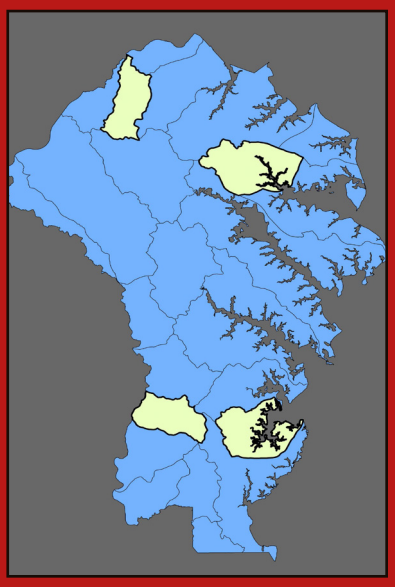

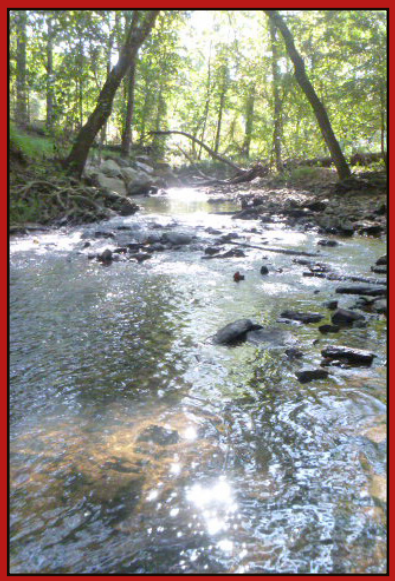

Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2020

Anne Arundel County, Maryland
Department of Public Works
Bureau of Watershed Protection and Restoration

ANNE ARUNDEL COUNTY MARYLAND

Anne Arundel County Bureau of Watershed Protection & Restoration

Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2020

Round Three—Year Four

May 2021

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Prepared for:

Anne Arundel County
Department of Public Works
Bureau of Watershed Protection and Restoration
Ecological Assessment and Evaluation Program

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Abstract

The Anne Arundel County Department of Public Works' Bureau of Watershed Protection and Restoration 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 2020 with sampling in four primary sampling units; Rock Branch, Stony Run, Upper Magothy, and West River. 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). The COVID-19 global pandemic of 2020 presented challenges to the collection of data during both the spring and summer of 2020. Field crews implemented strict safety protocols to protect themselves as well as the general public. The most notable impact to the County's program due to the pandemic was the closure of the water quality laboratory, University of Maryland's Center for Environmental Science (UMCES) Appalachian Laboratory. A commercial water quality laboratory was quickly contracted to provide the water quality analysis services that UMCES was unable to provide.

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

There was high variability in stream types throughout the sampling units in 2020. The largest portion of the sites were F type channels at 31%. Channel types E and G both were represented at approximately 18% of the sites were. *In situ* water quality measurements were within COMAR standards for temperature and instantaneous turbidity at all sites during both the spring and summer monitoring periods. Low pH values, which were below the acceptable range of values set forth by COMAR (i.e., 6.5-8.5 SU), were recorded at five sites spanning three of the four sampling units in the spring and at eight sites spanning all sampling units in the summer. For dissolved oxygen, three of the 31 sampleable sites in the summer had measured DO concentrations below the 5.0 mg/L standard. Thirteen of 32 sites in the spring and 15 sites of 31 sites in the summer had specific conductance values that exceeded the 247 µS/cm threshold of BIBI impairment developed from MBSS data. All streams were within their designated criteria (Use I) for temperature in 2020 (i.e., <32 °C).

No spring grab sample parameters tested in 2020 exceeded EPA or COMAR standards for chloride, copper, lead, turbidity, or zinc for all four sampling units. Due to differences in the laboratory used in 2020 relative to other Round 3 monitoring years, comparisons of orthophosphate, nitrite, and ammonia levels with categories used by MBSS were limited due to analytical detection limits, which exceeded the high category values used by MBSS (i.e., > 0.03 mg/L for orthophosphate; > 0.01 mg/L for nitrite; and > 0.07 mg/L for ammonia). Orthophosphate concentrations at all sites, nitrite concentrations at all but one site, and ammonia concentrations at 22 sites fell at or below the MDLs of 0.45 mg/L, 0.029 mg/L, and 0.088 mg/L, respectively, and could not be further categorized. Measurements of nitrite and ammonia that did not fall at or below the MDLs were also in the high category used by MBSS for those parameters. Nitrate values at all 2020 sites fell in the low or moderate categories used by MBSS. Total nitrogen values fell in the low or moderate categories used by MBSS at all sites sampled in both the Rock Branch and West River sampling units while four sites in the Stony Run sampling unit and one site in the Upper Magothy sampling unit had total nitrogen values that fell in the high category used by MBSS (i.e., >7.0 mg/L). Approximately 52% of the sites, across three of the four sampling units, had total phosphorus values that fell in the high category used by MBSS (i.e.,> 0.070 mg/L).

On average, BIBI scores improved in Rock Branch and Stony Run in Round 3, and remained the same in all other sampling units from Round One and Two to Round Three. Physical habitat comparisons between Round One and Three showed a significant increase in the both the mean RBP score and PHI score in the Stony Run. Upper Magothy showed a significant decrease in RBP scores between sampling Rounds Two and Three. No significant differences in for PHI scores were observed between sampling Round Two and Round Three.

Acknowledgements

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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 Bureau of Watershed Protection and Restoration in 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 2020 mark the fourth year of Round Three sampling with 32 randomly selected sites sampled throughout four 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 revisits of Round One and Round Two sites as well as several new sampling components to the Program. These additions to the Program were added prior to the beginning of Round Three and will continue through the completion of Round Three. Eight sites are sampled in each PSU including four new randomly selected sites, two revisit sites selected from previously sampled Round One sites, and two revisit sites selected from previously sampled Round Two sites. Each of the Round Three sites are considered randomly selected sites as Round One and Round Two revisit sites were selected at random during those respective rounds. 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 is 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 visit during the summer allows for 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 compared with the spring-collected RBP habitat assessment and the FIBI data are compared 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
2019	40	04-Sawmill Creek 17-Little Patuxent	12-Lower North River 18-Middle Patuxent	16-Upper Patuxent
2020	32	02-Stony Run 07-Upper Magothy	14-West River 20-Rock Branch	

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), since fish communities respond to different environmental stressors compared to benthic macroinvertebrates, 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.

At every site, physicochemical parameters are measured *in situ* and water quality grab samples are collected for laboratory analysis to supplement biological and physical data. Physicochemical parameter data provide some basic water quality condition information and ensure that extreme water quality conditions are not present during biological sample collection. Water chemistry grab sample 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 original Program design (Hill and Stribling, 2004) specified a stratified random sampling approach, stratified by stream order. Details of the current sampling program design, including the approach for the selection of sampling locations, can be found in Southerland et al.(2016). 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 2020, sites were randomly selected from each of the following PSUs (with PSU code); Stony Run (02), Upper Magothy (07), West River (14), and Rock Branch (20). Figure 1 shows the geographic distribution of PSUs assessed during this sampling period. Sampling was conducted at eight sites in each of the four PSUs during 2020. New for Round 3, in each PSU previously sampled sites from Rounds One and Two were randomly selected for resampling in this Round—two each from Round One and Round Two. 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.

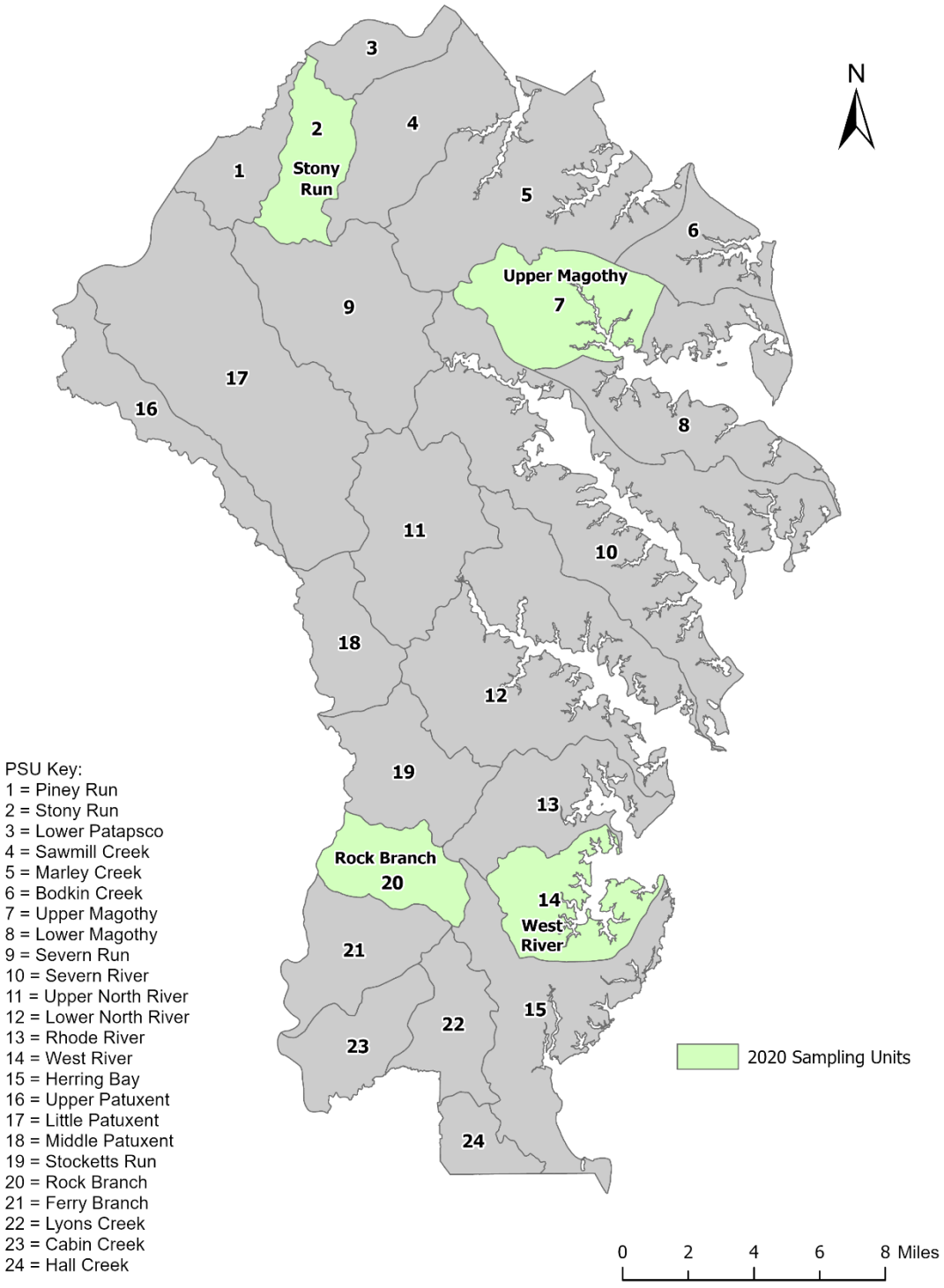

Figure 1 - 2020 Sampling Units

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 that lack rootmats. 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 in Boward and Friedman (2011). 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 (100 total grids) and each grid is picked clean of organisms until a count of 100 to 120 is reached. 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%) but keeps the total number of individuals below the 120 maximum set in the County QAPP.

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. Most taxa were identified using a stereoscope. Temporary slide mounts were used to identify Oligochaeta to family with a compound scope. Chironomidae identification was conducted using temporary slide wet mounts. Permanent slide mounts were used for Chironomidae for specimens in samples selected for secondary lab re-identification for quality control checks. 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 32 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 either triple-rinsed bottles or bottles with preservatives 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. In general, samples were preserved on ice immediately after collection and all transported to the lab within 48 hours; however, several samples were received and analyzed after the 48-hour hold time due to drop off and shipping delays associated with the COVID-19 pandemic. In addition, a duplicate sample was collected from each PSU for quality assurance purposes. Due to the 2020 COVID-19 global pandemic, the UMCES – Appalachian Laboratory was not open for operation at the time of sampling. All grab samples were shipped and analyzed by Eurofins TestAmerica at their laboratories located in Pittsburgh, PA and Canton, OH. The laboratory methods used by Eurofins TestAmerica are consistent with laboratory methods developed for the Maryland Biological Stream Survey (Kline and Morgan, 2006). The water quality component of the County biomonitoring program mirrors exactly the MBSS water quality component. A complete list of analytical parameters and methods, including method detection limits, is presented in Table 4 below. It should be noted that the detection limits for ammonia, nitrite, and orthophosphate were higher than detection limits previously achieved by UMCES Appalachian Lab.

Table 4 - Water Quality Parameters

Parameter	Method Detection Limit*	Method Number
Turbidity	0.050 NTU	EPA 180.1
Total Nitrogen	0.024	EPA Total Nitrogen
Total Phosphorus	0.037	SM 4500 P E-2011
Ammonia-N	0.088	EPA 350.1
TKN (calculated)	1.6 to 3.2	4500 NorgC-2011
Nitrate-Nitrogen	0.023	EPA 300.0 R2.1
Nitrite-Nitrogen	0.029	EPA 300.0 R2.1
Dissolved Organic Carbon	0.51	SM 5310C
Orthophosphate	0.45	EPA 300.3 R2.1
Total Organic Carbon	0.51	SM 5310C
Total Copper	0.69 µg/L	EPA 200.8 Rev 5
Total Lead	0.13 µg/L	EPA 200.8 Rev 5
Total Zinc	4.3 µg/L	EPA 200.8 Rev 5
Chloride	0.32 to 3.2	EPA 300.0 R2.1
Total Hardness	5.0	SM 2340C

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

To supplement the water quality grab sampling, *in situ* physicochemical water quality measurements (i.e., temperature, pH, specific conductance, dissolved oxygen, and turbidity) were taken at each site during both the spring and summer sampling visits. All measurements were collected from the upstream end of the site prior to any other sampling activities to ensure that measurements were not influenced by sampling activities within the stream and were measured with either a YSI ProDSS or a YSI Professional Plus series multiparameter meter. 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 cross-over reach, typically in a riffle feature, and monumented with iron reinforcement bars topped with yellow plastic survey marker caps. If the site was a resample site from a prior Round, then an attempt was made to recover and remeasure the original cross section. If the original cross section was partially or completely lost, new monuments as necessary were installed. 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 file 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 maximum score of 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).

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

FIBI 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. However, comparisons of nitrite, ammonia, and orthophosphate levels with categories used by MBSS were limited due to analytical detection limits greater than those achieved by UMCES Appalachian Lab in previous years of Round Three. Analyte concentrations were reported to varying degrees of

precision and resulted in a range of the number of decimal places an analyte was reported to by the laboratory. In order to retain as much information as possible, summary statistics were reported to the most common number of decimal places the analyte concentration was reported to, which was often to the greatest number of decimal places. When an analyte value was reported to be at or below the MDL (method detection limit), the MDL value was used for all summary statistic calculations. The Maryland Department of the Environment (MDE) has established water quality criteria for several of the water chemistry parameters measured in this study for each designated Stream Use Classification. All sites sampled during 2020 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 the criteria 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 is no State of Maryland criterion for specific conductance. 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. These values are used by the Program as informal criteria for this parameter.

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 2% 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 remaining 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. It should be noted, however, that an effort is made to cite the cross section at a location in the sampling reach that best represents typical physical conditions found within the reach, subject to the limitations discussed above.

- 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 Pro (Version 2.7.0). Land use analysis was completed with the use of the County's 2017 Land Cover GIS layer. Original land cover categories were combined into four primary land use classes to better summarize the conditions in the sampling units (Table 15). The County's 2017 impervious layer was used to assess imperviousness for 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 10.7.1. 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. Dominant land use was determined as land use that comprises the majority of the drainage area, relative to other land uses present.

Table 15 - Combined Land Use Classes

Land Use Class	Land Cover Type
Developed	Airport, Commercial, Industrial, Mining, 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 2020 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 2020. 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)

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
Rock Branch	71.45 ± 9.74 Partially Degraded	113.75 ± 12.15 Partially Supporting	2.89 ± 0.70 Poor	2.54 ± 0.75 Poor
Stony Run	65.06 ± 7.65 Degraded	124.88 ± 7.92 Partially Supporting	3.11 ± 0.48 Fair	3.37 ± 0.88 Fair
Upper Magothy	61.40 ± 10.96 Degraded	108.88 ± 18.69 Partially Supporting	2.14 ± 0.65 Poor	2.71 ± 0.95 Poor
West River	67.88 ± 4.60* Partially Degraded	111.00 ± 9.06 Partially Supporting	2.36 ± 0.56 Poor	1.29 ± 0.42 Very Poor

*n=7 for PHI

3.1.1 Biological and Habitat Assessment Summary

Overall, the majority of BIBI scores throughout the sampling units were split between a rating of 'Fair' (14 of 32; 43.8%) and 'Poor' (12 of 32; 37.5%), with a small percentage of sites rated as 'Very Poor' (6 of 32; 18.8%) and zero sites rated 'Good' (Figure 2). Three of the four sampling units assessed in 2020 had mean BIBI values that equate to 'Poor' biological condition ratings while one site had a mean BIBI value rating in the 'Fair' category (Table 16).

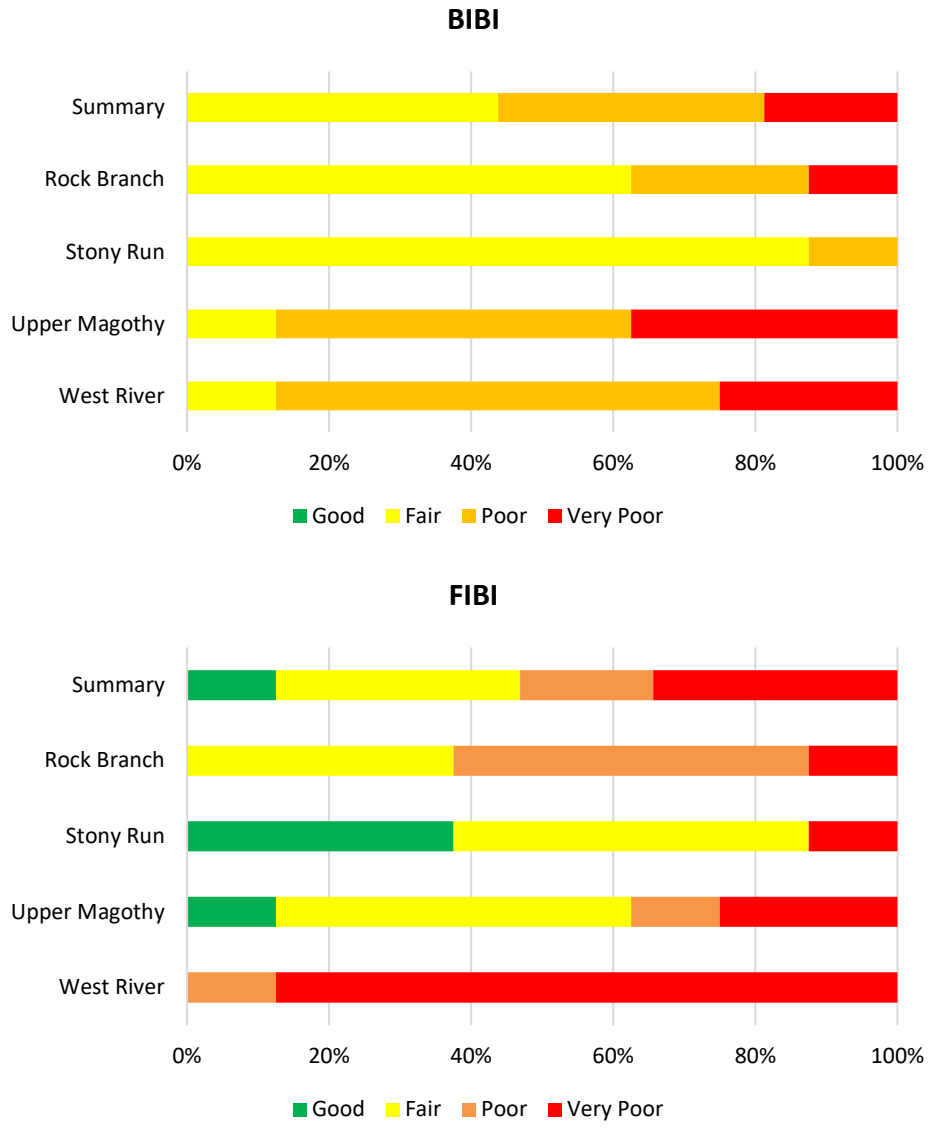

Figure 2 - Summary of biological conditions for sites assessed in 2020 (BIBI n=32, FIBI n=32)

The majority of FIBI sites sampled during 2020 were split between condition ratings of 'Fair' (11 of 32; 34.4%), 'Poor' (6 of 32; 18.8%) and 'Very Poor' (11 of 32; 34.4%). The remaining four (4) sites were rated 'Good' (12.5%; Figure 2). Two sampling units (Rock Branch and Upper Magothy) had mean FIBI scores equating to a 'Poor' biological condition rating, one had a mean FIBI rating of 'Fair' (Stony Run), and one had a mean FIBI rating of 'Very Poor' (West River; Table 16). West River was the sampling unit with the lowest mean FIBI score (1.29) equating to a 'Very Poor' condition rating. Stony Run had the highest mean FIBI rating of the sampling units from 2020, with a 3.37 mean equating to a 'Fair' biological condition rating.

Physical habitat conditions were assessed twice in 2020 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 all of the four sampling units, as determined by the sampling unit mean, received

ratings of 'Partially Supporting' (RBP; Table 16). The majority of the total sites sampled resulted in a RBP rating of 'Partially Supporting' (19 of 32; 59.4%) and another 25% of the sites (8 of 32) received a 'Supporting' rating (Figure 3). Only five sites were rated as 'Non-Supporting' (15.6%).

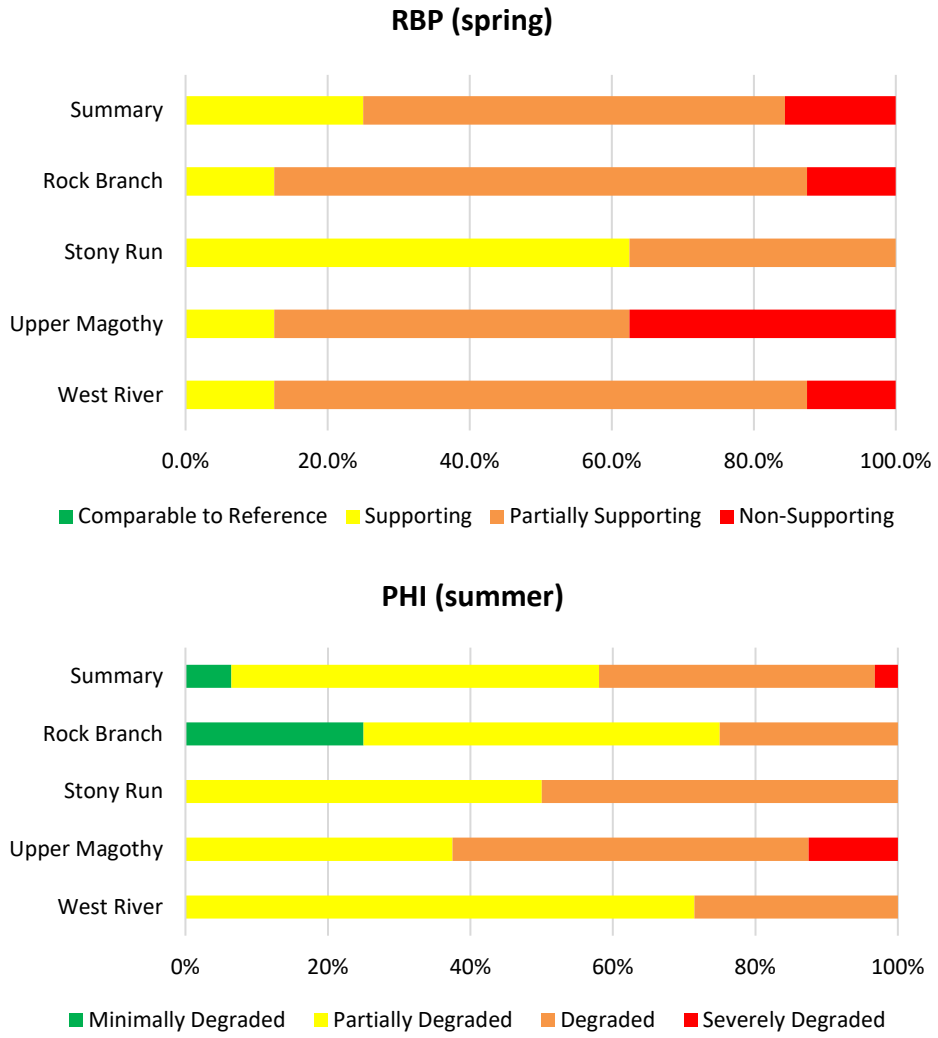

Figure 3- Summary of physical habitat conditions for sites assessed in 2020 (RBP n=32; PHI n=31)

Two of the four sampling units assessed during the summer season received a PHI rating of 'Partially Degraded' and two sampling units received a rating of 'Degraded', as determined by the sampling unit mean(Table 16). Just over half of the total sites sampled resulted in a PHI rating of 'Partially Degraded' (16 of 31; 51.6%), while greater than one-third of the sites received 'Degraded' ratings (12 of 31; 38.7%). Two sites (6.5%) received the highest possible rating of 'Minimally Degraded', while only one site (3.2%) received a 'Severely Degraded' rating (Figure 3).

3.1.2 Water Quality Assessment Summary

In situ water quality measurements of instantaneous turbidity met COMAR standards for turbidity at all sites sampled during the Spring and Summer Index Periods. 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 three of the four sampling units in the spring and at eight sites spanning all sampling units in the summer. Sites that did not meet COMAR water quality standards sampled in the spring and summer had pH values that ranged from 5.94 to 6.41 SU and 5.07 to 6.49 SU, respectively. Low dissolved oxygen (DO) values, which were outside the acceptable range of values set forth by COMAR (i.e., >5 mg/L), were recorded at three sites in the Upper Magothy sampling unit in the summer with values that ranged from 2.34 to 4.83 mg/L. No sites sampled in the summer in other sampling units and no sites sampled in the spring had DO levels below the COMAR criterion. For specific conductance, 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). Specific conductance values that exceeded 247 µS/cm were recorded at 13 sites spanning two of the four sampling units in the spring and at 15 sites spanning three sampling units in the summer. Specific conductance values exceeding the BIBI impairment threshold ranged from 255.7 to 446.6 µS/cm in the spring and 250.7 to 523.5 µS/cm in the summer. All streams were within their designated criteria (Use I) for temperature in 2020 (i.e., <32 °C).

No spring grab sample parameters tested in 2020 exceeded EPA or COMAR standards for chloride, copper, lead, turbidity, or zinc for all four sampling units. Chloride values ranged from 9.2 to 81 mg/L; copper ranged from 0.69 to 2.2 µg/L with 13 values falling at or below the MDL of 0.69 µg/L; lead ranged from 0.16 to 1.20 µg/L; turbidity ranged from 2.0 to 31.0 NTU; and zinc ranged from 6.3 to 18 µg/L with one value falling at or below the MDL of 4.3 µg/L. At all sites, orthophosphate fell at or below the MDL of 0.450 mg/L. Nitrite values were at or below the MDL of 0.029 mg/L for all but one site in the Stony Run sampling unit, with a value of 0.062 mg/L. MDLs for both parameters exceed the high categories used by MBSS (i.e., > 0.03 mg/L for orthophosphate and > 0.01 mg/L for nitrite) so further categorization could not be made. Nitrate values at all 2020 sites fell in the low or moderate categories used by MBSS with average sampling unit values ranging from 0.054 to 1.11 mg/L. Twenty-two sites sampled had ammonia values that fell at or below the MDL of 0.088 mg/L, which is above the threshold of the high category used by MBSS (i.e., > 0.07 mg/L). The remaining ten sites, spread across all four sampling units, had ammonia values that fell in the high category used by MBSS with values between 0.090 and 0.21 mg/L. Total nitrogen values fell in the low or moderate categories used by MBSS at all sites sampled in both the Rock Branch and West River sampling units. Four sites in the Stony Run sampling unit and one site in the Upper Magothy sampling unit had total nitrogen values that fell in the high category used by MBSS (i.e., >7.0 mg/L) with values ranging from 7.4 to 14 and a value of 9.9 mg/L, respectively. Sixteen sites, across three of the four sampling units, had total phosphorus values that fell in the high category used by MBSS (i.e.,> 0.070 mg/L) and ranged from 0.072 to 0.38 mg/L. No state or national water quality standards exist for dissolved organic carbon (DOC), total organic carbon (TOC), or hardness. Average values ranged from 2.4 to 5.8 mg/L for DOC, 2.4 to 5.9 mg/L for TOC, and 47 to 62 mg/L for hardness, across all four sampling units.

3.1.3 Geomorphic Assessment Summary

There was high variability in stream types throughout the sampling units in 2020. The largest portion of the sites were slightly entrenched E and entrenched F type channels (31.3% and 21.9%, respectively; Figure 4), which occurred in at least one site in all sampling units. Across all sampling units, 18.8% of sites were classified as G type channels, occurring in all sampling units except Stony Run. Approximately 12.5% of sites were classified as moderately entrenched B type channels, which mostly occurred in the Stony Run sampling unit. Approximately 9.4% of sites were classified as C type channels (3 total), occurring only

in the Stony Run and Upper Magothy sampling units. The remaining 6.3% of sites were placed into the 'Not Determined' category due to considerable anthropogenic modification (e.g., channel alteration, hardened banks) or due to natural influences that inhibit channel classification (e.g., 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 2020 were considered D channel types, DA channel types or transitional between two classification types.

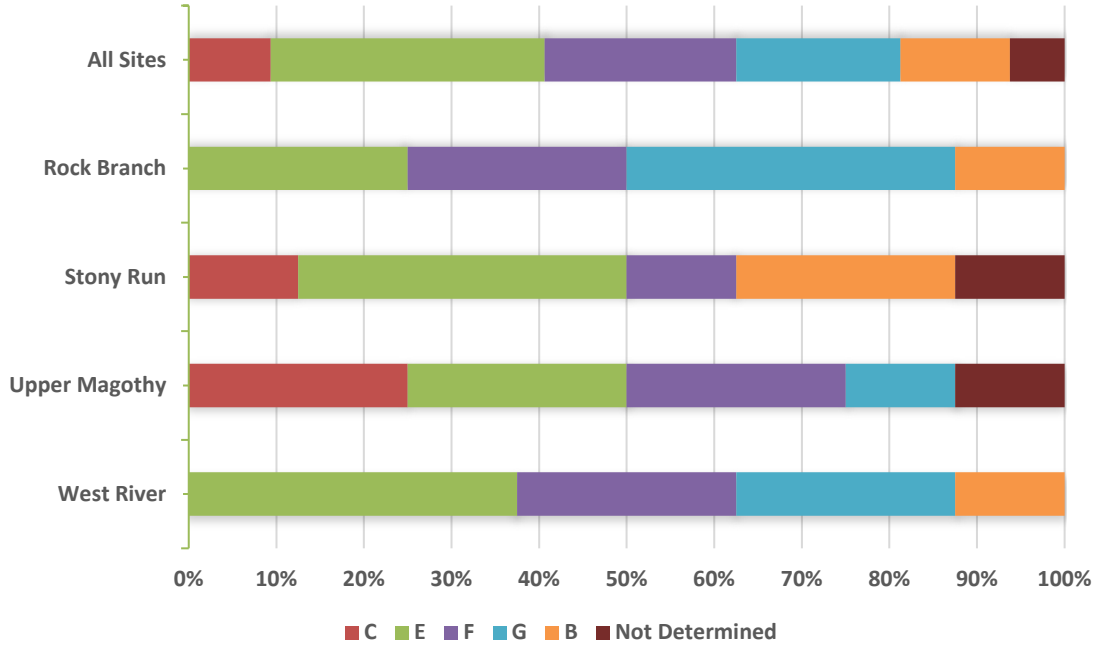

Figure 4 - Distribution of Rosgen stream types for sites assessed in 2020 (n=32)

The majority of the sites sampled in 2020 had channel substrate composed primarily of sand material (75%). Gravel-dominated streams comprised 15.6% of all sites, while gravel/sand systems comprised 9.45% of sites.

Stream slopes in the reaches assessed in 2020 were generally low (i.e., below 2%). The average slope of all reaches assessed was 0.57%. Individual site slopes ranged from 0.023% in the Rock Branch sampling unit to 2.00%, also in the Rock Branch sampling unit. Average slope for the sampling units ranged from 0.47% in Stony Run to 0.70% in Rock Branch.

3.1.4 Land Use Analysis and Impervious Surface Summary

A summary of land use and impervious surface across each sampling unit assessed in 2020 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
Rock Branch	6,131	3.8	26.7	40.4	24.7	8.1
Stony Run	6,203	18.3	53.5	29.8	0.0	16.7
Upper Magothy	10,031	13.9	70.4	24.5	0.3	4.8
West River	7,558	4.9	29.7	42.6	22.3	5.4

At the sampling unit scale, the Upper Magothy had the highest percentage of developed land at 70.4% of the total acreage, followed by Stony Run at 53.5% (Table 17). The Rock Branch and West River sampling units had moderate development, with developed land comprising 26.7% and 29.7%, respectively. The Rock Branch and West River sampling units also had the highest proportion of forested land that comprised 40.4% and 42.6%, respectively, of the sampling unit areas. The Stony Run and Upper Magothy sampling units had moderate forested land cover that comprised 29.8% and 24.5%, respectively, of the areas. The Rock Branch and West River sampling units had the highest proportions of agricultural land use, at 24.7% and 22.3%, respectively. The Stony Run and Upper Magothy sampling units had minimal agricultural land use that comprised less than 1% of the area for each sampling unit. Figure 5 shows land use for the entire County based on the County's 2017 Land Cover GIS layer. The sampling units with the highest percentage of impervious surface were Stony Run (18.3%), followed by the Upper Magothy (13.9%); while West River and Rock Branch had the lowest percentages of impervious surface (4.9% and 3.8%, respectively). Figure 6 shows impervious surface for the entire County based on the County's 2017 Impervious GIS layer.

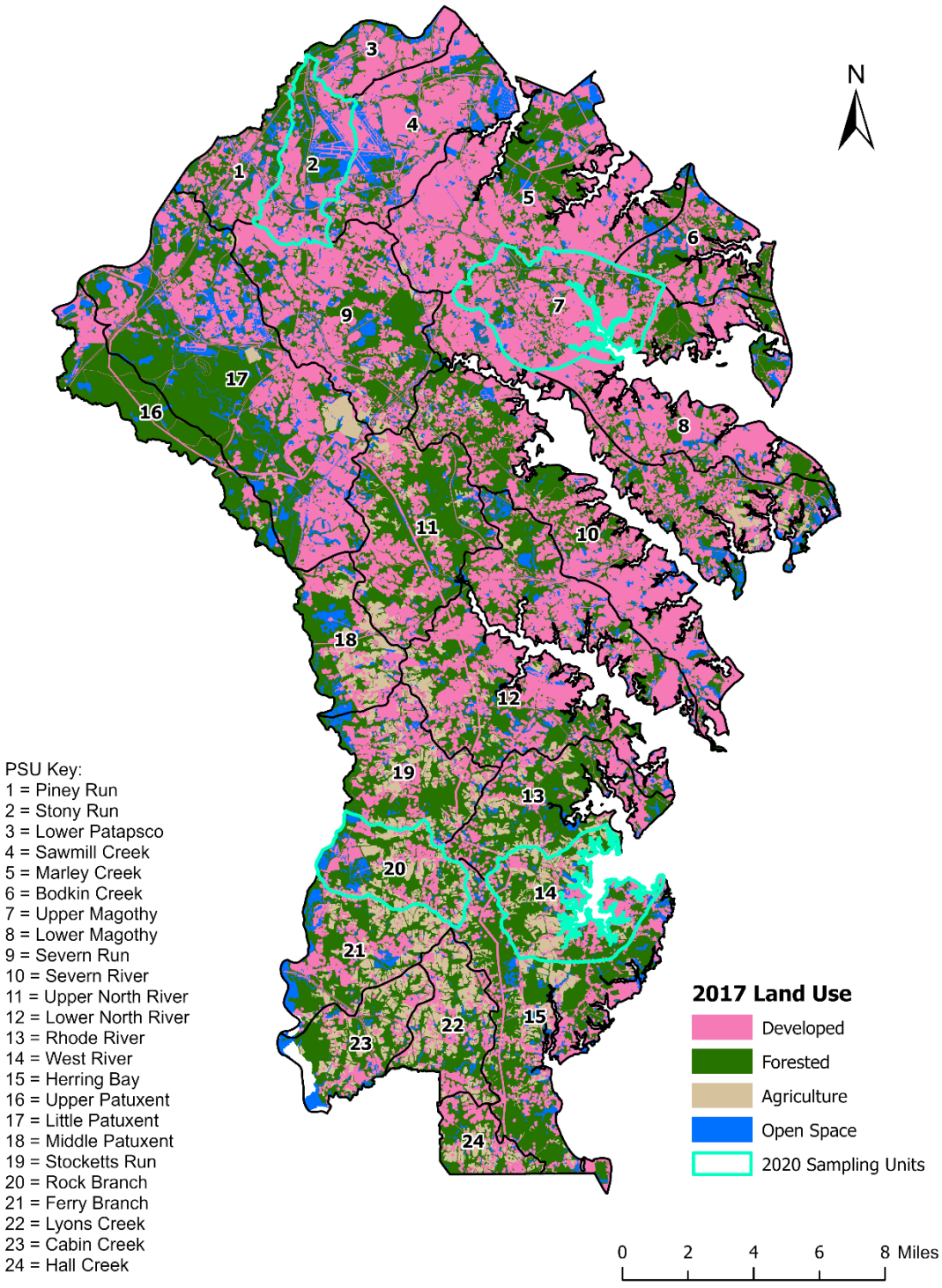

Figure 5 - Summarized land use in Anne Arundel County (2017)

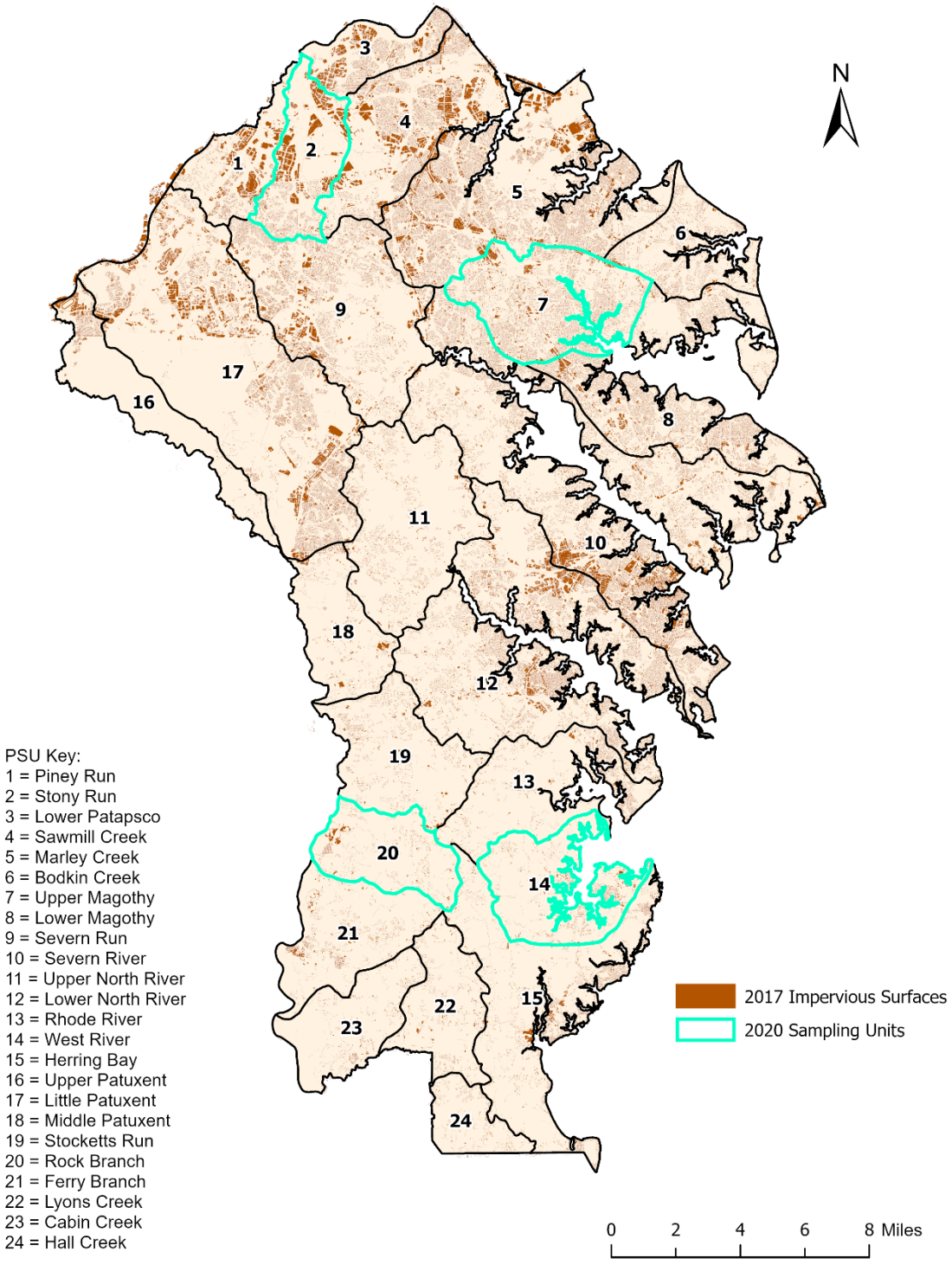

Figure 6 - Impervious surface in Anne Arundel County (2017)

4 Individual Sampling Unit Discussions

The following section summarizes the conditions within each of the four sampling units assessed during 2020. Site-specific data and assessment results can be found in Appendix D.

4.1 Rock Branch

The Rock Branch sampling unit is located along the southwestern edge of the county and borders Prince George's County (Figure 1). Rock Branch has a total drainage area of 6,131 acres and drains directly into the Patuxent River, which then drains into the Chesapeake Bay just north of Naval Air Station Patuxent River. The eight sampling locations have drainage areas ranging from 137 to 1,981 acres (Figure 10).

4.1.1 Land Use

The dominant land use for the Rock Branch sampling unit was forested land (40%), followed by developed land (27%), agriculture (25%), and open space (8%) (Table 17). The land use distribution within the sampling unit differed slightly when compared to the average land use among sites, which had higher average development and agriculture, and slightly lower forest cover and open space. Forest was the most prevalent land cover type for six of the eight sites, while the remaining two sites had a larger proportion of developed land (Figure 7). On average, land use among the eight sampling sites was comprised of 38% forested land, 33% agriculture, 28% developed land, and 2% open space. Impervious surfaces comprised 4% of the overall Rock Branch sampling unit (Table 17), with individual sites ranging from 1% to 6% impervious surfaces.

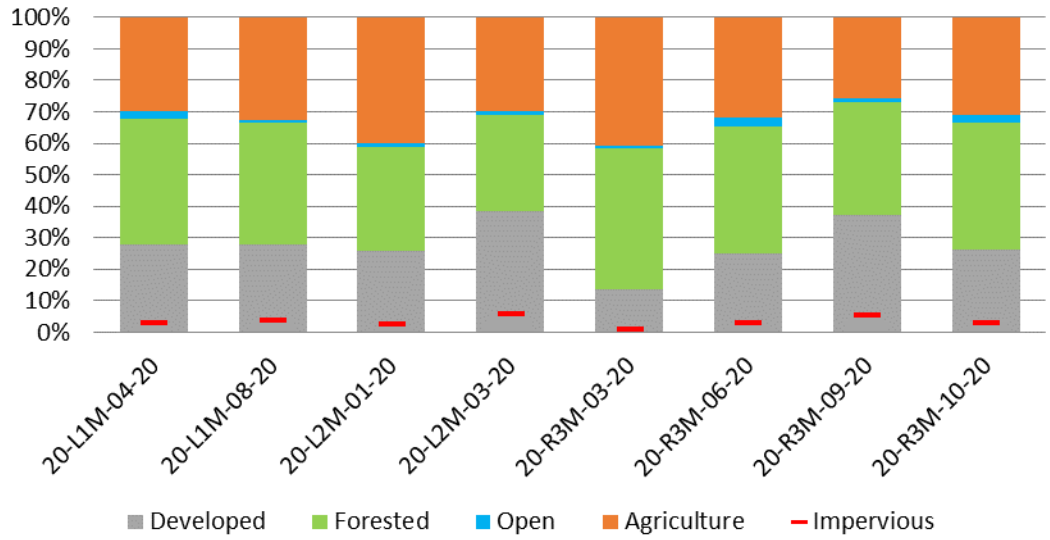

Figure 7 – Rock Branch land use (n=8)

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% of the Rock Branch sites received a rating of 'Partially Supporting,' 12.5% of sites received a 'Supporting', and the remaining 12.5% were rated 'Non-Supporting' (Figure 8). The average RBP score for the Rock Branch sampling unit was 113.75 ± 12.15, and the corresponding narrative rating was 'Partially Supporting'. Individual site scores ranged from 89 ('Non-Supporting') to 127

('Supporting'). Rock Branch had the second highest mean score for the spring RBP habitat assessment and the highest mean score for the summer PHI habitat assessment.

According to the PHI assessment (summer season), 50% of the Rock Branch sites were rated as 'Partially Degraded', 25% were rated as 'Degraded', and the remaining 25% of sites were rated as 'Minimally Degraded' (Figure 8). The average PHI rating was 'Partially Degraded' with a score of 71.45 ± 9.74. Individual site scores ranged from 56.07 ('Degraded') to 84.68 ('Minimally Degraded'). Instream habitat and epifaunal substrate generally scored in the 'Suboptimal' and 'Marginal' categories. The scaled metric for number of rootwads and woody debris scored above 90% at five of the eight sites. Bank stability exceeded 70% at only three of the eight sites. Percent shading also scored above 75% at all the sites.

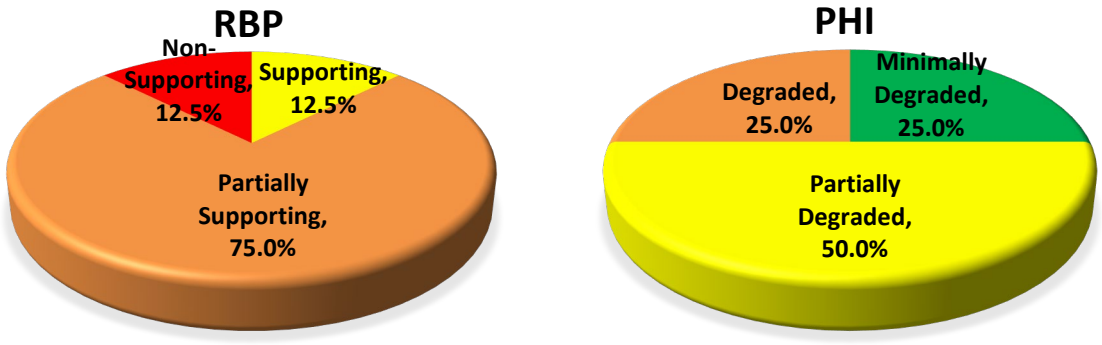

Figure 8 – Rock Branch Physical Habitat Conditions (RBP n=8; PHI n=8)

4.1.3 Benthic Macroinvertebrates

Of the eight sites sampled in Rock Branch, 62.5% of sites received a BIBI rating of 'Fair', 25% of the sites were rated as 'Poor', and the remaining 12.5% were rated as ' Very Poor' (Figure 9). The average BIBI score for the Rock Branch sampling unit is 2.89 ± 0.70, with an average biological condition of 'Poor'. This sampling unit had the second highest mean BIBI score and the third highest proportion of sites in the 'Very Poor' category. Individual BIBI scores ranged from 1.86 ('Very Poor') to 3.86 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

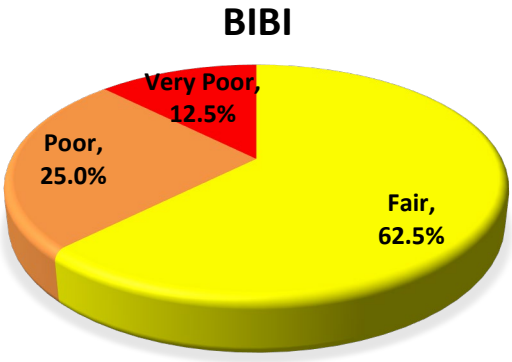

Figure 9 – Rock Branch BIBI Conditions (n=8)

Site 20-R3M-10-20 received the lowest score in the Rock Branch sampling unit of 1.86 with a 'Very Poor' narrative rating (Figure 10). The site had relatively low taxa diversity (15 taxa), and completely lacked in EPT, Ephemeroptera sp., and Scraper taxa. In contrast, site 20-L1M-04-20 received the highest BIBI score of 3.86, primarily due to a relatively high number of total taxa (23), three EPT taxa, four scraper taxa, and 12.5% of the sampling consisting of climbers. Additionally, two Ephemeroptera taxa were present and the sample comprised of 7% intolerant taxa.

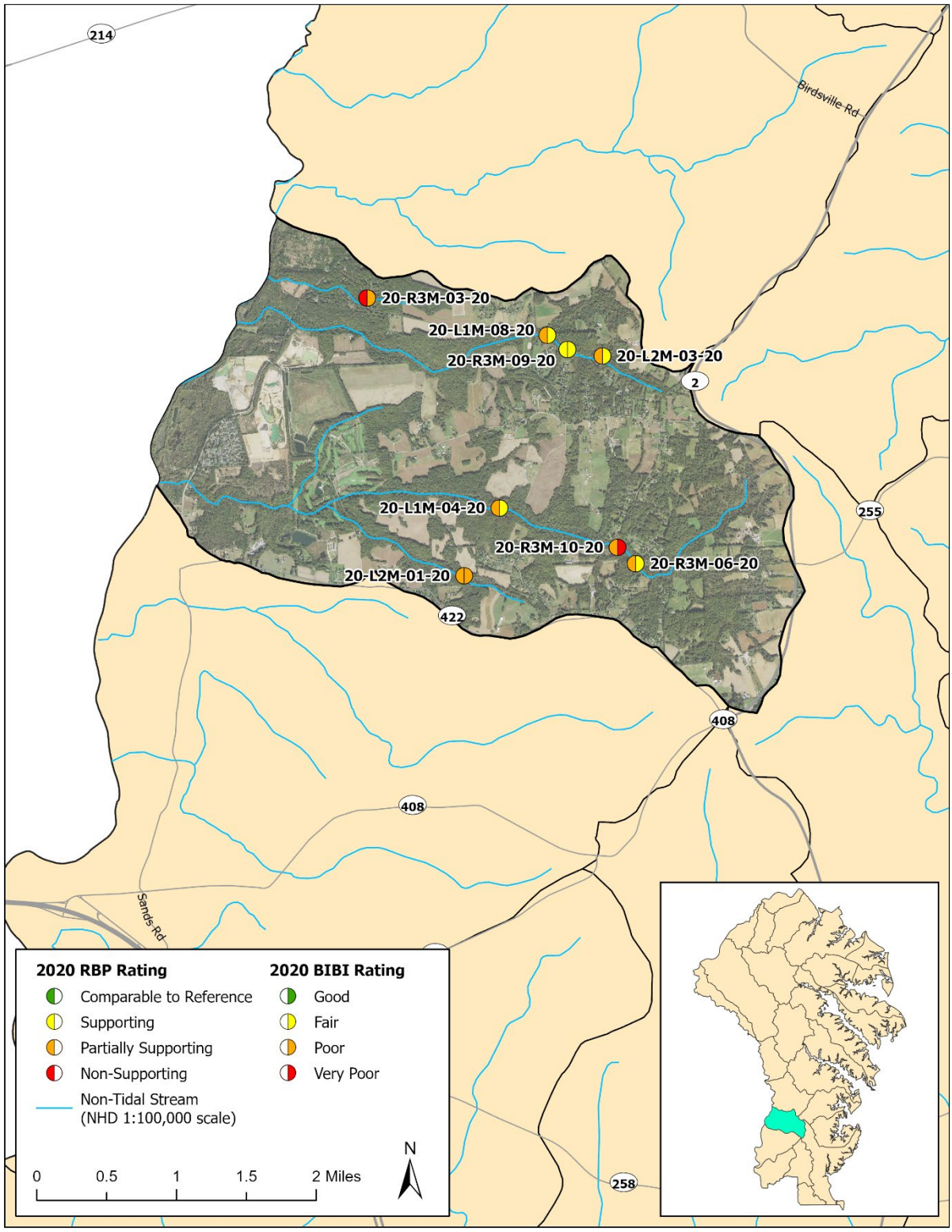

Figure 10 – Rock Branch Sampling Sites (BIBI and RBP)

4.1.4 Fish

The Rock Branch sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.54 ± 0.75. Half of the sites in this sampling unit received a biological condition rating of 'Poor' (50%), 37.5% scored a biological condition rating of 'Fair', with the remaining 12.5% scoring in the 'Very Poor' category (Figure 11). Individual FIBI scores ranged from 1.33 ('Very Poor') to 3.33 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

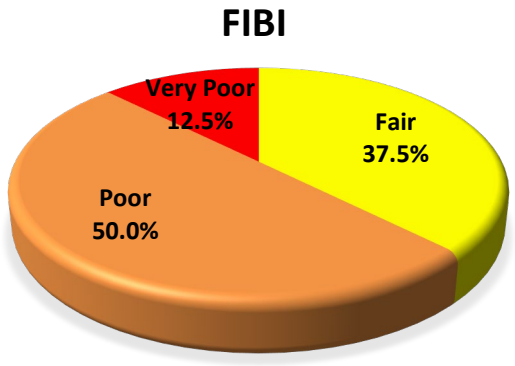

Figure 11 – Rock Branch FIBI Conditions (n=8)

One site, 20-L2M-01-20, received the lowest FIBI score of Rock Branch sites (1.33) with a narrative rating of 'Very Poor.' This site scored in the lowest category (1) for all metrics except abundance per square meter. In contrast, three of the eight sites received scores of 3.33 (Fair), the highest FIBI scores observed in the Rock Branch sampling unit. Additionally, these sites all scored in the highest category for adjusted number of benthic species and had some of the highest observed levels of diversity in the sampling unit, with 4-12 species observed at each site.

Blacknose Dace (*Rhinichthys atratulus*) was the most widely distributed species in the sampling unit, present at all eight sites, followed by American Eel (*Anguilla rostrata*) which was found at seven sites, and Tessellated Dater (*Etheostoma olmstedi*) found at six. Eastern Mudminnow (*Umbra pygmaea*), Bluegill (*Lepomis macrochirus)*, and Satinfin Shiner (*Cyprinella analostana*) were found at three of the eight sites. The least common species were White Sucker (*Catostomus commersonii*) and Least Brook Lamprey (*Lampetra aepyptera*), both of which were found at only a single site in this sampling unit. Thirteen species were observed in the sampling unit with two non-native species [Green Sunfish (*Lepomis cyanellus*) and Bluegill]. Eleven native species were also observed [American Eel, Blacknose Dace, Creek Chubsucker (*Erimyzon oblongus*), Eastern Mudminnow, Fallfish (*Semotilus corporalis*), Least Brook Lamprey, Rosyside Dace (*Clinostomus funduloides*), Tessellated Darter, Swallowtail Shiner (*Notropis procne*), Satinfin Shiner and White Sucker]. One round-bodied sucker (Creek Chubsucker) was present, along with two benthic fish species (Least Brook Lamprey and Tessellated Darter), and two species considered intolerant to pollution (Fallfish and Satinfin Shiner).

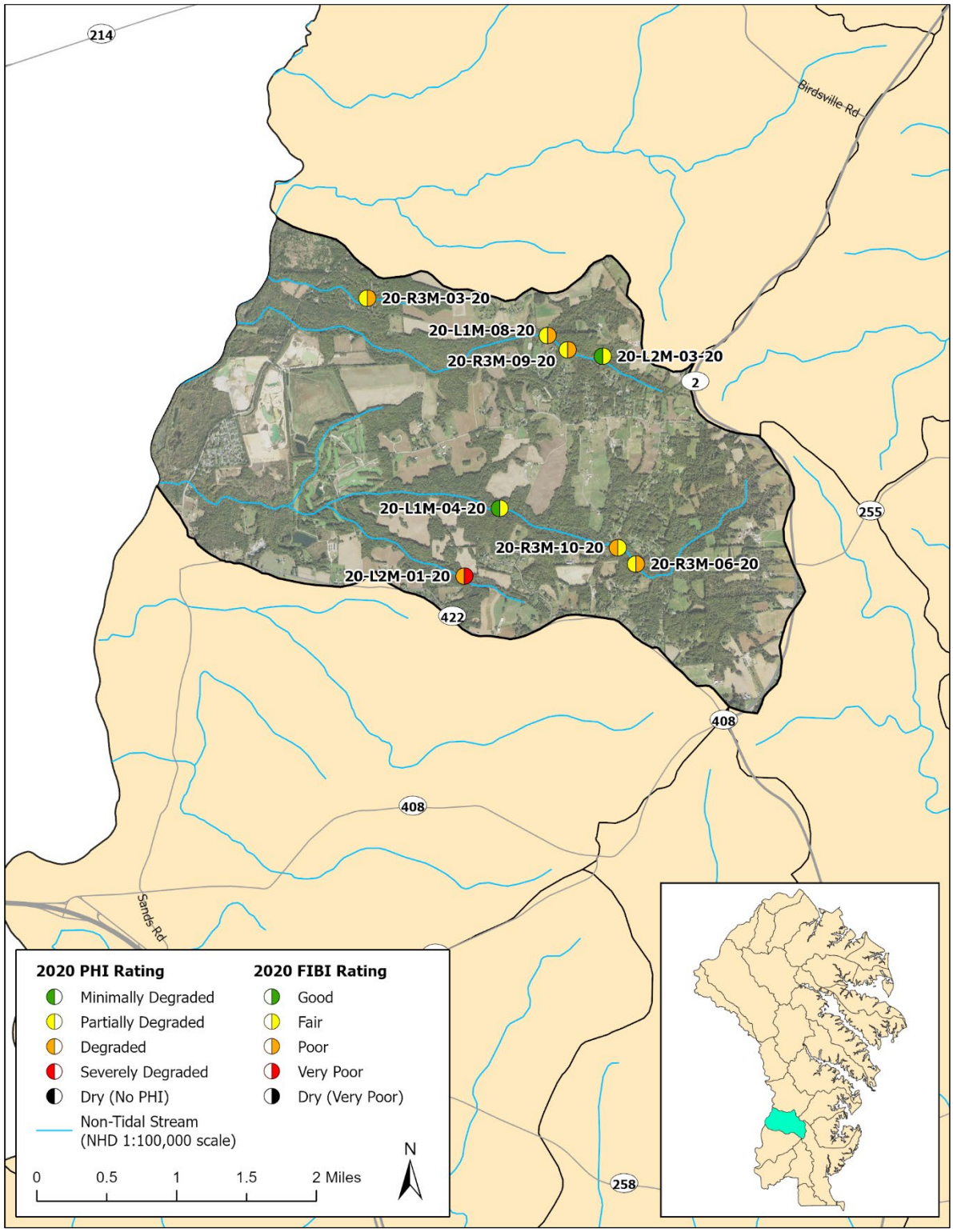

Figure 12 – Rock Branch Sampling Sites (FIBI and PHI)

4.1.5 Water Quality

Average spring and summer *in situ* water quality values for the Rock Branch sites are provided in Table 18. Seven of the eight sites sampled met COMAR standards for water quality in the spring. Site 20-R3M-03-20 fell below the COMAR standards for pH (i.e., 6.5-8.5 SU), with a value of 5.94. Water temperature ranged from 8.60 to 14.50 °C; DO ranged from 9.35 to 11.70 mg/L; pH ranged from 5.94 to 7.13 SU; specific conductance ranged from 103.0 to 239.0 µS/cm; and turbidity ranged from 1.90 to 22.30 NTU.

In the summer, all eight Rock Branch sites were sampleable with one site not meeting COMAR standards for water quality. Site 20-R3M-03-20 measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with a value of 5.12. Summer water temperature ranged from 18.60 to 23.00 °C; DO ranged from 6.54 to 8.74 mg/L; pH ranged from 5.12 to 7.30 SU; specific conductance ranged from 136.0 to 257.0 µS/cm; and turbidity ranged from 5.92 to 15.80 NTU.

Table 18 - Average *in situ* water quality values – Rock Branch

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	10.81 ± 2.03	10.84 ± 0.79	6.76 ± 0.40	195.8 ± 41.7	7.06 ± 7.25
Summer	20.33 ± 1.63	8.00 ± 0.75	6.72 ± 0.70	200.3 ± 36.2	8.95 ± 3.37

Average spring grab sample water quality values for the Rock Branch 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, with four sites having copper concentrations that fell at or below the MDL of 0.69 µg/L. Due to differences in the laboratory used in 2020 relative to other Round 3 monitoring years, comparisons of orthophosphate, nitrite, and ammonia levels with categories used by MBSS were limited due to analytical detection limits, which exceeded the high category values used by MBSS (i.e., > 0.03 mg/L for orthophosphate; > 0.01 mg/L for nitrite; and > 0.07 mg/L for ammonia). Additional details on the laboratory methods used in 2020 can be found in *Section 2.2.4*. All sites had nitrite and orthophosphate concentrations that fell below the MDLs of 0.029 mg/L and 0.45 mg/L, respectively, and could not be further categorized. Seven sites had ammonia concentrations that fell at or below the MDL of 0.088 mg/L, and site 20-R3M-03-20 had an ammonia concentration that fell in the high category used by MBSS with a value of 0.090 mg/L. All Rock Branch sites had total nitrogen and nitrate concentrations that fell in the low to moderate categories used by MBSS. Sites 20-L1M-04-20, 20-L1M-08-20, 20-L2M-01-20, 20-L2M-03-20, 20-R3M-06-20, 20-R3M-09-20, and 20-R3M-10-20 fell in the high category used by MBSS for total phosphorus (i.e., > 0.070 mg/L) with values of 0.180, 0.380, 0.099, 0.180, 0.110, 0.360, and 0.072 mg/L, respectively. No state or national water quality standards exist for DOC, TOC, or hardness. Based on spring grab samples, DOC ranged from 2.4 to 5.9 mg/L; TOC ranged from 2.4 to 6.6 mg/L; and hardness ranged from 26 to 68 mg/L.

Table 19 - Average grab samples water quality values – Rock Branch

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)
27 ± 6	0.179 ± 0.127	2.6 ± 2.1	0.450± 0.000	0.088 ± 0.001	0.029 ± 0.000	1.11 ± 0.63
Value ± Standard Deviation						
Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
3.5 ± 1.3	3.6 ± 1.6	56 ± 13	0.9 ± 0.3	9 ± 2	0.44 ± 0.39	10.7 ± 10.4

*The standard deviation for some parameters is 0 because all values were below the MDL.

4.1.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. The majority of the sites assessed in Rock Branch sampling unit were G type channel (37.5%; Figure 13). Half of the sites were entrenched F and slightly entrenched E channels (25.0% each). Moderately entrenched B type channels represented 12.5% of the sites surveyed.

The majority of the streams in this sampling unit had sand or a mix of sand and gravel dominated substrate (62.5% and 25.0% respectively), with the remainder of the sites being gravel dominated substrate (12.5%). The average D_{50} was 0.26 mm (medium sand). Individual site slopes ranged from 0.02% to 2.00%, with an average slope of 0.70%. The Rock Branch sampling unit had the greatest range in slopes across sites sampled.

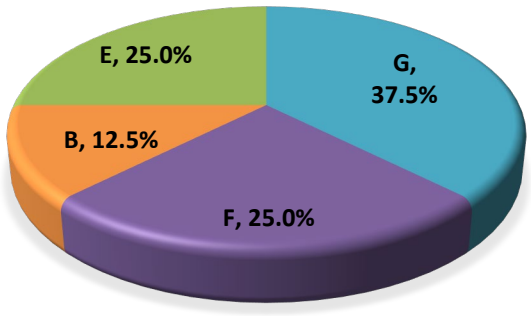

Figure 13 - Rosgen stream types observed in Rock Branch (n=8)

4.2 Stony Run

The Stony Run sampling unit, which drains directly to the Patapsco River near Howard and Baltimore Counties, is located in the north central edge of the county (Figure 1) and has a drainage area of 6,203 acres. The eight sampling sites have drainage areas ranging from 76 to 6,160 acres.

4.2.1 Land Use

Land use in the Stony Run sampling unit was primarily comprised of developed land (53%), followed by forested land (30%), open space (17%), and less than 1% agriculture (Table 17). The land use distribution within the sampling unit differed when compared to the average land use among sites, which had higher average development and lower average forest cover and open space. All sites were more than 50% developed, with varying amounts of forest (13% to 29%) and open space (1% to 17%). On average, the sites sampled in the Stony Run sampling unit were dominated by developed land cover (69%), followed by forested land cover (21%), and open space (10%), with little agriculture (<1%) (Figure 14). Impervious surfaces comprised 18% of Stony Run, with individual sites ranging from 15% to 20% impervious surfaces.

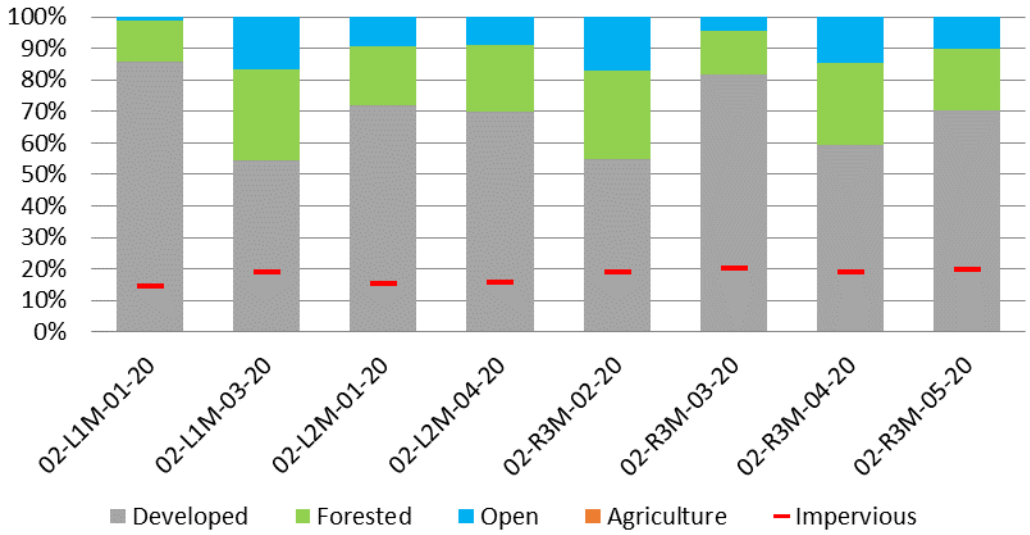

Figure 14 – Stony Run land use (n=8)

4.2.2 Physical Habitat

Physical habitat conditions during the spring season were variable for this sampling unit. Based on the RBP scores, 62.5% of the Stony Run sites received a rating of 'Supporting' and the remaining 37.5% received a rating of 'Partially Supporting' (Figure 15). The average RBP score for the Stony Run sampling unit was 124.88 ± 7.92 (Table 16), and the corresponding narrative rating was 'Partially Supporting'. Individual site scores ranged from 133 ('Supporting') to 108 (''Partially Supporting').

According to the PHI (summer), 50.0% of the Rock Branch sites were rated as 'Partially Degraded', 50.0% received a rating of 'Degraded'(Figure 15). The average PHI rating was 'Degraded' with a score of 65.06 ± 7.65. Individual site scores ranged from 55.70 ('Degraded') to 76.05 ('Partially Degraded'). Stony Run did not have any sites scoring in the lowest 'Severely Degraded' category, nor in the highest 'Minimally Degraded' category. Instream habitat and epifaunal substrate generally scored in the 'Suboptimal' and

'Marginal' categories; Stony Run had the second lowest mean for PHI habitat assessment for the 2020 sampling year. Remoteness was mostly in the 'Marginal' category with one site in the 'Poor' category. The scaled metric for number of rootwads and woody debris scored above 80% at five of the eight sites. Bank stability exceeded 70% at all but one site. Percent shading metric scored above 70% at half of the sites. Embeddedness was variable at the Stony Run sites, with two sites scoring 100% and the remaining scoring between 25% and 65%.

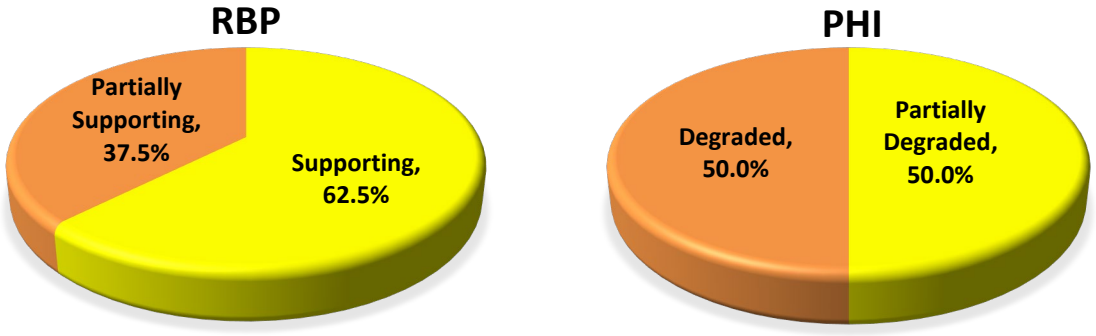

Figure 15 – Stony Run Physical Habitat Conditions (RBP n=8; PHI n=8)

4.2.3 Benthic Macroinvertebrates

Stony Run had the highest BIBI average out of all the sampling units in 2020. The Stony Run sampling unit received a BIBI narrative rating of 'Fair' with an average score of 3.11 ± 0.48 (Table 16). The majority of individual sites (87.5%) received a biological condition rating of 'Fair' and the remaining 12.5% received a 'Poor' rating (Figure 16). Individual BIBI scores ranged from 2.14 ('Poor') to 3.86 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

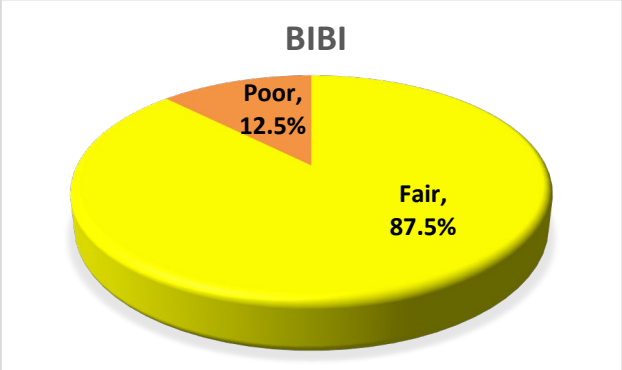

Figure 16 – Stony Run BIBI Conditions (n=8)

Site 02-L2M-04-20 received the lowest BIBI score of all Stony Run sites (2.14) with a narrative rating of 'Poor' (Figure 17). This site had only 14 total taxa, none of which were in the EPT group; Ephemeroptera taxa were completely absent. Additionally, very small percentages of intolerant taxa and climbers were observed at this site. In contrast, site 02-L1M-03-20 received the highest BIBI score (3.86; 'Fair') in the Stony Run sampling unit. This site had five EPT taxa, one Ephemeroptera taxa, and three scraper taxa from a total of 25 taxa present, with 4.3% of the sample consisting of climber taxa.

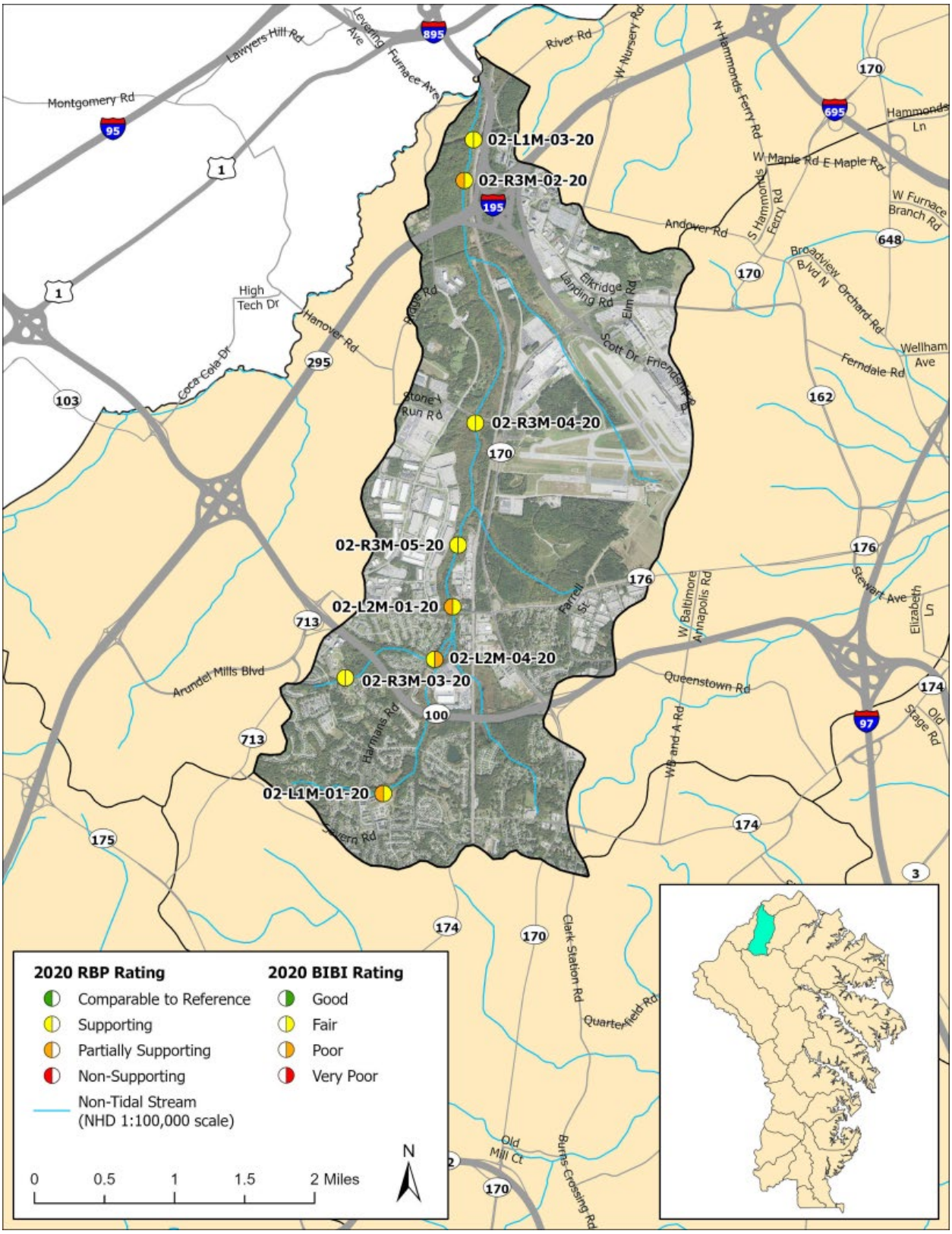

Figure 17 – Stony Run Sampling Sites (BIBI and RBP)

4.2.4 Fish

The Stony Run sampling unit received the highest FIBI score out of all four units. Stony Run received a FIBI narrative rating of 'Fair' with an average score of 3.37 ± 0.88 (Table 16). Fifty percent of the individual sites sampled in this unit received a biological condition rating of 'Fair', 37.5% received a 'Good' rating, and the remaining 12.5% of sites were rated as 'Very Poor' (Figure 18). 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.

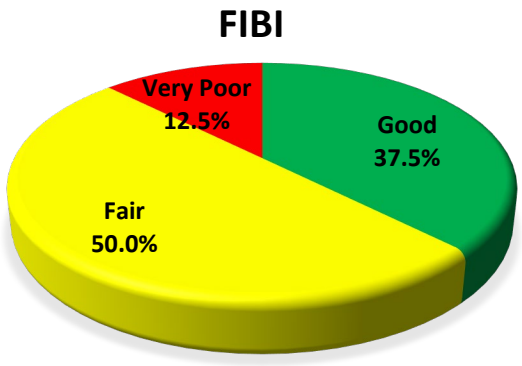

Figure 18 – Stony Run FIBI conditions (n=8)

Site 02-R3M-03-20 received the lowest FIBI score of all Stony Run sites (1.67) with a narrative rating of 'Very Poor.' This site scored in the lowest category (1) for all metrics except abundance per square meter. In contrast, sites 02-L1M-03-20 and 02-R3M-04-20 both received the highest FIBI score (4.33; 'Good') of sites sampled during 2020 in the Stony Run sampling unit. Both sites scored in the highest category for adjusted number of benthic species, percent tolerant, and percent abundance of dominant taxa. Site 02-L1M-03-20 scored in the middle category for percent round bodied suckers, and percent generalist, omnivores, and invertivores. This site also had the highest diversity in the sampling unit with 26 species observed. Site 02-R3M-04-20 scored in the middle category for abundance per square meter and percent generalist, omnivores, and invertivores. The Stony Run sampling unit had the highest FIBI score mean of all units sampled in 2020.

Blacknose Dace, Creek Chub (*Semotilus atromaculatus*), and Green Sunfish were the most widely distributed species in the sampling unit, present at all eight sites, followed by American Eel and Bluegill which were found at seven sites. The least common species in this sampling unit, only present at one site, were Spottail Shiner (*Notropis hudsonius*), Common Shiner (*Luxilus cornutus*), River Chub (*Nocomis micropogon*), Pumpkinseed (*Lepomis gibbosus*), Brown Bullhead (*Ameiurus nebulosus*), Warmouth (*Lepomis gulosus*), Rock Bass (*Ambloplites rupestris*), Golden Shiner (*Notemigonus crysoleucas*), Black Crappie (*Pomoxis nigromaculatus*), Sea Lamprey (*Petromyzon marinus*), Redfin Pickerel (*Esox americanus*), and Rosyside Dace. Thirty-three species were observed in the sampling unit with six non-native species [Bluegill, Largemouth Bass (*Micropterus salmoides)*, Green Sunfish, Smallmouth Bass (*Micropterus dolomieu*), Black Crappie, and Rock Bass], and twenty-seven native species [American Eel, Blacknose Dace, Brown Bullhead, Margined Madtom (*Noturus insignis*), Pumpkinseed, Redfin Pickerel, Redbreast Sunfish (*Lepomis auritus*), Eastern Mosquitofish (*Gambusia holbrooki*), Eastern Mudminnow, Tessellated Darter, Warmouth, Creek Chub, Least Brook Lamprey, White Sucker, Sea Lamprey, Fallfish, Rosyside Dace, Satinfin Shiner, Swallowtail Shiner, Yellow Bullhead (*Ameiurus natalis*), Spottail Shiner, Common Shiner, Golden Shiner, Central Stoneroller (*Campostoma anomalum*), Longnose Dace (*Rhinichthys cataractae*), Northern Hogsucker (*Hypentelium nigricans*), and River Chub]. One round-bodied sucker species (Northern Hogsucker) and three benthic fish (Tessellated Darter, Least Brook Lamprey, and Margined Madtom) were present in this sampling unit. Nine species considered intolerant to pollution (Fallfish, Central Stoneroller, Spottail Shiner, Common Shiner, River Chub, Margined Madtom, Northern Hogsucker, Satinfin Shiner, and Sea Lamprey) were present in this sampling unit.

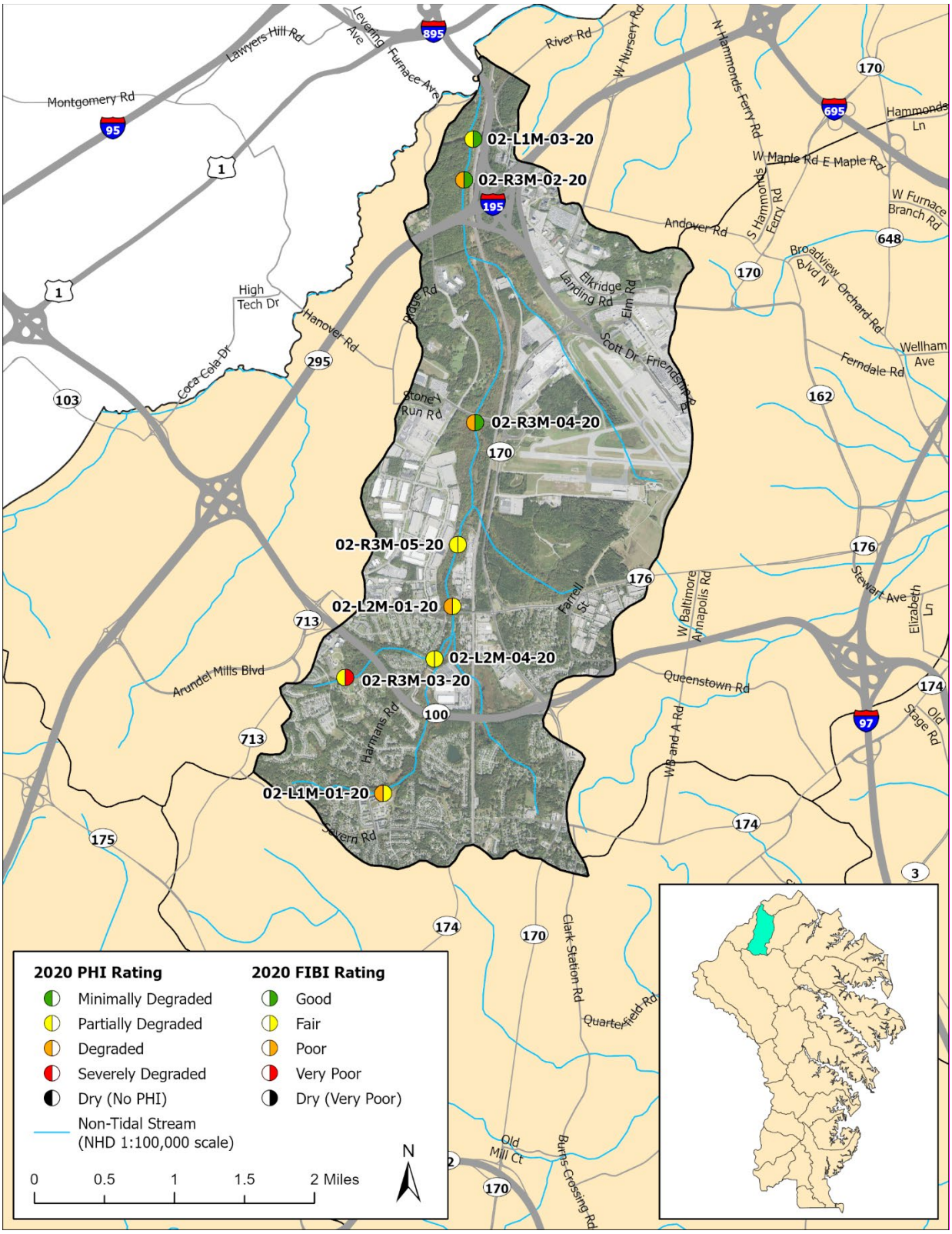

Figure 19 – Stony Run (FIBI and PHI)

4.2.5 Water Quality

Average spring and summer *in situ* water quality values for the Stony Run sites are provided in Table 18. All eight sites sampled in the spring meet COMAR standards for water quality. In the spring, water temperature ranged from 9.50 to 12.50 °C; DO ranged from 9.08 to 11.06 mg/L; pH ranged from 6.84 to 7.32 SU; specific conductance ranged from 194.2 to 446.6 µS/cm; and turbidity ranged from 5.48 to 40 NTU.

In the summer, all eight Stony Run sites were sampleable. One site did not meet COMAR standards for water quality in the summer. Site 02-L1M-01-20 measured outside of the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with a value of 6.35. In the summer, water temperature at Stony Run sites ranged from 14.20 to 25.10 °C; DO ranged from 5.54 to 9.22 mg/L; pH ranged from 6.35 to 7.48 SU; specific conductance ranged from 262.3 to 467.7 µS/cm; and turbidity ranged from 4.56 to 21.1 NTU.

Table 20 - Average *in situ* water quality values – Stony Run

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	11.19 ± 1.24	10.25 ± 0.74	7.11 ± 0.18	322.6 ± 84.4	11.22 ± 11.74
Summer	20.50 ± 3.42	7.77 ± 1.25	7.07 ± 0.38	335.4 ± 84.5	9.20 ± 5.83

Average spring grab sample water quality values for the Stony Run sites are provided in Table 21. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, lead, and turbidity. Due to differences in the laboratory used in 2020 relative to other Round 3 monitoring years, comparisons of orthophosphate, nitrite, and ammonia levels with categories used by MBSS were limited due to analytical detection limits, which exceeded the high category values used by MBSS (i.e., > 0.03 mg/L for orthophosphate; > 0.01 mg/L for nitrite; and > 0.07 mg/L for ammonia). Orthophosphate concentrations at all sites, nitrite concentrations at seven sites, and ammonia concentrations at five sites fell at or below the MDLs of 0.45 mg/L, 0.029 mg/L, and 0.088 mg/L, respectively, and could not be further categorized. Site 02-L2M-04-20 had a nitrite concentration of 0.062 mg/L which fell in the high category used by MBSS. Sites 02-L2M-01-20, 02-L2M-04-20, and 02-R3M-05-20 had ammonia concentrations of 0.10, 0.12, and 0.10 mg/L, respectively, and fell in the high category used by MBSS. Similarly, seven sites had total phosphorus values that fell at or below the MDL of 0.037 mg/L, which falls in the moderate category used by MBSS (i.e., 0.025-0.070 mg/L). The remaining site, 02-L1M-03-20, had a total phosphorus value of 0.040 mg/L which also fell in the moderate category used by MBSS. Sites 02-L1M-01-20, 02-L2M-01-20, 02-R3M-03-20, and 02-R3M-05-20 fell in the high category used by MBSS (i.e., >7.0 mg/L) for total nitrogen, with values of 14.0, 8.0, 14.0, and 7.4 mg/L, respectively. All other sites had total nitrogen values in the moderate category used by MBSS (i.e., 1.5-7.0 mg/L). All nitrate values for sites in the Stony Run sampling unit fell in the low to moderate categories used by MBSS. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 4.8 to 6.6 mg/L; TOC ranged from 5.1 to 6.5 mg/L; and hardness ranged from 50 to 72 mg/L.

Table 21 - Average grab sample water quality values – Stony 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)
50 ± 20	0.037 ± 0.001	7.3 ± 4.5	0.450 ± 0.000	0.095 ± 0.011	0.033 ± 0.012	1.07 ± 0.79
Value ± Standard Deviation						
Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
5.8 ± 0.6	5.9 ± 0.5	62 ± 7	1.8 ± 0.3	12 ± 3	0.46 ± 0.09	4.9 ± 2.0

*The standard deviation for some parameters is 0 because all values were below the MDL.

4.2.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results are presented in Appendix A. The majority of sites in the Stony Run sampling unit were slightly entrenched E type channels (37.5%; Figure 20). The next dominate type were moderately entrenched B type channels (25.0%). The remaining sites were classified as entrenched F and C type channels or 'Not Determined' (ND) (all 12.5%).

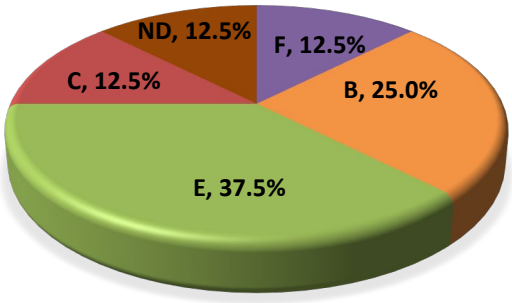

Figure 20 - Rosgen stream types observed in Stony Run (n=8)

All sites within the Stony Run sampling unit had stream bed substrate dominated by sand, gravel or a mix of the two (37.5%, 50%, and 12.5% respectively). The average D_{50} within the Stony Run sampling unit was 6.50 mm (fine gravel). Streams in this sampling unit had an average slope of 0.47%, with individual slopes ranging from 0.02% to 0.82%.

4.3 Upper Magothy

The Upper Magothy sampling unit is located in the northeast portion of the county, in Severna Park, Maryland. The sampling unit drains directly into the Magothy River, which then drains into the Chesapeake Bay just north of Sandy Point (Figure 1). The Upper Magothy sampling unit has a total drainage area of 10,031 acres, the largest of the 2020 sampling units. The eight sampling sites have drainage areas that range from 132 to 3,062 acres.

4.3.1 Land Use

The Upper Magothy sampling unit was the most developed of the 2020 sampling units with 70% developed land, followed by forested land (25%), open space (5%), and less than 1% agriculture (Table 17). Developed land was the primary land use type at all sites, followed by forest and open space (Figure

21). On average, land use among the eight sites was similar to that of the sampling unit, with 72% developed land, 22% forested land, 6% open space, and less than 1% agriculture. Impervious surfaces accounted for only 14% of the Upper Magothy sampling unit, with individual sites ranging from 9% to 21% impervious surfaces.

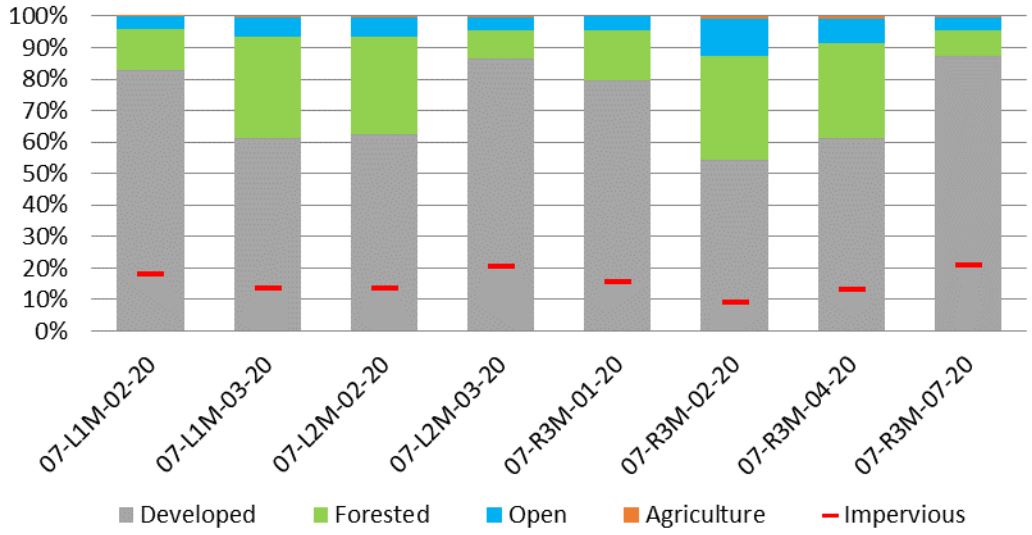

Figure 21 – Upper Magothy land use (n=8)

4.3.2 Physical Habitat

Based on the RBP scores, 50.0% of the Upper Magothy sites received a rating of 'Partially Supporting,' while 37.5% of sites were classified as 'Non-Supporting', and the remaining 12.5% sites were classified as 'Supporting' (Figure 22). The average RBP score for the Upper Magothy sampling unit was 108.88 ± 18.69, and the corresponding narrative rating was 'Partially Supporting.' Individual site scores ranged from 81 ('Non-Supporting') to 142 ('Supporting'). This sampling unit had no sites rated as 'Comparable to Reference' in 2020. Mean scores for both spring RBP and summer PHI were the lowest of the four sampling units assessed in 2020.

According to the PHI (summer), 37.5% of the Upper Magothy sites were rated as 'Partially Degraded', 50.0% were rated as 'Degraded', and the remaining 12.5% were rated as 'Severely Degraded' (Figure 22). The average PHI rating was 'Degraded' with a score of 61.40 ± 10.96. Individual site scores ranged from 37.27 ('Severely Degraded') to 72.15 ('Partially Degraded'). The majority of sites sampled received 'Suboptimal' to 'Poor' scores for both instream habitat and epifaunal substrate. Bank stability scored in the 'Suboptimal' to 'Marginal' categories for most sites, with one site scoring in the 'Poor' category. Embeddedness scored 100% at six of the eight sites with the remaining two sites scoring at 60%.

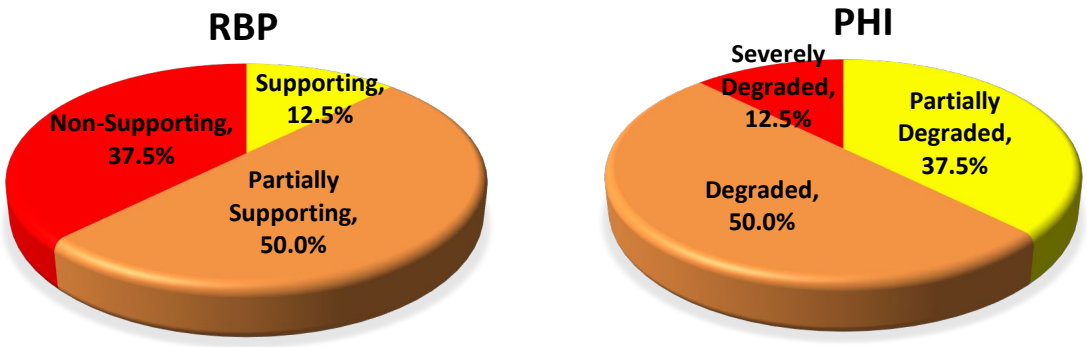

Figure 22 – Upper Magothy Physical Habitat Conditions (RBP n=8; PHI n=8)

4.3.3 Benthic Macroinvertebrates

The average BIBI rating for the Upper Magothy sampling unit is 'Poor' with an average BIBI score of 2.14 ± 0.65 (Table 16), and individual sites ranging from a low of 1.00 ('Very Poor') to 3.00 ('Fair'). Half of sites (50.0%) received a BIBI rating of 'Poor', 37.5% of the sites were rated as 'Very Poor', and the remaining 12.5% of sites were rated as 'Fair' (Figure 23). Upper Magothy was the sampling unit with the lowest mean BIBI score. Site-specific data and assessment results can be found in Appendix D.

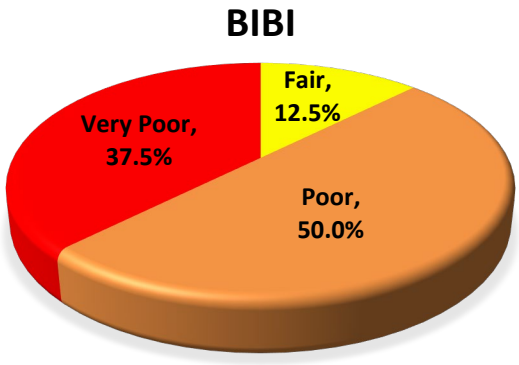

Figure 23 – Upper Magothy BIBI Conditions (n=8)

Site 07-R3M-01-20 received the lowest BIBI score of 2020 at 1.00 with a 'Very Poor' narrative rating (Figure 24). The site had relatively low taxa diversity (7 taxa), and completely lacked organisms from the EPT group. Scraper taxa were also absent from this site. Only 3% of intolerant organisms were present at this site. In contrast, site 07-L2M-02-20 received the highest BIBI score of 3.00, primarily due to a relatively high number of total taxa (33), three EPT taxa, two scraper taxa, and 21.0% of the sample consisting of intolerant organisms. All sites in the Upper Magothy sampling unit lacked Ephemeroptera taxa and only half of the sites had EPT taxa present in the sample.

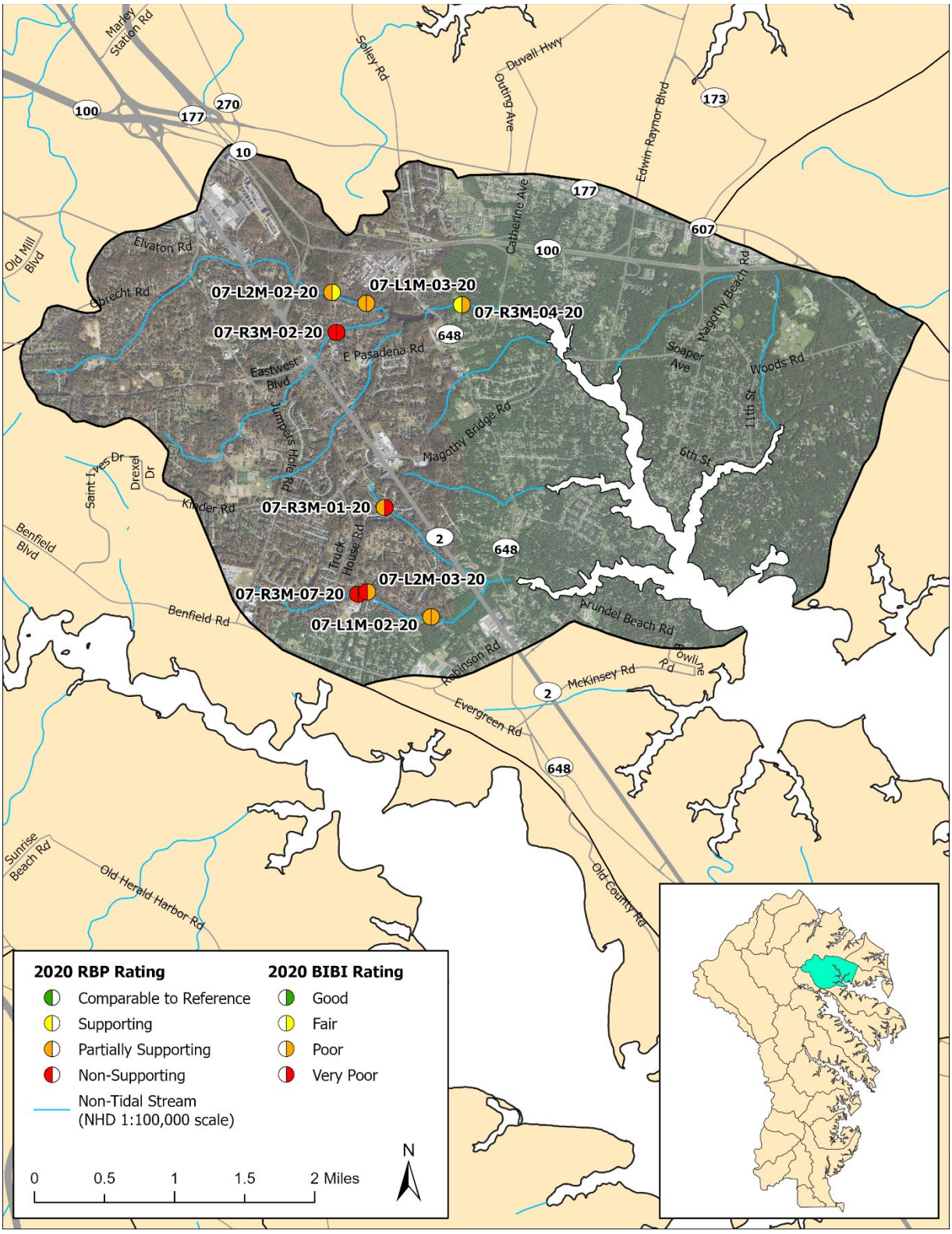

Figure 24 – Upper Magothy Sampling Sites (BIBI and RBP)

4.3.4 Fish

The Upper Magothy sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.71 ± 0.95 (Table 16). Of the sites in this sampling unit, 50.0% received a biological condition rating of 'Fair', while 12.5% received a rating of 'Good' and 'Poor' and 25.0% received a 'Very Poor' rating (Figure 25). Individual FIBI scores ranged from 1.00 ('Very Poor') to 4.00 ('Good'). Site-specific data and assessment results can be found in Appendix D.

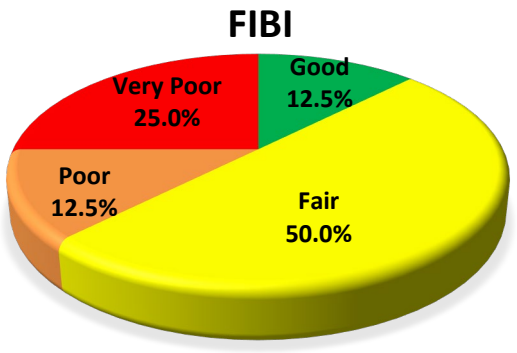

Figure 25 – Upper Magothy FIBI Conditions (n=8)

Site 07-R3M-01-20 received the lowest FIBI scores of Upper Magothy sites (1.00) with a narrative rating of 'Very Poor.' This site scored in the lowest category (1) for all six metrics. 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 07-R3M-04-20 received the highest FIBI score (4.00; 'Good') in the Upper Magothy sampling unit. This site scored in the highest category for abundance per square meter, adjusted number of benthic species, percent generalist, omnivores, and invertivores, and percent abundance of dominant taxon; in the middle category for percent tolerant; and in the lowest category for percent round bodied suckers. Site 07-L1M-02-20 had the highest diversity in the sampling unit with twelve species observed.

Eastern Mosquitofish was the most widely distributed species in the Upper Magothy sampling unit, present at seven of the eight sites. Bluegill and Eastern Mudminnow were both found at six of the eight sites. The least common species in this sampling unit were Warmouth, Bluespotted Sunfish (*Enneacanthus gloriosus*), Black Crappie, Mummichog (*Fundulus heteroclitus*), Tessellated Darter, and Spottail Shiner, each found only at a single site. Sixteen species were observed in the sampling unit with three non-native species (Bluegill, Black Crappie, and Largemouth Bass), and thirteen native species [American Eel, Eastern Mudminnow, Pumpkinseed, Tessellated Darter, Eastern Mosquitofish, Brown Bullhead, Creek Chubsucker, Warmouth, Mummichog, Bluespotted Sunfish, Golden Shiner, Spottail Shiner, and Banded Killifish (*Fundulus diaphanus*)]. One round-bodied sucker species (Creek Chubsucker) was present, along with one benthic fish (Tessellated Darter) in this sampling unit. One species considered intolerant to pollution (Spottail Shiner) was present.

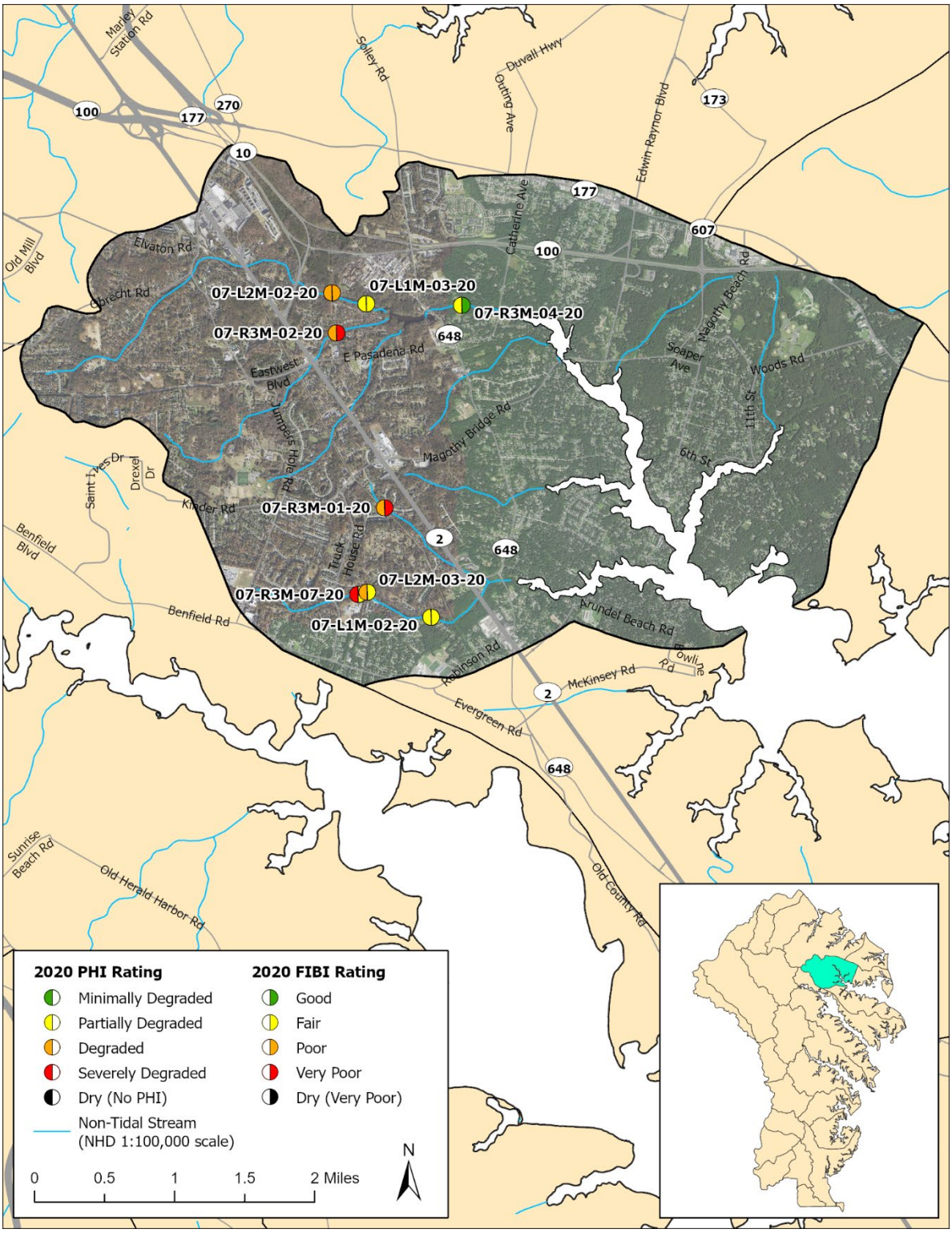

Figure 26 – Upper Magothy Sampling Sites (FIBI and PHI)

4.3.5 Water Quality

Average spring and summer *in situ* water quality values for the Upper Magothy sites are provided in Table 22. Of the eight sites sampled, three sites did not meet COMAR standards for water quality in the spring. Sites 07-L2M-02-20, 07-L2M-03-20, and 07-R3M-02-20 all measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5 SU) with values of 6.40, 6.04, and 6.41, respectively. All other parameters sampled met COMAR standards for water quality. In the spring, water temperature ranged from 9.90 to 20.70 °C; DO ranged from 6.13 to 11.45 mg/L; pH ranged from 6.04 to 7.06 SU; specific conductance ranged from 137.9 to 402.5 µS/cm; and turbidity ranged from 3.30 to 12.40 NTU.

In the summer, all eight sites in the Upper Magothy sampling unit were sampleable. Six sites did not meet COMAR standards for water quality. Sites 07-L1M-03-20, 07-L2M-02-20, 07-L2M-03-20, 07-R3M-01-20, and 07-R3M-02-20 measured values outside of the acceptable COMAR range for pH (i.e., 6.5-8.5 SU) with values of 6.14, 6.31, 5.07, 5.95, and 6.49 SU, respectively. Sites 07-L2M-03-20, 07-R3M-01-20, and 07-R3M-07-20 had values lower than the acceptable COMAR standard (i.e., ≥ 5 mg/L) for DO, with measurements of 4.83, 2.34, and 4.61, respectively. Water temperature ranged from 19.20 to 26.50 °C; DO ranged from 2.34 to 7.54 mg/L; pH ranged from 5.07 to 7.25 SU; specific conductance ranged from 237.6 to 523.5 µS/cm; and turbidity ranged from 3.82 to 10.50 NTU.

Table 22 - Average *in-situ* water quality values – Upper Magothy

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	15.30 ± 3.77	8.63 ± 1.48	6.57 ± 0.31	285.5 ± 81.8	6.17 ± 2.87
Summer	22.56 ± 2.69	5.70 ± 1.71	6.35 ± 0.67	359.4 ± 127.3	7.68 ± 2.45

Average spring grab sample water quality values for the Upper Magothy 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, lead, and turbidity. Due to differences in the laboratory used in 2020 relative to other Round 3 monitoring years, comparisons of orthophosphate, nitrite, and ammonia levels with categories used by MBSS were limited due to analytical detection limits, which exceeded the high category values used by MBSS (i.e., > 0.03 mg/L for orthophosphate; > 0.01 mg/L for nitrite; and > 0.07 mg/L for ammonia). Orthophosphate and nitrite concentrations at all sites and ammonia concentrations at four sites fell at or below the MDLs of 0.45 mg/L, 0.029 mg/L, and 0.088 mg/L, respectively, and could not be further categorized. Ammonia concentrations at sites 07-L1M-02-20, 07-L1M-03-20, 07-R3M-04-20, and 07-R3M-07-20 fell in the high category used by MBSS (i.e., > 0.07 mg/L), with values of 0.150, 0.170, 0.210, and 0.200 mg/L. Similarly, four sites had total phosphorus values that fell below the MDL of 0.037 mg/L, which falls in the moderate category used by MBSS (i.e., 0.025-0.070 mg/L). Site 07-R3M-02-20 had a total phosphorus concentration that fell in the high category used by MBSS (i.e., > 0.070 mg/L), with a value of 0.089 mg/L. The remaining three sites had total phosphorus concentrations falling in the moderate category used by MBSS. Site 07-R3M-07-20 had a total nitrogen value of 9.9 mg/L which fell in the high category used by MBSS (i.e., > 7.0 mg/L). All other sites had total nitrogen values that fell in the low or moderate categories used by MBSS. Nitrate values at seven sites fell in the moderate or low categories used by MBSS and one site had a value that fell below the MDL of 0.023 mg/L. No state or national water quality standards exist for DOC, TOC, or hardness. Based on spring grab samples, DOC ranged from 3.5 to 9.1 mg/L; TOC ranged from 3.6 to 9.0 mg/L; and hardness ranged from 40 to 74 mg/L.

Table 23 - Average grab sample water quality values – Upper Magothy

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)
46 ± 20	0.046 ± 0.018	4.0 ± 2.7	0.45 ± 0.00	0.135 ± 0.054	0.029 ± 0.000	0.73 ± 0.44
Value ± Standard Deviation						
Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
5.7 ± 2.0	5.9 ± 1.9	55 ± 11	1.6 ± 0.5	12 ± 4	0.63 ± 0.25	5.8 ± 3.7

*The standard deviation for some parameters is 0 because all values were below the MDL.

4.3.6 Geomorphic Assessment

Site-specific geomorphic assessment results can be found in Appendix A. There was an equal proportion of sites in the Upper Magothy sampling unit that were classified as entrenched F type channels and slightly entrenched E and C type channels (25.0% each; Figure 27). The remaining 25% of sites were G channel types or 'Not Determined' (ND), as they were unable to be classified within the Rosgen stream type (12.5% each).

All streams sampled in this sampling unit had predominantly sand substrate (100%). The average D_{50} for the Upper Magothy sampling unit was 0.33 mm (medium sand). The average slope was 0.47%, with individual sites ranging from 0.06% to 1.30%.

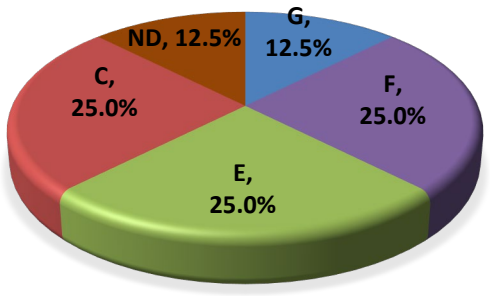

Figure 27- Rosgen stream types observed in Upper Magothy (n=8)

4.4 West River

The West River sampling unit is located in the southeastern portion of the county (Figure 1) near Shady Side, Maryland. The sampling unit drains into the tidal West River, which drains directly into the Chesapeake Bay, just north of Shady Side. The West River sampling unit has a total drainage area of 7,558 acres, with the eight sites shown in Figure 31 having drainage areas ranging from 81 to 536 acres.

4.4.1 Land Use

Land use in the West River sampling unit was primarily comprised of forested land (43%), followed by developed land (30%), agriculture (22%), and 5% open space (Table 17). On average, sites had slightly more forested (45%) and developed (33%) land and less agriculture (17%) than the overall sampling unit (Figure 28). Developed land was the most dominant cover type for five sites and forested land was the most dominant cover type for the remaining three sites. West River had 5% impervious surfaces, and the individual sites ranged from 1% to 5% impervious surfaces.

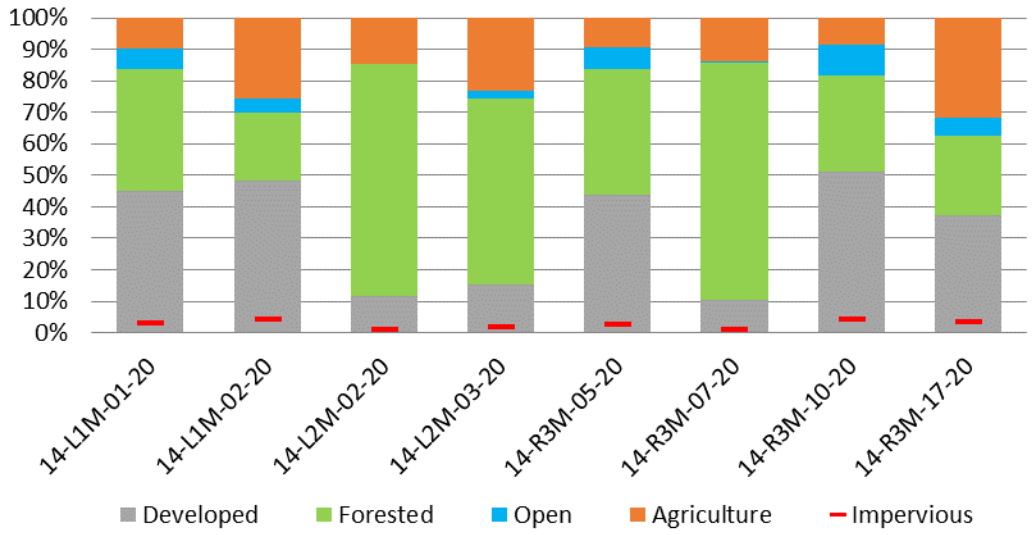

Figure 28 – West River land use (n=8)

4.4.2 Physical Habitat

Based on the RBP index assessed during the spring season, the majority of sites were rated as 'Partially Supporting' (75.0%), 12.5% were rated as 'Supporting', and 12.5% were 'Non-Supporting' (Figure 29). With an average RBP score of 111.00 ± 9.06 and a narrative rating of 'Partially Supporting'. RBP scores ranged from a minimum of 98 ('Non-Supporting') to a maximum of 126 ('Supporting').

The PHI (summer season) rated 71.4% of sites as 'Partially Degraded', and 28.6% of sites as 'Degraded' (Figure 29). The average PHI rating was 'Partially Degraded' with a score of 67.88 ± 4.60 and was the second lowest mean PHI rating of the units sampled during 2020. Individual PHI scores ranged from 60.41 ('Degraded') to 73.82 ('Partially Degraded'). One site that was visited the summer of 2020 was dry in the West River sampling unit. This site was not sampled and no PHI calculation was made. The majority of sites assessed received 'Marginal' to 'Poor' scores for instream habitat, epifaunal substrate, and pool/glide/eddy quality. Bank stability was rated as 'Optimal' or 'Suboptimal' for most sites. Embeddedness was consistent at the West River sites, with all of sites scoring 100%.

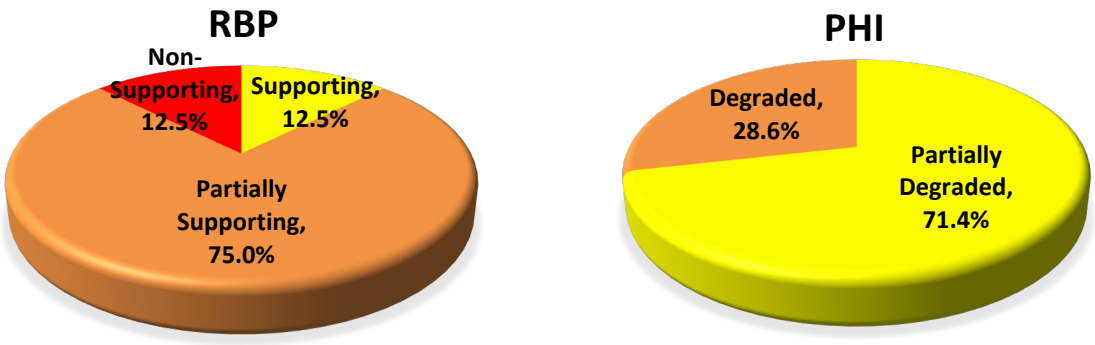

Figure 29 – West River Physical Habitat Conditions (RBP n=8; PHI n=7)

4.4.3 Benthic Macroinvertebrates

Among the West River sampling unit sites, 62.5% of the sites received 'Poor' BIBI ratings, 25.0% were rated as 'Very Poor', and the remaining 12.5% of sites received a 'Fair' rating (Figure 30). The average BIBI score for the sampling unit was 2.36 ± 0.56, resulting in a 'Poor' biological condition rating (Table 16). Individual BIBI scores ranged from 1.29 ('Very Poor') to 3.00 ('Fair'). Individual site data and assessment results can be found in Appendix D.

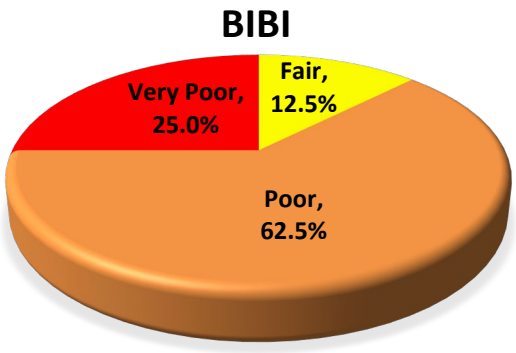

Figure 30 – West River BIBI Conditions (n=8)

Site 14-R3M-05-20 received the lowest BIBI score of 1.29 with a 'Very Poor' rating. Thirteen taxa were present in this sample, none of which were EPT or scraper taxa. In contrast, site 14-R3M-07-20 received the highest BIBI score for this sampling unit of 3.00, resulting in a 'Fair' biological condition rating. This site had 18 total taxa, including four EPT taxa, including one Ephemeroptera taxon, and over 31% of intolerant taxa. Ephemeroptera taxa were present at only three of the eight sites sampled during 2020 in the West River sampling unit, with percentages ranging from 0.88% to 1.87%.

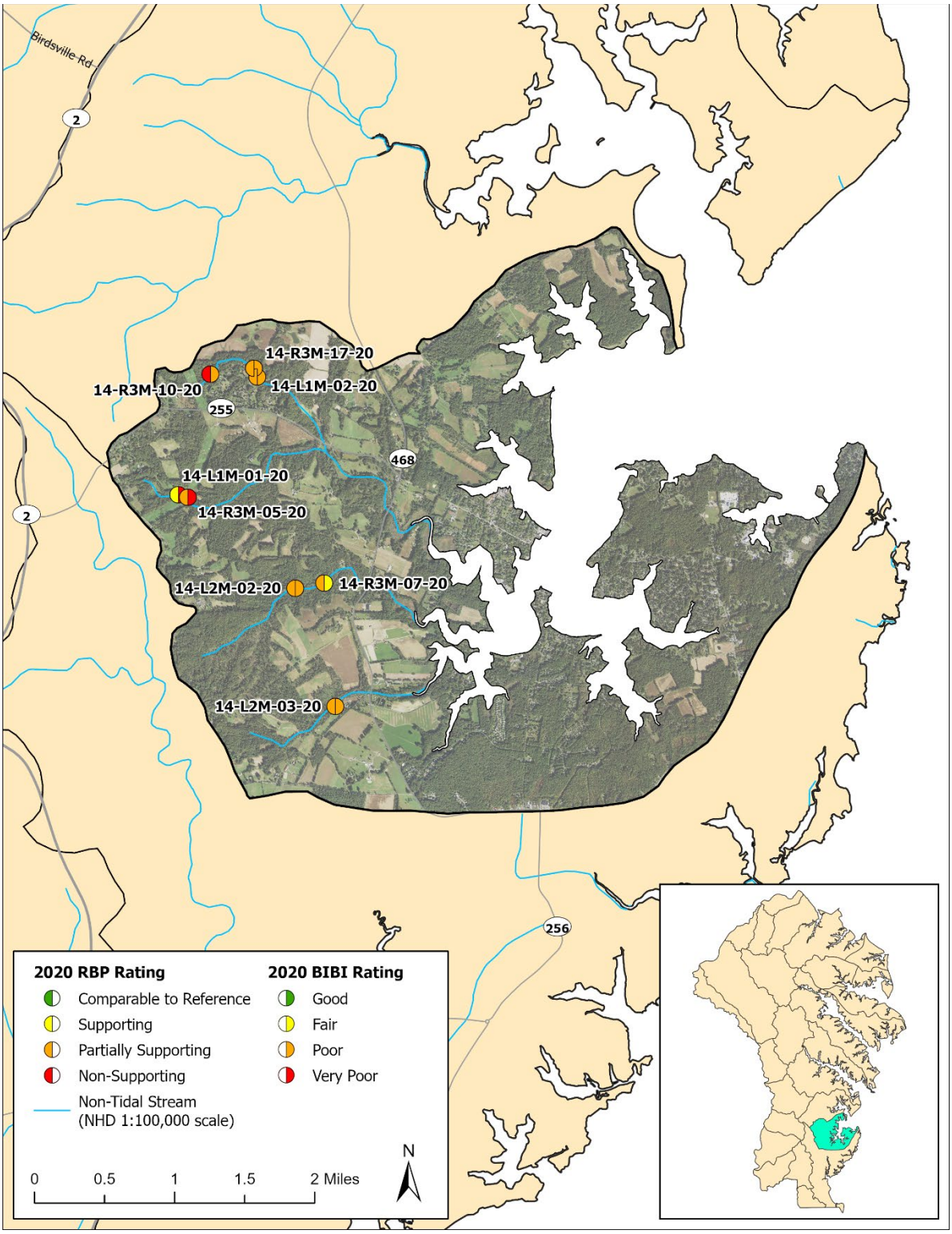

Figure 31 – West River Sampling Sites (BIBI and RBP)

4.4.4 Fish

The West River sampling unit received a FIBI narrative rating of 'Very Poor' with an average score of 1.29 ±0.42 (Table 16). A biological condition rating of 'Very Poor' was given to 87.5% of the sites, while the remaining 12.5% was rated as 'Poor' (Figure 32). Individual FIBI scores ranged from 1.00 ('Very Poor') to 2.00 ('Poor'). Site-specific data and assessment results can be found in Appendix D.

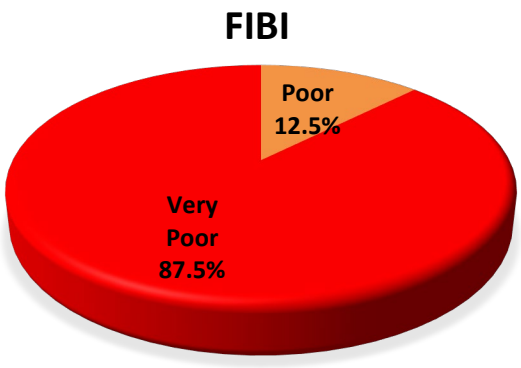

Figure 32 – West River FIBI Conditions (n=8)

Site 14-L2M-02-20 received the highest FIBI score (2.00; 'Poor') in the West River sampling unit. This site scored in the highest category (5) for percent of tolerant organisms from the sample. The West River sampling unit had the lowest FIBI mean of all units sampled during the 2020 season (1.29; 'Very Poor'). More than half of the sites received a FIBI score 1.00 due to no fish being caught during sampling or the site being dry during the summer visit. Sites 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. One site was dry during the 2020 summer season, and as MBSS does in this case a FIBI score of 1.00 was assigned.

Largemouth Bass was the most widely distributed species in the sampling unit, present at two of the sites. The least common species in this sampling unit were Bluegill, Green Sunfish, and Eastern Mosquitofish each found at only one site. Four species were observed in the sampling unit with three non-native species (Green Sunfish, Bluegill, and Largemouth Bass), and one native species (Eastern Mosquitofish). No round-bodied suckers were present, and no benthic fish species were present. No species considered intolerant to urban stressors were found in this sampling unit.

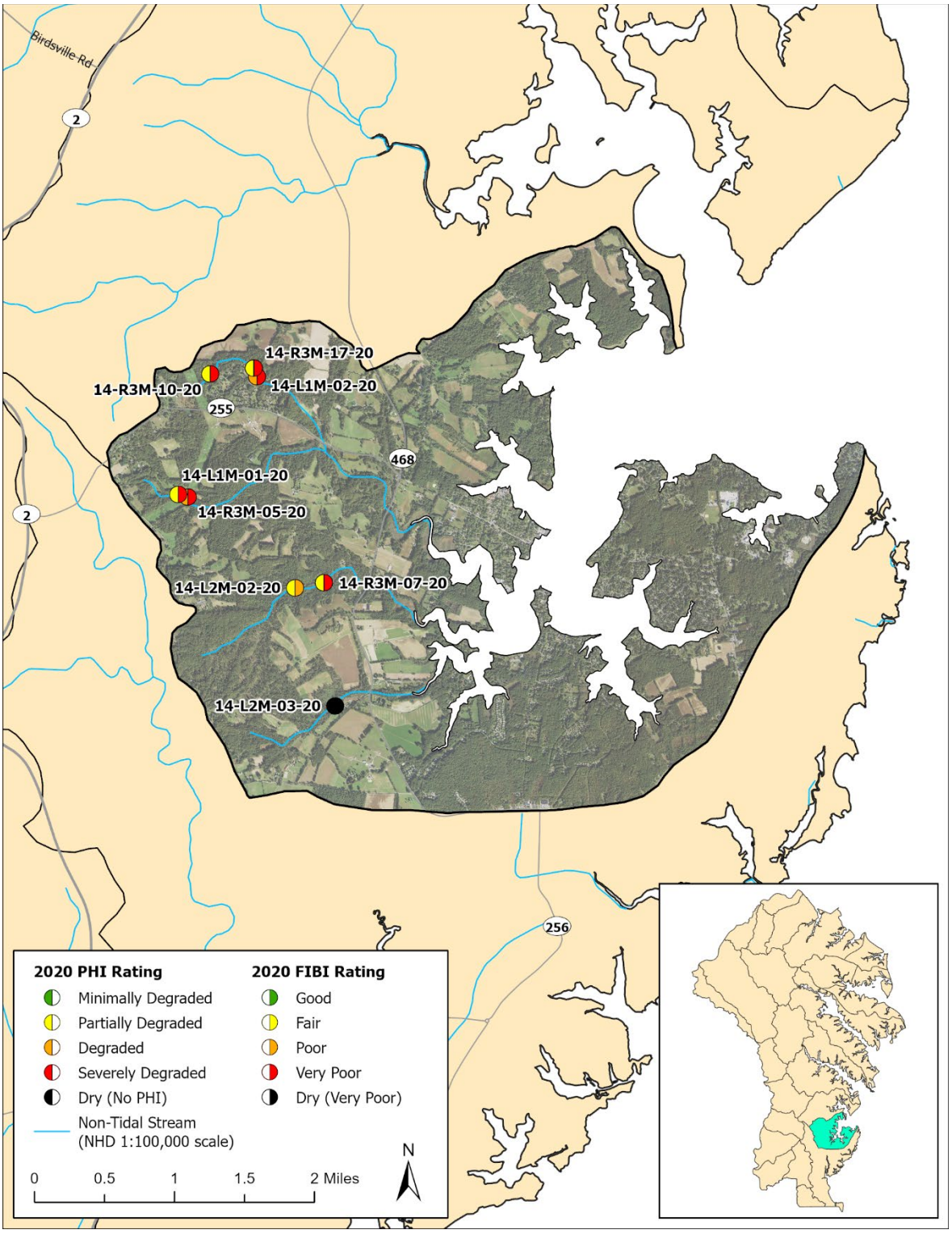

Figure 33 – West River Sampling Sites (FIBI and PHI)

4.4.5 Water Quality

Average spring and summer *in situ* water quality values for the West River sites are provided in Table 24. Seven of the eight sites sampled in the spring met COMAR standards for water quality. The pH at site 14-R3M-10-20 was lower than the COMAR standard (i.e., 6.5-8.5 SU), with a value of 5.98. Spring water temperature ranged from 7.60 to 12.40 °C; DO ranged from 9.90 to 11.68 mg/L; pH ranged from 5.98 to 6.99 SU; specific conductance ranged from 110.0 to 226.0 µS/cm; and turbidity ranged from 2.50 to 7.60 NTU.

In the summer, only seven of the eight West River sites were sampleable as site 14-L2M-03-20 was dry. One site did not meet COMAR standards for water quality during the summer. Site 14-L2M-02-20 measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5 SU), with a value of 6.40. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 15.90 to 21.60 °C; DO ranged from 7.73 to 9.48 mg/L; pH ranged from 6.40 to 7.29 SU; specific conductance ranged from 109.0 to 230.0 µS/cm; and turbidity ranged from 2.00 to 20.1 NTU.

Table 24 - Average *in-situ* water quality values – West River

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	9.50 ± 1.60	10.92 ± 0.60	6.66 ± 0.30	182.1 ± 46.5	5.13 ± 1.94
Summer	19.71 ± 2.62	8.33 ± 0.74	6.88 ± 0.28	166.3 ± 42.7	12.84 ± 7.75

The average spring grab sample water quality values for the West River sites are provided in Table 25. All eight sites sampled met EPA standards for chloride concentration and COMAR standards for copper, zinc, lead, and turbidity. All eight sites had copper values falling below the MDL of 0.69 µg/L. Due to differences in the laboratory used in 2020 relative to other Round 3 monitoring years, comparisons of orthophosphate, nitrite, and ammonia levels with categories used by MBSS were limited due to analytical detection limits, which exceeded the high category values used by MBSS (i.e., > 0.03 mg/L for orthophosphate; > 0.01 mg/L for nitrite; and > 0.07 mg/L for ammonia). Orthophosphate and nitrite concentrations at all sites and ammonia concentrations at six sites fell at or below the MDLs of 0.45 mg/L, 0.029 mg/L, and 0.088 mg/L, respectively, and could not be further categorized. Sites 14-L1M-02-20 and 14-R3M-17-20 had ammonia concentrations that fell in the high category used by MBSS (i.e., > 0.07 mg/L) with values of 0.170 and 0.110 mg/L, respectively. For total nitrogen and nitrate, all values at the West River sites fell in the low or moderate categories used by MBSS. All eight sites had total phosphorus levels that fell in the high category used by MBSS (i.e., 0.070 mg/L) and values ranged from 0.160 to 0.290 mg/L. No state or national water quality standards exist for DOC, TOC, or hardness. Based on spring grab samples, DOC ranged from 1.8 to 3.4 mg/L; TOC ranged from 1.8 to 3.2 mg/L; and hardness ranged from 36 to 60 mg/L.

All eight sites sampled met EPA standards for chloride concentration and COMAR standards for copper, zinc, lead, and turbidity. All eight sites had copper values falling below the MDL of 0.69 µg/L. Due to differences in the laboratory used in 2020 relative to other Round 3 monitoring years, comparisons of orthophosphate, nitrite, and ammonia levels with categories used by MBSS were limited due to analytical detection limits, which exceeded the high category values used by MBSS (i.e., > 0.03 mg/L for orthophosphate; > 0.01 mg/L for nitrite; and > 0.07 mg/L for ammonia). Orthophosphate and nitrite

concentrations at all sites and ammonia concentrations at six sites fell at or below the MDLs of 0.45 mg/L, 0.029 mg/L, and 0.088 mg/L, respectively, and could not be further categorized. Sites 14-L1M-02-20 and 14-R3M-17-20 had ammonia concentrations that fell in the high category used by MBSS (i.e., > 0.07 mg/L) with values of 0.170 and 0.110 mg/L, respectively. For total nitrogen and nitrate, all values at the West River sites fell in the low or moderate categories used by MBSS. All eight sites had total phosphorus levels that fell in the high category used by MBSS (i.e., 0.070 mg/L) and values ranged from 0.160 to 0.290 mg/L. No state or national water quality standards exist for DOC, TOC, or hardness. Based on spring grab samples, DOC ranged from 1.8 to 3.4 mg/L; TOC ranged from 1.8 to 3.2 mg/L; and hardness ranged from 36 to 60 mg/L.

Table 25 - Average grab sample water quality values – West 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)
24 ± 10	0.220 ± 0.048	2.5 ± 1.2	0.45 ± 0.00	0.101 ± 0.029	0.029 ± 0.000	0.54 ± 0.38
Value ± Standard Deviation						
Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
2.4 ± 0.5	2.4 ± 0.4	47 ± 9	0.7 ± 0.0	14 ± 1	0.24 ± 0.04	6.4 ± 3.2

*The standard deviation for some parameters is 0 because all values were below the MDL.

4.4.6 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. In the West River sampling unit, 37.5% of the sites were classified as slightly entrenched E type channels. An additional 50.0% of the sites were classified as entrenched F and G type channels (25.0% each; Figure 34). Moderately entrenched B channels made up the remaining 12.5% of sites.

All of the streams in this sampling unit had a sand dominated substrate (100%). The average D_{50} for the sampling unit was 0.17 mm (fine sand) and slopes ranged from 0.20% to 1.50%, with an average slope of 0.64%.

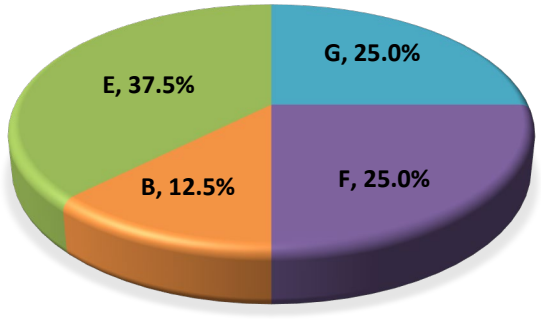

Figure 34 - Rosgen stream types observed in West River (n=8)

5 Round Comparisons for Repeated Sites

In Round Three, a subset of sites from Round One and Two (i.e., two sites from each previous round per PSU) were re-established and sampled 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 26).

From Round One and Two to Round Three, substrate coarsened in the Rock Branch and Stony Run sampling units and remained the same in the Upper Magothy and West River sampling units, based on the average D_{50} values. Substrate size increased from fine sand to fine gravel in the Rock Branch sampling unit and from fine gravel to medium gravel in the Stony Run sampling unit. The Upper Magothy sampling unit substrate size was medium sand during both Rounds and West River substrate remained as fine sand. Trends in BIBI scores at revisit sites also varied by sampling unit. On average, BIBI scores remained the same in Upper Magothy and West River and improved in Rock Branch and Stony Run. There seems to be a slight trend in coarser substrate resulting in higher BIBI scores, this may be due to larger substrate sizes being less mobile and providing more stable habitat for benthic macroinvertebrates. No consistent trend between BIBI score and cross-sectional area was apparent for the 2020 sampling units.

Rock Branch

Cross-section overlays at Rock Branch sites indicate that channels generally became wider and more incised since the initial assessments in Rounds One and Two. Site 20-L1M-04-20 was re-established due to missing cross-section pins and no overlay was conducted. Two of the three remaining sites experienced decreases in cross-sectional area (Table 26). For sites 20-L2M-01-20 and 20-L2M-03-20, bankfull cross-sectional area decreased noticeably despite significant erosion on the left bank of both sites and downcutting at 20-L2M-01-20. The decrease in cross sectional area was likely due to different bankfull features being identified during the Round 2 and Round 3 site visits because of the erosion and channel shifting. At both sites, the bankfull features identified in Round 3 did not match those identified in Round 2. Since there were poor indicators at both sites, the features used in the 2020 comparison were chosen in the field to relate closely with the regional curve. All revisited sites had increasing D_{50} values in Round Three. Although no overlay was conducted due to missing cross-section pins, site 20-L1M-04-20 changed stream classification from a G to an F type channel. Similar to other sites in the sampling unit, this is potentially due to downcutting and widening that has occurred along that section of stream since Round One, increasing the overall width/depth ratio at bankfull. Site 20-L2M-01-20 changed stream classification since the initial Round Two assessment, transitioning from a B channel to an F channel. This was again due to downcutting and widening of the overall channel. Site 20-L2M-03-20 has also changed stream classification since the initial Round Two assessment, transitioning from an E channel to a G channel, due to downcutting and widening of the overall channel which caused the entrenchment ratio to exemplify that of a G type channel. Site 20-L1M-08-20 remained a G channel type, however it followed the same trend of downcutting and widening, specifically on the left bank. Overall, channels appear to be getting larger at revisit sites within the Rock Branch sampling unit, through a combination of channel widening and downcutting.

In general, BIBI scores at Rock Branch revisit sites increased slightly from previous rounds from 'Poor' to 'Fair' (Table 26). Round One revisit site 20-L1M-04-20 experienced the largest improvement in BIBI score of all of the revisit sites sampled in 2020, increasing from 'Very Poor' to 'Fair'. Sites 20-L1M-08-20 and 20-L2M-03-20 BIBI scores improved from 'Poor' to 'Fair.' The BIBI score at Round Two site 20-L2M-01-20

improved slightly but resulted in no change in the rating. Substrate size increased and BIBI scores improved at all revisit sites in Rock Branch sampling unit, suggesting that increased substrate size may have a positive effect on benthic macroinvertebrate community health in the sampling unit. Overall, no major trends were evident between changes in BIBI score and changes in bankfull cross-sectional area. There was a notable increase in substrate size (D_{50}) for sites that also showed in improvement in BIBI score, indicating that coarser substrate may have benefited the benthic macroinvertebrate communities.

Stony Run

All Stony Run sites, with the exception of 02-L2M-01-20, were re-established due to missing cross-sectional pins (Table 26). Therefore, a cross-section overlay was only completed for site 02-L1M-01-20 within the Stony Run sampling unit. The four revisited sites had similar D_{50} values in Round Three, than in previous rounds. Round One revisit site 02-L1M-01-20 transitioned from a C channel to a B channel due to slight downcutting. Site 02-L1M-03-20 remained a C channel type and 02-L2M-04-20 remained as an E channel type. Site 02-L2M-01-20 was a short distance downstream of a road culvert and a Rosgen type was Not Determined during both Round Two and Round Three assessments, although little change in cross sectional area or channel form was observed in the 10 years since the original characterization was performed.

BIBI scores at Stony Run increased in Round Three (Table 26) at three sites resampled in Round Three. The BIBI score at site 02-L2M-04-20 declined but remained in the 'Poor' category. A relationship between BIBI score and cross-sectional area could not be determined due to the re-establishment of cross-sectional pins at the majority of Stony Run sites.

Upper Magothy

Changes in bankfull cross-sectional area in the Upper Magothy revisit sites varied in direction and magnitude. Cross-section pins could not be located at 07-L1M-03-20, so no cross-section overlay was conducted for that site. On average, bankfull cross-sectional area increased by 35.2% from Round One and Two to Round Three (Table 26). Bankfull cross-sectional area increased at two of revisit sites, and decreased by 8.6% at 07-L1M-02-20. The overall channel at 07-L1M-02-20 widened substantially with erosion on both banks and slight downcutting. The decrease in cross-sectional area is likely due to the method of identifying bankfull elevation. Since there were poor indicators at the site, the features used in the 2020 comparison were chosen in the field to relate closely with the regional curve. In Round Three, sites 07-L1M-03-20 and 07-L2M-02-20 remained classified as low gradient stream types (E or C type channels). Site 07-L2M-03-20 cross-sectional area increased substantially due to downcutting and erosion on both banks, causing a transition from an E to F channel type. Site 07-L1M-02-20 was downstream of a road culvert and the Rosgen type was not determined in Round Three. All D_{50} values in Round Three were in the medium sand substrate classification type.

BIBI scores at Upper Magothy revisit sites declined slightly in Round Three compared to previous rounds but generally remained in the 'Poor' category (Table 26). All revisit sites experienced a decrease in BIBI scores or remained the same, with the exception of site 07-L2M-03-20, where the BIBI score improved slightly in Round Three ('Very Poor' rating to a 'Poor' rating). Both Round One revisit sites declined from a 'Fair' biological rating to 'Poor.' No trends were evident between changes in BIBI score and changes in cross-sectional area.

West River

Cross-section overlays at West River revisit sites showed only slight increases in cross-sectional area, with the exception of site 14-L1M-02-20, where there was no geomorphic survey performed in Round One. Site 14-L1M-01-20 transitioned from a B channel to a G channel (Table 26). The channel bottom and banks both aggraded, so the change in channel type may be due to bankfull features used in the 2020 comparison being chosen in the field to relate closely with the regional curve due to lack of indicators. Site 14-L1M-02-20, not classified in Round two, and site 14-L2M-02-20 were both entrenched F channel types in Round Three. Site 14-L2M-03-20 remained an E channel type. In Round Three, all revisit sites had a substrate D_{50} of fine sand with no major changes from previous rounds.

West River revisit site BIBI scores slightly improved from previous rounds to Round Three but generally remained in the 'Poor' category (Table 26). With the exception of one site, 14-L1M-02-20, all BIBI scores were unchanged from the previous round. Site 14-L1M-02-20 improved from 'Very Poor' to a 'Poor' rating in Round Three. No trends were evident between changes in BIBI score and changes in cross-sectional area or substrate size. A representative cross-sectional overlay can be found in Figure 35. Individual site cross-sectional overlays can be found in Appendix D: Individual Site Summaries.

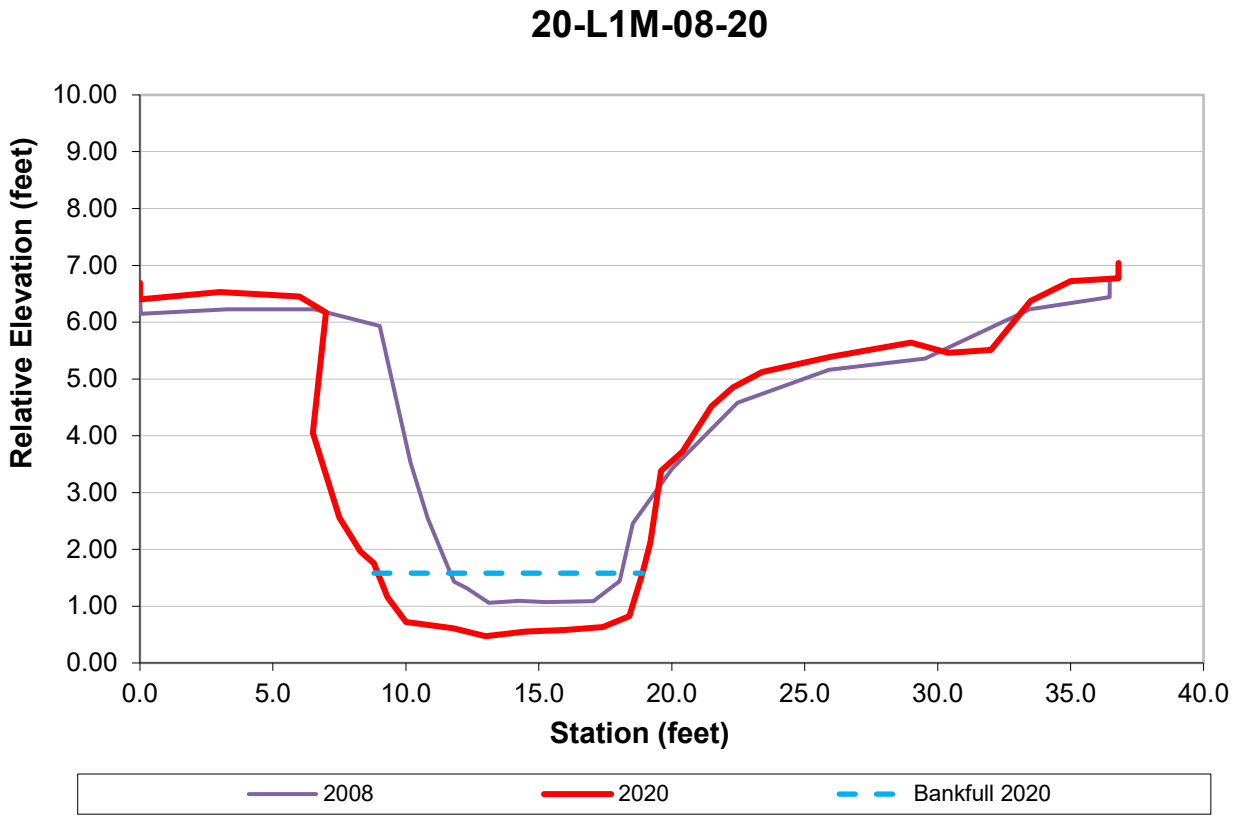

Figure 35- Representative cross-section overlay in the Rock Branch sampling unit

Table 26 - Comparison of Round One and Round Two (2004 - 2013) with Round Three (2020) geomorphological and biological data

2020 Site Name	Year First Sampled	Bankfull Cross-Sectional Area (ft2)			D50 Substrate Classification (Size in mm)		Rosgen Classification		BIBI Narrative Ranking (Score)	
		R1/R2	R3	%Δ	R1/R2	R3	R1/R2	R3	R1/R2	R3
20-L1M-04-20	2008	22.8	20.5	---[2]	fine sand (0.17)	fine gravel (4.30)	G5c	F4/5	Very Poor (1.86)	Fair (3.86)
20-L1M-08-20	2008	8.9	9.0	0.6	medium sand (0.25)	medium gravel (13)	G5c	G4c	Poor (2.14)	Fair (3.57)
20-L2M-01-20	2009	12.7	4.6	-63.7	very fine sand (0.06)	very fine sand (0.09)	B6c	F5	Poor (2.14)	Poor (2.43)
20-L2M-03-20	2009	8.4	4.7	-43.6	fine sand (0.16)	very coarse sand (1.40)	E5	G4/5c	Poor (2.43)	Fair (3.00)
Rock Branch Average		13.2	9.7	-35.6	fine sand (0.16)	fine gravel (4.70)	---	---	Poor (2.14)	Fair (3.22)
02-L1M-01-20	2007	4.8	6.6	---[2]	medium sand (0.32)	fine sand (0.22)	C5	B5c	Fair (3.00)	Fair (3.00)
02-L1M-03-20	2007	41.9	60.0	---[2]	coarse gravel (22)	coarse gravel (22)	C4	C4	Poor (2.71)	Fair (3.86)
02-L2M-01-20	2010	28.2	28.8	2.3	fine gravel (6.90)	medium gravel (11)	ND	ND	Poor (2.71)	Fair (3.00)
02-L2M-04-20	2010	8.8	7.1	---[2]	very fine sand 0.06	very fine sand (0.09)	E6	E5	Poor (2.43)	Poor (2.14)
Stony Run Average		20.9	25.6	2.3	fine gravel (7.32)	medium gravel (8.33)	---	---	Poor (2.71)	Fair (3.00)
07-L1M-02-20	2006	14.9	13.6	-8.6	---	medium sand (0.39)	---	ND	Fair (3.00)	Poor (2.43)
07-L1M-03-20	2006	18.2	18.6	---[2]	fine sand (0.14)	medium sand (0.28)	E5	E5	Fair (3.86)	Poor (2.71)
07-L2M-02-20	2011	13.6	19.2	41.0	medium sand (0.35)	medium sand (0.35)	C5	C5	Fair (3.00)	Fair (3.00)
07-L2M-03-20	2011	6.9	11.9	73.2	medium sand (0.38)	medium sand (0.39)	E5/4	F5	Very Poor (1.86)	Poor (2.14)
Upper Magothy Average		13.4	15.8	35.2	medium sand (0.29)	medium sand (0.35)	---	---	Poor (2.93)	Poor (2.57)
14-L1M-01-20	2008	4.2	4.2	0.3	medium sand (0.25)	fine sand (0.16)	B5c	G5c	Very Poor (1.86)	Very Poor (1.86)
14-L1M-02-20	2008	---[1]	4.2	---	---	fine sand (0.17)	---	F5	Very Poor (1.57)	Poor (2.71)
14-L2M-02-20	2009	5.9	6.2	5.8	fine sand (0.17)	fine sand (0.23)	F5	F5	Poor (2.71)	Poor (2.71)
14-L2M-03-20	2009	5.2	5.3	2.0	very fine sand (0.10)	fine sand (0.13)	E5	E5	Poor (2.71)	Poor (2.71)
West River Average		5.1	5.0	2.7	fine sand (0.17)	fine sand (0.17)	---	---	Poor (2.21)	Poor (2.50)

[1]Geomorph survey not performed in 2008, [2]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)

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 four PSUs assessed in 2020. Refer to Figure 36 for box plots comparing mean BIBI, RBP, and PHI results from Rounds One, Two and Three in the Rock Branch, Stony Run, Upper Magothy, and West River sampling units.

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

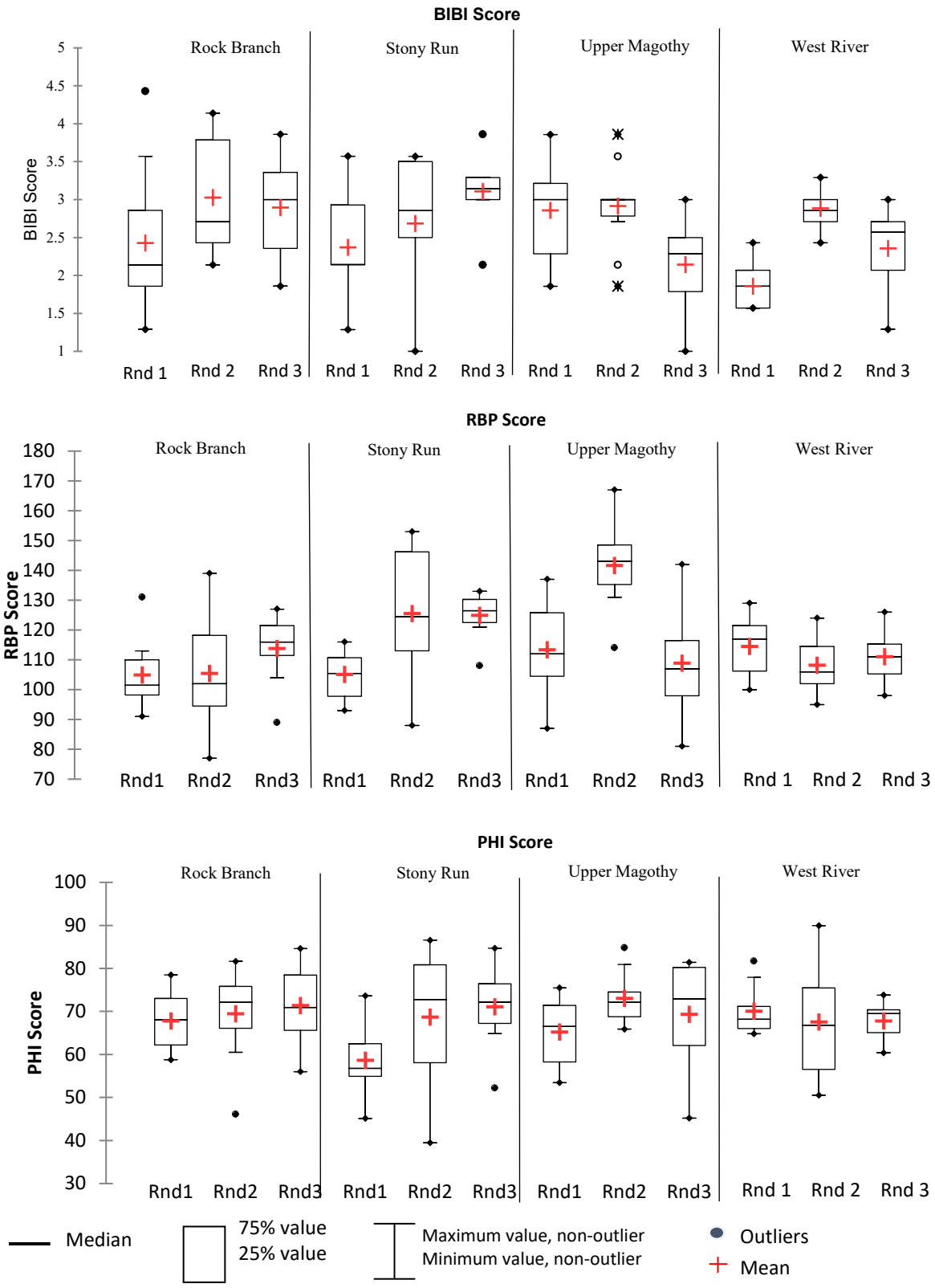

Figure 36 - Box plots comparing mean BIBI, RBP and PHI scores between Rounds One, Two and Three

6.1 Biological Conditions

Only one PSU, Upper Magothy showed significant changes in mean BIBI scores between sampling Rounds Two and Three (Table 27). The mean BIBI score decreased from 2.91 ±0.19 in Round Two to 2.14 ±0.23 in Round 3. Two PSUs, Stony Run and Upper Magothy, saw significant changes in BIBI scores between Round One and Round Three. Stony Run increased from 2.37 ±0.22 in Round One to 3.11 ±0.17 in Round 3. Upper Magothy, on the other hand, saw a decrease from 2.86 ±0.21 in Round One to 2.14 ±0.23 in Round Three. (Table 28).

Table 27 - 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			
Rock Branch	2.89	0.25	3.03	0.74	1.67	-1.39	No
Stony Run	3.11	0.17	2.69	0.31	0.27	-1.11	No
Upper Magothy	2.14	0.23	2.91	0.19	1.35	0.19	Yes (Decrease)
West River	2.36	0.20	2.89	0.28	1.20	-0.14	No

Table 28 - 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			
Rock Branch	2.89	0.25	2.43	0.97	1.50	-2.42	No
Stony Run	3.11	0.17	2.37	0.22	-0.20	-1.28	Yes (Increase)
Upper Magothy	2.14	0.23	2.86	0.21	1.33	0.11	Yes (Decrease)
West River	2.36	0.20	1.86	0.30	0.21	-1.21	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 29 and Table 30, respectively. Comparisons between Round Two and Three showed a significant decrease in one PSU, the Upper Magothy, with the mean RBP score decreasing from 141.6 ±4.46 in Round Two to 108.88 ±6.61 in Round Three. The comparisons between Round One and Round Three showed a significant increase in one PSU, the Stony Run, with the mean RBP score increasing from 105.1 ±2.66 in Round One to 124.88 ±2.80 in Round Three.

Table 29 - 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			
Rock Branch	113.75	4.30	105.4	18.1	28.11	-44.81	No
Stony Run	124.88	2.80	125.5	7.20	15.76	-14.52	No
Upper Magothy	108.88	6.61	141.6	4.46	48.35	17.09	Yes (Decrease)
West River	111.00	3.20	108.2	9.3	16.48	-22.08	No

Table 30 - 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			
Rock Branch	113.75	4.30	104.9	3.60	2.14	-19.84	No
Stony Run	124.88	2.80	105.1	2.66	-12.21	-27.35	Yes (Increase)
Upper Magothy	108.88	6.61	113.3	5.32	21.05	-12.21	No
West River	111.00	3.20	114.5	3.11	12.25	-5.25	No

Comparisons of physical habitat conditions between Rounds Two and Three and Rounds One and Three for the PHI are shown in Table 31 and Table 32, respectively. There were no significant changes between Round Two and Round Three for physical habitat conditions. Only one PSU, Upper Patuxent, showed significant changes in PHI habitat conditions between sampling Rounds One and Three. The mean PHI score increased from 58.66 ±2.50 in Round One to 71.07 ±3.46 in Round Three.

Table 31 - 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			
Rock Branch	71.35	3.42	69.50	10.3	19.42	-23.12	No
Stony Run	71.07	3.46	68.66	4.77	9.14	-13.96	No
Upper Magothy	69.34	4.66	73.04	1.87	13.54	-6.14	No
West River	67.81	1.73	67.55	4.11	8.48	-9.00	No

Table 32 - 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			
Rock Branch	71.35	3.42	67.80	8.9	15.14	-22.24	No
Stony Run	71.07	3.46	58.66	2.50	-4.04	-20.78	Yes (Increase)
Upper Magothy	69.34	4.66	65.22	2.54	6.28	-14.52	No
West River	67.81	1.73	70.10	5.9	14.34	-9.76	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 2020 assessment indicate impaired biological conditions in all four sampling units. Three of the four sampling units had mean BIBI scores in the 'Poor' category, and one sampling unit (Stony Run) had a mean BIBI of 'Fair'. Two of the four had mean FIBI scores in the 'Poor' category, one sampling unit (West River) had a mean FIBI of 'Very Poor', and one sampling unit (Stony Run) had mean FIBI of 'Fair'.

A significant increase and a significant decrease in mean BIBI scores were both observed between Round One and Round Three in the Stony Run PSU and the Upper Magothy PSU, respectively. Mean scores increased from 2.37 ±0.22 in Round One to 3.11 ±0.17 in Round Three in Stony Run and decreased from 2.86 ±0.21 in Round One to 2.14 ±0.23 in Round Three in Upper Magothy (Table 28).

Upper Magothy showed a significant decrease in mean BIBI scores between Rounds 2 and 3 (Table 27), and also in Rounds 1 and 3. Stony Run showed a significant positive difference of mean BIBI scores between Rounds 1 and 3, while the other two sampling units had no significant change in BIBI scores between these same Rounds. There were no discernable trends in PHI habitat data at three of the four sampling units. Stony Run showed a statistically significant increase in mean PHI scores between Round 1 and Round 3 but no change between Round 2 and Round 3. Upper Magothy showed a significant decrease in mean RBP scores between Rounds 2 and 3. Stony Run showed a significant increase in mean RBP scores between Round 1 and Round 3. West River and Rock Branch showed no significant trends in mean PHI or 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 either of their concurrent BIBI or FIBI scores. A comparison of narrative BIBI ratings to spring-collected RBP habitat condition ratings for each site is shown in Table 33. Similarly, Table 34 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. Analysis at the end of Round 3 will investigate relationships between habitat conditions and FIBI score as well. Results from the RBP method showed the majority of sites with 'Supporting' or 'Partially Supporting' physical habitat conditions (84.4%); however, nearly a quarter of sites in those two categories (22.2%) actually resulted in biological conditions that were lower than the habitat category may suggest is possible (Table 33). Similar to the RBP method, results from the PHI method showed the majority of sites with a 'Partially Degraded' or 'Degraded' rating (80.6%), with 68.0% of those sites in those two categories with biological conditions that were lower than the habitat category may suggest is possible (Table 34).

Table 33 - 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				
Supporting		02-L1M-03-20 02-R3M-03-20 02-R3M-04-20 02-R3M-05-20 20-R3M-06-20	02-L2M-04-20 07-R3M-04-20	14-L1M-01-20
Partially Supporting		02-L1M-01-20 02-L2M-01-20 02-R3M-02-20 07-L2M-02-20 14-R3M-07-20 20-L1M-04-20 20-L1M-08-20 20-L2M-03-20 20-R3M-06-20	07-L1M-02-20 07-L1M-03-20 14-L1M-02-20 14-L2M-02-20 14-L2M-03-20 14-R3M-17-20 20-L2M-01-20	07-R3M-01-20 14-R3M-05-20 20-R3M-10-20
Non-Supporting			07-L2M-03-20 14-R3M-10-20 20-R3M-03-20	07-R3M-02-20 07-R3M-07-20

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=32

Table 34 - Comparison of FIBI to summer-collected MBSS PHI habitat condition ratings.

MBSS PHI Habitat Rating	FIBI Rating			
	Good	Fair	Poor	Very Poor
Minimally Degraded	02-L1M-03-20 07-R3M-04-20	07-L1M-03-20 20-L1M-04-20 20-L2M-03-20		
Partially Degraded	02-R3M-02-20 02-R3M-04-20	02-L1M-01-20 02-R3M-05-20 07-L1M-02-20	07-L2M-02-20 07-L2M-03-20 14-L2M-02-20 20-L1M-08-20 20-R3M-03-20 20-R3M-06-20 20-R3M-09-20	02-R3M-03-20 14-L1M-01-20 14-R3M-07-20 14-R3M-10-20 14-R3M-17-20
Degraded		02-L2M-01-20 02-L2M-04-20 20-R3M-10-20		07-R3M-01-20 07-R3M-02-20 14-L1M-02-20 14-R3M-05-20 20-L2M-01-20
Severely Degraded		07-R3M-07-20		

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=31; 1 dry site not sampled

Although physical habitat conditions show impairment in all four watersheds, habitat impairment 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. Recent research focused on urban stream restoration found that distance to source populations of benthic macroinvertebrates for recolonization after restoration plays an important role in ecological condition improvement (Southerland et al, 2018). Additional analysis at the end of Round 3 will investigate relationships between habitat and IBI scores along with confounding variables such as water quality and land use.

In developed sampling units with a higher percentage of impervious surfaces, such as the Stony Run and Upper Magothy sampling units, water quality stressors are likely strong contributors to impaired biological conditions. Elevated specific conductance values (i.e., >247 µS/cm) were observed at 13 of 32 sites in the spring and 15 of 31 sites in the summer had specific conductance values that exceeded the 247 µS/cm threshold of BIBI impairment developed from MBSS data (Morgan et al, 2007; Morgan et al, 2012). The expected pattern of increased imperviousness leading to increased specific conductance measurements was not evident in 2017 data but was observed with 2018 and 2019 spring and summer data and again in the 2020 data. There was a significant trend (R^2=0.407; p<0.0001) toward increased springtime specific conductance with increased impervious surfaces for the sites sampled in 2020. There was a stronger trend (R^2=0.684; p<0.0001) between summertime specific conductance and impervious surfaces for these sites. The PSU with the largest amount of imperviousness, Stony Run (18.0%) had the highest mean specific conductance (322.6 µS/cm) of the spring measurements but contrary to the expected pattern of a decrease in ecological condition with increasing specific conductance (Morgan and Cushman, 2005; Morgan et al, 2007), Stony Run had the highest mean BIBI and FIBI scores during 2020. The second highest

mean specific conductance was observed in Upper Magothy (285.5 µS/cm) which had the second largest amount of imperviousness (14.0%). Upper Magothy had the highest mean specific conductance (359.4 µS/cm) during the summer. The PSU with the second lowest amount of imperviousness, West River (5.0%), had the lowest mean specific conductance measurement in both the spring (182.1 µS/cm) and summer (166.3 µS/cm). There was a positive trend between spring specific conductance and BIBI score, although not significant (R^2=0.106; p=0.069) but there was a significant positive trend between summer specific conductance and FIBI scores (R^2=0.244; p=0.005). The results run counter to what have been displayed by the MBSS results and merit further investigation. Continued sampling across all sampling units within the County will help create a larger dataset to investigate further the effects of specific conductance 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 2020 sites, drainage area has a significant positive effect on BIBI score (R^2=0.255; p=0.003) 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, 2018, and 2019, data from 2020 sampling shows a significant correlation between increasing drainage area and FIBI score (R^2=0.511; p<=0.0001). This relationship is consistent with patterns observed throughout Maryland by the MBSS (Southerland et al, 2005).

7.2 Geomorphologic Conditions

The geomorphic assessment field data were compared to the Maryland Coastal Plain (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 37, Figure 38, and Figure 39, respectively. Channels where Rosgen classifications could not be determined (ND, sites with channelization, culverts, and riprap stabilization) or were considered transitional were not included in these analyses.

Comparisons of bankfull width values show the trendline for F (R^2 = 0.95), B (R^2 = 0.96) and E (R^2 = 0.55) channels as the closest to matching the MCP curve (Figure 37). The trendline for C (R^2 = 0.01) channels contained the least variability in bankfull widths, with data points scattered mostly above the MCP curve. The lack of variability for the C channels, which all wider than the predicted widths, could be due to the

trend of over widening due to bank erosion. The two ND channel widths matched the MCP curve very well, but this is likely due to not having definitive bankfull indicators present in these altered channels, thus forcing increased reliance on the regional curve data to make bankfull calls in these situations. The correlation supports that generally the F type channels had a bankfull width that was wider than the MCP curve would suggest, and the E type channels had a bankfull width that was narrower than the MCP curve would suggest. The trendline for G (R^2 = 0.70) type channels was slightly above the MCP curve, indicating wider 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 E type channels (R^2 = 0.78) closely matching the MCP curve, with most values just slightly above the curve indicating deeper bankfull depths than predicted (Figure 38). For F (R^2 = 0.79) and B (R^2 = 0.90) channel types, points were scattered below the curve, indicating that mean bankfull depths were shallower than predicted by the MCP. The C channels fell well below the MCP curve, which suggests the large variance in width/depth ratios as the sites were well above the mean width MCP curve. The G type channels closely match the MCP curve, but this was due to reliance on the curve while doing the field assessment in an incised channel with limited bankfull indicators. As with bankfull width, the channel types follow the expected mean bankfull depth relationship (Rosgen, 1996).

Comparisons of bankfull cross-sectional area values show the trendlines for all stream types closely match the MCP curve (Figure 39). The trendlines for G (R^2 = 1.00), F (R^2 = 1.00) and C (R^2 = 0.99) had the smallest amount of variability. Very few channel cross-sectional areas, mainly E type channels, fell below the MCP curve. Somewhat unexpectedly, E type channels had the most variability in cross-sectional area. This could be due to site specific conditions as it relates to bankfull indicators, whereas many of the other stream types relied heavily on the MCP curve. Overall, most sites assessed in 2020 were below one square mile drainage areas and are therefore much smaller than sites used to create the MCP regional regression.

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, based on BIBI scores. For example, of the sites classified as F type and G type channels in 2020 (n=13), three sites (23.1%) received a 'Very Poor' biological rating, 4 sites (30.7%) received a 'Poor' rating, and 6 sites (46.2%) received a 'Fair' rating. When compared across all channel types sampled in 2020, a similar proportion of sites had BIBI scores in the 'Very Poor' and 'Poor' categories (21.8% for F and G type channels and 37.5% for all other channel types sampled), indicating degraded benthic macroinvertebrate communities regardless of channel type. No site received a 'Good' rating, with the remaining sites in 2020 (n=13) scoring as 'Fair' (18.7% for F and G type channels and 21.8% for all other channel types).

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 2020 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.

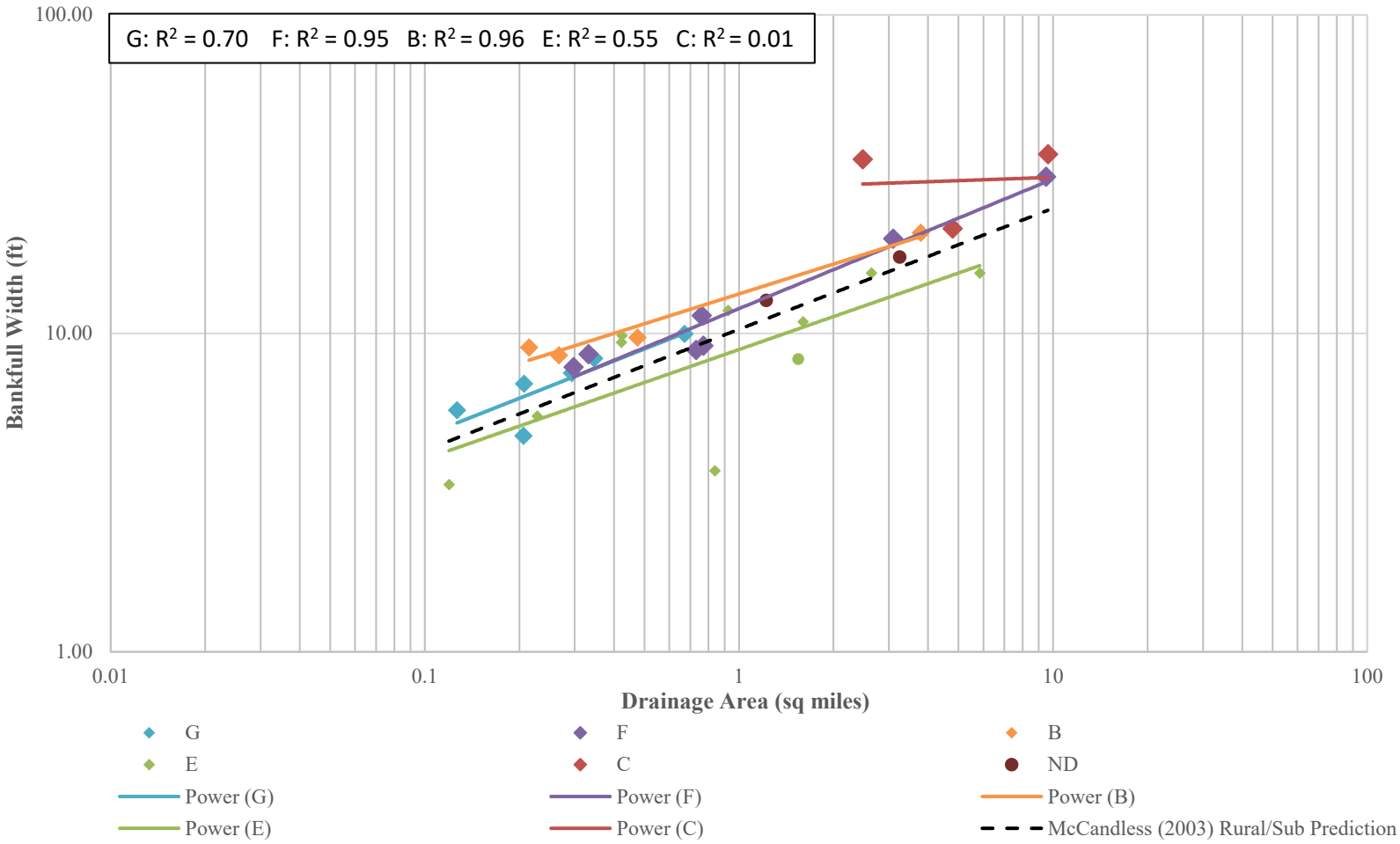

Figure 37- Comparison of bankfull width - Drainage area relationship between field data and regional curve data

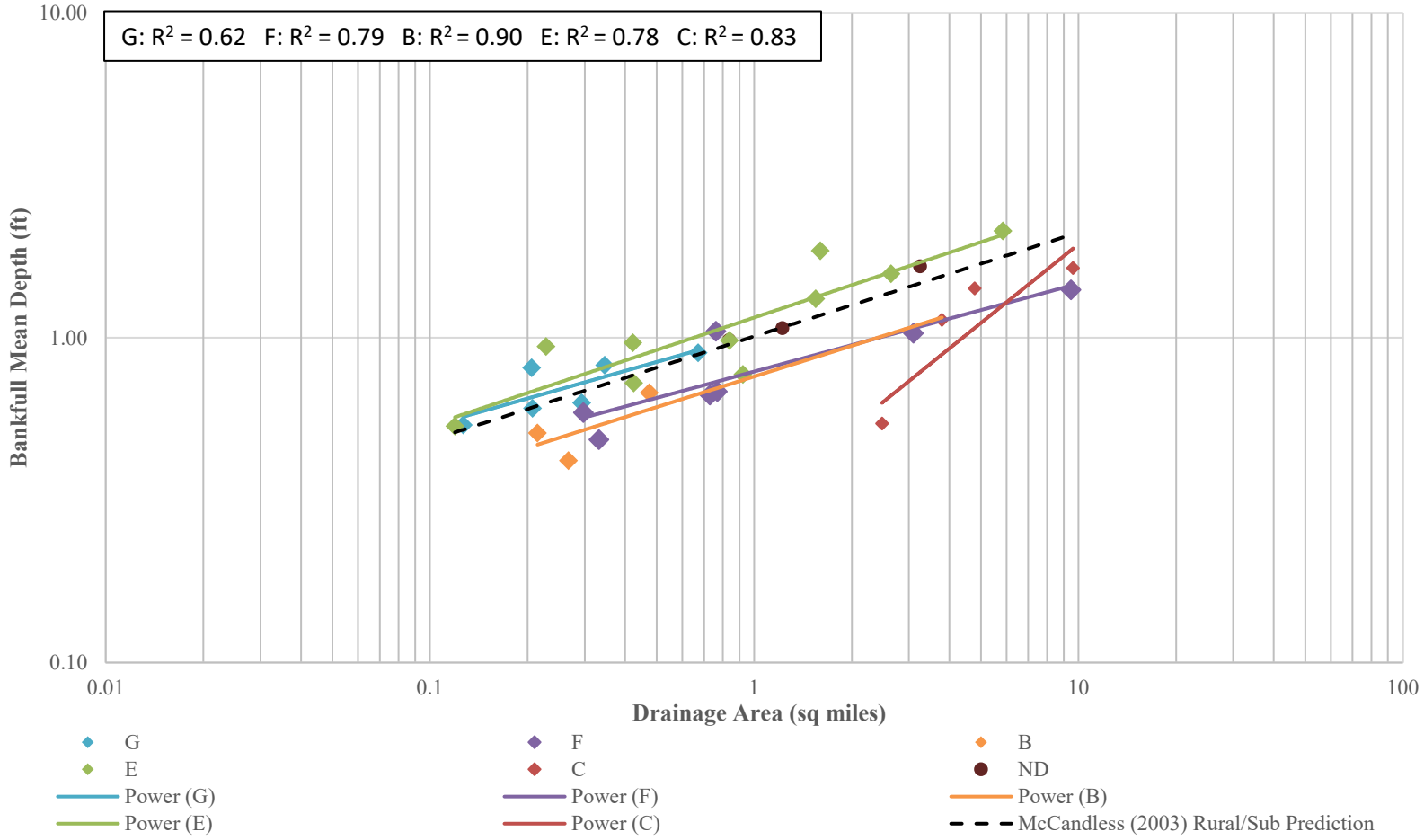

Figure 38 - Comparison of mean bankfull depth - Drainage area relationship between field data and regional curve data

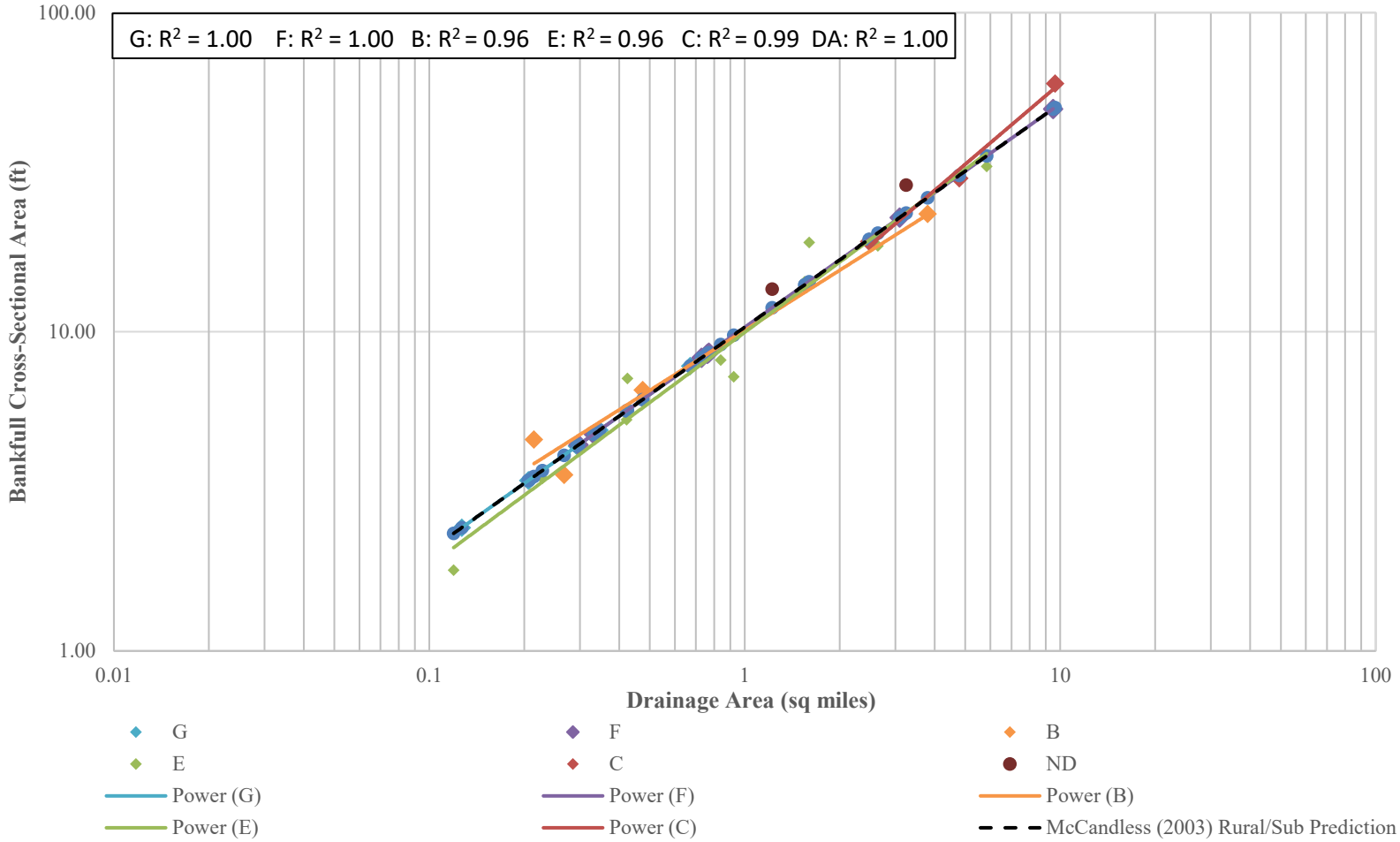

Figure 39 - Comparison of the bankfull cross-sectional area - Drainage area relationship between field data and regional curve data

7.3 Water Quality Conditions

In situ water quality measurements were within COMAR standards for temperature and instantaneous turbidity at all sites during both the spring and summer monitoring periods. 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 three of the four sampling units in the spring and at eight sites spanning all sampling units in the summer. Low pH values are likely the result of soils within the 2020 sampling units being generally strongly to very strongly acidic (NRCS 2020).

In the spring, none of the sites sampled had DO values below the COMAR criterion (i.e., > 5 mg/L). In the summer, DO values below the acceptable defined by COMAR were recorded at three sites in the Upper Magothy sampling unit. For specific conductance, 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). Specific conductance values that exceeded 247 µS/cm were recorded at approximately 41% of the sites sampled in the spring and were all located in the Stony Run and Upper Magothy sampling units. Approximately 48% of sites sampled in the summer, located in the Rock Branch, Stony Run, and Upper Magothy sampling units, had specific conductance values that exceeded the BIBI impairment threshold. Despite elevated specific conductance levels at a large portion of sites sampled in 2020, there was no significant trend between specific conductance and BIBI. There was a significant positive relationship between specific conductance and FIBI scores during 2020; as specific conductance values increased, FIBI scores also increased. This FIBI and specific conductance result is counter to published literature and could very well be influence by the small sample size. Analysis of the entire Round 3 data set after 2021 will help clarify the relationship between specific conductance and stream ecological condition in Anne Arundel County.

All 2020 sites met COMAR or EPA standards based on grab sample parameters for chloride, copper, zinc, lead, and turbidity. Due to differences in the laboratory used in 2020 relative to other Round 3 monitoring years, comparisons of orthophosphate, nitrite, and ammonia levels with categories used by MBSS were limited due to analytical detection limits, which exceeded the high category values used by MBSS (i.e., > 0.03 mg/L for orthophosphate; > 0.01 mg/L for nitrite; and > 0.07 mg/L for ammonia). Orthophosphate concentrations at all sites, nitrite concentrations at all but one site, and ammonia concentrations at 22 sites fell at or below the MDLs of 0.45 mg/L, 0.029 mg/L, and 0.088 mg/L, respectively, and could not be further categorized. Measurements of nitrite and ammonia that did not fall at or below the MDLs were also in the high category used by MBSS for those parameters. Nitrate values at all 2020 sites fell in the low or moderate categories used by MBSS. Total nitrogen values fell in the low or moderate categories used by MBSS at all sites sampled in both the Rock Branch and West River sampling units. Four sites in the Stony Run sampling unit and one site in the Upper Magothy sampling unit had total nitrogen values that fell in the high category used by MBSS (i.e., >7.0 mg/L). Approximately 52% of the sites, across three of the four sampling units, had total phosphorus values that fell in the high category used by MBSS (i.e.,> 0.070 mg/L).

There was a strong positive correlation between specific conductance and chloride concentration for all sampling units sampled in 2020 (R^2 = 0.92; Figure 40). Of the sampling units, West River had the weakest relationship between specific conductance and chloride (R^2 = 0.54; Figure 40), which may be due to the limited range of specific conductance and chloride values across sites within that sampling unit. 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).

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., expanded 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.

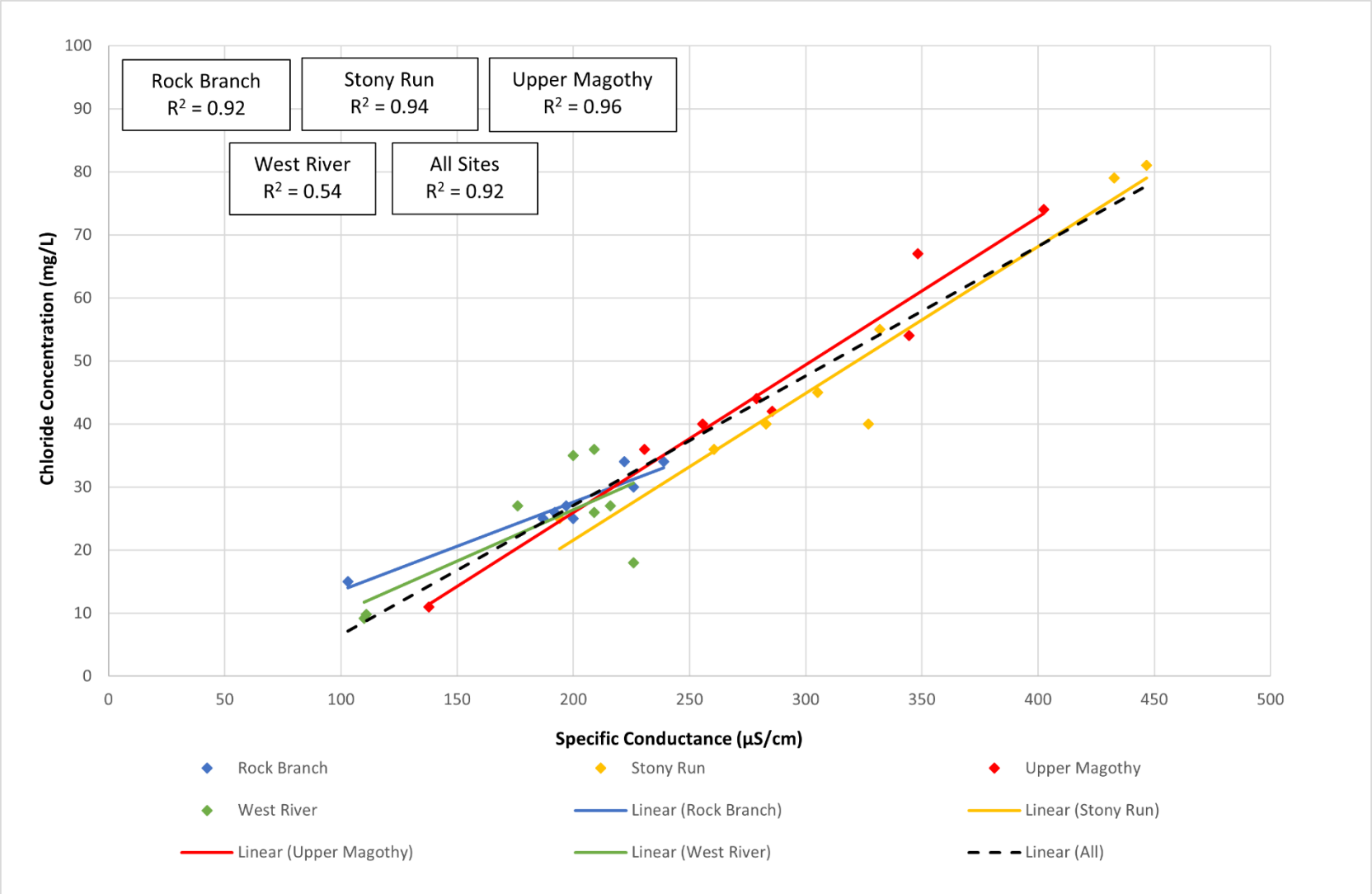

Figure 40 – Relationship between specific conductance and chloride concentration for each PSU

Best Management Practices

Stormwater Management

Two of the sampling units, Stony Run and Upper Magothy, have been developed extensively (54% - 70% 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 the Rock Branch and West River sampling units contained less developed land, PSU mean and individual BIBI scores still show signs of impairment. These 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 rural subwatersheds.

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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
02-L1M-01-20	0.47	9.7	0.7	15.1	1.6	14.3	6.6	0.62	1.2	0.22	B5c	Small stream with sewer crossing around station 215. Did not find flagging or cross section pins from Round 1 visit. Stream has access to floodplain. Adjacent to new housing development.
02-L1M-03-20	9.62	36.5	1.6	97.2	2.7	22.2	60.0	0.66	1.1	22	C4	R1 revisit site. Unable to locate r1 pins, reinstalled XS pins. Site appears to have changed a great deal since R1 visit. Large amounts of sediment on banks and adjacent floodplain. Sewer line protected with large boulders. Sewer manhole in stream channel near upstream end of site, causing bank erosion.
02-L2M-01-20	3.24	17.4	1.7	120.0	6.9	10.4	28.8	0.38	1.1	11	ND	Revisit site, located both R2 XS pins, resurveyed exact R2 XS. Site short distance downstream of road culvert and exposed sewer(?) pipe.
02-L2M-04-20	0.42	9.8	0.7	200.0	20.3	13.6	7.1	0.65	1.1	0.095	E5	Located R2 XS pins but R2 XS on old, abandoned channel. Had to reinstall a XS on the stream in its current location. Stream appears to have changed position multiple times. Adj WD -0.2
02-R3M-02-20	9.49	31.0	1.4	36.8	1.2	22.1	43.6	0.026	1.6	18	F4	Incised stream. Severe bank erosion on meander bends. Adjacent to Amtrak RR in Patapsco Valley State Park. Appears to move a lot of sediment, large sandy bars present.
02-R3M-03-20	0.12	3.4	0.5	60.8	18.1	6.3	1.8	0.82	1.1	0.18	E5	Very small channel adjacent to County park. Evidence of very old trash dumping in and around site. Stream obviously has full access to floodplain.
02-R3M-04-20	5.84	15.4	2.1	1025.0	66.4	7.2	33.0	0.13	1.1	2	E4/5	Just upstream of Stoney Run Rd overpass. Sewer easement on left bank parallel to stream.
02-R3M-05-20	3.79	20.7	1.1	28.5	1.4	18.2	23.4	0.45	1.1	13	B4c	Incised channel. Typical urban stream for this area.
07-L1M-02-20	1.22	12.7	1.1	17.0	1.3	11.8	13.6	0.57	1.4	0.39	ND	Downstream of road culvert. Relocated and resurveyed R1 XS. Site shifted downstream to avoid wide wetland for summer electrofishing visit.
07-L1M-03-20	2.64	11.8	1.6	128.0	10.8	7.5	18.6	0.32	1.1	0.28	E5	Unable to locate r1 XS, re-established XS. Large wetland floodplain on right bank.
07-L2M-02-20	2.48	35.2	0.5	130.0	3.7	64.6	19.2	0.062	1.1	0.35	C5	Found R2 XS pins and resurveyed. Few bedform features in reach.
07-L2M-03-20	0.76	11.4	1.0	17.3	1.5	10.8	11.9	0.5	1.2	0.39	F5	Located R2 XS, but only right pin. Reset left pin using R2 photos. XS now in a pool. Lots of sediment moving through stream. Channel has enlarged significantly since previous survey. Adj. WD +2.0
07-R3M-01-20	0.21	4.8	0.8	6.9	1.4	5.9	3.9	0.37	1.0	0.13	G5c	Stream is incised more as you moved downstream through site. Earthen berm on right bank for upper half of site, believe site was straightened in the past. Adj ENT -0.1 to fit G type.
07-R3M-02-20	0.92	9.4	0.8	68.0	7.3	12.1	7.2	0.31	1.1	0.32	E5	Slightly incised channel but appears to still regularly access the floodplain. Adj. WD -1.0 to fit E type.
07-R3M-04-20	4.78	21.3	1.4	125.0	5.9	15.0	30.3	0.39	1.2	1.1	C5	Large tree across channel creating large scour pool. Few bankful indicators within reach.

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
07-R3M-07-20	0.73	8.9	0.7	11.5	1.3	13.3	5.9	1.3	1.3	0.31	F5	Very incised channel. Appears to move a great deal of sediment. All riffles in segment are transverse. XS placed in only straight reach. Banks are actively slumping. Appears to be transitioning from a F to B type channel.
14-L1M-01-20	0.21	6.9	0.6	9.4	1.4	11.4	4.2	0.31	1.2	0.16	G5c	--
14-L1M-02-20	0.33	8.6	0.5	10.3	1.2	17.7	4.2	1.1	1.0	0.17	F5	Revisit, old Meck says no XS surveyed.
14-L2M-02-20	0.77	9.1	0.7	10.4	1.1	13.4	6.2	0.2	1.1	0.23	F5	US of site 14-L2M-03-20. Mature forest, lots of trees down in stream and along bank, banks 3-4+ ft high with some areas of active erosion. Mostly sand with some cobble and hard pan on the banks. Poorly defined Riffle/Run features, lumped them all as Riffles.
14-L2M-03-20	0.42	5.5	1.0	100.0	18.2	5.7	5.3	0.58	1.0	0.13	E5	Small stream. Features too small to determine, assumed all to be run. Lots of woody debris disposed of by property owner in stream.
14-R3M-05-20	0.23	3.7	0.9	70.0	18.9	3.9	3.5	1.5	1.2	0.15	E5	Channel is downcut from original floodplain, now forming new floodplain within downcut channel. Floodplain/top of bank called with respect to newly forming floodplain and banks. FPA width measured in GIS.
14-R3M-07-20	0.84	8.3	1.0	34.0	4.1	8.4	8.2	0.26	1.4	0.36	E5	DS of 14-L2M-02-20. Mature forest with lots of downed trees and moderate understory of spicebush and paw paw. 3' banks, historic downcutting, but stabilized with benches on inside meanders and banks don't look like they are actively eroding. Adjacent stream/wetland complex is strange, looks artificially backed up. Not a lot of evidence of the stream accessing the floodplain.
14-R3M-10-20	0.13	5.7	0.5	7.5	1.3	10.6	3.1	0.92	1.1	0.18	G5c	--
14-R3M-17-20	0.27	8.5	0.4	11.9	1.4	20.4	3.6	0.25	1.1	0.18	B5c	--
20-L1M-04-20	3.09	19.8	1.0	22.2	1.1	19.2	20.5	0.35	1.1	4.3	F4/5	Old left end pin found, right not found. New pins installed. New XS established in riffle at old XS.
20-L1M-08-20	0.67	10.0	0.9	12.0	1.2	11.1	9.0	0.85	1.1	13	G4c	Entrenched channel with lots of hard pan clay on the bed and in the lower banks. Shear 5-6 ft banks with few bkfl indicators. Wide mature forest, trees fallen into stream and along banks. Well defined riffles and pools where not downcut to hardpan.
20-L2M-01-20	0.30	7.8	0.6	10.1	1.3	13.3	4.6	0.68	1.1	0.096	F5	--
20-L2M-03-20	0.29	7.5	0.6	10.4	1.4	11.9	4.7	0.87	1.0	1.4	G4/5c	Both XS pins were found. Mature riparian forest, site had good bankfull features and riffle features. Wetland seep parallel on RB.
20-R3M-03-20	0.21	9.0	0.5	12.3	1.4	17.7	4.6	2	1.1	0.097	B5	--
20-R3M-06-20	1.55	10.9	1.3	76.0	7.0	8.2	14.3	0.12	1.2	0.12	E5	Mature forest along RB. LB maintained lawn. Some small benches present. Bed material is mostly fine sands, no real riffle features present.
20-R3M-09-20	0.35	8.3	0.8	9.8	1.2	10.1	6.9	0.72	1.0	0.41	G5c	3-4' eroded banks. Wetland system along LB in FP, gravel and sand predominate, but hard pan clay where stream has eroded down. Mature forest with nice understory.

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
20-R3M-10-20	1.60	10.3	1.9	400.0	38.9	5.5	19.1	0.023	1.0	0.086	E5	High vertical banks, occasional bkf bench forming before terrace/fp at tob. Pool and run features only, material mostly silt clay and sandy, no riffles or gravel. Measured floodprone area in GIS.

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 Biological Monitoring Program (Program) 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. Due to precautions in place due to the COVID-19 pandemic, no Summer Index Period training was held by MBSS. Field staff holding valid summer certifications at the end of 2019 had those certifications extended by MBSS through 2020. 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 that held a Fish Taxonomist certification. 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 four primary sampling units (PSUs) sampled in 2020, for a total of 8 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. Two metrics, Number of EPT Taxa and Percent Climbers, exceeded the MQO for mRPD. The BIBI was within the acceptable range for all MQOs in the QC dataset.

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 0 taxa yielded an RPD of 200, 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 the Percent Climber metric was likely due to the variability within this metric between sites sampled in which values range from 0.0% to 13.7%, most of which were below 10%.

Number of EPT Taxa also exceeded the MQO for CV, but passed for RMSE. This suggests that the low mean number of EPT taxa in the QC data set (1.7) skewed the CV value upward and just

barely exceeded the MQO of 50.0. Had the mean for this data set been 2.0 taxa, this metric would have been below the acceptable threshold.

Only one metric, Number of Scraper Taxa, exceeded the MQO for RMSE. This is largely due to one outlier sample pair, which had a difference of three (3) scrapers. All other sample pairs had either identical numbers or a difference of only one scraper taxa. Since only one outlier was present in the data set, mRPD and CV remained within acceptable ranges.

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.

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
20-L1M-04-20	23	3	2	7.1	5.4	4	12.5	3.86	Fair
20-L1M-04-20-QC	18	5	2	8.3	6.3	1	10.4	3.57	Fair
20-R3S-08-20	18	1	0	7.2	0.0	0	0.0	1.29	Very Poor
20-R3S-08-20-QC	18	1	0	6.5	0.0	0	0.0	1.29	Very Poor
02-R3M-04-20	22	3	1	11.0	1.7	4	0.8	3.29	Fair
02-R3M-04-20-QC	18	3	1	9.1	0.9	5	5.5	3.00	Fair
02-R3S-11-20	18	0	0	0.9	0.0	0	9.2	1.86	Very Poor
02-R3S-11-20-QC	13	1	0	0.0	0.0	1	13.7	1.86	Very Poor
07-L1M-03-20	17	0	0	29.5	0.0	2	1.8	2.71	Poor
07-L1M-03-20-QC	16	1	0	10.2	0.0	2	4.6	2.43	Poor
07-R3S-06-20	29	1	0	2.9	0.0	1	5.8	2.14	Poor
07-R3S-06-20-QC	26	3	0	10.3	0.0	1	1.9	2.71	Poor
14-L1M-01-20	18	1	0	8.8	0.0	1	5.9	1.86	Very Poor
14-L1M-01-20-QC	19	0	0	6.7	0.0	1	3.8	1.86	Very Poor
14-R3S-04-20	15	1	0	43.3	0.0	0	0.0	1.86	Very Poor
14-R3S-04-20-QC	18	3	0	46.2	0.0	0	2.9	2.43	Poor
Median RPD	14.5	**100**	0.0	23.5	0.0	0.0	**65.7**	7.8	-
RMSE	3.2	0.9	0.0	8.2	0.3	**1.3**	3.4	0.4	-
CV	16.7	**51.1**	0.0	63.4	39.4	88.9	68.2	15.9	-

Laboratory Sorting and Subsampling

Bias

All sorting was completed following the SOPs described in the QAPP. For these samples, 100% (90 samples) underwent quality control procedures for sorting, exceeding the ten percent requirement. Average percent sorting efficiency was 99.1% (n=72). All samples sorted by

laboratory personnel in training (i.e., not consistently achieving >90% sorting efficiency) were checked, while a minimum of 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

Eight samples (02-R3M-04-20, 02-R3S-10-20, 02-R3S-13-20, 07-R3S-05-20, 07-R3S-12-20, 14-L1M-02-20, 14-R3S-12-20, 20-R3S-15-20) were randomly selected for QC identification and enumeration by an independent lab. Initial identification was performed by EcoAnalysts[1]. Re-identification of the randomly selected samples was completed by Ellen Friedman, former lead benthic macroinvertebrate taxonomist at the Maryland Department of Natural Resources. 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 eight samples are found in Table 6 through Table 13. 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 Crangonyctidae and the secondary laboratory identified the same specimen as *Crangonyx* (genus of the family Crangonyctidae) this would be considered a hierarchical disagreement.

Only one sample exceeded the threshold for PTD. Sample 14-R3S-12-20 had fewer than 80 specimens present; therefore, relatively small differences between taxa resulted in a skewed PDE value since there were fewer than 100 organisms present. Since MQO targets were based on a 100-organism subsample, comparisons of outlier samples with 20 fewer organisms present will not provide results that are representative of the larger data set. The average PDE for all samples was 0.9% with a range between 0.3% and 1.8%. The average PTD was 12.5% with a range between 4.7% and 35.4%.

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.

[1] Address: 1420 S. Blaine St., Suite 14 Moscow, ID 83843

A total of 6 duplicate water quality grab sample pairs 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 2020, there were no parameters that exceeded 20% mRPD (median RPD). Therefore, 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 collected at two of the eight QC sites during 2020. Results of individual parameter values for both field blank samples are presented in Table 4. At site 07-L1M-03-20-QC, three individual parameters had values exceeding the method detection limits, which include Total Nitrogen, Kjeldahl Nitrogen and turbidity. It should be noted that all three values had data qualifiers in the lab report. Kjeldahl nitrogen (MDL = 1.6 mg/L, RDL = 5.0 mg/L) and total nitrogen (calculated) had a qualifier that the result is less than the RL but greater than the MDL and the concentration is an approximate value. Turbidity was flagged as being prepped or analyzed beyond the specific holding time. At site 14-L1M-01-20-QC, values for Total Nitrogen, Kjeldahl Nitrogen, hardness and zinc exceeded the method detection limit, with all other parameter values falling below. The turbidity value had a data qualifier in the lab report that was flagged as being prepped or analyzed beyond the specific holding time. It is unclear what caused the elevated levels of Kjeldahl nitrogen, and subsequently total nitrogen, but since it occurred across teams and in different PSU, it is likely the result of contaminated deionized water used in the blanks.

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	Dissolved Organic Carbon
20-R3S-08-20	41.0	0.150	0.54	BDL	BDL	BDL	0.54	1.8
20-R3S-08-20-QC	37.0	0.110	0.55	BDL	BDL	BDL	0.55	1.8
20-L1M-04-20-QC	27.0	0.120	0.82	BDL	BDL	BDL	0.82	2.9
20-L1M-04-20	27.0	0.180	0.82	BDL	BDL	BDL	0.82	2.9
02-R3M-04-20	55.0	BDL	2.90	BDL	BDL	BDL	0.71	5.4
02-R3M-04-20-QC	52.0	BDL	3.50	BDL	BDL	BDL	0.67	5.3
02-R3S-11-20	36.0	0.200	2.30	BDL	BDL	0.035	0.08	8.2
02-R3S-11-20-QC	37.0	0.210	2.90	BDL	BDL	0.031	0.07	8.2
07-R3S-06-20	42.0	0.095	3.40	BDL	BDL	BDL	1.70	7.8
07-R3S-06-20-QC	44.0	0.095	3.50	BDL	BDL	BDL	1.80	7.6
14-R3S-04-20	13.0	0.210	0.59	BDL	BDL	BDL	0.59	5.6
14-R3S-04-20-QC	15.0	0.270	2.80	BDL	0.095	BDL	0.62	6.3
Median RPD	4.7	14.9	2.9	N/A	N/A	12.1	5.0	0.0

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)
20-R3S-08-20	0.9533	3.34	12.1	44.06	0.300	23.7	0.238	15.2
20-R3S-08-20-QC	0.9075	3.34	12.1	43.93	0.277	23.3	0.199	14.8
20-L1M-04-20-QC	6.1512	5.47	22.0	77.51	1.44	190.6	0.172	5.6
20-L1M-04-20	5.7263	5.50	23.3	80.74	1.71	199.0	0.364	9.5
02-R3M-04-20	3.7355	3.95	12.9	48.33	1.13	20.4	0.238	5.6
02-R3M-04-20-QC	3.8834	3.99	13.2	49.35	1.17	19.8	0.224	4.5
02-R3S-11-20	3.4865	1.28	1.59	9.22	1.57	12.8	0.450	4.4
02-R3S-11-20-QC	3.5352	1.26	1.60	9.19	1.54	12.5	0.460	4.5
07-R3S-06-20	2.6773	3.63	8.05	35.05	0.590	12.0	0.425	15.5
07-R3S-06-20-QC	2.9801	3.69	8.24	35.74	0.511	11.3	0.310	10.4
14-R3S-04-20	1.7303	3.85	22.7	72.58	0.139	8.91	0.058	5.9
14-R3S-04-20-QC	1.6515	3.87	23.0	73.25	0.132	7.93	0.049	6.0
Median RPD	4.5	24.0	0.0	5.1	6.0	9.5	8.2	4.5

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	07-L1M-03-20-QC	14-L1M-01-20-QC	Parameter	07-L1M-03-20-QC	14-L1M-01-20-QC
Chloride	BDL	BDL	Total Organic Carbon	ND	ND
Total Phosphorus	BDL	BDL	Kjeldahl Nitrogen	2.2	5
Total Nitrogen	2.2	5.5	Hardness	ND	ND
Orthophosphate	BDL	BDL	Total Copper (µg/L)	ND	ND
Total Ammonia Nitrogen	BDL	BDL	Total Zinc (µg/L)	ND	9.9
Nitrite-N	BDL	BDL	Total Lead (µg/L)	ND	ND
Nitrate-N	BDL	BDL	Turbidity (NTU)	1.4	0.2
Dissolved Organic Carbon	BDL	BDL			

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 5. While several individual metrics had exceeded measures for mRPD and CV, the overall BIBI was within acceptable limits for all measures of precision. 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 also within the desired 90% confidence interval for the BIBI (0.62), well below the MQO of ≤0.96.

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 possibly random error due to the spatial heterogeneity of habitats and taxa distribution between adjacent reaches. MBSS uses a QC site approach were the duplicate benthic sample is collected within the same reach as the non-QC sample, in as similar proportions of best available habitat as possible. While the institutional history of this decision is not published, MBSS staff feel this was done in an attempt to limit or control as much variability between the QC and non-QC samples as possible (Boward, D., 2020). Potential future research into differences between these approaches to QC site establishment may help Anne Arundel County identify external influences or variability that potentially exist in this aspect of the Program's QC work.

All MQOs were met during the 2020 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	2020 Results
Field Sampling	Precision	mRPD (BIBI)	<20	7.8
		RMSE (BIBI)	<0.6	0.4
Laboratory Sorting/Subsampling	Bias	PSE	>90	99.1
Taxonomic Identification	Precision	PDE	<5	0.9
		PTD	<15	12.5
Site Assessment	Sensitivity	90% CI (BIBI)	≤0.96	0.62

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

Table 6 - Taxonomic Identification and Enumeration Results: 20-R3S-15-20

Order	Family	Tribe	Final ID	20-R3S-15-20		
				Taxonomist 1	Taxonomist 2	# of agreements
Haplotaxida	Enchytraeidae		Enchytraeidae	1		0
			LUMBRICULIDAE		1	0
	Naididae		Naididae	28	30	28
Diptera	not identified		Diptera	1	2	1
	Ceratopogonidae		Ceratopogoninae	1	1	1
			Orthocladinae		4	0
	Chironomidae		Corynoneura	7	6	6
	Chironomidae		Diplocladius	8	8	8
	Chironomidae		Nanocladius	1	1	1
	Chironomidae		Orthocladius	11	10	10
	Chironomidae		Parametriocnemus	6	4	4
	Chironomidae	Chironomini	Polypedilum	6	6	6
	Chironomidae	Pentaneurini	Zavrelimyia	2		0
			Tanypodinae		2	0
	Simuliidae	Simuliini	Simulium	6	4	4
			SIMULIIDAE		2	2
Lepidoptera	not identified		Lepidoptera	1	1	1
Plecoptera	Nemouridae		Nemouridae	1		0
			Ostrocerca sp.		1	0
	Nemouridae		Amphinemura	3	3	3
Amphipoda	Crangonyctidae		Crangonyctidae	1	1	1
	Crangonyctidae		Synurella	5	4	4
Isopoda	Asellidae		Caecidotea	17	18	17
			Total	106	105	97
			PDE			1.40
			PTD			8.49

Table 7 - Taxonomic Identification and Enumeration Results: 14-L1M-02-20

Order	Family	Tribe	Final ID	**14-L1M-02-20** Taxonomist 1	Taxonomist 2	# of agreements
Lumbriculida	Lumbriculidae	-	Lumbriculidae	1	1	1
Haplotaxida	Naididae	-	Naididae	2	2	2
Diptera	Ceratopogonidae	-	Ceratopogoninae	4	3	3
		-	Orthocladinae		1	0
	Chironomidae	-	Corynoneura	2	2	2
	Chironomidae	-	Cricotopus	1		0
	Chironomidae	-	Diplocladius	2	3	2
	Chironomidae	-	Orthocladius	43	43	43
	Chironomidae	-	Parametriocnemus	2	2	2
	Chironomidae	Chironomini	Polypedilum	7	7	7
	Chironomidae	-	Rheocricotopus	1	1	1
	Chironomidae	Tanytarsini	Tanytarsus	3	1	1
			Micropsectra sp.		2	0
	Chironomidae	-	Thienemannimyia group	1	1	1
	Empididae	Hemerodromiini	Hemerodromia	1	1	1
	Tipulidae	-	Tipula	2	2	2
			TIPULIDAE		1	0
Plecoptera	Nemouridae	-	Amphinemura	1	1	1
Trichoptera	Hydropsychidae	-	Diplectrona	6	6	6
	Uenoidae	-	Neophylax	1	1	1
Amphipoda	not identified	-	Amphipoda	2	4	2
	Crangonyctidae	-	Synurella	2		0
			CRANGONYCTIDAE		2	0
			Crangonyx sp.		2	0
	Gammaridae	-	Gammarus	13	10	10
Isopoda	Asellidae	-	Caecidotea	6	7	6
			Total	103	106	94
			PDE			1.44

Order	Family	Tribe	Final ID	14-L1M-02-20 Taxonomist 1	Taxonomist 2	# of agreements
			PTD			8.74

Table 8 - Taxonomic Identification and Enumeration Results: 14-R3S-12-20

Order	Family	Tribe	Final ID	14-R3S-12-20 Taxonomist 1	Taxonomist 2	# of agreements
Veneroida	Pisidiidae	-	Sphaeriidae	2		0
		-	Musculium sp.		4	0
	Pisidiidae	-	Sphaerium	5	3	3
Haplotaxida	Enchytraeidae	-	Enchytraeidae	4	2	2
	Naididae	-	Naididae	12	19	12
Diptera	Chironomidae	Chironomini	Microtendipes	1	1	1
Amphipoda	Crangonyctidae	-	Crangonyctidae	3	17	3
	Crangonyctidae	-	Crangonyx	1	5	1
	Crangonyctidae	-	Synurella	48	28	28
	Gammaridae	-	Gammarus	2		0
Isopoda	Asellidae	-	Caecidotea	1	1	1
			Total	79	80	51
			PDE			0.63
			PTD			35.44

Table 9 - Taxonomic Identification and Enumeration Results: 07-R3S-12-20

Order	Family	Tribe	Final ID	07-R3S-12-20 Taxonomist 1	Taxonomist 2	# of agreements
Hirudinida	Erpobdellidae	-	Erpobdella	1	1	1
Haplotaxida	Enchytraeidae	-	Enchytraeidae	4	1	1
	Naididae	-	Naididae	3	6	3
Diptera	Chironomidae	-	Chaetocladius	8	8	8
		-	Chironominae		3	0
			Chironomini		1	0
	Chironomidae	-	Corynoneura	1	1	1
	Chironomidae	-	Diplocladius	1		0
	Chironomidae	-	Eukiefferiella	1	1	1
	Chironomidae	Tanytarsini	Micropsectra	71	68	68
			Tanypodinae		1	0
	Chironomidae	Chironomini	Polypedilum	5	5	5
	Chironomidae	Chironomini	Saetheria	3	3	3
			Orthocladiinae		1	0
	Chironomidae	Pentaneurini	Zavrelimyia	1		0
Basommatophora	Physidae	-	Physa	1		0
			GASTROPODA		1	0
			Total	100	101	91
			PDE			0.50
			PTD			9.90

Table 10 - Taxonomic Identification and Enumeration Results: 07-R3S-05-20

Order	Family	Tribe	Final ID	07-R3S-05-20 Taxonomist 1	07-R3S-05-20 Taxonomist 2	07-R3S-05-20 # of agreements
Haplotaxida	Naididae	-	Naididae	60	64	60
Lumbricina	not identified	-	Lumbricina	2	2	2
Amphipoda	Crangonyctidae	-	Synurella	14	7	7
	Crangonyctidae	-	Crangonyx	6	5	5
		-	CRANGONYCTIDAE		9	0
Diptera	Chironomidae	-	Chaetocladius	21	24	21
		-	Diptera		1	0
	Chironomidae	-	Corynoneura	1	1	1
	Chironomidae	-	Limnophyes	4	2	2
	Chironomidae	-	Thienemannimyia group	1	1	1
	Chironomidae	Pentaneurini	Zavrelimyia	3		0
			Total	112	116	99
			PDE			1.75
			PTD			14.66

Table 11 - Taxonomic Identification and Enumeration Results: 02-R3S-10-20

Order	Family	Tribe	Final ID	02-R3S-10-20 Taxonomist 1	02-R3S-10-20 Taxonomist 2	02-R3S-10-20 # of agreements
Haplotaxida	Naididae	-	Naididae	7	15	7
Lumbriculida	Lumbriculidae	-	Lumbriculidae	3	2	2
Diptera	Chironomidae	-	Orthocladiinae	1		0
	Chironomidae	-	Orthocladius	3	3	3
	Chironomidae	Tanytarsini	Paratanytarsus	5	5	5
	Chironomidae	Chironomini	Polypedilum	1	1	1
	Tipulidae	-	Erioptera	3	3	3
	Tipulidae	-	Tipula	1	1	1

Order	Family	Tribe	Final ID	02-R3S-10-20 Taxonomist 1	Taxonomist 2	# of agreements
Trichoptera	Hydropsychidae	-	Cheumatopsyche	1	1	1
	not identified	-	Trichoptera	1		0
			LIMNEPHILIDAE		1	0
			LIBELLULIDAE		1	0
Amphipoda	Gammaridae	-	Gammarus	62	18	18
			GAMMARIDAE		47	44
	not identified	-	Amphipoda	6		0
Veneroida	not identified	-	Veneroida	1		0
	Pisidiidae	-	Sphaeriidae	3		0
		-	PISIDIIDAE		4	4
Basommatophora	Physidae	-	Physa	1	1	1
Hoplonemertea	Tetrastemmatidae	-	Prostoma	1		0
	not identified	-	Turbellaria	2		0
			DUGESIIDAE		2	0
			Total	102	103	90
			PDE			0.49
			PTD			11.76

Table 12 - Taxonomic Identification and Enumeration Results: 02-R3M-04-20

Order	Family	Tribe	Final ID	02-R3M-04-20 Taxonomist 1	Taxonomist 2	# of agreements
Coleoptera	Elmidae	-	Ancyronyx	1	1	1
	Elmidae	-	Optioservus	1	1	1
	Elmidae	-	Oulimnius	12	12	12
	Elmidae	-	Stenelmis	16	15	15
Diptera	Chironomidae	-	Chaetocladius	1	1	1
	Chironomidae	-	Cricotopus	1		0
	Chironomidae	-	Eukiefferiella	1	1	1

Order	Family	Tribe	Final ID	02-R3M-04-20 Taxonomist 1	02-R3M-04-20 Taxonomist 2	02-R3M-04-20 # of agreements
	Chironomidae	-	Thienemannimyia group	3	3	3
	Chironomidae	-	Orthocladius	21	19	19
			Orthocladinae		3	0
	Chironomidae	Diamesini	Potthastia	1	1	1
	Chironomidae	-	Rheocricotopus	1	1	1
	Chironomidae	Chironomini	Stenochironomus	1	1	1
	Chironomidae	Tanytarsini	Tanytarsus	1	1	1
	Chironomidae	-	Tvetenia	5	5	5
	Empididae	Hemerodromiini	Hemerodromia	3	3	3
	Empididae	-	Neoplasta	1	1	1
Ephemeroptera	Baetidae	-	Plauditus	2		0
			BAETIDAE		2	0
Trichoptera	Hydropsychidae	-	Cheumatopsyche	5	5	5
	Hydropsychidae	-	Hydropsyche	2	2	2
Amphipoda	Gammaridae	-	Gammarus	32	13	13
	not identified	-	Amphipoda	5	24	24
		-	Nematoda	1	1	1
	not identified	-	Turbellaria	1		0
			Girardia sp.		1	0
			Total	118	117	111
			PDE			0.43
			PTD			5.13

Table 13 - Taxonomic Identification and Enumeration Results: 02-R3S-13-20

Order	Family	Tribe	Final ID	02-R3S-13-20 Taxonomist 1	02-R3S-13-20 Taxonomist 2	02-R3S-13-20 # of agreements
Haplotaxida	Enchytraeidae	-	Enchytraeidae	4	3	3

Order	Family	Tribe	Final ID	02-R3S-13-20		
				Taxonomist 1	Taxonomist 2	# of agreements
	Naididae	-	Naididae	30	30	30
Amphipoda	not identified	-	Amphipoda	2	3	2
	Crangonyctidae	-	Synurella	3	2	2
Diptera	Chironomidae	-	Chaetocladius	4	4	4
	Chironomidae	Chironomini	Chironomus	6	6	6
	Chironomidae	-	Rheocricotopus	1	1	1
			SCIOMYZIDAE		1	0
Isopoda	Asellidae	-	Caecidotea	102	110	102
	Asellidae	-	Asellidae	6		0
Veneroida	not identified	-	Veneroida	1		0
			PISIDIIDAE		1	0
			NEMATODA		1	0
			Total	159	160	150
			PDE			0.31
			PTD			6.25

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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	Orthocladius	Orthocladius	Collector	sp, bu	9.2	426	12.40%	30	93.8%
Haplotaxida	Naididae	not identified	Naididae	Collector	bu	8.5	328	9.60%	28	87.5%
Amphipoda	Gammaridae	Gammarus	Gammarus	Shredder	sp	6.7	299	8.70%	16	50.0%
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3	198	5.80%	24	75.0%
Amphipoda	Crangonyctidae	Synurella	Synurella	0	0	0.4	184	5.40%	12	37.5%
Coleoptera	Elmidae	Stenelmis	Stenelmis	Scraper	cn	7.1	180	5.30%	16	50.0%
Diptera	Chironomidae	Diplocladius	Diplocladius	Collector	sp	5.9	155	4.50%	21	65.6%
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6	97	2.80%	11	34.4%
Diptera	Simuliidae	Simulium	Simulium	Filterer	cn	5.7	89	2.60%	12	37.5%
Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	Collector	sp	4.6	88	2.60%	19	59.4%
Coleoptera	Elmidae	Oulimnius	Oulimnius	Scraper	cn	2.7	80	2.30%	5	15.6%
Diptera	Chironomidae	Chaetocladius	Chaetocladius	Collector	sp	7	65	1.90%	15	46.9%
Ephemeroptera	Baetidae	Plauditus	Plauditus	0	0	na	59	1.70%	7	21.9%
Diptera	Chironomidae	Tvetenia	Tvetenia	Collector	sp	5.1	54	1.60%	20	62.5%
Diptera	Chironomidae	Corynoneura	Corynoneura	Collector	sp	4.1	53	1.50%	16	50.0%
Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia group	Predator	sp	8.2	52	1.50%	21	65.6%
Plecoptera	Nemouridae	Amphinemura	Amphinemura	Shredder	sp, cn	3	50	1.50%	9	28.1%
Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	Collector	sp	6.7	50	1.50%	5	15.6%
Diptera	Chironomidae	Tanytarsus	Tanytarsus	Filterer	cb, cn	4.9	49	1.40%	17	53.1%
Amphipoda	Crangonyctidae	not identified	Crangonyctidae	Collector	sp	6.5	46	1.30%	7	21.9%
Diptera	Ceratopogonidae	not identified	Ceratopogoninae	0	0	na	45	1.30%	17	53.1%
Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	Collector	sp	6.2	41	1.20%	13	40.6%
Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	Filterer	cn	6.5	40	1.20%	10	31.3%
Veneroida	not identified	not identified	Veneroida	0	0	na	40	1.20%	3	9.4%
Diptera	Chironomidae	Micropsectra	Micropsectra	Collector	cb, sp	2.1	38	1.10%	5	15.6%
Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	Collector	sp	6.1	36	1.10%	9	28.1%
Veneroida	Pisidiidae	not identified	Sphaeriidae	Filterer	bu	6.5	34	1.00%	8	25.0%
Trichoptera	Limnephilidae	Ironoquia	Ironoquia	Shredder	sp	4.9	31	0.90%	8	25.0%
Coleoptera	Elmidae	Optioservus	Optioservus	Scraper	cn	5.4	30	0.90%	5	15.6%
Lumbriculida	Lumbriculidae	not identified	Lumbriculidae	Collector	bu	6.6	29	0.80%	9	28.1%
Trichoptera	Philopotamidae	Chimarra	Chimarra	Filterer	cn	4.4	26	0.80%	3	9.4%
Amphipoda	not identified	not identified	Amphipoda	0	sp	6	24	0.70%	9	28.1%
Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	Predator	sp	5.3	22	0.60%	8	25.0%
Diptera	Chironomidae	Thienemanniella	Thienemanniella	Collector	sp	5.1	21	0.60%	11	34.4%
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7	20	0.60%	9	28.1%
Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	Filterer	cn	2.7	16	0.50%	5	15.6%
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7	16	0.50%	6	18.8%
Amphipoda	Gammaridae	not identified	Gammaridae	0	0	6	14	0.40%	4	12.5%

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
0	0	not identified	Nematoda	0	0	na	14	0.40%	9	28.1%
Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	Shredder	0	7.7	13	0.40%	4	12.5%
Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	Filterer	cn	7.5	13	0.40%	6	18.8%
Diptera	Tipulidae	Tipula	Tipula	Shredder	bu	6.7	13	0.40%	6	18.8%
Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	Collector	bu	9.1	11	0.30%	8	25.0%
Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	Filterer	cn	7.2	11	0.30%	6	18.8%
Diptera	Chironomidae	Potthastia	Potthastia	Collector	sp	0.01	10	0.30%	8	25.0%
Basommatophora	Ancylidae	Ferrissia	Ferrissia	Scraper	cb	7	9	0.30%	5	15.6%
Diptera	Chironomidae	Brillia	Brillia	Shredder	bu, sp	7.4	8	0.20%	4	12.5%
Basommatophora	Planorbidae	Menetus	Menetus	Scraper	cb	7.6	8	0.20%	3	9.4%
Plecoptera	Taeniopterygidae	Taeniopteryx	Taeniopteryx	Shredder	sp, cn	4.8	8	0.20%	3	9.4%
Diptera	Chironomidae	Cricotopus	Cricotopus	Shredder	cn, bu	9.6	7	0.20%	6	18.8%
Coleoptera	Elmidae	Microcylloepus	Microcylloepus	Collector	0	4.8	7	0.20%	4	12.5%
Diptera	Chironomidae	Odontomesa	Odontomesa	Collector	sp	6.6	7	0.20%	2	6.3%
Odonata	Calopterygidae	Calopteryx	Calopteryx	Predator	cb	8.3	6	0.20%	4	12.5%
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9	6	0.20%	4	12.5%
Diptera	Chironomidae	Parakiefferiella	Parakiefferiella	Collector	sp	2.1	6	0.20%	3	9.4%
Diptera	Chironomidae	Paralauterborniella	Paralauterborniella	Collector	cn	6.6	6	0.20%	5	15.6%
Diptera	Chironomidae	Paratendipes	Paratendipes	Collector	bu	6.6	6	0.20%	3	9.4%
Odonata	0	not identified	Anisoptera	Predator	0	na	5	0.10%	2	6.3%
Diptera	Chironomidae	Chironomus	Chironomus	Collector	bu	4.6	5	0.10%	4	12.5%
Coleoptera	Dytiscidae	not identified	Dytiscidae	Predator	sw, dv	5.4	5	0.10%	4	12.5%
Coleoptera	Elmidae	Ancyronyx	Ancyronyx	Scraper	cn, sp	7.8	4	0.10%	4	12.5%
Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	Predator	sp, bu	7.6	4	0.10%	2	6.3%
Diptera	Chironomidae	Limnophyes	Limnophyes	Collector	sp	8.6	4	0.10%	3	9.4%
Trichoptera	Uenoidae	Neophylax	Neophylax	Scraper	cn	2.7	4	0.10%	2	6.3%
Diptera	Chironomidae	Paracladopelma	Paracladopelma	Collector	sp	6.6	4	0.10%	4	12.5%
Diptera	Chironomidae	Prodiamesa	Prodiamesa	Collector	bu, sp	6.6	4	0.10%	2	6.3%
Hoplonemertea	Tetrastemmatidae	Prostoma	Prostoma	Predator	0	7.3	4	0.10%	4	12.5%
Odonata	Aeshnidae	Boyeria	Boyeria	Predator	cb, sp	6.3	3	0.10%	2	6.3%
Diptera	Tabanidae	Chrysops	Chrysops	Predator	sp, bu	2.9	3	0.10%	2	6.3%
Plecoptera	Perlodidae	Isoperla	Isoperla	Predator	cn, sp	2.4	3	0.10%	2	6.3%
Lumbricina	not identified	not identified	Lumbricina	Collector	bu	na	3	0.10%	3	9.4%
Coleoptera	Dytiscidae	Neoporus	Neoporus	Predator	0	na	3	0.10%	1	3.1%
Diptera	Chironomidae	Procladius	Procladius	Predator	sp	1.2	3	0.10%	1	3.1%
Diptera	Chironomidae	Saetheria	Saetheria	Collector	bu	6.6	3	0.10%	1	3.1%
Diptera	Chironomidae	not identified	Tanypodinae	Predator	0	7.5	3	0.10%	1	3.1%
Diptera	Chironomidae	Tribelos	Tribelos	Collector	bu	7	3	0.10%	3	9.4%

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
Ephemeroptera	Baetidae	Acerpenna	Acerpenna	Collector	sw, cn	2.6	2	0.10%	2	6.3%
Diptera	Tipulidae	Antocha	Antocha	Collector	cn	8	2	0.10%	2	6.3%
Diptera	Tipulidae	Dicranota	Dicranota	Predator	sp, bu	1.1	2	0.10%	2	6.3%
Trichoptera	Limnephilidae	not identified	Limnephilidae	Shredder	cb, sp, cn	3.4	2	0.10%	2	6.3%
Coleoptera	Elmidae	Macronychus	Macronychus	Scraper	cn	6.8	2	0.10%	1	3.1%
Veneroida	Pisidiidae	Musculium	Musculium	Filterer	0	5.5	2	0.10%	2	6.3%
Diptera	Chironomidae	Nanocladius	Nanocladius	Collector	sp	7.6	2	0.10%	2	6.3%
Plecoptera	Nemouridae	not identified	Nemouridae	Shredder	sp, cn	2.9	2	0.10%	2	6.3%
Diptera	Chironomidae	not identified	Orthocladiinae	Collector	0	7.6	2	0.10%	2	6.3%
Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	Collector	sp	7.7	2	0.10%	2	6.3%
Basommatophora	Planorbidae	not identified	Planorbidae	Scraper	cb	7.6	2	0.10%	1	3.1%
Coleoptera	Psephenidae	Psephenus	Psephenus	Scraper	cn	4.4	2	0.10%	1	3.1%
Diptera	Chironomidae	Rheosmittia	Rheosmittia	0	0	6.6	2	0.10%	1	3.1%
Diptera	Simuliidae	Stegopterna	Stegopterna	Filterer	cn	2.4	2	0.10%	1	3.1%
Diptera	Chironomidae	Stenochironomus	Stenochironomus	Shredder	bu	7.9	2	0.10%	2	6.3%
Diptera	Tipulidae	not identified	Tipulidae	Predator	bu, sp	4.8	2	0.10%	2	6.3%
not identified	not identified	not identified	Turbellaria	Predator	sp	4	2	0.10%	2	6.3%
Ephemeroptera	Baetidae	Acentrella	Acentrella	Collector	sw, cn	4.9	1	0.00%	1	3.1%
Isopoda	Asellidae	not identified	Asellidae	0	0	3.3	1	0.00%	1	3.1%
Ephemeroptera	Baetidae	not identified	Baetidae	Collector	sw, cn	2.3	1	0.00%	1	3.1%
Odonata	Calopterygidae	not identified	Calopterygidae	Predator	0	6	1	0.00%	1	3.1%
Decapoda	Cambaridae	not identified	Cambaridae	Shredder	sp	2.8	1	0.00%	1	3.1%
Plecoptera	Capniidae	not identified	Capniidae	Shredder	sp, cn	3.7	1	0.00%	1	3.1%
Diptera	Chironomidae	Chironomini	Chironomini	0	0	5.9	1	0.00%	1	3.1%
Odonata	Coenagrionidae	Coenagrion/Enallagma	Coenagrion/Enallagma	Predator	cb	na	1	0.00%	1	3.1%
Odonata	Cordulegastridae	Cordulegaster	Cordulegaster	Predator	bu	2.4	1	0.00%	1	3.1%
Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	Collector	bu	9	1	0.00%	1	3.1%
Coleoptera	Elmidae	Dubiraphia	Dubiraphia	Scraper	cn, cb	5.7	1	0.00%	1	3.1%
Trichoptera	Hydropsychidae	not identified	Hydropsychidae	Filterer	cn	5.7	1	0.00%	1	3.1%
Plecoptera	Leuctridae	Leuctra	Leuctra	Shredder	cn	0.4	1	0.00%	1	3.1%
Diptera	Chironomidae	Microtendipes	Microtendipes	Filterer	cn	4.9	1	0.00%	1	3.1%
Diptera	Empididae	Neoplasta	Neoplasta	Predator	0	na	1	0.00%	1	3.1%
Diptera	Chironomidae	Nilotanypus	Nilotanypus	Predator	sp	6.6	1	0.00%	1	3.1%
Decapoda	Cambaridae	Orconectes	Orconectes	Shredder	sp	2.8	1	0.00%	1	3.1%
Diptera	Chironomidae	Parachaetocladius	Parachaetocladius	Collector	sp	3.3	1	0.00%	1	3.1%
Plecoptera	Perlidae	not identified	Perlidae	Predator	cn	2.2	1	0.00%	1	3.1%
Trichoptera	Limnephilidae	Pycnopsyche	Pycnopsyche	Shredder	sp, cb, cn	3.1	1	0.00%	1	3.1%
Diptera	Sciomyzidae	not identified	Sciomyzidae	Predator	bu	6	1	0.00%	1	3.1%

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	Simuliidae	not identified	Simuliidae	Filterer	cn	3.2	1	0.00%	1	3.1%
Diptera	Chironomidae	not identified	Tanytarsini	Collector	0	3.5	1	0.00%	1	3.1%
Trichoptera	Leptoceridae	Triaenodes	Triaenodes	Shredder	sw, cb	5	1	0.00%	1	3.1%

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	944	23.0%	16	50.0%
Eastern Mosquitofish	*Gambusia holbrooki*	NOTYPE	IV	N	NOTYPE	781	19.0%	14	43.8%
Green Sunfish	*Lepomis cyanellus*	T	GE	N	NOTYPE	393	9.6%	14	43.8%
Bluegill	*Lepomis macrochirus*	T	IV	N	NOTYPE	353	8.6%	17	53.1%
Eastern Mudminnow	*Umbra pygmaea*	T	IV	N	NOTYPE	237	5.8%	13	40.6%
American Eel	*Anguilla rostrata*	NOTYPE	GE	N	NOTYPE	227	5.5%	18	56.3%
Tessellated Darter	*Etheostoma olmstedi*	T	IV	N	B	220	5.4%	13	40.6%
Fallfish	*Semotilus corporalis*	I		Y	NOTYPE	150	3.6%	7	21.9%
Redbreast Sunfish	*Lepomis auritus*	NOTYPE	GE	N	NOTYPE	119	2.9%	5	15.6%
Creek Chub	*Semotilus atromaculatus*	T	GE	Y	NOTYPE	95	2.3%	8	25.0%
Pumpkinseed	*Lepomis gibbosus*	T	IV	N	NOTYPE	57	1.4%	4	12.5%
Largemouth Bass	*Mictopterus salmoides*	T	TP	N	NOTYPE	56	1.4%	12	37.5%
Swallowtail Shiner	*Notropis procne*	NOTYPE	IV	Y	NOTYPE	55	1.3%	6	18.8%
Longnose Dace	*Rhinichthys cataractae*	NOTYPE	OM	N	NOTYPE	54	1.3%	5	15.6%
White Sucker	*Catostomus commersonii*	T	OM	Y	NOTYPE	41	1.0%	6	18.8%
Creek Chubsucker	*Erimyzon oblongus*	NOTYPE	IV	N	R	40	1.0%	5	15.6%
Central Stoneroller	*Campostoma anomalum*	I	AL	Y	NOTYPE	25	0.6%	3	9.4%
Golden Shiner	*Notemigonus crysoleucas*	T	OM	N	NOTYPE	25	0.6%	5	15.6%
Brown Bullhead	*Ameiurus nebulosus*	T	OM	N	NOTYPE	22	0.5%	4	12.5%
Margined Madtom	*Noturus insignis*	I	IV	N	B	21	0.5%	2	6.3%
Yellow Bullhead	*Ameiurus natalis*	NOTYPE	OM	N	NOTYPE	20	0.5%	4	12.5%
Satinfin Shiner	*Cyprinella analostana*	I	IV	N	NOTYPE	19	0.5%	5	15.6%
Spottail Shiner	*Notropis hudsonius*	I	OM	Y	NOTYPE	19	0.5%	2	6.3%
Warmouth	*Lepomis gulosus*	NOTYPE	GE	N	NOTYPE	19	0.5%	2	6.3%
Bluespotted Sunfish	*Enneacanthus gloriosus*	NOTYPE	IV	N	NOTYPE	17	0.4%	1	3.1%
Common Shiner	*Luxilus cornutus*	I	OM	Y	NOTYPE	17	0.4%	1	3.1%
Mummichog	*Fundulus heteroclitus*	NOTYPE	IV	N	NOTYPE	16	0.4%	1	3.1%
Rosyside Dace	*Clinostomus funduloides*	NOTYPE	IV	Y	NOTYPE	14	0.3%	3	9.4%
Northern Hogsucker	*Hypentelium nigricans*	I	IV	Y	R	13	0.3%	3	9.4%
Least Brook Lamprey	*Lampetra aepyptera*	NOTYPE	FF	N	B	12	0.3%	4	12.5%
Banded Killifish	*Fundulus diaphanus*	NOTYPE	IV	N	NOTYPE	10	0.2%	2	6.3%
River Chub	*Nocomis micropogon*	I	OM	Y	NOTYPE	6	0.1%	1	3.1%
Black Crappie	*Pomoxis nigromaculatus*	NOTYPE	GE	N	NOTYPE	4	0.1%	2	6.3%
Redfin Pickerel	*Esox americanus*	T	TP	N	NOTYPE	4	0.1%	1	3.1%
Smallmouth Bass	*Micropterus dolomieu*	NOTYPE	TP	N	NOTYPE	3	0.1%	2	6.3%
Sea Lamprey	*Petromyzon marinus*	I	FF	N	NOTYPE	2	0.0%	1	3.1%
Rock Bass	*Ambloplites rupestris*	NOTYPE	GE	Y	NOTYPE	1	0.0%	1	3.1%

Crayfish

Common Name	Scientific Name	Total Number of Sites	% of Sites
Devil Crawfish	*Cambarus diogenes*	7	22%
Spinycheek Crayfish	*Orconectes limosus*	6	19%
Virile Crayfish	*Orconectes virilis*	3	9%
n/a	*Procambarus acutus/zonangulus*	2	6%
Red Swamp Crawfish	*Procambarus clarkii*	2	6%

Herpetofauna

Common Name	Scientific Name	Total Number of Sites	% of Sites
Northern Green Frog	*Lithobates clamitans*	22	69%
Northern Two-lined Salamander	*Eurycea bislineata*	13	41%
Pickerel Frog	*Lithobates palustris*	9	28%
Northern Spring Peeper	*Pseudacris crucifer*	6	19%
Southern Leopard Frog	*Lithobates sphenocephala*	4	13%
American Bullfrog	*Lithobates catesbeianus*	3	9%
Gray Treefrog	*Hyla versicolor*	3	9%
Wood Frog	*Lithobates sylvaticus*	3	9%
Eastern Box Turtle	*Terrapene carolina*	2	6%
Snapping Turtle	*Chelydra serpentina*	2	6%
Eastern Cricket Frog	*Acris crepitans*	2	6%
Northern Water Snake	*Nerodia sipedon sipedon*	2	6%
Common Five-lined Skink	*Plestiodon fasciatus*	2	6%
Cope’s Gray Treefrog	*Hyla chrysoscelis*	1	3%
Eastern American Toad	*Anaxyrus americanus*	1	3%
Fowler’s Toad	*Anaxyrus fowleri*	1	3%

Non-native Riparian Plants

Common Name	Scientific Name	Total Number of Sites	% of Sites
Japanese stiltgrass	*Microstegium vimineum*	27	84%
Multiflora rose	*Rosa multiflora*	24	75%
Japanese honeysuckle	*Lonicera japonica*	18	56%
Oriental bittersweet	*Celastrus orbiculatus*	15	47%
Garlic mustard	*Alliaria petiolata*	8	25%
Porecelain Berry	*Ampelopsis brevipedunculata*	8	25%
Mile-a-Minute	*Persicaria perfoliata*	6	19%
English ivy	*Hedera helix*	3	9%
Ground ivy	*Glechoma hederacea*	3	9%
Japanese barberry	*Berberis thunbergii*	3	9%
Privet Sp.	*Ligustrum sp.*	3	9%
Tree of Heaven	*Ailanthus altissima*	3	9%
Autumn Olive	*Commelina communis*	1	3%
Bamboo Sp.	n/a	1	3%
Callery pear	*Pyrus calleryana*	1	3%
Creeping Charlie	*Glechoma hederacea*	1	3%
Curly Dock	*Rumex crispus*	1	3%
Indian strawberry	*Duchesnea indica*	1	3%
Japanese Hops	*Humulus japonicus*	1	3%
Wavyleaf basketgrass	*Oplismenus hirtellus*	1	3%
Wineberry	*Rubus phoenicolasius*	1	3%
Winged Euoynmus	*Euonymus alatus*	1	3%

Freshwater Mussels/Corbicula

Common Name	Scientific Name	Total Number of Sites	% of Sites
Asiatic clam	*Corbicula sp.*	3	9%

Appendix D: Individual Site Summaries

Site ID 02-L1M-01-20

Revist of site R1-02-04

Upstream View - 2020

Downstream View - 2020

Upstream View - 2007

Downstream View - 2007

Summary Results

	2020 Data	2007 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially 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) 303.84

Land Cover	2020 Acres	2007 Acres	2020 % Area	2007 % Area
Developed Land	261.07	214.79	85.92	70.63
Forested Land	38.77	56.74	12.76	18.66
Open Land	4.00	6.60	1.32	2.17
Agricultural Land	0.00	25.96	0.00	8.54

Impervious Surface	2020 Acres	2007 Acres	2020 % Area	2007 % Area
Impervious Land	44.72	68.42	14.72	22.51

Site ID 02-L1M-01-20

Revist of site R1-02-04

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2007 Spring
Dissolved Oxygen (mg/L)	9.78	7.66	12.4
Turbidity (NTU)	6.88	4.56	n/a
Temperature (°C)	9.7	22	4.07
pH (Standard Units)	7.14	6.35	n/a
Specific Conductivity (µS/cm)	283	317.5	842

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	40.000
Total Nitrogen (mg/L)	14.000	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	2.500
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	18.000
Nitrate-N (mg/L)	1.900	Total Lead (µg/L)	0.530
Total Kjehldal N (mg/L)	12.000	Turbidity (NTU)	2.0
Dissolved Organic C (mg/L)	5.800		
Total Organic C (mg/L)	5.800		
Hardness (mg eq. $CaCO_3$/L)	58.00		

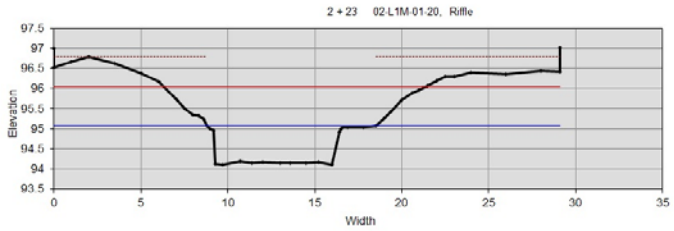
Geomorphic Assessment

Rosgen Level II Classification Data

	2020	2007		2020	2007
Drainage Area (mi²)	0.47		Sinuosity	1.21	1.20
Bankfull Width (ft)	9.7	9.6	D50 (mm)	0.22	0.32
Mean Bankfull Depth (ft)	0.7	0.5	Adjustments?	None	Sin
Floodprone Width (ft)	15.1	105.0			
Entrenchment Ratio	1.6	10.9			
Width to Depth Ratio	14.3	19.3			
Cross Sectional Area (ft²)	6.6	4.8			
Water Surface Slope (%)	0.620	0.670			

Rosgen Stream Type	
2020	2007
B5c	**C5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2007 Spring Value	2007 Spring Score
Remoteness	7.53	40.55	9.00	48.47
Shading	35	36.34	55	54.42
Epifaunal Substrate	8	65.45	12	88.68
Instream Habitat	7	61.02	12	88.76
Instream Woody Debris	9	83.62	7	77.69
Bank Stability	13.47	82.06	14.00	83.67

	2020 Score	2007 Score
MPHI Habitat Score	61.51	73.61
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2020 Score	2007 Score		2020 Score	2007 Score
Epifaunal Substrate/Available Cover	5	12	Bank Stability - Right Bank	8	8
Pool Substrate Characterization	11	0	Bank Stability - Left Bank	8	8
Pool Variability	3	0	Vegetative Protection - Right Bank	4	8
Sediment Deposition	16	11	Vegetative Protection - Left Bank	4	8
Channel Flow Status	17	18	Riparian Veg. Zone Width - Right Bank	8	6
Channel Alteration	20	16	Riparian Veg. Zone Width - Left Bank	9	8
Channel Sinuosity	8	8			

	2020 Score	2007 Score
RBP Habitat Score	121	111
RBP Rating	Partially Supporting	Partially Supporting

Site ID 02-L1M-01-20

Revist of site R1-02-04

Biological Assessments

BIBI Metric Values	2020	2007
Total Taxa	17	18
EPT Taxa	3	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	36.11	76.24
% Ephemeroptera	0.00	0.00
Scraper Taxa	5	2
% Climbers	0.93	0.99

FIBI Metric Values (2020 only)	
Abundance per m²	0.82
Adj. No. of Benthic Species	1.19
% Tolerant	96.77
% Gen., Omni., Invert.	95.97
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	50.00

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

FIBI Metric Scores (2020 only)	
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	3.00	3.00
BIBI Rating	Fair	Fair

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Fauna (2020 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Pickerel Frog

Fish Taxa	Number
American Eel	4
Blacknose Dace	23
Bluegill	3
Creek Chub	13
Eastern Mudminnow	1
Green Sunfish	62
Largemouth Bass	5
Tessellated Darter	13

Benthic Macroinvertebrate Taxa

2020	Number
Amphipoda	4
Ancyronyx	1
Boyeria	1
Calopterygidae	1
Corynoneura	5
Diplectrona	1
Diplocladius	2
Gammarus	37
Hydropsyche	1
Lumbriculidae	1
Naididae	1
Nematoda	1
Neophylax	3
Optioservus	1
Orthocladius	3
Oulimnius	35
Sphaeriidae	3
Stenelmis	6
Veneroida	1

Original Visit	Number
Spirosperma	1
Oulimnius	67
Ablabesmyia	1
Corynoneura	5
Hydrobaenus	1
Orthocladius/Cricotopus	1
Parametriocnemus	1
Pseudosmittia	1
Thienemanniella	4
Simulium	1
Boyeria	1
Amphinemura	6
Cheumatopsyche	1
Diplectrona	4
Gammaridae	1
Physa	1
Menetus	1
Sphaeriidae (Mollusca)	3

Site ID 02-L1M-03-20

Revist of site R1-02-18A

Upstream View - 2020

Downstream View - 2020

Upstream View - 2007

Downstream View - 2007

Summary Results

	2020 Data	2007 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	High conductivity; Elevated nutrients	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 6159.57

Land Cover	2020 Acres	2007 Acres	2020 % Area	2007 % Area
Developed Land	3360.97	3090.56	54.56	51.25
Forested Land	1761.65	2008.54	28.60	33.31
Open Land	1035.22	897.79	16.81	14.89
Agricultural Land	1.74	33.71	0.03	0.56

Impervious Surface	2020 Acres	2007 Acres	2020 % Area	2007 % Area
Impervious Land	1162.19	1845.36	18.87	30.60

Site ID 02-L1M-03-20

Revist of site R1-02-18A

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2007 Spring
Dissolved Oxygen (mg/L)	11.05	9.22	13.6
Turbidity (NTU)	5.48	5.85	n/a
Temperature (°C)	12.5	14.2	4.61
pH (Standard Units)	7.24	7.44	n/a
Specific Conductivity (µS/cm)	446.6	467.7	570

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.040	Chloride (mg/L)	81.000
Total Nitrogen (mg/L)	3.400	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	2.100
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	10.000
Nitrate-N (mg/L)	0.590	Total Lead (µg/L)	0.410
Total Kjehldal N (mg/L)	2.800	Turbidity (NTU)	3.9
Dissolved Organic C (mg/L)	5.000		
Total Organic C (mg/L)	5.100		
Hardness (mg eq. $CaCO_3$/L)	72.00		

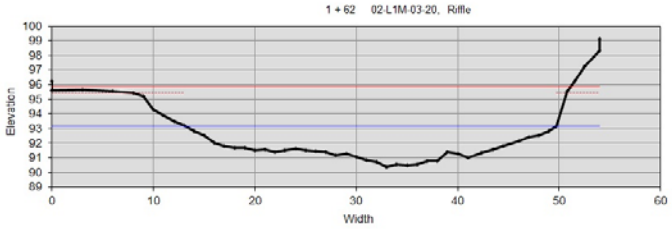
Geomorphic Assessment

Rosgen Level II Classification Data

	2020	2007		2020	2007
Drainage Area (mi²)	9.62		Sinuosity	1.12	1.10
Bankfull Width (ft)	36.5	25.1	D50 (mm)	22.00	22.00
Mean Bankfull Depth (ft)	1.6	1.7	Adjustments?	SIN +0.1	None
Floodprone Width (ft)	97.2	140.0			
Entrenchment Ratio	2.7	5.6			
Width to Depth Ratio	22.2	15.0			
Cross Sectional Area (ft²)	60.0	41.9			
Water Surface Slope (%)	0.660	1.130			

Rosgen Stream Type	
2020	2007
C4	**C4**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2007 Spring Value	2007 Spring Score
Remoteness	6.61	35.62	8.00	43.08
Shading	85	84.56	45	45.47
Epifaunal Substrate	13	74.89	9	51.79
Instream Habitat	14	69.06	14	69.28
Instream Woody Debris	29	100.00	3	32.04
Bank Stability	15.70	88.60	12.00	77.46

	2020 Score	2007 Score
MPHI Habitat Score	75.46	53.19
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2020 Score	2007 Score		2020 Score	2007 Score
Epifaunal Substrate/Available Cover	15	14	Bank Stability - Right Bank	7	7
Pool Substrate Characterization	16	9	Bank Stability - Left Bank	4	5
Pool Variability	16	12	Vegetative Protection - Right Bank	7	5
Sediment Deposition	8	11	Vegetative Protection - Left Bank	8	4
Channel Flow Status	13	18	Riparian Veg. Zone Width - Right Bank	7	5
Channel Alteration	12	10	Riparian Veg. Zone Width - Left Bank	10	8
Channel Sinuosity	7	8			

	2020 Score	2007 Score
RBP Habitat Score	130	116
RBP Rating	Supporting	Partially Supporting

Site ID 02-L1M-03-20

Revist of site R1-02-18A

Biological Assessments

BIBI Metric Values	2020	2007
Total Taxa	25	26
EPT Taxa	5	6
Ephemeroptera Taxa	1	0
% Intolerant to Urban	2.61	6.73
% Ephemeroptera	15.65	0.00
Scraper Taxa	3	1
% Climbers	4.35	4.81

FIBI Metric Values (2020 only)	
Abundance per m²	0.77
Adj. No. of Benthic Species	0.65
% Tolerant	23.36
% Gen., Omni., Invert.	93.92
% Round-bodied Suckers	0.73
% Abund. Dominant Taxon	18.98

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

FIBI Metric Scores (2020 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	3
% Abund. Dominant Taxon	5

BIBI Score	3.86	2.71
BIBI Rating	Fair	Poor

FIBI Score	4.33
FIBI Rating	Good

Supplemental Fauna (2020 only)

Crayfish

Orconectes limosus

Mussels

Corbicula sp.

Herpetofauna

Pickerel Frog

Fish Taxa	Number
American Eel	38
Blacknose Dace	3
Bluegill	23
Brown Bullhead	2
Central Stoneroller	22
Common Shiner	17
Creek Chub	4
Eastern Mosquitofish	14
Fallfish	78
Green Sunfish	48
Largemouth Bass	1
Longnose Dace	8
Margined Madtom	14
Northern Hogsucker	3
Pumpkinseed	2
Redbreast Sunfish	51
River Chub	6
Rock Bass	1
Satinfin Shiner	10
Smallmouth Bass	2
Spottail Shiner	15
Swallowtail Shiner	28
Tessellated Darter	8

Benthic Macroinvertebrate Taxa

2020	Number
Amphinemura	1
Amphipoda	3
Ancyronyx	1
Baetidae	1
Brillia	1
Cheumatopsyche	4
Chimarra	3
Cricotopus/Orthocladius	8
Enchytraeidae	1
Eukiefferiella	1
Gammarus	17
Hemerodromia	1
Lumbricina	1
Microcylloepus	1
Micropsectra	1
Naididae	16
Orthocladius	2
Plauditus	17
Polypedilum	1
Prostoma	1
Psephenus	2
Rheotanytarsus	1
Simulium	2
Stenelmis	20
Taeniopteryx	1
Tanytarsus	3
Thienemannimyia group	1
Tvetenia	3

Original Visit	Number
Nais	3
Macronychus	2
Microcylloepus	4
Optioservus	1
Oulimnius	2
Stenelmis	13
Brillia	1
Eukiefferiella	1
Hydrobaenus	19
Orthocladius/Cricotopus	17
Polypedilum	1
Pseudorthocladius	1
Sympotthastia	1
Rheotanytarsus	3
Tanytarsus	3
Simulium	1
Stegopterna	4
Boveria	1
Capniidae/Leuctridae	1
Cheumatopsyche	10
Hydropsyche	6
Chimarra	1
Lype	1
Neophylax	1
Gammarus	5
Nematoda	1

Fish Taxa cont'd

Warmouth	1
White Sucker	5
Yellow Bullhead	7

Site ID 02-L2M-01-20

Revist of site R2-02-10

Upstream View - 2020

Downstream View - 2020

Upstream View - 2010

Downstream View - 2010

Summary Results

	2020 Data	2010 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially 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) 2075.25

Land Cover	2020 Acres	2010 Acres	2020 % Area	2010 % Area
Developed Land	1489.75	1366.40	71.79	65.70
Forested Land	396.12	520.10	19.09	25.00
Open Land	187.64	33.70	9.04	1.60
Agricultural Land	1.74	161.00	0.08	7.70

Impervious Surface	2020 Acres	2010 Acres	2020 % Area	2010 % Area
Impervious Land	317.40	532.67	15.29	25.60

Site ID 02-L2M-01-20

Revist of site R2-02-10

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2010 Spring
Dissolved Oxygen (mg/L)	10.54	6.85	11.17
Turbidity (NTU)	9.35	9.43	8.89
Temperature (°C)	9.5	21.3	11.3
pH (Standard Units)	7.32	7.48	7.11
Specific Conductivity (µS/cm)	326.9	262.3	403.9

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	40.000
Total Nitrogen (mg/L)	8.000	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	0.100	Total Copper (µg/L)	2.000
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	11.000
Nitrate-N (mg/L)	0.700	Total Lead (µg/L)	0.560
Total Kjehldal N (mg/L)	7.300	Turbidity (NTU)	7.5
Dissolved Organic C (mg/L)	6.200		
Total Organic C (mg/L)	6.200		
Hardness (mg eq. $CaCO_3$/L)	60.00		

Geomorphic Assessment

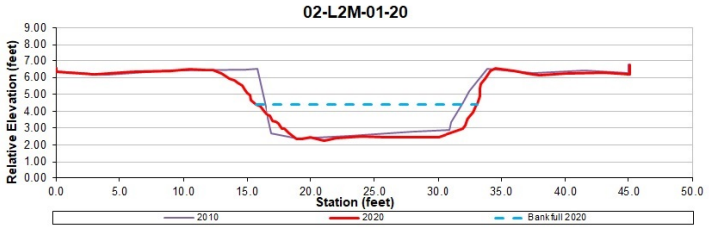
Rosgen Level II Classification Data

	2020	2010		2020	2010
Drainage Area (mi²)	3.24		Sinuosity	1.11	1.00
Bankfull Width (ft)	17.4	15.6	D50 (mm)	11.00	6.90
Mean Bankfull Depth (ft)	1.7	1.8	Adjustments?	None	None
Floodprone Width (ft)	120.0	120.0			
Entrenchment Ratio	6.9	7.7			
Width to Depth Ratio	10.4	8.7			
Cross Sectional Area (ft²)	28.8	28.2			
Water Surface Slope (%)	0.380	0.370			

Rosgen Stream Type

2020	2010
ND	**ND**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2010 Spring Value	2010 Spring Score
Remoteness	5.53	29.79	3.00	16.16
Shading	65	63.55	55	54.42
Epifaunal Substrate	13	81.98	12	76.15
Instream Habitat	12	69.10	12	69.07
Instream Woody Debris	9	61.87	7	55.92
Bank Stability	4.00	44.72	7.00	59.16

	2020 Score	2010 Score
MPHI Habitat Score	58.50	55.15
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2020 Score	2010 Score		2020 Score	2010 Score
Epifaunal Substrate/Available Cover	8	12	Bank Stability - Right Bank	1	3
Pool Substrate Characterization	11	11	Bank Stability - Left Bank	1	4
Pool Variability	9	12	Vegetative Protection - Right Bank	6	3
Sediment Deposition	11	13	Vegetative Protection - Left Bank	5	4
Channel Flow Status	15	16	Riparian Veg. Zone Width - Right Bank	7	5
Channel Alteration	19	14	Riparian Veg. Zone Width - Left Bank	8	8
Channel Sinuosity	7	8			

	2020 Score	2010 Score
RBP Habitat Score	108	113
RBP Rating	Partially Supporting	Partially Supporting

Site ID 02-L2M-01-20

Revist of site R2-02-10

Biological Assessments

BIBI Metric Values	2020	2010
Total Taxa	22	23
EPT Taxa	3	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	21.15	2.60
% Ephemeroptera	0.00	0.00
Scraper Taxa	4	7
% Climbers	1.92	4.40

FIBI Metric Values (2020 only)	
Abundance per m²	0.71
Adj. No. of Benthic Species	0.88
% Tolerant	71.18
% Gen., Omni., Invert.	97.82
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	45.85

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	5
% Climbers	3	3

FIBI Metric Scores (2020 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	3.00	2.71
BIBI Rating	Fair	Poor

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Fauna (2020 only)

Crayfish

Orconectes limosus

Mussels

None Observed

Herpetofauna

None Observed

Fish Taxa	Number
American Eel	5
Black Crappie	1
Blacknose Dace	2
Bluegill	29
Creek Chub	7
Eastern Mosquitofish	15
Eastern Mudminnow	1
Fallfish	15
Golden Shiner	2
Green Sunfish	105
Largemouth Bass	1
Least Brook Lamprey	4
Longnose Dace	4
Redbreast Sunfish	7
Satinfin Shiner	1
Swallowtail Shiner	6
Tessellated Darter	9
White Sucker	7
Yellow Bullhead	8

Benthic Macroinvertebrate Taxa

2020	Number
Ancyronyx	1
Antocha	1
Cambaridae	1
Chaetocladius	1
Cheumatopsyche	11
Chimarra	1
Corynoneura	1
Crangonyx	1
Cricotopus	2
Gammarus	7
Hydropsyche	6
Microcylloepus	4
Optioservus	12
Orthocladius	5
Oulimnius	21
Polypedilum	1
Rheocricotopus	1
Simulium	2
Stenelmis	20
Tanytarsus	1
Thienemanniella	1
Tvetenia	3

Original Visit	Number
Ancyronyx	3
Caloptervx	5
Cheumatopsyche	15
Chironominae	1
Cricotopus	2
Dubiraphia	2
Enchytraeidae	2
Gammarus	15
Hyalella	3
Hydrobaenus	1
Hydropsyche	6
Hydropsychidae	1
Libellulidae	1
Macronychus	10
Microcylloepus	6
Naididae	3
Optioservus	2
Orthocladiinae	2
Orthocladius	3
Oulimnius	3
Prostoma	1
Rheotanytarsus	4
Simulium	4
Stenelmis	17
Taeniopteryx	1
Tvetenia	1

Site ID 02-L2M-04-20

Revist of site R2-02-02

Upstream View - 2020

Downstream View - 2020

Upstream View - 2010

Downstream View - 2010

Summary Results

	2020 Data	2010 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Partially 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) 271.64

Land Cover	2020 Acres	2010 Acres	2020 % Area	2010 % Area
Developed Land	190.03	183.10	69.95	69.10
Forested Land	57.63	68.20	21.22	25.70
Open Land	23.99	0.00	8.83	0.00
Agricultural Land		13.90	0.00	5.20

Impervious Surface	2020 Acres	2010 Acres	2020 % Area	2010 % Area
Impervious Land	43.04	71.50	15.84	27.00

Site ID 02-L2M-04-20

Revist of site R2-02-02

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2010 Spring
Dissolved Oxygen (mg/L)	9.08	5.54	10.72
Turbidity (NTU)	9.47	7.37	10.8
Temperature (°C)	12.5	21.9	11.33
pH (Standard Units)	6.95	7.05	7.24
Specific Conductivity (µS/cm)	260.5	276.6	319.6

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	36.000
Total Nitrogen (mg/L)	5.000	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	0.120	Total Copper (µg/L)	1.500
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	13.000
Nitrate-N (mg/L)	2.700	Total Lead (µg/L)	0.370
Total Kjehldal N (mg/L)	2.200	Turbidity (NTU)	7.0
Dissolved Organic C (mg/L)	6.100		
Total Organic C (mg/L)	6.300		
Hardness (mg eq. $CaCO_3$/L)	58.00		

Geomorphic Assessment

Rosgen Level II Classification Data

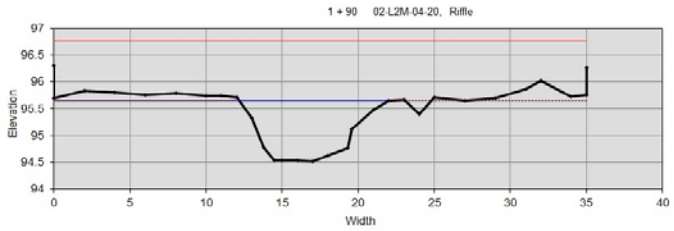
	2020	2010
Drainage Area (mi²)	0.42	
Bankfull Width (ft)	9.8	10.1
Mean Bankfull Depth (ft)	0.7	0.9
Floodprone Width (ft)	200.0	100.0
Entrenchment Ratio	20.3	9.9
Width to Depth Ratio	13.6	11.7
Cross Sectional Area (ft²)	7.1	8.8
Water Surface Slope (%)	0.650	0.770

	2020	2010
Sinuosity	1.07	1.10
D50 (mm)	0.10	0.06
Adjustments?	WD -0.2, SIN +0.4	None

Rosgen Stream Type

2020	2010
E5	**E6**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2010 Spring Value	2010 Spring Score
Remoteness	6.52	35.14	3.00	16.16
Shading	80	78.67	60	58.94
Epifaunal Substrate	5	48.75	6	54.72
Instream Habitat	7	62.17	4	45.78
Instream Woody Debris	14	99.68	4	70.37
Bank Stability	12.60	79.37	18.00	94.87

	2020 Score	2010 Score
MPHI Habitat Score	67.30	56.80
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2020 Score	2010 Score		2020 Score	2010 Score
Epifaunal Substrate/Available Cover	4	5	Bank Stability - Right Bank	10	9
Pool Substrate Characterization	7	5	Bank Stability - Left Bank	10	9
Pool Variability	5	5	Vegetative Protection - Right Bank	9	8
Sediment Deposition	18	10	Vegetative Protection - Left Bank	9	8
Channel Flow Status	18	18	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	19	14	Riparian Veg. Zone Width - Left Bank	5	9
Channel Sinuosity	7	11			

	2020 Score	2010 Score
RBP Habitat Score	131	121
RBP Rating	Supporting	Partially Supporting

Site ID 02-L2M-04-20

Revist of site R2-02-02

Biological Assessments

BIBI Metric Values	2020	2010
Total Taxa	14	16
EPT Taxa	0	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.98	0.00
% Ephemeroptera	0.00	0.00
Scraper Taxa	2	4
% Climbers	7.84	14.90

FIBI Metric Values (2020 only)	
Abundance per m²	1.39
Adj. No. of Benthic Species	0.00
% Tolerant	58.24
% Gen., Omni., Invert.	98.82
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	41.18

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	5	5
% Climbers	3	5

FIBI Metric Scores (2020 only)	
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	2.14	2.43
BIBI Rating	Poor	Poor

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Fauna (2020 only)

Crayfish

Orconectes virilis

Mussels

None Observed

Herpetofauna

Pickerel Frog

Northern Green Frog

Fish Taxa

Fish Taxa	Number
American Eel	1
Blacknose Dace	52
Bluegill	10
Creek Chub	12
Eastern Mosquitofish	70
Green Sunfish	23
Largemouth Bass	2

Benthic Macroinvertebrate Taxa

2020	Number
Ceratopogoninae	1
Chaetocladius	22
Diplocladius	1
Gammarus	18
Micropsectra	1
Naididae	13
Nematoda	1
Orthocladius	27
Physa	1
Polypedilum	4
Rheocricotopus	6
Stenelmis	1
Tanytarsus	2
Tvetenia	4

Original Visit	Number
Cheumatopsyche	6
Fossaria	1
Gammarus	4
Lumbriculidae	4
Menetus	4
Musculium	4
Parametriocnemus	3
Physa	12
Pisidiidae	13
Pisidium	10
Sphaerium	3
Stenelmis	1
Thienemannimyia	2
Tubificidae	44
Turbellaria	1
Xylotopus	1
Zavrelimyia	1

Site ID: 02-R3M-02-20

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Good
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) 6071.96

Land Cover

	Acres	% Area
Developed Land	3333.93	54.91
Forested Land	1706.44	28.10
Open Land	1029.85	16.96
Agricultural Land	1.74	0.03

Impervious Surface

	Acres	% Area
Impervious Land	1155.88	19.04

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.06
Turbidity (NTU)	5.48
Temperature (°C)	11.1
pH (Standard Units)	7.32
Specific Conductivity (µS/cm)	432.8

Laboratory Measurements

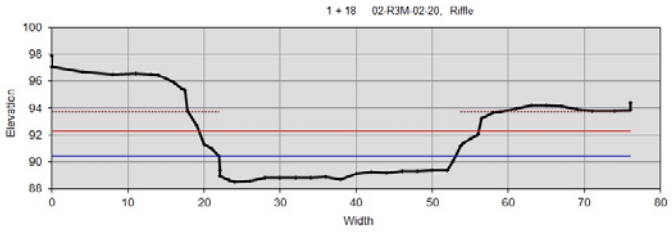
Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	79.000
Total Nitrogen (mg/L)	3.500	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	2.200
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	12.000
Nitrate-N (mg/L)	0.660	Total Lead (µg/L)	0.300
Total Kjehldal N (mg/L)	2.800	Turbidity (NTU)	4.8
Dissolved Organic C (mg/L)	4.800		
Total Organic C (mg/L)	5.200		
Hardness (mg eq. $CaCO_3$/L)	70.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	9.49	Sinuosity	1.57
Bankfull Width (ft)	31.0	D50 (mm)	18.00
Mean Bankfull Depth (ft)	1.4	Adjustments?	None
Floodprone Width (ft)	36.8		
Entrenchment Ratio	1.2		
Width to Depth Ratio	22.1	**Rosgen Stream Type**	**F4**
Cross Sectional Area (ft²)	43.6		
Water Surface Slope (%)	0.026		

Cross-sectional Survey



Site ID: 02-R3M-02-20

Biological Assessments

BIBI Metric Values

Total Taxa	19
EPT Taxa	4
Ephemeroptera Taxa	1
% Intolerant to Urban	1.82
% Ephemeroptera	26.36
Scraper Taxa	2
% Climbers	3.64

FIBI Metric Values

Abundance per m²	0.36
Adj. No. of Benthic Species	0.65
% Tolerant	26.40
% Gen., Omni., Invert.	98.48
% Round-bodied Suckers	3.05
% Abund. Dominant Taxon	19.29

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	3.29
BIBI Rating	Fair

FIBI Score	4.00
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Antocha	1
Cheumatopsyche	3
Chimarra	22
Cricotopus	1
Cricotopus/Orthocladius	3
Dicrotendipes	1
Gammarus	2
Hemerodromia	1
Hydropsyche	1
Hydropsychidae	1
Lumbricina	1
Naididae	3
Optioservus	4
Orthocladius	8
Plauditus	29
Polypedilum	3
Potthastia	2
Stenelmis	13
Tanytarsus	1
Thienemannimyia group	3
Tvetenia	7

Fish Taxa

American Eel	33
Blacknose Dace	16
Bluegill	4
Central Stoneroller	2
Creek Chub	4
Eastern Mosquitofish	4
Eastern Mudminnow	1
Fallfish	24
Green Sunfish	10
Longnose Dace	38
Margined Madtom	7
Northern Hogsucker	6
Redbreast Sunfish	30
Smallmouth Bass	1
Tessellated Darter	8
White Sucker	9

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	123
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.75	36.34
Shading	75	73.32
Epifaunal Substrate	9	51.74
Instream Habitat	12	58.11
Instream Woody Debris	6	40.84
Bank Stability	10.90	73.83

MPHI Habitat Score	55.70
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Orconectes virilis

Herpetofauna

Pickerel Frog

Mussels

Corbicula sp.

Site ID: 02-R3M-03-20

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 76.38

Land Cover	Acres	% Area
Developed Land	62.40	81.70
Forested Land	10.56	13.83
Open Land	3.42	4.48
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	15.45	20.22

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.78
Turbidity (NTU)	40
Temperature (°C)	10.3
pH (Standard Units)	6.84
Specific Conductivity (µS/cm)	194.2

Laboratory Measurements

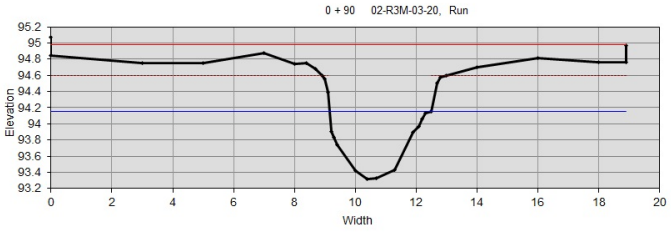
Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	25.000
Total Nitrogen (mg/L)	14.000	Magnesium (mg/L)	
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	1.400
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	7.200
Nitrate-N (mg/L)	0.590	Total Lead (µg/L)	0.490
Total Kjehldal N (mg/L)	13.000	Turbidity (NTU)	3.3
Dissolved Organic C (mg/L)	6.600		
Total Organic C (mg/L)	6.500		
Hardness (mg eq. $CaCO_3$/L)	50.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.12	Sinuosity	1.08
Bankfull Width (ft)	3.4	D50 (mm)	0.18
Mean Bankfull Depth (ft)	0.5	Adjustments?	SIN +0.4
Floodprone Width (ft)	60.8		
Entrenchment Ratio	18.1		
Width to Depth Ratio	6.3	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	1.8		
Water Surface Slope (%)	0.82		

Cross-sectional Survey



Site ID: 02-R3M-03-20

Biological Assessments

BIBI Metric Values

Total Taxa	24
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	3.06
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	8.16

FIBI Metric Values

Abundance per m²	1.75
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	80.49

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	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	3.00
BIBI Rating	Fair

FIBI Score	1.67
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Ceratopogoninae	9
Corvnoneura	13
Diplocladius	21
Dytiscidae	1
Enchytraeidae	1
Ferrissia	1
Limnephilidae	1
Naididae	12
Nematoda	2
Nemouridae	1
Orthocladius	5
Ostracoda	5
Paralauterborniella	1
Parametriocnemus	2
Paratendipes	4
Polypedilum	1
Rheocricotopus	1
Simulium	1
Sphaeriidae	3
Stegopterna	2
Stenelmis	1
Tanytarsus	5
Thienemanniella	6
Thienemannimyia group	3
Tvetenia	1

Fish Taxa

Blacknose Dace	66
Creek Chub	11
Green Sunfish	5

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	4
Pool Substrate Characterization	11
Pool Variability	3
Sediment Deposition	13
Channel Flow Status	16
Channel Alteration	18
Channel Sinuosity	8
Bank Stability - Right Bank	8
Bank Stability - Left Bank	8
Vegetative Protection - Right Bank	10
Vegetative Protection - Left Bank	10
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	8

RBP Habitat Score	127
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.48	45.64
Shading	90	91.34
Epifaunal Substrate	7	68.63
Instream Habitat	5	64.06
Instream Woody Debris	10	100.00
Bank Stability	15.00	86.61

MPHI Habitat Score	76.05
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Orconectes virilis

Herpetofauna

Northern Green Frog

Gray Treefrog

Mussels

None Observed

Site ID: 02-R3M-04-20

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 3737.36

Land Cover

	Acres	% Area
Developed Land	2211.00	59.16
Forested Land	979.14	26.20
Open Land	545.47	14.60
Agricultural Land	1.74	0.05

Impervious Surface

	Acres	% Area
Impervious Land	710.69	19.02

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.5
Turbidity (NTU)	5.95
Temperature (°C)	11.6
pH (Standard Units)	7.11
Specific Conductivity (µS/cm)	331.9

Laboratory Measurements

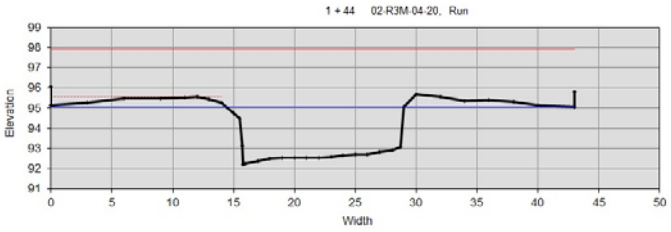
Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	55.000
Total Nitrogen (mg/L)	2.900	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	2.100
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	13.000
Nitrate-N (mg/L)	0.710	Total Lead (µg/L)	0.500
Total Kjehldal N (mg/L)	2.200	Turbidity (NTU)	3.8
Dissolved Organic C (mg/L)	5.400		
Total Organic C (mg/L)	5.700		
Hardness (mg eq. $CaCO_3$/L)	64.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	5.84	Sinuosity	1.08
Bankfull Width (ft)	15.4	D50 (mm)	2.00
Mean Bankfull Depth (ft)	2.1	Adjustments?	SIN +0.4
Floodprone Width (ft)	1025.0		
Entrenchment Ratio	66.4		
Width to Depth Ratio	7.2	**Rosgen Stream Type**	**E4/5**
Cross Sectional Area (ft²)	33.0		
Water Surface Slope (%)	0.13		

Cross-sectional Survey



Site ID: 02-R3M-04-20

Biological Assessments

BIBI Metric Values

Total Taxa	22
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	11.02
% Ephemeroptera	1.69
Scraper Taxa	4
% Climbers	0.85

FIBI Metric Values

Abundance per m²	0.61
Adj. No. of Benthic Species	0.75
% Tolerant	55.37
% Gen., Omni., Invert.	92.66
% Round-bodied Suckers	2.26
% Abund. Dominant Taxon	17.51

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	3.29
BIBI Rating	Fair

FIBI Score	4.33
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Amphipoda	5
Ancyronyx	1
Chaetocladius	1
Cheumatopsyche	5
Cricotopus	1
Eukiefferiella	1
Gammarus	32
Hemerodromia	3
Hydropsyche	2
Nematoda	1
Neoplasta	1
Optioservus	1
Orthocladius	21
Oulimnius	12
Plauditus	2
Potthastia	1
Rheocricotopus	1
Stenelmis	16
Stenochironomus	1
Tanytarsus	1
Thienemanniella group	3
Turbellaria	1
Tvetenia	5

Fish Taxa

American Eel	19
Blacknose Dace	3
Bluegill	13
Creek Chub	8
Eastern Mosquitofish	7
Eastern Mudminnow	15
Fallfish	8
Green Sunfish	31
Largemouth Bass	2
Least Brook Lamprey	5
Longnose Dace	1
Northern Hogsucker	4
Redbreast Sunfish	19
Redfin Pickerel	4
Sea Lamprey	2
Swallowtail Shiner	10
Tessellated Darter	13
White Sucker	9
Yellow Bullhead	4

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	126
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.29	33.89
Shading	40	40.96
Epifaunal Substrate	12	72.33
Instream Habitat	13	68.63
Instream Woody Debris	13	67.04
Bank Stability	11.07	74.39

MPHI Habitat Score	59.54
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Orconectes limosus

Herpetofauna

Pickerel Frog

Northern Green Frog

Mussels

None Observed

Site ID: 02-R3M-05-20

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	High conductivity; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2427.34

Land Cover

	Acres	% Area
Developed Land	1711.81	70.52
Forested Land	472.14	19.45
Open Land	241.65	9.96
Agricultural Land	1.74	0.07

Impervious Surface

	Acres	% Area
Impervious Land	478.52	19.71

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.21
Turbidity (NTU)	7.12
Temperature (°C)	12.3
pH (Standard Units)	6.98
Specific Conductivity (µS/cm)	305.1

Laboratory Measurements

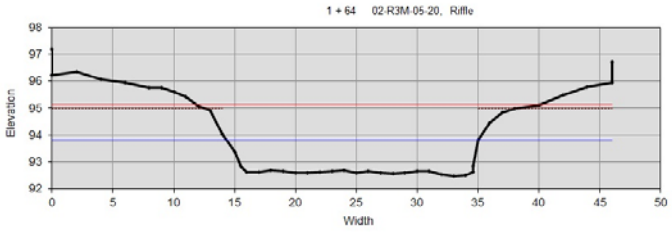
Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	45.000
Total Nitrogen (mg/L)	7.400	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	0.100	Total Copper (µg/L)	1.700
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	12.000
Nitrate-N (mg/L)	0.730	Total Lead (µg/L)	0.540
Total Kjehldal N (mg/L)	6.700	Turbidity (NTU)	6.7
Dissolved Organic C (mg/L)	6.100		
Total Organic C (mg/L)	6.200		
Hardness (mg eq. $CaCO_3$/L)	62.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	3.79	Sinuosity	1.10
Bankfull Width (ft)	20.7	D50 (mm)	13.00
Mean Bankfull Depth (ft)	1.1	Adjustments?	SIN +0.1
Floodprone Width (ft)	28.5		
Entrenchment Ratio	1.4		
Width to Depth Ratio	18.2	**Rosgen Stream Type**	**B4c**
Cross Sectional Area (ft²)	23.4		
Water Surface Slope (%)	0.45		

Cross-sectional Survey



Site ID: 02-R3M-05-20

Biological Assessments

BIBI Metric Values

Total Taxa	19
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	11.71
% Ephemeroptera	2.70
Scraper Taxa	3
% Climbers	0.90

FIBI Metric Values

Abundance per m²	0.57
Adj. No. of Benthic Species	0.86
% Tolerant	72.41
% Gen., Omni., Invert.	98.28
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	18.39

BIBI Metric Scores

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

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	3.29
BIBI Rating	Fair

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Amphipoda	3
Cheumatopsyche	2
Coenagrion/Enallagma	1
Enchytraeidae	1
Gammarus	4
Naididae	32
Nilotanypus	1
Optioservus	12
Orconectes	1
Orthocladius	7
Oulimnius	11
Paratanytarsus	1
Plauditus	3
Potthastia	1
Rheotanytarsus	1
Sphaeriidae	1
Stenelmis	25
Taeniopteryx	2
Turbellaria	1
Tvetenia	1

Fish Taxa

American Eel	16
Blacknose Dace	17
Bluegill	16
Central Stoneroller	1
Creek Chub	36
Eastern Mosquitofish	4
Fallfish	3
Green Sunfish	32
Largemouth Bass	1
Least Brook Lamprey	1
Longnose Dace	3
Redbreast Sunfish	12
Rosyside Dace	5
Swallowtail Shiner	2
Tessellated Darter	21
White Sucker	3
Yellow Bullhead	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	12
Pool Substrate Characterization	14
Pool Variability	9
Sediment Deposition	13
Channel Flow Status	14
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	2
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	10

RBP Habitat Score	133
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.57	40.76
Shading	60	58.94
Epifaunal Substrate	11	69.34
Instream Habitat	9	50.85
Instream Woody Debris	26	100.00
Bank Stability	12.33	78.53

MPHI Habitat Score	66.40
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Orconectes limosus

Herpetofauna

None Observed

Mussels

None Observed

Site ID 07-L1M-02-20

Revist of site R1-07-02

Upstream View - 2020

Downstream View - 2020

Upstream View - 2006

Downstream View - 2006

Summary Results

	2020 Data	2006 Data
Benthic Macroinvertebrate Community	Poor	Fair
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Non-supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	Elevated nitrogen	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 781.72

Land Cover	2020 Acres	2006 Acres	2020 % Area	2006 % Area
Developed Land	647.81	572.79	82.87	74.11
Forested Land	102.35	167.23	13.09	21.64
Open Land	30.30	32.88	3.88	4.25
Agricultural Land	1.26	0.00	0.16	0.00

Impervious Surface	2020 Acres	2006 Acres	2020 % Area	2006 % Area
Impervious Land	141.63	151.49	18.12	19.64

Site ID 07-L1M-02-20

Revist of site R1-07-02

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2006 Spring
Dissolved Oxygen (mg/L)	7.88	6.18	7.1
Turbidity (NTU)	7.62	9.7	n/a
Temperature (°C)	18.4	26.5	9.46
pH (Standard Units)	6.54	7.02	6.17
Specific Conductivity (µS/cm)	230.7	237.6	173

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	36.000
Total Nitrogen (mg/L)	3.300	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	0.150	Total Copper (µg/L)	1.000
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	13.000
Nitrate-N (mg/L)	0.470	Total Lead (µg/L)	0.570
Total Kjehldal N (mg/L)	2.800	Turbidity (NTU)	5.7
Dissolved Organic C (mg/L)	5.100		
Total Organic C (mg/L)	5.400		
Hardness (mg eq. $CaCO_3$/L)	46.00		

Geomorphic Assessment

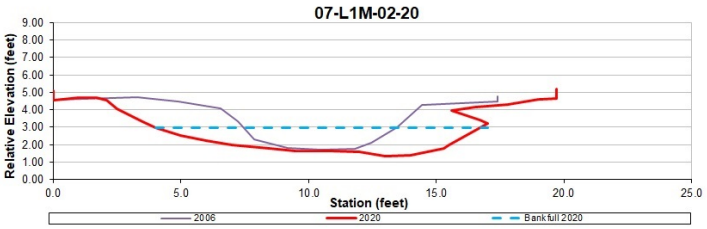
Rosgen Level II Classification Data

	2020	2006		2020	2006
Drainage Area (mi²)	1.22		Sinuosity	1.36	n/a
Bankfull Width (ft)	12.7	7.9	D50 (mm)	0.39	n/a
Mean Bankfull Depth (ft)	1.1	1.9	Adjustments?	None	None
Floodprone Width (ft)	17.0	n/a			
Entrenchment Ratio	1.3	n/a			
Width to Depth Ratio	11.8	4.2			
Cross Sectional Area (ft²)	13.6	14.9			
Water Surface Slope (%)	0.570	n/a			

Rosgen Stream Type

2020	2006
ND	

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2006 Spring Value	2006 Spring Score
Remoteness	2.55	13.76	0.00	0.00
Shading	70	68.32	60	58.94
Epifaunal Substrate	11	76.72	13	88.41
Instream Habitat	13	84.64	14	90.31
Instream Woody Debris	18	99.55	2	52.34
Bank Stability	8.60	65.58	6.00	54.77

	2020 Score	2006 Score
MPHI Habitat Score	68.09	57.46
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2020 Score	2006 Score		2020 Score	2006 Score
Epifaunal Substrate/Available Cover	10	13	Bank Stability - Right Bank	3	4
Pool Substrate Characterization	8	8	Bank Stability - Left Bank	2	4
Pool Variability	7	8	Vegetative Protection - Right Bank	7	4
Sediment Deposition	14	8	Vegetative Protection - Left Bank	7	4
Channel Flow Status	15	10	Riparian Veg. Zone Width - Right Bank	9	5
Channel Alteration	12	6	Riparian Veg. Zone Width - Left Bank	9	5
Channel Sinuosity	10	8			

	2020 Score	2006 Score
RBP Habitat Score	113	87
RBP Rating	Partially Supporting	Non-supporting

Site ID 07-L1M-02-20

Revist of site R1-07-02

Biological Assessments

BIBI Metric Values	2020	2006
Total Taxa	17	29
EPT Taxa	1	3
Ephemeroptera Taxa	0	1
% Intolerant to Urban	22.73	2.63
% Ephemeroptera	0.00	0.88
Scraper Taxa	1	0
% Climbers	48.18	13.16

FIBI Metric Values (2020 only)	
Abundance per m²	3.98
Adj. No. of Benthic Species	0.00
% Tolerant	20.95
% Gen., Omni., Invert.	99.51
% Round-bodied Suckers	2.44
% Abund. Dominant Taxon	70.04

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

FIBI Metric Scores (2020 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	5
% Abund. Dominant Taxon	1

BIBI Score	2.43	3.00
BIBI Rating	Poor	Fair

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Fauna (2020 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

American Bullfrog

Northern Green Frog

Eastern Snapping Turtle

Northern Spring Peeper

Fish Taxa	Number
American Eel	16
Black Crappie	3
Bluegill	138
Bluespotted Sunfish	17
Brown Bullhead	10
Creek Chubsucker	20
Eastern Mosquitofish	575
Eastern Mudminnow	13
Golden Shiner	6
Largemouth Bass	4
Pumpkinseed	1
Warmouth	18

Benthic Macroinvertebrate Taxa

2020	Number
Cheumatopsyche	3
Corynoneura	1
Diplocladius	1
Enchytraeidae	1
Eukiefferiella	1
Gammarus	3
Lumbricina	1
Micropsectra	25
Naididae	2
Orthocladius	4
Polypedilum	24
Rheotanytarsus	4
Stenelmis	32
Tanytarsus	4
Thienemanniella	2
Thienemannimyia group	1
Tvetenia	1

Original Visit	Number
Argia	1
Caecidotea	1
Chaetocladius	2
Cheumatopsyche	2
Cryptotendipes	1
Dero	1
Dicrotendipes	2
Dubiraphia	16
Eurylophella	1
Gammarus	2
Ironoquia	3
Limnodrilus	1
Nanocladius	2
Orthocladius	15
Orthocladius/Cricotopus	5
Parametriocnemus	1
Paratendipes	2
Phaenopsectra	1
Physa	1
Polypedilum	5
Rheotanytarsus	3
Simulium	16
Stegopterna	2
Stenelmis	9
Stenochironomus	5
Tanytarsus	10
Thienemannimyia	2
Tribelos	1
Tubificidae	1

Site ID 07-L1M-03-20

Revist of site R1-07-09

Upstream View - 2020

Downstream View - 2020

Upstream View - 2006

Downstream View - 2006

Summary Results

	2020 Data	2006 Data
Benthic Macroinvertebrate Community	Poor	Fair
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Elevated nutrients	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1689.57

Land Cover	2020 Acres	2006 Acres	2020 % Area	2006 % Area
Developed Land	1037.93	865.12	61.43	53.46
Forested Land	542.99	709.72	32.14	43.86
Open Land	100.28	43.35	5.94	2.68
Agricultural Land	8.36	0.01	0.49	0.00

Impervious Surface	2020 Acres	2006 Acres	2020 % Area	2006 % Area
Impervious Land	227.39	294.51	13.46	18.20

Site ID 07-L1M-03-20

Revist of site R1-07-09

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2006 Spring
Dissolved Oxygen (mg/L)	8.58	7.02	9.35
Turbidity (NTU)	12.4	8.11	n/a
Temperature (°C)	12.9	19.2	9.89
pH (Standard Units)	6.82	6.14	6.13
Specific Conductivity (µS/cm)	402.5	523.5	237

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.042	Chloride (mg/L)	74.000
Total Nitrogen (mg/L)	4.500	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	0.170	Total Copper (µg/L)	1.700
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	16.000
Nitrate-N (mg/L)	1.100	Total Lead (µg/L)	0.790
Total Kjehldal N (mg/L)	3.400	Turbidity (NTU)	14.0
Dissolved Organic C (mg/L)	5.200		
Total Organic C (mg/L)	5.800		
Hardness (mg eq. $CaCO_3$/L)	64.00		

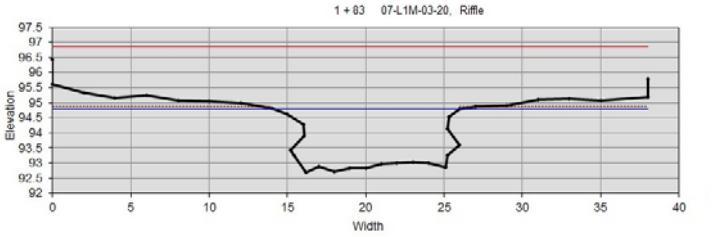
Geomorphic Assessment

Rosgen Level II Classification Data

	2020	2006		2020	2006
Drainage Area (mi²)	2.64		Sinuosity	1.13	1.30
Bankfull Width (ft)	11.8	11.5	D50 (mm)	0.28	0.14
Mean Bankfull Depth (ft)	1.6	1.6	Adjustments?	SIN +0.4	None
Floodprone Width (ft)	128.0	144.4			
Entrenchment Ratio	10.8	12.6			
Width to Depth Ratio	7.5	7.3			
Cross Sectional Area (ft²)	18.6	18.2			
Water Surface Slope (%)	0.320	0.460			

Rosgen Stream Type	
2020	2006
E5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2006 Spring Value	2006 Spring Score
Remoteness	7.72	41.58	12.00	64.62
Shading	85	84.56	85	84.56
Epifaunal Substrate	11	71.70	12	77.79
Instream Habitat	13	76.75	10	60.55
Instream Woody Debris	15	81.94	5	52.85
Bank Stability	11.67	76.38	12.00	77.46

	2020 Score	2006 Score
MPHI Habitat Score	72.15	69.64
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2020 Score	2006 Score		2020 Score	2006 Score
Epifaunal Substrate/Available Cover	14	12	Bank Stability - Right Bank	3	6
Pool Substrate Characterization	8	12	Bank Stability - Left Bank	2	6
Pool Variability	9	10	Vegetative Protection - Right Bank	9	10
Sediment Deposition	8	10	Vegetative Protection - Left Bank	9	10
Channel Flow Status	15	14	Riparian Veg. Zone Width - Right Bank	10	6
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	6
Channel Sinuosity	7	15			

	2020 Score	2006 Score
RBP Habitat Score	124	137
RBP Rating	Partially Supporting	Supporting

Site ID 07-L1M-03-20

Revist of site R1-07-09

Biological Assessments

BIBI Metric Values	2020	2006
Total Taxa	17	26
EPT Taxa	0	5
Ephemeroptera Taxa	0	1
% Intolerant to Urban	29.46	25.93
% Ephemeroptera	0.00	4.63
Scraper Taxa	2	1
% Climbers	1.79	34.26

FIBI Metric Values (2020 only)	
Abundance per m²	0.71
Adj. No. of Benthic Species	0.00
% Tolerant	59.03
% Gen., Omni., Invert.	92.36
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	30.56

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

FIBI Metric Scores (2020 only)	
Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	2.71	3.86
BIBI Rating	Poor	Fair

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Fauna (2020 only)

Crayfish

Procambarus clarkii

Mussels

None Observed

Herpetofauna

Northern Green Frog

Common Five-lined Skink

Northern Spring Peeper

Fish Taxa	Number
American Eel	13
Banded Killifish	8
Bluegill	44
Brown Bullhead	8
Eastern Mosquitofish	22
Eastern Mudminnow	22
Largemouth Bass	11
Mummichog	16

Benthic Macroinvertebrate Taxa

2020	Number
Amphipoda	1
Brillia	4
Caecidotea	29
Corynoneura	2
Crangonyctidae	12
Crangonyx	9
Naididae	5
Orthocladiinae	1
Orthocladius	23
Oulimnius	1
Parakiefferiella	2
Parametriocnemus	11
Polypedilum	2
Potthastia	1
Prodiamesa	3
Simulium	1
Stenelmis	2
Thienemanniella	1
Thienemannimyia group	1
Tvetenia	1

Original Visit	Number
Acerpenna	5
Ancyronyx	1
Caecidotea	1
Calopteryx	5
Corynoneura	1
Diplectrona	2
Gomphus	1
Macronychus	2
Nigronia	2
Oecetis	2
Orthocladius/Cricotopus	2
Oulimnius	2
Parametriocnemus	11
Paratendipes	1
Polycentropus	10
Polypedilum	1
Rheocricotopus	7
Rheotanytarsus	3
Simulium	2
Stenelmis	1
Synurella	5
Tanytarsus	31
Thienemannimyia	7
Tipula	1
Triaenodes	1
Zacrelimyia	1

Site ID 07-L2M-02-20

Revist of site R2-07-08

Upstream View - 2020

Downstream View - 2020

Upstream View - 2011

Downstream View - 2011

Summary Results

	2020 Data	2011 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Comparable to Reference
MPHI Habitat Condition	Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Low pH; Elevated phosphorus	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1585.54

Land Cover	2020 Acres	2011 Acres	2020 % Area	2011 % Area
Developed Land	989.76	832.60	62.42	58.40
Forested Land	492.25	536.10	31.05	37.30
Open Land	95.17	16.00	6.00	1.10
Agricultural Land	8.36	45.20	0.53	3.10

Impervious Surface	2020 Acres	2011 Acres	2020 % Area	2011 % Area
Impervious Land	217.11	303.90	13.69	21.20

Site ID 07-L2M-02-20

Revist of site R2-07-08

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2011 Spring
Dissolved Oxygen (mg/L)	9.08	7.54	10.66
Turbidity (NTU)	5.69	3.82	12.83
Temperature (°C)	17.3	21.3	4.88
pH (Standard Units)	6.4	6.31	6.72
Specific Conductivity (µS/cm)	348.3	512.2	324.5

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.051	Chloride (mg/L)	67.000
Total Nitrogen (mg/L)	1.100	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	14.000
Nitrate-N (mg/L)	1.100	Total Lead (µg/L)	0.790
Total Kjehldal N (mg/L)	<1.600	Turbidity (NTU)	6.7
Dissolved Organic C (mg/L)	5.300		
Total Organic C (mg/L)	5.600		
Hardness (mg eq. $CaCO_3$/L)	54.00		

Geomorphic Assessment

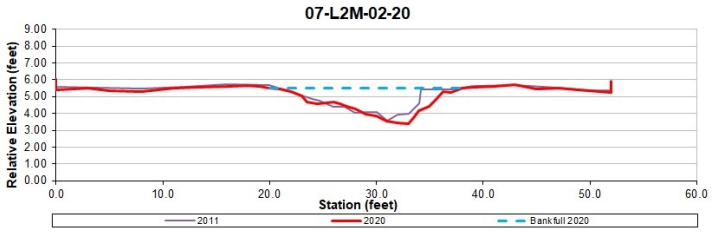
Rosgen Level II Classification Data

	2020	2011		2020	2011
Drainage Area (mi²)	2.48		Sinuosity	1.09	1.09
Bankfull Width (ft)	35.2	19.0	D50 (mm)	0.35	0.35
Mean Bankfull Depth (ft)	0.5	0.7	Adjustments?	SIN +0.1	None
Floodprone Width (ft)	130.0	130.0			
Entrenchment Ratio	3.7	6.8			
Width to Depth Ratio	64.6	26.7			
Cross Sectional Area (ft²)	19.2	13.6			
Water Surface Slope (%)	0.062	0.110			

Rosgen Stream Type

2020	2011
C5	**C5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2011 Spring Value	2011 Spring Score
Remoteness	8.78	47.27	13.00	70.01
Shading	75	73.32	45	45.47
Epifaunal Substrate	8	54.68	12	78.56
Instream Habitat	6	38.57	13	78.42
Instream Woody Debris	9	64.91	9	66.03
Bank Stability	15.00	86.61	18.00	94.87

	2020 Score	2011 Score
MPHI Habitat Score	60.89	72.23
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2020 Score	2011 Score		2020 Score	2011 Score
Epifaunal Substrate/Available Cover	11	13	Bank Stability - Right Bank	3	9
Pool Substrate Characterization	7	14	Bank Stability - Left Bank	3	9
Pool Variability	7	15	Vegetative Protection - Right Bank	7	10
Sediment Deposition	11	16	Vegetative Protection - Left Bank	7	10
Channel Flow Status	14	20	Riparian Veg. Zone Width - Right Bank	7	8
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	13			

	2020 Score	2011 Score
RBP Habitat Score	114	167
RBP Rating	Partially Supporting	Comparable to Reference

Site ID 07-L2M-02-20

Revist of site R2-07-08

Biological Assessments

BIBI Metric Values	2020	2011
Total Taxa	33	26
EPT Taxa	3	5
Ephemeroptera Taxa	0	0
% Intolerant to Urban	20.91	8.00
% Ephemeroptera	0.00	0.00
Scraper Taxa	2	5
% Climbers	1.82	2.70

FIBI Metric Values (2020 only)	
Abundance per m²	0.46
Adj. No. of Benthic Species	0.00
% Tolerant	66.67
% Gen., Omni., Invert.	98.48
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	46.97

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

FIBI Metric Scores (2020 only)	
Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	3.00	3.00
BIBI Rating	Fair	Fair

FIBI Score	2.67
FIBI Rating	Poor

Supplemental Fauna (2020 only)

Crayfish

Procambarus clarkii

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa

Fish Taxa	Number
American Eel	15
Bluegill	8
Eastern Mosquitofish	7
Eastern Mudminnow	31
Golden Shiner	1
Largemouth Bass	1
Pumpkinseed	3

Benthic Macroinvertebrate Taxa

2020	Number
Caecidotea	3
Ceratopogoninae	1
Crangonyx	23
Cricotopus	1
Cryptochironomus	1
Dicranota	1
Diplectrona	3
Enchytraeidae	1
Macronychus	2
Microcylloepus	1
Naididae	1
Nanocladius	1
Odontomesa	1
Orthocladius	4
Paracladopelma	1
Parakiefferiella	2
Paralauterborniella	1
Parametriocnemus	7
Paratendipes	1
Potthastia	1
Rheotanytarsus	1
Simulium	6
Stenelmis	14
Synurella	13
Taeniopteryx	5
Tanytarsus	1
Thienemanniella	1
Thienemannimyia group	3
Tipula	1
Triaenodes	1
Tribelos	1
Tvetenia	1
Veneroida	5

Original Visit	Number
Amphipoda	2
Ancyronyx	5
Brachycentrus	2
Caecidotea	1
Chimarra	2
Chironomini	1
Corynoneura	2
Diplectrona	6
Dubiraphia	1
Enchytraeidae	1
Hyalella	6
Leptoceridae	1
Lype	4
Macronychus	16
Orthocladiinae	1
Orthocladius	1
Parametriocnemus	7
Paraphaenocladius	1
Phaenopsectra	2
Polypedilum	1
Rheotanytarsus	22
Simulium	6
Stenelmis	10
Synurella	4
Tanytarsini	1
Tanytarsus	2
Thienemannimyia group	1
Tubificidae	1
Tvetenia	1
Xylotopus	1

Site ID 07-L2M-03-20

Revist of site R2-07-04

Upstream View - 2020

Downstream View - 2020

Upstream View - 2011

Downstream View - 2011

Summary Results

	2020 Data	2011 Data
Benthic Macroinvertebrate Community	Poor	Very Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Non-Supporting	Supporting
MPHI Habitat Condition	Degraded	Partially Degraded
Water Quality Conditions	High conductivity; Low pH; Elevated nitrogen	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 487.14

Land Cover	2020 Acres	2011 Acres	2020 % Area	2011 % Area
Developed Land	422.05	382.80	86.64	77.40
Forested Land	42.75	88.00	8.78	17.80
Open Land	21.08	0.00	4.33	0.00
Agricultural Land	1.26	24.00	0.26	4.90

Impervious Surface	2020 Acres	2011 Acres	2020 % Area	2011 % Area
Impervious Land	99.78	159.10	20.48	32.10

Site ID 07-L2M-03-20

Revist of site R2-07-04

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2011 Spring
Dissolved Oxygen (mg/L)	11.45	4.83	6.27
Turbidity (NTU)	3.76	7.44	9.27
Temperature (°C)	20.7	19.2	5.58
pH (Standard Units)	6.04	5.07	6.53
Specific Conductivity (µS/cm)	255.7	250.7	306.2

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	40.000
Total Nitrogen (mg/L)	4.300	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	2.000
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	13.000
Nitrate-N (mg/L)	0.920	Total Lead (µg/L)	0.490
Total Kjehldal N (mg/L)	3.400	Turbidity (NTU)	2.8
Dissolved Organic C (mg/L)	3.500		
Total Organic C (mg/L)	3.600		
Hardness (mg eq. $CaCO_3$/L)	50.00		

Geomorphic Assessment

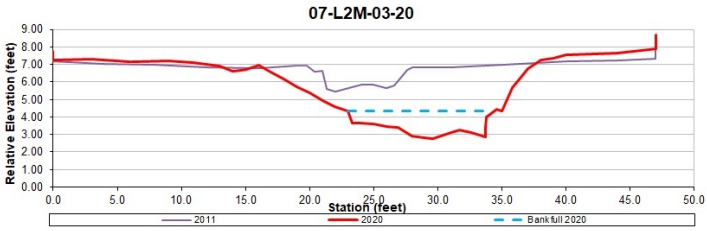
Rosgen Level II Classification Data

	2020	2011
Drainage Area (mi²)	0.76	
Bankfull Width (ft)	11.4	9.6
Mean Bankfull Depth (ft)	1.0	0.7
Floodprone Width (ft)	17.3	100.0
Entrenchment Ratio	1.5	10.4
Width to Depth Ratio	10.8	13.4
Cross Sectional Area (ft²)	11.9	6.9
Water Surface Slope (%)	0.500	0.810

	2020	2011
Sinuosity	1.24	1.16
D50 (mm)	0.39	0.38
Adjustments?	WD +2.0	Yes, WD - 1.5

Rosgen Stream Type	
2020	2011
F5	**E5/4**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2011 Spring Value	2011 Spring Score
Remoteness	7.01	37.72	10.00	53.85
Shading	85	84.56	75	73.32
Epifaunal Substrate	4	39.13	11	79.69
Instream Habitat	7	56.19	9	67.12
Instream Woody Debris	4	63.48	7	72.17
Bank Stability	10.10	71.07	10.00	70.71

	2020 Score	2011 Score
MPHI Habitat Score	58.69	69.48
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2020 Score	2011 Score		2020 Score	2011 Score
Epifaunal Substrate/Available Cover	3	10	Bank Stability - Right Bank	1	5
Pool Substrate Characterization	6	13	Bank Stability - Left Bank	1	5
Pool Variability	2	10	Vegetative Protection - Right Bank	5	7
Sediment Deposition	4	12	Vegetative Protection - Left Bank	5	7
Channel Flow Status	6	16	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	15	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	11			

	2020 Score	2011 Score
RBP Habitat Score	81	131
RBP Rating	Non-Supporting	Supporting

Site ID 07-L2M-03-20

Revist of site R2-07-04

Biological Assessments

BIBI Metric Values	2020	2011
Total Taxa	15	20
EPT Taxa	0	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	6.80	1.80
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	1
% Climbers	10.68	2.80

FIBI Metric Values (2020 only)	
Abundance per m²	0.52
Adj. No. of Benthic Species	0.00
% Tolerant	39.02
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	15.85
% Abund. Dominant Taxon	45.12

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	3
% Climbers	5	3

FIBI Metric Scores (2020 only)	
Abundance per m²	3
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	5
% Abund. Dominant Taxon	3

BIBI Score	2.14	1.86
BIBI Rating	Poor	Very Poor

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Fauna (2020 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Eastern Snapping Turtle

Fish Taxa	Number
Bluegill	1
Creek Chubsucker	13
Eastern Mosquitofish	37
Eastern Mudminnow	18
Golden Shiner	13

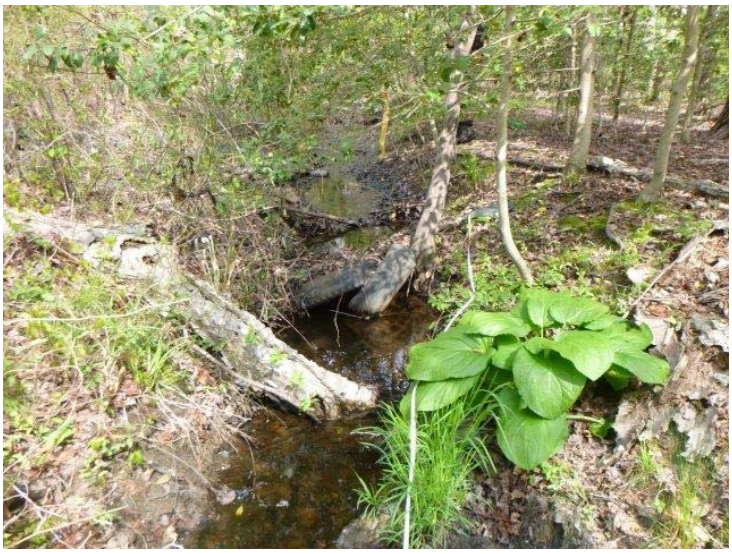
Benthic Macroinvertebrate Taxa

2020	Number
Chaetocladius	1
Diplocladius	2
Enchytraeidae	2
Eukiefferiella	2
Limnophyes	1
Micropsectra	7
Naididae	43
Orthocladius	24
Polypedilum	3
Prodiamesa	1
Simulium	13
Stenelmis	1
Tanytarsus	1
Tipulidae	1
Tvetenia	1

Original Visit	Number
Caecidotea	1
Calopteryx	1
Chironomini	1
Dicrotendipes	18
Enchytraeidae	6
Georthocladius	1
Limonia	1
Lumbricina	1
Lumbriculidae	35
Musculium	1
Naididae	1
Natarsia	3
Neoporus	1
Paraphaenocladius	1
Physa	1
Pisidiidae	1
Pisidium	1
Polypedilum	1
Pseudorthocladius	1
Somatochlora	1
Stenochironomus	2
Tubificidae	29

Site ID: 07-R3M-01-20

Upstream View



Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 131.73

Land Cover	Acres	% Area
Developed Land	104.75	79.52
Forested Land	21.02	15.95
Open Land	5.97	4.53
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	20.70	15.72

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	6.13
Turbidity (NTU)	3.3
Temperature (°C)	9.9
pH (Standard Units)	6.61
Specific Conductivity (µS/cm)	137.9

Laboratory Measurements

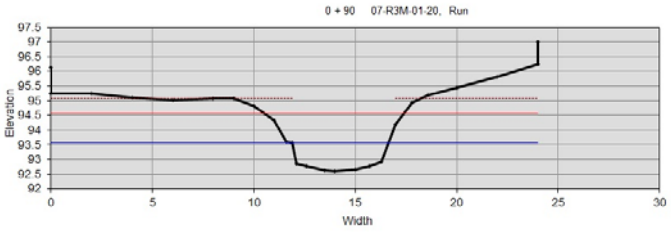
Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	11.000
Total Nitrogen (mg/L)	3.400	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	1.800
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	<4.300
Nitrate-N (mg/L)	<0.023	Total Lead (µg/L)	0.430
Total Kjehldal N (mg/L)	3.400	Turbidity (NTU)	2.2
Dissolved Organic C (mg/L)	8.100		
Total Organic C (mg/L)	8.000		
Hardness (mg eq. $CaCO_3$/L)	40.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.21	Sinuosity	1.01
Bankfull Width (ft)	4.8	D50 (mm)	0.13
Mean Bankfull Depth (ft)	0.8	Adjustments?	ER -0.1, SIN +0.2
Floodprone Width (ft)	6.9		
Entrenchment Ratio	1.4		
Width to Depth Ratio	5.9	**Rosgen Stream Type**	**G5c**
Cross Sectional Area (ft²)	3.9		
Water Surface Slope (%)	0.37		

Cross-sectional Survey



Site ID: 07-R3M-01-20

Biological Assessments

BIBI Metric Values

Total Taxa	7
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	3.00
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	0.00

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

Ceratopogoninae	1
Chironomus	2
Diplocladius	4
Lumbriculidae	21
Musculium	1
Naididae	20
Procladius	3
Sphaeriidae	14
Veneroida	34

Fish Taxa

NO FISH

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	2
Pool Substrate Characterization	6
Pool Variability	2
Sediment Deposition	14
Channel Flow Status	14
Channel Alteration	14
Channel Sinuosity	6
Bank Stability - Right Bank	7
Bank Stability - Left Bank	7
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	5
Riparian Veg. Zone Width - Left Bank	8

RBP Habitat Score	101
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.52	35.14
Shading	90	91.34
Epifaunal Substrate	3	41.84
Instream Habitat	2	41.84
Instream Woody Debris	10	96.04
Bank Stability	13.13	81.04

MPHI Habitat Score	64.54
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Pickerel Frog

Mussels

None Observed

Site ID: 07-R3M-02-20

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; Low pH; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 590.53

Land Cover

	Acres	% Area
Developed Land	320.21	54.22
Forested Land	196.25	33.23
Open Land	68.03	11.52
Agricultural Land	6.04	1.02

Impervious Surface

	Acres	% Area
Impervious Land	55.15	9.34

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	8.87
Turbidity (NTU)	5.09
Temperature (°C)	17.4
pH (Standard Units)	6.41
Specific Conductivity (µS/cm)	344.5

Laboratory Measurements

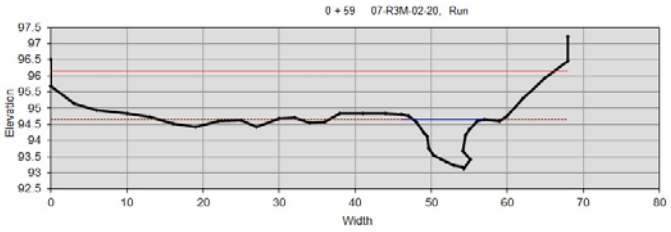
Total Phosphorus (mg/L)	0.089	Chloride (mg/L)	54.000
Total Nitrogen (mg/L)	1.300	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	2.000
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	12.000
Nitrate-N (mg/L)	1.300	Total Lead (µg/L)	0.580
Total Kjehldal N (mg/L)	<1.6	Turbidity (NTU)	3.9
Dissolved Organic C (mg/L)	5.700		
Total Organic C (mg/L)	6.200		
Hardness (mg eq. $CaCO_3$/L)	74.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.92	Sinuosity	1.10
Bankfull Width (ft)	9.4	D50 (mm)	0.32
Mean Bankfull Depth (ft)	0.8	Adjustments?	WD -1.0, SIN +0.4
Floodprone Width (ft)	68.0		
Entrenchment Ratio	7.3		
Width to Depth Ratio	12.1	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	7.2		
Water Surface Slope (%)	0.31		

Cross-sectional Survey



Site ID: 07-R3M-02-20

Biological Assessments

BIBI Metric Values

Total Taxa	19
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	13.59

FIBI Metric Values

Abundance per m²	0.29
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	3
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	1
% Ephemeroptera	1
Scraper Taxa	1
% Climbers	5

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	1

BIBI Score	1.86
BIBI Rating	Very Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Brillia	2
Caloptervx	3
Ceratopogoninae	3
Cheumatopsyche	3
Corvnoneura	5
Crangonyx	3
Cryptochironomus	3
Lumbriculidae	1
Naididae	4
Odontomesa	6
Orthocladius	22
Paracladopelma	1
Parametriocnemus	2
Polvpedilum	11
Rheosmittia	2
Saetheria	3
Simulium	26
Thienemanniella	2
Tribelos	1

Fish Taxa

Eastern Mosquitofish	10

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	98
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.01	37.72
Shading	95	99.94
Epifaunal Substrate	4	37.88
Instream Habitat	3	32.03
Instream Woody Debris	3	58.35
Bank Stability	16.40	90.56

MPHI Habitat Score	59.41
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Procambarus acutus/zonangulus

Herpetofauna

Eastern Box Turtle

Northern Green Frog

Mussels

None Observed

Site ID: 07-R3M-04-20

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 3061.80

Land Cover

	Acres	% Area
Developed Land	1880.87	61.43
Forested Land	915.34	29.90
Open Land	243.22	7.94
Agricultural Land	22.37	0.73

Impervious Surface

	Acres	% Area
Impervious Land	400.64	13.09

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	8.11
Turbidity (NTU)	5.13
Temperature (°C)	14.6
pH (Standard Units)	6.69
Specific Conductivity (µS/cm)	278.9

Laboratory Measurements

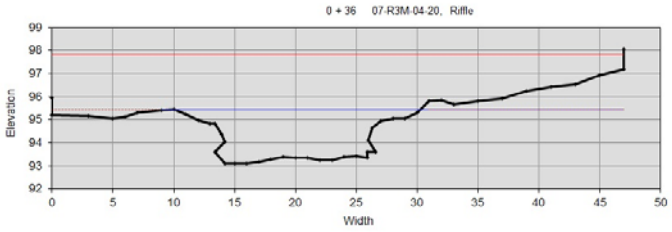
Total Phosphorus (mg/L)	0.038	Chloride (mg/L)	44.000
Total Nitrogen (mg/L)	4.500	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	0.210	Total Copper (µg/L)	2.100
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	9.600
Nitrate-N (mg/L)	0.580	Total Lead (µg/L)	1.100
Total Kjehldal N (mg/L)	3.900	Turbidity (NTU)	5.8
Dissolved Organic C (mg/L)	9.100		
Total Organic C (mg/L)	9.000		
Hardness (mg eq. $CaCO_3$/L)	52.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	4.78	Sinuosity	1.22
Bankfull Width (ft)	21.3	D50 (mm)	1.10
Mean Bankfull Depth (ft)	1.4	Adjustments?	None
Floodprone Width (ft)	125.0		
Entrenchment Ratio	5.9		
Width to Depth Ratio	15.0	**Rosgen Stream Type**	**C5**
Cross Sectional Area (ft²)	30.3		
Water Surface Slope (%)	0.39		

Cross-sectional Survey



Site ID: 07-R3M-04-20

Biological Assessments

BIBI Metric Values

Total Taxa	22
EPT Taxa	4
Ephemeroptera Taxa	0
% Intolerant to Urban	8.91
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	5.94

FIBI Metric Values

Abundance per m²	0.80
Adj. No. of Benthic Species	0.39
% Tolerant	77.37
% Gen., Omni., Invert.	89.47
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	28.42

BIBI Metric Scores

Total Taxa	5
EPT Taxa	3
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	5
% Tolerant	3
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	4.00
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Caecidotea	7
Calopteryx	1
Chaetocladius	1
Cheumatopsyche	3
Crangonyx	14
Cricotopus	1
Dicranota	1
Hydropsyche	2
Leuctra	1
Limnephilidae	1
Microcylloepus	1
Naididae	11
Nematoda	2
Orthocladius	1
Polypedilum	4
Prostoma	1
Rheotanytarsus	3
Simulium	8
Stenelmis	26
Thienemanniella	2
Thienemannimyia group	2
Tvetenia	8

Fish Taxa

American Eel	36
Banded Killifish	2
Bluegill	54
Brown Bullhead	2
Eastern Mosquitofish	1
Eastern Mudminnow	2
Largemouth Bass	20
Pumpkinseed	51
Spottail Shiner	4
Tessellated Darter	18

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	13
Pool Substrate Characterization	13
Pool Variability	16
Sediment Deposition	14
Channel Flow Status	17
Channel Alteration	20
Channel Sinuosity	8
Bank Stability - Right Bank	3
Bank Stability - Left Bank	3
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	7
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	142
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.29	33.89
Shading	75	73.32
Epifaunal Substrate	12	73.63
Instream Habitat	13	70.67
Instream Woody Debris	21	92.96
Bank Stability	11.67	76.38

MPHI Habitat Score	70.14
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Orconectes limosus

Herpetofauna

None Observed

Mussels

Corbicula sp.

Site ID: 07-R3M-07-20

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 466.89

Land Cover

	Acres	% Area
Developed Land	408.21	87.43
Forested Land	37.71	8.08
Open Land	19.71	4.22
Agricultural Land	1.26	0.27

Impervious Surface

	Acres	% Area
Impervious Land	97.69	20.92

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	8.94
Turbidity (NTU)	6.33
Temperature (°C)	11.2
pH (Standard Units)	7.06
Specific Conductivity (µS/cm)	285.6

Laboratory Measurements

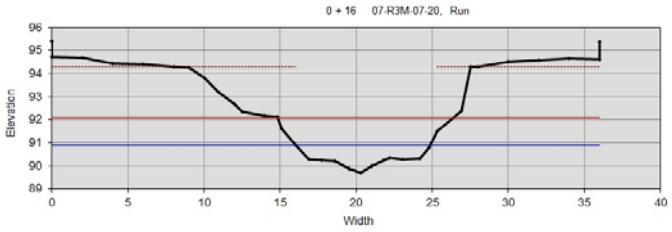
Total Phosphorus (mg/L)	<0.037	Chloride (mg/L)	42.000
Total Nitrogen (mg/L)	9.900	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	0.200	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	13.000
Nitrate-N (mg/L)	0.380	Total Lead (µg/L)	0.300
Total Kjehldal N (mg/L)	9.500	Turbidity (NTU)	5.6
Dissolved Organic C (mg/L)	3.700		
Total Organic C (mg/L)	3.800		
Hardness (mg eq. $CaCO_3$/L)	58.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.73	Sinuosity	1.28
Bankfull Width (ft)	8.9	D50 (mm)	0.31
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	11.5		
Entrenchment Ratio	1.3		
Width to Depth Ratio	13.3	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	5.9		
Water Surface Slope (%)	1.3		

Cross-sectional Survey



Site ID: 07-R3M-07-20

Biological Assessments

BIBI Metric Values

Total Taxa	13
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	3.70
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	4.63

FIBI Metric Values

Abundance per m²	0.50
Adj. No. of Benthic Species	0.00
% Tolerant	64.58
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	6.25
% Abund. Dominant Taxon	56.25

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

BIBI Score	1.57
BIBI Rating	Very Poor

FIBI Score	3.00
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Chaetocladius	7
Chironomus	1
Diplocladius	2
Enchytraeidae	3
Eukiefferiella	4
Lumbriculidae	1
Micropsectra	4
Naididae	56
Orthocladius	12
Physa	1
Simulium	15
Thienemannimyia group	1
Tvetenia	1

Fish Taxa

Bluegill	1
Creek Chubsucker	3
Eastern Mosquitofish	14
Eastern Mudminnow	27
Golden Shiner	3

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	3
Pool Substrate Characterization	6
Pool Variability	6
Sediment Deposition	11
Channel Flow Status	12
Channel Alteration	20
Channel Sinuosity	9
Bank Stability - Right Bank	1
Bank Stability - Left Bank	1
Vegetative Protection - Right Bank	5
Vegetative Protection - Left Bank	5
Riparian Veg. Zone Width - Right Bank	9
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	98
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	7.61	40.97
Shading	45	45.47
Epifaunal Substrate	3	33.60
Instream Habitat	5	45.53
Instream Woody Debris	2	58.05
Bank Stability	0.00	0.00

MPHI Habitat Score	37.27
MPHI Rating	Severely Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Mussels

None Observed

Site ID 14-L1M-01-20

Revist of site R1-14-06

Upstream View - 2020

Downstream View - 2020

Upstream View - 2008

Downstream View - 2008

Summary Results

	2020 Data	2008 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Minimally Degraded
Water Quality Conditions	Elevated nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 132.42

Land Cover	2020 Acres	2008 Acres	2020 % Area	2008 % Area
Developed Land	59.81	43.91	45.17	31.36
Forested Land	50.84	67.74	38.39	48.39
Open Land	8.63	8.63	6.52	6.16
Agricultural Land	13.14	19.72	9.93	14.08

Impervious Surface	2020 Acres	2008 Acres	2020 % Area	2008 % Area
Impervious Land	4.04	6.30	3.05	4.50

Site ID 14-L1M-01-20

Revist of site R1-14-06

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2008 Spring
Dissolved Oxygen (mg/L)	11.38	7.97	13.81
Turbidity (NTU)	2.5	20.1	n/a
Temperature (°C)	9.8	21.3	7.85
pH (Standard Units)	6.73	6.96	6.64
Specific Conductivity (µS/cm)	216	179	199

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.190	Chloride (mg/L)	27.000
Total Nitrogen (mg/L)	2.100	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	4.300
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	15.000
Nitrate-N (mg/L)	0.420	Total Lead (µg/L)	0.270
Total Kjehldal N (mg/L)	1.700	Turbidity (NTU)	2.9
Dissolved Organic C (mg/L)	1.900		
Total Organic C (mg/L)	1.800		
Hardness (mg eq. $CaCO_3$/L)	60.00		

Geomorphic Assessment

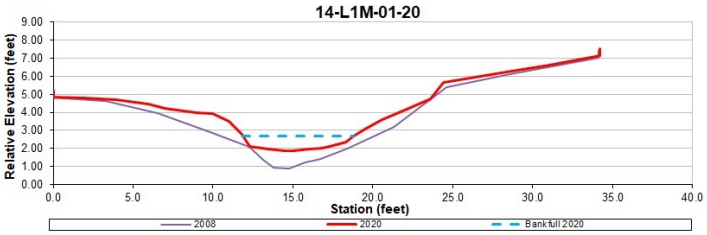
Rosgen Level II Classification Data

	2020	2008		2020	2008
Drainage Area (mi²)	0.21		Sinuosity	1.21	1.00
Bankfull Width (ft)	6.9	6.0	D50 (mm)	0.16	0.25
Mean Bankfull Depth (ft)	0.6	0.7	Adjustments?	None	None
Floodprone Width (ft)	9.4	10.4			
Entrenchment Ratio	1.4	1.7			
Width to Depth Ratio	11.4	8.6			
Cross Sectional Area (ft²)	4.2	4.2			
Water Surface Slope (%)	0.310	0.428			

Rosgen Stream Type

2020	2008
G5c	**B5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2008 Spring Value	2008 Spring Score
Remoteness	14.05	75.67	13.00	70.01
Shading	95	99.94	95	99.94
Epifaunal Substrate	3	41.81	3	41.45
Instream Habitat	4	52.88	12	96.70
Instream Woody Debris	6	84.15	10	95.35
Bank Stability	15.67	88.51	15.00	86.61

	2020 Score	2008 Score
MPHI Habitat Score	73.82	81.67
MPHI Rating	Partially Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2020 Score	2008 Score		2020 Score	2008 Score
Epifaunal Substrate/Available Cover	9	12	Bank Stability - Right Bank	9	7
Pool Substrate Characterization	10	10	Bank Stability - Left Bank	9	8
Pool Variability	8	5	Vegetative Protection - Right Bank	6	7
Sediment Deposition	10	9	Vegetative Protection - Left Bank	6	8
Channel Flow Status	15	17	Riparian Veg. Zone Width - Right Bank	9	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	9	10
Channel Sinuosity	6	6			

	2020 Score	2008 Score
RBP Habitat Score	126	129
RBP Rating	Supporting	Supporting

Site ID 14-L1M-01-20

Revist of site R1-14-06

Biological Assessments

BIBI Metric Values	2020	2008
Total Taxa	18	16
EPT Taxa	1	2
Ephemeroptera Taxa	0	0
% Intolerant to Urban	8.82	13.76
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	5.88	0.00

FIBI Metric Values (2020 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	1	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	3
% Ephemeroptera	1	1
Scraper Taxa	3	1
% Climbers	3	1

FIBI Metric Scores (2020 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	1.86	1.86
BIBI Rating	Very Poor	Very Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Fauna (2020 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Wood Frog

Northern Two-lined Salamander

Fish Taxa	Number
NO FISH	

Benthic Macroinvertebrate Taxa

2020	Number
Amphinemura	1
Amphipoda	2
Caecidotea	5
Ceratopogoninae	4
Chironomini	1
Corynoneura	3
Diplocladius	12
Dytiscidae	1
Gammaridae	9
Gammarus	25
Menetus	5
Naididae	6
Orthocladius	2
Parakiefferiella	2
Parametriocnemus	5
Polypedilum	1
Prostoma	1
Rheocricotopus	12
Synurella	1
Thienemanniella group	1
Zavrelimyia	3

Original Visit	Number
Orthocladius/Cricotopus	5
Tubificinae	1
Tipula	1
Stegopterna	1
Pisidiidae	2
Rheocricotopus	4
Prosimulium	12
Diplocladius	40
Pseudorthocladius	2
Chaetocladius	33
Limnephilidae	1
Limnodrilus	3
Limnophyes	1
Nemouridae	1
Orthocladius	1
Caecidotea	1

Site ID 14-L1M-02-20

Revist of site R1-14-16A

Upstream View - 2020

Downstream View - 2020

Upstream View - 2008

Downstream View - 2008

Summary Results

	2020 Data	2008 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	Degraded	Partially Degraded
Water Quality Conditions	Elevated nutrients	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 212.51

Land Cover	2020 Acres	2008 Acres	2020 % Area	2008 % Area
Developed Land	102.72	46.17	48.34	25.37
Forested Land	45.66	67.12	21.48	36.89
Open Land	10.00	11.97	4.71	6.58
Agricultural Land	54.14	56.72	25.47	31.17

Impervious Surface	2020 Acres	2008 Acres	2020 % Area	2008 % Area
Impervious Land	9.47	5.64	4.46	3.09

Site ID 14-L1M-02-20

Revist of site R1-14-16A

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2008 Spring
Dissolved Oxygen (mg/L)	10.2	8.14	11.26
Turbidity (NTU)	6.7	15.3	n/a
Temperature (°C)	10.7	21.5	10.76
pH (Standard Units)	6.88	7.29	6.48
Specific Conductivity (µS/cm)	200	180	199

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.180	Chloride (mg/L)	35.000
Total Nitrogen (mg/L)	2.900	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	0.170	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	12.000
Nitrate-N (mg/L)	1.200	Total Lead (µg/L)	0.220
Total Kjehldal N (mg/L)	1.700	Turbidity (NTU)	6.2
Dissolved Organic C (mg/L)	2.400		
Total Organic C (mg/L)	2.500		
Hardness (mg eq. $CaCO_3$/L)	50.00		

Geomorphic Assessment

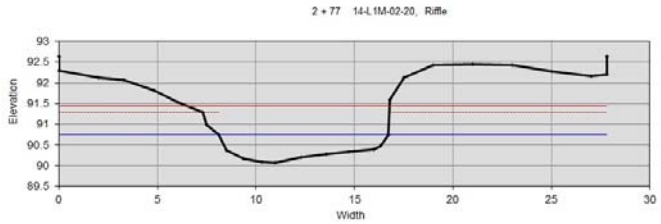
Rosgen Level II Classification Data

	2020	2008		2020	2008
Drainage Area (mi²)	0.33		Sinuosity	1.03	n/a
Bankfull Width (ft)	8.6	n/a	D50 (mm)	0.17	n/a
Mean Bankfull Depth (ft)	0.5	n/a	Adjustments?	SIN +0.2	None
Floodprone Width (ft)	10.3	n/a			
Entrenchment Ratio	1.2	n/a			
Width to Depth Ratio	17.7	n/a			
Cross Sectional Area (ft²)	4.2	n/a			
Water Surface Slope (%)	1.100	n/a			

Rosgen Stream Type

2020	2008
F5	

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2008 Spring Value	2008 Spring Score
Remoteness	0.62	3.31	6.00	32.31
Shading	95	99.94	90	91.34
Epifaunal Substrate	5	50.35	3	39.74
Instream Habitat	6	59.14	7	66.27
Instream Woody Debris	5	75.83	6	80.55
Bank Stability	18.20	95.40	15.00	86.61

	2020 Score	2008 Score
MPHI Habitat Score	63.99	66.14
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2020 Score	2008 Score		2020 Score	2008 Score
Epifaunal Substrate/Available Cover	7	7	Bank Stability - Right Bank	9	7
Pool Substrate Characterization	5	6	Bank Stability - Left Bank	9	8
Pool Variability	6	6	Vegetative Protection - Right Bank	6	7
Sediment Deposition	12	9	Vegetative Protection - Left Bank	7	8
Channel Flow Status	16	14	Riparian Veg. Zone Width - Right Bank	6	6
Channel Alteration	11	11	Riparian Veg. Zone Width - Left Bank	6	6
Channel Sinuosity	6	6			

	2020 Score	2008 Score
RBP Habitat Score	106	101
RBP Rating	Partially Supporting	Partially Supporting

Site ID 14-L1M-02-20

Revist of site R1-14-16A

Biological Assessments

BIBI Metric Values	2020	2008
Total Taxa	20	15
EPT Taxa	3	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	15.53	9.52
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	9.71	0.00

FIBI Metric Values (2020 only)	
Abundance per m²	0.08
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	12.50
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	87.50

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

FIBI Metric Scores (2020 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.71	1.57
BIBI Rating	Poor	Very Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Fauna (2020 only)

Crayfish

Cambarus diogenes

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Northern Green Frog

Pickerel Frog

Northern Water Snake

Fish Taxa	Number
Bluegill	1
Largemouth Bass	7

Benthic Macroinvertebrate Taxa

2020	Number
Amphinemura	1
Amphipoda	2
Caecidotea	6
Ceratopogoninae	4
Corynoneura	2
Cricotopus	1
Diplectrona	6
Diplocladius	2
Gammarus	13
Hemerodromia	1
Lumbriculidae	1
Naididae	2
Neophylax	1
Orthocladius	43
Parametriocnemus	2
Polypedilum	7
Rheocricotopus	1
Synurella	2
Tanytarsus	3
Thienemannimyia group	1
Tipula	2

Original Visit	Number
Gonomyia	1
Nemoura	4
Tubificinae	4
Stegopterna	2
Pisidiidae	8
Simuliidae	1
Rheocricotopus	9
Ironoquia	10
Diplocladius	2
Chaetocladius	56
Enchytraeidae	2
Caecidotea	1
Amphinemura	3
Aedes	1
Limnodrilus	1

Site ID 14-L2M-02-20

Revist of site R2-14-14A

Upstream View - 2020

Downstream View - 2020

Upstream View - 2009

Downstream View - 2009

Summary Results

	2020 Data	2009 Data
Benthic Macroinvertebrate Community	Poor	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	Elevated nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 492.49

Land Cover	2020 Acres	2009 Acres	2020 % Area	2009 % Area
Developed Land	56.72	42.23	11.52	8.14
Forested Land	362.76	413.84	73.66	79.79
Open Land	1.63	55.47	0.33	10.69
Agricultural Land	71.38	7.12	14.49	1.37

Impervious Surface	2020 Acres	2009 Acres	2020 % Area	2009 % Area
Impervious Land	5.36	5.60	1.09	1.10

Site ID 14-L2M-02-20

Revist of site R2-14-14A

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2009 Spring
Dissolved Oxygen (mg/L)	11.3	9.31	10.26
Turbidity (NTU)	4.1	2.1	n/a
Temperature (°C)	10.3	15.9	13.02
pH (Standard Units)	6.64	6.4	6.61
Specific Conductivity (µS/cm)	111	109	122

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.230	Chloride (mg/L)	9.800
Total Nitrogen (mg/L)	1.900	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	12.000
Nitrate-N (mg/L)	0.200	Total Lead (µg/L)	0.190
Total Kjehldal N (mg/L)	1.700	Turbidity (NTU)	6.0
Dissolved Organic C (mg/L)	2.600		
Total Organic C (mg/L)	2.400		
Hardness (mg eq. $CaCO_3$/L)	36.00		

Geomorphic Assessment

Rosgen Level II Classification Data

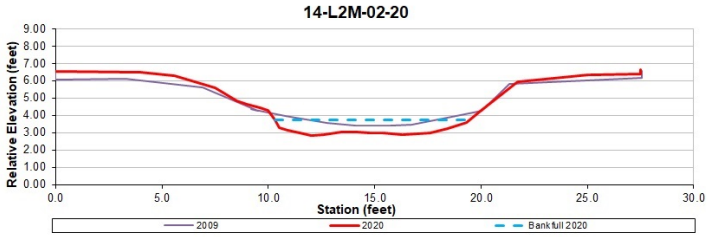
	2020	2009
Drainage Area (mi²)	0.77	
Bankfull Width (ft)	9.1	10.4
Mean Bankfull Depth (ft)	0.7	0.6
Floodprone Width (ft)	10.4	13.0
Entrenchment Ratio	1.1	1.3
Width to Depth Ratio	13.4	18.0
Cross Sectional Area (ft²)	6.2	5.9
Water Surface Slope (%)	0.200	0.150

	2020	2009
Sinuosity	1.09	1.10
D50 (mm)	0.23	0.17
Adjustments?	SIN +0.1	Yes, increased Sin

Rosgen Stream Type

2020	2009
F5	**F5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2009 Spring Value	2009 Spring Score
Remoteness	18.37	98.95	20.00	100.00
Shading	85	84.56	70	68.32
Epifaunal Substrate	7	56.49	4	38.72
Instream Habitat	5	44.98	7	55.54
Instream Woody Debris	10	81.11	4	62.77
Bank Stability	5.70	53.39	12.00	77.46

	2020 Score	2009 Score
MPHI Habitat Score	69.91	67.14
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2020 Score	2009 Score		2020 Score	2009 Score
Epifaunal Substrate/Available Cover	9	7	Bank Stability - Right Bank	2	6
Pool Substrate Characterization	10	8	Bank Stability - Left Bank	2	5
Pool Variability	9	3	Vegetative Protection - Right Bank	6	6
Sediment Deposition	7	5	Vegetative Protection - Left Bank	7	5
Channel Flow Status	15	18	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	5			

	2020 Score	2009 Score
RBP Habitat Score	114	108
RBP Rating	Partially Supporting	Partially supporting

Site ID 14-L2M-02-20

Revist of site R2-14-14A

Biological Assessments

BIBI Metric Values	2020	2009
Total Taxa	17	18
EPT Taxa	4	5
Ephemeroptera Taxa	1	0
% Intolerant to Urban	49.12	67.52
% Ephemeroptera	0.88	0.00
Scraper Taxa	0	0
% Climbers	0.00	2.56

FIBI Metric Values (2020 only)	
Abundance per m²	0.01
Adj. No. of Benthic Species	0.00
% Tolerant	50.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	50.00

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

FIBI Metric Scores (2020 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 Fauna (2020 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Northern Spring Peeper

Eastern Cricket Frog

Fish Taxa	Number
Eastern Mosquitofish	1
Green Sunfish	1

Benthic Macroinvertebrate Taxa

2020	Number
Acentrella	1
Amphinemura	20
Anisoptera	2
Caecidotea	1
Capniidae	1
Ceratopogoninae	3
Chaetocladius	1
Crangonyctidae	11
Diplocladius	6
Ironoquia	3
Naididae	10
Neoporus	3
Orthocladius	3
Parametriocnemus	1
Pisidium	1
Rheocricotopus	1
Synurella	35
Thienemannimyia group	11

Original Visit	Number
Crangonyx	1
Neoporus	1
Pisidium	1
Pseudorthocladius	1
Rheocricotopus	1
Simuliidae	1
Caecidotea	2
Diplocladius	2
Nais	2
Nemouridae	2
Orthocladius/Cricotopus	2
Limnephilidae	3
Amphinemura	4
Tubificinae	6
Hydrobaenus	8
Ironoquia	9
Paranemoura	16
Stegopterna	55

Site ID 14-L2M-03-20

Revist of site R2-14-08

Upstream View - 2020

Downstream View - 2020

Upstream View - 2009

Downstream View - 2009

Summary Results

	2020 Data	2009 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Non-supporting
MPHI Habitat Condition	Dry Site	Severely Degraded
Water Quality Conditions	Elevated nutrients	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 270.08

Land Cover	2020 Acres	2009 Acres	2020 % Area	2009 % Area
Developed Land	41.69	66.58	15.44	17.36
Forested Land	159.28	192.10	58.97	50.08
Open Land	6.60	92.88	2.44	24.21
Agricultural Land	62.52	32.01	23.15	8.35

Impervious Surface	2020 Acres	2009 Acres	2020 % Area	2009 % Area
Impervious Land	5.23	8.00	1.94	2.10

Site ID 14-L2M-03-20

Revist of site R2-14-08

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2009 Spring
Dissolved Oxygen (mg/L)	11.08	n/a	9.93
Turbidity (NTU)	4.4	n/a	n/a
Temperature (°C)	8.6	n/a	12.76
pH (Standard Units)	6.99	n/a	6.38
Specific Conductivity (µS/cm)	226	n/a	159

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.290	Chloride (mg/L)	18.000
Total Nitrogen (mg/L)	2.500	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	14.000
Nitrate-N (mg/L)	0.330	Total Lead (µg/L)	0.280
Total Kjehldal N (mg/L)	2.200	Turbidity (NTU)	8.1
Dissolved Organic C (mg/L)	3.400		
Total Organic C (mg/L)	3.200		
Hardness (mg eq. $CaCO_3$/L)	40.00		

Geomorphic Assessment

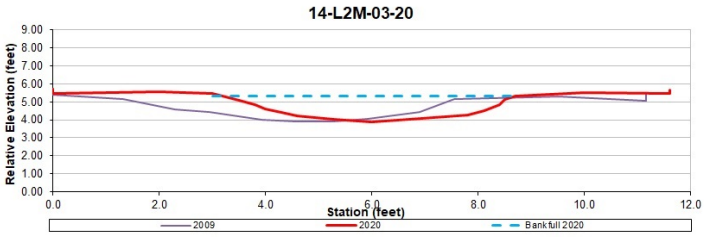
Rosgen Level II Classification Data

	2020	2009		2020	2009
Drainage Area (mi²)	0.42		Sinuosity	1.03	1.00
Bankfull Width (ft)	5.5	6.2	D50 (mm)	0.13	0.10
Mean Bankfull Depth (ft)	1.0	0.8	Adjustments?	SIN +0.5	Yes, increased Sin
Floodprone Width (ft)	100.0	138.0			
Entrenchment Ratio	18.2	22.2			
Width to Depth Ratio	5.7	7.4			
Cross Sectional Area (ft²)	5.3	5.2			
Water Surface Slope (%)	0.580	0.420			

Rosgen Stream Type

2020	2009
E5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2009 Spring Value	2009 Spring Score
Remoteness	Dry Site	No PHI	3.00	16.16
Shading			50	49.95
Epifaunal Substrate			5	46.49
Instream Habitat			8	64.18
Instream Woody Debris			3	63.22
Bank Stability			8.00	63.25

	2020 Score	2009 Score
MPHI Habitat Score	No PHI	50.54
MPHI Rating	Dry Site	Severely Degraded

Rapid Bioassessment Protocol

	2020 Score	2009 Score		2020 Score	2009 Score
Epifaunal Substrate/Available Cover	7	10	Bank Stability - Right Bank	8	4
Pool Substrate Characterization	11	6	Bank Stability - Left Bank	8	4
Pool Variability	5	3	Vegetative Protection - Right Bank	4	4
Sediment Deposition	10	5	Vegetative Protection - Left Bank	5	4
Channel Flow Status	15	18	Riparian Veg. Zone Width - Right Bank	2	2
Channel Alteration	18	20	Riparian Veg. Zone Width - Left Bank	9	10
Channel Sinuosity	6	5			

	2020 Score	2009 Score
RBP Habitat Score	108	95
RBP Rating	Partially Supporting	Non-supporting

Site ID 14-L2M-03-20

Revist of site R2-14-08

Biological Assessments

BIBI Metric Values	2020	2009
Total Taxa	14	23
EPT Taxa	3	5
Ephemeroptera Taxa	1	0
% Intolerant to Urban	74.77	63.33
% Ephemeroptera	1.87	0.00
Scraper Taxa	0	0
% Climbers	0.00	0.00

FIBI Metric Values (2020 only)	
Abundance per m²	Dry Site
Adj. No. of Benthic Species	Dry Site
% Tolerant	Dry Site
% Gen., Omni., Invert.	Dry Site
% Round-bodied Suckers	Dry Site
% Abund. Dominant Taxon	Dry Site

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

FIBI Metric Scores (2020 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	2.71	2.71
BIBI Rating	Poor	Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Fauna (2020 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Cope's Gray Treefrog

Fish Taxa	Number
DRY SITE	

Benthic Macroinvertebrate Taxa

2020	Number
Amphinemura	5
Caecidotea	11
Cordulegaster	1
Corynoneura	1
Crangonyctidae	6
Diplocladius	2
Ironoquia	3
Lumbriculidae	1
Naididae	1
Orthocladius	4
Parametriocnemus	4
Pisidium	2
Plauditus	2
Synurella	63
Thienemannimyia group	1

Original Visit	Number
Diplocladius	1
Dolichopodidae	1
Limnodrilus	1
Lumbriculidae	1
Nais	1
Orthocladius/Cricotopus	1
Perlodidae	1
Rhynchelmis	1
Crangonyx	2
Lumbricidae	2
Pisidium	2
Stenochironomus	2
Amphinemura	3
Enchytraeidae	3
Nemouridae	3
Rheocricotopus	3
Simuliidae	3
Zavrelimyia	3
Ironoquia	4
Tubificinae	13
Caecidotea	15
Stegopterna	15
Paranemoura	39

Site ID: 14-R3M-05-20

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very 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) 145.87

Land Cover	Acres	% Area
Developed Land	64.10	43.94
Forested Land	58.22	39.91
Open Land	9.85	6.75
Agricultural Land	13.69	9.39

Impervious Surface	Acres	% Area
Impervious Land	4.20	2.88

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.92
Turbidity (NTU)	3.1
Temperature (°C)	8.3
pH (Standard Units)	6.73
Specific Conductivity (µS/cm)	209

Laboratory Measurements

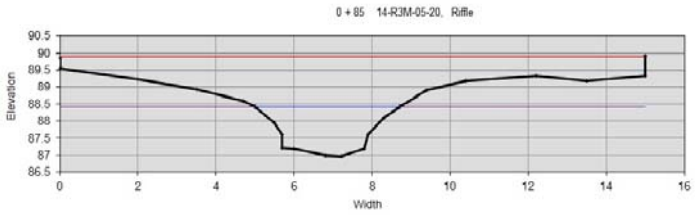
Total Phosphorus (mg/L)	0.160	Chloride (mg/L)	26.000
Total Nitrogen (mg/L)	2.100	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	15.000
Nitrate-N (mg/L)	0.350	Total Lead (µg/L)	0.230
Total Kjehldal N (mg/L)	1.700	Turbidity (NTU)	3.1
Dissolved Organic C (mg/L)	2.100		
Total Organic C (mg/L)	2.000		
Hardness (mg eq. $CaCO_3$/L)	58.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.23	Sinuosity	1.20
Bankfull Width (ft)	3.7	D50 (mm)	0.15
Mean Bankfull Depth (ft)	0.9	Adjustments?	SIN +0.3
Floodprone Width (ft)	70.0		
Entrenchment Ratio	18.9		
Width to Depth Ratio	3.9	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	3.5		
Water Surface Slope (%)	1.5		

Cross-sectional Survey



Site ID: 14-R3M-05-20

Biological Assessments

BIBI Metric Values

Total Taxa	13
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	6.93
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	1.98

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	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	1.29
BIBI Rating	Very Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Caecidotea	4
Ceratopogoninae	1
Chaetocladius	2
Diplocladius	6
Gammaridae	3
Gammarus	22
Naididae	7
Orthocladius	42
Parametriocnemus	6
Polypedilum	2
Rheocricotopus	1
Simulium	1
Synurella	3
Thienemanniella	1

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	11
Channel Flow Status	16
Channel Alteration	15
Channel Sinuosity	6
Bank Stability - Right Bank	2
Bank Stability - Left Bank	2
Vegetative Protection - Right Bank	5
Vegetative Protection - Left Bank	5
Riparian Veg. Zone Width - Right Bank	9
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	103
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	12.59	67.81
Shading	40	40.96
Epifaunal Substrate	6	58.61
Instream Habitat	7	68.53
Instream Woody Debris	0	65.30
Bank Stability	7.50	61.24

MPHI Habitat Score	60.41
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Water Snake

Pickerel Frog

Northern Green Frog

Northern Two-lined Salamander

Mussels

None Observed

Site ID: 14-R3M-07-20

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Very 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) 536.42

Land Cover	Acres	% Area
Developed Land	56.81	10.59
Forested Land	404.08	75.33
Open Land	2.02	0.38
Agricultural Land	73.52	13.71

Impervious Surface	Acres	% Area
Impervious Land	5.44	1.01

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.68
Turbidity (NTU)	5.2
Temperature (°C)	7.6
pH (Standard Units)	6.75
Specific Conductivity (µS/cm)	110

Laboratory Measurements

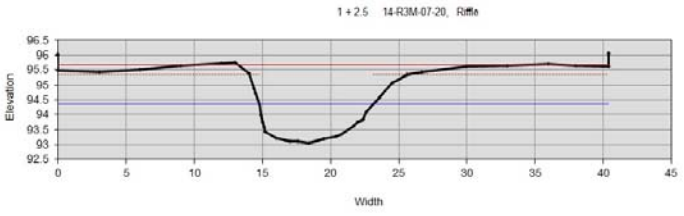
Total Phosphorus (mg/L)	0.200	Chloride (mg/L)	9.200
Total Nitrogen (mg/L)	3.000	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	12.000
Nitrate-N (mg/L)	0.180	Total Lead (µg/L)	0.180
Total Kjehldal N (mg/L)	2.800	Turbidity (NTU)	5.3
Dissolved Organic C (mg/L)	2.500		
Total Organic C (mg/L)	2.500		
Hardness (mg eq. $CaCO_3$/L)	36.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.84	Sinuosity	1.37
Bankfull Width (ft)	8.3	D50 (mm)	0.36
Mean Bankfull Depth (ft)	1.0	Adjustments?	SIN +0.1
Floodprone Width (ft)	34.0		
Entrenchment Ratio	4.1		
Width to Depth Ratio	8.4	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	8.2		
Water Surface Slope (%)	0.26		

Cross-sectional Survey



Site ID: 14-R3M-07-20

Biological Assessments

BIBI Metric Values

Total Taxa	18
EPT Taxa	4
Ephemeroptera Taxa	1
% Intolerant to Urban	30.77
% Ephemeroptera	0.96
Scraper Taxa	0
% Climbers	1.92

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	3
Ephemeroptera Taxa	3
% Intolerant to Urban	5
% Ephemeroptera	3
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	3.00
BIBI Rating	Fair

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Amphinemura	15
Asellidae	1
Caecidotea	4
Chrysops	2
Crangonyctidae	1
Diplocladius	9
Enchytraeidae	1
Isoperla	2
Naididae	30
Nemouridae	1
Orthocladius	3
Parachaetocladius	1
Parametriocnemus	1
Plauditus	1
Polypedilum	2
Rheocricotopus	7
Stenochironomus	1
Synurella	8
Tipula	3
Zavrelimyia	11

Fish Taxa

NO FISH

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	9
Pool Substrate Characterization	11
Pool Variability	8
Sediment Deposition	8
Channel Flow Status	14
Channel Alteration	20
Channel Sinuosity	6
Bank Stability - Right Bank	4
Bank Stability - Left Bank	5
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	119
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	13.83	74.47
Shading	80	78.67
Epifaunal Substrate	7	55.93
Instream Habitat	5	44.11
Instream Woody Debris	15	94.93
Bank Stability	12.47	78.95

MPHI Habitat Score	71.18
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Unknown (not caught)

Herpetofauna

Southern Leopard Frog

Eastern Cricket Frog

Common Five-lined Skink

Gray Treefrog

Northern Green Frog

Northern Spring Peeper

Mussels

None Observed

Site ID: 14-R3M-10-20

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Very Poor
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Low pH; Elevated phosphorus

Land Use/Land Cover Analysis

Total Drainage Area (acres) 81.02

Land Cover	Acres	% Area
Developed Land	41.47	51.18
Forested Land	24.59	30.35
Open Land	7.97	9.84
Agricultural Land	7.00	8.64

Impervious Surface	Acres	% Area
Impervious Land	3.65	4.51

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.9
Turbidity (NTU)	7.6
Temperature (°C)	12.4
pH (Standard Units)	5.98
Specific Conductivity (µS/cm)	209

Laboratory Measurements

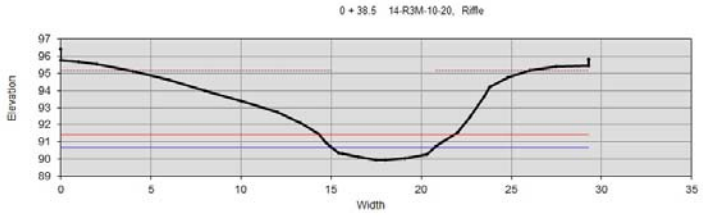
Total Phosphorus (mg/L)	0.290	Chloride (mg/L)	36.000
Total Nitrogen (mg/L)	0.630	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	15.000
Nitrate-N (mg/L)	0.630	Total Lead (µg/L)	0.300
Total Kjehldal N (mg/L)	<1.6	Turbidity (NTU)	6.4
Dissolved Organic C (mg/L)	1.800		
Total Organic C (mg/L)	2.200		
Hardness (mg eq. $CaCO_3$/L)	50.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.13	Sinuosity	1.13
Bankfull Width (ft)	5.7	D50 (mm)	0.18
Mean Bankfull Depth (ft)	0.5	Adjustments?	SIN +0.1
Floodprone Width (ft)	7.5		
Entrenchment Ratio	1.3		
Width to Depth Ratio	10.6	**Rosgen Stream Type**	**G5c**
Cross Sectional Area (ft²)	3.1		
Water Surface Slope (%)	0.92		

Cross-sectional Survey



Site ID: 14-R3M-10-20

Biological Assessments

BIBI Metric Values

Total Taxa	15
EPT Taxa	4
Ephemeroptera Taxa	0
% Intolerant to Urban	6.86
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	35.29

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	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

Amphinemura	1
Caloptervx	1
Chrysops	1
Corvnoneura	3
Diplectrona	5
Ferrissia	5
Gammaridae	1
Gammarus	39
Ironoquia	5
Parametriocnemus	2
Pisidium	1
Polvpedilum	29
Pvcnopsyche	1
Thienemanniella	2
Thienemannimvia group	1
Tipula	5

Fish Taxa

NO FISH

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	6
Pool Variability	5
Sediment Deposition	9
Channel Flow Status	16
Channel Alteration	10
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	8
Riparian Veg. Zone Width - Left Bank	4

RBP Habitat Score	98
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.57	35.38
Shading	95	99.94
Epifaunal Substrate	5	56.63
Instream Habitat	4	57.91
Instream Woody Debris	7	92.67
Bank Stability	11.33	75.28

MPHI Habitat Score	69.63
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Northern Two-lined Salamander

Northern Green Frog

Northern Two-lined Salamander

Northern Green Frog

Mussels

None Observed

Site ID: 14-R3M-17-20

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Very 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) 171.10

Land Cover	Acres	% Area
Developed Land	63.55	37.14
Forested Land	43.41	25.37
Open Land	10.00	5.84
Agricultural Land	54.14	31.64

Impervious Surface	Acres	% Area
Impervious Land	5.70	3.33

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.93
Turbidity (NTU)	7.4
Temperature (°C)	8.3
pH (Standard Units)	6.55
Specific Conductivity (µS/cm)	176

Laboratory Measurements

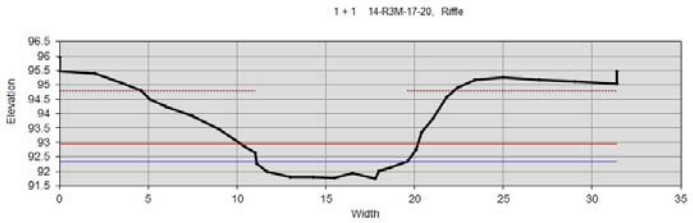
Total Phosphorus (mg/L)	0.220	Chloride (mg/L)	27.000
Total Nitrogen (mg/L)	4.900	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	0.110	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	14.000
Nitrate-N (mg/L)	1.000	Total Lead (µg/L)	0.230
Total Kjehldal N (mg/L)	3.900	Turbidity (NTU)	13.0
Dissolved Organic C (mg/L)	2.200		
Total Organic C (mg/L)	2.200		
Hardness (mg eq. $CaCO_3$/L)	46.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.27	Sinuosity	1.15
Bankfull Width (ft)	8.5	D50 (mm)	0.18
Mean Bankfull Depth (ft)	0.4	Adjustments?	SIN +0.1
Floodprone Width (ft)	11.9		
Entrenchment Ratio	1.4		
Width to Depth Ratio	20.4	**Rosgen Stream Type**	**B5c**
Cross Sectional Area (ft²)	3.6		
Water Surface Slope (%)	0.25		

Cross-sectional Survey



Site ID: 14-R3M-17-20

Biological Assessments

BIBI Metric Values

Total Taxa	16
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	4.42
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	5.31

FIBI Metric Values

Abundance per m²	0.01
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	0.00
% 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	3

FIBI Metric Scores

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

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Ceratopogoninae	5
Gammaridae	1
Gammarus	65
Ironoquia	10
Lumbriculidae	1
Menetus	1
Naididae	2
Orthocladius	1
Paralauterborniella	1
Parametriocnemus	3
Perlidae	1
Pisidium	7
Polypedilum	5
Rheocricotopus	3
Sphaeriidae	1
Synurella	4
Tvetenia	1
Zavrelimyia	1

Fish Taxa

Largemouth Bass	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	6
Pool Substrate Characterization	6
Pool Variability	6
Sediment Deposition	10
Channel Flow Status	15
Channel Alteration	20
Channel Sinuosity	6
Bank Stability - Right Bank	6
Bank Stability - Left Bank	7
Vegetative Protection - Right Bank	7
Vegetative Protection - Left Bank	7
Riparian Veg. Zone Width - Right Bank	9
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	114
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.52	35.14
Shading	95	99.94
Epifaunal Substrate	4	45.95
Instream Habitat	5	55.81
Instream Woody Debris	2	69.41
Bank Stability	16.67	91.29

MPHI Habitat Score	66.25
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Northern Two-lined Salamander

Northern Green Frog

Northern Spring Peeper

Mussels

None Observed

Site ID 20-L1M-04-20

Revist of site R1-20-01

Upstream View - 2020

Downstream View - 2020

Upstream View - 2008

Downstream View - 2008

Summary Results

	2020 Data	2008 Data
Benthic Macroinvertebrate Community	Fair	Very Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Minimally Degraded	Partially Degraded
Water Quality Conditions	Elevated phosphorus	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1980.60

Land Cover	2020 Acres	2008 Acres	2020 % Area	2008 % Area
Developed Land	551.75	392.34	27.86	19.62
Forested Land	791.39	951.59	39.96	47.58
Open Land	48.40	107.15	2.44	5.36
Agricultural Land	589.07	548.76	29.74	27.44

Impervious Surface	2020 Acres	2008 Acres	2020 % Area	2008 % Area
Impervious Land	58.36	79.99	2.95	3.95

Site ID 20-L1M-04-20

Revist of site R1-20-01

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2008 Spring
Dissolved Oxygen (mg/L)	11.44	8.74	13.78
Turbidity (NTU)	3	5.92	n/a
Temperature (°C)	8.8	19.4	5.29
pH (Standard Units)	7	7.22	6.51
Specific Conductivity (µS/cm)	197	184	150

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.180	Chloride (mg/L)	27.000
Total Nitrogen (mg/L)	0.820	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	6.900
Nitrate-N (mg/L)	0.820	Total Lead (µg/L)	0.160
Total Kjehldal N (mg/L)	<1.600	Turbidity (NTU)	5.3
Dissolved Organic C (mg/L)	2.900		
Total Organic C (mg/L)	3.200		
Hardness (mg eq. $CaCO_3$/L)	56.00		

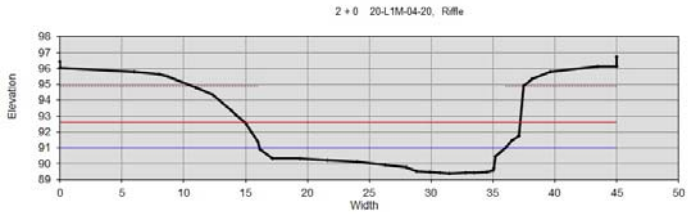
Geomorphic Assessment

Rosgen Level II Classification Data

	2020	2008		2020	2008
Drainage Area (mi²)	3.09		Sinuosity	1.06	1.10
Bankfull Width (ft)	19.8	17.2	D50 (mm)	4.30	0.17
Mean Bankfull Depth (ft)	1.0	1.3	Adjustments?	SIN +0.1	None
Floodprone Width (ft)	22.2	20.0			
Entrenchment Ratio	1.1	1.2			
Width to Depth Ratio	19.2	13.0			
Cross Sectional Area (ft²)	20.5	22.8			
Water Surface Slope (%)	0.350	0.415			

Rosgen Stream Type	
2020	2008
F4/5	**G5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2008 Spring Value	2008 Spring Score
Remoteness	15.31	82.45	14.00	75.39
Shading	85	84.56	100	100.00
Epifaunal Substrate	11	70.66	12	76.41
Instream Habitat	13	75.13	13	75.03
Instream Woody Debris	36	100.00	14	77.08
Bank Stability	11.80	76.81	9.00	67.08

	2020 Score	2008 Score
MPHI Habitat Score	81.60	78.50
MPHI Rating	Minimally Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2020 Score	2008 Score		2020 Score	2008 Score
Epifaunal Substrate/Available Cover	11	13	Bank Stability - Right Bank	4	4
Pool Substrate Characterization	11	9	Bank Stability - Left Bank	4	5
Pool Variability	11	9	Vegetative Protection - Right Bank	7	4
Sediment Deposition	7	7	Vegetative Protection - Left Bank	7	5
Channel Flow Status	13	11	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	6	6			

	2020 Score	2008 Score
RBP Habitat Score	121	113
RBP Rating	Partially Supporting	Partially Supporting

Site ID 20-L1M-04-20

Revist of site R1-20-01

Biological Assessments

BIBI Metric Values	2020	2008
Total Taxa	23	12
EPT Taxa	3	3
Ephemeroptera Taxa	2	0
% Intolerant to Urban	7.14	71.57
% Ephemeroptera	5.36	0.00
Scraper Taxa	4	0
% Climbers	12.50	0.00

FIBI Metric Values (2020 only)	
Abundance per m²	0.44
Adj. No. of Benthic Species	0.89
% Tolerant	70.44
% Gen., Omni., Invert.	98.74
% Round-bodied Suckers	1.26
% Abund. Dominant Taxon	34.59

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

FIBI Metric Scores (2020 only)	
Abundance per m²	1
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	3
% Abund. Dominant Taxon	5

BIBI Score	3.86	1.86
BIBI Rating	Fair	Very Poor

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Fauna (2020 only)

Crayfish

Orconectes limosus

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Pickerel Frog

Fowler's Toad

Fish Taxa	Number
American Eel	12
Blacknose Dace	44
Bluegill	2
Creek Chubsucker	2
Fallfish	15
Green Sunfish	3
Least Brook Lamprey	2
Rosyside Dace	5
Satinfin Shiner	5
Swallowtail Shiner	6
Tessellated Darter	55
White Sucker	8

Benthic Macroinvertebrate Taxa

2020	Number
Acerpenna	1
Amphinemura	5
Boyeria	2
Ceratopogoninae	1
Chaetocladius	1
Corynoneura	1
Diplocladius	2
Dubiraphia	1
Eukiefferiella	20
Ferrissia	1
Gammarus	1
Menetus	2
Orthocladius	32
Parametriocnemus	12
Plauditus	5
Polypedilum	5
Potthastia	2
Simulium	9
Stenelmis	1
Tanytarsus	3
Thienemannimyia group	2
Tribelos	1
Tvetenia	2

Original Visit	Number
Ironoquia	1
Amphinemura	1
Tubificinae	1
Simuliidae	1
Prosimulium	72
Orthocladius/Cricotopus	4
Eukiefferiella	5
Diplocladius	12
Enchytraeidae	2
Allocapnia	1
Hydrobaenus	1
Chaetocladius	1

Site ID 20-L1M-08-20

Revist of site R1-20-05

Upstream View - 2020

Downstream View - 2020

Upstream View - 2008

Downstream View - 2008

Summary Results

	2020 Data	2008 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	Elevated phosphorus	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 429.16

Land Cover	2020 Acres	2008 Acres	2020 % Area	2008 % Area
Developed Land	119.33	167.98	27.80	29.89
Forested Land	166.68	245.21	38.84	43.64
Open Land	2.24	28.96	0.52	5.15
Agricultural Land	140.91	119.75	32.83	21.31

Impervious Surface	2020 Acres	2008 Acres	2020 % Area	2008 % Area
Impervious Land	16.03	31.47	3.73	5.61

Site ID 20-L1M-08-20

Revist of site R1-20-05

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2008 Spring
Dissolved Oxygen (mg/L)	10.24	8.37	13.49
Turbidity (NTU)	22.3	7.8	n/a
Temperature (°C)	12.5	21.2	8.62
pH (Standard Units)	7.09	6.62	6.82
Specific Conductivity (µS/cm)	192	215	174

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.380	Chloride (mg/L)	26.000
Total Nitrogen (mg/L)	0.600	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	12.000
Nitrate-N (mg/L)	0.600	Total Lead (µg/L)	1.200
Total Kjehldal N (mg/L)	<1.600	Turbidity (NTU)	31.0
Dissolved Organic C (mg/L)	5.100		
Total Organic C (mg/L)	5.800		
Hardness (mg eq. $CaCO_3$/L)	58.00		

Geomorphic Assessment

Rosgen Level II Classification Data

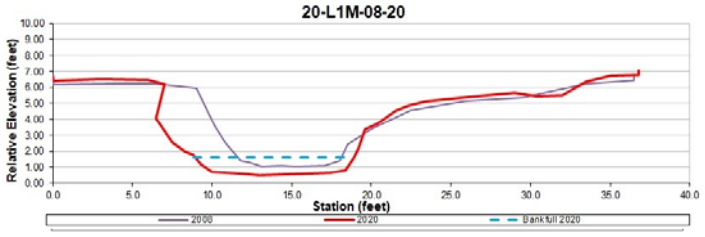
	2020	2008
Drainage Area (mi²)	0.67	
Bankfull Width (ft)	10.0	7.6
Mean Bankfull Depth (ft)	0.9	1.2
Floodprone Width (ft)	12.0	10.9
Entrenchment Ratio	1.2	1.4
Width to Depth Ratio	11.1	6.5
Cross Sectional Area (ft²)	9.0	8.9
Water Surface Slope (%)	0.850	0.616

	2020	2008
Sinuosity	1.09	1.20
D50 (mm)	13.00	0.25
Adjustments?	SIN +0.1	None

Rosgen Stream Type

2020	2008
G4c	**G5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2008 Spring Value	2008 Spring Score
Remoteness	8.23	44.33	6.00	32.31
Shading	95	99.94	85	84.56
Epifaunal Substrate	7	57.39	4	38.20
Instream Habitat	7	57.49	11	76.93
Instream Woody Debris	17	100.00	7	70.74
Bank Stability	5.80	53.85	5.00	50.00

	2020 Score	2008 Score
MPHI Habitat Score	68.83	58.79
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2020 Score	2008 Score		2020 Score	2008 Score
Epifaunal Substrate/Available Cover	10	11	Bank Stability - Right Bank	3	3
Pool Substrate Characterization	7	9	Bank Stability - Left Bank	2	2
Pool Variability	10	7	Vegetative Protection - Right Bank	8	3
Sediment Deposition	13	7	Vegetative Protection - Left Bank	8	2
Channel Flow Status	15	10	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	9	10
Channel Sinuosity	8	7			

	2020 Score	2008 Score
RBP Habitat Score	123	101
RBP Rating	Partially Supporting	Partially Supporting

Site ID 20-L1M-08-20

Revist of site R1-20-05

Biological Assessments

BIBI Metric Values	2020	2008
Total Taxa	26	15
EPT Taxa	2	4
Ephemeroptera Taxa	1	0
% Intolerant to Urban	1.98	51.00
% Ephemeroptera	0.99	0.00
Scraper Taxa	2	0
% Climbers	21.78	0.00

FIBI Metric Values (2020 only)	
Abundance per m²	0.88
Adj. No. of Benthic Species	1.01
% Tolerant	99.30
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	88.81

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

FIBI Metric Scores (2020 only)	
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	3.57	2.14
BIBI Rating	Fair	Poor

FIBI Score	2.33
FIBI Rating	Poor

Supplemental Fauna (2020 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Gray Treefrog

Eastern American Toad

Fish Taxa

Fish Taxa	Number
American Eel	1
Blacknose Dace	127
Tessellated Darter	15

Benthic Macroinvertebrate Taxa

2020	Number
Acerpenna	1
Ceratopogoninae	2
Chaetocladius	5
Corynoneura	6
Cricotopus/Orthocladius	1
Diplocladius	8
Eukiefferiella	1
Gammarus	6
Ironoquia	1
Limnophyes	1
Microtendipes	1
Naididae	4
Nematoda	1
Orthocladiinae	1
Orthocladius	20
Paralauterborniella	2
Parametriocnemus	7
Physa	7
Pisidium	2
Polypedilum	15
Potthastia	1
Rheocricotopus	2
Stenelmis	1
Thienemanniella	2
Thienemannimyia group	1
Tvetenia	1
Zavrelimyia	1

Original Visit	Number
Neophylax	3
Stegopterna	9
Paranemoura	2
Simuliidae	10
Pseudorthocladius	1
Prosimulium	34
Orthocladius/Cricotopus	4
Diplocladius	23
Limnodrilus	1
Ironoquia	1
Hydrobaenus	5
Eukiefferiella	1
Enchytraeidae	2
Dolichopodidae	1
Nemouridae	3

Site ID 20-L2M-01-20

Revist of site R2-20-17A

Upstream View - 2020

Downstream View - 2020

Upstream View - 2009

Downstream View - 2009

Summary Results

	2020 Data	2009 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Non-supporting
MPHI Habitat Condition	Degraded	Partially Degraded
Water Quality Conditions	Elevated nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 190.17

Land Cover	2020 Acres	2009 Acres	2020 % Area	2009 % Area
Developed Land	49.00	57.01	25.77	28.91
Forested Land	62.57	74.03	32.90	37.55
Open Land	2.33	50.82	1.23	25.78
Agricultural Land	76.26	15.30	40.10	7.76

Impervious Surface	2020 Acres	2009 Acres	2020 % Area	2009 % Area
Impervious Land	4.58	8.10	2.41	4.10

Site ID 20-L2M-01-20

Revist of site R2-20-17A

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2009 Spring
Dissolved Oxygen (mg/L)	11.55	8.22	9.15
Turbidity (NTU)	2.1	7.5	n/a
Temperature (°C)	12	20.9	16.12
pH (Standard Units)	6.51	7.3	7.4
Specific Conductivity (µS/cm)	222	207	202

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.099	Chloride (mg/L)	34.000
Total Nitrogen (mg/L)	4.700	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	1.200
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	9.800
Nitrate-N (mg/L)	2.500	Total Lead (µg/L)	0.410
Total Kjehldal N (mg/L)	2.200	Turbidity (NTU)	3.7
Dissolved Organic C (mg/L)	2.400		
Total Organic C (mg/L)	2.500		
Hardness (mg eq. $CaCO_3$/L)	68.00		

Geomorphic Assessment

Rosgen Level II Classification Data

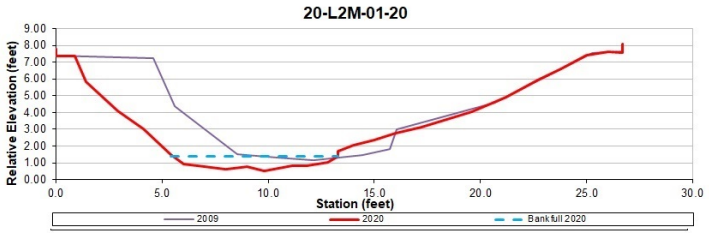
	2020	2009
Drainage Area (mi²)	0.30	
Bankfull Width (ft)	7.8	9.0
Mean Bankfull Depth (ft)	0.6	1.4
Floodprone Width (ft)	10.1	15.0
Entrenchment Ratio	1.3	1.7
Width to Depth Ratio	13.3	6.4
Cross Sectional Area (ft²)	4.6	12.7
Water Surface Slope (%)	0.680	0.960

	2020	2009
Sinuosity	1.09	1.20
D50 (mm)	0.10	0.06
Adjustments?	SIN +0.1	Yes, increased WD

Rosgen Stream Type

2020	2009
F5	**B6c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2009 Spring Value	2009 Spring Score
Remoteness	9.44	50.84	16.00	86.16
Shading	90	91.34	100	100.00
Epifaunal Substrate	5	51.07	3	39.22
Instream Habitat	5	54.72	7	65.46
Instream Woody Debris	8	85.97	7	82.61
Bank Stability	3.47	41.63	6.00	54.77

	2020 Score	2009 Score
MPHI Habitat Score	62.60	71.37
MPHI Rating	Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2020 Score	2009 Score		2020 Score	2009 Score
Epifaunal Substrate/Available Cover	7	7	Bank Stability - Right Bank	3	2
Pool Substrate Characterization	9	7	Bank Stability - Left Bank	3	3
Pool Variability	5	5	Vegetative Protection - Right Bank	8	3
Sediment Deposition	10	7	Vegetative Protection - Left Bank	8	3
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	9			

	2020 Score	2009 Score
RBP Habitat Score	114	94
RBP Rating	Partially Supporting	Non-supporting

Site ID 20-L2M-01-20

Revist of site R2-20-17A

Biological Assessments

BIBI Metric Values	2020	2009
Total Taxa	15	20
EPT Taxa	2	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.00	0.92
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	47.75	33.94

FIBI Metric Values (2020 only)	
Abundance per m²	0.68
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	98.95

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

FIBI Metric Scores (2020 only)	
Abundance per m²	3
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	1.33
FIBI Rating	Very Poor

Supplemental Fauna (2020 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Southern Leopard Frog

Fish Taxa	Number
Blacknose Dace	94
Bluegill	1

Benthic Macroinvertebrate Taxa

2020	Number
Brillia	1
Chaetocladius	2
Cheumatopsyche	4
Corynoneura	1
Diplocladius	5
Eukiefferiella	5
Hydropsyche	1
Naididae	1
Orthocladius	31
Paracladopelma	1
Paralauterborniella	1
Polypedilum	49
Rheocricotopus	2
Stenelmis	1
Tanytarsus	4
Thienemannimyia group	2

Original Visit	Number
Chaetocladius	1
Cheumatopsyche	1
Hemerodromia	1
Limnodrilus	1
Lumbriculidae	1
Neophylax	1
Neoplasta	1
Paratendipes	1
Tanytarsus	1
Thienemannimyia group	1
Tubificinae	1
Physa	2
Aulodrilus	3
Diplocladius	5
Orthocladius/Cricotopus	5
Parametriocnemus	6
Crangonyctidae	9
Ironoquia	9
Gammarus	23
Polypedilum	36

Site ID 20-L2M-03-20

Revist of site R2-20-01

Upstream View - 2020

Downstream View - 2020

Upstream View - 2009

Downstream View - 2009

Summary Results

	2020 Data	2009 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially supporting
MPHI Habitat Condition	Minimally Degraded	Partially Degraded
Water Quality Conditions	Elevated nutrients	High conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 187.94

Land Cover	2020 Acres	2009 Acres	2020 % Area	2009 % Area
Developed Land	72.22	56.72	38.43	32.18
Forested Land	57.75	69.90	30.73	39.66
Open Land	2.24	35.09	1.19	19.91
Agricultural Land	55.73	14.55	29.65	8.25

Impervious Surface	2020 Acres	2009 Acres	2020 % Area	2009 % Area
Impervious Land	10.99	10.00	5.85	5.70

Site ID 20-L2M-03-20

Revist of site R2-20-01

Water Chemistry

In Situ Measurements

	2020 Spring	2020 Summer	2009 Spring
Dissolved Oxygen (mg/L)	11.08	8.69	13.46
Turbidity (NTU)	4.4	6.4	n/a
Temperature (°C)	8.6	18.7	8.25
pH (Standard Units)	6.99	7.1	7.24
Specific Conductivity (µS/cm)	226	229	254

Laboratory Measurements (collected 2020 only)

Total Phosphorus (mg/L)	0.180	Chloride (mg/L)	30.000
Total Nitrogen (mg/L)	2.500	Magnesium (mg/L)	n/a
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	n/a
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	0.920
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	6.300
Nitrate-N (mg/L)	0.820	Total Lead (µg/L)	0.310
Total Kjehldal N (mg/L)	1.700	Turbidity (NTU)	7.4
Dissolved Organic C (mg/L)	3.400		
Total Organic C (mg/L)	3.200		
Hardness (mg eq. $CaCO_3$/L)	64.00		

Geomorphic Assessment

Rosgen Level II Classification Data

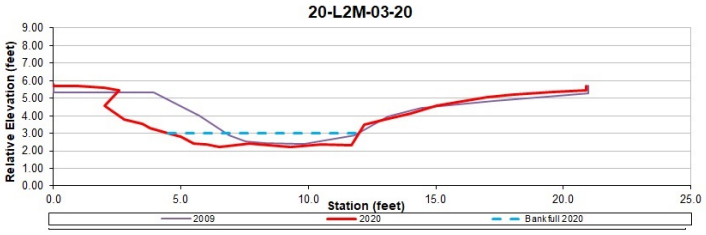
	2020	2009
Drainage Area (mi²)	0.29	
Bankfull Width (ft)	7.5	7.4
Mean Bankfull Depth (ft)	0.6	1.1
Floodprone Width (ft)	10.4	259.0
Entrenchment Ratio	1.4	35.2
Width to Depth Ratio	11.9	6.4
Cross Sectional Area (ft²)	4.7	8.4
Water Surface Slope (%)	0.870	0.520

	2020	2009
Sinuosity	1.04	1.20
D50 (mm)	1.40	0.16
Adjustments?	SIN +0.1	Yes, increased Sin

Rosgen Stream Type

2020	2009
G4/5c	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2020 Summer Value	2020 Summer Score	2009 Spring Value	2009 Spring Score
Remoteness	8.37	45.09	8.00	43.08
Shading	95	99.94	100	100.00
Epifaunal Substrate	11	86.00	6	57.38
Instream Habitat	12	93.68	11	88.81
Instream Woody Debris	18	100.00	9	89.80
Bank Stability	13.90	83.37	13.00	80.63

	2020 Score	2009 Score
MPHI Habitat Score	84.68	76.62
MPHI Rating	Minimally Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2020 Score	2009 Score		2020 Score	2009 Score
Epifaunal Substrate/Available Cover	12	11	Bank Stability - Right Bank	3	6
Pool Substrate Characterization	8	9	Bank Stability - Left Bank	3	7
Pool Variability	10	5	Vegetative Protection - Right Bank	7	6
Sediment Deposition	8	11	Vegetative Protection - Left Bank	7	7
Channel Flow Status	12	10	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	9	10
Channel Sinuosity	6	8			

	2020 Score	2009 Score
RBP Habitat Score	115	120
RBP Rating	Partially Supporting	Partially supporting

Site ID 20-L2M-03-20

Revist of site R2-20-01

Biological Assessments

BIBI Metric Values	2020	2009
Total Taxa	27	24
EPT Taxa	2	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	1.94	17.20
% Ephemeroptera	0.00	0.00
Scraper Taxa	2	0
% Climbers	20.39	41.94

FIBI Metric Values (2020 only)	
Abundance per m²	0.91
Adj. No. of Benthic Species	1.89
% Tolerant	94.50
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	0.92

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

FIBI Metric Scores (2020 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.00	2.43
BIBI Rating	Fair	Poor

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Fauna (2020 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Two-lined Salamander

Northern Green Frog

Wood Frog

American Bullfrog

Fish Taxa

Fish Taxa	Number
American Eel	6
Blacknose dace	69
Green Sunfish	33
Tessellated Darter	1

Benthic Macroinvertebrate Taxa

2020	Number
Amphipoda	1
Calopteryx	1
Ceratopogoninae	1
Chaetocladius	5
Chironomus	1
Corynoneura	4
Diplectrona	1
Diplocladius	4
Eukiefferiella	1
Ferrissia	1
Gammarus	8
Ironoquia	5
Limnophyes	2
Musculium	1
Naididae	2
Orthocladius	16
Paracladopelma	1
Parametriocnemus	9
Physa	4
Pisidium	1
Polypedilum	12
Sciomyzidae	1
Synurella	1
Tanytarsus	3
Thienemanniymia group	8
Tipula	1
Tvetenia	6
Zavrelimyia	2

Original Visit	Number
Ironoquia	1
Nemata	1
Nigronia	1
Odontomesa	1
Orthocladiinae	1
Parakiefferiella	1
Paratendipes	1
Phaenopsectra	1
Physa	1
Stenelmis	1
Tvetenia	1
Paratanytarsus	2
Prosimulium	2
Rheotanytarsus	2
Stempellinella	2
Bezzia/Palpomyia	3
Limnephilidae	3
Orthocladius/Cricotopus	3
Pisidiidae	3
Rheocricotopus	3
Zavrelimyia	3
Simulium	4
Thienemanniymi group	4
Diplocladius	7
Tanytarsus	9
Parametriocnemus	12
Gammarus	13
Pisidium	13
Micropsectra	24
Polypedilum	24

Site ID: 20-R3M-03-20

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Poor
RBP Habitat Condition	Non-Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Low pH, Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 137.35

Land Cover	Acres	% Area
Developed Land	18.77	13.66
Forested Land	61.19	44.55
Open Land	1.33	0.97
Agricultural Land	56.07	40.82

Impervious Surface	Acres	% Area
Impervious Land	1.22	0.89

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.35
Turbidity (NTU)	1.9
Temperature (°C)	10.4
pH (Standard Units)	5.94
Specific Conductivity (µS/cm)	103

Laboratory Measurements

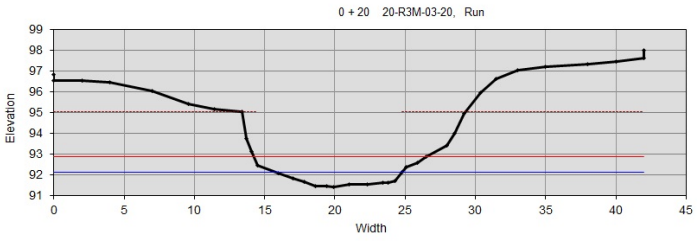
Total Phosphorus (mg/L)	0.051	Chloride (mg/L)	15.000
Total Nitrogen (mg/L)	5.500	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	0.090	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	9.300
Nitrate-N (mg/L)	1.000	Total Lead (µg/L)	0.210
Total Kjehldal N (mg/L)	4.500	Turbidity (NTU)	2.7
Dissolved Organic C (mg/L)	2.400		
Total Organic C (mg/L)	2.600		
Hardness (mg eq. $CaCO_3$/L)	26.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.21	Sinuosity	1.06
Bankfull Width (ft)	9.0	D50 (mm)	0.10
Mean Bankfull Depth (ft)	0.5	Adjustments?	SIN +0.1
Floodprone Width (ft)	12.3		
Entrenchment Ratio	1.4		
Width to Depth Ratio	17.7	**Rosgen Stream Type**	**B5**
Cross Sectional Area (ft²)	4.6		
Water Surface Slope (%)	2		

Cross-sectional Survey



Site ID: 20-R3M-03-20

Biological Assessments

BIBI Metric Values

Total Taxa	19
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	0.94
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	19.81

FIBI Metric Values

Abundance per m²	3.05
Adj. No. of Benthic Species	0.00
% Tolerant	99.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	64.25

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

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	2.00
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Ceratopogoninae	1
Chaetocladius	2
Cheumatopsyche	2
Cricotopus/Orthocladius	1
Diplocladius	45
Lumbriculidae	1
Naididae	6
Orthocladius	8
Parametriocnemus	3
Paratendipes	1
Planorbidae	2
Polypedilum	9
Potthastia	1
Simulium	5
Sphaeriidae	2
Tanytarsus	10
Thienemannimyia group	2
Tipula	1
Tvetenia	4

Fish Taxa

American Eel	4
Blacknose Dace	257
Eastern Mudminnow	102
Green Sunfish	37

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	5
Pool Substrate Characterization	6
Pool Variability	11
Sediment Deposition	7
Channel Flow Status	12
Channel Alteration	11
Channel Sinuosity	7
Bank Stability - Right Bank	4
Bank Stability - Left Bank	6
Vegetative Protection - Right Bank	6
Vegetative Protection - Left Bank	5
Riparian Veg. Zone Width - Right Bank	5
Riparian Veg. Zone Width - Left Bank	4

RBP Habitat Score	89
RBP Rating	Non-Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	0.62	3.31
Shading	85	84.56
Epifaunal Substrate	8	70.62
Instream Habitat	10	85.80
Instream Woody Debris	7	86.69
Bank Stability	9.60	69.28

MPHI Habitat Score	66.71
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Northern Two-lined Salamander

Eastern Box Turtle

American Bullfrog

Northern Green Frog

Southern Leopard Frog

Northern Two-lined Salamander

Mussels

None Observed

Site ID: 20-R3M-06-20

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
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) 989.59

Land Cover

	Acres	% Area
Developed Land	248.40	25.10
Forested Land	399.09	40.33
Open Land	25.06	2.53
Agricultural Land	317.05	32.04

Impervious Surface

	Acres	% Area
Impervious Land	28.40	2.87

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.87
Turbidity (NTU)	4.9
Temperature (°C)	9.9
pH (Standard Units)	6.71
Specific Conductivity (µS/cm)	187

Laboratory Measurements

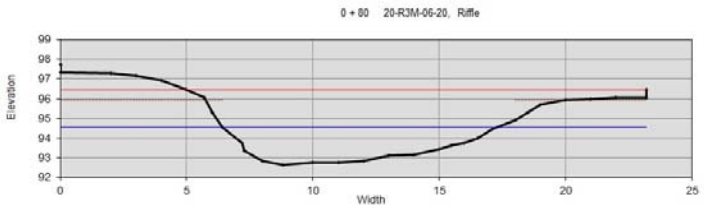
Total Phosphorus (mg/L)	0.110	Chloride (mg/L)	25.000
Total Nitrogen (mg/L)	4.700	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	9.900
Nitrate-N (mg/L)	1.300	Total Lead (µg/L)	0.190
Total Kjehldal N (mg/L)	3.400	Turbidity (NTU)	7.4
Dissolved Organic C (mg/L)	2.800		
Total Organic C (mg/L)	2.700		
Hardness (mg eq. $CaCO_3$/L)	52.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.55	Sinuosity	1.16
Bankfull Width (ft)	10.9	D50 (mm)	0.12
Mean Bankfull Depth (ft)	1.3	Adjustments?	SIN +0.3
Floodprone Width (ft)	76.0		
Entrenchment Ratio	7.0		
Width to Depth Ratio	8.2	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	14.3		
Water Surface Slope (%)	0.12		

Cross-sectional Survey



Site ID: 20-R3M-06-20

Biological Assessments

BIBI Metric Values

Total Taxa	24
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	29.63
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	4.63

FIBI Metric Values

Abundance per m²	0.34
Adj. No. of Benthic Species	0.57
% Tolerant	98.61
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	55.56

BIBI Metric Scores

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

FIBI Metric Scores

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	3.00
BIBI Rating	Fair

FIBI Score	2.00
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Caecidotea	6
Ceratopogoninae	4
Chaetocladius	5
Corynoneura	2
Crangonyctidae	13
Diplocladius	2
Dytiscidae	1
Ironoquia	2
Isoperla	1
Naididae	9
Nanocladius	1
Nematoda	1
Orthocladius	5
Parametriocnemus	8
Paratanytarsus	1
Physa	2
Pisidium	3
Polypedilum	2
Rheotanytarsus	1
Sphaeriidae	8
Synurella	25
Tanytarsus	1
Thienemannimyia group	1
Tipulidae	1
Tvetenia	2
Zavrelimyia	1

Fish Taxa

American Eel	1
Blacknose Dace	40
Eastern Mudminnow	1
Green Sunfish	1
Tessellated Darter	29

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	13
Pool Substrate Characterization	13
Pool Variability	10
Sediment Deposition	7
Channel Flow Status	15
Channel Alteration	20
Channel Sinuosity	6
Bank Stability - Right Bank	5
Bank Stability - Left Bank	3
Vegetative Protection - Right Bank	6
Vegetative Protection - Left Bank	7
Riparian Veg. Zone Width - Right Bank	3
Riparian Veg. Zone Width - Left Bank	9

RBP Habitat Score	117
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.10	49.00
Shading	80	78.67
Epifaunal Substrate	13	86.80
Instream Habitat	14	87.78
Instream Woody Debris	16	90.96
Bank Stability	10.33	71.88

MPHI Habitat Score	77.52
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

un-identified salamander

Northern Two-lined Salamander

Mussels

None Observed

Site ID: 20-R3M-09-20

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Poor
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Elevated phosphorus

Land Use/Land Cover Analysis

Total Drainage Area (acres) 221.43

Land Cover	Acres	% Area
Developed Land	82.00	37.03
Forested Land	80.14	36.19
Open Land	2.24	1.01
Agricultural Land	57.05	25.77

Impervious Surface	Acres	% Area
Impervious Land	12.20	5.51

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.45
Turbidity (NTU)	13.9
Temperature (°C)	14.5
pH (Standard Units)	7.13
Specific Conductivity (µS/cm)	239

Laboratory Measurements

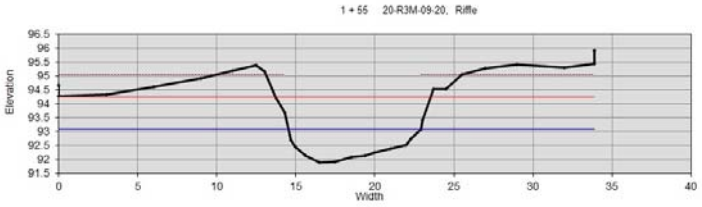
Total Phosphorus (mg/L)	0.360	Chloride (mg/L)	34.000
Total Nitrogen (mg/L)	0.570	Magnesium (mg/L)	N/A
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	N/A
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	1.600
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	8.800
Nitrate-N (mg/L)	0.570	Total Lead (µg/L)	0.910
Total Kjehldal N (mg/L)	<1.6	Turbidity (NTU)	23.0
Dissolved Organic C (mg/L)	5.900		
Total Organic C (mg/L)	6.600		
Hardness (mg eq. $CaCO_3$/L)	66.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.35	Sinuosity	1.03
Bankfull Width (ft)	8.3	D50 (mm)	0.44
Mean Bankfull Depth (ft)	0.8	Adjustments?	SIN +0.2
Floodprone Width (ft)	9.8		
Entrenchment Ratio	1.2		
Width to Depth Ratio	10.1	**Rosgen Stream Type**	**G5c**
Cross Sectional Area (ft²)	6.9		
Water Surface Slope (%)	0.72		

Cross-sectional Survey



Site ID: 20-R3M-09-20

Biological Assessments

BIBI Metric Values

Total Taxa	24
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	20.00
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	8.18

FIBI Metric Values

Abundance per m²	0.79
Adj. No. of Benthic Species	1.13
% Tolerant	93.51
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	88.31

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	3.29
BIBI Rating	Fair

FIBI Score	2.67
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Amphinemura	1
Ceratopogoninae	2
Chaetocladius	9
Corynoneura	3
Crangonyctidae	1
Diplocladius	9
Dytiscidae	2
Ferrissia	1
Ironoquia	2
Lumbriculidae	1
Naididae	2
Nematoda	2
Orthocladius	32
Parametriocnemus	2
Physa	1
Pisidium	1
Polypedilum	4
Rheocricotopus	3
Simuliidae	1
Synurella	21
Tanytarsus	3
Thienemanniella	1
Thienemannimyia group	3
Tvetenia	1
Zavrelimyia	2

Fish Taxa

American Eel	4
Blacknose Dace	68
Green Sunfish	2
Satinfin Shiner	1
Tessellated Darter	2

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	11
Pool Substrate Characterization	12
Pool Variability	8
Sediment Deposition	10
Channel Flow Status	11
Channel Alteration	20
Channel Sinuosity	8
Bank Stability - Right Bank	5
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	10

RBP Habitat Score	127
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	10.17	54.78
Shading	90	91.34
Epifaunal Substrate	9	73.32
Instream Habitat	8	69.81
Instream Woody Debris	18	100.00
Bank Stability	5.50	52.44

MPHI Habitat Score	73.62
MPHI Rating	Partially Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Wood Frog

Northern Green Frog

Southern Leopard Frog

Northern Two-lined Salamander

Mussels

None Observed

Site ID: 20-R3M-10-20

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1022.87

Land Cover	Acres	% Area
Developed Land	268.93	26.29
Forested Land	411.38	40.22
Open Land	25.06	2.45
Agricultural Land	317.50	31.04

Impervious Surface	Acres	% Area
Impervious Land	30.70	3.00

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	11.7
Turbidity (NTU)	4
Temperature (°C)	9.8
pH (Standard Units)	6.74
Specific Conductivity (µS/cm)	200

Laboratory Measurements

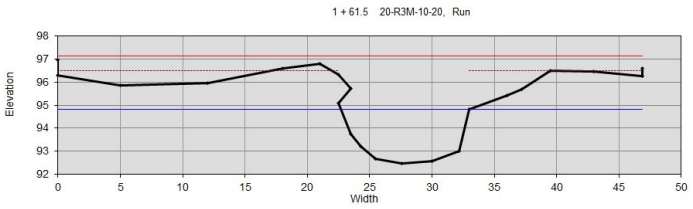
Total Phosphorus (mg/L)	0.072	Chloride (mg/L)	25.000
Total Nitrogen (mg/L)	1.300	Magnesium (mg/L)	
Orthophosphate (mg/L)	<0.450	Calcium (mg/L)	
Total Ammonia N (mg/L)	<0.088	Total Copper (µg/L)	<0.690
Nitrite-N (mg/L)	<0.029	Total Zinc (µg/L)	8.200
Nitrate-N (mg/L)	1.300	Total Lead (µg/L)	0.160
Total Kjehldal N (mg/L)	<1.6	Turbidity (NTU)	4.9
Dissolved Organic C (mg/L)	2.800		
Total Organic C (mg/L)	2.400		
Hardness (mg eq. $CaCO_3$/L)	56.00		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.60	Sinuosity	1.01
Bankfull Width (ft)	10.3	D50 (mm)	0.09
Mean Bankfull Depth (ft)	1.9	Adjustments?	SIN +0.5
Floodprone Width (ft)	400.0		
Entrenchment Ratio	38.9		
Width to Depth Ratio	5.5	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	19.1		
Water Surface Slope (%)	0.023		

Cross-sectional Survey



Site ID: 20-R3M-10-20

Biological Assessments

BIBI Metric Values

Total Taxa	16
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	19.83
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	4.31

FIBI Metric Values

Abundance per m²	1.07
Adj. No. of Benthic Species	0.57
% Tolerant	82.50
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	1.67
% Abund. Dominant Taxon	52.50

BIBI Metric Scores

Total Taxa	3
EPT Taxa	1
Ephemeroptera Taxa	1
% Intolerant to Urban	3
% 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.	1
% Round-bodied Suckers	3
% Abund. Dominant Taxon	3

BIBI Score	1.86
BIBI Rating	Very Poor

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Amphipoda	3
Anisoptera	3
Caecidotea	21
Ceratopogoninae	2
Chironomus	1
Crangonyctidae	2
Diplocladius	10
Naididae	27
Nematoda	3
Orthocladius	16
Parametriocnemus	1
Pisidium	2
Polypedilum	2
Prostoma	1
Sphaeriidae	2
Synurella	8
Tanypodinae	3
Tanytarsini	1
Tanytarsus	3
Zavrelimyia	1

Fish Taxa

American Eel	3
Blacknose Dace	63
Bluegill	5
Creek Chubsucker	2
Eastern Mudminnow	3
Fallfish	7
Rosyside Dace	4
Satinfin Shiner	2
Swallowtail Shiner	3
Tessellated Darter	28

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	5
Pool Substrate Characterization	6
Pool Variability	7
Sediment Deposition	2
Channel Flow Status	18
Channel Alteration	20
Channel Sinuosity	6
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	8

RBP Habitat Score	104
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	4.28	23.05
Shading	90	91.34
Epifaunal Substrate	7	51.73
Instream Habitat	7	48.60
Instream Woody Debris	8	66.92
Bank Stability	6.00	54.77

MPHI Habitat Score	56.07
MPHI Rating	Degraded

Supplemental Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Northern Green Frog

Northern Two-lined Salamander

Mussels

None Observed

Appendix E: Water Quality Data

Sampling Unit	Sample ID	Date Sampled	Collection Time	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)	Hardness (mg equivalent CaCO3/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
Rock Branch	20-L1M-04-20	4/10/2020	9:00	27	0.18	0.82 †	< 0.45	< 0.088	< 0.029	0.82	< 3.2	2.9	3.2	56	< 0.69	6.9	0.16 †	5.3
	20-L1M-08-20	4/9/2020	9:00	26	0.38	0.60 †	< 0.45 ‡	< 0.088	< 0.029 ‡	0.6 ‡	< 3.2	5.1	5.8	58	1.2 †	12	1.2	31 ‡
	20-L2M-01-20	3/31/2020	13:00	34	0.099 †	4.7 †	< 0.45	< 0.088	< 0.029	2.5	2.2 †	2.4	2.5	68	0.92 ^†	9.8	0.41 †	3.7
	20-L2M-03-20	4/16/2020	9:00	30	0.18	2.5 †	< 0.45 ‡	< 0.088	< 0.029 ‡	0.82 ‡	3.2 †	3.4	3.2	64	0.88 †	6.3	0.31 †§	7.4 ‡
	20-R3M-03-20	3/31/2020	8:30	15 *	0.051 †	5.5	< 0.45 *	0.090 †	< 0.029 *	1.0 *	4.5 †	2.4	2.6	26	< 0.69 ^	9.3	0.21	2.7
	20-R3M-06-20	4/16/2020	11:30	25	0.11	4.7 †	< 0.45	< 0.088	< 0.029	1.3	3.2 †	2.8	2.7	52	< 0.69	9.9	0.19 †§	7.4
	20-R3M-09-20	4/9/2020	11:00	34	0.36	0.57 †	< 0.45	< 0.088	< 0.029	0.57	< 3.2	5.9	6.6	66	1.6 †	8.8	0.91	23
	20-R3M-10-20	4/2/2020	11:30	25	0.072 †	1.3 †	< 0.45 ‡	< 0.088	< 0.029 ‡	1.3 ‡	< 1.6	2.8	2.4	56	< 0.69	8.2	0.16	4.9
	Average ± SD	--	--	**27 ± 6**	**0.179 ± 0.127**	**2.6 ± 2.1**	**0.45 ± 0.000**	**0.088 ± 0.001**	**0.029 ± 0.000**	**1.11 ± 0.63**	**2.9 ± 1.0**	**3.5 ± 1.3**	**3.6 ± 1.6**	**56 ± 13**	**0.9 ± 0.3**	**9 ± 2**	**0.44 ± 0.39**	**10.7 ± 10.4**
Stony Run	02-L1M-01-20	4/21/2020	8:10	40	< 0.037	14	< 0.45	< 0.088	< 0.029	1.9	12	5.8	5.8	58	2.1 §	18	0.53 †	2.0
	02-L1M-03-20	3/31/2020	12:30	81	0.04 †	3.4 †	< 0.45 α	< 0.088	< 0.029	0.59	2.8 †	5.0	5.1	72	2.0	10	0.41 †	3.9
	02-L2M-01-20	4/20/2020	13:00	40	< 0.037	8.0	< 0.45	0.10	< 0.029	0.70	7.3	6.2	6.2	60	1.5 †	11	0.56 †	7.5
	02-L2M-04-20	3/31/2020	15:00	36	< 0.037	5.0	< 0.45 ‡	0.12	0.062	2.7	2.2 †	6.1	6.3	58	1.7 †	13	0.37 †	7.0
	02-R3M-02-20	4/1/2020	14:00	79	< 0.037	3.5 †	< 0.45 ‡	< 0.088	< 0.029	0.66	2.8 †	4.8	5.2	70	2.2	12	0.30 ^†	4.8
	02-R3M-03-20	4/21/2020	8:30	25	< 0.037	14	< 0.45	< 0.088	< 0.029	0.59	13	6.6	6.5	50	1.4 †§	7.2	0.49 †	3.3
	02-R3M-04-20	3/31/2020	8:30	55	< 0.037	2.9 †	< 0.45 α	< 0.088	< 0.029	0.71	2.2 †	5.4	5.7	64	2.1	13	0.50 †	3.8
	02-R3M-05-20	4/20/2020	12:00	45	< 0.037	7.4	< 0.45	0.10	< 0.029	0.73	6.7	6.1	6.2	62	1.7 †	12	0.54 †	6.7
	Average ± SD	--	--	**50 ± 20**	**0.037 ± 0.001**	**7.3 ± 4.5**	**0.45 ± 0.000**	**0.095 ± 0.011**	**0.033 ± 0.012**	**1.07 ± 0.79**	**6.1 ± 4.4**	**5.8 ± 0.6**	**5.9 ± 0.5**	**62 ± 7**	**1.8 ± 0.3**	**12 ± 3**	**0.46 ± 0.09**	**4.9 ± 2.0**
Upper Magothy	07-L1M-02-20	4/8/2020	12:00	36	< 0.037	3.3 †	< 0.45 *	0.15	< 0.029	0.47	2.8 †	5.1	5.4	46	1.7 †	13	0.57 †	5.7
	07-L1M-03-20	4/9/2020	9:00	74	0.042 †	4.5 †	< 0.45 ‡	0.17 α	< 0.029 ‡	1.1 ‡	3.2 †	5.2	5.8	64	1.8 †	16	0.79 †	14 ‡
	07-L2M-02-20	4/9/2020	15:30	67	0.051 †	1.1 †	< 0.45	< 0.088	< 0.029	1.1	< 3.2	5.3	5.6	54	2.0	14	0.79 †	6.7
	07-L2M-03-20	4/8/2020	14:00	40	< 0.037	4.3 †	< 0.45	< 0.088	< 0.029	0.92	3.2 †	3.5	3.6	50	0.93 †	13	0.49 †	2.8
	07-R3M-01-20	4/17/2020	11:30	11	< 0.037	3.4 †	< 0.45	< 0.088	< 0.029	< 0.023	3.2 †	8.1	8.0	40	1.8 †	< 4.3	0.43 †§	2.2
	07-R3M-02-20	4/9/2020	13:00	54	0.089 †	1.3 †	< 0.45	< 0.088	< 0.029	1.3	< 3.2	5.7	6.2	74	2.0	12	0.58 †	3.9
	07-R3M-04-20	4/17/2020	14:00	44	0.038 †	4.5 †	< 0.45	0.21	< 0.029	0.58	3.9 †	9.1	9.0	52	2.1	9.6	1.1 †	5.8
	07-R3M-07-20	4/20/2020	9:00	42	< 0.037	9.9	< 0.45	0.20	< 0.029	0.38	9.5	3.7	3.8	58	< 0.69	13	0.30 †	5.6
	Average ± SD	--	--	**46 ± 20**	**0.046 ± 0.018**	**4.0 ± 2.7**	**0.45 ± 0.000**	**0.135 ± 0.054**	**0.029 ± 0.000**	**0.73 ± 0.44**	**4.1 ± 2.2**	**5.7 ± 2.0**	**5.9 ± 1.9**	**55 ± 11**	**1.6 ± 0.5**	**12 ± 4**	**0.63 ± 0.25**	**5.8 ± 3.7**
West River	14-L1M-01-20	4/3/2020	10:40	27	0.19	2.1 †	< 0.45	< 0.088	< 0.029	0.42	3.2 †	1.9	1.8	60	< 0.69	15	0.27 †	2.9
	14-L1M-02-20	4/6/2020	8:30	35	0.18	2.9 †	< 0.45 ‡	0.17	< 0.029 ‡	1.2 ‡	3.2 †	2.4	2.5	50	< 0.69	12	0.22 †	6.2 ‡
	14-L2M-02-20	4/22/2020	11:00	9.8	0.23	1.9 †	< 0.45	< 0.088	< 0.029	0.20	3.2 †	2.6	2.4	36	< 0.69	12	0.19 †	6.0
	14-L2M-03-20	4/22/2020	14:00	18	0.29	2.5 †	< 0.45	< 0.088	< 0.029	0.33	2.2 †	3.4	3.2	40	< 0.69	14	0.28 †	8.1
	14-R3M-05-20	4/3/2020	8:30	26	0.16	2.1 †	< 0.45	< 0.088	< 0.029	0.35	3.2 †	2.1	2.0	58	< 0.69	15	0.23 †	3.1
	14-R3M-07-20	4/22/2020	9:00	9.2	0.20	3.0 †	< 0.45	< 0.088	< 0.029	0.18	2.8 †	2.5	2.5	36	< 0.69	12	0.18 †	5.3
	14-R3M-10-20	4/6/2020	11:40	36	0.29	0.63 †	< 0.45 ‡	< 0.088	< 0.029	0.63	< 1.6	1.8	2.2	50	< 0.69	15	0.30 †	6.4
	14-R3M-17-20	4/17/2020	9:00	27	0.22	4.9 †	< 0.45	0.11 *	< 0.029	1.0	3.9 †	2.2	2.2	46	< 0.69	14	0.23 †§	13
	Average ± SD	--	--	**24 ± 10**	**0.220 ± 0.048**	**2.5 ± 1.2**	**0.45 ± 0.000**	**0.101 ± 0.029**	**0.029 ± 0.000**	**0.54 ± 0.38**	**2.2 ± 0.8**	**2.4 ± 0.5**	**2.4 ± 0.4**	**47 ± 9**	**0.7 ± 0.0**	**14 ± 1**	**0.24 ± 0.04**	**6.4 ± 3.2**

< Sample concentration was below the method detection limit, so the method detection limit is the reported value.

α Lab control sample or lab control sample duplicate is outside acceptance limits.

^ Instrument related quality control is outside acceptance limits.

§ Compound was found in the blank and sample.

* Matrix spike and/or matrix spike duplicate recovery exceeds control limits.

‡ Sample was received, prepped, and/or analyzed beyond the specified holding time.

† Result is less than reporting limit but greater than or equal to the method detection limit and the concentration is an approximate value.