	1
Tipula	1
Zavrelimyia	1

Original Visit	Number
Caloptervx	2
Chironomus	1
Corynoneura	2
Culicoides	1
Dicrotendipes	4
Enchytraeidae	3
Erioptera	1
Fossaria	1
Nais	3
Nanocladius	2
Cricotopus/Orthocladius	27
Paracladopelma	12
Parametriocnemus	1
Paratanytarsus	6
Phaenopsectra	3
Physa	4
Pisidium	1
Polypedilum	20
Prostoma	1
Slavina	1
Stenochironomus	1
Tanytarsus	2
Thienemanniella	6
Tribelos	1
Tubificinae	7

Site ID: 05-R3M-02-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Low pH; High conductivity; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 249.75

Land Cover

	Acres	% Area
Developed Land	148.37	59.41
Forested Land	82.43	33.00
Open Land	14.72	5.90
Agricultural Land	4.23	1.69

Impervious Surface

	Acres	% Area
Impervious Land	46.24	18.51

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	13.83
Turbidity (NTU)	63.2
Temperature (°C)	7
pH (Standard Units)	6.02
Specific Conductivity (µS/cm)	272.3

Laboratory Measurements

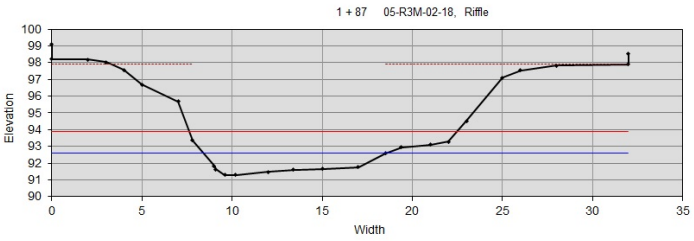
Total Phosphorus (mg/L)	0.038	Chloride (mg/L)	40.750
Total Nitrogen (mg/L)	1.684	Magnesium (mg/L)	2.918
Orthophosphate (mg/L)	0.006	Calcium (mg/L)	20.59
Total Ammonia N (mg/L)	0.024	Total Copper (µg/L)	3.231
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	10.210
Nitrate-N (mg/L)	1.412	Total Lead (µg/L)	0.357
Total Kjehldal N (mg/L)	0.267	Turbidity (NTU)	64.6
Dissolved Organic C (mg/L)	6.848		
Total Organic C (mg/L)	7.068		
Hardness (mg eq. $CaCO_3$/L)	63.43		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.39	Sinuosity	1.13
Bankfull Width (ft)	10.1	D50 (mm)	4.70
Mean Bankfull Depth (ft)	0.9	Adjustments?	W/D +1.0
Floodprone Width (ft)	15.7		
Entrenchment Ratio	1.6		
Width to Depth Ratio	11.1	**Rosgen Stream Type**	**B4/5c**
Cross Sectional Area (ft²)	9.1		
Water Surface Slope (%)	0.58		

Cross-sectional Survey



Site ID: 05-R3M-02-18

Biological Assessments

BIBI Metric Values

Total Taxa	25
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	37.27

FIBI Metric Values

Abundance per m²	0.94
Adj. No. of Benthic Species	1.64
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	89.73

BIBI Metric Scores

Total Taxa	5
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	5

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.71
BIBI Rating	Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Ablabesmyia	2
Antocha	1
Chaetocladius	1
Cheumatopsyche	2
Corynoneura	4
Cricotopus	6
Cricotopus/Orthocladius	2
Cryptochironomus	1
Diplocladius	4
Macronychus	1
Naididae	1
Orthocladius	1
Parametriocnemus	10
Paratanytarsus	1
Phaenopsectra	7
Physa	2
Polypedilum	36
Rheotanytarsus	5
Simulium	1
Stictochironomus	3
Tanytarsus	3
Thienemanniella	4
Thienemannimyia group	6
Tipula	1
Tvetenia	5

Fish Taxa

Blacknose dace	131
Eastern mudminnow	11
Tessellated darter	4

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	8
Pool Substrate Characterization	7
Pool Variability	6
Sediment Deposition	6
Channel Flow Status	13
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	3
Bank Stability - Left Bank	3
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	109
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.13	43.76
Shading	85	84.56
Epifaunal Substrate	5	49.29
Instream Habitat	4	46.39
Instream Woody Debris	8	82.88
Bank Stability	10.20	71.42

MPHI Habitat Score	63.05
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Mussels

None Observed

Site ID: 05-R3M-03-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Good
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	High conductivity; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1044.20

Land Cover

	Acres	% Area
Developed Land	916.15	87.74
Forested Land	75.68	7.25
Open Land	52.38	5.02
Agricultural Land	0.00	0.00

Impervious Surface

	Acres	% Area
Impervious Land	79.25	20.42

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.14
Turbidity (NTU)	8.2
Temperature (°C)	9
pH (Standard Units)	7
Specific Conductivity (µS/cm)	873

Laboratory Measurements

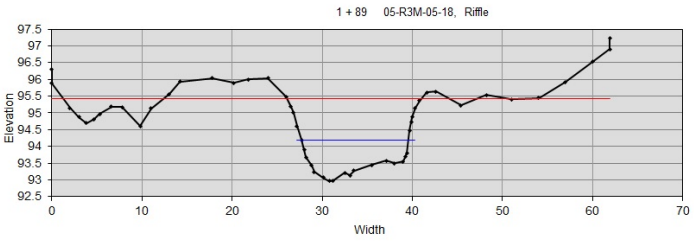
Total Phosphorus (mg/L)	0.049	Chloride (mg/L)	196.945
Total Nitrogen (mg/L)	1.506	Magnesium (mg/L)	5.362
Orthophosphate (mg/L)	0.006	Calcium (mg/L)	39.96
Total Ammonia N (mg/L)	0.134	Total Copper (µg/L)	4.488
Nitrite-N (mg/L)	0.026	Total Zinc (µg/L)	42.564
Nitrate-N (mg/L)	0.825	Total Lead (µg/L)	0.346
Total Kjehldal N (mg/L)	0.656	Turbidity (NTU)	9.0
Dissolved Organic C (mg/L)	9.492		
Total Organic C (mg/L)	9.481		
Hardness (mg eq. $CaCO_3$/L)	121.86		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.63	Sinuosity	1.03
Bankfull Width (ft)	26.1	D50 (mm)	1.40
Mean Bankfull Depth (ft)	0.6	Adjustments?	None
Floodprone Width (ft)	30.8		
Entrenchment Ratio	1.2		
Width to Depth Ratio	44.8	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	15.2		
Water Surface Slope (%)	0.0093		

Cross-sectional Survey



Site ID: 05-R3M-03-18

Biological Assessments

BIBI Metric Values

Total Taxa	22
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	3
% Climbers	26.67

FIBI Metric Values

Abundance per m²	0.96
Adj. No. of Benthic Species	0.68
% Tolerant	38.46
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	7.28
% Abund. Dominant Taxon	27.44

BIBI Metric Scores

Total Taxa	5
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	5

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	5
% Abund. Dominant Taxon	5

BIBI Score	2.71
BIBI Rating	Poor

FIBI Score	4.33
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Ablabesmyia	4
Argia	6
Calopteryx	1
Cricotopus	1
Dicrotendipes	5
Erpobdella	1
Ferrissia	2
Gammaridae	2
Gammarus	17
Glyptotendipes	1
Gyraulus	1
Ischnura	1
Lumbriculidae	14
Menetus	16
Naididae	3
Orthocladius	13
Paratanytarsus	1
Phaenopsectra	4
Polypedilum	1
Prostoma	1
Thienemannimyia group	8
Tribelos	1
Turbellaria	1

Fish Taxa

American eel	9
Banded killifish	6
Bluegill	13
Brown bullhead	5
Creek chubsucker	35
Eastern mosquitofish	99
Eastern mudminnow	1
Golden shiner	9
Goldfish	3
Mummichog	132
Pumpkinseed	126
Redbreast sunfish	9
Spottail shiner	2
Tessellated darter	21
Warmouth	1
White sucker	10

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	10
Pool Substrate Characterization	12
Pool Variability	12
Sediment Deposition	7
Channel Flow Status	14
Channel Alteration	16
Channel Sinuosity	5
Bank Stability - Right Bank	6
Bank Stability - Left Bank	9
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	127
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	5.07	27.32
Shading	85	84.56
Epifaunal Substrate	5	39.98
Instream Habitat	8	53.94
Instream Woody Debris	12	78.52
Bank Stability	16.00	89.45

MPHI Habitat Score	62.29
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

American Bullfrog

Mussels

None Observed

Site ID: 05-R3M-05-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 407.01

Land Cover	Acres	% Area
Developed Land	361.36	88.79
Forested Land	28.30	6.95
Open Land	17.34	4.26
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	433.86	41.55

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	13.17
Turbidity (NTU)	5.6
Temperature (°C)	4.6
pH (Standard Units)	7.48
Specific Conductivity (µS/cm)	282.7

Laboratory Measurements

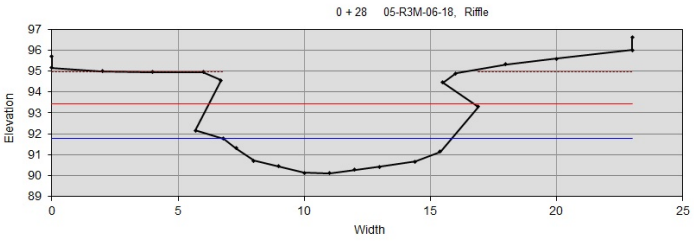
Total Phosphorus (mg/L)	0.008	Chloride (mg/L)	30.720
Total Nitrogen (mg/L)	1.048	Magnesium (mg/L)	3.028
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	24.55
Total Ammonia N (mg/L)	0.017	Total Copper (µg/L)	1.565
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	4.747
Nitrate-N (mg/L)	0.757	Total Lead (µg/L)	0.169
Total Kjehldal N (mg/L)	0.284	Turbidity (NTU)	6.7
Dissolved Organic C (mg/L)	5.128		
Total Organic C (mg/L)	5.212		
Hardness (mg eq. $CaCO_3$/L)	73.77		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.64	Sinuosity	1.11
Bankfull Width (ft)	11.9	D50 (mm)	0.22
Mean Bankfull Depth (ft)	0.8	Adjustments?	None
Floodprone Width (ft)	14.0		
Entrenchment Ratio	1.2		
Width to Depth Ratio	14.4	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	9.8		
Water Surface Slope (%)	0.1		

Cross-sectional Survey



Site ID: 05-R3M-05-18

Biological Assessments

BIBI Metric Values

Total Taxa	<60 orgs
EPT Taxa	<60 orgs
Ephemeroptera Taxa	<60 orgs
% Intolerant to Urban	<60 orgs
% Ephemeroptera	<60 orgs
Scraper Taxa	<60 orgs
% Climbers	<60 orgs

FIBI Metric Values

Abundance per m²	1.39
Adj. No. of Benthic Species	0.00
% Tolerant	92.02
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	92.02

BIBI Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	1

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.00
BIBI Rating	Very Poor

FIBI Score	2.00
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Calopteryx	1
Cricotopus	1
Dicrotendipes	1
Diplocladius	1
Ferrissia	1
Gastropoda	1
Naididae	1
Orthocladius	14
Phaenopsectra	12
Physa	10
Polypedilum	2
Rheotanytarsus	1
Sphaeriidae	1
Thienemannimyia group	6

Fish Taxa

Blacknose Dace	242
Eastern Mosquitofish	21

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	6
Pool Substrate Characterization	10
Pool Variability	9
Sediment Deposition	7
Channel Flow Status	10
Channel Alteration	19
Channel Sinuosity	7
Bank Stability - Right Bank	1
Bank Stability - Left Bank	3
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	9
Riparian Veg. Zone Width - Left Bank	7

RBP Habitat Score	104
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	2.93	15.79
Shading	95	99.94
Epifaunal Substrate	6	51.92
Instream Habitat	7	58.03
Instream Woody Debris	12	89.18
Bank Stability	12.27	78.32

MPHI Habitat Score	65.53
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

Procambaris clarkii

Herpetofauna

Northern Green Frog

Northern watersnake

Mussels

None Observed

Site ID: 05-R3M-06-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Fair
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Severely Degraded
Water Quality Conditions	Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 388.09

Land Cover	Acres	% Area
Developed Land	241.75	62.29
Forested Land	123.61	31.85
Open Land	17.82	4.59
Agricultural Land	4.90	1.26

Impervious Surface	Acres	% Area
Impervious Land	132.87	32.64

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.84
Turbidity (NTU)	38.6
Temperature (°C)	7.8
pH (Standard Units)	6.52
Specific Conductivity (µS/cm)	245.7

Laboratory Measurements

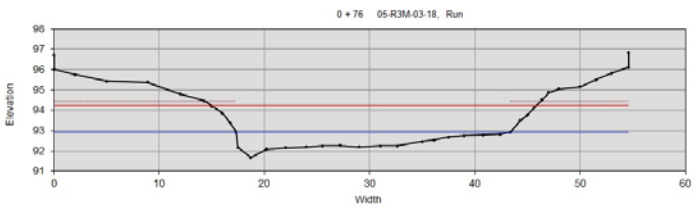
Total Phosphorus (mg/L)	0.034	Chloride (mg/L)	38.069
Total Nitrogen (mg/L)	1.371	Magnesium (mg/L)	2.918
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	18.21
Total Ammonia N (mg/L)	0.016	Total Copper (µg/L)	2.886
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	10.959
Nitrate-N (mg/L)	1.034	Total Lead (µg/L)	0.670
Total Kjehldal N (mg/L)	0.333	Turbidity (NTU)	29.2
Dissolved Organic C (mg/L)	7.876		
Total Organic C (mg/L)	8.123		
Hardness (mg eq. $CaCO_3$/L)	57.49		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.61	Sinuosity	1.00
Bankfull Width (ft)	9.0	D50 (mm)	13.00
Mean Bankfull Depth (ft)	1.2	Adjustments?	None
Floodprone Width (ft)	10.4		
Entrenchment Ratio	1.2		
Width to Depth Ratio	7.7	**Rosgen Stream Type**	**G4/6**
Cross Sectional Area (ft²)	10.6		
Water Surface Slope (%)	2.2		

Cross-sectional Survey



Site ID: 05-R3M-06-18

Biological Assessments

BIBI Metric Values

Total Taxa	32
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	6
% Climbers	22.86

FIBI Metric Values

Abundance per m²	1.10
Adj. No. of Benthic Species	1.15
% Tolerant	59.92
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.39
% Abund. Dominant Taxon	38.13

BIBI Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	5

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.00
BIBI Rating	Fair

FIBI Score	3.67
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Argia	6
Caloptervx	2
Ceratopogonidae	1
Cheumatopsyche	6
Coenagrionidae	1
Crangonyctidae	3
Cricotopus	1
Cricotopus/Orthocladius	1
Cryptochironomus	3
Diamesa	1
Dubiraphia	1
Helichus	2
Hemerodromia	1
Hydropsyche	1
Macronychus	1
Menetus	1
Microtendipes	14
Natarsia	1
Optioservus	2
Parametriocnemus	5
Paratanytarsus	6
Phaenopsectra	1
Polypedilum	11
Rheotanytarsus	2
Stenelmis	5
Stictochironomus	2
Tanytarsus	2
Thienemannimyia group	11
Tipula	1
Tribelos	7
Tvetenia	1

Fish Taxa

Blacknose Dace	29
Bluegill	8
Brown Bullhead	55
Creek Chubsucker	1
Eastern Mosquitofish	98
Eastern Mudminnow	5
Golden Shiner	3
Pumpkinseed	39
Redbreast Sunfish	4
Tessellated Darter	2
White Sucker	13

Benthic Macroinvertebrate Taxa Cont'd

Veneroida	1
Zavrelimyia	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	11
Pool Variability	8
Sediment Deposition	14
Channel Flow Status	10
Channel Alteration	9
Channel Sinuosity	6
Bank Stability - Right Bank	2
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	3
Vegetative Protection - Left Bank	3
Riparian Veg. Zone Width - Right Bank	3
Riparian Veg. Zone Width - Left Bank	3

RBP Habitat Score	81
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.29	33.89
Shading	40	40.96
Epifaunal Substrate	4	40.61
Instream Habitat	7	58.52
Instream Woody Debris	5	69.02
Bank Stability	0.67	18.26

MPHI Habitat Score	43.54
MPHI Rating	Severely Degraded

Supplemental Flora and Fauna

Crayfish

Procambaris clarkii

Herpetofauna

American Bullfrog

Northern Green Frog

Northern watersnake

Mussels

None Observed

Site ID 08-L1M-01-18

Revist of site R1-08-05

Upstream View - 2018

Downstream View - 2018

Upstream View - 2007

Downstream View - 2007

Summary Results

	2018 Data	2007 Data
Benthic Macroinvertebrate Community	Very Poor	Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Non-Supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 292.06

Land Cover	2018 Acres	2007 Acres	2018 % Area	2007 % Area
Developed Land	183.07	189.63	62.68	61.99
Forested Land	73.59	79.62	25.20	26.03
Open Land	35.40	36.65	12.12	11.98
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2007 Acres	2018 % Area	2007 % Area
Impervious Land	78.22	94.73	26.78	30.97

Site ID 08-L1M-01-18

Revist of site R1-08-05

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2007 Spring
Dissolved Oxygen (mg/L)	11.65	6.58	10.3
Turbidity (NTU)	2.6	8.7	n/a
Temperature (°C)	5.9	23.3	3.96
pH (Standard Units)	6.71	7.14	n/a
Specific Conductivity (µS/cm)	490	384	1383

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.010	Chloride (mg/L)	117.171
Total Nitrogen (mg/L)	0.729	Magnesium (mg/L)	7.429
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	18.40
Total Ammonia N (mg/L)	0.237	Total Copper (µg/L)	0.474
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	24.654
Nitrate-N (mg/L)	0.399	Total Lead (µg/L)	0.046
Total Kjehldal N (mg/L)	0.325	Turbidity (NTU)	15.7
Dissolved Organic C (mg/L)	1.023		
Total Organic C (mg/L)	1.170		
Hardness (mg eq. $CaCO_3$/L)	76.54		

Geomorphic Assessment

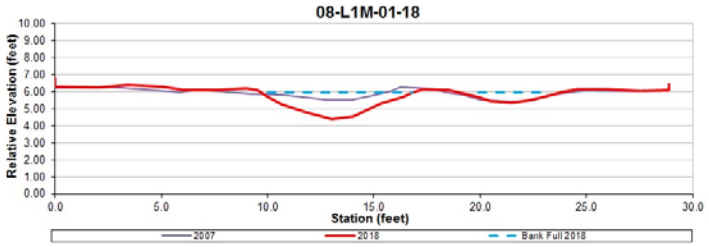
Rosgen Level II Classification Data

	2018	2007		2018	2007
Drainage Area (mi²)	0.46		Sinuosity	1.14	1.00
Bankfull Width (ft)	7.1	15.7	D50 (mm)	0.12	0.25
Mean Bankfull Depth (ft)	0.9	0.3	Adjustments?	None	Sin
Floodprone Width (ft)	130.0	133.0			
Entrenchment Ratio	18.3	8.5			
Width to Depth Ratio	7.9	46.5			
Cross Sectional Area (ft²)	6.4	5.3			
Water Surface Slope (%)	0.900	0.590			

Rosgen Stream Type

2018	2007
E5	**C5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2007 Spring Value	2007 Spring Score
Remoteness	6.39	34.39	4.00	21.54
Shading	90	91.34	80	78.67
Epifaunal Substrate	6	54.08	5	47.97
Instream Habitat	8	66.98	6	55.41
Instream Woody Debris	24	100.00	10	86.50
Bank Stability	17.67	93.99	6.00	54.77

	2018 Score	2007 Score
MPHI Habitat Score	73.46	57.48
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2018 Score	2007 Score		2018 Score	2007 Score
Epifaunal Substrate/Available Cover	13	6	Bank Stability - Right Bank	8	4
Pool Substrate Characterization	9	9	Bank Stability - Left Bank	8	4
Pool Variability	8	8	Vegetative Protection - Right Bank	7	3
Sediment Deposition	9	3	Vegetative Protection - Left Bank	10	3
Channel Flow Status	13	16	Riparian Veg. Zone Width - Right Bank	4	3
Channel Alteration	20	17	Riparian Veg. Zone Width - Left Bank	10	9
Channel Sinuosity	7	6			

	2018 Score	2007 Score
RBP Habitat Score	126	91
RBP Rating	Supporting	Non-Supporting

Site ID 08-L1M-01-18

Revist of site R1-08-05

Biological Assessments

BIBI Metric Values	2018	2007
Total Taxa	17	18
EPT Taxa	1	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.85	11.02
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	1
% Climbers	40.17	0.85

FIBI Metric Values (2018 only)	
Abundance per m²	0.17
Adj. No. of Benthic Species	0.00
% Tolerant	55.17
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	51.72

BIBI Metric Scores		
Total Taxa	3	3
EPT Taxa	1	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	3
% Ephemeroptera	1	1
Scraper Taxa	1	3
% Climbers	5	1

FIBI Metric Scores (2018 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	1.86	2.14
BIBI Rating	Very Poor	Poor

FIBI Score	2.00
FIBI Rating	Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

Cambarus diogenes

Mussels

None Observed

Herpetofauna

Northern Green Frog

Northern Spring Peeper

Fish Taxa

Fish Taxa	Number
American eel	9
Eastern mosquitofish	4
Eastern mudminnow	15
Golden shiner	1

Benthic Macroinvertebrate Taxa

2018	Number
Bezzia/Palpomyia	2
Boveria	1
Cheumatopsyche	1
Diplocladius	3
Gomphidae	1
Hemerodromia	1
Naididae	11
Nematoda	1
Parametriocnemus	1
Phaenopsectra	3
Pisidium	13
Polypedilum	46
Prostoma	3
Pseudorthocladius	1
Rheotanytarsus	4
Sphaeriidae	4
Stenochironomus	3
Thienemanniella group	11
Veneroida	7

Original Visit	Number
Tubificinae	4
Spirosperma	1
Corynoneura	1
Diplocladius	4
Orthocladius/Cricotopus	1
Stenochironomus	1
Thienemanniella	2
Thienemannimyia	27
Paratanytarsus	2
Boveria	1
Diplectrona	1
Psilotreta	1
Lype	1
Caecidotea	11
Physa	35
Menetus	1
Pisidium	22
Prostoma	2

Site ID 08-L1M-02-18

Revist of site R1-08-15A

Upstream View - 2018

Downstream View - 2018

Upstream View - 2007

Downstream View - 2007

Summary Results

	2018 Data	2007 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	NO FIBI	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Partially Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 350.08

Land Cover	2018 Acres	2007 Acres	2018 % Area	2007 % Area
Developed Land	231.31	222.12	66.07	66.26
Forested Land	78.15	80.43	22.32	24.00
Open Land	40.62	32.65	11.60	9.74
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2007 Acres	2018 % Area	2007 % Area
Impervious Land	88.01	96.73	25.14	28.86

Site ID 08-L1M-02-18

Revist of site R1-08-15A

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2007 Spring
Dissolved Oxygen (mg/L)	11.04	7.03	11.17
Turbidity (NTU)	4.8	5	n/a
Temperature (°C)	6.4	21.6	12.84
pH (Standard Units)	6.59	6.78	n/a
Specific Conductivity (µS/cm)	330	236	738

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.019	Chloride (mg/L)	57.159
Total Nitrogen (mg/L)	0.991	Magnesium (mg/L)	5.375
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	17.13
Total Ammonia N (mg/L)	0.021	Total Copper (µg/L)	0.468
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	14.568
Nitrate-N (mg/L)	0.790	Total Lead (µg/L)	0.092
Total Kjehldal N (mg/L)	0.198	Turbidity (NTU)	5.4
Dissolved Organic C (mg/L)	1.981		
Total Organic C (mg/L)	2.009		
Hardness (mg eq. $CaCO_3$/L)	64.91		

Geomorphic Assessment

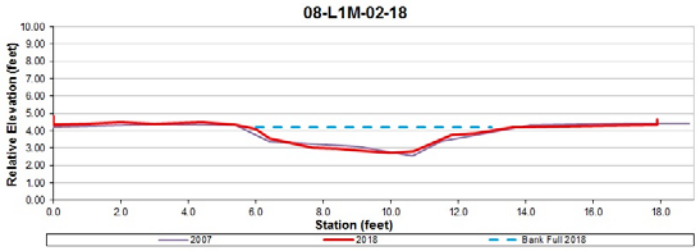
Rosgen Level II Classification Data

	2018	2007		2018	2007
Drainage Area (mi²)	0.55		Sinuosity	1.10	1.10
Bankfull Width (ft)	7.8	8.7	D50 (mm)	0.06	0.13
Mean Bankfull Depth (ft)	0.9	0.9	Adjustments?	None	↑Sin
Floodprone Width (ft)	120.0	200.0			
Entrenchment Ratio	15.4	23.1			
Width to Depth Ratio	9.0	9.3			
Cross Sectional Area (ft²)	6.7	8.0			
Water Surface Slope (%)	0.450	0.210			

Rosgen Stream Type

2018	2007
E6	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2007 Spring Value	2007 Spring Score
Remoteness	6.70	36.10	5.00	26.93
Shading	10	8.55	70	68.32
Epifaunal Substrate	7	58.71	6	53.19
Instream Habitat	7	59.57	10	76.66
Instream Woody Debris	18	100.00	2	61.80
Bank Stability	20.00	100.00	10.00	70.71

	2018 Score	2007 Score
MPHI Habitat Score	60.49	59.60
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2018 Score	2007 Score		2018 Score	2007 Score
Epifaunal Substrate/Available Cover	14	10	Bank Stability - Right Bank	10	6
Pool Substrate Characterization	14	10	Bank Stability - Left Bank	10	6
Pool Variability	8	7	Vegetative Protection - Right Bank	7	5
Sediment Deposition	16	9	Vegetative Protection - Left Bank	7	5
Channel Flow Status	19	18	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	18	Riparian Veg. Zone Width - Left Bank	8	4
Channel Sinuosity	7	7			

	2018 Score	2007 Score
RBP Habitat Score	150	115
RBP Rating	Supporting	Partially Supporting

Site ID 08-L1M-02-18

Revist of site R1-08-15A

Biological Assessments

BIBI Metric Values	2018	2007
Total Taxa	18	31
EPT Taxa	1	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.00	15.89
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	17.12	2.80

FIBI Metric Values (2018 only)	
Abundance per m²	Qualitative
Adj. No. of Benthic Species	Qualitative
% Tolerant	Qualitative
% Gen., Omni., Invert.	Qualitative
% Round-bodied Suckers	Qualitative
% Abund. Dominant Taxon	Qualitative

BIBI Metric Scores		
Total Taxa	3	5
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	3
% Ephemeroptera	1	1
Scraper Taxa	3	1
% Climbers	5	3

FIBI Metric Scores (2018 only)	
Abundance per m²	Qualitative
Adj. No. of Benthic Species	Qualitative
% Tolerant	Qualitative
% Gen., Omni., Invert.	Qualitative
% Round-bodied Suckers	Qualitative
% Abund. Dominant Taxon	Qualitative

BIBI Score	2.14	2.14
BIBI Rating	Poor	Poor

FIBI Score	Qualitative
FIBI Rating	NO FIBI

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
American eel	Common
Banded killifish	Abundant
Brown bullhead	Rare
Eastern mosquitofish	Common
Eastern mudminnow	Common
Mummichog	Abundant
Pumpkinseed	Rare

Benthic Macroinvertebrate Taxa

2018	Number
Cheumatopsyche	1
Corydalus	6
Cricotopus	1
Dasyhelea	1
Enchytraeidae	1
Forcipomyia	1
Gammarus	7
Lumbriculidae	2
Naididae	2
Nematoda	5
Ostracoda	9
Physa	1
Polypedilum	17
Rheotanytarsus	44
Sphaeriidae	9
Tanytarsus	1
Thienemanniella	2
Thienemannimyia group	1

Original Visit	Number
Thyadinae	1
Helobdella	1
Enchytraeidae	5
Tubificinae	21
Aulodrilus	2
Limnodrilus	1
Ancyronyx	3
Macronychus	2
Bezzia/Palpomyia	1
Ablabesmyia	1
Clinotanypus	1
Corydalus	1
Cryptochironomus	2
Parametriocnemus	1
Polypedilum	3
Rheocricotopus	1
Stenochironomus	1
Thienemannimyia	3
Paratanytarsus	1
Rheotanytarsus	1
Gomphus	1
Lype	1
Crangonyx	3
Gammarus	12
Caecidotea	16
Lymnaeidae	1
Physidae	2
Sphaeriidae	9
Nematoda	1
Prostoma	1
Planariidae	7

Site ID 08-L2M-01-18

Revist of site R2-08-10

Upstream View - 2018

Downstream View - 2018

Upstream View - 2013

Downstream View - 2013

Summary Results

	2018 Data	2013 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 593.29

Land Cover	2018 Acres	2013 Acres	2018 % Area	2013 % Area
Developed Land	406.68	388.17	68.55	67.94
Forested Land	153.48	164.93	25.87	28.87
Open Land	29.16	14.41	4.91	2.52
Agricultural Land	3.98	3.83	0.67	0.67

Impervious Surface	2018 Acres	2013 Acres	2018 % Area	2013 % Area
Impervious Land	116.77	104.52	19.68	18.29

Site ID 08-L2M-01-18

Revist of site R2-08-10

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2013 Spring
Dissolved Oxygen (mg/L)	11.91	8.29	11.95
Turbidity (NTU)	1.8	4.6	3.1
Temperature (°C)	6.8	20.6	8.77
pH (Standard Units)	6.55	7.61	6.64
Specific Conductivity (µS/cm)	269	242	240.2

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.009	Chloride (mg/L)	49.141
Total Nitrogen (mg/L)	1.921	Magnesium (mg/L)	5.351
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	13.85
Total Ammonia N (mg/L)	0.103	Total Copper (µg/L)	0.170
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	19.404
Nitrate-N (mg/L)	1.745	Total Lead (µg/L)	0.028
Total Kjehldal N (mg/L)	0.171	Turbidity (NTU)	7.5
Dissolved Organic C (mg/L)	0.877		
Total Organic C (mg/L)	0.927		
Hardness (mg eq. $CaCO_3$/L)	56.62		

Geomorphic Assessment

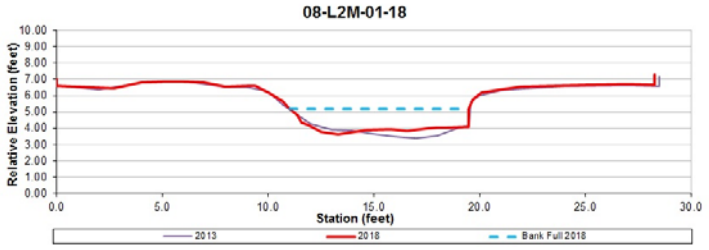
Rosgen Level II Classification Data

	2018	2013		2018	2013
Drainage Area (mi²)	0.93		Sinuosity	1.07	1.10
Bankfull Width (ft)	8.5	8.6	D50 (mm)	0.41	0.15
Mean Bankfull Depth (ft)	1.2	1.3	Adjustments?	None	None
Floodprone Width (ft)	160.0	152.0			
Entrenchment Ratio	18.8	17.7			
Width to Depth Ratio	7.0	6.4			
Cross Sectional Area (ft²)	10.4	11.5			
Water Surface Slope (%)	0.046	0.170			

Rosgen Stream Type

2018	2013
E5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2013 Spring Value	2013 Spring Score
Remoteness	6.48	34.89	7.00	37.70
Shading	90	91.34	85	84.56
Epifaunal Substrate	5	43.66	7	55.52
Instream Habitat	8	59.72	8	60.11
Instream Woody Debris	24	100.00	19	100.00
Bank Stability	10.00	70.71	5.00	50.00

	2018 Score	2013 Score
MPHI Habitat Score	66.72	64.65
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2018 Score	2013 Score		2018 Score	2013 Score
Epifaunal Substrate/Available Cover	12	8	Bank Stability - Right Bank	6	2
Pool Substrate Characterization	13	9	Bank Stability - Left Bank	7	3
Pool Variability	10	11	Vegetative Protection - Right Bank	9	3
Sediment Deposition	13	12	Vegetative Protection - Left Bank	9	4
Channel Flow Status	14	16	Riparian Veg. Zone Width - Right Bank	6	7
Channel Alteration	20	16	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	6	8			

	2018 Score	2013 Score
RBP Habitat Score	135	109
RBP Rating	Supporting	Partially Supporting

Site ID 08-L2M-01-18

Revist of site R2-08-10

Biological Assessments

BIBI Metric Values	2018	2013
Total Taxa	24	22
EPT Taxa	1	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	2.68	8.40
% Ephemeroptera	0.00	0.00
Scraper Taxa	3	2
% Climbers	19.64	4.82

FIBI Metric Values (2018 only)	
Abundance per m²	0.26
Adj. No. of Benthic Species	0.00
% Tolerant	57.14
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	42.86

BIBI Metric Scores		
Total Taxa	5	5
EPT Taxa	1	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	5	5
% Climbers	5	3

FIBI Metric Scores (2018 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	2.71	2.71
BIBI Rating	Poor	Poor

FIBI Score	2.00
FIBI Rating	Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Northern Green Frog

American Bullfrog

Pickerel Frog

Fish Taxa	Number
American eel	21
Bluegill	1
Eastern mudminnow	7
Golden shiner	15
Pumpkinseed	5

Benthic Macroinvertebrate Taxa

2018	Number
Caecidotea	1
Caloptervx	4
Dicranota	1
Diplocladius	1
Ferrissia	1
Lumbricina	1
Lumbriculidae	4
Menetus	6
Naididae	23
Odontomesa	5
Parametriocnemus	15
Phaenopsectra	1
Physa	6
Pilaria	1
Pisidium	7
Planorbidae	1
Polycentropodidae	1
Polypedilum	4
Prodiamesa	1
Rheotanytarsus	2
Sphaeriidae	2
Thienemannimyia group	15
Tipula	1
Tribelos	3
Xylotopus	1
Zavrelimyia	4

Original Visit	Number
Ablabesmyia	6
Caloptervx	1
Conchapelopia	1
Corynoneura	1
Ironoquia	1
Lumbriculidae	2
Lype	1
Micropsectra	2
Naididae	5
Odontomesa	1
Parametriocnemus	4
Paratendipes	2
Phaenopsectra	2
Physa	1
Pisidium	2
Polycentropus	5
Pseudorthocladius	1
Rheotanytarsus	4
Stenochironomus	1
Thienemannimyia group	8
Tipula	1
Tubificidae	19
Zavrelimyia	12

Site ID 08-L2M-02-18

Revist of site R2-08-17A

Upstream View - 2018

Downstream View - 2018

Upstream View - 2013

Downstream View - 2013

Summary Results

	2018 Data	2013 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nutrients	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 107.91

Land Cover	2018 Acres	2013 Acres	2018 % Area	2013 % Area
Developed Land	89.79	88.05	83.21	82.93
Forested Land	15.24	15.07	14.12	14.20
Open Land	2.88	3.05	2.67	2.87
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2018 Acres	2013 Acres	2018 % Area	2013 % Area
Impervious Land	30.66	29.71	28.41	27.99

Site ID 08-L2M-02-18

Revist of site R2-08-17A

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2013 Spring
Dissolved Oxygen (mg/L)	7.06	3.88	6.13
Turbidity (NTU)	0.9	5	7.35
Temperature (°C)	11.3	22.9	4.27
pH (Standard Units)	6.59	6.73	6.76
Specific Conductivity (µS/cm)	265	198	213.37

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.028	Chloride (mg/L)	8.482
Total Nitrogen (mg/L)	0.731	Magnesium (mg/L)	7.637
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	36.01
Total Ammonia N (mg/L)	0.167	Total Copper (µg/L)	0.436
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	17.416
Nitrate-N (mg/L)	0.258	Total Lead (µg/L)	0.153
Total Kjehldal N (mg/L)	0.467	Turbidity (NTU)	9.7
Dissolved Organic C (mg/L)	0.511		
Total Organic C (mg/L)	0.539		
Hardness (mg eq. $CaCO_3$/L)	121.37		

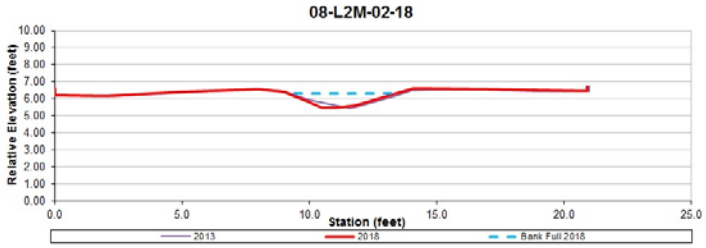
Geomorphic Assessment

Rosgen Level II Classification Data

	2018	2013		2018	2013
Drainage Area (mi²)	0.17		Sinuosity	1.15	1.10
Bankfull Width (ft)	4.2	7.1	D50 (mm)	0.06	0.06
Mean Bankfull Depth (ft)	0.5	0.4	Adjustments?	None	None
Floodprone Width (ft)	55.0	55.0			
Entrenchment Ratio	13.1	7.7			
Width to Depth Ratio	8.4	19.1			
Cross Sectional Area (ft²)	2.1	2.6			
Water Surface Slope (%)	1.000	1.400			

Rosgen Stream Type	
2018	2013
E6	**ND**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2013 Spring Value	2013 Spring Score
Remoteness	8.64	46.55	7.00	37.70
Shading	90	91.34	80	78.67
Epifaunal Substrate	5	54.76	6	60.68
Instream Habitat	4	54.97	5	60.69
Instream Woody Debris	7	89.42	14	100.00
Bank Stability	18.80	96.96	18.00	94.87

	2018 Score	2013 Score
MPHI Habitat Score	72.34	72.10
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2018 Score	2013 Score		2018 Score	2013 Score
Epifaunal Substrate/Available Cover	4	6	Bank Stability - Right Bank	9	9
Pool Substrate Characterization	10	6	Bank Stability - Left Bank	9	9
Pool Variability	7	7	Vegetative Protection - Right Bank	10	9
Sediment Deposition	7	13	Vegetative Protection - Left Bank	10	9
Channel Flow Status	7	10	Riparian Veg. Zone Width - Right Bank	9	6
Channel Alteration	18	14	Riparian Veg. Zone Width - Left Bank	8	7
Channel Sinuosity	8	10			

	2018 Score	2013 Score
RBP Habitat Score	116	115
RBP Rating	Partially Supporting	Partially Supporting

Site ID 08-L2M-02-18

Revist of site R2-08-17A

Biological Assessments

BIBI Metric Values	2018	2013
Total Taxa	16	9
EPT Taxa	1	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	2.86	2.00
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	1
% Climbers	7.14	1.00

FIBI Metric Values (2018 only)	
Abundance per m²	2.08
Adj. No. of Benthic Species	0.00
% Tolerant	63.19
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	63.19

BIBI Metric Scores		
Total Taxa	3	1
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	3	3
% Climbers	3	3

FIBI Metric Scores (2018 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	1.86	1.57
BIBI Rating	Very Poor	Very Poor

FIBI Score	2.67
FIBI Rating	Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

American Bullfrog

Northern Green Frog

Fish Taxa

Fish Taxa	Number
American eel	3
Eastern mosquitofish	50
Eastern mudminnow	91

Benthic Macroinvertebrate Taxa

2018	Number
Bezzia/Palpomyia	1
Bittacomorpha	1
Caecidotea	1
Corydalidae	1
Crangonyctidae	3
Diptera	3
Gastropoda	4
Ironoquia	2
Lumbricina	4
Lumbriculidae	9
Naididae	4
Nematoda	1
Ostracoda	2
Physa	5
Pilaria	1
Pisidium	16
Sphaeriidae	10
Stenochironomus	2

Original Visit	Number
Bezzia/Palpomyia	3
Cyphon	1
Enchytraeidae	1
Lumbricidae	19
Pisidium	19
Prostoma	1
Pseudorthocladius	2
Synurella	2
Tubificidae	52

Site ID: 08-R3M-02-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Poor
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 269.82

Land Cover	Acres	% Area
Developed Land	187.40	69.45
Forested Land	45.48	16.85
Open Land	36.94	13.69
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	70.11	25.98

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.02
Turbidity (NTU)	3.4
Temperature (°C)	7.4
pH (Standard Units)	6.78
Specific Conductivity (µS/cm)	174

Laboratory Measurements

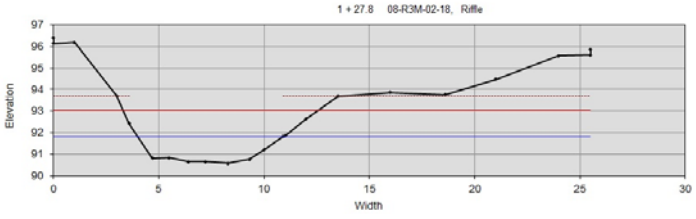
Total Phosphorus (mg/L)	0.040	Chloride (mg/L)	26.074
Total Nitrogen (mg/L)	1.005	Magnesium (mg/L)	2.377
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	11.17
Total Ammonia N (mg/L)	0.035	Total Copper (µg/L)	1.883
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	13.003
Nitrate-N (mg/L)	0.562	Total Lead (µg/L)	0.263
Total Kjehldal N (mg/L)	0.438	Turbidity (NTU)	4.6
Dissolved Organic C (mg/L)	3.876		
Total Organic C (mg/L)	3.948		
Hardness (mg eq. $CaCO_3$/L)	37.68		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.42	Sinuosity	1.31
Bankfull Width (ft)	6.9	D50 (mm)	0.29
Mean Bankfull Depth (ft)	0.9	Adjustments?	None
Floodprone Width (ft)	9.3		
Entrenchment Ratio	1.3		
Width to Depth Ratio	7.5	**Rosgen Stream Type**	**G5c**
Cross Sectional Area (ft²)	6.4		
Water Surface Slope (%)	0.6		

Cross-sectional Survey



Site ID: 08-R3M-02-18

Biological Assessments

BIBI Metric Values

Total Taxa	12
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	73.15

FIBI Metric Values

Abundance per m²	0.52
Adj. No. of Benthic Species	0.00
% Tolerant	29.85
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	29.85

BIBI Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	5

FIBI Metric Scores

Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	1.57
BIBI Rating	Very Poor

FIBI Score	2.67
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Ceratopogoninae	1
Chaetocladius	1
Cheumatopsyche	2
Corynoneura	1
Cryptochironomus	1
Gammaridae	1
Gammarus	6
Naididae	3
Paracladopelma	5
Pisidium	4
Polypedilum	76
Sphaeriidae	2
Tanytarsus	3
Tribelos	2

Fish Taxa

American eel	19
Banded killifish	4
Eastern mosquitofish	24
Eastern mudminnow	20

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	9
Pool Substrate Characterization	9
Pool Variability	12
Sediment Deposition	11
Channel Flow Status	13
Channel Alteration	20
Channel Sinuosity	8
Bank Stability - Right Bank	6
Bank Stability - Left Bank	4
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	7

RBP Habitat Score	127
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.94	48.14
Shading	85	84.56
Epifaunal Substrate	4	42.98
Instream Habitat	5	51.14
Instream Woody Debris	22	100.00
Bank Stability	5.70	53.39

MPHI Habitat Score	63.37
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Mussels

None Observed

Site ID: 08-R3M-03-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Fair
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Low pH; High conductivity; Elevated phosphorus

Land Use/Land Cover Analysis

Total Drainage Area (acres) 332.99

Land Cover	Acres	% Area
Developed Land	217.73	65.39
Forested Land	74.64	22.42
Open Land	40.62	12.20
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	83.78	25.16

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.02
Turbidity (NTU)	4.4
Temperature (°C)	6.9
pH (Standard Units)	5.93
Specific Conductivity (µS/cm)	265

Laboratory Measurements

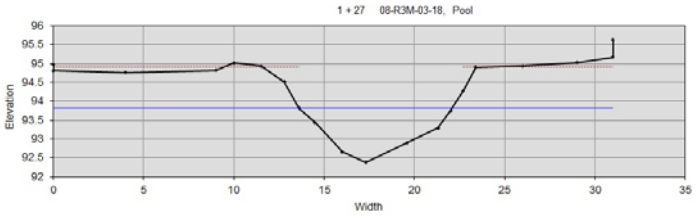
Total Phosphorus (mg/L)	0.033	Chloride (mg/L)	49.634
Total Nitrogen (mg/L)	1.099	Magnesium (mg/L)	4.413
Orthophosphate (mg/L)	<0.003	Calcium (mg/L)	14.31
Total Ammonia N (mg/L)	0.012	Total Copper (µg/L)	1.013
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	15.870
Nitrate-N (mg/L)	0.812	Total Lead (µg/L)	0.195
Total Kjehldal N (mg/L)	0.284	Turbidity (NTU)	6.0
Dissolved Organic C (mg/L)	1.937		
Total Organic C (mg/L)	2.080		
Hardness (mg eq. $CaCO_3$/L)	53.90		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.52	Sinuosity	1.25
Bankfull Width (ft)	8.5	D50 (mm)	0.09
Mean Bankfull Depth (ft)	0.8	Adjustments?	None
Floodprone Width (ft)	115.0		
Entrenchment Ratio	13.5		
Width to Depth Ratio	10.1	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	7.2		
Water Surface Slope (%)	0.44		

Cross-sectional Survey



Site ID: 08-R3M-03-18

Biological Assessments

BIBI Metric Values

Total Taxa	30
EPT Taxa	3
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	3
% Climbers	25.00

FIBI Metric Values

Abundance per m²	1.29
Adj. No. of Benthic Species	0.00
% Tolerant	64.14
% Gen., Omni., Invert.	99.60
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	63.35

BIBI Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	5

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	3.00
BIBI Rating	Fair

FIBI Score	3.00
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Ancyronyx	3
Caloptervx	1
Cheumatopsyche	6
Corvnoneura	1
Cryptochironomus	2
Dicrotendipes	1
Diplocladius	1
Erioptera	1
Gammarus	7
Hemerodromia	1
Hydropsyche	1
Microtendipes	1
Naididae	2
Nematoda	1
Paracladopelma	1
Parametriocnemus	1
Paratanytarsus	5
Phylocentropus	1
Physa	1
Pisidium	1
Polypedilum	25
Rheocricotopus	1
Rheotanytarsus	32
Stenelmis	5
Stictochironomus	1
Tanytarsus	1
Thienemannimyia group	1
Tipula	1
Tribelos	5
Xylotopus	1

Fish Taxa

American eel	31
Banded killifish	3
Bluegill	1
Brown bullhead	1
Chain pickerel	1
Eastern mosquitofish	55
Eastern mudminnow	159

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	8
Pool Substrate Characterization	10
Pool Variability	9
Sediment Deposition	9
Channel Flow Status	20
Channel Alteration	17
Channel Sinuosity	8
Bank Stability - Right Bank	9
Bank Stability - Left Bank	8
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	136
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.48	45.64
Shading	85	84.56
Epifaunal Substrate	9	70.66
Instream Habitat	8	65.64
Instream Woody Debris	25	100.00
Bank Stability	16.47	90.74

MPHI Habitat Score	76.21
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

American Bullfrog

Mussels

None Observed

Site ID: 08-R3M-04-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 648.58

Land Cover

	Acres	% Area
Developed Land	418.01	64.45
Forested Land	189.57	29.23
Open Land	40.79	6.29
Agricultural Land	0.20	0.03

Impervious Surface

	Acres	% Area
Impervious Land	150.51	23.21

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.92
Turbidity (NTU)	3.5
Temperature (°C)	3.7
pH (Standard Units)	7.05
Specific Conductivity (µS/cm)	531

Laboratory Measurements

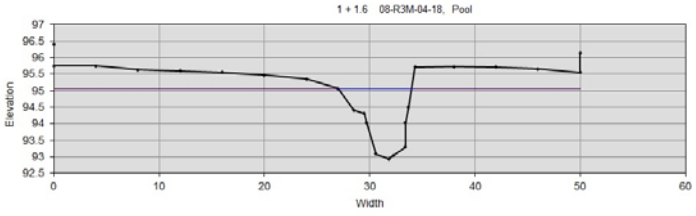
Total Phosphorus (mg/L)	0.010	Chloride (mg/L)	118.591
Total Nitrogen (mg/L)	0.890	Magnesium (mg/L)	7.458
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	19.65
Total Ammonia N (mg/L)	0.228	Total Copper (µg/L)	0.385
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	21.258
Nitrate-N (mg/L)	0.566	Total Lead (µg/L)	0.117
Total Kjehldal N (mg/L)	0.319	Turbidity (NTU)	12.6
Dissolved Organic C (mg/L)	1.299		
Total Organic C (mg/L)	1.446		
Hardness (mg eq. $CaCO_3$/L)	79.78		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.01	Sinuosity	1.71
Bankfull Width (ft)	7.0	D50 (mm)	0.06
Mean Bankfull Depth (ft)	1.2	Adjustments?	None
Floodprone Width (ft)	84.0		
Entrenchment Ratio	12.0		
Width to Depth Ratio	5.6	**Rosgen Stream Type**	**E6**
Cross Sectional Area (ft²)	8.7		
Water Surface Slope (%)	1.1		

Cross-sectional Survey



Site ID: 08-R3M-04-18

Biological Assessments

BIBI Metric Values

Total Taxa	24
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	0.95
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	7.62

FIBI Metric Values

Abundance per m²	0.42
Adj. No. of Benthic Species	0.00
% Tolerant	32.61
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	41.30

BIBI Metric Scores

Total Taxa	5
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	5
% Climbers	3

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	2.00
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Ceratopogoninae	2
Cheumatopsyche	10
Corydalidae	1
Dasyhelea	1
Diplocladius	4
Enchytraeidae	1
Gymnometriocnemus	1
Hemerodromia	1
Lymnaeidae	1
Naididae	12
Nematoda	1
Orthocladius	2
Parametriocnemus	3
Paratendipes	1
Phaenopsectra	1
Physa	6
Polypedilum	1
Prostoma	10
Pseudorthocladius	5
Rheotanytarsus	3
Sphaeriidae	2
Stenochironomus	7
Thienemanniella	2
Thienemannimyia group	26
Tipula	1

Fish Taxa

American eel	7
Bluegill	2
Eastern mosquitofish	5
Eastern mudminnow	6
Golden shiner	2
Mummichog	19
Pumpkinseed	5

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	11
Pool Substrate Characterization	13
Pool Variability	10
Sediment Deposition	11
Channel Flow Status	14
Channel Alteration	20
Channel Sinuosity	12
Bank Stability - Right Bank	6
Bank Stability - Left Bank	6
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	141
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.30	44.71
Shading	70	68.32
Epifaunal Substrate	8	60.51
Instream Habitat	7	53.26
Instream Woody Debris	19	100.00
Bank Stability	10.00	70.71

MPHI Habitat Score	66.25
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Two-lined Salamander

Eastern Box Turtle

Northern Water Snake

Mussels

None Observed

Site ID: 08-R3M-05-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 171.16

Land Cover	Acres	% Area
Developed Land	131.76	76.98
Forested Land	18.31	10.70
Open Land	21.08	12.32
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	50.11	29.28

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	8.79
Turbidity (NTU)	9.9
Temperature (°C)	8.6
pH (Standard Units)	6.97
Specific Conductivity (µS/cm)	234

Laboratory Measurements

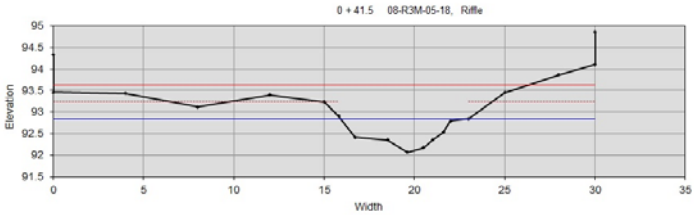
Total Phosphorus (mg/L)	0.132	Chloride (mg/L)	37.691
Total Nitrogen (mg/L)	1.147	Magnesium (mg/L)	2.095
Orthophosphate (mg/L)	0.007	Calcium (mg/L)	14.35
Total Ammonia N (mg/L)	0.043	Total Copper (µg/L)	2.640
Nitrite-N (mg/L)	0.009	Total Zinc (µg/L)	14.454
Nitrate-N (mg/L)	0.151	Total Lead (µg/L)	0.513
Total Kjehldal N (mg/L)	0.987	Turbidity (NTU)	13.8
Dissolved Organic C (mg/L)	7.557		
Total Organic C (mg/L)	7.946		
Hardness (mg eq. $CaCO_3$/L)	44.46		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.27	Sinuosity	1.19
Bankfull Width (ft)	7.1	D50 (mm)	0.08
Mean Bankfull Depth (ft)	0.4	Adjustments?	None
Floodprone Width (ft)	27.8		
Entrenchment Ratio	3.9		
Width to Depth Ratio	16.7	**Rosgen Stream Type**	**C5**
Cross Sectional Area (ft²)	3.0		
Water Surface Slope (%)	0.78		

Cross-sectional Survey



Site ID: 08-R3M-05-18

Biological Assessments

BIBI Metric Values

Total Taxa	13
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	7.41
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	2.78

FIBI Metric Values

Abundance per m²	3.50
Adj. No. of Benthic Species	0.00
% Tolerant	2.07
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	96.64

BIBI Metric Scores

Total Taxa	1
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	3
% Climbers	3

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.57
BIBI Rating	Very Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Amphipoda	2
Caecidotea	2
Enchytraeidae	2
Glyptotendipes	6
Lumbricina	1
Lumbriculidae	13
Naididae	42
Nematoda	2
Physa	2
Pilaria	1
Pisidium	6
Polypedilum	1
Sphaeriidae	12
Synurella	6
Turbellaria	10

Fish Taxa

American eel	4
Banded killifish	1
Bluegill	1
Eastern mosquitofish	374
Eastern mudminnow	7

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	4
Pool Substrate Characterization	12
Pool Variability	7
Sediment Deposition	7
Channel Flow Status	13
Channel Alteration	16
Channel Sinuosity	9
Bank Stability - Right Bank	9
Bank Stability - Left Bank	9
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	9
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	120
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.95	42.78
Shading	85	84.56
Epifaunal Substrate	7	63.38
Instream Habitat	6	61.35
Instream Woody Debris	14	100.00
Bank Stability	18.27	95.57

MPHI Habitat Score	74.61
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Eastern Spadefoot

American Bullfrog

Northern Green Frog

Common Five-lined Skink

Mussels

None Observed

Site ID 19-L1M-01-18

Revist of site R1-19-09

Upstream View - 2018

Downstream View - 2018

Upstream View - 2005

Downstream View - 2005

Summary Results

	2018 Data	2005 Data
Benthic Macroinvertebrate Community	Fair	Good
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Elevated nutrients	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 3685.28

Land Cover	2018 Acres	2005 Acres	2018 % Area	2005 % Area
Developed Land	1074.52	841.09	29.16	23.10
Forested Land	1707.78	1929.78	46.34	53.00
Open Land	131.37	200.26	3.56	5.50
Agricultural Land	771.61	673.60	20.94	18.50

Impervious Surface	2018 Acres	2005 Acres	2018 % Area	2005 % Area
Impervious Land	176.42	163.85	4.79	4.50

Site ID 19-L1M-01-18

Revist of site R1-19-09

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2005 Spring
Dissolved Oxygen (mg/L)	12.86	8.26	6.15
Turbidity (NTU)	2.6	3.4	11.4
Temperature (°C)	8.1	22.1	12.51
pH (Standard Units)	7.41	7.39	6.79
Specific Conductivity (µS/cm)	207	219	149

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.104	Chloride (mg/L)	31.795
Total Nitrogen (mg/L)	0.575	Magnesium (mg/L)	2.793
Orthophosphate (mg/L)	0.027	Calcium (mg/L)	17.58
Total Ammonia N (mg/L)	0.008	Total Copper (µg/L)	0.298
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	4.975
Nitrate-N (mg/L)	0.378	Total Lead (µg/L)	0.050
Total Kjehldal N (mg/L)	0.193	Turbidity (NTU)	3.3
Dissolved Organic C (mg/L)	2.588		
Total Organic C (mg/L)	2.643		
Hardness (mg eq. $CaCO_3$/L)	55.40		

Geomorphic Assessment

Rosgen Level II Classification Data

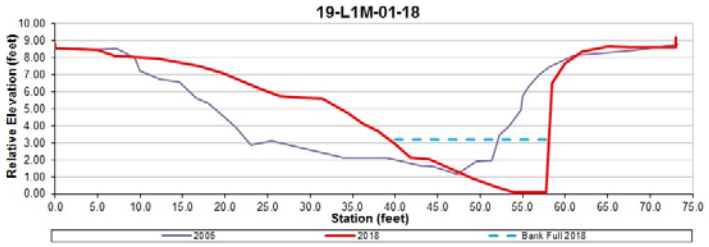
	2018	2005
Drainage Area (mi²)	5.76	
Bankfull Width (ft)	18.0	29.5
Mean Bankfull Depth (ft)	1.9	0.9
Floodprone Width (ft)	18.0	36.1
Entrenchment Ratio	1.0	1.2
Width to Depth Ratio	9.7	32.0
Cross Sectional Area (ft²)	33.5	27.2
Water Surface Slope (%)	0.220	0.100

	2018	2005
Sinuosity	1.59	1.20
D50 (mm)	7.10	1.25
Adjustments?	None	↓ER, ↑Sin

Rosgen Stream Type

2018	2005
G4c	**F5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2005 Spring Value	2005 Spring Score
Remoteness	9.59	51.66	n/a	37.50
Shading	60	58.94	80	78.67
Epifaunal Substrate	11	66.62	11	66.70
Instream Habitat	13	68.77	13	68.90
Instream Woody Debris	21	90.87	11	61.42
Bank Stability	13.87	83.27	n/a	89.45

	2018 Score	2005 Score
MPHI Habitat Score	70.02	67.10
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2018 Score	2005 Score		2018 Score	2005 Score
Epifaunal Substrate/Available Cover	17	11	Bank Stability - Right Bank	3	6
Pool Substrate Characterization	15	11	Bank Stability - Left Bank	5	6
Pool Variability	17	15	Vegetative Protection - Right Bank	6	7
Sediment Deposition	10	8	Vegetative Protection - Left Bank	7	7
Channel Flow Status	15	12	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	10	14			

	2018 Score	2005 Score
RBP Habitat Score	145	136
RBP Rating	Supporting	Supporting

Site ID 19-L1M-01-18

Revist of site R1-19-09

Biological Assessments

BIBI Metric Values	2018	2005
Total Taxa	20	27
EPT Taxa	6	9
Ephemeroptera Taxa	2	2
% Intolerant to Urban	12.62	53.68
% Ephemeroptera	8.74	12.63
Scraper Taxa	1	1
% Climbers	20.39	12.60

FIBI Metric Values (2018 only)	
Abundance per m²	1.84
Adj. No. of Benthic Species	1.43
% Tolerant	37.04
% Gen., Omni., Invert.	85.77
% Round-bodied Suckers	0.19
% Abund. Dominant Taxon	21.64

BIBI Metric Scores		
Total Taxa	3	5
EPT Taxa	5	5
Ephemeroptera Taxa	5	5
% Intolerant to Urban	3	5
% Ephemeroptera	3	5
Scraper Taxa	3	3
% Climbers	5	5

FIBI Metric Scores (2018 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.86	4.71
BIBI Rating	Fair	Good

FIBI Score	4.33
FIBI Rating	Good

Supplemental Flora and Fauna (2018 only)

Crayfish

Orconectes limosus

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

American Bullfrog

Northern Green Frog

Fish Taxa	Number
American eel	11
Blacknose dace	66
Bluegill	1
Creek chubsucker	1
Fallfish	55
Glassy darter	2
Green sunfish	17
Largemouth bass	1
Least brook lamprey	14
Rosyside dace	72
Sea lamprey	56
Spottail shiner	1
Swallowtail shiner	111
Tessellated darter	87
White sucker	18

Benthic Macroinvertebrate Taxa

2018	Number
Acerpenna	8
Amphipoda	1
Calopteryx	1
Crangonyctidae	2
Eukiefferiella	1
Gammarus	1
Hydrobaenus	25
Ironoquia	1
Isoperla	2
Leptophlebiidae	1
Leuctra	1
Microtendipes	0
Orthocladiinae	1
Orthocladius	17
Parametriocnemus	2
Polypedilum	16
Prosimulium	1
Rheotanytarsus	6
Simuliidae	3
Simulium	7
Tanytarsus	4
Trichoptera	1
Zavrelimyia	1

Original Visit	Number
Turbellaria	1
Acerpenna	7
Ephemerella	5
Amphinemura	3
Clioperla	1
Isoperla	23
Enochrus	1
Helichus	1
Diplocladius	2
Nanocladius	1
Parakiefferiella	6
Paratanytarsus	7
Polypedilum	6
Tanytarsus	5
Thienemannimyia group	3
Tvetenia	1
Hemerodromia	2
Hexatoma	1
Simulium	2
Tabanus	1
Cheumatopsyche	1
Hydatophylax	1
Ironoquia	7
Polycentropus	1
Oligochaeta	2
Caecidotea	1
Gammarus	2

Site ID 19-L1M-03-18

Revist of site R1-19-06

Upstream View - 2018

Downstream View - 2018

Upstream View - 2005

Downstream View - 2005

Summary Results

	2018 Data	2005 Data
Benthic Macroinvertebrate Community	Good	Fair
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	Elevated nutrients	Low pH; Low DO

Land Use/Land Cover Analysis

Total Drainage Area (acres) 393.70

Land Cover	2018 Acres	2005 Acres	2018 % Area	2005 % Area
Developed Land	99.44	76.10	25.26	21.00
Forested Land	153.15	155.47	38.90	42.90
Open Land	4.08	43.49	1.04	12.00
Agricultural Land	137.02	87.70	34.80	24.20

Impervious Surface	2018 Acres	2005 Acres	2018 % Area	2005 % Area
Impervious Land	15.53	12.68	3.95	3.50

Site ID 19-L1M-03-18

Revist of site R1-19-06

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2005 Spring
Dissolved Oxygen (mg/L)	12.61	8.41	4.68
Turbidity (NTU)	1.8	2	16
Temperature (°C)	5.4	20.6	14.8
pH (Standard Units)	6.98	7.04	4.52
Specific Conductivity (µS/cm)	187	168	97

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.080	Chloride (mg/L)	21.871
Total Nitrogen (mg/L)	1.126	Magnesium (mg/L)	3.545
Orthophosphate (mg/L)	0.015	Calcium (mg/L)	17.53
Total Ammonia N (mg/L)	0.014	Total Copper (µg/L)	0.342
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	12.937
Nitrate-N (mg/L)	0.933	Total Lead (µg/L)	0.055
Total Kjehldal N (mg/L)	0.190	Turbidity (NTU)	2.9
Dissolved Organic C (mg/L)	1.857		
Total Organic C (mg/L)	1.919		
Hardness (mg eq. $CaCO_3$/L)	58.37		

Geomorphic Assessment

Rosgen Level II Classification Data

	2018	2005
Drainage Area (mi²)	0.62	
Bankfull Width (ft)	14.7	5.5
Mean Bankfull Depth (ft)	0.7	1.2
Floodprone Width (ft)	19.4	10.3
Entrenchment Ratio	1.3	1.9
Width to Depth Ratio	19.9	4.8
Cross Sectional Area (ft²)	10.9	6.4
Water Surface Slope (%)	0.310	1.100

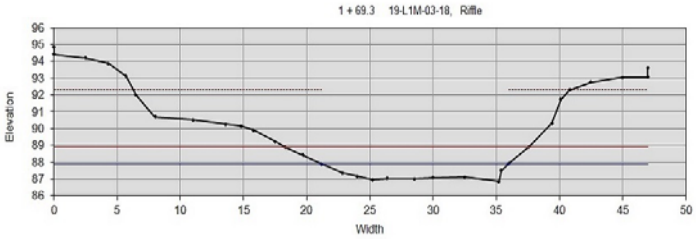
	2018	2005
Sinuosity	1.17	1.00
D50 (mm)	2.00	1.00
Adjustments?	None	↑W/D

Rosgen Stream Type

2018	2005
F4/5	**B5c**

Cross-sectional Survey

(R1 XS not located)



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2005 Spring Value	2005 Spring Score
Remoteness	14.66	78.93	n/a	81.26
Shading	95	99.94	80	78.67
Epifaunal Substrate	6	52.14	7	58.49
Instream Habitat	6	52.82	2	31.48
Instream Woody Debris	20	100.00	3	63.87
Bank Stability	13.30	81.55	n/a	70.71

	2018 Score	2005 Score
MPHI Habitat Score	77.56	64.08
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2018 Score	2005 Score		2018 Score	2005 Score
Epifaunal Substrate/Available Cover	12	7	Bank Stability - Right Bank	6	4
Pool Substrate Characterization	9	8	Bank Stability - Left Bank	6	4
Pool Variability	8	1	Vegetative Protection - Right Bank	7	5
Sediment Deposition	7	10	Vegetative Protection - Left Bank	6	5
Channel Flow Status	11	9	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	11			

	2018 Score	2005 Score
RBP Habitat Score	120	103
RBP Rating	Partially Supporting	Partially Supporting

Site ID 19-L1M-03-18

Revist of site R1-19-06

Biological Assessments

BIBI Metric Values	2018	2005
Total Taxa	25	23
EPT Taxa	8	3
Ephemeroptera Taxa	2	0
% Intolerant to Urban	22.50	31.96
% Ephemeroptera	13.33	0.00
Scraper Taxa	4	1
% Climbers	34.17	6.18

FIBI Metric Values (2018 only)	
Abundance per m²	0.49
Adj. No. of Benthic Species	1.17
% Tolerant	68.06
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	63.89

BIBI Metric Scores		
Total Taxa	5	5
EPT Taxa	5	3
Ephemeroptera Taxa	5	1
% Intolerant to Urban	3	5
% Ephemeroptera	5	1
Scraper Taxa	5	3
% Climbers	5	3

FIBI Metric Scores (2018 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	4.71	3.00
BIBI Rating	Good	Fair

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Wood Frog

Fish Taxa	Number
American eel	8
Blacknose dace	46
Fallfish	8
Rosyside dace	7
Tessellated darter	3

Benthic Macroinvertebrate Taxa

2018	Number
Acerpenna	14
Amphinemura	1
Ceratopogoninae	5
Cryptochironomus	1
Diplectrona	4
Eukiefferiella	1
Hydrobaenus	6
Hydropsyche	1
Isoperla	1
Maccaffertium	2
Micropsectra	1
Nemouridae	1
Neophylax	2
Orthocladius	12
Parametriocnemus	11
Paratanytarsus	5
Polypedilum	25
Pseudorthocladius	1
Rheotanytarsus	2
Tabanidae	1
Tanytarsus	15
Thienemannimyia group	3
Tvetenia	5

Original Visit	Number
Amphinemura	5
Leuctra	1
Cyphon	1
Corynoneura	1
Cricotopus	1
Diplocladius	1
Heterotrissocladius	1
Micropsectra	1
Cricotopus/orthocladius	5
Parametriocnemus	7
Phaenopsectra	1
Polypedilum	4
Pseudorthocladius	2
Rheotanytarsus	1
Thienemannimyia group	1
Zavrelimyia	1
Culicoides	2
Molophilus	4
Simulium	21
Stegopterna	16
Diplectrona	6
Oligochaeta	13
Pedicia	1

Site ID 19-L2M-01-18

Revist of site R2-19-07

Upstream View - 2018

Downstream View - 2018

Upstream View - 2013

Downstream View - 2013

Summary Results

	2018 Data	2013 Data
Benthic Macroinvertebrate Community	Good	Poor
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Comparable to Reference	Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Low pH; Elevated nutrients	Within acceptable range

Land Use/Land Cover Analysis

Total Drainage Area (acres) 3354.22

Land Cover	2018 Acres	2013 Acres	2018 % Area	2013 % Area
Developed Land	987.79	850.19	29.45	25.38
Forested Land	1537.82	1670.62	45.85	49.88
Open Land	113.03	249.83	3.37	7.46
Agricultural Land	715.58	578.82	21.33	17.28

Impervious Surface	2018 Acres	2013 Acres	2018 % Area	2013 % Area
Impervious Land	163.79	134.52	4.88	4.02

Site ID 19-L2M-01-18

Revist of site R2-19-07

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2013 Spring
Dissolved Oxygen (mg/L)	12.99	7.55	12.81
Turbidity (NTU)	2.2	4.1	5.41
Temperature (°C)	2.4	20.3	12.2
pH (Standard Units)	6.06	7.55	7.63
Specific Conductivity (µS/cm)	239	212	183.3

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.081	Chloride (mg/L)	32.259
Total Nitrogen (mg/L)	1.107	Magnesium (mg/L)	2.780
Orthophosphate (mg/L)	0.024	Calcium (mg/L)	18.49
Total Ammonia N (mg/L)	0.008	Total Copper (µg/L)	0.271
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	7.705
Nitrate-N (mg/L)	0.937	Total Lead (µg/L)	0.059
Total Kjehldal N (mg/L)	0.165	Turbidity (NTU)	4.8
Dissolved Organic C (mg/L)	2.256		
Total Organic C (mg/L)	2.364		
Hardness (mg eq. $CaCO_3$/L)	57.62		

Geomorphic Assessment

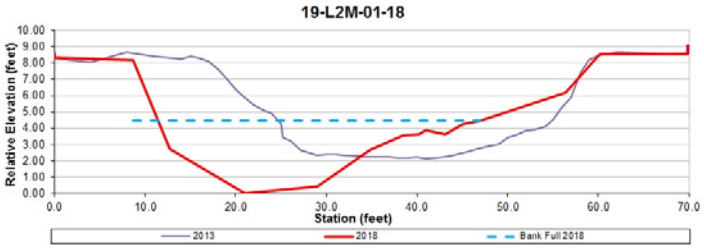
Rosgen Level II Classification Data

	2018	2013		2018	2013
Drainage Area (mi²)	5.24		Sinuosity	1.52	1.30
Bankfull Width (ft)	35.6	27.9	D50 (mm)	0.28	1.30
Mean Bankfull Depth (ft)	2.4	1.3	Adjustments?	None	None
Floodprone Width (ft)	236.0	35.1			
Entrenchment Ratio	6.6	1.3			
Width to Depth Ratio	14.6	21.5			
Cross Sectional Area (ft²)	86.6	36.1			
Water Surface Slope (%)	0.330	0.280			

Rosgen Stream Type

2018	2013
ND	**F4/5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2013 Spring Value	2013 Spring Score
Remoteness	6.66	35.86	11.00	59.24
Shading	75	73.32	70	68.32
Epifaunal Substrate	14	84.66	13	78.86
Instream Habitat	15	80.83	13	69.75
Instream Woody Debris	17	80.10	16	77.16
Bank Stability	12.00	77.46	8.00	63.25

	2018 Score	2013 Score
MPHI Habitat Score	72.04	69.43
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2018 Score	2013 Score		2018 Score	2013 Score
Epifaunal Substrate/Available Cover	17	13	Bank Stability - Right Bank	6	5
Pool Substrate Characterization	15	11	Bank Stability - Left Bank	6	3
Pool Variability	16	13	Vegetative Protection - Right Bank	9	4
Sediment Deposition	14	13	Vegetative Protection - Left Bank	8	7
Channel Flow Status	14	14	Riparian Veg. Zone Width - Right Bank	10	9
Channel Alteration	20	18	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	10	15			

	2018 Score	2013 Score
RBP Habitat Score	155	135
RBP Rating	Comparable to Reference	Supporting

Site ID 19-L2M-01-18

Revist of site R2-19-07

Biological Assessments

BIBI Metric Values	2018	2013
Total Taxa	22	11
EPT Taxa	6	5
Ephemeroptera Taxa	2	1
% Intolerant to Urban	19.27	8.30
% Ephemeroptera	10.09	1.04
Scraper Taxa	5	1
% Climbers	29.36	0.00

FIBI Metric Values (2018 only)	
Abundance per m²	2.29
Adj. No. of Benthic Species	0.99
% Tolerant	35.43
% Gen., Omni., Invert.	89.35
% Round-bodied Suckers	0.70
% Abund. Dominant Taxon	30.72

BIBI Metric Scores		
Total Taxa	5	1
EPT Taxa	5	5
Ephemeroptera Taxa	5	3
% Intolerant to Urban	3	1
% Ephemeroptera	3	3
Scraper Taxa	5	3
% Climbers	5	1

FIBI Metric Scores (2018 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	4.43	2.43
BIBI Rating	Good	Poor

FIBI Score	4.33
FIBI Rating	Good

Supplemental Flora and Fauna (2018 only)

Crayfish

Orconectes limosus

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

American Bullfrog

Northern Green Frog

Fish Taxa	Number
American eel	6
Blacknose dace	84
Bluegill	6
Creek chubsucker	4
Eastern mudminnow	1
Fallfish	30
Green sunfish	15
Largemouth bass	1
Least brook lamprey	38
Rosyside dace	94
Sea lamprey	22
Swallowtail shiner	176
Tessellated darter	81
White sucker	15

Benthic Macroinvertebrate Taxa

2018	Number
Acerpenna	10
Brillia	1
Cladotanytarsus	1
Dubiraphia	1
Hexatoma	1
Hydrobaenus	23
Isoperla	1
Limnephilidae	2
Maccaffertium	1
Menetus	1
Microtendipes	2
Nemouridae	1
Orthocladius	18
Polypedilum	8
Prosimulium	7
Rheotanytarsus	3
Stenelmis	1
Stictochironomus	1
Strophopteryx	2
Tanytarsus	20
Tvetenia	3
Zavrelimyia	1

Original Visit	Number
Acerpenna	1
Amphinemura	1
Caecidotea	1
Cheumatopsyche	2
Cricotopus/Orthocladius	2
Diplocladius	2
Gammarus	2
Hydrobaenus	75
Isoperla	4
Oemopteryx	1
Orthocladiinae	2
Orthocladius	1
Tubificidae	2

Site ID 19-L2M-07-18

Revist of site R2-19-10

Upstream View - 2018

Downstream View - 2018

Upstream View - 2013

Downstream View - 2013

Summary Results

	2018 Data	2013 Data
Benthic Macroinvertebrate Community	Poor	Very Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nutrients	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 68.37

Land Cover	2018 Acres	2013 Acres	2018 % Area	2013 % Area
Developed Land	36.44	34.66	53.29	39.69
Forested Land	9.10	16.27	13.31	18.63
Open Land	9.16	17.25	13.40	19.75
Agricultural Land	13.67	19.15	20.00	21.93

Impervious Surface	2018 Acres	2013 Acres	2018 % Area	2013 % Area
Impervious Land	5.17	5.89	7.56	6.75

Site ID 19-L2M-07-18

Revist of site R2-19-10

Water Chemistry

In Situ Measurements

	2018 Spring	2018 Summer	2013 Spring
Dissolved Oxygen (mg/L)	10.92	7.92	12.27
Turbidity (NTU)	5.6	7.9	11.1
Temperature (°C)	11.3	21.1	5.9
pH (Standard Units)	6.82	6.87	6.29
Specific Conductivity (µS/cm)	275	226	272.37

Laboratory Measurements (collected 2018 only)

Total Phosphorus (mg/L)	0.156	Chloride (mg/L)	50.110
Total Nitrogen (mg/L)	1.197	Magnesium (mg/L)	3.020
Orthophosphate (mg/L)	0.019	Calcium (mg/L)	19.60
Total Ammonia N (mg/L)	0.153	Total Copper (µg/L)	0.340
Nitrite-N (mg/L)	0.013	Total Zinc (µg/L)	9.224
Nitrate-N (mg/L)	0.634	Total Lead (µg/L)	0.093
Total Kjehldal N (mg/L)	0.551	Turbidity (NTU)	7.4
Dissolved Organic C (mg/L)	3.260		
Total Organic C (mg/L)	3.392		
Hardness (mg eq. $CaCO_3$/L)	61.38		

Geomorphic Assessment

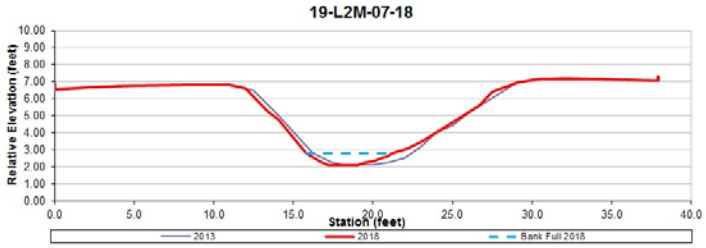
Rosgen Level II Classification Data

	2018	2013		2018	2013
Drainage Area (mi²)	0.11		Sinuosity	1.20	1.10
Bankfull Width (ft)	5.4	6.3	D50 (mm)	0.70	0.06
Mean Bankfull Depth (ft)	0.5	0.5	Adjustments?	None	W/D -0.3
Floodprone Width (ft)	8.0	8.0			
Entrenchment Ratio	1.5	1.3			
Width to Depth Ratio	10.7	12.3			
Cross Sectional Area (ft²)	2.7	3.2			
Water Surface Slope (%)	0.910	0.630			

Rosgen Stream Type

2018	2013
G5c	**G6c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2018 Summer Value	2018 Summer Score	2013 Spring Value	2013 Spring Score
Remoteness	14.52	78.21	13.00	70.01
Shading	95	99.94	50	49.95
Epifaunal Substrate	5	57.73	7	67.76
Instream Habitat	5	65.19	5	62.69
Instream Woody Debris	13	100.00	12	100.00
Bank Stability	5.00	50.00	10.00	70.71

	2018 Score	2013 Score
MPHI Habitat Score	75.18	70.19
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2018 Score	2013 Score		2018 Score	2013 Score
Epifaunal Substrate/Available Cover	6	6	Bank Stability - Right Bank	8	6
Pool Substrate Characterization	3	7	Bank Stability - Left Bank	7	4
Pool Variability	6	7	Vegetative Protection - Right Bank	8	8
Sediment Deposition	16	10	Vegetative Protection - Left Bank	8	6
Channel Flow Status	13	16	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	16	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	9			

	2018 Score	2013 Score
RBP Habitat Score	122	115
RBP Rating	Partially Supporting	Partially Supporting

Site ID 19-L2M-07-18

Revist of site R2-19-10

Biological Assessments

BIBI Metric Values	2018	2013
Total Taxa	17	15
EPT Taxa	1	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	1.80	5.90
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	9.01	1.98

FIBI Metric Values (2018 only)	
Abundance per m²	0.11
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	100.00

BIBI Metric Scores		
Total Taxa	3	3
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	1
% Ephemeroptera	1	1
Scraper Taxa	3	1
% Climbers	5	3

FIBI Metric Scores (2018 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.14	1.57
BIBI Rating	Poor	Very Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Flora and Fauna (2018 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

American Toad

Fish Taxa	Number
Blacknose dace	7

Benthic Macroinvertebrate Taxa

2018	Number
Bezzia/Palpomyia	7
Chaetocladius	19
Chrysops	2
Diplocladius	10
Gammaridae	4
Gammarus	13
Ironoquia	4
Naididae	3
Orthocladius	3
Parametriocnemus	24
Physa	7
Pilaria	2
Pisidium	2
Polypedilum	3
Prostoma	2
Sphaeriidae	1
Thienemannimyia group	3
Tipula	1
Zavrelimyia	1

Original Visit	Number
Caecidotea	1
Chrysops	1
Crangonyx	5
Cricotopus/Orthocladius	8
Diplocladius	48
Enchytraeidae	1
Gastropoda	1
Micropsectra	1
Naididae	6
Orthocladiinae	1
Paraphaenocladius	1
Pisidium	17
Polypedilum	1
Stegopterna	3
Thienemannimyia group	1
Tubificidae	5

Site ID: 19-R3M-01-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Low pH; High conductivity; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 246.60

Land Cover

	Acres	% Area
Developed Land	126.57	51.33
Forested Land	41.49	16.83
Open Land	6.23	2.53
Agricultural Land	72.30	29.32

Impervious Surface

	Acres	% Area
Impervious Land	26.05	10.56

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.5
Turbidity (NTU)	8.9
Temperature (°C)	12.1
pH (Standard Units)	6.46
Specific Conductivity (µS/cm)	380

Laboratory Measurements

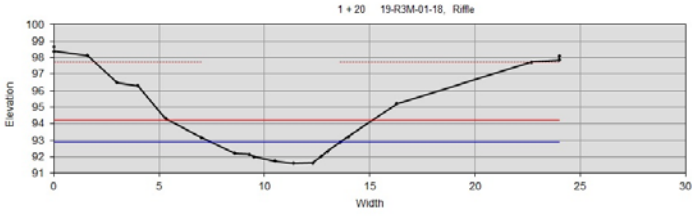
Total Phosphorus (mg/L)	0.104	Chloride (mg/L)	77.757
Total Nitrogen (mg/L)	2.620	Magnesium (mg/L)	3.633
Orthophosphate (mg/L)	0.013	Calcium (mg/L)	24.93
Total Ammonia N (mg/L)	0.044	Total Copper (µg/L)	0.389
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	13.583
Nitrate-N (mg/L)	2.405	Total Lead (µg/L)	0.258
Total Kjehldal N (mg/L)	0.209	Turbidity (NTU)	9.8
Dissolved Organic C (mg/L)	1.520		
Total Organic C (mg/L)	1.519		
Hardness (mg eq. $CaCO_3$/L)	77.21		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.39	Sinuosity	1.12
Bankfull Width (ft)	6.1	D50 (mm)	0.18
Mean Bankfull Depth (ft)	0.8	Adjustments?	None
Floodprone Width (ft)	9.6		
Entrenchment Ratio	1.6		
Width to Depth Ratio	7.3	**Rosgen Stream Type**	**G4c**
Cross Sectional Area (ft²)	5.1		
Water Surface Slope (%)	0.44		

Cross-sectional Survey



Site ID: 19-R3M-01-18

Biological Assessments

BIBI Metric Values

Total Taxa	15
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	10.91

FIBI Metric Values

Abundance per m²	0.55
Adj. No. of Benthic Species	1.73
% Tolerant	97.30
% Gen., Omni., Invert.	97.30
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	77.03

BIBI Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	3
% Climbers	5

FIBI Metric Scores

Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	2.67
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Bezzia/Palpomyia	2
Cryptochironomus	1
Diplocladius	4
Gammarus	1
Lumbriculidae	9
Naididae	16
Orthocladius	8
Parametriocnemus	5
Physa	1
Pisidium	30
Polypedilum	10
Ptilostomis	1
Rheocricotopus	1
Sphaeriidae	19
Thienemannimyia group	1
Tipula	1

Fish Taxa

Blacknose dace	57
Green sunfish	1
Largemouth bass	2
Swallowtail shiner	2
Tessellated darter	12

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	7
Pool Variability	7
Sediment Deposition	9
Channel Flow Status	13
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	5
Bank Stability - Left Bank	3
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	6
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	1

RBP Habitat Score	103
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	10.45	56.27
Shading	80	78.67
Epifaunal Substrate	6	55.19
Instream Habitat	5	52.06
Instream Woody Debris	23	100.00
Bank Stability	9.97	70.59

MPHI Habitat Score	68.80
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Two-lined Salamander

Northern Green Frog

Eastern American Toad

Mussels

None Observed

Site ID: 19-R3M-03-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Very Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 93.76

Land Cover	Acres	% Area
Developed Land	60.44	64.47
Forested Land	9.64	10.28
Open Land	5.61	5.98
Agricultural Land	18.07	19.27

Impervious Surface	Acres	% Area
Impervious Land	14.20	15.15

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.01
Turbidity (NTU)	7
Temperature (°C)	9
pH (Standard Units)	6.51
Specific Conductivity (µS/cm)	462

Laboratory Measurements

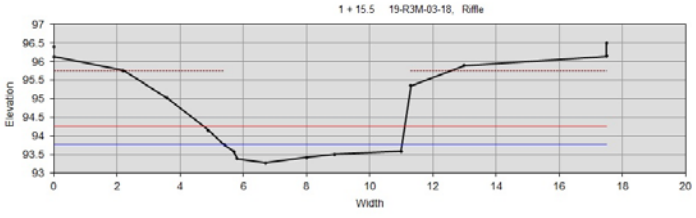
Total Phosphorus (mg/L)	0.063	Chloride (mg/L)	105.915
Total Nitrogen (mg/L)	1.372	Magnesium (mg/L)	4.318
Orthophosphate (mg/L)	0.006	Calcium (mg/L)	24.77
Total Ammonia N (mg/L)	0.044	Total Copper (µg/L)	0.460
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	21.869
Nitrate-N (mg/L)	1.113	Total Lead (µg/L)	0.220
Total Kjehldal N (mg/L)	0.257	Turbidity (NTU)	5.6
Dissolved Organic C (mg/L)	1.275		
Total Organic C (mg/L)	1.280		
Hardness (mg eq. $CaCO_3$/L)	79.63		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.15	Sinuosity	1.25
Bankfull Width (ft)	5.6	D50 (mm)	0.20
Mean Bankfull Depth (ft)	0.3	Adjustments?	None
Floodprone Width (ft)	6.4		
Entrenchment Ratio	1.1		
Width to Depth Ratio	18.4	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	1.7		
Water Surface Slope (%)	0.87		

Cross-sectional Survey



Site ID: 19-R3M-03-18

Biological Assessments

BIBI Metric Values

Total Taxa	17
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	1.83
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	5.50

FIBI Metric Values

Abundance per m²	No Fish
Adj. No. of Benthic Species	No Fish
% Tolerant	No Fish
% Gen., Omni., Invert.	No Fish
% Round-bodied Suckers	No Fish
% Abund. Dominant Taxon	No Fish

BIBI Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	3

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	1.57
BIBI Rating	Very Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Ceratopogoninae	1
Chrysops	1
Cryptochironomus	4
Diplocladius	1
Enchytraeidae	1
Erioptera	1
Gammaridae	11
Gammarus	3
Naididae	31
Orthocladius	1
Parametriocnemus	1
Pisidium	19
Polypedilum	6
Rheocricotopus	2
Sphaeriidae	10
Stegopterna	1
Thienemannimyia group	2
Tipula	1
Tribelos	1
Veneroida	11

Fish Taxa

NO FISH

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	8
Pool Variability	8
Sediment Deposition	9
Channel Flow Status	9
Channel Alteration	20
Channel Sinuosity	8
Bank Stability - Right Bank	5
Bank Stability - Left Bank	4
Vegetative Protection - Right Bank	7
Vegetative Protection - Left Bank	6
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	110
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	10.20	54.93
Shading	80	78.67
Epifaunal Substrate	3	44.06
Instream Habitat	4	56.41
Instream Woody Debris	13	100.00
Bank Stability	11.67	76.38

MPHI Habitat Score	68.41
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Pickerel Frog

Mussels

None Observed

Site ID: 19-R3M-06-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Very Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 105.40

Land Cover	Acres	% Area
Developed Land	61.56	58.41
Forested Land	14.39	13.65
Open Land	5.61	5.32
Agricultural Land	23.84	22.62

Impervious Surface	Acres	% Area
Impervious Land	14.77	14.01

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.26
Turbidity (NTU)	7
Temperature (°C)	7.9
pH (Standard Units)	6.47
Specific Conductivity (µS/cm)	409

Laboratory Measurements

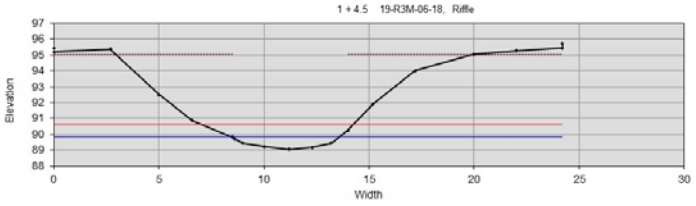
Total Phosphorus (mg/L)	0.077	Chloride (mg/L)	88.263
Total Nitrogen (mg/L)	1.802	Magnesium (mg/L)	4.019
Orthophosphate (mg/L)	0.008	Calcium (mg/L)	23.64
Total Ammonia N (mg/L)	0.047	Total Copper (µg/L)	0.499
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	20.616
Nitrate-N (mg/L)	1.648	Total Lead (µg/L)	0.271
Total Kjehldal N (mg/L)	0.151	Turbidity (NTU)	6.6
Dissolved Organic C (mg/L)	1.380		
Total Organic C (mg/L)	1.485		
Hardness (mg eq. $CaCO_3$/L)	75.58		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.16	Sinuosity	1.04
Bankfull Width (ft)	5.1	D50 (mm)	0.09
Mean Bankfull Depth (ft)	0.5	Adjustments?	None
Floodprone Width (ft)	7.2		
Entrenchment Ratio	1.4		
Width to Depth Ratio	9.2	**Rosgen Stream Type**	**G5c**
Cross Sectional Area (ft²)	2.8		
Water Surface Slope (%)	0.36		

Cross-sectional Survey



Site ID: 19-R3M-06-18

Biological Assessments

BIBI Metric Values

Total Taxa	17
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	4.55
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	10.91

FIBI Metric Values

Abundance per m²	0.03
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	100.00

BIBI Metric Scores

Total Taxa	3
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	3
% Climbers	5

FIBI Metric Scores

Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Bezzia/Palpomyia	2
Caloptervx	2
Chrysops	1
Crangonyctidae	2
Diplectrona	2
Diplocladius	1
Gammaridae	3
Gammarus	45
Ironoquia	5
Limnephilidae	4
Lumbricina	1
Naididae	12
Neoporus	1
Orthocladius	2
Physa	2
Pisidium	7
Polypedilum	4
Sphaeriidae	3
Synurella	2
Thienemannimyia group	2
Tipula	6
Tipulidae	1

Fish Taxa

Blacknose dace	3

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	7
Pool Variability	3
Sediment Deposition	12
Channel Flow Status	10
Channel Alteration	16
Channel Sinuosity	6
Bank Stability - Right Bank	2
Bank Stability - Left Bank	4
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	9
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	103
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.44	50.84
Shading	95	99.94
Epifaunal Substrate	4	49.11
Instream Habitat	3	49.67
Instream Woody Debris	4	80.81
Bank Stability	2.50	35.36

MPHI Habitat Score	60.95
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Northern Green Frog

Mussels

None Observed

Site ID: 19-R3M-07-18

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Good
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Minimally Degraded
Water Quality Conditions	Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 376.76

Land Cover	Acres	% Area
Developed Land	99.44	26.39
Forested Land	136.44	36.21
Open Land	4.08	1.08
Agricultural Land	136.79	36.31

Impervious Surface	Acres	% Area
Impervious Land	15.53	4.12

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	12.36
Turbidity (NTU)	1.7
Temperature (°C)	7.4
pH (Standard Units)	6.92
Specific Conductivity (µS/cm)	185

Laboratory Measurements

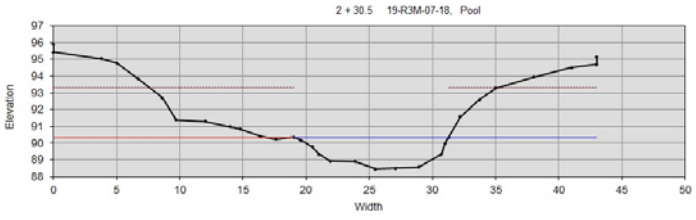
Total Phosphorus (mg/L)	0.083	Chloride (mg/L)	22.199
Total Nitrogen (mg/L)	1.063	Magnesium (mg/L)	3.373
Orthophosphate (mg/L)	0.018	Calcium (mg/L)	17.33
Total Ammonia N (mg/L)	0.010	Total Copper (µg/L)	0.325
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	12.212
Nitrate-N (mg/L)	0.919	Total Lead (µg/L)	0.058
Total Kjehldal N (mg/L)	0.140	Turbidity (NTU)	2.6
Dissolved Organic C (mg/L)	1.775		
Total Organic C (mg/L)	1.858		
Hardness (mg eq. $CaCO_3$/L)	57.16		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.59	Sinuosity	2.56
Bankfull Width (ft)	12.3	D50 (mm)	0.62
Mean Bankfull Depth (ft)	1.3	Adjustments?	None
Floodprone Width (ft)	14.5		
Entrenchment Ratio	1.2		
Width to Depth Ratio	9.2	**Rosgen Stream Type**	**G5c**
Cross Sectional Area (ft²)	16.4		
Water Surface Slope (%)	1.6		

Cross-sectional Survey



Site ID: 19-R3M-07-18

Biological Assessments

BIBI Metric Values

Total Taxa	23
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	10.09
% Ephemeroptera	8.26
Scraper Taxa	1
% Climbers	15.60

FIBI Metric Values

Abundance per m²	0.87
Adj. No. of Benthic Species	1.14
% Tolerant	42.47
% Gen., Omni., Invert.	99.32
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	31.51

BIBI Metric Scores

Total Taxa	5
EPT Taxa	3
Ephemeroptera Taxa	3
% Intolerant to Urban	3
% Ephemeroptera	3
Scraper Taxa	3
% Climbers	5

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.57
BIBI Rating	Fair

FIBI Score	4.00
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Acerpenna	9
Caecidotea	1
Calopteryx	1
Cricotopus	1
Diplectrona	1
Gammaridae	3
Gammarus	7
Haplotaxidae	1
Hemerodromia	1
Hydrobaenus	21
Naididae	11
Nematoda	1
Orthocladius	11
Paracladopelma	1
Parametriocnemus	12
Phaenopsectra	1
Pisidium	3
Platambus	1
Polypedilum	14
Pycnopsyche	1
Tanytarsus	1
Thienemannimyia group	1
Tipula	2
Tvetenia	3

Fish Taxa

American eel	17
Blacknose dace	22
Bluegill	6
Fallfish	21
Green sunfish	7
Largemouth bass	1
Rosyside dace	46
Tessellated darter	13
White sucker	13

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	11
Pool Substrate Characterization	9
Pool Variability	10
Sediment Deposition	9
Channel Flow Status	11
Channel Alteration	20
Channel Sinuosity	17
Bank Stability - Right Bank	6
Bank Stability - Left Bank	6
Vegetative Protection - Right Bank	7
Vegetative Protection - Left Bank	5
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	131
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	17.62	94.87
Shading	94	97.98
Epifaunal Substrate	8	64.04
Instream Habitat	9	69.92
Instream Woody Debris	28	100.00
Bank Stability	7.27	60.28

MPHI Habitat Score	81.18
MPHI Rating	Minimally Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Two-lined Salamander

American Bullfrog

Wood Frog

Northern Green Frog

Mussels

None Observed

Appendix E: Water Quality Data

KCI - Anne Arundel County Project Water Chemistry Data - Spring 2018

Sample ID	Date Collected	Time Collected	Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Orthophosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-N (mg/L)	Nitrate-N (mg/L)	Total Kjehldal Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg equivalent CaCO3/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)	Comments
01-L1M-01-18	04/10/18	8:20	216.8	0.0405	1.716	< 0.0031	0.6501	0.0218	0.7841	0.9101	1.563	1.572	6.706	27.96	97.43	1.609	10.47	0.086	3.9	
01-L1M-02-18	04/04/18	12:30	174.8	0.0082	0.7385	< 0.0031	0.0176	0.0047	0.5194	0.2144	1.206	1.218	10.58	36.85	135.6	1.175	5.609	0.063	5.3	
01-L2M-01-18	04/10/18	13:40	37.06	0.0130	0.2092	< 0.0031	0.0120	< 0.0022	0.0323	0.1747	2.268	2.314	2.660	8.094	31.16	1.116	12.75	0.197	4.7	
01-L2M-02-18	04/19/18	8:30	161.6	0.0190	0.6633	< 0.0031	0.0215	0.0048	0.4527	0.2058	1.784	1.793	4.764	34.60	106.0	1.898	6.923	0.191	7.0	
01-R3M-01-18	04/04/18	9:40	191.5	0.0090	0.7587	< 0.0031	0.0199	0.0060	0.5247	0.2280	1.249	1.287	10.46	44.26	153.6	1.097	5.697	0.051	3.9	
01-R3M-02-18	04/11/18	8:15	83.62	0.0083	1.195	< 0.0031	0.0195	0.0064	1.016	0.1718	1.651	1.664	6.060	23.11	82.66	1.071	16.22	0.165	3.2	
01-R3M-03-18	04/04/18	8:40	186.7	0.0638	1.551	0.0046	0.0117	0.0127	1.200	0.3385	1.625	1.714	6.698	27.38	95.95	2.093	16.05	0.141	6.4	
01-R3M-03-18-QC	04/04/18	8:45	< 0.0032	< 0.0044	0.0513	< 0.0031	< 0.0026	< 0.0022	< 0.0041	0.0450	0.1881	0.1611*	< 0.067	< 0.021	< 0.78	< 0.008	< 0.078	< 0.006	< 0.1	Field Blank
01-R3M-04-18	04/10/18	11:00	149.9	0.5760	6.400	0.4148	5.4471	0.0462	0.4618	5.892	2.892	3.041	5.856	20.58	75.50	3.350	26.77	0.078	5.1	
01-R3S-02-18	04/09/18	8:30	22.70	0.0121	0.8918	< 0.0031	0.0154	0.0026	0.6058	0.2834	3.602	3.619	2.869	9.842	36.39	1.351	17.13	0.186	7.9	
01-R3S-04-18	04/09/18	14:30	24.07	0.0117	0.8517	< 0.0031	0.0126	0.0065	0.5948	0.2504	4.327	4.384	2.570	12.10	40.80	1.574	7.251	0.124	3.6	
01-R3S-05-18	04/09/18	12:45	23.84	0.0092	0.7049	< 0.0031	0.0181	0.0061	0.4606	0.2382	4.222	4.270	2.494	11.63	39.31	1.492	6.159	0.108	2.7	
01-R3S-07-18	04/11/18	14:30	13.42	0.0093	0.8011	< 0.0031	0.0092	0.0022	0.6175	0.1814	2.485	2.546	3.364	3.699	23.09	1.191	11.29	0.217	2.0	
01-R3S-09-18	04/11/18	11:30	82.63	0.0411	1.046	< 0.0031	0.0156	0.0027	0.5551	0.4886	2.315	2.592	6.924	40.91	130.7	0.921	7.618	0.109	21.0	
01-R3S-10-18	04/12/18	8:30	17.02	0.0189	2.042	< 0.0031	0.0219	< 0.0022	1.879	0.1608	2.333	2.677	3.311	6.854	30.75	1.342	34.98	0.242	9.5	
01-R3S-11-18	04/09/18	10:00	24.50	0.0098	0.6174	< 0.0031	0.0075	< 0.0022	0.4168	0.1984	4.258	4.2504*	2.757	12.86	43.46	1.414	6.381	0.118	2.3	
01-R3S-13-18	04/04/18	8:45	176.9	0.0066	0.7680	< 0.0031	0.0295	< 0.0022	0.6042	0.1616	1.035	1.072	6.697	21.14	80.36	1.834	25.95	0.072	3.6	
01-R3S-13-18-QC	04/04/18	8:50	174.8	0.0061	0.8541	< 0.0031	0.0212	< 0.0022	0.6109	0.2410	1.077	1.135	6.846	21.80	82.63	1.919	26.59	0.080	2.0	
03-L1M-02-18	03/28/18	12:20	100.5	0.0068	1.453	< 0.0031	0.0065	0.0032	1.379	0.0713	0.9578	0.9654	5.535	15.45	61.37	0.653	3.072	0.056	0.6	
03-L1M-03-18	04/12/18	13:30	146.0	0.0169	3.642	< 0.0031	0.1043	0.0336	3.354	0.2541	0.6878	0.7237	8.672	21.30	88.90	1.600	5.605	0.302	1.8	
03-L2M-01-18	04/18/18	8:00	108.4	0.0380	2.007	0.0057	0.0656	0.0101	1.609	0.3886	3.251	3.2184*	4.035	29.04	89.13	2.861	5.966	0.523	24.4	
03-L2M-03-18	04/18/18	10:00	95.98	0.0359	2.026	0.0076	0.0105	0.0092	1.631	0.3853	3.374	3.3511*	3.640	24.28	75.62	2.977	6.180	0.531	20.8	
03-L2M-03-18-QC	04/18/18	11:00	95.83	0.0387	1.886	0.0053	0.0097	0.0092	1.561	0.3158	3.366	3.2867*	3.623	23.52	73.65	2.952	6.009	0.521	21.6	
03-R3M-01-18	03/29/18	8:50	924.3	0.0439	0.8999	< 0.0031	0.0073	0.0160	0.2251	0.6588	1.823	1.890	8.148	50.18	158.9	4.311	16.43	0.435	9.7	
03-R3M-03-18	03/28/18	9:00	129.2	< 0.0044	1.632	< 0.0031	0.0035	0.0029	1.574	0.0542	0.6318	0.6438	8.742	19.20	83.94	0.689	8.253	0.047	0.6	
03-R3M-04-18	03/29/18	11:00	1263	0.0225	0.7183	0.0036	0.0071	0.0074	0.2493	0.4616	1.026	1.050	11.25	76.47	237.3	3.613	13.27	0.236	6.6	
03-R3M-05-18	03/29/18	13:40	653.6	0.0182	0.3960	0.0044	0.0605	< 0.0022	0.1018	0.2920	1.098	1.122	6.878	39.08	125.9	2.320	3.595	0.184	1.3	
03-R3S-02-18	04/17/18	13:00	118.2	0.0080	2.929	< 0.0031	0.0080	< 0.0022	2.907	0.0201	1.127	1.0734*	5.446	35.90	112.1	0.635	10.17	0.104	0.5	
03-R3S-03-18	04/12/18	11:00	233.5	0.0089	0.6585	< 0.0031	0.0122	< 0.0022	0.3540	0.3023	1.652	1.658	11.22	76.53	237.3	2.217	6.384	0.575	4.3	
03-R3S-06-18	04/17/18	10:15	55.36	0.1567	0.9680	< 0.0031	0.2359	0.0022	< 0.0041	0.9617	2.512	5.415	3.741	38.77	112.2	2.672	12.81	10.66	30.2	
03-R3S-07-18	04/17/18	8:30	50.31	0.0242	0.4079	< 0.0031	0.2136	0.0025	< 0.0041	0.4013	2.552	2.850	3.538	40.98	116.9	1.048	3.102	2.944	34.2	
03-R3S-08-18	04/18/18	13:00	33.35	0.0248	0.0994	0.0033	0.0123	< 0.0022	0.0189	0.0783	2.227	2.251	1.811	4.867	19.61	1.864	4.693	1.053	7.4	
03-R3S-17-18	04/23/18	8:30	163.3	0.0146	0.8024	< 0.0031	0.1874	0.0075	0.2448	0.5501	2.473	2.4717*	5.012	73.82	205.0	2.781	8.295	0.353	5.7	
03-R3S-18-18	04/19/18	12:30	80.51	0.1142	0.6949	0.0135	0.0103	0.0040	0.0057	0.6852	13.807	14.068	3.911	16.28	56.76	8.060	8.791	1.804	76.3	
03-R3S-18-18-QC	04/19/18	13:00	80.56	0.1379	0.7077	0.0143	0.0127	0.0038	0.0067	0.6972	13.600	13.931	3.871	15.95	55.77	7.879	8.409	1.702	82.9	
03-R3S-19-18	04/23/18	12:00	44.29	0.1716	1.870	0.0070	1.4311	0.0041	0.0049	1.861	0.9088	0.9158	4.504	22.80	75.48	1.314	4.889	0.927	38.9	
05-L1M-03-18	03/14/18	9:15	93.59	0.0078	0.5309	< 0.0031	0.0165	0.0033	0.2096	0.3180	4.662	4.747	3.575	20.99	67.13	2.656	64.45	0.689	2.9	
05-L1M-04-18	04/02/18	14:20	50.71	0.0139	0.4992	0.0057	0.0112	< 0.0022	0.0208	0.4762	12.457	13.604	4.142	21.18	69.94	3.567	7.865	0.541	9.0	
05-L2M-02-18	04/02/18	11:45	57.10	0.0109	1.846	< 0.0031	0.0131	0.0031	1.593	0.2501	3.921	3.949	3.803	17.80	60.11	1.322	16.03	0.232	1.8	
05-L2M-03-18	04/10/18	11:30	28.29	0.0300	0.9184	< 0.0031	0.0111	0.0074	0.4939	0.4171	4.803	4.927	2.629	23.32	69.06	1.526	4.941	0.207	8.8	
05-L2M-03-18-QC	04/10/18	14:15	28.79	0.0179	0.7944	< 0.0031	0.0094	0.0072	0.5762	0.2110	4.761	4.764	2.613	22.06	65.84	1.345	8.851	0.168	6.2	
05-R3M-02-18	03/27/18	13:00	40.75	0.0378	1.684	0.0059	0.0242	0.0054	1.412	0.2672	6.848	7.068	2.918	20.59	63.43	3.231	10.21	0.357	64.6	
05-R3M-03-18	04/03/18	13:30	196.9	0.0487	1.506	0.0058	0.1344	0.0259	0.8249	0.6555	9.492	9.481*	5.362	39.96	121.9	4.488	42.56	0.346	9.0	
05-R3M-05-18	03/14/18	12:30	30.72	0.0078	1.048	< 0.0031	0.0174	0.0064	0.7568	0.2843	5.128	5.212	3.028	24.55	73.77	1.565	4.747	0.169	6.7	
05-R3M-06-18	03/27/18	14:40	38.07	0.0344	1.371	0.0046	0.0164	0.0047	1.034	0.3326	7.876	8.123	2.918	18.21	57.49	2.886	10.96	0.670	29.2	
05-R3S-01-18	04/03/18	8:30	17.63	0.0084	0.4672	< 0.0031	0.0131	< 0.0022	0.1854	0.2796	7.218	7.339	1.418	7.836	25.41	2.117	24.68	0.650	3.4	
05-R3S-02-18	03/26/18	11:00	92.80	0.0055	1.950	0.0033	0.0263	0.0027	1.801	0.1463	1.969	1.976	4.938	14.10	55.54	1.212	16.69	0.193	1.1	
05-R3S-02-18-QC	03/26/18	13:00	108.6	0.0045	1.749	< 0.0031	0.0302	0.0028	1.633	0.1132	1.628	1.671	5.036	16.07	60.87	1.012	10.84	0.136	1.0	
05-R3S-07-18	03/26/18	8:30	56.48	< 0.0044	2.877	< 0.0031	0.0153	< 0.0022	2.843	0.0323	1.153	1.197	4.398	9.675	42.27	2.413	27.87	0.320	1.0	
05-R3S-08-18	04/02/18	8:30	244.8	0.1732	3.676	0.0960	0.6022	0.0682	1.697	1.911	22.812	23.201	1.375	15.34	43.97	10.10	75.59	1.541	9.4	
05-R3S-09-18	03/27/18	8:20	6.871	0.0056	1.272	< 0.0031	0.0183	< 0.0022	0.9896	0.2803	5.366	5.531	1.310	4.529	16.70	2.279	37.07	2.286	1.8	
05-R3S-11-18	03/26/18	14:30	138.2	< 0.0044	2.017	0.0034	0.0083	0.0054	1.907	0.1053	0.9826	1.018	4.818	16.38	60.74	1.241	15.89	0.276	1.4	
05-R3S-14-18	04/03/18	10:43	91.94	0.0085	3.059	< 0.0031	0.0270	0.0056	2.931	0.1226	1.790	1.803	9.125	45.18	150.4	0.700	8.027	0.014	0.4	
05-R3S-16-18	04/10/18	8:30	43.32	0.0093	1.733	< 0.0031	0.0066	< 0.0022	1.537	0.1942	3.607	3.623	4.205	19.92	67.06	1.450	21.57	0.966	1.2	
08-L1M-01-18	03/26/18	11:30	117.2	0.0102	0.7291	< 0.0031	0.2374	0.0051	0.3986	0.3254	1.023	1.170	7.429	18.40	76.54	0.474	24.65	0.046	15.7	
08-L1M-02-18	03/14/18	13:56	57.16	0.0187	0.9910	0.0049	0.0210	0.0028	0.7902	0.1980	1.981	2.009	5.375	17.13	64.91	0.468	14.57	0.092	5.4	
08-L1M-02-18-QC	03/14/18	13:58	0.0357	< 0.0044	0.0250	< 0.0031	< 0.0026	< 0.0022	< 0.0041	0.0187	0.1652	0.1167*	< 0.067	< 0.021	< 0.78	< 0.008	< 0.078	< 0.006	0.2	Field Blank
08-L2M-01-18	03/27/18	11:15	49.14	0.0091	1.921	< 0.0031	0.1034	0.0058	1.745	0.1705	0.8769	0.9272	5.351	13.85	56.62	0.170	19.40	0.028	7.5	
08-L2M-02-18	04/05/18	12:30	8.482	0.0280	0.7309	< 0.0031	0.1674	0.0060	0.2584	0.4665	0.5109	0.5389	7.637	36.01	121.4	0.436	17.42	0.153	9.7	
08-R3M-02-18	03/28/18	8:35	26.07	0.0403	1.005	0.0052	0.0353	0.0041	0.5622	0.4382	3.876	3.948	2.377	11.17	37.68	1.883	13.00	0.263	4.6	

KCI - Anne Arundel County Project Water Chemistry Data - Spring 2018

Sample ID	Date Collected	Time Collected	Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)		Orthophosphate (mg/L)	Total Ammonia Nitrogen (mg/L)		Nitrite-N (mg/L)		Nitrate-N (mg/L)	Total Kjehldal Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg equivalent CaCO3/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)	Comments
08-R3M-03-18	03/15/18	13:25	49.63	0.0326	1.099	<	0.0031	0.0115		0.0024		0.8124	0.2841	1.937	2.080	4.413	14.31	53.90	1.013	15.87	0.195	6.0	
08-R3M-04-18	03/26/18	9:10	118.6	0.0098	0.8895		0.0031	0.2284		0.0050		0.5657	0.3188	1.299	1.446	7.458	19.65	79.78	0.385	21.26	0.117	12.6	
08-R3M-05-18	04/05/18	10:45	37.69	0.1323	1.147		0.0073	0.0434		0.0087		0.1512	0.9868	7.557	7.946	2.095	14.35	44.46	2.640	14.45	0.513	13.8	
08-R3S-01-18	04/04/18	8:30	189.4	0.0175	0.3419	<	0.0031	0.0386	<	0.0022		0.0540	0.2857	1.595	1.914	3.820	14.02	50.74	0.604	59.76	0.850	3.7	
08-R3S-02-18	03/27/18	14:15	23.90	0.0428	0.5941		0.0070	0.0884		0.0025		0.0549	0.5367	9.616	9.658	3.995	20.79	68.36	1.111	15.81	0.448	8.1	
08-R3S-03-18	03/26/18	15:15	102.6	0.0216	1.562	<	0.0031	0.0238		0.0026		1.477	0.0824	0.4631	0.4893	5.694	15.60	62.40	0.146	23.30	0.021	3.6	
08-R3S-04-18	03/26/18	13:40	80.36	0.0097	1.452	<	0.0031	0.0361		0.0030		1.389	0.0603	0.5414	0.5981	5.635	18.46	69.30	0.110	20.37	0.017	5.0	
08-R3S-05-18	04/05/18	8:00	85.14	0.0121	1.593	<	0.0031	0.0448		0.0035		1.412	0.1775	0.8548	0.8927	7.058	14.12	64.32	0.250	39.96	0.054	3.1	
08-R3S-07-18	03/28/18	11:45	136.9	0.0229	0.7112		0.0033	0.2560		0.0036		0.3988	0.3088	0.7850	0.9260	6.844	18.16	73.53	0.940	34.64	0.124	13.4	
08-R3S-08-18	04/04/18	11:25	17.74	0.0615	0.4641	<	0.0031	0.0908	<	0.0022	<	0.0041	0.4578	4.896	6.147	2.482	9.498	33.94	0.718	21.48	0.315	27.0	
08-R3S-08-18-QC	04/04/18	12:30	13.66	0.0101	0.2251	<	0.0031	0.0387	<	0.0022		0.0041	0.2188	3.520	3.905	2.031	8.044	28.45	0.635	21.83	0.138	4.3	
08-R3S-09-18	03/27/18	8:35	7.381	0.0107	0.2148		0.0050	0.0080	<	0.0022		0.0049	0.2077	7.182	7.501	0.863	1.550	7.42	1.582	40.75	0.857	0.7	
19-L1M-01-18	04/12/18	10:00	31.80	0.1042	0.5750		0.0268	0.0082		0.0038		0.3783	0.1929	2.588	2.643	2.793	17.58	55.40	0.298	4.975	0.050	3.3	
19-L1M-03-18	04/11/18	8:30	21.87	0.0799	1.126		0.0152	0.0142		0.0034		0.9328	0.1899	1.857	1.919	3.545	17.53	58.37	0.342	12.94	0.055	2.9	
19-L2M-01-18	03/15/18	8:25	32.26	0.0811	1.107		0.0240	0.0076		0.0041		0.9372	0.1652	2.256	2.364	2.780	18.49	57.62	0.271	7.705	0.059	4.8	
19-L2M-07-18	04/11/18	13:30	50.11	0.1559	1.197		0.0187	0.1528		0.0126		0.6335	0.5507	3.260	3.392	3.020	19.60	61.38	0.340	9.224	0.093	7.4	
19-R3M-01-18	03/29/18	12:30	77.76	0.1040	2.620		0.0133	0.0436		0.0056		2.405	0.2093	1.520	1.5194*	3.633	24.93	77.21	0.389	13.58	0.258	9.8	
19-R3M-03-18	03/29/18	9:50	105.9	0.0626	1.372		0.0063	0.0435		0.0023		1.113	0.2574	1.275	1.280	4.318	24.77	79.63	0.460	21.87	0.220	5.6	
19-R3M-06-18	03/29/18	8:15	88.26	0.0773	1.802		0.0082	0.0470		0.0035		1.648	0.1505	1.380	1.485	4.019	23.64	75.58	0.499	20.62	0.271	6.6	
19-R3M-07-18	04/11/18	10:00	22.20	0.0826	1.063		0.0180	0.0102		0.0039		0.9188	0.1404	1.775	1.858	3.373	17.33	57.16	0.325	12.21	0.058	2.6	
19-R3M-07-18-QC	04/11/18	12:00	22.43	0.0991	1.009		0.0263	0.0121		0.0048		0.8474	0.1569	1.919	1.962	3.317	17.18	56.56	0.356	10.69	0.063	2.8	
19-R3S-01-18	03/15/18	11:02	34.74	0.0223	0.3328		0.0040	0.0140	<	0.0022		0.1819	0.1487	1.463	1.589	4.274	8.416	38.62	0.324	18.73	0.107	4.1	
19-R3S-04-18	04/12/18	15:00	76.04	0.0918	1.081		0.0149	0.0394		0.0053		0.8215	0.2541	1.327	1.416	2.794	25.37	74.85	0.190	6.433	0.094	8.3	
19-R3S-04-18-QC	04/12/18	14:30	76.87	0.0856	1.042		0.0115	0.0564		0.0050		0.8390	0.1982	1.249	1.300	2.806	24.74	73.33	0.248	7.997	0.152	7.2	
19-R3S-07-18	04/19/18	9:00	53.61	0.4199	1.006		0.0996	0.0967		0.0084		0.4533	0.5443	4.726	4.851	3.090	38.02	107.7	0.647	5.718	0.232	8.7	
19-R3S-11-18	04/19/18	11:30	77.02	0.0645	0.2587		0.0063	0.0152	<	0.0022		0.1004	0.1561	2.165	2.252	4.185	12.88	49.40	0.728	14.71	0.124	9.0	
19-R3S-14-18	04/09/18	10:40	113.8	0.1071	1.451		0.0780	0.0077		0.0041		1.267	0.1799	1.106	1.118	3.651	26.21	80.48	0.355	10.52	0.082	1.2	
19-R3S-16-18	04/09/18	8:30	9.984	0.0718	0.9611		0.0257	0.0085	<	0.0022		0.7470	0.2119	2.962	2.988	2.516	12.84	42.42	0.403	23.24	0.118	3.0	
19-R3S-19-18	04/18/18	8:30	32.74	0.0601	1.258		0.0095	0.0393		0.0023		1.079	0.1771	2.546	2.620	3.383	14.45	50.01	0.468	19.61	0.172	5.6	
19-R3S-15-18	04/09/18	13:00	4.334	0.1148	0.2797		0.0537	0.0094	<	0.0022		0.0074	0.2701	6.394	6.447	1.368	5.732	19.95	0.647	19.86	0.432	6.3	

* Although the dissolved organic carbon concentration exceeds the total dissolved organic carbon value, the excess is within the precision of the analytical technique and, therefore, not statistically significant.