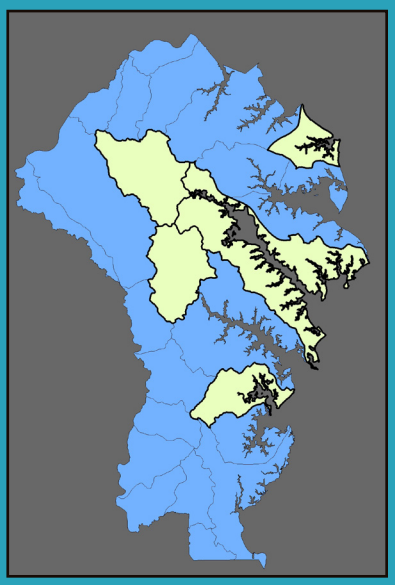
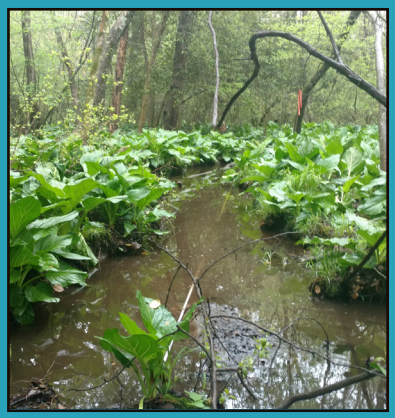
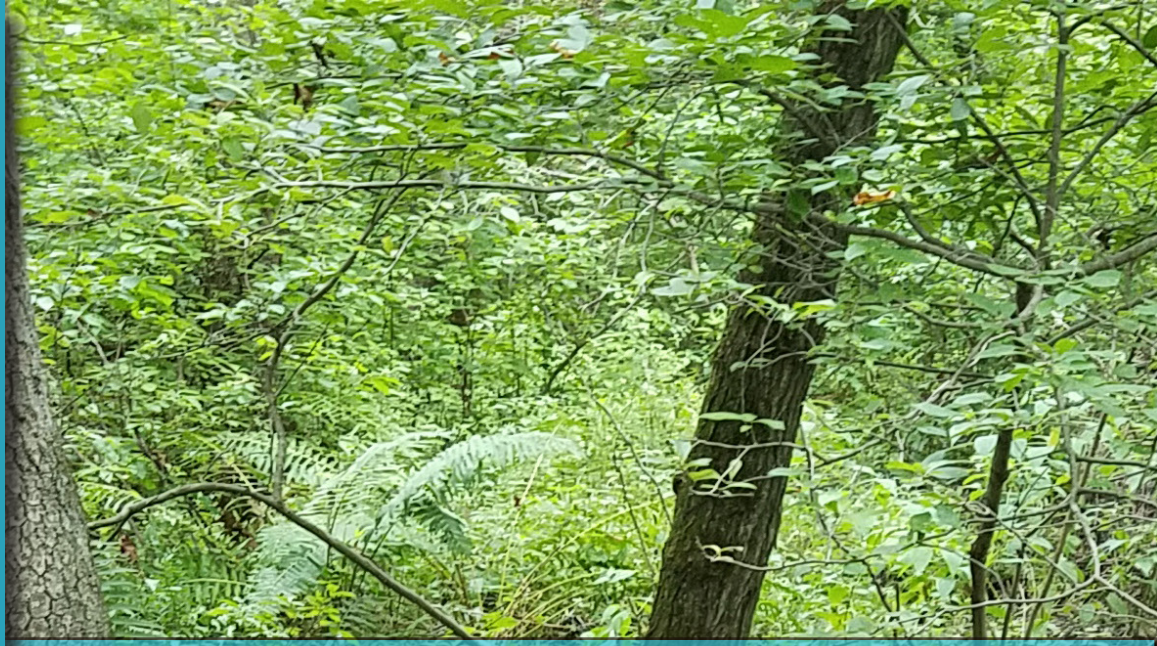
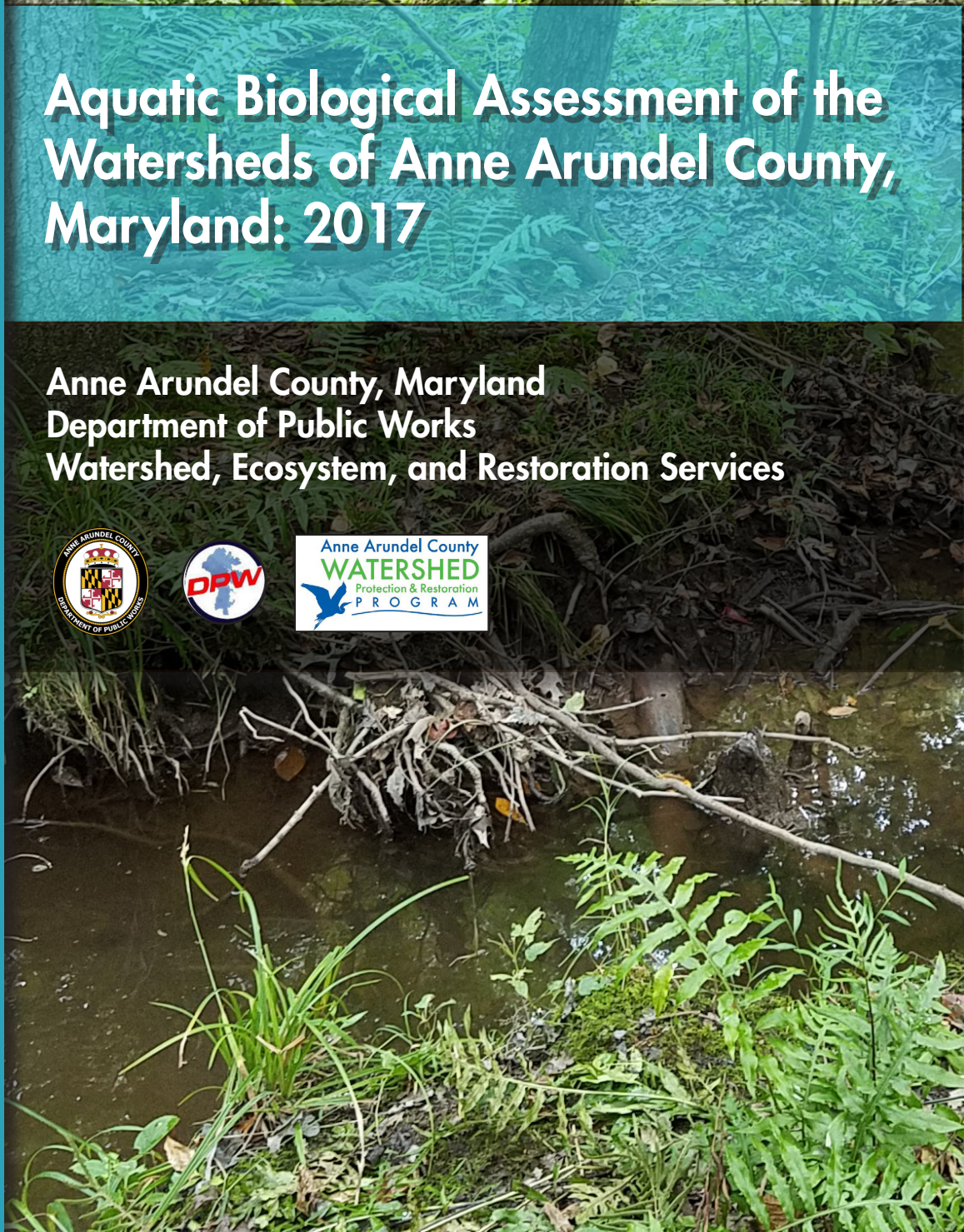






Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2017

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



Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2017 Round Three—Year One

June 2018 - Final

Prepared for:

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

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Abstract

The Anne Arundel County Department of Public Works' Watershed Protection and Restoration Program assesses water resource quality using a comprehensive countywide Biological Monitoring and Assessment Program. The primary goals of the Program are to document and track the ecological health of County streams and watersheds, identify the primary stressors on ecological health, and support natural resource management decision-making as it relates to the intended uses of County waterbodies and State regulations. One intended use of all water bodies is the support of aquatic life. A stream's ability to support aquatic life is assessed for the entire County through probabilistic (random) site selection, sampling of biological specimens, and observations of the physical habitat and water quality.

The County's assessment Program was continued in 2017 with sampling in five primary sampling units; Bodkin Creek, Rhode River, Severn River, Severn Run, and Upper North River (South 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).

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

More than one-half of reaches (approximately 58 percent) were slightly entrenched E channels and approximately 18 percent of the sites classified as C channels. Water quality measurements were within COMAR standards for turbidity at all sites during spring and summer. Sixteen of 40 sites in the spring and 13 of 32 sites in the summer had recorded pH values that fell below state standards of 6.5 standard units. For dissolved oxygen, six of 40 sites in the spring and 11 of 32 sites in the summer had measured DO concentrations below the 5.0 mg/L standard. Eighteen of 40 sites in the spring and 20 of 32 sites in the summer had conductivity values that exceeded 247 µS/cm threshold of BIBI impairment developed from MBSS data.

On average, BIBI scores improved in Bodkin Creek, declined in Severn Run, Severn River, and Rhode River, and remained the same in Upper North River from Round One and Two to Round Three. In addition, no consistent trend was detected between changes in BIBI scores and changes in cross-sectional area or substrate distribution.

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1 Introduction

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

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

The County initiated the Program, in part, to establish a baseline ecological stream condition for all of the County's watersheds and to track changes in condition over time. The Program is designed on a five-year rotating basis such that each of the County's 24 watersheds or primary sampling units (PSU) will be sampled once every five years. In general, four to five PSUs are sampled each year. During Rounds 1 and 2, 10 sites were sampled in each PSU. However, beginning in Round Three the sampling approach was revised to allow for sampling eight sites per PSU. Table 1 illustrates the progress made to date within the Program. The first sampling rotation, Round One, was completed from 2004-2008, while Round Two was completed from 2009-2013. Sampling efforts in 2017 mark the first year of Round Three sampling with 40 randomly selected sites sampled throughout five sampling units (i.e., 8 per PSU).

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

Table 1 - Summary of Bioassessment Progress

Year	Number of Sites	Primary Sampling Unit (code and name)		
Round 1				
2004	50	03-Lower Patapsco 09-Severn Run	10-Severn River 18-Middle Patuxent	21-Ferry Branch
2005	50	11-Upper North River 12-Lower North River	15-Herring Bay 19-Stocketts Run	22-Lyons Creek
2006	40	05-Marley Creek 06-Bodkin Creek	07-Upper Magothy 24-Hall Creek	
2007	50	01-Piney Run 02-Stony Run	08-Lower Magothy 16-Upper Patuxent	17-Little Patuxent
2008	50	04-Sawmill Creek 13-Rhode River	14-West River 20-Rock Branch	23-Cabin Branch
Round 2				
2009	50	05-Marley Creek 12-Lower North River	14-West River 17-Little Patuxent	20-Rock Branch
2010	50	02-Stony Run 04-Sawmill Creek	15-Herring Bay 18-Middle Patuxent	21-Ferry Branch
2011	50	06-Bodkin Creek 07-Upper Magothy	09-Severn Run 11-Upper North River	16-Upper Patuxent
2012	40	01-Piney Run 03-Lower Patapsco	13-Rhode River 24-Hall Creek	
2013	50	08-Lower Magothy 10-Severn River	19-Stocketts Run 22-Lyons Creek	23-Cabin Branch
Round 3				
2017	40	06-Bodkin Creek 09-Severn Run	10-Severn River 11-Upper North River	13-Rhode River

1.1 Purpose of Biological and Physical Habitat Assessment

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

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

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

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

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

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

2 Methods

2.1 Network Design

2.1.1 Summary of Sampling Design

The sampling design uses a stratified random sampling approach, stratified by stream order. Details of the overall sampling program design, including the approach for the selection of sampling locations, can be found in Design of the Biological Monitoring and Assessment Program for Anne Arundel County, Maryland (Southerland et al, 2016; Hill and Stribling, 2004). Stream assessment protocols including documented standard operating procedures (SOPs) for data collection, sample processing, taxonomic identification, and data management, the technical rationale behind the procedures, and the series of activities and reporting procedures that are used to document and communicate data quality are included in Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan (QAPP) (Anne Arundel County, 2017). Documentation of data quality and method performance characteristics, including measurement and data quality objectives (MQOs and DQOs), are presented in Hill and Pieper (2011a).

2.1.2 Site Selection

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

For 2017, sites were randomly selected from each of the following PSUs (with PSU code); Bodkin Creek (06), Rhode River (13), Severn River (10), Severn Run (09), and Upper North River (11). Figure 1 shows the geographic distribution of PSUs assessed during this sampling period. Sampling was conducted at eight sites in each of the five PSUs during 2017. 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.

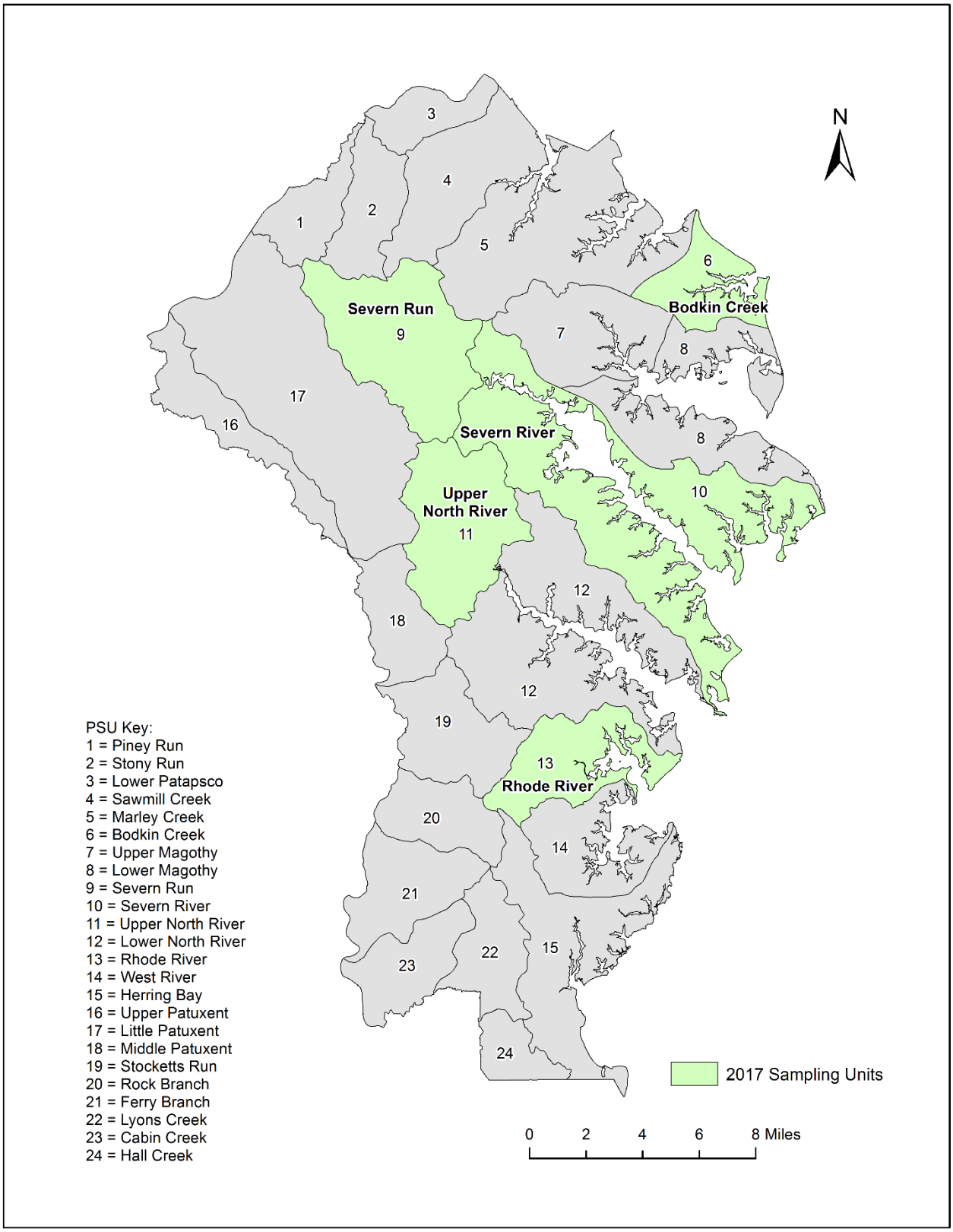


Figure 1 - 2017 Sampling Units

2.2 Field and Laboratory Procedures

2.2.1 Stream Physical Habitat Assessment

Each biological monitoring site was characterized based on visual observation of physical characteristics and various habitat parameters. Both the EPA's Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al., 1999) and the Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI; Paul et al., 2003) were used to visually assess the physical habitat at each site. Both physical habitat assessment methods were completed during the Spring and Summer assessments. Both assessment techniques rely on subjective scoring of selected habitat parameters. To reduce individual sampler bias, both assessments were completed as a team with discussion and agreement of the scoring for each parameter. In addition to the visual assessments, photo-documentation of the assessment reach was performed. Photographs were taken from three locations within the sampling reach (downstream end, mid-point, and upstream end) facing in the upstream and downstream direction to document general reach conditions, Four additional photographs were taken at the cross section location facing in the upstream, downstream, left bank, and right bank directions, documenting the channel conditions at the cross section for a total of ten photographs per site. Additional photographs were occasionally taken to document important or unusual site features.

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health. Each parameter is given a numerical score from 0-20 (20=best, 0=worst), or 0-10 (10=best, 0=worst) for individual bank parameters, and a categorical rating of 'Optimal', 'Suboptimal', 'Marginal', or 'Poor'. Overall habitat quality typically increases as the total score for each site increases. The RBP parameters assessed for low gradient streams are listed in Table 2.

Table 2 - RBP Low Gradient Habitat Parameters

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

Source: Barbour et al. 1999

The PHI incorporates the results of a series of habitat parameters selected for Coastal Plain, Piedmont, and Highlands regions. While all parameters are rated during the field assessment, the Coastal Plain parameters are used to develop the PHI score. In developing the PHI, MBSS identified six parameters that have the most discriminatory power for the Coastal Plain streams (Table 3). Each habitat parameter is given an assessment score ranging from 0-20, with the exception of shading (percentage) and woody debris and rootwads (total count).

Table 3 - PHI Habitat Parameters

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

Source: Paul et al. 2003

2.2.2 Benthic Macroinvertebrate Sampling and Processing

Benthic macroinvertebrate samples were collected during the Spring Index Period (March 1 through April 30) following the sampling protocols in the QAPP, which closely mirrors MBSS procedures (Stranko et al. 2017). The approach was used to sample a range of the most productive habitat types within the reach. In this multi-habitat sampling approach, a total of twenty jabs sampling approximately 1 square foot of habitat per jab are distributed among the most productive habitats present within the 75-meter reach and sampled in proportion to their dominance within the segment using a D-frame net. The most productive stream habitats are riffles followed by, rootwads, rootmats and woody debris and associated snag habitat; leaf packs; submerged macrophytes and associated substrate; and undercut banks. Less preferred habitats include gravel, broken peat, and clay lumps located within moving water and detrital or sand areas in runs.

All sorting and identification of the subsampled specimens was conducted by EcoAnalysts, Inc., which currently holds certification for laboratory sorting by the MBSS and employs taxonomists who hold taxonomic identification certification from the Society for Freshwater Science. Benthic macroinvertebrate samples were processed and subsampled according to the County QAPP and based on the methods described by Caton (1991). Subsampling is conducted to standardize the sample size and reduce variation caused by samples of different size. In this method, the sample is spread evenly across a gridded tray (30 total grids) and each grid is picked clean of organisms until a minimum count of 100 is reached. If the initial count exceeds 120 organisms, the sample is further subsampled using a gridded petri dish until the final count is between 100 and 120 organisms. If there were any samples containing greater than 120 organisms after taxonomic identification and enumeration, a post-processing subsampling procedure was conducted using an Excel spreadsheet application (Tetra Tech, 2006). This post-processing application is designed to randomly subsample all identified organisms within a given sample to a desired target number. Each taxon is subsampled based on its original proportion to the entire sample. In this case, the desired sample size selected was 110 individuals. This allows for a final sample size of approximately 110 individuals (±20 percent) but keeps the total number of individuals below the 120 maximum.

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

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

2.2.3 Fish Sampling

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

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

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

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

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

2.2.4 Water Quality Sampling

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

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

Table 4 - Water Quality Parameters

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

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

To supplement the water quality grab sampling, *in situ* water quality measurements were taken at each site during both the spring and summer sampling visits. Field measured water chemistry parameters include pH, specific conductivity, dissolved oxygen, temperature, and turbidity. All measurements were collected from the upstream end of the site, prior to any other sampling activites to ensure that measurements were not influenced by sampling activities within the stream. *In situ* parameters (i.e., temperature, pH, specific conductivity, and dissolved oxygen, turbidity) were measured with either a YSI ProDSS or a YSI Professional Plus series multiprobe. At some sites, however, turbidity was measured with a Hach 2100 Turbidimeter. Water quality meters were regularly inspected, maintained, and calibrated to ensure proper usage and accuracy of the readings. Calibration logs were kept by field crew leaders and checked by the project manager regularly.

2.2.5 Geomorphic Assessment

Geomorphic assessments, which included a cross section survey, a simplified longitudinal profile survey for measurement of channel slope, and a modified Wolman pebble count, were conducted within each 75-meter sampling reach. Data were directly entered into the Ohio Department of Natural Resources (ODNR) Reference Reach Spreadsheet Version 4.3L (Mecklenburg, 2006) in the field using a computer loaded with Microsoft Excel software. Data collected from the assessments were primarily used to determine the morphological stream type of each sampling reach according to the Rosgen Stream

Classification (Rosgen, 1994, 1996). Assessment methods followed the standard operating procedures (SOPs) described in the QAPP, and are described briefly below.

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

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

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

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

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

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

2.3 Data Analysis

2.3.1 Data Structure

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

2.3.2 Physical Habitat

The individual RBP habitat parameters for each reach were summed to obtain an overall RBP assessment score. The total score was then placed into one of four categories based on their percent comparability to reference conditions (Table 5). Since adequate reference condition scores do not currently exist for Anne Arundel County, the categories used in this report were adapted from Plafkin et al. (1989) and are based on western Coastal Plain reference conditions obtained from Prince George's County streams using a score 168 (Stribling et al., 1999).

Using the raw habitat values recorded in the field, a scaled PHI score (ranging from 0-100) for each parameter is calculated following the methods described in Paul et al. (2003). Several of the parameters (i.e., epifaunal substrate, instream habitat, and woody debris and rootwads) have been found to be drainage area dependent and are scaled according to the drainage area to each site. A detailed description of the procedure used to delineate site-specific drainage areas is included in section 2.3.7 *Land Use Analysis and Impervious Surface*. Calculated metric scores are then averaged to obtain the overall PHI index score, and a corresponding narrative rating of the physical habitat condition is applied (Table 6).

Table 5 - EPA RBP Scoring

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

Source: Stribling et al. 1999

Table 6 - MBSS PHI Scoring

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

Source: Paul et al. 2003

2.3.3 Biological Index Rating

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

Raw values from each metric are given a score of one (1), three (3) or five (5) based on ranges of values developed for each metric, as shown in Table 7. The scored metrics are combined and averaged into a scaled BIBI score ranging from 1.00 to 5.00, and a corresponding narrative biological condition rating is assigned (Table 8). Three sets of metric calculations have been developed for Maryland streams based on broad physiographic regions, which include the Coastal Plain, Piedmont, and Combined Highlands regions. Anne Arundel County is located entirely within the Coastal Plain region; therefore, the metrics selected and calibrated specifically for Maryland Coastal Plain streams were used for the BIBI scoring and include:

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

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

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

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

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

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

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

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

Table 7 - MBSS Coastal Plain BIBI Metric Scoring

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

Source: Southerland et al. 2005

Table 8 - MBSS Biological Condition Rating

BIBI Score	Narrative Rating	Characteristics
4.00 – 5.00	Good	Comparable to reference streams considered to be minimally impacted.
3.00 – 3.99	Fair	Comparable to reference conditions, but some aspects of biological integrity may not resemble minimally impacted streams.
2.00 – 2.99	Poor	Significant deviation from reference conditions, indicating some degradation.
1.00 – 1.99	Very Poor	Strong deviation from reference conditions, with most aspects of biological integrity not resembling minimally impacted streams indicating severe degradation.

2.3.4 Fish Index Analysis

Fish data for all sites were analyzed using methods developed by MBSS as outlined in the *New Biological Indicators to Better Assess the Condition of Maryland Streams* (Southerland et al. 2005). The IBI approach involves statistical analysis using metrics that have a predictable response to water quality and/or habitat impairment. Raw values from each metric were assigned a score of one (1), three (3) or five (5) based on ranges of values developed for each metric. The results were combined into a scaled FIBI score, ranging from 1.00 to 5.00, and a corresponding narrative rating of 'Good', 'Fair', 'Poor' or 'Very Poor' was applied, again in accordance with standard practice.

Four sets of FIBI metric calculations have been developed for Maryland streams. These include the Coastal Plain, Eastern Piedmont, and warmwater and coldwater Highlands. All sites were located in the Coastal Plain region, therefore, 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.

Table 9 – Fish Metric Scoring for the Coastal Plain FIBI

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

*Adjusted for catchment size

Table 10 – MBSS FIBI Condition Ratings

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

2.3.5 Water Quality

The water quality grab sample parameters were compared against published acute and chronic water quality criteria for aquatic life and criteria for toxic substances in surface waters (Table 11) for each corresponding parameter. MBSS has established water quality ranges for nutrients from the distribution of concentrations from the MBSS dataset and published in Southerland et al. (2005), which are listed in Table 12. The Maryland Department of the Environment (MDE) has established acceptable standards for several of the water chemistry parameters measured in this study for each designated Stream Use Classification. All sites sampled during 2017 were located on streams listed as Use Class I in *Code of Maryland Regulations (COMAR) 26.08.02.08 – Stream Segment Designations.* Water quality data were compared to acceptable standards for the appropriate designated use listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality* (Table 13). Specific designated uses for Use I streams include water contact sports, fishing, the growth and propagation of fish, and agricultural, and industrial water supply. Currently, there are no standards available for specific conductivity. However, Morgan et al. (2007) identified a critical threshold of impairment of BIBI scores for Maryland streams at 247 µS/cm. Furthermore, Morgan et al. (2012) identified a critical threshold of 469 µS/cm for fish within the Coastal Plain physiographic region.

Table 11 - Water Quality Criteria

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

** EPA National Recommended Water Quality Criteria for Aquatic Life

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

Table 12 - MBSS Water Quality Ranges for Nutrients

Parameter	Low	Moderate	High
Nitrate (NO3)	< 1.0	1.0 – 5.0	> 5.0
Nitrite (NO2)	<	0.0025 – 0.01	> 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

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
- D_{50}

Data from the geomorphic assessments were used to determine the stream type of each reach as categorized by the Rosgen Stream Classification (Rosgen, 1996). In this classification method, streams are categorized based on their measured values of entrenchment ratio, width/depth ratio, sinuosity, water surface slope, and channel materials. General descriptions for each major stream type (i.e., A, G, F, B, E, C, D and DA) and delineative criteria for broad level (Level I) classification are provided in Table 14. Rosgen Level II characterization incorporates a numeric code (1 – 6) for dominant bed materials and a slope range modifier (i.e., a+, a, b, c, or c-) to provide a more detailed morphological description. For instance, a G type stream with gravel dominated bed and a water surface slope of less than two percent would be classified as a G4c stream.

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

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

Source: Rosgen, 1996

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

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

2.3.7 Land Use Analysis and Impervious Surface

All geospatial analysis was performed using Countywide GIS coverages in ArcGIS 10.5.1. Land use analysis was completed with the use of the County's 2014 Land Cover GIS layer. Original land cover categories were combined into four primary land use classes to better summarize the conditions in the sampling units (Table 15). The County's 2014 impervious layer was used to assess imperviousness to each site. Site specific land use and impervious surface analysis was completed using drainage areas delineated to each sampling point. The drainage area to each point was delineated using Anne Arundel County's raster grid digital elevation model (DEM) and flow accumulation grid using ESRI's ArcMap 10.3.1. Bioassessment sampling points were snapped to the closest point on the new stream grid generated from the DEM; then, batch sub-watersheds were generated using these three files. Subwatersheds were then summed where necessary to generate the appropriate drainage area to each bioassessment site.

Table 15 - Combined Land Use Classes

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

3 Results and Discussion

This section first discusses the overall results across the 2017 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 2017. 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
Bodkin Creek	79.77 ± 9.67 Partially Degraded	138.63 ± 12.74 Supporting	2.54 ± 0.51 Poor	2.29 ± 0.57 Poor
Rhode River	70.94 ± 12.32 Partially Degraded	133.75 ± 10.91 Supporting	2.36 ± 0.52 Poor	1.46 ± 0.85 Very Poor
Severn River	73.09 ± 9.49 Partially Degraded	133.50 ± 17.46 Supporting	2.57 ± 0.51 Poor	2.08 ± 0.61 Poor
Severn Run	65.25 ± 8.33 Degraded	127.50 ± 13.63 Supporting	2.82 ± 1.17 Poor	2.17 ± 0.92 Poor
Upper North River (South River)	70.04 ± 7.77 Partially Degraded	119.0 ± 21.40 Partially Supporting	2.68 ± 0.74 Poor	3.08 ± 1.57 Fair

3.1.1 Biological and Habitat Assessment Summary

Overall, the majority of BIBI scores throughout the sampling units were split between a rating of 'Poor' (55 percent) and Fair (25 percent), with a small proportion of sites rated as 'Very Poor' (15 percent) and

only three sites rated as 'Good' (five percent; Figure 2). All sampling units had mean BIBI values that equate to 'Poor' biological condition ratings (Table 16).

The vast majority of sites sampled had FIBI condition ratings of 'Poor' (32.5%) or 'Very Poor' (40.0%) and only a small percentage of sites rated 'Good' (7.5%) or 'Fair' (20.0%; Figure 2). Three sampling units (Bodkin Creek, Severn River, Severn Run) had mean FIBI scores equating to a 'Poor' biological condition rating (Table 16). Rhode River was the sampling unit with the lowest mean FIBI score (1.46) equating to a 'Very Poor' condition rating. Upper North River (South River) had the highest mean FIBI rating of the sampling units from 2017, with a 3.08 mean equating to a 'Fair' biological condition rating. This large proportion of sites scoring 'Very Poor' is influenced by ten sites that were either dry (eight sites) or had no fish observed (two sites) during the summer 2017 visit.

Physical habitat conditions were assessed twice in 2017 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 four of the five sampling units, as determined by the sampling unit mean, received ratings of 'Supporting' and one received 'Partially Supporting' (RBP; Table 16). Over half (53 percent) of the total sites sampled resulted in a RBP rating of 'Supporting,' and approximately one-third of the samples (38 percent) resulted in a 'Partially Supporting' rating (Figure 3). Only a small proportion of sites were rated as either 'Non Supporting' (3 percent) or 'Comparable to Reference' (8 percent).

Four sampling units assessed during the summer season received a PHI rating of 'Partially Degraded', as determined by the sampling unit mean. The one remaining sampling unit received a rating of 'Degraded' (Table 16). Over half of the total sites sampled resulted in a PHI rating of 'Partially Degraded' (53.1 percent), one quarter of the sites received 'Degraded' ratings (25.0 percent), and 21.9 percent resulted in 'Minimally Degraded' ratings. It is important to note that a total of eight sites were dry during the summer season assessment: 13-L1M-03-17, 13-L1M-04-17 and 13-L2M-03-17 in the Rhode River unit; 10-L1M-05-17 in the Severn River unit; 09-L2M-02-17 and 09-R3M-04-17 in the Severn Run unit; and 11-L1M-04-17 and 11-R3M-08-17 in the Upper North River Unit. For that reason, the habitat assessment was not performed and the dry sites did not receive a PHI rating.

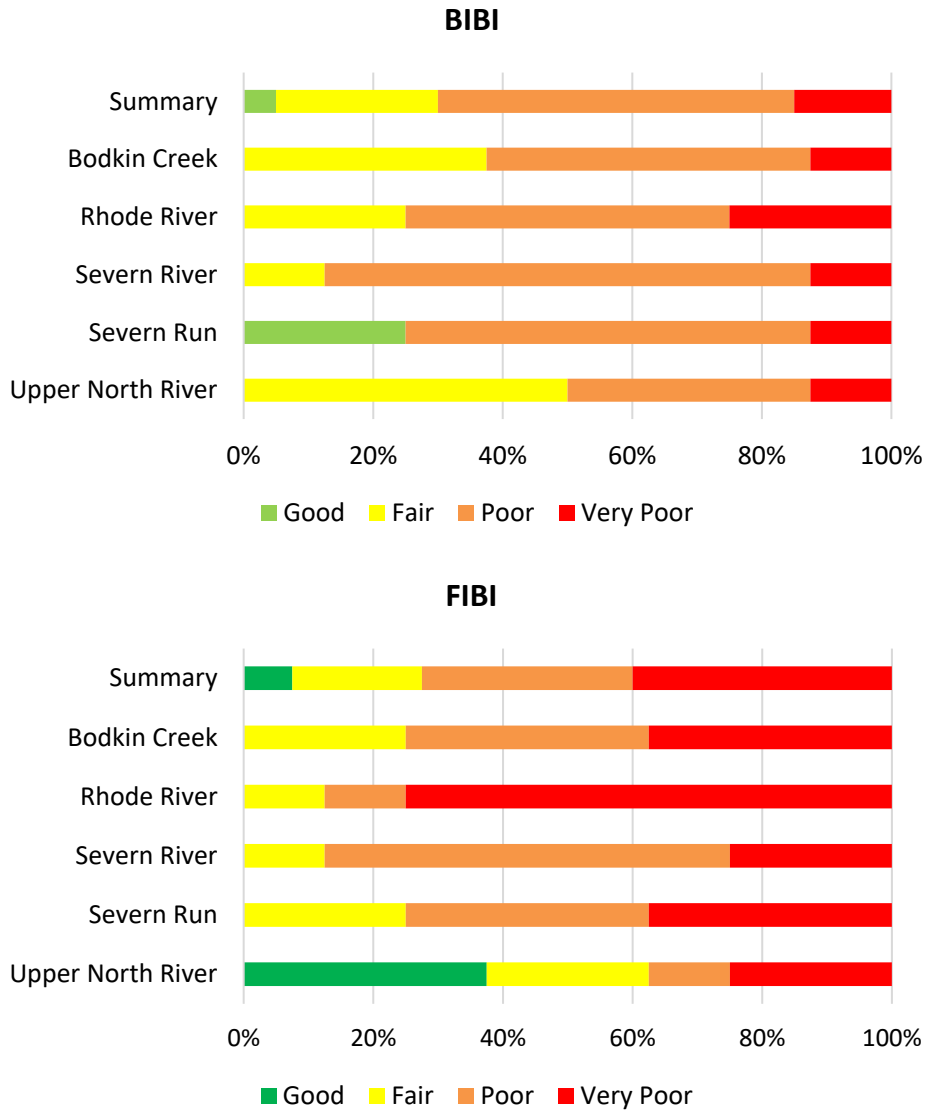


Figure 2 - Summary of biological conditions for sites assessed in 2017 (n=40)

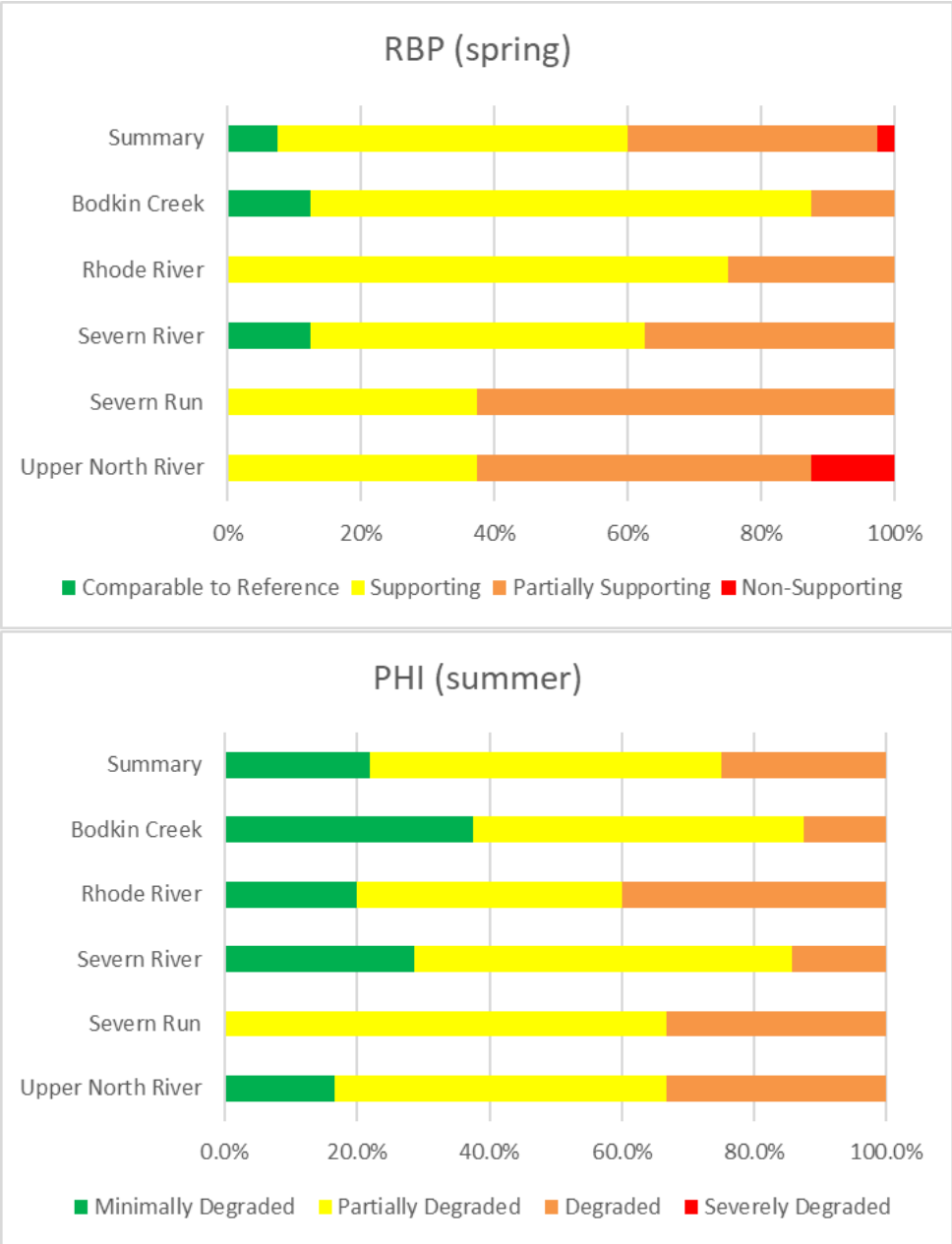


Figure 3- Summary of physical habitat conditions for sites assessed in 2017 (RBP n=40; PHI n=32)

3.1.2 Water Quality Assessment Summary

In situ water quality measurements were within COMAR standards for 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), were recorded at 16 sites spanning all five sampling units in the spring and 13 sites spanning four of the five sampling units in the summer. The pH values ranged from 5.73 to 6.46 in the spring and 5.02 to 6.35 in the summer, for the sites that did not meet COMAR standards for water quality. Low DO values, which were outside the acceptable range of values set forth by COMAR (i.e., >5 mg/L), were recorded at six sites spanning four of the five sampling units in the spring and 11 sites

spanning all five sampling units in the summer. The DO values ranged from 3.78 to 4.68 mg/L in the spring and 0.48 to 4.97 mg/L in the summer, for the sites that did not meet COMAR criteria. Approximately half of the sites sampled in the spring (i.e., 18 sites) and summer (i.e., 20 sites) had conductivity values that exceeded 247 µS/cm, which is the critical threshold between 'Fair' and 'Poor' stream quality determined for urban Maryland streams, based on BIBI scores (Morgan et al., 2007). All Use I and Use IV streams were within their designated criteria for temperature in 2017 (i.e., <32 °C and <23.9 °C, respectively). However, one site in the Severn Run sampling unit, the only Use III site sampled in 2017, slightly exceeded COMAR standards (i.e. <20 °C) during the summer visit, with a value of 20.6 °C.

Although variable by site, the average chloride concentration was fairly consistent across sampling units sampled in 2017, ranging from 40.71 to 52.19 mg/L. All chloride values met EPA standards for acute (i.e., <230 mg/L) and chronic (i.e., <860 mg/L) exposure.

With the exception of one site, all 2017 sites met COMAR or EPA standards for heavy metal concentrations. In the Bodkin Creek sampling unit, one site exceeded COMAR standards for chronic lead concentration (i.e., <2.5 µg/L), with a value of 3.2 µg/L. For total nitrogen, nitrite, and nitrate, all 2017 sites fell in the low or moderate categories used by MBSS. Twenty percent of sites sampled in 2017 fell in the high category used by MBSS for total phosphorus (i.e., >0.07 mg/L), with values ranging from 0.073 to 0.327 mg/L. The majority of these sites were located in the Rhode River sampling unit. Only one site fell in the high category used by MBSS for orthophosphate concentration (i.e., >0.03 mg/L). This site was located in the Rhode River sampling unit and had a value of 0.048 mg/L. Forty percent of sites sampled in 2017 fell in the high category used by MBSS for total ammonia (i.e., >0.07 mg/L), with values ranging from 0.078 to 0.273 mg/L. The majority of these sites were located in the Upper North River sampling unit. No water quality criteria exist for dissolved organic carbon (DOC), total organic carbon (TOC), magnesium, calcium, or hardness, however average values for these parameters were similar among sampling units, ranging from 1.26 to 5.98 mg/L for DOC, 1.39 to 6.06 mg/L for TOC, 3.00 to 4.16 mg/L for magnesium, 7.87 to 19.59 mg/L for calcium, and 33.42 to 62.98 mg/L for hardness.

3.1.3 Geomorphic Assessment Summary

Stream types throughout the sampling units were highly variable, with the largest portion of the sites being slightly entrenched E channels (57.5 percent; Figure 4). Approximately 18 percent of the sites were classified as C channels, the majority of which were located in the Bodkin Creek, Rhode River, and Severn Run sampling units. Fifteen percent of the sites were classified as entrenched F channels, the majority of which were located in the Rhode River and Upper North River sampling units. Five percent of the sites were classified as type G channels and found only in the Upper North River. Comprising 2.5 percent, anastomosed DA type channels were found only in the Severn River. The remaining 2.5 percent of sites were placed into the 'ND' (Not Determined) category due to considerable anthropogenic modification (i.e., channel alteration, hardened banks) or due to natural influences which inhibit channel classification (i.e., beaver dams). A major assumption of the Rosgen characterization 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 sites were classified as 'Transitional'.

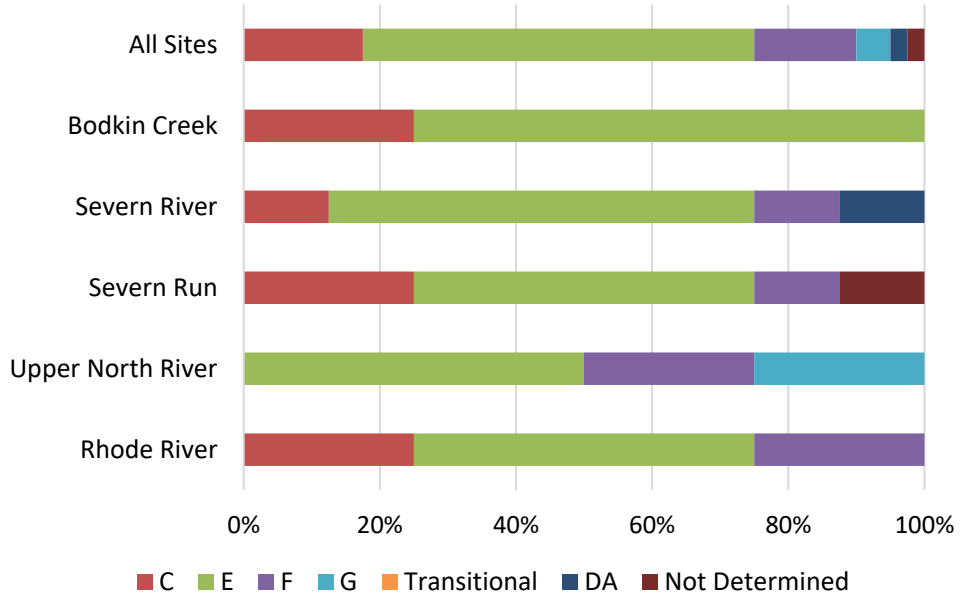


Figure 4 - Distribution of Rosgen stream types for sites assessed in 2017 (n=40)

Over two-thirds of sites sampled in 2017 (70 percent) had channel substrate composed primarily of sand. Silt/clay dominated streams comprised under one-fourth (17.5 percent) of the total sites. The remaining 12 percent of sites had predominantly gravel channel substrates (5 percent), or were had equal amounts of sand and silt/clay (5.1 percent), or gravel and sand (2.6 percent). Stream slopes in the assessment reaches were generally low (i.e., below one percent). The average slope of all reaches assessed was 0.44 percent. Average slopes for the sampling units ranged from 0.24 percent in Rhode River to 0.58 percent in Severn Run.

3.1.4 Land Use Analysis and Impervious Surface Summary

A summary of land use and impervious surface across each sampling unit assessed in 2017 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
Bodkin Creek	5,872	13.6	53.4	35.7	0.9	10.0
Severn Run	15,424	19.6	52.6	37.1	2.9	7.4
Severn River	28,920	19.9	58.5	31.1	2.8	7.6
Upper North River	12,797	7.0	37.6	48.9	9.3	4.2
Rhode River	8,737	6.1	28.4	51.5	13.7	6.4

More than one-half of the sites sampled in 2017 had developed land as the dominant land use (55 percent), while the remaining sites were dominated by forested land (45 percent). At the sampling unit scale, Severn River had the highest percentage of developed land at 58.5 percent of the total acreage, which was followed by Bodkin Creek at 53.4 percent (Table 17). With over 50 percent of the drainage area comprised of developed land, Severn Run, Bodkin Creek, and Severn River can be considered urbanized subwatersheds. In contrast, Rhode River was the least developed, with 28.4 percent of the sampling unit attributed to developed land. Developed land was also low in Upper North River (37.6 percent), which along with Rhode River were the least developed PSUs of the five PSUs sampled during 2017. Rhode River and Upper North River had the highest proportion of forested land at 51.5 and 48.9, respectively, while Severn River, Bodkin Creek, and Severn Run had the lowest proportion (31.1, 35.7, and 37.1 percent, respectively). The highest proportion of agricultural land use occurred in Rhode River at 13.7 percent, followed by Upper North River at 9.3 percent. In contrast, agricultural land use was not as predominant in Severn Run (2.9 percent), Severn River (2.8 percent), and Bodkin Creek (0.9 percent). Figure 5 shows land use for the entire County based on the County's 2014 Land Cover GIS layer. The sampling units with the highest percentage of impervious surface were Severn River (19.9 percent), Severn Run (19.6 percent), and Bodkin Creek (13.6 percent), while Rhode River had the lowest percentage of impervious surface (6.1 percent). Figure 6 shows impervious surface for the entire County based on the County's 2014 Impervious GIS layer.

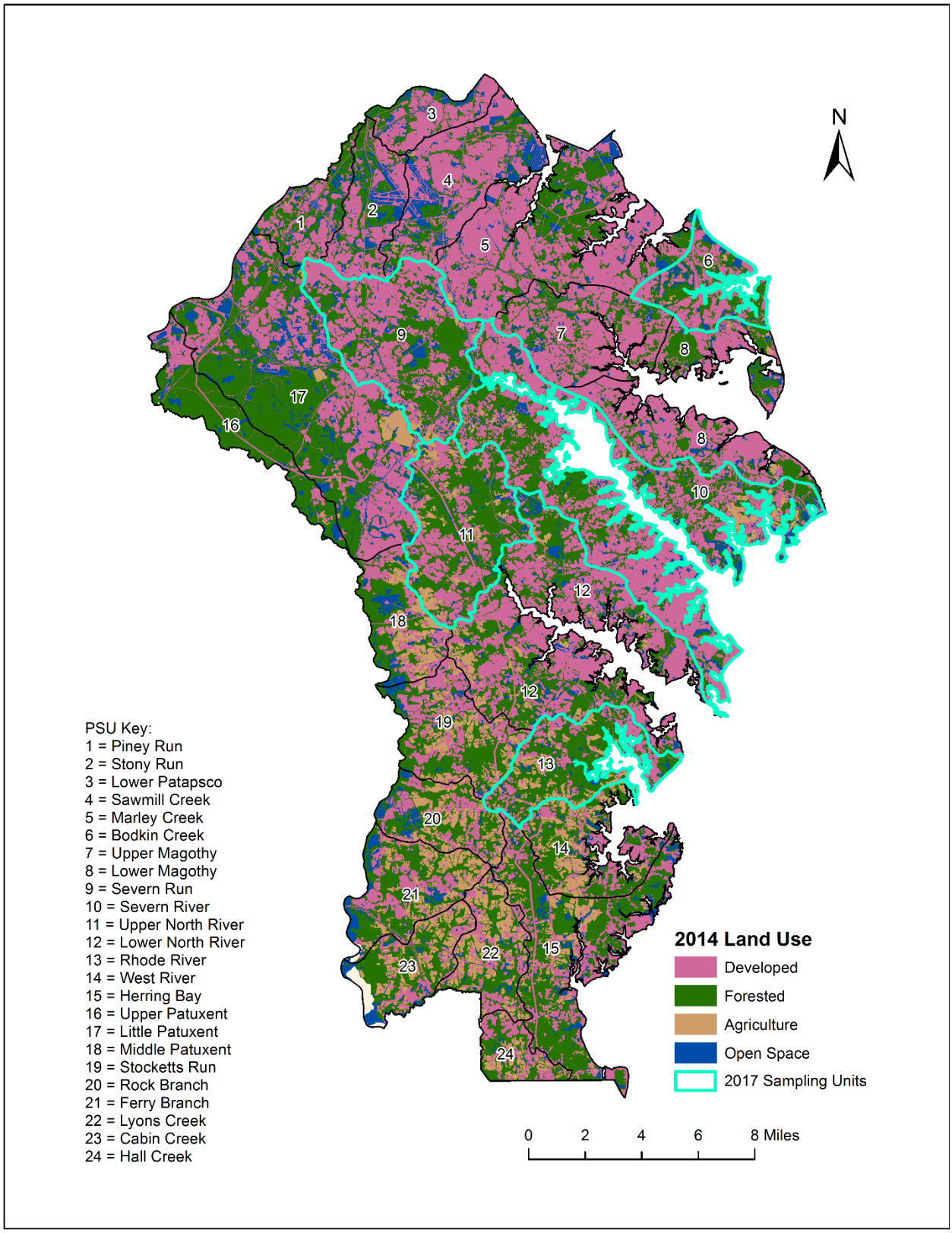


Figure 5 - Summarized land use in Anne Arundel County (2014)

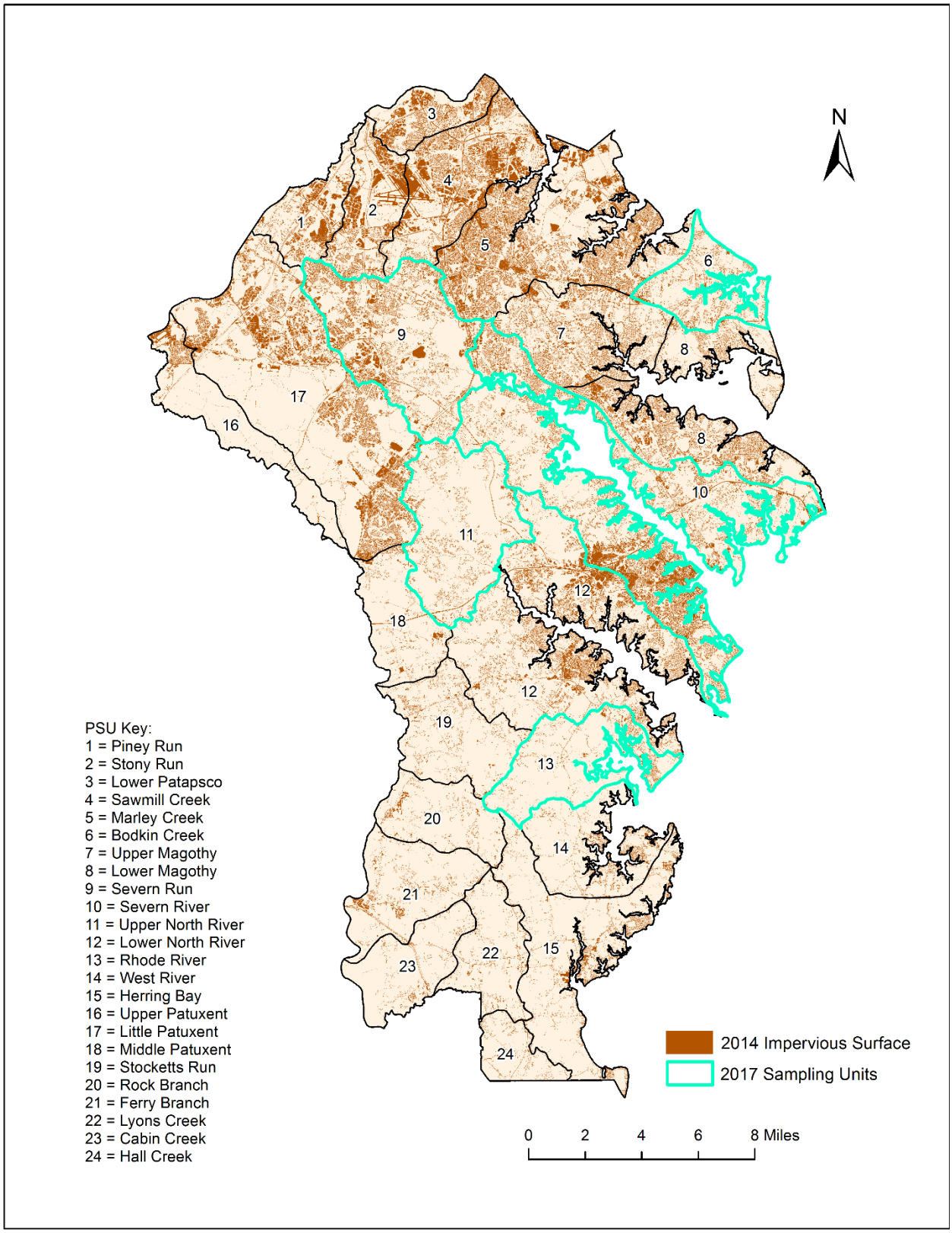


Figure 6 - Impervious surface in Anne Arundel County (2014)

4 Individual Sampling Unit Discussions

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

4.1 Bodkin Creek

The Bodkin Creek sampling unit, located in the northeastern edge of the County (Figure 7), has a total drainage area of 5,872 acres and drains directly into Bodkin Creek, which drains into the Chesapeake Bay. The eight sampling sites, all 1st order streams, shown in Figure 10, have drainage areas ranging from 215 to 761 acres. The dominant land use for the Bodkin Creek sampling unit is developed land (53 percent), followed by forested land (36 percent), open land (10 percent), and agriculture (1 percent) (Table 17). The land use distribution within the sampling unit was similar to the average land use among sampling sites. Seven of eight sites had developed land as the largest land use category in the upstream drainage area, and the eighth site had forested land use as the largest category (Figure 8). Impervious surfaces comprise 13.6 percent of the overall Bodkin Creek sampling unit (Table 17), with individual sites ranging from 10.6 percent to 14.1 percent impervious surface.

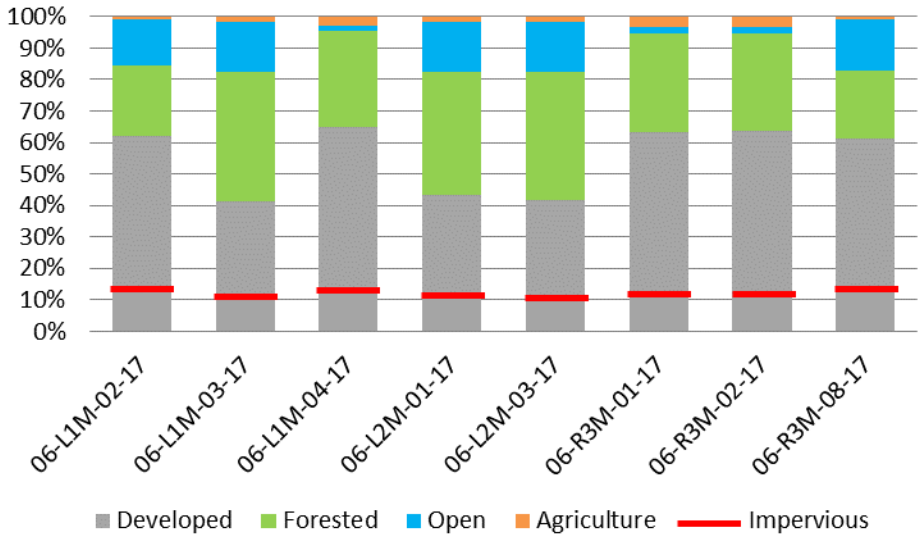


Figure 7 - Bodkin Creek land use

4.1.1 Physical Habitat

Physical habitat conditions were fairly variable for this sampling unit during the spring season. Based on the RBP scores, 75.0 percent of the Bodkin Creek sites received a rating of "Supporting," 12.5 percent received a "Partially Supporting" rating, and the remainder 12.5 percent of sites were classified as 'Comparable to Reference' (Figure 8). The average RBP score for the Bodkin Creek sampling unit was 138.63 ± 12.74, and the corresponding narrative rating was 'Supporting'. Individual site scores ranged from 124 ('Partially Supporting') to 161 ('Comparable to Reference'), which was one of the highest scoring sites in 2017.

According to the PHI (summer season), 50.0 percent of the Bodkin Creek sites were rated as 'Partially Degraded', 37.5 percent received a rating of 'Minimally Degraded', and 12.5 percent were rated as

'Degraded' (Figure 8). The average PHI rating was 'Partially Degraded' with a score of 79.77 ± 9.67. Individual site scores ranged from 61.33 ('Degraded') to 91.57 ('Minimally Degraded'). Note that the Bodkin Creek was the only sampling unit that did not have any dry sites during the summer assessment season. Bank stability, instream woody debris, instream habitat, and vegetative bank protection were variable between reaches. Embeddedness and shading received 'Optimal' to 'Suboptimal' scores at the Bodkin Creek sites.

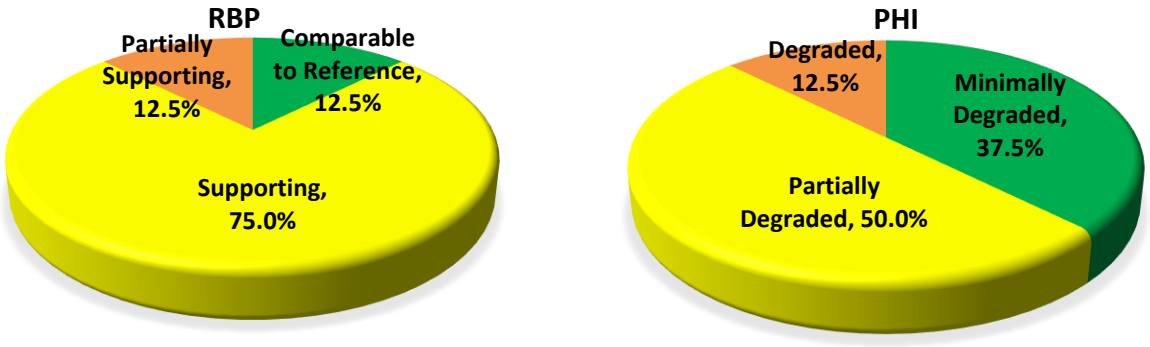


Figure 8 - Bodkin Creek Physical Habitat Conditions (RBP n=8; PHI n=8)

4.1.2 Benthic Macroinvertebrates

Of the eight sites sampled in Bodkin Creek, 50.0 percent of sites received a BIBI rating of 'Poor' while 37.5 percent of the sites were 'Fair,' and the remaining 12.5 percent were rated as 'Very Poor' (Figure 10). The average BIBI score for the Bodkin Creek sampling unit is 2.54 ± 0.51, with an average biological condition of 'Poor'. Individual BIBI scores ranged from 1.86 ('Very Poor') to 3.29 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

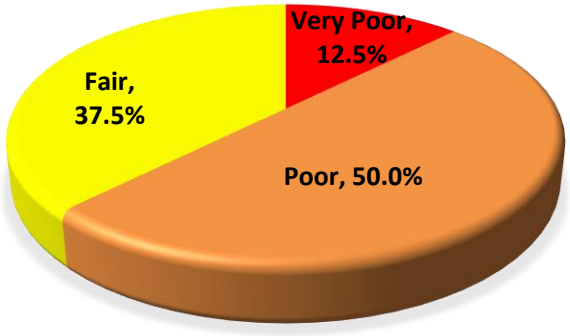


Figure 9 - Bodkin Creek BIBI Conditions (n=8)

Site 06-R3M-02-17 (Figure 10) received the lowest BIBI score of 1.86 and was the only site in this sampling unit to receive a biological rating of 'Very Poor.' The stream segment in question displays low to moderate scores for instream habitat, epifaunal substrate and woody debris. The site had relatively low total taxa (14), it lacked Ephemeroptera taxa, and only one scraper taxa was identified at the sampling site. On the other hand, site 06-L1M-03-17 received the highest BIBI score, with a score of 3.29 and a 'Fair' biological rating. This site had a high number of total taxa (29), including six EPT taxa, and over 30 percent of the sample consisted of individuals intolerant to urban stressors.

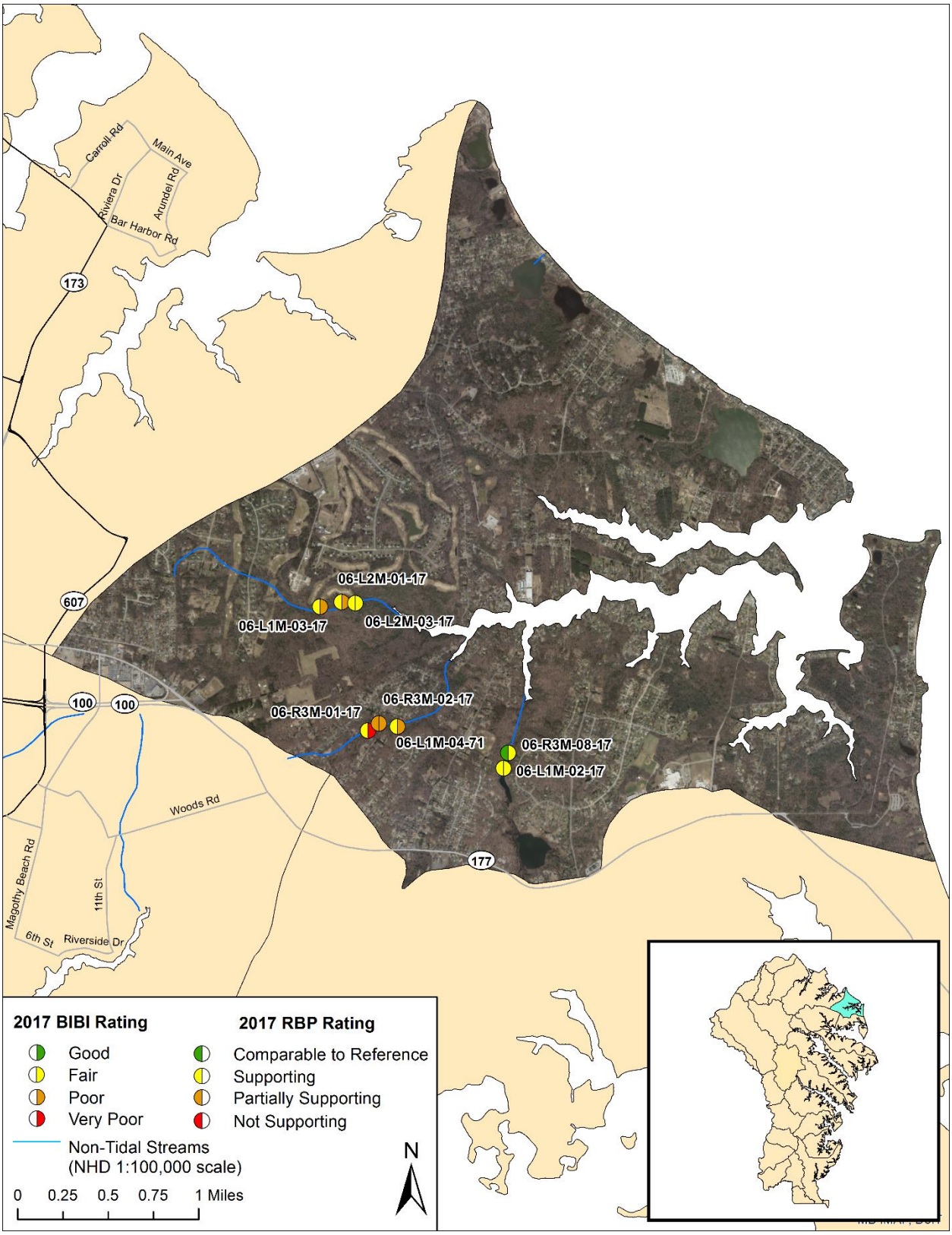


Figure 10 - Bodkin Creek Sampling Sites (BIBI and RBP)

4.1.3 Fish

The Bodkin Creek sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.29 ± 0.57. Twenty-five percent of the individual sites received a biological condition rating of 'Fair', 37.5 percent received a 'Poor' rating, and the remaining 37.5 percent of sites were rated as 'Very Poor' (Figure 12). Individual FIBI scores ranged from 1.67 ('Very Poor') to 3.00 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

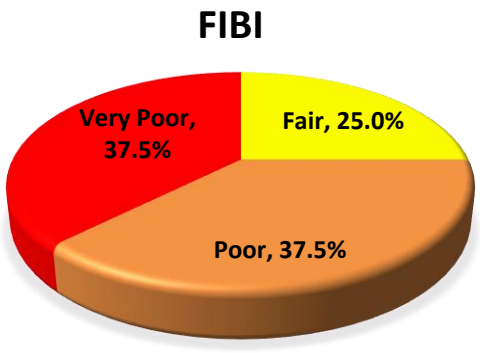


Figure 11 – Bodkin Creek FIBI Conditions (n=8)

Sites 06-L1M-04-17, 06-R3M-01-17, and 06-R3M-02-17 received the lowest FIBI scores of all Bodkin Creek sites (1.67) with a narrative rating of 'Very Poor.' These sites scored in the lowest category (1) for all metrics except abundance per square meter, where they each scored in the highest category (5). Sites 06-L1M-02-17 and 06-R3M-08-17 received the highest FIBI scores (3.00; 'Fair') in the Bodkin Creek sampling unit. Both sites scored in the highest category for abundance per square meter and percent abundance of dominate taxon; in the middle category for both percent tolerant and percent generalist, omnivores, and invertivores; and in the lowest category for both adjusted number of benthic species and percent round-bodied suckers. These two sites had the highest diversity in Bodkin Creek with 06-L1M-02-17 having 11 species and 06-R3M-08-17 having nine species.

Eastern Mudminnow (*Umbra pygmaea*) was the most widely distributed species in the sampling unit, present at each of the eight sites. Both American Eel (*Anguilla rostrata*) and Green Sunfish (*Lepomis cyanellus*) were found at seven of the eight sites. The least common species in this sampling unit were Brown Bullhead (*Ameiurus nebulosus*), Largemouth Bass (*Micropterus salmoides*), and Mummichog (*Fundulus heteroclitus*) each found at two sites. Eleven species were observed in the sampling unit with three non-native species (Bluegill (*Lepomis macrochirus*), Green Sunfish, Largemouth Bass) and eight native species (American Eel, Golden Shiner (*Notemigonus crysoleucas*), Brown Bullhead, Eastern Mudminnow, Banded Killifish (*Fundulus diaphanus*), Mummichog, Eastern Mosquitofish (*Gambusia holbrooki*), Pumpkinseed (*Lepomis gibbosus*). No round-bodied suckers nor any species considered intolerant to pollution were observed in this sampling unit.

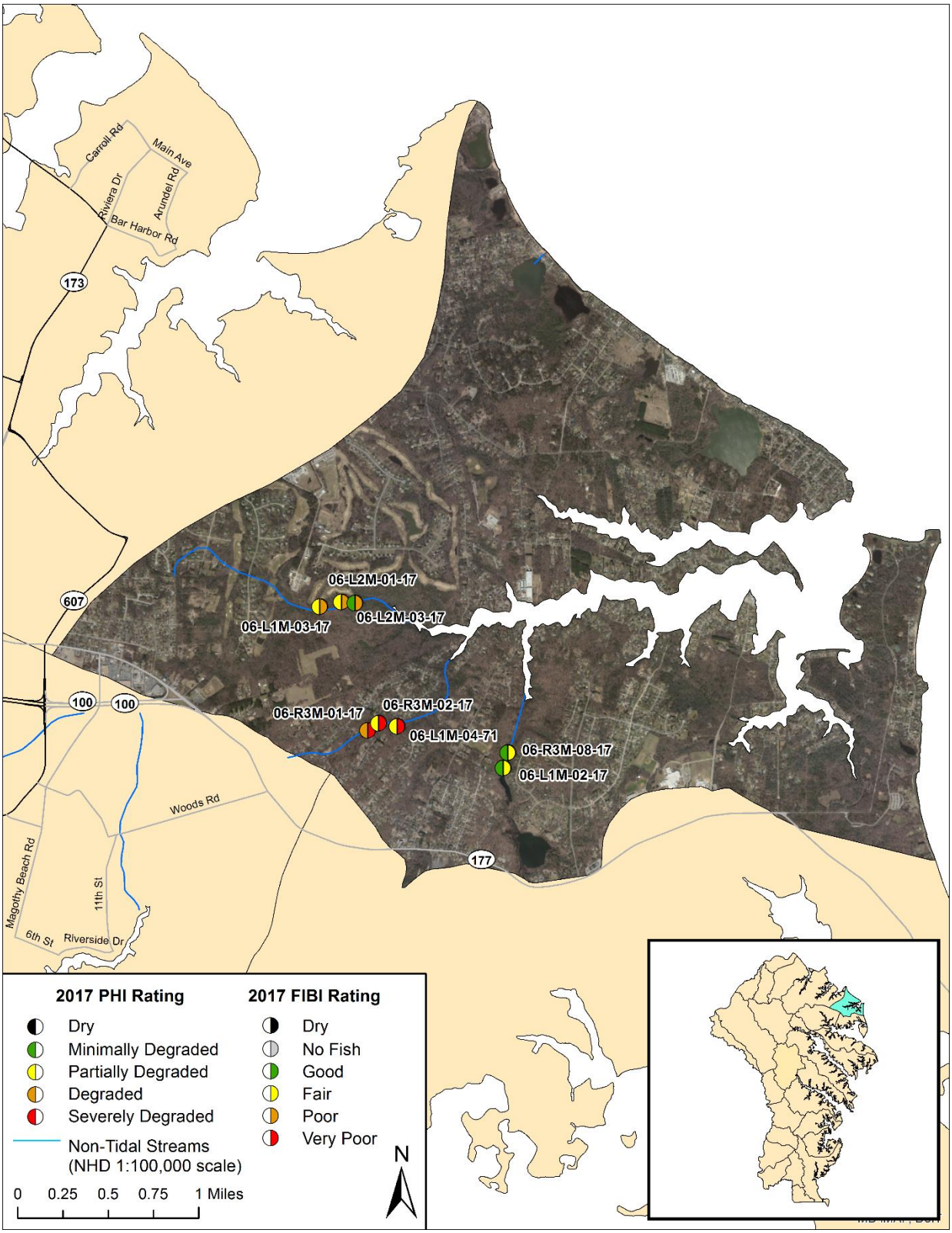


Figure 12 - Bodkin Creek (FIBI and PHI)

4.1.4 Water Quality

Average spring and summer *in situ* water quality values for the Bodkin Creek sites are provided in Table 18. Of the eight sites sampled, five sites did not meet COMAR standards for water quality in the spring. Sites 06-L2M-01-17, 06-L2M-03-17, 06-R3M-01-17, 06-R3M-02-17, and 06-R3M-08-17 all measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5), with values of 5.85, 6.00, 6.30, 6.07, and 6.28, respectively. The majority of soils in the Bodkin Creek sampling unit are very strongly acidic, with a pH of 4.5 to 5.0 (NRCS 2017). Sites 06-R3M-01-17 and 06-R3M-02-17 also fell outside the acceptable COMAR range for DO (i.e., >5 mg/L), with values of 3.78 and 3.98, respectively. All other sites sampled met COMAR standards for water quality. In the spring, water temperature ranged from 7.3 to 16.3 °C; dissolved oxygen ranged from 3.78 to 10.02 mg/L; pH ranged from 5.85 to 7.79; specific conductance ranged from 104.3 to 388.7 µS/cm; and, turbidity ranged from 2.96 to 7.96 NTU.

In the summer, all eight Bodkin Creek sites held water and were sampled. Six sites did not meet COMAR standards for water quality in the summer. Sites 06-L1M-03-17, 06-L1M-04-17, 06-L2M-03-17, 06-R3M-01-17, and 06-R3M-02-17 all measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5), with values of 5.25, 5.61, 5.02, 6.07, and 5.20, respectively. Sites 06-L2M-01-17, 06-R3M-01-17, and 06-R3M-02-17 all fell outside the acceptable COMAR range for DO (i.e., >5 mg/L), with values of 4.26, 2.21, and 0.48 mg/L, respectively. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 16.9 to 24.7 °C; dissolved oxygen ranged from 0.48 to 7.15 mg/L; pH ranged from 5.02 to 7.50; specific conductance ranged from 105.3 to 364.3 µS/cm; and, turbidity ranged from 2.33 to 36.4 NTU.

Table 18 - Average in situ water quality values - Bodkin Creek

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	11.83 ± 3.42	7.31 ± 2.58	6.56 ± 0.69	252.5 ± 111.3	4.66 ± 1.55
Summer	20.58 ± 2.79	4.81 ± 2.36	6.06 ± 0.94	261.8 ± 103.4	9.14 ± 11.31

The average spring grab sample water quality values for the Bodkin Creek sites are provided in Table 19. All eight sites sampled met EPA standards for chloride concentration and all but one site met COMAR standards for copper, zinc, lead, and turbidity. Site 06-R3M-08-17 met COMAR criteria for acute total lead concentration, but exceeded the acceptable COMAR range for chronic total lead (i.e., <2.5 µg/L), with a value of 3.189 µg/L. For total nitrogen, orthophosphate, nitrite, and nitrate, all values at Bodkin Creek sites fell in the low or moderate categories used by MBSS. For total phosphorus, site 06-L1M-04-17 fell in the high category used by MBSS (i.e., >0.07 mg/L), with a value of 0.083 mg/L. For total ammonia, sites 06-L1M-02-17, 06-R3M-01-17, and 06-R3M-02-17 fell in the high category used by MBSS (i.e., >0.07 mg/L), with values of 0.091, 0.110, and 0.150 mg/L, respectively. All other Bodkin Creek sites fell in the low or moderate categories used by MBSS for total phosphorus and total ammonia. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 1.36 to 12.24 mg/L; TOC ranged from 1.42 to 12.62 mg/L; magnesium ranged from 2.50 to 4.50 mg/L; calcium ranged from 4.55 to 14.96 mg/L; and hardness ranged from 22.92 to 53.23 mg/L.

Table 19 - Average grab sample water quality values - Bodkin Creek

Value ± Standard Deviation							
Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Turbidity (NTU)
50.65 ± 31.74	0.032 ± 0.028	0.884 ± 0.454	0.006 ± 0.004	0.072 ± 0.044	0.004 ± 0.002	0.393 ± 0.270	8.6 ± 10.6
Value ± Standard Deviation							
Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)
5.717 ± 4.834	5.943 ± 4.907	3.343 ± 0.632	7.87 ± 3.72	33.42 ± 11.53	2.256 ± 1.367	12.78 ± 3.25	1.053 ± 0.996

Two sites within the Bodkin Creek sampling unit were characterized by low pH, high DOC levels, and low DO levels, partially meeting criteria for blackwater streams (i.e., pH <6.0; DOC >8.0 mg/L; DO <5.0 mg/L). Sites 06-R3M-01-17 and 06-R3M-02-17 both met blackwater criteria for DOC and DO and had pH levels slightly above 6.0, with values of 6.30 and 6.07, respectively. Although no blackwater streams are suspected to occur in the Bodkin Creek sampling unit (DNR 2016), these streams may be undocumented blackwater reaches or they may be low-flow wetland drainages with similar chemical properties.

4.1.5 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. All of the sites assessed (100 percent) within Bodkin Creek were slightly entrenched C or E type streams (25 and 75 percent, respectively; Figure 13).

The majority of the streams in this sampling unit were sand bottom channels (75 percent) with the remainder of the sites equally split between silt/clay and sand/silt/clay bottoms. The average D50 was 0.19 mm (fine sand). Individual slopes ranged from 0.08 percent to 0.88 percent, with an average slope of 0.57 percent. All sites had slopes that were less than one percent.

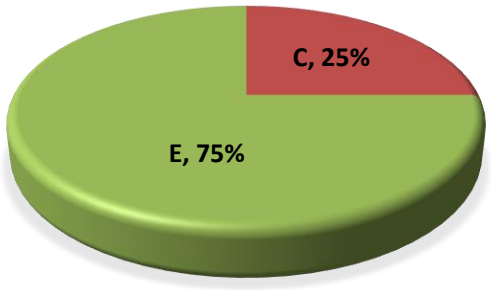


Figure 13 - Rosgen stream types observed in Bodkin Creek (n=8)

4.2 Rhode River

The Rhode River sampling unit, which drains directly to the Rhode River and into the West River, is located in the eastern edge of the south-central portion of the County (Figure 1), and has a drainage area of 8,737 acres. The eight sampling sites (six 1st order and two 2nd order streams) shown in Figure 17 have drainage areas ranging from 175 to 2,497 acres. Land use in the Rhode River sampling unit is primarily comprised of forested land (52 percent), followed by developed land (28 percent) and agriculture (14 percent) (Table 17), which is similar to the average land use observed among sampling sites. The majority of sites sampled in the Rhode River sampling unit have predominantly forested land cover (62.5 percent),

followed by developed land cover (37.5 percent) (Figure 14). Impervious surfaces comprise just 6.1 percent of the overall sampling unit, with individual sites ranging from 3.4 percent to 6.7 percent.

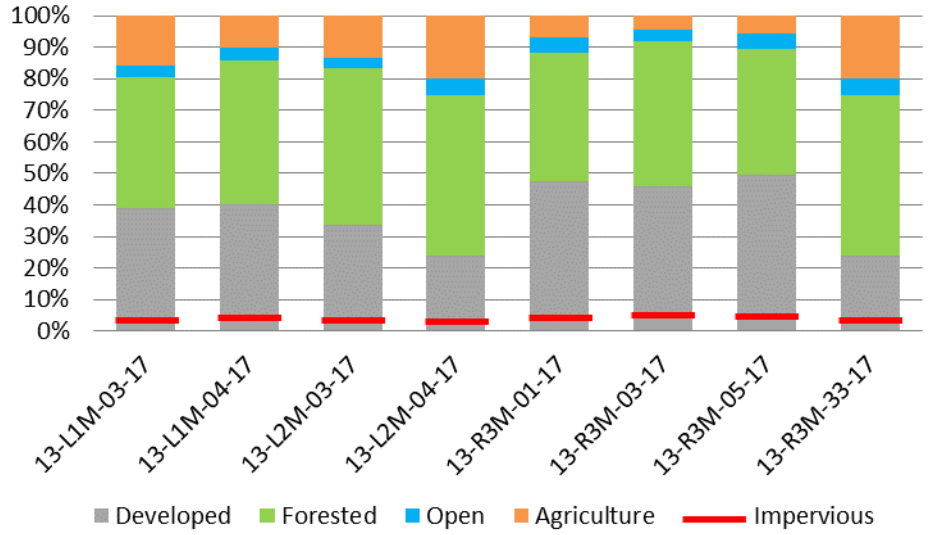


Figure 14 - Rhode River land use

4.2.1 Physical Habitat

Physical habitat conditions during the spring season were fairly variable for this sampling unit. Based on the RBP scores, 75 percent of the Rhode River sites received a rating of 'Supporting,' and 25 percent received a 'Partially Supporting' rating (Figure 15). The average RBP score for the Rhode River sampling unit was 133.75 ± 10.91 (Table 16), and the corresponding narrative rating was 'Supporting.' Individual site scores ranged from 120 ('Partially Supporting') to 150 ('Supporting').

According to the PHI (summer), 20.0 percent of the Rhode River sites were rated as 'Minimally Degraded', 40.0 percent received a rating of 'Partially Degraded', and 40.0 percent were rated as 'Degraded' (Figure 15). However, it is important to note that the Rhode River sampling unit had the greatest amount of dry sites, resulting in three of the eight sites (37.5 percent) not receiving a PHI numeric rating. The average PHI rating was 'Partially Degraded' with a score of 70.94 ± 12.32. Individual site scores ranged from 53.12 ('Degraded') to 83.91 ('Minimally Degraded'). Instream woody debris, epifaunal substrate, and instream habitat were variable between reaches. Shading and bank stability received 'Optimal' to 'Suboptimal' scores for at the Rhode River sites, and embeddedness received 'Optimal' scores for all assessed sites.

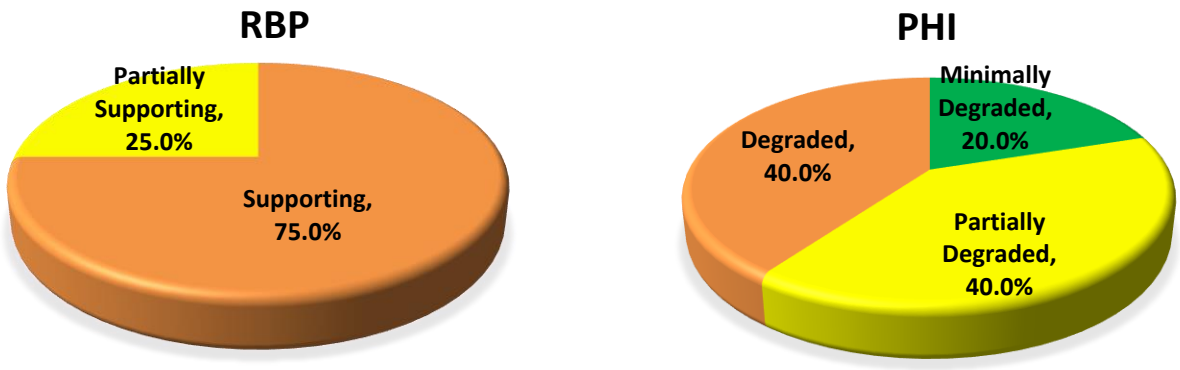


Figure 15 - Rhode River Physical Habitat Conditions (RBP n=8; PHI n=5)

4.2.2 Benthic Macroinvertebrates

The Rhode River sampling unit received a BIBI narrative rating of 'Poor' with an average score of 2.36 ± 0.52 (Table 16). Twenty-five percent of the individual sites received a biological condition rating of 'Fair', 50 percent received a 'Poor' rating, and the remaining 25 percent of sites were rated as 'Very Poor' (Figure 15). Individual BIBI scores ranged from 1.57 ('Very Poor') to 3.00 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

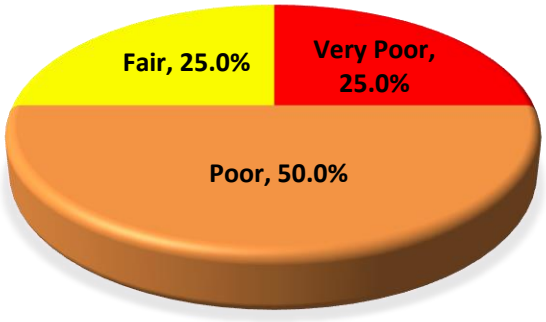


Figure 16 - Rhode River BIBI Conditions (n=8)

Site 13-L1M-03-17 received the lowest BIBI score of all Rhode River sites (1.57) with a narrative rating of 'Very Poor.' This site had comparatively low taxa diversity (19 taxa) with a complete absence of EPT, Ephemeroptera and scraper taxa and consisted of six percent of intolerant taxa. Out of the 108 individuals in the sample, 53 percent was represented by individuals of the Chironomidae family with tolerance values ranging from 6.2 to 9.2. One additional site received a 'Very Poor' biological rating (13-L2M-03-17) where no Ephemeroptera, scraper, or climber taxa were present. Sites 13-R3M-01 and 13-R3M-03-17 received the highest BIBI scores (3.00; 'Fair') in the Rhode River sampling unit. For 13-R3M-01, four EPT taxa and four scraper taxa were identified from a total of 20 taxa, with 13 percent of the sample consisting of climber taxa and 19 percent being intolerant urban. For 13-R3M-03-17, two EPT and two scraper taxa were present, with 35 percent of the sample consisting of climber taxa and 18 percent being intolerant urban (Figure 17).

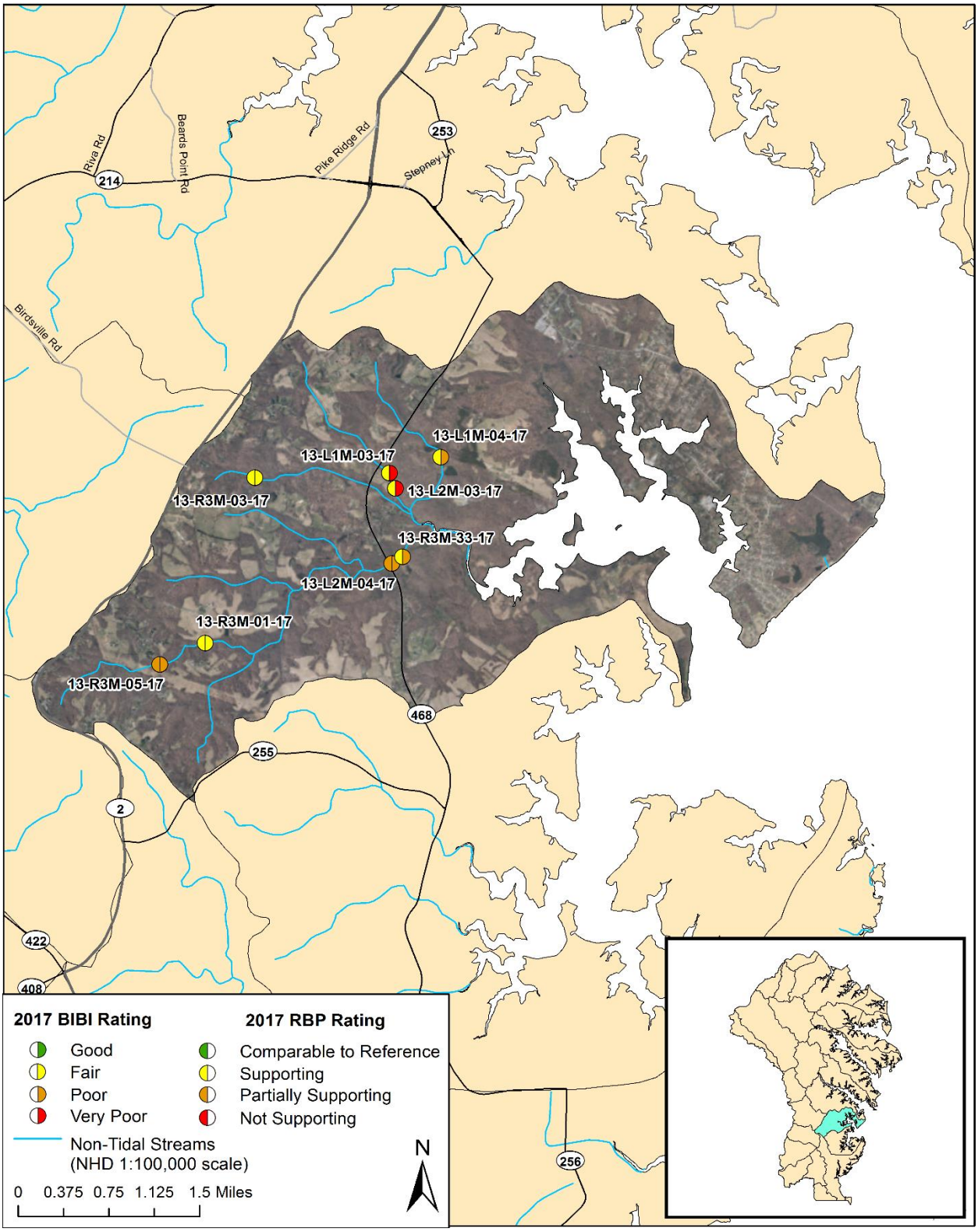


Figure 17 - Rhode River Sampling Sites (BIBI and RBP)

4.2.3 Fish

The Rhode River sampling unit received the lowest FIBI narrative rating among all sampling units sampled during 2017. The Rhode River received a FIBI narrative rating of 'Very Poor' with an average score of 1.46 ± 0.85 (Table 16). Twelve and a half percent of the individual sites received a biological condition rating of 'Fair', 12.5 percent received a 'Poor' rating, and the remaining 75.0 percent of sites were rated as 'Very Poor' (Figure 19). Individual FIBI scores ranged from 1.00 ('Very Poor') to 3.00 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

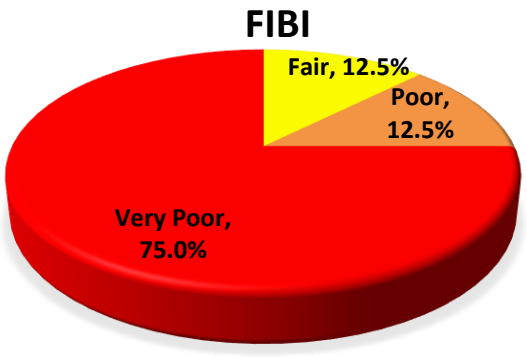


Figure 18 – Rhode River FIBI Conditions (n=8)

Sites 13-L1M-03-17, 13-L1M-04-17, 13-L2M-03-17, 13-R3M-01-17, 13-R3M-03-17 and 13-R3M-05-17 received the lowest FIBI score of all Rhode River sites (1.00) with a narrative rating of 'Very Poor.' Sites 13-L1M-03-17, 13-L1M-04-17, and 13-L2M-03-17 scored a 1.00 because the stream was completely dry at the time of sampling and no fish were encountered. Sites 13-R3M-01-17, 13-R3M-03-17 and 13-R3M-05-17 scored a 1.00 because no fish were encountered during sampling even though there was water in the stream channel. Sites 13-L2M-04-17 (2.67; 'Poor') and 13-R3M-33-17 (3.00; 'Fair') received the highest FIBI scores in the Rhode River sampling unit. These two sites scored similarly for adjusted number of benthic species (1); percent tolerant (5); percent generalist, omnivores, and invertivores (3); and percent round-bodied suckers (1). Site 13-L2M-04-17 scored higher for percent abundance of dominant taxon while 13-R3M-33-17 scored higher for abundance per square meter. Sites 13-L2M-04-17 and 13-R3M-33-17 were the most diverse sites, with nine species present. A total of nine species were observed in the Rhode River sampling unit with six native species (American Eel, Golden Shiner, Brown Bullhead, Banded Killifish, Mummichog, Eastern Mosquitofish) and three introduced species (Bluegill, Green Sunfish, Lepomis hybrid (*Lepomis* sp.). No intolerant species or any round-bodied suckers were collected in the Rhode River sampling unit.

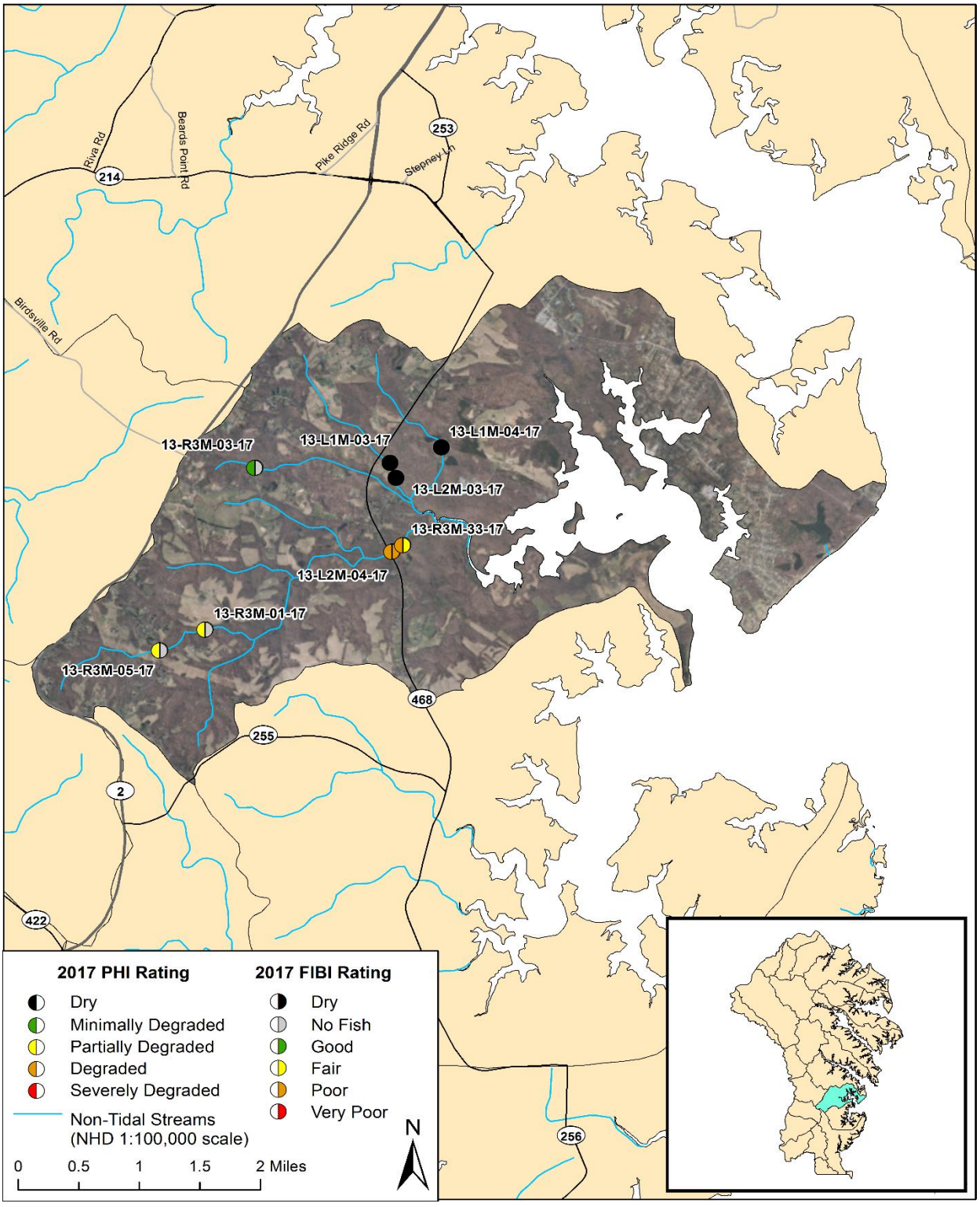


Figure 19 - Rhode River Sampling Sites (FIBI and PHI)

4.2.4 Water Quality

Average spring and summer *in situ* water quality values for the Rhode River sites are provided in Table 20. Of the eight sites sampled, three sites did not meet COMAR standards for water quality in the spring. Sites 13-L1M-03-17, 13-L1M-04-17, and 13-L2M-03-17 all measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5), with values of 6.38, 6.11, and 6.27, respectively. All other sites sampled met COMAR standards for water quality. In the spring, water temperature ranged from 8.1 to 18.5°C; dissolved oxygen ranged from 8.63 to 12.24 mg/L; pH ranged from 6.11 to 7.10; specific conductance ranged from 172 to 308 µS/cm; and, turbidity ranged from 3.0 to 11.1 NTU.

In the summer, three of the eight sites were dry in the Rhode River. Of the remaining five sites, one site did not meet COMAR standards for water quality in the summer. Site 13-R3M-33-17 measured outside the acceptable COMAR range for DO (i.e., >5.0 mg/L), with a value of 3.10 mg/L. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 19.7 to 23.2 °C; dissolved oxygen ranged from 3.10 to 8.32 mg/L; pH ranged from 6.53 to 7.05; specific conductance ranged from 202 to 1574 µS/cm; and, turbidity ranged from 2.3 to 74.3 NTU.

Table 20 - Average in-situ water quality values - Rhode River

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	14.59 ± 3.38	10.43 ± 1.11	6.70 ± 0.39	219.4 ± 49.5	7.14 ± 3.05
Summer	22.02 ± 1.36	6.20 ± 2.09	6.77 ± 0.22	540.6 ± 579.8	21.48 ± 30.50

Average spring grab sample water quality values for the Rhode River 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. For total nitrogen, nitrite, and nitrate, all values at Rhode River sites fell in the low or moderate categories used by MBSS. For total phosphorus, sites 13-L2M-03-17, 13-L2M-04-17, 13-R3M-01-17, 13-R3M-03-17, 13-R3M-05-17, and 13-R3M-33-17 all fell in the high category used by MBSS (>0.07 mg/L), with values of 0.073, 0.133, 0.150, 0.114, 0.327, and 0.196 mg/L, respectively. For orthophosphate, site 13-R3M-01-17 fell in the high category used by MBSS (i.e., >0.03 mg/L), with a value of 0.048 mg/L. For total ammonia, site 13-R3M-05-17 fell in the high category used by MBSS (i.e., >0.07 mg/L), with a value of 0.078 mg/L. All other Rhode River sites fell in the low or moderate categories used by MBSS for total phosphorus, orthophosphate, and total ammonia. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 2.43 to 4.26 mg/L; TOC ranged from 2.44 to 4.46 mg/L; magnesium ranged from 2.57 to 4.37 mg/L; calcium ranged from 12.31 to 31.09 mg/L; and hardness ranged from 45.70 to 94.32 mg/L.

Table 21 - Average grab sample water quality values - Rhode 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)	Turbidity (NTU)
40.71 ± 10.67	0.139 ± 0.090	0.481 ± 0.117	0.021 ± 0.013	0.031 ± 0.021	0.005 ± 0.002	0.175 ± 0.096	9.1 ± 4.1
Value ± Standard Deviation							
Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)
3.460 ± 0.722	3.567 ± 0.779	3.417 ± 0.700	19.59 ± 6.91	62.98 ± 16.73	0.447 ± 0.079	8.43 ± 5.15	0.213 ± 0.110

One site within the Rhode River sampling unit was located in the vicinity of a suspected blackwater stream (DNR 2016). This site, 13-L1M-04-17, was characterized by low pH (i.e., 6.11) and relatively high DOC levels (i.e., 4.26 mg/L), however, it did not meet blackwater criteria for pH, DOC levels, or DO levels based on spring sampling (i.e., pH <6.0; DOC >8.0 mg/L; DO <5.0 mg/L).

4.2.5 Geomorphic Assessment

Site-specific geomorphic assessment summary results are presented in Appendix A. The majority of sites in the Rhode River sampling unit (75 percent) were slightly entrenched and classified as either C or E channels (25 and 50 percent respectively; Figure 20). The remaining 25 percent of sites were more entrenched, and were classified as F type streams.

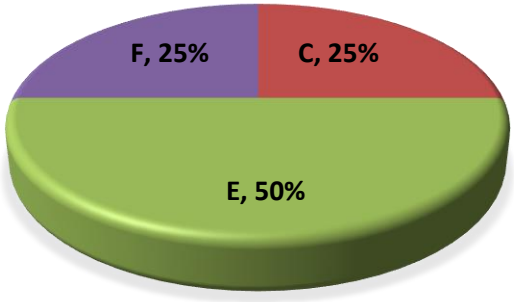


Figure 20- Rosgen stream types observed in Rhode River

The majority of sites in Rhode River were sand bed channels (50 percent) with 37.5 percent of sites dominated by silt/clay and 12.5 percent of sites dominated by sand/gravel. The average D50 was 0.16 mm (fine sand). Streams in this sampling unit had an average slope of 0.24 percent, with individual slopes ranging from <0.001 percent to 0.51 percent. All sites had slopes that were less than one percent.

4.3 Severn River

The Severn River sampling unit is located in the eastern central edge of the County, bordering the Severn River (Figure 1), and has a total drainage area of 28,920 acres, which drains directly to the Severn River. The city of Annapolis is located in the southern portion of the Severn River sampling unit with Route 50/301 traveling through the center of the sampling unit. Of the eight sites assessed, seven were located

on 1st order streams and one on a 2nd order stream as shown in Figure 24. Drainage areas to sampling sites ranged from 203 to 1,353 acres. Land use in the Severn River sampling unit is comprised primarily of developed land (59 percent), followed by forested land (31 percent) (Table 17). Five of eight sites had developed land as the largest land use category in the upstream drainage area, and the remaining three sites had forested land use as the largest category. Impervious surfaces account for 19.9 percent of the Severn River sampling unit, the highest amount for PSUs in 2017 (Table 17), with individual sites ranging from 7.0 to 24.2 percent imperviousness.

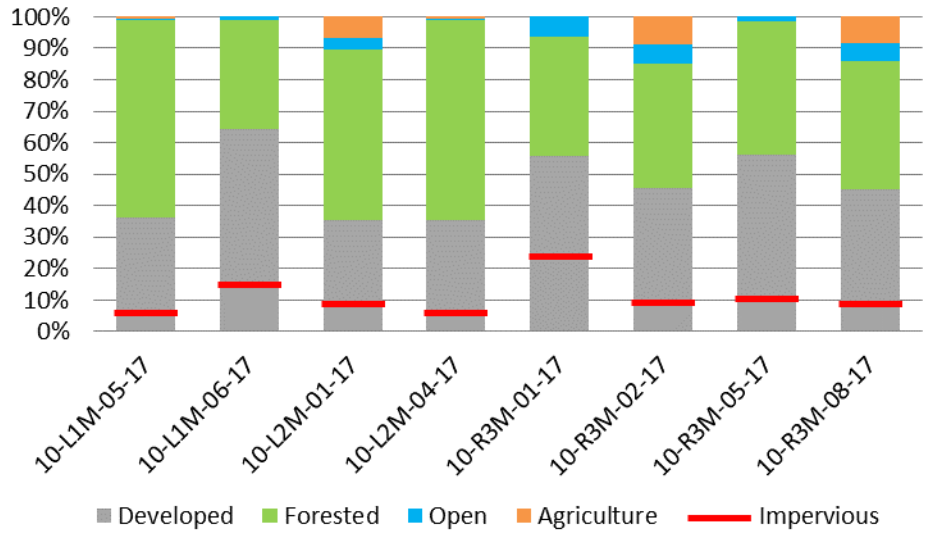


Figure 21 - Severn River land use (n=8)

4.3.1 Physical Habitat

Physical habitat conditions were fairly variable for this sampling unit during the spring season. Based on the RBP scores, 50.0 percent of the Severn River sites received a rating of 'Supporting,' 37.5 percent received a 'Partially Supporting' rating, and the remainder 12.5 percent of sites were classified as 'Comparable to Reference' (Figure 22). The average RBP score for the Severn River sampling unit was 133.5 ± 17.46, and the corresponding narrative rating was 'Supporting.' Individual site scores ranged from 114 ('Partially Supporting') to 165 ('Comparable to Reference'), which was the second highest score observed in 2017.

According to the PHI (summer), 28.6 percent of the Severn River sites were rated as 'Minimally Degraded', 57.1 percent received a rating of 'Partially Degraded', and 14.3 percent were rated as 'Degraded' (Figure 22). The average PHI rating was 'Partially Degraded' with a score of 73.09 ± 9.49. Individual site scores ranged from 56.19 ('Degraded') to 84.67 ('Minimally Degraded'). One site was dry at the time of the summer visit and did not receive a PHI rating. All of the reaches sampled received 'Marginal' to 'Poor' scores for instream habitat and epifaunal substrate. Bank stability, instream woody debris, and vegetative bank protection were variable between reaches. Embeddedness received 'Optimal' to 'Suboptimal' scores at all sites.

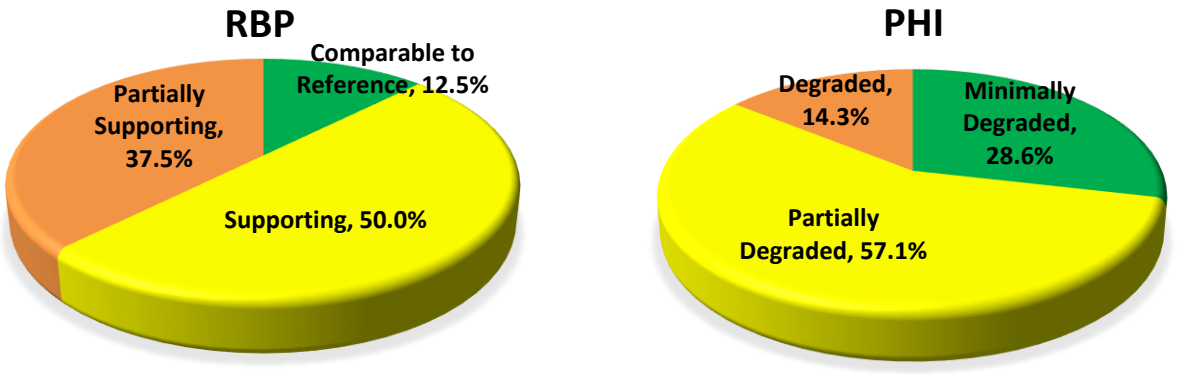


Figure 22 - Severn River Physical Habitat Conditions (RBP n=8; PHI n=7)

4.3.2 Benthic Macroinvertebrates

The average BIBI rating for the Severn River sampling unit is 'Poor' with an average BIBI score of 2.57 ± 0.51 (Table 16), and individual sites ranging from a low of 1.86 ('Very Poor') to 3.57 ('Fair'). The majority of sites (75.0 percent) received a BIBI rating of 'Poor', 12.5 percent of the sites were rated as 'Very Poor', and the remaining sites received a 'Fair' rating (12.5 percent; Figure 23). Site-specific data and assessment results can be found in Appendix D.

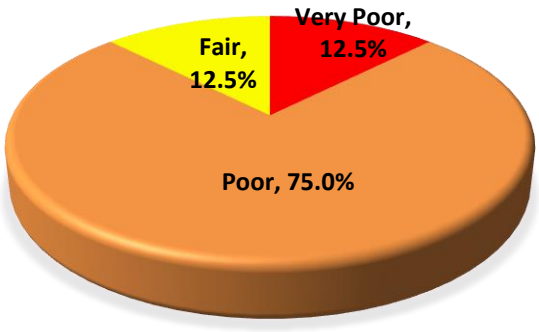


Figure 23 - Severn River BIBI Conditions (n=8)

Site 10-R3M-02-17 received the lowest score in the Severn River sampling unit of 1.86 with a 'Very Poor' narrative rating. The site had relatively low taxa diversity (15 taxa), only had two EPT taxa and completely lacked Ephemeroptera, scraper and climber taxa. Additionally, only 12 percent of the sample consisted of taxa intolerant to urban. In contrast, site 10-L2M-01-17 received the highest BIBI score of 3.57 due to its relatively high number of total taxa (24) and having six EPT taxa; however, only one scraper taxa and no Ephemeroptera taxa were present (Figure 24).

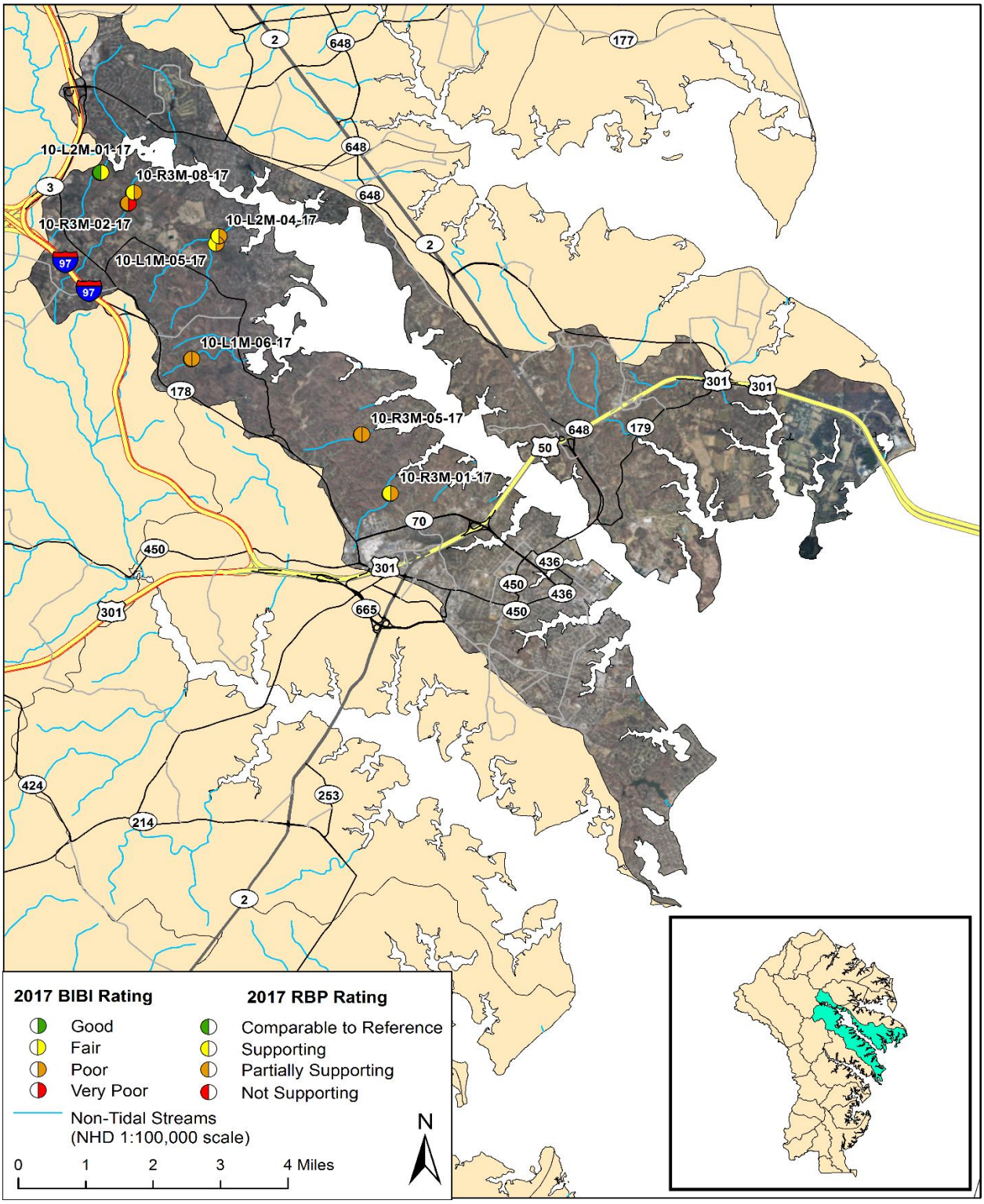


Figure 24 - Severn River Sampling Sites (BIBI and RBP)

4.3.3 Fish

The Severn River sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.08 ± 0.61 (Table 16). Twelve and a half percent of the individual sites received a biological condition rating of 'Fair', 62.5 percent received a 'Poor' rating, and the remaining 25.0 percent of sites were rated as 'Very Poor' (Figure 26). Individual FIBI scores ranged from 1.00 ('Very Poor') to 3.00 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

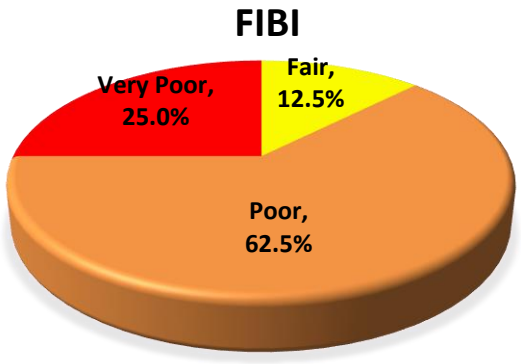


Figure 25 – Severn River FIBI Conditions (n=8)

Site 10-L1M-05-17 received the lowest FIBI score of all Severn River sites (1.00) with a narrative rating of 'Very Poor.' This site scored a 1.00 because the stream was completely dry at the time of sampling and no fish were encountered. Sites 10-L2M-01-17 (3.00; 'Fair') and 10-R3M-01-17 (2.67; 'Poor') received the highest FIBI scores in the Severn River sampling unit. These two sites scored similarly for percent tolerant (5), percent generalist, omnivores, and invertivores (1), percent round-bodied suckers (1), and percent abundance of dominant taxon (3). Site 10-R3M-01-17 scored higher for abundance per square meter, while 10-L2M-01-17 scored higher for adjusted number of benthic species. Site 10-R3M-01-17 was the most diverse site, with five species present. Site 10-L1M-05-17 was dry and had no species present, and site 10-L1M-06-17 had only one species present. American Eel and Eastern Mudminnow were the most widely distributed species in this sampling unit, found at six sites each. Golden Shiner, Brown Bullhead, Banded Killifish, Bluegill, and Tessellated Darter (*Etheostoma olmstedi*) were the least common species in this sampling unit, each being found at only a single site. A total of eight species were observed in the Severn River sampling unit with seven native species (American Eel, Golden Shiner, Brown Bullhead, Eastern Mudminnow, Banded Killifish, Mummichog, Tessellated Darter) and one introduced species (Bluegill). No intolerant species or round-bodied suckers were collected in the Severn River sampling unit.

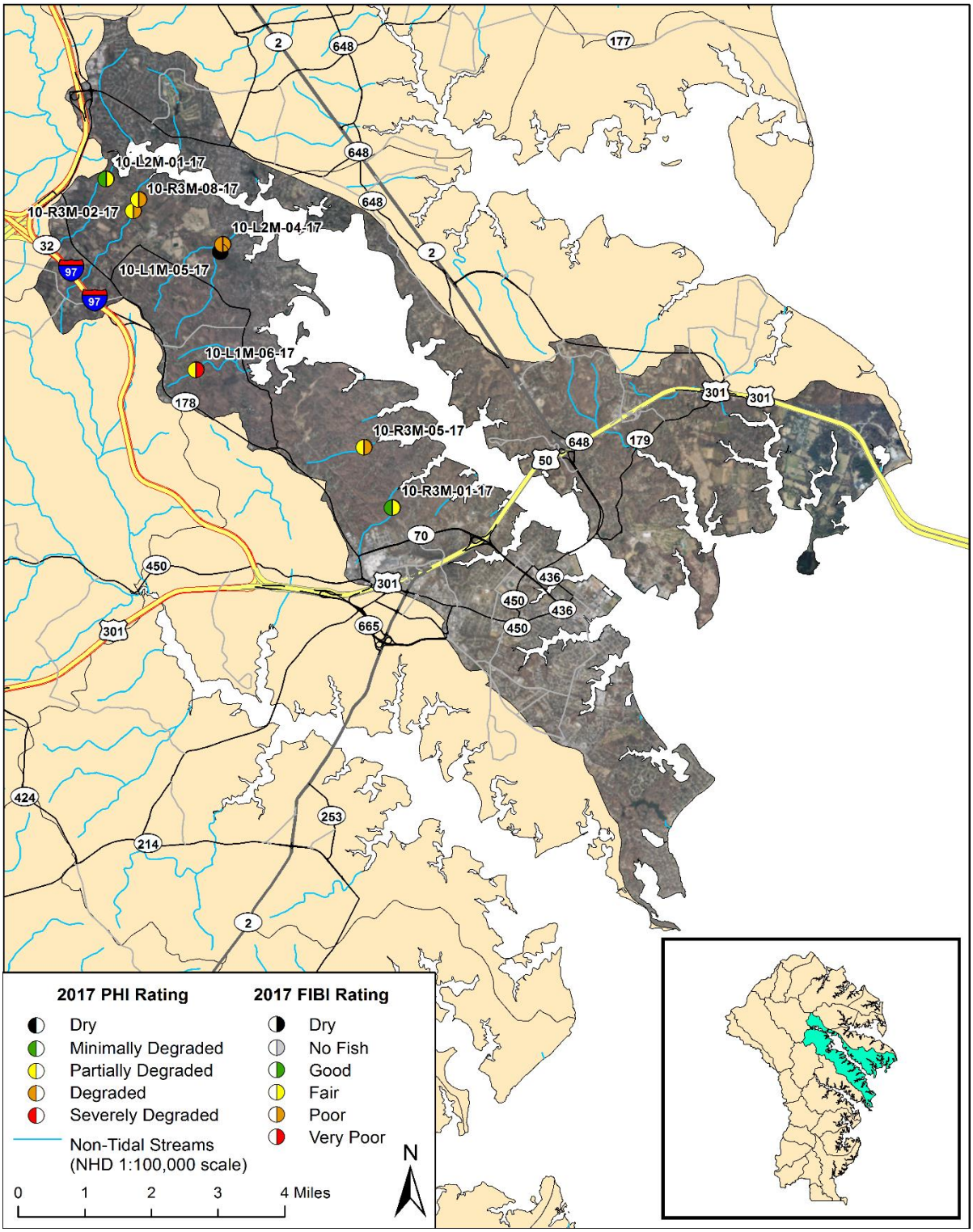


Figure 26 - Severn River Sampling Sites (FIBI and PHI)

4.3.4 Water Quality

Average spring and summer in situ water quality values for the Severn River sites are provided in Table 22. Of the eight sites sampled, five sites did not meet COMAR standards for water quality in the spring. Sites 10-L1M-06-17, 10-L2M-01-17, 10-L2M-04-17, 10-R3M-02-17, and 10-R3M-08-17 all measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5), with values of 6.04, 6.13, 6.24, 5.73, and 6.46, respectively. The majority of soils in the Severn River sampling unit are strongly to very strongly acidic, with pH values ranging from 4.5 to 5.5 (NRCS 2017). Site 10-R3M-02-17 also fell outside the acceptable COMAR range for DO (i.e., >5 mg/L), with a value of 4.13 mg/L. All other sites sampled met COMAR standards for water quality. In the spring, water temperature ranged from 8.5 to 18.2 °C; dissolved oxygen ranged from 4.13 to 10.85 mg/L; pH ranged from 5.73 to 6.99; specific conductance ranged from 50 to 400 µS/cm; and, turbidity ranged from 0.8 to 9.0 NTU.

In the summer, one of the eight sites was dry in the Severn River sampling unit. Of the remaining seven sites, six sites did not meet COMAR standards for water quality in the summer. Sites 10-L1M-06-17, 10-L2M-01-17, 10-R3M-01-17, 10-R3M-02-17, and 10-R3M-08-17 all measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5), with values of 6.34, 6.02, 6.26, 5.35, and 5.44, respectively. Sites 10-L1M-06-17, 10-L2M-04-17, and 10-R3M-02-17 all fell outside the acceptable COMAR range for DO (i.e., >5 mg/L), with values of 4.97, 1.92, and 4.97 mg/L, respectively. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 18.2 to 22.2 °C; dissolved oxygen ranged from 1.92 to 7.89 mg/L; pH ranged from 5.35 to 6.86; specific conductance ranged from 52 to 394 µS/cm; and, turbidity ranged from 0.6 to 66.4 NTU.

Table 22 - Average in-situ water quality values - Severn River

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	14.54 ± 3.12	7.20 ± 2.21	6.41 ± 0.45	208.4 ± 121.7	4.90 ± 2.77
Summer	20.77 ± 1.32	5.47 ± 1.89	6.35 ± 0.60	212.1 ± 121.8	15.10 ± 23.24

Average spring grab sample water quality values for the Severn River 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. For total phosphorus, total nitrogen, orthophosphate, nitrite, and nitrate, all values for Severn River sites fell in the low or moderate categories used by MBSS. For total ammonia, sites 10-L1M-05-17, 10-R3M-02-17, 10-R3M-05-17, and 10-R3M-08-17 fell in the high category used by MBSS (i.e., >0.07 mg/L), with values of 0.100, 0.158, 0.156, and 0.095 mg/L, respectively. All other Severn River sites fell in the low or moderate categories used by MBSS for total ammonia. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 0.69 to 2.34 mg/L; TOC ranged from 0.75 to 3.52 mg/L; magnesium ranged from 1.23 to 6.49 mg/L; calcium ranged from 1.43 to 18.18 mg/L; and hardness ranged from 8.62 to 71.58 mg/L.

Table 23 - Average grab sample water quality values - Severn 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)	Turbidity (NTU)
52.19 ± 30.01	0.019 ± 0.006	0.509 ± 0.114	0.003 ± 0.00004	0.085 ± 0.053	0.002 ± 0.0005	0.310 ± 0.145	6.9 ± 1.8
Value ± Standard Deviation							
Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)
1.493 ± 0.506	1.753 ± 0.816	4.155 ± 1.839	10.02 ± 6.89	42.12 ± 24.44	1.060 ± 1.785	13.09 ± 9.17	0.177 ± 0.285

4.3.5 Geomorphic Assessment

A variety of stream types were present in the Severn River sampling unit (Figure 27). The majority of sites (87.5 percent) assessed in the Severn River sampling unit were classified as slightly entrenched C, E, or F type channels, at 12.5, 62.5, and 12.5 percent, respectively. The remaining 12.5 percent of sites were anastomosed DA type channels (Figure 27). Site-specific geomorphic assessment results can be found in Appendix A.

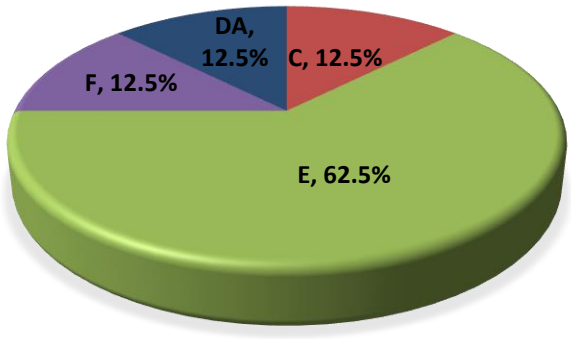


Figure 27 - Rosgen stream types observed in Severn River (n=8)

The majority of streams in this sampling unit had predominantly sand substrate (87.5 percent) with the remaining sites dominated by silt/clay (12.5 percent). The average D50 for the sampling unit was 0.27 mm (medium sand). With the exception of one site, slopes were less than one percent, and had an average slope of 0.56 percent, ranging from 0.01 percent to 0.09 percent. Two sites were atypical; 10-L2M-04-17 had a slope of two percent and 10-L2M-04-17 had a head-cut.

4.4 Severn Run

With a drainage area of 15,424 acres, the Severn Run sampling unit is located in the northern center of the County (Figure 1) and drains directly into the Severn River which in turn drains into the Chesapeake Bay. The eight sampling sites (three 1st order, five 2nd order streams), shown in Figure 31 have drainage areas ranging from 112 to 2,728 acres. With 19.6 percent of the Severn Run sampling unit comprised of impervious surface, this was the second most developed sampling unit assessed in 2017 (Table 17). Site-specific drainage areas ranged from 13.3 to 27.8 percent impervious, which was the highest percentage observed for all sites visited in 2017. Developed land comprised 53 percent of the total land use in the Severn Run sampling unit, including numerous residential developments, while forested land comprised 37 percent of the land cover (Table 17). This distribution is similar to the average land use among sampling

sites. Six of eight sites had developed land as the largest land use category in the upstream drainage area, and the remaining two sites had forested land use as the largest category (Figure 28).

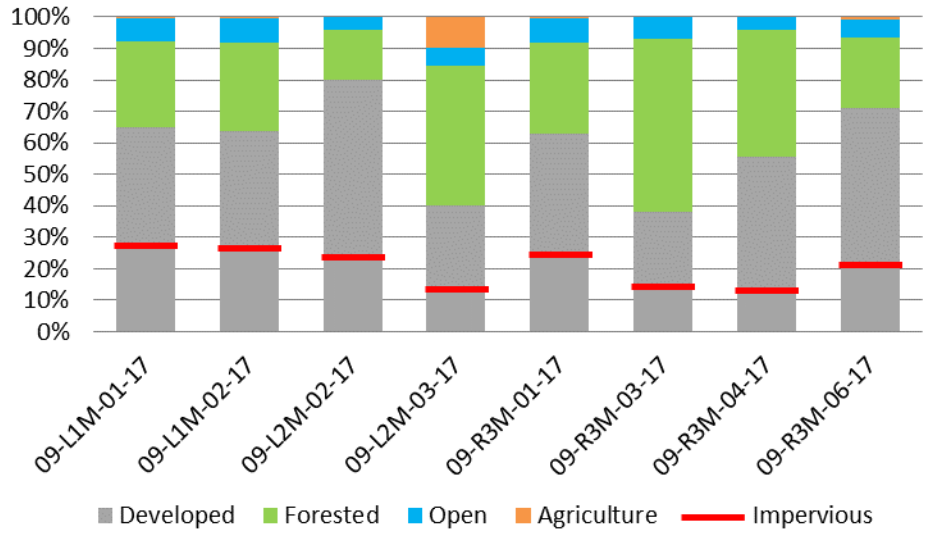
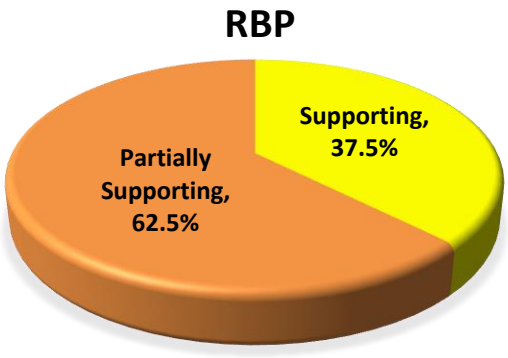


Figure 28 - Severn Run land use

4.4.1 Physical Habitat

Based on the RBP index assessed during the spring season, almost two-thirds of the sites were rated as 'Partially Supporting' (62.5 percent), and the remaining one-third were rated as 'Supporting' (37.5 percent; Figure 29). With an average RBP score of 127.5 ± 13.63 and a narrative rating of 'Supporting'. Individual RBP scores ranged from a minimum of 105 ('Partially Supporting') to a maximum of 149 ('Supporting').

The PHI (summer season) rated 66.7 percent of sites as 'Partially Degraded', and 33.3 percent as 'Degraded' (Figure 29). The average PHI rating was 'Degraded' with a score of 65.25 ± 8.33 and was the lowest mean PHI rating of the PSUs sampled during 2017. Individual PHI scores ranged from 53.11 ('Degraded') to 75.16 ('Partially Degraded'). The Severn Run sampling unit had two dry sites during the summer assessment, neither of which received a PHI score. The majority of sites assessed received 'Marginal' to 'Suboptimal' scores for instream habitat, epifaunal substrate, riffle/run quality, and pool variability. All sites received 'Suboptimal' to 'Optimal' scores for embeddedness and shading, except for site 09-L2M-03-17.



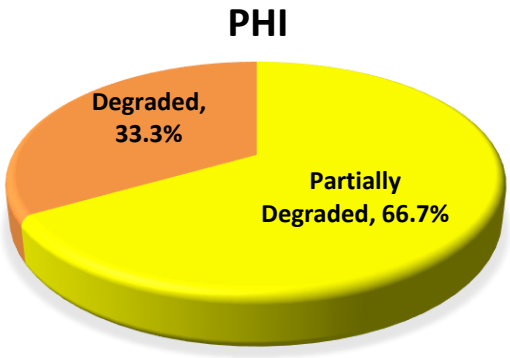


Figure 29 - Severn Run Physical Habitat Conditions (RBP n=8; PHI n=6)

4.4.2 Benthic Macroinvertebrates

Among the Severn Run sampling units, 62.5 percent of the sites received 'Poor' BIBI ratings, 25.0 percent were rated as 'Good', while the remaining 12.5 percent of sites received a 'Very Poor' rating (Figure 30). The average BIBI score for the sampling unit was 2.82 ± 1.17, resulting in a 'Poor' biological condition rating (Table 16); nonetheless, the Severn River PSU had the highest average BIBI of all PSUs evaluated in 2017. Individual BIBI scores ranged from 1.29 ('Very Poor') to 4.71 ('Good'). Individual site data and assessment results can be found in Appendix D.

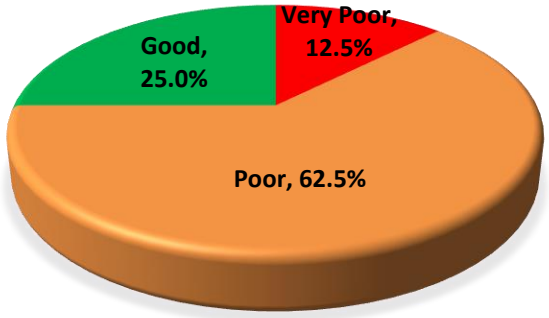


Figure 30 - Severn Run Biological Conditions (n=8)

Site 09-L2M-02-17 received the lowest BIBI score of 1.29 with a 'Very Poor' rating. A total of fourteen taxa were present in this sample, which was predominantly comprised of *Dipocladius* (Order Chironomidae, TV=5.9) that accounted for 64 percent of the sample. This sample did not contain any EPT, Ephemeroptera, scraper, climber or taxa intolerant to urban stressors. On the other hand, site 09-L2M-03-17 received the highest BIBI score among all sampling units in 2017 of 4.71, resulting in a 'Good' biological condition rating. Of the 30 taxa identified in this sample, seven were EPT taxa with four scraper taxa. This sample also had a moderate percentage of climber taxa (11.9 percent), and a relatively high percentage of taxa intolerant to urban stressors (31 percent).

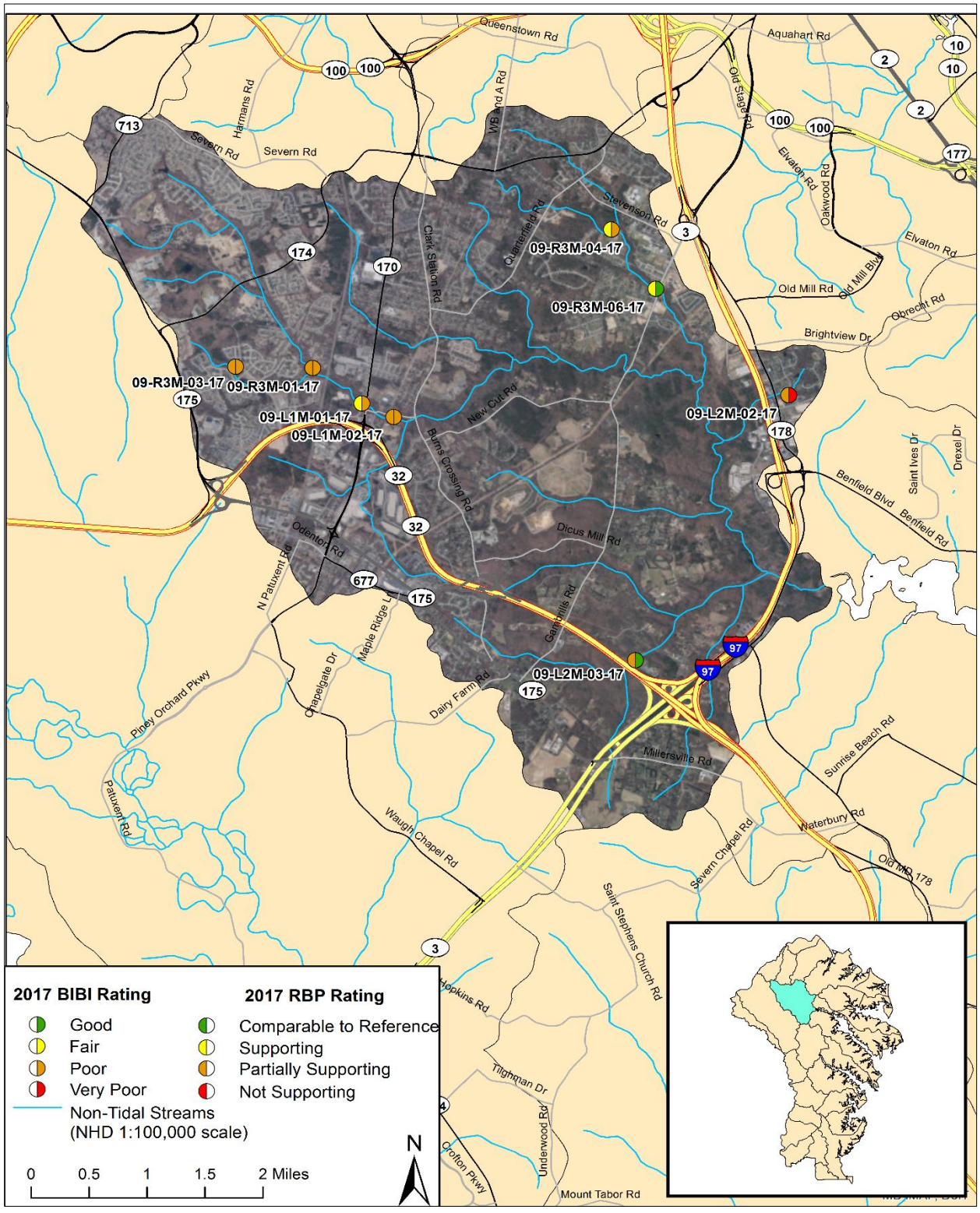


Figure 31 - Severn Run Sampling Sites (BIBI and RBP)

4.4.3 Fish

The Severn Run sampling unit received a FIBI narrative rating of 'Poor' with an average score of 2.17 ± 0.92 (Table 16). Twenty-five percent of the individual sites received a biological condition rating of 'Fair', 37.5 percent received a 'Poor' rating, and the remaining 37.5 percent of sites were rated as 'Very Poor' (Figure 33). Individual FIBI scores ranged from 1.00 ('Very Poor') to 3.33 ('Fair'). Site-specific data and assessment results can be found in Appendix D.

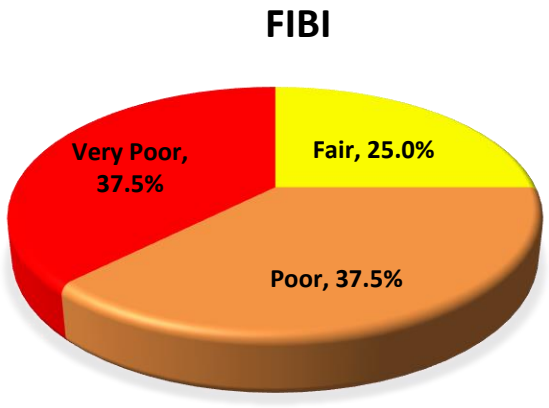


Figure 32 – Severn Run FIBI Conditions (n=8)

Sites 09-L2M-02-17 and 09-R3M-04-17 received the lowest FIBI score of all Severn Run sites (1.00) with a narrative rating of 'Very Poor.' These sites both scored a 1.00 because the stream was completely dry at the time of sampling and no fish were encountered. Sites 09-L1M-02-17 and 09-R3M-06-17 received the highest FIBI scores (3.33; 'Fair') in the Severn Run sampling unit. These two sites scored similarly for adjusted number of benthic species (5), percent tolerant (3), and percent round-bodied suckers (1). Site 09-L1M-02-17 scored higher for abundance per square meter, and percent abundance of dominant taxon while 09-R3M-06-17 scored higher for percent generalist, omnivores, and invertivores. Site 09-L1M-02-17 was the most diverse site, with eight species present. Site 09-R3M-03-17 had only one species present. American Eel, Blacknose Dace (*Rhinichthys atratulus*), and Eastern Mudminnow were the most widely distributed species in this sampling unit, found at five sites each. Swallowtail Shiner (*Notropis procne*), Redfin Pickerel (*Esox americanus*), and Brook Trout (*Salvelinus fontinalis*) were the least common species in this sampling unit, each being found at only a single site. A total of ten species were observed in the Severn Run sampling unit with nine native species (American Eel, Blacknose Dace, Swallowtail Shiner, White Sucker *Catostomus commersonii*), Redfin Pickerel, Brook Trout, Pumpkinseed, Tessellated Darter) and one introduced species (Bluegill). One individual of one intolerant species, Brook Trout, was collected at one site on Jabez Branch.

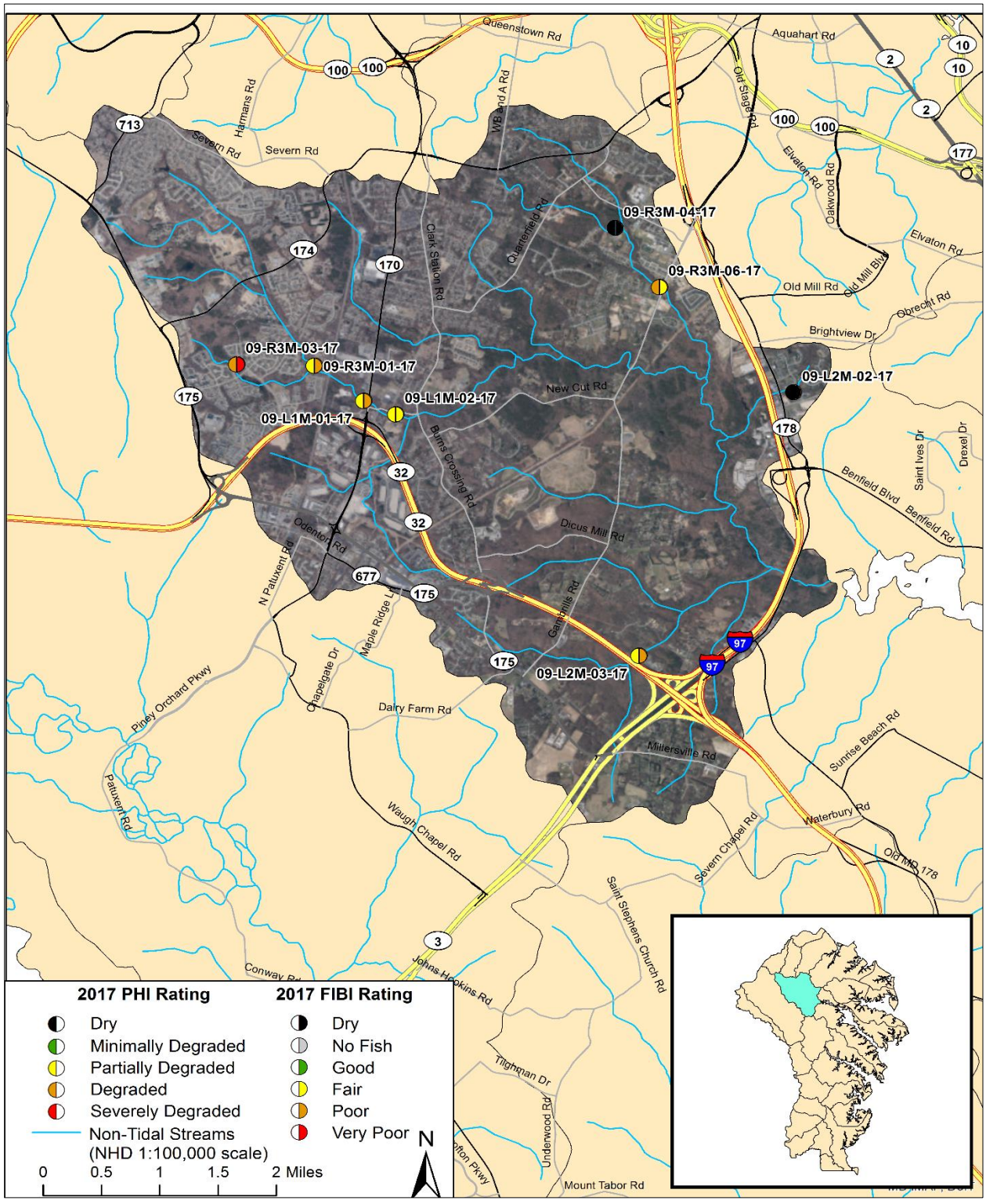


Figure 33 - Severn Run Sampling Sites (FIBI and PHI)

4.4.4 Water Quality

Average spring and summer in situ water quality values for the Severn Run sites are provided in Table 24. Of the eight sites sampled, two sites did not meet COMAR standards for water quality in the spring. Site 09-R3M-04-17 measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5) and DO (i.e., >5 mg/L), with values of 6.26 and 4.3 mg/L, respectively. Site 09-R3M-06-17 also measured outside the acceptable COMAR range for DO, with a value of 4.68 mg/L. All other sites sampled met COMAR standards for water quality. In the spring, water temperature ranged from 5.6 to 20.1 °C; dissolved oxygen ranged from 4.30 to 10.27 mg/L; pH ranged from 6.26 to 7.83; specific conductance ranged from 166.1 to 552.2 µS/cm; and, turbidity ranged from 0 to 8.05 NTU.

In the summer, two of the eight sites were dry in the Severn Run sampling unit. Of the remaining six sites, two sites did not meet COMAR standards for water quality in the summer. Site 09-R3M-03-17 measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5) and DO (i.e., >5 mg/L), with values of 6.35 and 1.34 mg/L, respectively. Site 09-L2M-03-17, the only Use III site sampled in the sampling unit in 2017, fell outside the acceptable COMAR range for temperature (i.e., >20 °C), with a value of 20.6 °C. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 15.1 to 21.5 °C; dissolved oxygen ranged from 1.34 to 10.34 mg/L; pH ranged from 6.35 to 7.47; specific conductance ranged from 237.0 to 275.4 µS/cm; and, turbidity ranged from 4.1 to 17.4 NTU.

Table 24 - Average *in situ* water quality values - Severn Run

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	14.20 ± 4.43	7.63 ± 2.33	6.96 ± 0.47	279.5 ± 121.6	4.47 ± 3.01
Summer	19.43 ± 2.41	7.24 ± 3.26	6.91 ± 0.47	255.2 ± 15.1	7.73 ± 4.99

Average spring grab sample water quality values for the Severn Run sites are provided in Table 25. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, lead, and turbidity. For total phosphorus, total nitrogen, orthophosphate, nitrite, and nitrate, all values at Severn Run sites fell in the low or moderate categories used by MBSS. For total ammonia, site 09-L2M-03 fell in the high category used by MBSS (i.e., >0.07 mg/L), with a value of 0.107 mg/L. All other Severn Run sites fell in the low or moderate categories used by MBSS for total ammonia. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 1.50 to 12.29 mg/L; TOC ranged from 1.56 to 12.47 mg/L; magnesium ranged from 2.22 to 3.44 mg/L; calcium ranged from 5.19 to 23.13 mg/L; and hardness ranged from 24.38 to 71.93 mg/L.

Table 25 - Average grab samples water quality values - Severn 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)	Turbidity (NTU)
45.51 ± 20.32	0.019 ± 0.006	1.049 ± 0.442	0.004 ± 0.001	0.037 ± 0.032	0.002 ± 0.001	0.663 ± 0.521	4.5 ± 2.9
Value ± Standard Deviation							
Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)
5.982 ± 4.154	6.056 ± 4.188	2.997 ± 0.385	13.86 ± 5.03	46.95 ± 13.61	1.896 ± 0.737	10.97 ± 4.26	0.553 ± 0.377

Two sites within the Severn Run sampling unit were characterized by low pH, high DOC levels, and low DO levels, partially meeting criteria for blackwater streams (i.e., pH <6.0; DOC >8.0 mg/L; DO <5.0 mg/L). Sites 09-R3M-03-17 and 09-R3M-06-17 both met blackwater criteria for DOC, and had DO and pH levels slightly above blackwater criteria. Both of these sites fall in the vicinity of a suspected blackwater stream reach (DNR 2016), and may meet blackwater criteria during certain times of the year.

4.4.5 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. A variety of stream types were present in the Severn Run sampling unit (Figure 34). Fifty percent of sites were classified as E type channels and 25 percent were classified as type C channels. The remaining 25 percent of the sites assessed were equally split between F type and not determined (12.5 percent each). Site 09-R3M-03-17, located on an unnamed tributary to Severn Run, was not determined because the channel was heavily modified with large gabion weirs installed across the floodplain for grade control.

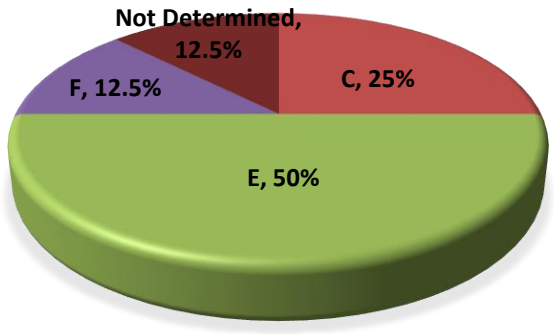


Figure 34 - Rosgen stream types observed in Severn Run

The majority of streams in this sampling unit had a sand (50 percent) dominated substrate. The average D50 for the sampling unit was 1.5 mm (very coarse sand). Slopes ranged from 0.08 to 1.50 percent, with an average slope of 0.58%. All sites except site 09-R2M-06-17 were less than 1%. Site 09-R3M-03-17 was atypical due to multiple headcuts located in the reach, which resulted in an overall slope of 1.5 percent.

4.5 Upper North River (South River)

The Upper North River sampling unit, which consists of direct tributaries to the South River, is located in the middle of the County (Figure 1) and has a drainage area of 12,797 acres. Part of the city of Annapolis is located in the northern portion of the Upper North River sampling unit with Route 50/301 and part of I-97 traveling through the center of the sampling unit. The eight sampling sites (six 1st order, one 2nd order, and one 3rd order streams) shown in Figure 38 have drainage areas ranging from 381 to 5,306 acres. Land use in the Upper North River sampling unit is primarily comprised of forested land (49 percent), followed by developed land (38 percent) (Table 17), which is similar to the average land use observed among sampling sites. Seven of eight sites had forested land as the largest land use category in the upstream drainage area, and the eighth site had developed land use as the largest category (Figure 35). Impervious surfaces comprise 7.0 percent of the overall sampling unit, with individual sites ranging from 3.1 percent to 9.7 percent. Site 11-L1M-04-17 in this sampling unit has the lowest percentage of imperviousness of any sites visited in 2017.

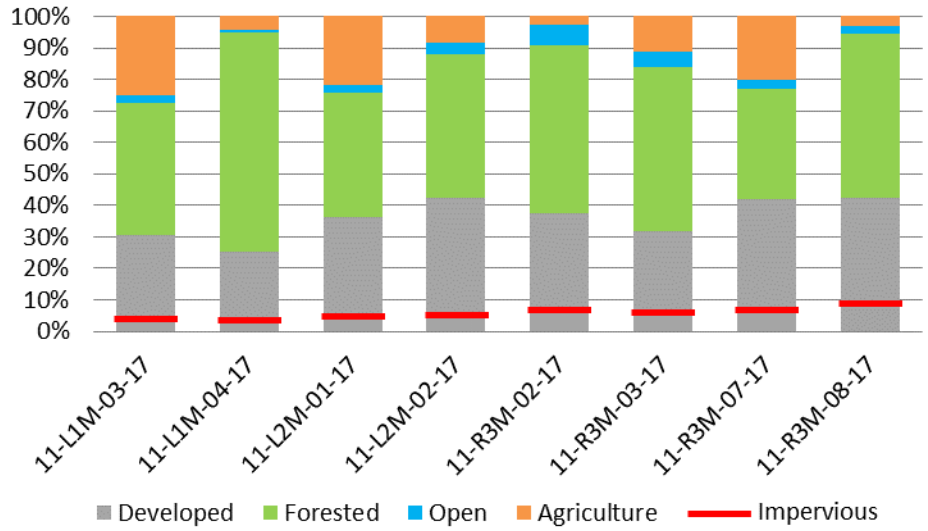


Figure 35 - Upper North River land use

4.5.1 Physical Habitat

Half of the sites sampled during the spring season in the Upper North sampling unit (50 percent) received a 'Partially Supporting' narrative RBP rating, while 38 percent of the sites received a 'Supporting' rating, and the remaining 13 percent received a RBP rating of 'Non-Supporting' (Figure 36). The average RBP score for the sampling unit was 119.0 ± 21.40, and the corresponding narrative rating was 'Partially Supporting.' Individual RBP scores ranged from a minimum of 87 ('Non Supporting') to a maximum of 147 ('Supporting').

The PHI (summer season) rated 16.7 percent of sites as 'Minimally Degraded', 50.0 percent as 'Partially Degraded', and 33.3 percent as 'Degraded' (Figure 36). The average PHI rating was 'Partially Degraded' with a score of 70.04 ± 7.77. Individual PHI scores ranged from 59.38 ('Degraded') to 81.16 ('Minimally Degraded'). Two of the sites visited during the summer where dry and did not received a PHI rating. The majority of sites received moderate to 'Suboptimal' scores for instream habitat, epifaunal substrate, and instream woody debris. Bank stability, riparian vegetative zone and embeddedness received 'Suboptimal' to 'Optimal' scores for all assessed sites.

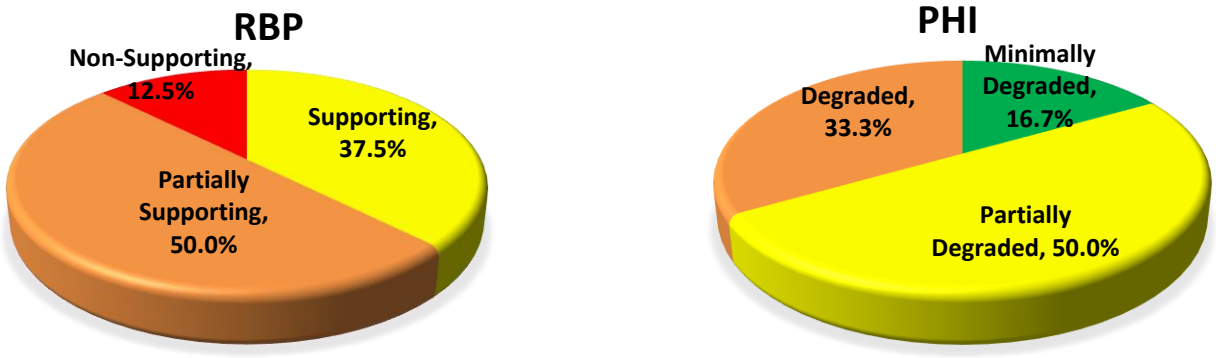


Figure 36 - Upper North Physical Habitat Conditions (RBP n=8; PHI n=6)

4.5.2 Benthic Macroinvertebrates

Half of the sites sampled within the Upper North sampling unit received 'Fair' BIBI ratings, 38 percent received a 'Poor' rating, while the remaining 13 percent of sites were rated as 'Very Poor' (Figure 37). The average BIBI score for the sampling unit was 2.68 ± 0.74 resulting in a 'Poor' biological condition rating (Table 16). Individual BIBI scores ranged from 1.57 ('Very Poor') to 3.86 ('Fair'). Individual site data and assessment results can be found in Appendix D.

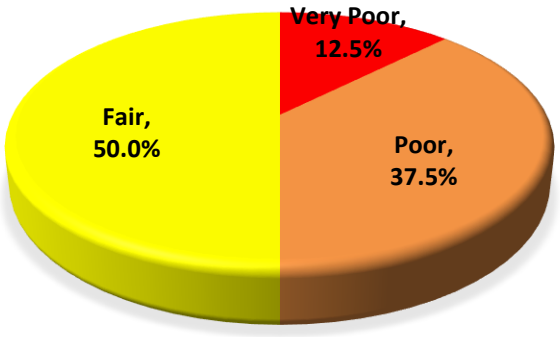


Figure 37 - Upper North BIBI Conditions (n= 8)

Located near Interstate 97, site 11-R3M-08-17 (Figure 38) received the lowest BIBI score of 1.57 with a 'Very Poor' rating. Twelve taxa were present in this sample, which contained three percent of urban intolerant taxa and 64 percent of climber taxa; however, the sample did not contain any EPT, Ephemeroptera or scraper taxa. Furthermore, the site was dominated by midges (*Polypedilum*, TV= 6.3). Site 11-L1M-03-17 received the highest score in Upper North (3.86), resulting in a biological condition rating of 'Fair.' Located near the Fairview Airport and northwest of Bell Branch Road, site 11-L1M-03-17 had a greater amount of woody debris and shading present. Of the 29 taxa identified in this sample, seven were EPT including one Ephemeroptera taxon in addition to one scraper taxon. The site also had percent of intolerant urban taxa of 15.8 percent and percent climbers of 17.5 percent.

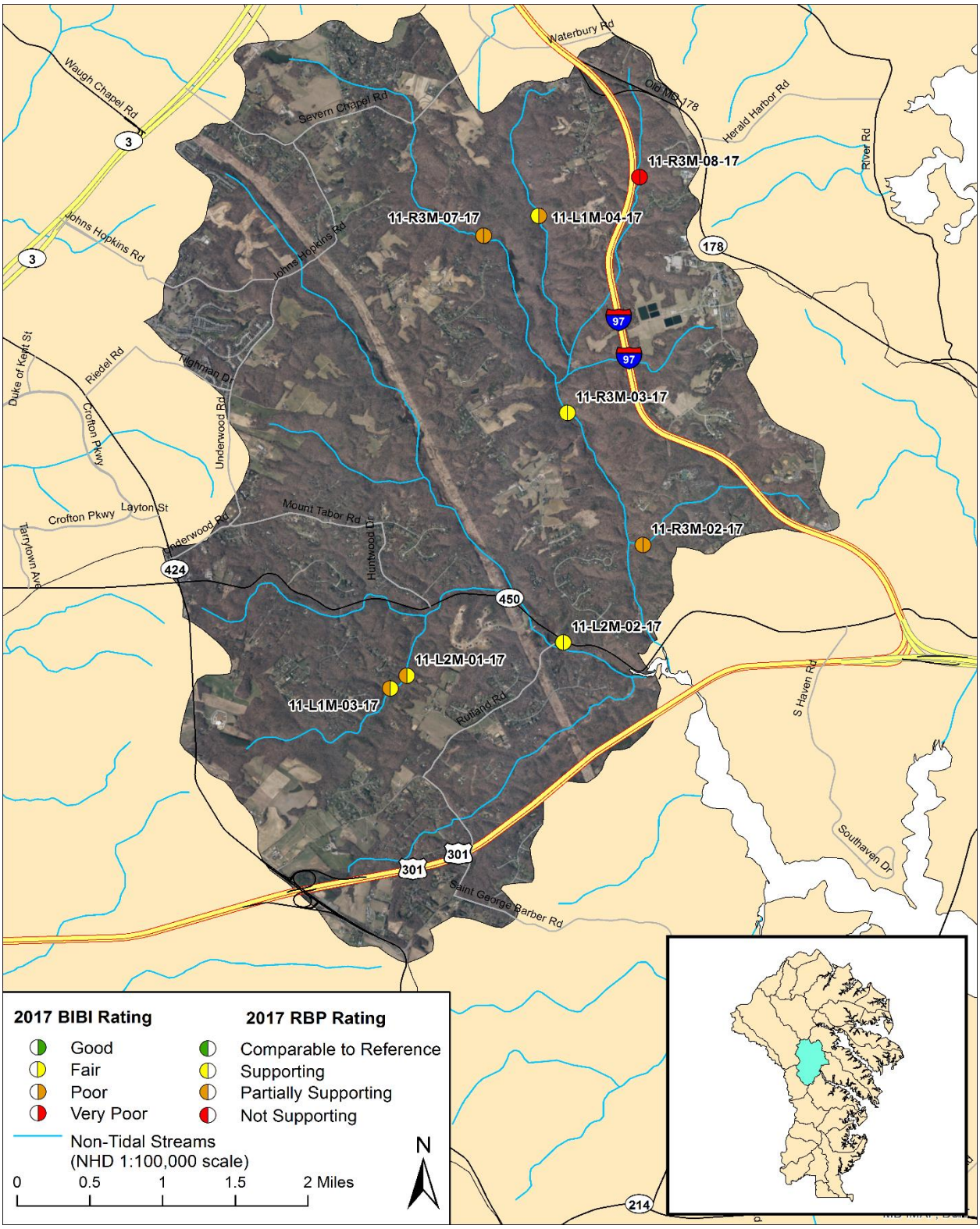


Figure 38 - Upper North River Sampling Sites (BIBI and RBP)

4.5.3 Fish

The Upper North River (South River) sampling unit received the highest FIBI narrative rating of all sampling units during 2017. The Upper North River received a narrative rating of 'Fair' with an average FIBI score of 3.08 ± 1.57 (Table 16). Thirty-seven and a half percent of the individual sites received a biological condition rating of 'Good', 25 percent received a 'Fair' rating, 12.5 percent received a 'Poor' rating, and the remaining 25 percent of sites were rated as 'Very Poor' (Figure 40). Individual FIBI scores ranged from 1.00 ('Very Poor') to 5.00 ('Good'). Site-specific data and assessment results can be found in Appendix D.

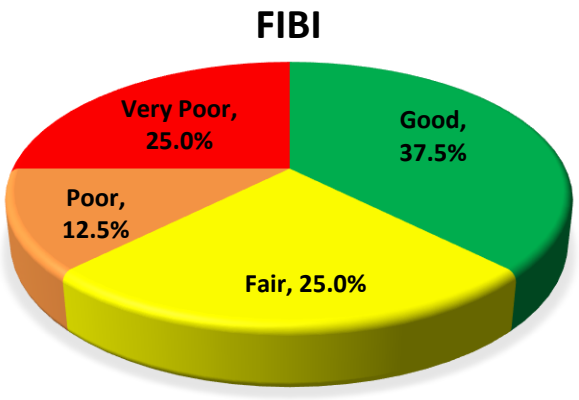


Figure 39 – Upper North FIBI Condition (n=8)

Sites 11-L1M-04-17 and 11-R3M-07-17 received the lowest FIBI score of all Upper North River (South River) sites (1.00) with a narrative rating of 'Very Poor.' These sites both scored a 1.00 because the streams were completely dry at the time of sampling and no fish were encountered. Sites 11-L2M-02-17 (5.00; 'Good') and 11-R3M-03-17 (4.67; 'Good') received the highest FIBI scores in the Upper North River (South River) sampling unit. These two sites scored similarly for all metrics except percent generalist, omnivores, and invertivores where 11-L2M-02-17 scored higher (5) than 11-R3M-03-17. Site 11-L2M-02-17 was the most diverse site of all sites sampled during 2017, with seventeen species present. Sites 11-L1M-04-17 and 11-R3M-07-17 were dry and had no species present, and site 11-R3M-08-17 had only three species present. Eastern Mudminnow and Tessellated Darter were the most widely distributed species in this sampling unit, found at six sites each. Brown Bullhead, Largemouth Bass, Warmouth (*Lepomis gulosus*), and Pumpkinseed were the least common species in this sampling unit, each being found at only a single site. A total of eighteen species were observed in the Upper North River (South River) sampling unit with fifteen native species (Least Brook Lamprey (*Lampetra aepyptera*), American Eel, Blacknose Dace, Fallfish (*Semotilus corporalis*), Golden Shiner, Rosyside Dace (*Clinostomus funduloides*), Creek Chubsucker (*Erimyzon oblongus*), Brown Bullhead, Tadpole Madtom (*Noturus gyrinus*), Chain Pickerel (*Esox niger*), Eastern Mudminnow, Bluespotted Sunfish (*Enneacanthus gloriosus*), Pumpkinseed, Warmouth, Tessellated Darter) and three introduced species (Bluegill, Green Sunfish, Largemouth Bass). One intolerant species, Fallfish, was collected in this sampling unit.

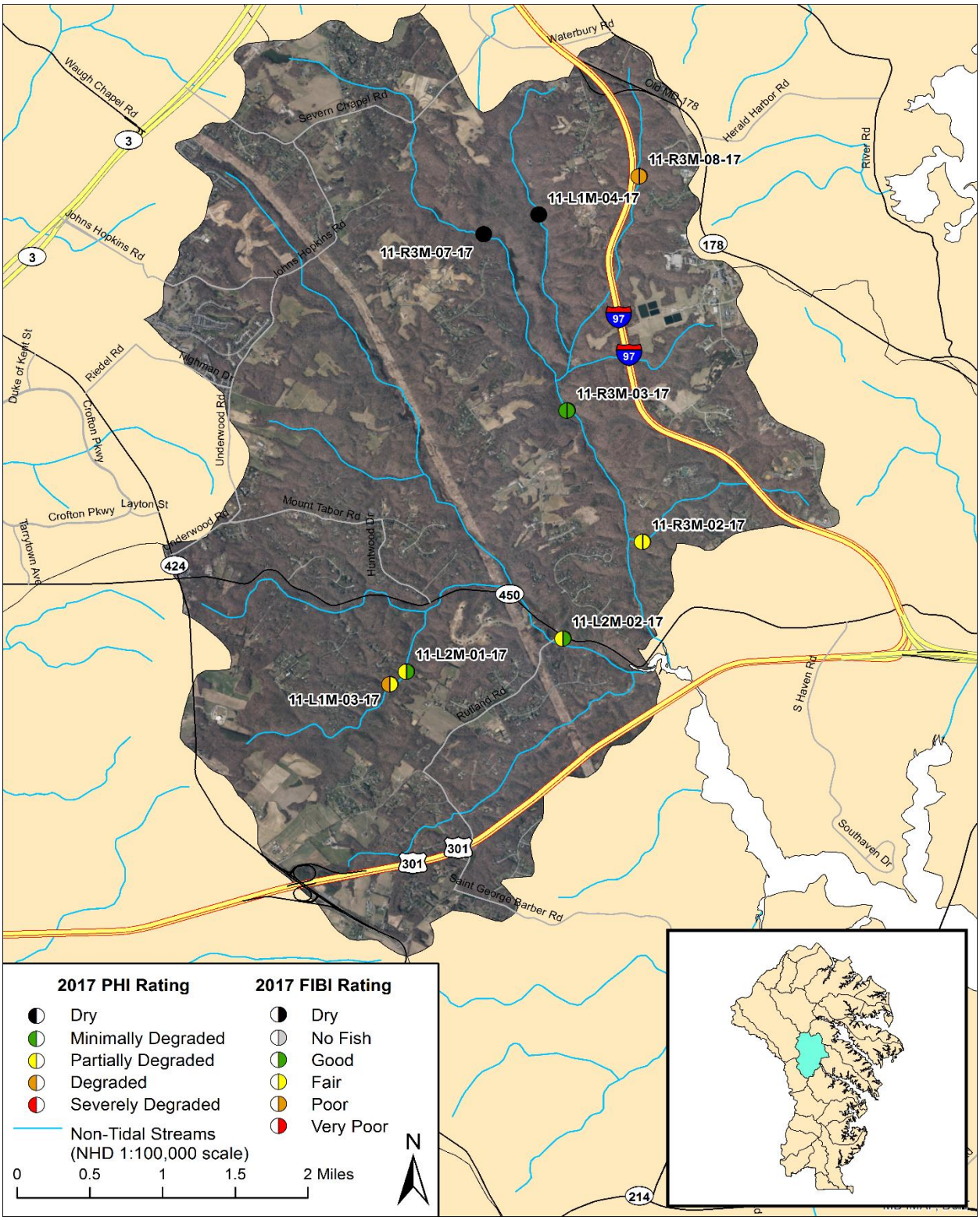


Figure 40 - Upper North River Sampling Sites (FIBI and PHI)

4.5.4 Water Quality

Average spring and summer *in situ* water quality values for the Upper North River sites are provided in Table 26. Of the eight sites sampled, two sites did not meet COMAR standards for water quality in the spring. Sites 11-R3M-07-17 and 11-R3M-08-17 both measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5), with values of 5.33, and 6.11, respectively. Site 11-R3M-07-17 also fell outside the acceptable COMAR range for DO (i.e., >5 mg/L), with a value of 4.31. All other sites sampled met COMAR standards for water quality. In the spring, water temperature ranged from 7.3 to 15.3°C; dissolved oxygen ranged from 4.31 to 11.52 mg/L; pH ranged from 5.33 to 7.20; specific conductance ranged from 100 to 430 µS/cm; and, turbidity ranged from 0.9 to 12.5 NTU.

In the summer, two of the eight sites were dry in the Upper North River. Of the remaining six sites, three sites did not meet COMAR standards for water quality in the summer. Sites 11-R3M-03-17 and 11-R3M-08-17 both measured outside the acceptable COMAR range for pH (i.e., 6.5-8.5), with values of 6.16 and 6.23, respectively. Sites 11-L2M-02-17 and 11-R3M-03-17 both fell outside the acceptable COMAR range for DO (i.e., >5 mg/L), with values of 3.36 and 4.15 mg/L, respectively. All other sites sampled met COMAR standards for water quality. In the summer, water temperature ranged from 18.8 to 24.4°C; dissolved oxygen ranged from 3.36 to 8.77 mg/L; pH ranged from 6.12 to 7.03; specific conductance ranged from 168 to 464 µS/cm; and, turbidity ranged from 3.2 to 30.4 NTU.

Table 26 - Average *in situ* water quality values - Upper North River

Season	Value ± Standard Deviation				
	Temperature (°C)	DO (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Spring	10.93 ± 2.96	9.27 ± 2.26	6.48 ± 0.56	216.6 ± 103.8	4.31 ± 3.76
Summer	21.50 ± 1.98	6.85 ± 2.42	6.55 ± 0.42	269.5 ± 104.8	14.93 ± 11.29

Average spring grab sample water quality values for the Upper North River sites are provided in Table 27. All eight sites sampled met EPA standards for chloride concentration and all sites met COMAR standards for copper, zinc, lead, and turbidity. For total nitrogen, orthophosphate, nitrite, and nitrate, all values at Upper North River sites fell in the low or moderate categories used by MBSS. For total phosphorus, site 11-R3M-03-17 fell in the high category used by MBSS (i.e., >0.07 mg/L), with a value of 0.085 mg/L. For total ammonia, 11-L1M-03-17, 11-L1M-04-17, 11-L2M-01-17, 11-L2M-02-17, 11-R3M-02-17, 11-R3M-03-17, and 11-R3M-08-17 fell in the high category used by MBSS (i.e., >0.07 mg/L), with values of 0.091, 0.088, 0.101, 0.132, 0.208, 0.197, and 0.273 mg/L, respectively. All other Upper North River sites fell in the low or moderate categories used by MBSS for total phosphorus and total ammonia. No state or national water quality standards exist for DOC, TOC, magnesium, calcium, or hardness. Based on spring grab samples, DOC ranged from 0.68 to 1.97 mg/L; TOC ranged from 0.73 to 2.18 mg/L; magnesium ranged from 2.18 to 6.51 mg/L; calcium ranged from 5.06 to 16.02 mg/L; and hardness ranged from 21.63 to 66.82 mg/L.

Table 27 - Average grab sample water quality values - Upper North 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)	Turbidity (NTU)
47.41 ± 32.14	0.031 ± 0.022	0.444 ± 0.154	0.003 ± 0*	0.138 ± 0.083	0.003 ± 0.002	0.197 ± 0.061	12.5 ± 8.9
Value ± Standard Deviation							
Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)
1.264 ± 0.564	1.389 ± 0.617	3.957 ± 1.457	11.60 ± 3.69	45.25 ± 14.26	0.238 ± 0.203	20.62 ± 8.60	0.211 ± 0.236

*All values were below the detection limit of 0.003mg/L.

4.5.5 Geomorphic Assessment

Site-specific geomorphic assessment summary results can be found in Appendix A. The majority of sites in the Upper North River sampling unit were classified as slightly entrenched E type channels (50 percent; Figure 41). The stream type of the remaining 50 percent of sites were entrenched F or G type channels (25 percent each).

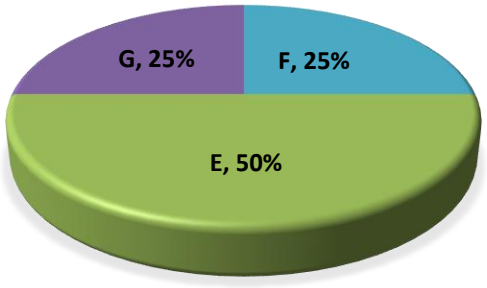


Figure 41 - Rosgen stream types observed in Upper North River (n=8)

Dominant substrate type varied little throughout the sites in this sampling unit. Majority of sites were sand dominated (87.5 percent), while the remaining 12.5 percent of sites were gravel dominated. The average D50 for the sampling unit was 2.5 mm (very fine gravel). The average slope was 0.31 percent, with individual reach slopes ranging from 0.18 percent to 0.50 percent. Site 11-L2M-02-17 was atypical due to a knick-point within the reach, though the overall slope was still just 0.24 percent.

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) were reestablished and resampled in order to track changes through time at individual sites within each sampling unit. For these sites, cross-sectional area, Rosgen classification, substrate distribution, and BIBI scores were compared across sampling years (Table 28). In order to allow comparisons for revisited sites, Round One and Two bankfull lines were adjusted in order to match the bankfull elevation in 2017. In general, cross-sectional overlays of Round One and Round Two sites resampled in Round Three showed cross-sectional area to increase in all sampling units, except for the Rhode River. Overall, the D_{50} of all sampling units was sandy substrate in all sampling units except for Severn Run and Upper North River. The substrate decreased from medium to fine sand within Bodkin Creek, remained fine sand within Rhode River, increased from very fine to medium sand within Severn River, increased from fine to very fine gravel within Severn Run, and increased from very coarse sand to fine gravel within Upper North River. Trends in BIBI scores at revisit sites also varied by sampling unit. On average, BIBI scores improved in Bodkin Creek, declined in Severn Run, Severn River, and Rhode River, and remained the same in Upper North River from Round One and Two to Round Three. In addition, no consistent trend was observed between changes in BIBI scores and changes in cross-sectional area or substrate distribution.

Cross-section overlays of Bodkin Creek sites resampled in Round Three showed an increase in cross-sectional area at all four sites, representing an average increase of 38 percent which ranged from 28 to 48 percent. Stream channels at these sites also changed from C and D type to E type channels (Table 28). Sites 06-L1M-02-17 and 06-L1M-04-17 experienced the greatest change in cross-sectional areas, of 42 and 48 percent respectively. A representative cross-sectional overlay can be found in Figure 33. Individual site cross-sectional overlays can be found in Appendix D: Individual Site Summaries. Large Bodkin Creek streams all contained sandy substrates ranging from fine through coarse sand (D_{50} = 0.16 to 0.50) in their initial visit to fine through medium sand (D_{50} = 0.16 to 0.30) in Round 3. This represented an increase in particle size at site 06-L1M-02-17 from fine to medium sand and a decrease in particle size at 06-L2M-03-17 from coarse to fine sand. Other sampled sites experienced no change in particle size.

On average, BIBI scores at Bodkin Creek revisit sites improved slightly from previous rounds to Round Three, but still received a 'Poor' biological rating (Table 28). The BIBI score at site 06-L1M-03-17 improved notably from Round One ('Very Poor' rating) to Round Three ('Fair' rating), despite an increase in cross-sectional area and no overall change in substrate distribution. The BIBI score at site 06-L2M-01-17 also improved from Round Two ('Very Poor' rating) to Round Three ('Poor' rating), which also corresponded to an increase in cross-sectional area and no overall change in substrate distribution. The BIBI scores at all other sites in Bodkin Creek remained relatively unchanged from previous rounds to Round Three.

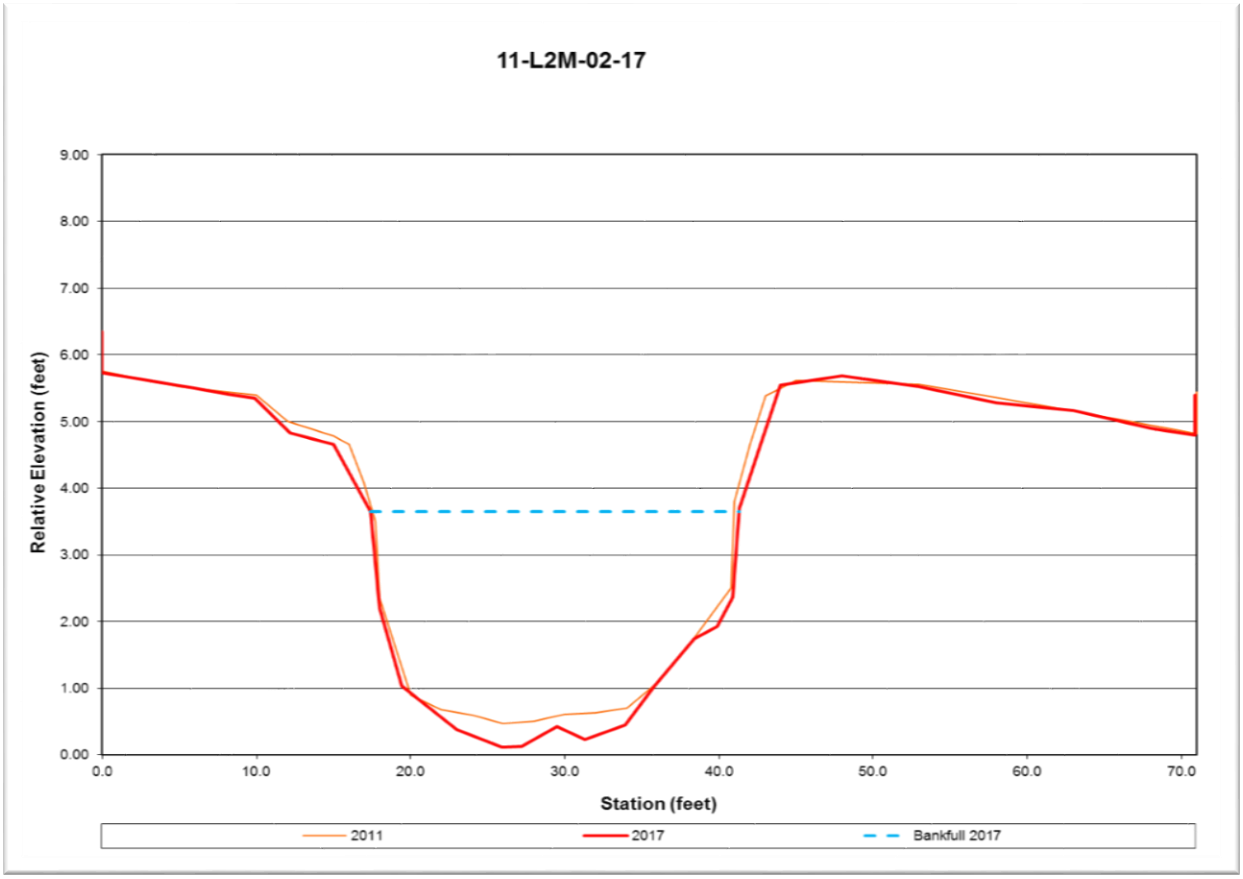


Figure 42- Representative cross-section overlay in Upper North River

Table 28 - Comparison of Round One and Round Two (2004 - 2013) with Round Three (2017) geomorphological and biological data

2017 Site Name	Year First Sampled	Cross-Sectional Area (ft^2)			D_{50} Substrate Classification (Size in mm)		Rosgen Classification		BIBI Narrative Ranking (Score)	
		R1/R2	R3	%Δ	R1/R2	R3	R1/R2	R3	R1/R2	R3
06-L1M-02-17	2006	5.2	7.4	42.3	fine sand (0.16)	medium sand (0.28)	E5	E5	Fair (3.00)	Fair (3.00)
06-L1M-03-17	2006	8.2	10.5	28.0	medium sand (0.25)	medium sand (0.27)	E5	E5	Very Poor (1.86)	Fair (3.29)
06-L1M-04-17	2006	2.3	3.4	47.8	fine sand (0.13)	fine sand (0.16)	C5	E5	Poor (2.71)	Poor (2.14)
06-L2M-01-17	2011	5.9	7.9	33.9	medium sand (0.40)	medium sand (0.30)	E5	E5	Very Poor (1.29)	Poor (2.43)
06-L2M-03-17	2011	22*	10.2**	**	coarse sand (0.50)	fine sand (0.22)	DA5	E5	Poor (2.71)	Poor (2.43)
Bodkin Creek Average		5.4	7.9	38.0	medium sand (0.29)	fine sand (0.25)	--	--	Poor (2.31)	Poor (2.66)
09-L1M-01-17	2004	ND	32.1	ND	ND	medium gravel (9.40)	ND	E4/5	Poor (2.43)	Poor (2.71)
09-L1M-02-17	2004	ND	31.1	ND	ND	medium sand (0.28)	ND	F5	Poor (2.71)	Poor (2.14)
09-L2M-02-17	2011	0.1	2.7	2600.0	fine sand (0.17)	fine sand (0.18)	DA5	E5	Poor (2.71)	Very Poor (1.29)
09-L2M-03-17	2011	6.7	15.0	123.9	medium sand (0.29)	coarse sand (0.58)	C5	E5	Fair (3.86)	Good (4.71)
Severn Run Average		3.4	20.2	1361.9	fine sand (0.23)	medium sand (0.35)	--	--	Poor (2.93)	Poor (2.71)
10-L1M-05-17	2004	ND	4.4	ND	ND	fine sand (0.21)	ND	E5	Poor (2.71)	Poor (2.71)
10-L1M-06-17	2004	ND	5.2	ND	ND	coarse sand (0.53)	ND	F5	Fair (3.00)	Poor (2.14)
10-L2M-01-17	2013	2.7	3.3	22.2	very fine sand (0.09)	coarse sand (0.55)	DA5	DA5	Fair (3.57)	Fair (3.57)
10-L2M-04-17	2013	4.9	6.8	38.8	very fine sand (0.06)	medium sand (0.29)	E6	E5	Fair (3.57)	Poor (2.43)
Severn River Average		3.8	4.9	30.5	very fine sand (0.08)	medium sand (0.40)	--	--	Fair (3.21)	Poor (2.71)
11-L1M-03-17	2005	8.2	14.2	73.2	medium sand (0.30)	fine sand (0.23)	B5c	G5	Good (4.14)	Fair (3.86)
11-L1M-04-17	2005	8.53*	**	--	fine sand (0.19)	fine sand (0.22)	C5	E5	Fair (3.86)	Poor (2.43)
11-L2M-01-17	2011	11.9	15.0	26.1	medium sand (0.32)	fine sand (0.18)	F5	G5	Poor (2.43)	Fair (3.00)
11-L2M-02-17	2011	61.4	66.6	8.5	fine gravel (4.10)	coarse gravel (18.00)	ND	E4	Poor (2.14)	Fair (3.29)
Upper North River Avg***		27.2	31.9	35.9	very coarse sand (1.23)	fine gravel (4.66)	--	--	Fair (3.14)	Fair (3.15)
13-L1M-03-17	2008	11.4	10.5	-7.9	fine sand (0.16)	medium sand (0.27)	C5	C5	Poor (2.43)	Very Poor (1.57)
13-L1M-04-17	2008	8.9	4.3	-51.7	medium sand (0.25)****	fine sand (0.13)	C5	E5	Poor (2.14)	Poor (2.14)
13-L2M-03-17	2012	6.3	6.8	7.9	fine sand (0.22)	very fine sand (0.06)	C6	C6	Very Poor (1.86)	Very Poor (1.86)
13-L2M-04-17	2012	25.8	26.0	0.8	fine sand (0.13)	very fine sand (0.06)	ND	E6	Poor (2.43)	Poor (2.43)
Rhode River Average		13.1	11.9	-12.7	fine sand (0.19)	fine sand (0.13)	--	--	Poor (2.22)	Poor (2.00)

ND - no data collected; -- = did not calculate; * - Round One or Two cross-sectional area not adjusted to match the bankfull elevation from 2017 due to lack of 2017 data; ** - overlay not completed due to change in placement of one or more end pins; *** - Cross-sectional averages do not include sites where cross-section overlays could not be completed; **** - value estimated in Round One; R1 - Round One; R2 - Round Two; R3 - Round Three; %Δ = ((R3 cross-sectional area - R1 or R2 cross-sectional area)/ R1 or R2 cross-sectional area) * 100

Cross-sections were not completed in the first year of Round One (2004), so geomorphological comparisons could only be made with past Round Two sites within the Severn Run sampling unit. With this in mind, of the Severn Run streams resampled in Round Three, cross-section overlays showed the greatest change across 2017 sampling units, with sites also changing from C and D type to E type channels (Table 28). Site 09-L2M-03-17 increased in cross-sectional area by 124 percent. The channel downcut substantially at 09-L2M-02-17. In 2011 the flow was spread across the floodplain in multiple channels (DA stream type), and in 2017 flow was concentrated into one channel (E channel type). A representative cross-sectional overlay can be found in Figure 43 and individual site cross-sectional overlays can be found in Appendix D: Individual Site Summaries. While particle size increased at both sites, D50 at 09-L2M-02-17 only went up five percent and remained fine sand while there was a fifty percent increase in D50 at 09-L2M-03-17 that represented a shift from medium to coarse sand.

The average Round Three BIBI score at Severn Run revisit sites was similar to the average observed in Round Two, with both receiving a 'Poor' biological rating (Table 28). The BIBI score at site 09-L2M-02-17 declined substantially from Round Two ('Poor' rating) to Round Three ('Very Poor' rating), which corresponded to an increase in cross-sectional area due to downcutting in 2017, but no overall change in substrate distribution. The BIBI score at site 09-L2M-03-17 improved substantially from Round Two ('Fair' rating) to Round Three ('Good' rating), which corresponded to substantial increase in cross-sectional area and an increase in substrate distribution from medium to coarse sand. The BIBI scores at both Round One revisit sites in Severn Run remained relatively unchanged, both receiving a 'Poor' biological rating in Round One and Three.

Cross-sections were not completed in the first year of the project (2004), and so only two geomorphological comparisons could be made within the Severn River sampling unit. A representative cross-sectional overlay can be found in Figure 33 and individual site cross-sectional overlays can be found in Appendix D Individual Site Summaries. Revisits of Round Three Severn River streams showed cross-sectional area to increase at both sites at a range of 31 to 39 percent, with no change in channel type (Table 28). The D50 also increased at both of the Large Severn River sites, though they remained in the sand category. The D50 of 10-L2M-01-17 went from very fine sand to coarse sand, and the D50 of 10-L2M-04-17 went from very fine sand to medium sand.

On average, BIBI scores at Severn River revisit sites declined from previous rounds to Round Three, decreasing from a 'Fair' to 'Poor' biological rating (Table 28). The BIBI scores at sites 10-L1M-06-17 and 10-L2M-04-17 both declined substantially from previous rounds ('Fair' rating) to Round Three ('Poor' rating). This change at site 10-L2M-04-17, corresponded to an increase in cross-sectional area and an in increase in substrate distribution from very fine sand to medium sand. Because geomorphological surveys were not completed at all Round One sites, no comparisons can be made for 10-L1M-01-17. The BIBI scores at all other Severn River revisit sites were the same in Round Three and previous rounds.

On average, resampled Upper North River streams in Round Three showed that all four sites increased in cross-sectional area, ranging from 8.5 to 73.2 percent increase as they shifted to E and G type channels (Table 28). A representative cross-sectional overlay can be found in Figure 42 and individual site cross-sectional overlays can be found in Appendix D: Individual Site Summaries. When initially sampled, particle sizes of Upper North River reaches ranged from fine sand to fine gravel (D50= 0.19 to 4.10) and when revisited, a majority of these sites were fine sand with one having coarse gravel (D50 = 0.18 to 18.00). The D50 at 11-L1M-03-17 and 11-L2M-01-17 decreased from medium to fine sand, whereas the D50 at 11-

L2M-02-17 increased fine to coarse gravel. The remaining site, 11-L1M-04-17, experienced no change in particle size.

On average, BIBI scores at Upper North River revisit sites remained the same from previous rounds to Round Three, receiving a 'Fair' biological rating (Table 28). Changes in BIBI score were site specific, with scores increasing at the Round Two revisit sites and decreasing at the Round One revisit sites. The BIBI scores at both Round Two revisit sites (11-L2M-01-17 and 11-L2M-02-17) improved substantially from Round Two ('Poor' rating) to Round Three ('Fair' rating). These changes corresponded to an increase in cross-sectional area at both sites and an increase in substrate distribution from fine gravel to coarse gravel at 11-L2M-02-17 and decrease in substrate distribution from medium sand to fine sand at 11-L2M-01-17. The BIBI scores at 11-L1M-03-17 and 11-L1M-04-17 declined substantially from a 'Good' to 'Fair' and 'Fair' to 'Poor' biological ratings, respectively. These changes in BIBI scores corresponded to an increase in cross-sectional area and a decrease in substrate distribution from medium sand to fine sand at 11-L1M-03-17 and no change in substrate distribution at 11-L1M-04-17.

Of the four Rhode River streams resampled in Round Three, cross-section overlays showed an average decrease in cross-sectional area by fourteen percent with most sites maintaining C type channels (Table 28). Site 13-L1M-03-17 decreased in cross-sectional area by eight percent, 13-L1M-04-17 decreased in cross-sectional area by 52 percent, and 13-L2M-03-17 increased in cross-sectional area by eight percent, while cross-sectional area remained nearly the same at 13-L2M-04-17 with an increase of just one percent. A representative cross-sectional overlay can be found in Figure 42 and individual site cross-sectional overlays can be found in Appendix D: Individual Site Summaries. In the first visit to Rhode River sites, particle sizes ranged from fine to medium sand (D50 = 0.13 to 0.25) and when revisited, particle size ranged from very fine to medium sand (D50 = 0.06 to 0.27). This represented an increase in particle size at site 13-L1M-03-17 from fine to medium sand, a decrease in particle size at 13-L1M-04-17 from medium to fine sand, a decrease in particle size at 13-L2M-03-17 from fine to very fine sand, and a decrease in particle size at 13-L2M-04-17 from fine to very fine sand.

On average, BIBI scores at Rhode River remained similar between previous rounds and Round Three, receiving a 'Poor' biological rating overall (Table 28). The BIBI score at site 13-L1M-03-17 declined from Round One ('Poor' rating) to Round Three ('Very Poor' rating), which corresponded to a decrease in cross-sectional area and a decrease in substrate distribution from medium sand to fine sand. The BIBI scores at all other sites in Rhode River revisit sites remained unchanged from previous rounds to Round Three, all receiving 'Poor' or 'Very Poor' biological ratings.

6 Comparison of Results with Previous Rounds

This section presents a brief comparison of the biological and physical habitat assessment results collected as part of Round Three, with results from Round One and Round Two for each of the five PSUs assessed in 2017. Refer to Figure 43 for box plots comparing mean BIBI, RBP, and PHI results from Rounds One, Two and Three in the Bodkin Creek, Rhode River, Severn River, Severn Run, and Upper North 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.

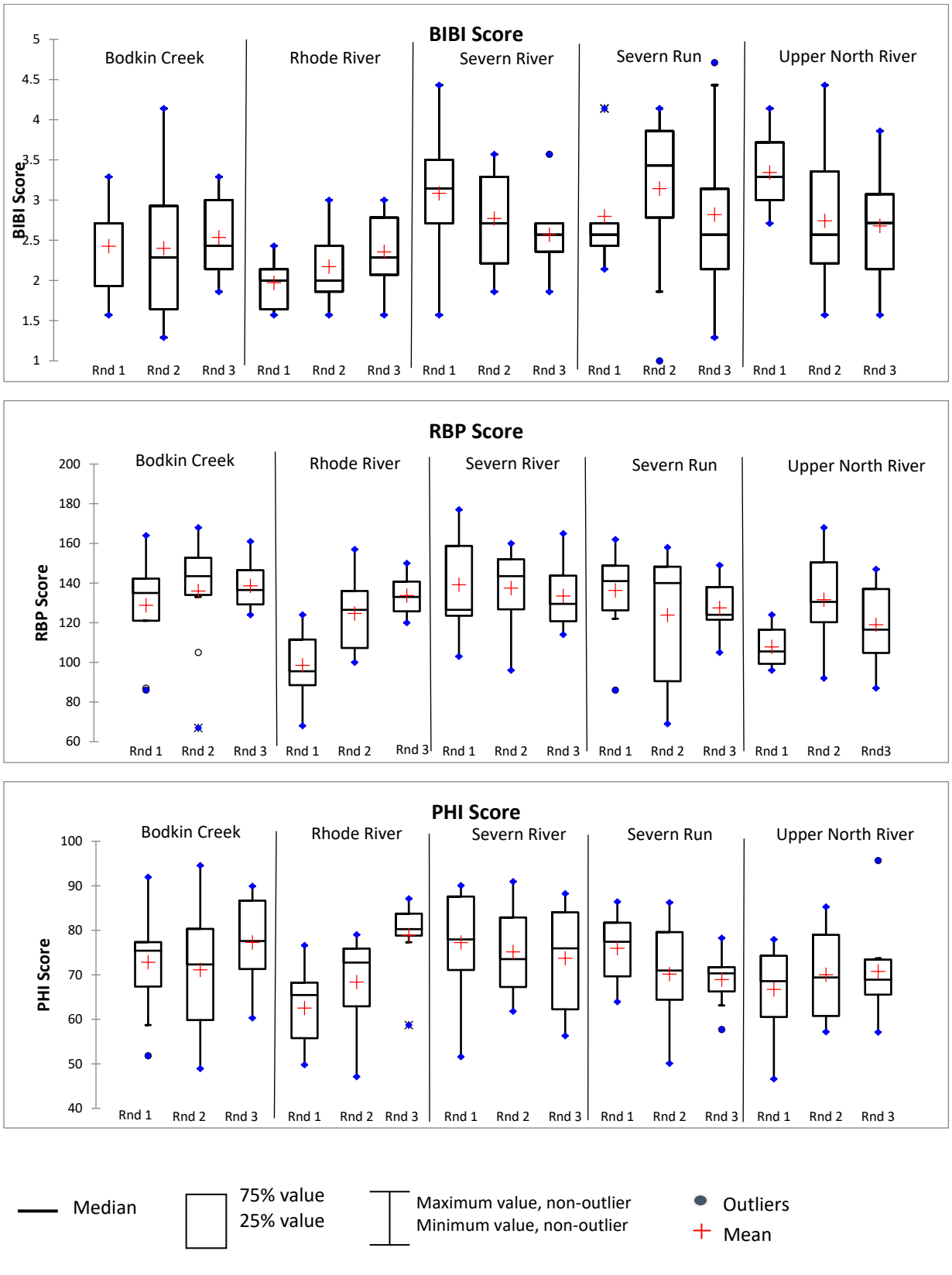


Figure 43 - Box plots comparing mean BIBI, RBP and PHI scores between Rounds One, Two and Three

6.1 Biological Conditions

A comparison of mean BIBI scores between Round Two and Round Three showed no significant changes between sampling rounds (Table 29 and Table 30). However, a comparison of mean BIBI scores between Round One and Round Three showed a significant decrease in the Upper North River PSU between sampling rounds from 3.34 ±0.15 and a biological condition rating of 'Fair' to 2.68 ±0.15 and a rating of 'Poor' (Table 30).

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

PSU	Round 3		Round 2		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean IBI	SE	Mean IBI	SE			
Bodkin Creek	2.54	0.18	2.40	0.29	0.53	-0.80	No
Severn Run	2.82	0.41	3.14	0.33	1.36	-0.72	No
Severn River	2.57	0.18	2.77	0.20	0.73	-0.32	No
Upper North River	2.68	0.26	2.74	0.28	0.81	-0.68	No
Rhode River	2.36	0.19	2.17	0.14	0.28	-0.64	No

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

PSU	Round 3		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean IBI	SE	Mean IBI	SE			
Bodkin Creek	2.54	0.18	2.43	0.19	0.40	-0.62	No
Severn Run	2.82	0.41	2.80	0.23	0.91	-0.95	No
Severn River	2.57	0.18	3.09	0.27	1.15	-0.12	No
Upper North River	2.68	0.26	3.34	0.15	1.25	0.08	Yes (Decrease)
Rhode River	2.36	0.19	1.97	0.11	0.03	-0.80	No

6.2 Physical Habitat Conditions

Comparisons of physical habitat conditions between Rounds Two and Three and Rounds One and Three for the RBP are shown in Table 31 and Table 32, respectively. There were no significant changes in RBP habitat conditions between sampling Rounds Two and Three. Comparisons between Round One and Three showed a significant increase in Rhode River, with the mean RBP score increasing from 98.5 ±5.34 and a rating of "Non Supporting" in Round One to 133.8 ±3.86 and a rating of "Supporting" in Round Three.

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

PSU	Round 3		Round 2		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean RBP	SE	Mean RBP	SE			
Bodkin Creek	138.6	4.50	136.0	9.39	17.79	-23.04	No
Severn Run	127.5	4.82	123.9	11.62	21.05	-28.25	No
Severn River	133.5	6.17	137.5	6.26	21.24	-13.24	No
Upper North River	119.0	7.57	131.6	8.27	34.56	-9.36	No
Rhode River	133.8	3.86	124.7	6.09	5.08	-23.18	No

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

PSU	Round 3		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean RBP	SE	Mean RBP	SE			
Bodkin Creek	138.6	4.50	128.8	8.22	8.55	-28.20	No
Severn Run	127.5	4.82	136.3	6.94	25.37	-7.77	No
Severn River	133.5	6.17	139.2	8.05	25.58	-14.18	No
Upper North River	119.0	7.57	107.8	3.21	4.91	-27.31	No
Rhode River	133.8	3.86	98.5	5.34	-22.34	-48.16	Yes (Increase)

Comparisons of physical habitat conditions between Rounds Two and Three and Rounds One and Three for the PHI are shown in Table 33 and Table 34, respectively. Only one PSU, Rhode River, showed significant changes in PHI habitat conditions between sampling Rounds Two and Three. The mean PHI score increased from 68.39 ±3.26 and a rating of "Partially Degraded" in Round Two to 78.90 ±3.10 and a rating of "Partially Degraded" in Round 3. Two PSUs, Severn Run and Rhode River, saw significant changes in PHI scores between Round One and Round Three. Rhode River increased from 62.54 ±3.00 and a rating of "Degraded" in Round One to 78.90 ±3.10 and a rating of "Partially Degraded" in Round 3. Severn Run, on the other hand, saw a decrease from 75.96 ±2.56 and a rating of "Partially Degraded" in Round One to 68.92 ±2.22 and a rating of "Partially Degraded" in Round Three.

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

PSU	Round 3		Round 2		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean PHI	SE	Mean PHI	SE			
Bodkin Creek	77.29	3.89	71.12	4.48	5.45	-17.79	No
Severn Run	68.92	2.22	70.15	3.75	9.77	-7.31	No
Severn River	73.73	4.38	75.16	3.19	12.04	-9.19	No
Upper North River	70.78	4.07	70.01	3.19	9.37	-10.91	No
Rhode River	78.90	3.10	68.39	3.26	-1.71	-19.33	Yes (Increase)

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

PSU	Round 3		Round 1		Upper 95% CI	Lower 95%CI	Significant Difference? (Direction)
	Mean PHI	SE	Mean PHI	SE			
Bodkin Creek	77.29	3.89	72.82	4.03	6.50	-15.44	No
Severn Run	68.92	2.22	75.96	2.56	13.68	0.39	Yes (Decrease)
Severn River	73.73	4.38	77.25	3.84	14.93	-7.89	No
Upper North River	70.78	4.07	66.75	3.16	6.07	-14.14	No
Rhode River	78.90	3.10	62.54	3.00	-7.92	-24.82	Yes (Increase)

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 2017 assessment indicate impaired biological conditions in all five sampling units. All five sampling units had mean BIBI scores in the 'Poor' category. Three of the five had mean FIBI scores in the 'Poor' category, one sampling unit had mean FIBI of 'Very Poor', and the last sampling unit had mean FIBI score in the 'Fair' category. Changes in mean BIBI scores for sampling units were not significant between Rounds 2 and 3, and only Upper North (South River) showed a significant positive difference of mean BIBI scores between Rounds 1 and 3, the other four sampling units had no significant change in BIBI scores between these same Rounds. There were no discernable trends in PHI habitat data at three of the five sampling units. Rhode River showed a statistically significant increase in mean PHI scores between Round 1 and Round 3 and between Round 2 and Round 3. Severn Run showed a small significant decrease in mean PHI scores between Rounds 1 and 3. Mean scores for RBP between Rounds 2 and 3 showed no significant trend. Mean RBP scores for Round 1 versus Round 3 showed a significant increase for only the Rhode River.

Overall, both physical habitat assessment methods yielded scores that did not correspond well with predicted BIBI nor FIBI scores. A comparison of narrative BIBI ratings to spring-collected RBP habitat condition ratings for each site is shown in Table 35. Similarly, Table 36 compares FIBI ratings to summer-collected PHI habitat ratings. These results are similar to those found by Roberts et al. (2006) and Stribling et al. 2008, and suggest that BIBI scores are not singularly affected by habitat conditions alone and additional stressors are likely present in these systems. It is likely that holds true for FIBI scores as well. Results from the RBP method showed the majority of sites with 'Comparable to Reference' or 'Supporting' physical habitat conditions (60 percent); however, more than two-thirds of these sites (71 percent) actually resulted in biological conditions that were lower than the habitat category may suggest is possible (Table 35). Similar to the RBP method, results from the PHI method showed the majority of sites with a

'Minimally Degraded' or 'Partially Degraded' rating (66 percent), with 76 percent of those sites resulting in biological conditions that were lower than the habitat category may suggest is possible (Table 36).

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

EPA RBP Habitat Rating	BIBI Rating			
	Good	Fair	Poor	Very Poor
Comparable to Reference		06-L1M-02-17 10-L2M-01-17		
Supporting	09-R3M-06-17	06-L1M-03-17 06-R3M-08-17 11-L2M-02-17 11-R3M-03-17 13-R3M-01-17 13-R3M-03-17	06-L1M-04-17 06-L2M-01-17 06-L2M-03-17 09-L1M-01-17 09-R3M-04-17 10-L1M-05-17 10-L2M-04-17 10-R3M-01-17 10-R3M-08-17 11-L1M-04-17 13-L1M-04-17 13-R3M-33-17	**06-R3M-02-17** **13-L1M-03-17** **13-L2M-03-17**
Partially Supporting	**09-L2M-03-17**	11-L1M-03-17 11-L2M-01-17	06-R3M-01-17 09-L1M-02-17 09-R3M-01-17 09-R3M-03-17 10-L1M-06-17 10-R3M-05-17 11-R3M-02-17 11-R3M-07-17 13-L2M-04-17 13-R3M-05-17	09-L2M-02-17 10-R3M-02-17
Non-Supporting				11-R3M-08-17

Blue cells: stations where the biological community was less impaired than the habitat scores would predict.
Gray cells: stations where biological community matched available habitat.
Orange cells: stations where the biological community was more impaired than the habitat scores would predict.
Bold type stations have biological conditions that differ by at least two qualitative habitat categories.
n=40

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

MBSS PHI Habitat Rating	FIBI Rating			
	Good	Fair	Poor	Very Poor
Minimally Degraded	11-R3M-03-17	06-L1M-02-17 06-R3M-08-17 10-L2M-01-17	**06-L1M-03-17** **10-R3M-01-17**	**13-R3M-03-17**
Partially Degraded	11-L2M-01-17 11-L2M-02-17	09-L1M-02-17 11-R3M-02-17	06-L2M-01-17 06-L2M-03-17 09-L1M-01-17 09-L2M-03-17 09-R3M-01-17	**06-L1M-04-17** **06-R3M-01-17** **13-R3M-01-17** **13-R3M-05-17** **10-L1M-06-17**
Degraded		13-R3M-33-17 09-R3M-06-17 11-L1M-03-17	13-L2M-04-17 10-R3M-02-17 10-R3M-05-17 10-R3M-08-17 10-L2M-04-17 11-R3M-08-17	06-R3M-02-17 09-R3M-03-17
Severely Degraded				

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; 8 dry sites with no habitat assessed

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

In developed sampling units with a higher percentage of impervious surfaces, such as Bodkin Creek, Severn River, and Severn Run, water quality stressors are likely strong contributors to impaired biological conditions. Elevated conductivity values (i.e., >247 µS/cm) were observed at 18 of 40 sites in the spring and 20 of 32 sites in the summer had conductivity values that exceeded the 247 µS/cm threshold of BIBI impairment developed from MBSS data. The expected pattern of increased imperviousness leading to increased conductivity measurements was not evident in these data. There was a non-significant trend (R^2=0.08; p=0.07) toward increased springtime conductivity with increased impervious surfaces for the sites sampled in 2017. There was no trend (R^2=0.03; p=0.32) between summertime conductivity and impervious surfaces for these sites. The PSU with the lowest amount of imperviousness, Rhode River (6.1 percent) had the highest mean conductivity (540.6 µS/cm) of either spring or summer measurements. This is likely driven by a small sample size of five, as three sites were dry at the summer visit so no conductivity data were collected at these locations. Also, Rhode River had the highest single conductivity measurement of 1,574 µS/cm taken at 13-R3M-33-17 during the summer. The PSU with the highest amount of imperviousness, Severn River, had the lowest mean conductivity measurements in both the spring (208.4 µS/cm) and summer (212.1 µS/cm) visits. There were no significant trends between conductivity and BIBI score (R^2=0.002; p=0.78) nor FIBI (R^2=0.003; p=0.77) scores. Further sampling across all sampling units within the County will help create a larger dataset to investigate further the effects of conductivity on the ecological condition of the County's streams.

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

Previous years of this study have shown drainage area may influence biological community composition with larger drainage areas providing an increased potential for full colonization by benthic macroinvertebrate communities (Hill and Pieper, 2011b). Using data from 2017 sites, drainage area has a non-significant weak positive effect on BIBI score (R^2=0.05; p=0.16) with increased drainage area. With the addition of fish data in 2017, similar correlation can be investigated for the drainage area effect on the FIBI in Anne Arundel County. Data from 2017 sampling shows a significant correlation between increasing drainage area and FIBI score (R^2=0.44; p<0.001). 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 MCP regional relationships of bankfull channel geometry versus drainage area (McCandless, 2003), which were derived from E type and C type streams, in order to determine how channel dimensions observed in the field compare to those predicted for rural/suburban subwatersheds. Comparisons of bankfull width, mean bankfull depth, and bankfull cross-sectional area, stratified by Rosgen Level I stream type, are shown in Figure 44, Figure 45, and Figure 46, respectively. Channels where Rosgen classifications could not be determined (ND, one site) or were considered transitional were not included in these analyses.

A comparison of bankfull width values show the trendline for E channels (R^2 = 0.54) as the closest to matching the MCP curve (Figure 44). Trendlines from C (R^2 = 0.59) and F (R^2 = 0.89) channels contained the least variability, with data points scattered mostly above the MCP curve. This suggests that C and F type channels assessed in 2017 were generally wider than the streams used to derive the MCP regional relationships. On the other hand, the trendline for E type (R^2 = 0.54) channels was below the MCP curve, indicating narrower channels than predicted by the regional curve. These results are somewhat expected given that F type channels tend to have greater width/depth ratios as compared to E and G type channels (Rosgen, 1996).

Mean bankfull depth values showed the trendline for E type channels (R^2 = 0.70) closely matching the MCP curve, with the exception of a few outliers above and below the curve (Figure 45). F type channels exhibited the highest degree of variability (R^2 = 0.50), with points scattered only below the curve, showing depths that were shallower than predicted by the MCP. All C channels (R^2 = 0.55) fell below the MCP curve, again suggesting shallower channels than the MCP would predict. The single DA channel was furthest from the MCP curve, falling well below and suggesting a much shallower channel than the MCP would predict.

As with bankfull width, the channel types follow the expected mean bankfull depth relationship (Rosgen, 1996). That is, for the same drainage area, G channels were the deepest followed by E, F, DA, C, and ND.

Comparisons of bankfull cross-sectional area values show the trendlines for C type (R^2 = 0.73) and F type (R^2 = 0.88) channels closely matching the MCP curve (Figure 46). The trendline for E type channels (R^2 = 0.69) was also approximately parallel to the MCP curve, but slightly lower. Stream characteristics associated with channel roughness and obstruction of flow (e.g., instream woody debris, bank vegetation, etc.) have the potential to decrease erosion rates and, therefore, may affect cross-sectional area. For the E type stream channels sampled in 2017, however, there was no apparent relationship between cross-sectional area and instream woody debris or bank vegetative protection. Bank vegetative protection scores were, however, generally high for all E type channels.

The results of the comparison are surprising considering that the streams used to derive the MCP curves were E type and C type streams, which explains why these stream types typically show a good fit to the MCP predictions of channel dimensions, primarily cross-sectional area. Conversely, this also helps to explain why F, G, and DA channels often deviate from the predictions, since the curve was created exclusively from C and E type channels.

Sediment deposition as a result of bank erosion and channel instability may be a significant stressor on the benthic macroinvertebrate communities in these sampling units; however, the extent of these impacts was not clear in Rounds One and Two. Typically, reaches classified as unstable G and F type streams would be expected to have more impaired biological communities than reaches classified as more stable stream types (such as E, C, and B channels). However, geomorphic and biological results from this sampling period, as well as those from Rounds One and Two, do not support this notion as degraded stream types do not necessarily result in degraded biological conditions. For example, of the sites classified as F type and G type channels in 2017 (n=7), one site (14.3 percent) received a 'Very Poor' biological rating, four sites (57.1 percent) received a 'Poor' rating, and the remaining two sites (28.6 percent) received a 'Fair' rating. This breakdown is similar to the overall distribution of BIBI scores across all channel types sampled in 2017 (15 percent 'Very Poor'; 55 percent 'Very Poor'; 25 percent 'Fair'; and five percent 'Good', which were dominated by E type channels (58 percent).

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). The pace and age of development may be influencing channel evolution and the types of stream channels found in these sampling units, as suggested by Stribling et al. (2008). It appears as though stream channels are degrading in all PSUs except for Rhode River, where it is possible that some of the "stable" E and C type streams are experiencing an aggradation phase of channel evolution whereby an increased sediment supply from bank erosion begins to fill the channel, decreasing stream depth and increasing floodplain connectivity. All other PSUs

revisited in 2017 appear to be experiencing a degradation phase whereby erosion loosens bank sediment and moves the sediment downstream, widening and deepening the channels. However, these observations are based on first year revisits from a small set of sites.

7.3 Water Quality Conditions

In general, in situ water quality measurements were within COMAR standards for turbidity and temperature across sites sampled in 2017. Low pH values, which were outside the acceptable range of values set forth by COMAR (i.e., 6.5-8.5), were recorded at approximately 40 percent of the sites spanning all five sampling units in the spring and four of the five sampling units in the summer. Low pH values are likely the result of soils within the 2017 sampling units being generally strongly to very strongly acidic (NRCS 2017). Low DO values, which were outside the acceptable range of values set forth by COMAR (i.e., >5 mg/L), were recorded at 15 percent of the sites spanning four of the five sampling units in the spring and 34 percent of the sites across all five sampling units in the summer. Approximately half of the sites sampled in the spring (45 percent) and summer (63 percent) had conductivity values that exceeded 247 µS/cm, which is the critical threshold between 'Fair' and 'Poor' stream quality determined for urban Maryland streams, based on BIBI scores (Morgan et al., 2007). Despite elevated conductivity levels in the majority of sites sampled in 2017, there was no significant trend between conductivity and BIBI or FIBI scores.

Overall, heavy metal concentrations for all sites sampled in 2017 met COMAR or EPA criteria. One site in the Bodkin Creek sampling unit slightly exceeded COMAR standards for chronic lead concentration (i.e., <2.5 µg/L), with a value of 3.2 µg/L. Given that an individual grab sample provides data at a single time and place, additional sampling would be needed to determine if lead concentrations exceed the COMAR standard over a long period of time. For total nitrogen, nitrite, and nitrate, all 2017 sites fell in the low or moderate categories used by MBSS, suggesting low to moderate anthropogenic stress based on these parameters. Twenty percent of sites sampled in 2017 fell in the high category used by MBSS for total phosphorus (i.e., >0.07 mg/L), the majority of which fell in the Rhode River sampling unit. Only one site fell in the high category used by MBSS for orthophosphate concentration (i.e., >0.03 mg/L), which was also located in the Rhode River. Forty percent of sites sampled in 2017 fell in the high category used by MBSS for total ammonia (i.e., >0.07 mg/L). The majority of these sites were located in the Upper North River sampling unit.

Although variable by site, the average chloride concentration was fairly consistent across sampling units sampled in 2017, ranging from 40.71 to 52.19 mg/L. All chloride values met EPA standards for acute (i.e., <230 mg/L) and chronic (i.e., <860 mg/L) exposure. There was a strong positive correlation between conductivity and chloride concentration for all sampling units sampled in 2017 (Figure 47). There was also a positive correlation between magnesium and chloride for all of the sampling units, and chloride concentrations were generally not positively correlated with the suite of nutrient parameters. 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). Based on the negligible (Spearman's rank correlation coefficient <0.5; Severn Run, Severn River, and Rhode River) and negative (Bodkin Creek) correlations between chlorides and nutrients across all sampling units except for the Upper North River, elevated chloride and magnesium levels may be the result of runoff following road salt and brine applications and/or underlying geology. In the Upper North River sampling unit, however, chloride concentrations were positively correlated (Spearman's rank

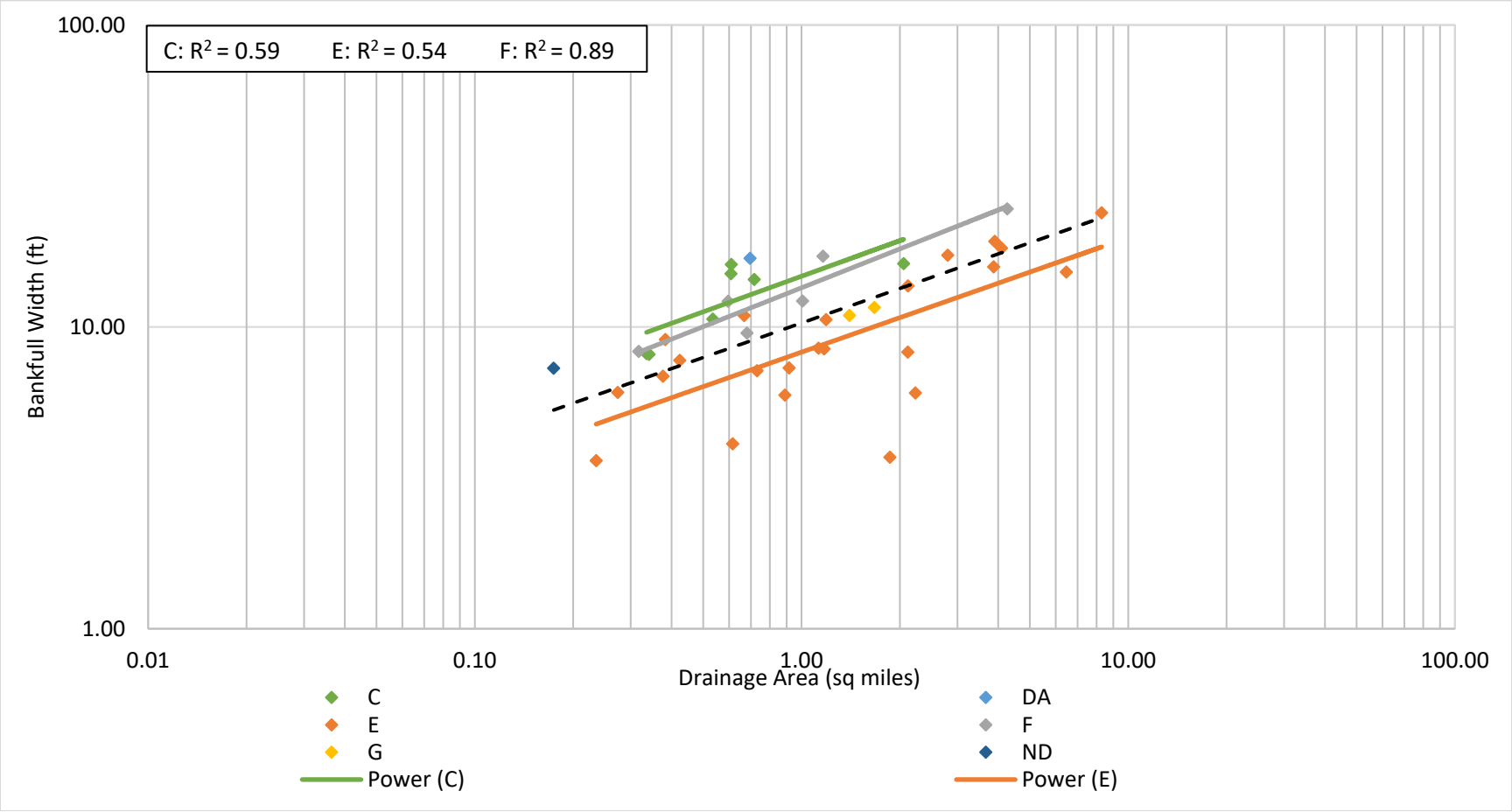


Figure 44- Comparison of bankfull width - Drainage area relationship between field data and regional curve data

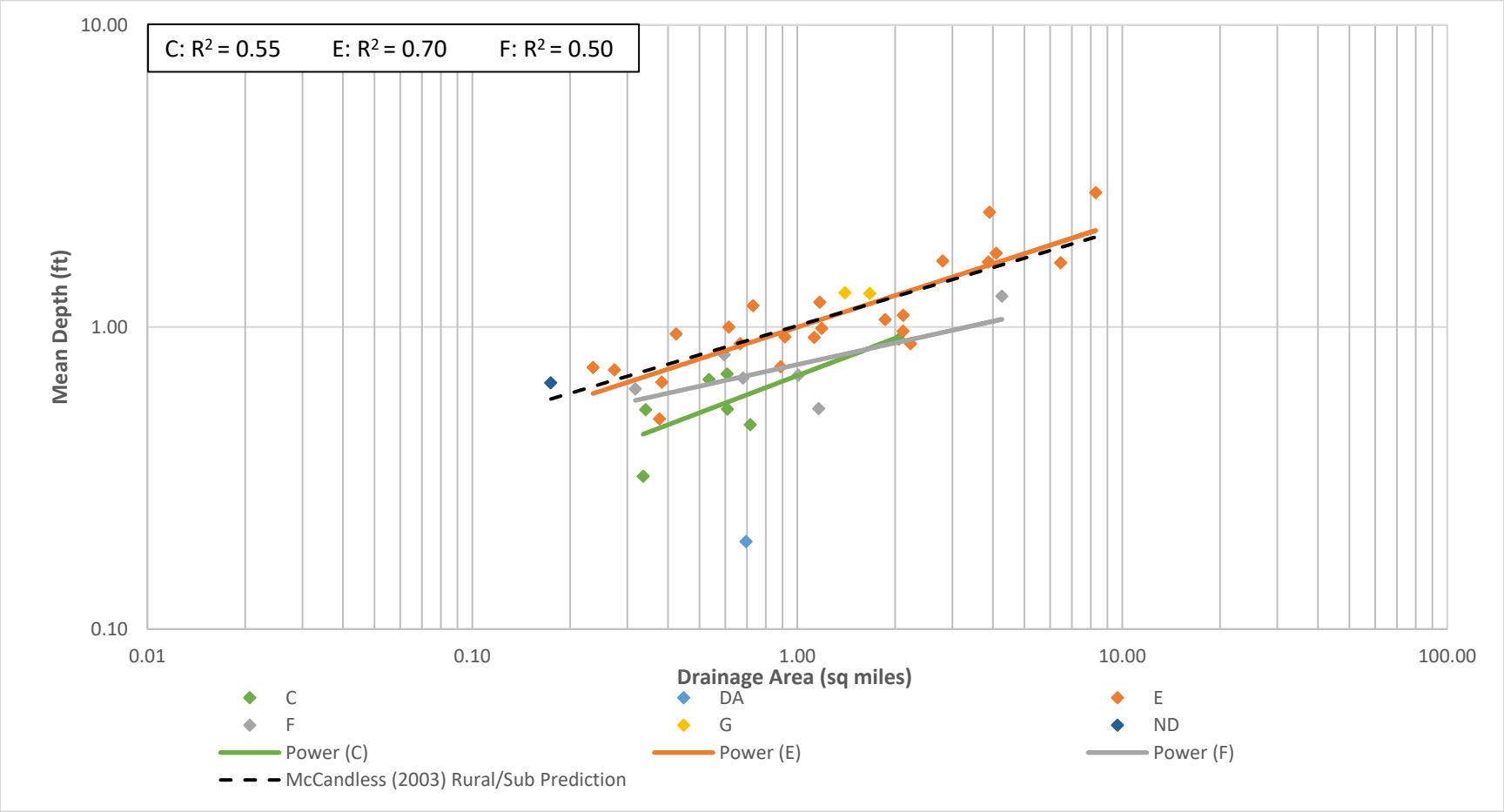


Figure 45 - Comparison of mean bankfull depth - Drainage area relationship between field data and regional curve data

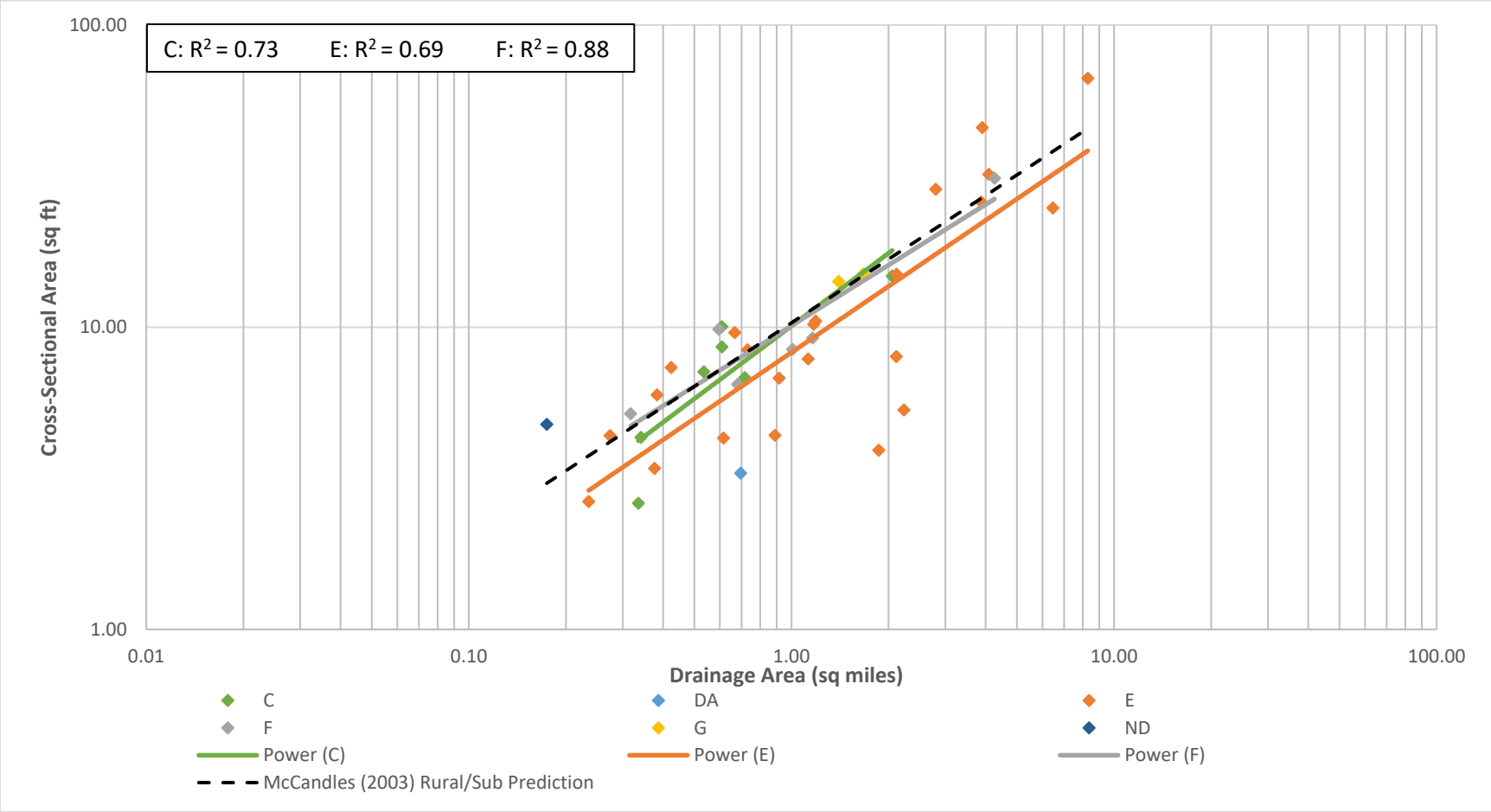


Figure 46 - Comparison of the bankfull cross-sectional area - Drainage area relationship between field data and regional curve data

correlation coefficient >0.8) with several of the nutrient parameters, including total nitrogen, total ammonia and total nitrate. This suggests that elevated chloride and nutrient levels in the Upper North River may be driven by fertilizer applications within the watershed.

No state or federal water quality criteria exist for dissolved organic carbon (DOC), however, DOC concentrations can be used to characterize different stream types. Blackwater streams, characterized by sluggish flow, low pH, high DOC levels, and low DO levels, are identified as key wildlife habitats and are suspected to occur in the Severn Run and Rhode River sampling units based on information from Maryland DNR (DNR 2016). Although none of the sites sampled in 2017 met all criteria for pH (i.e., <6.0), DOC (i.e., >8.0 mg/L), and DO (i.e., <5.0 mg/L), two sites in the Severn River sampling unit and one site in the Rhode River sampling unit were located within the vicinity of suspected blackwater reaches and partially met criteria for blackwater streams. In addition, several sites in the Bodkin Creek sampling unit were characterized by high DOC levels and relatively low pH; however, no known blackwater reaches occur in Bodkin Creek. Low pH was observed throughout all sampling units and is likely the result of strongly to very strongly acidic soils dominating drainage areas within the 2017 sampling units (NRCS 2017).

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 PSUs. 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.

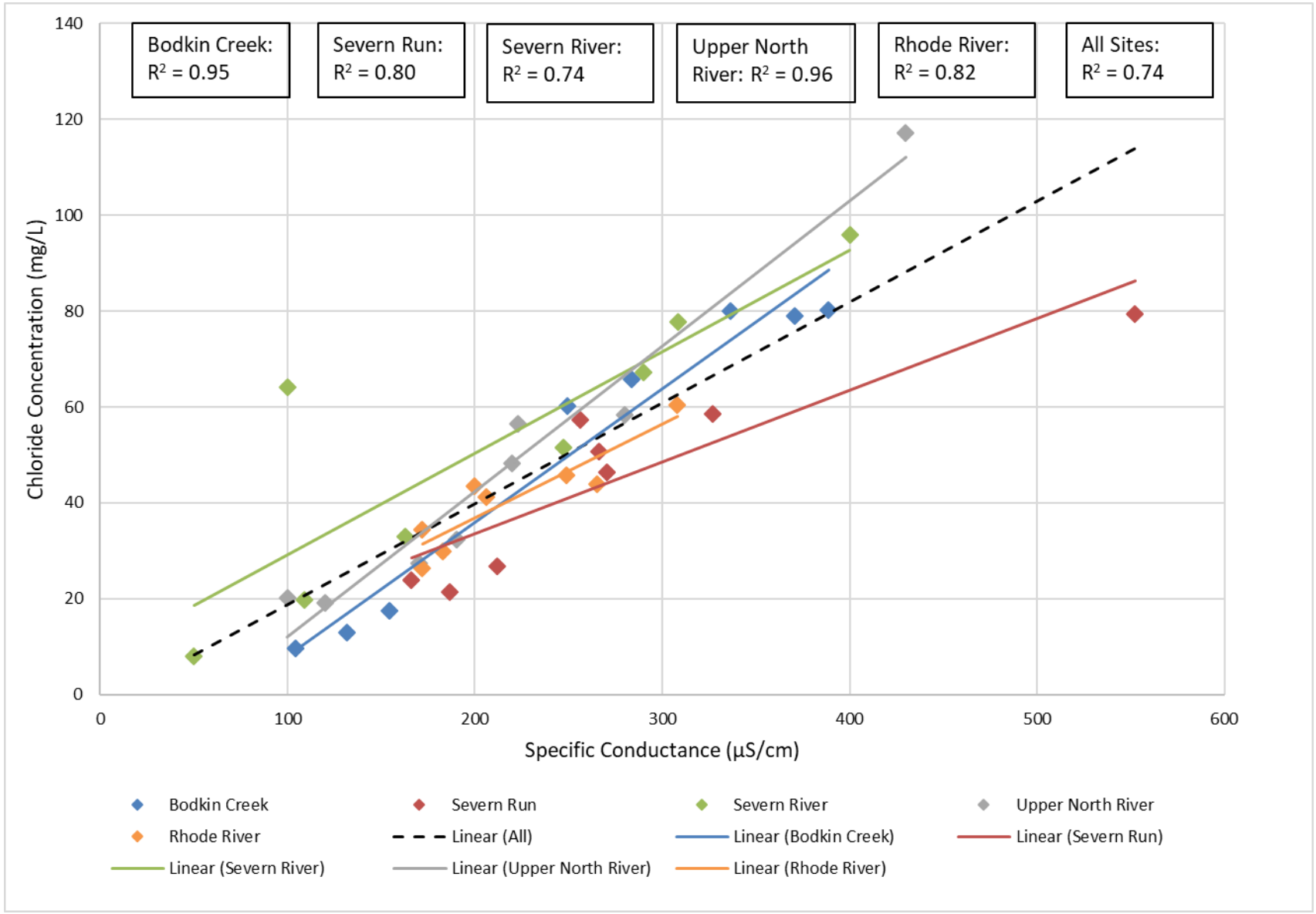


Figure 47 – Relationship between Specific Conductivity and Chloride concentration for each PSU

Stressor Identification Studies

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

Best Management Practices

Stormwater Management

Three of the sampling units, Bodkin Creek, Severn River, and Severn Run have been developed extensively (53% - 59% 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 Rhode River sampling unit contained less developed land, overall BIBI scores still show signs of impairment. This subwatershed may be impacted by current and historical agricultural land use and may benefit from increasing BMPs to treat agricultural runoff. It is recommended that the County consider working with current landowners to improve existing agricultural BMPs and/or initiate new BMPs, wherever practical and feasible, in the Rhode River subwatersheds.

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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
06-L1M-02-17	0.54	7.8	0.9	103.0	13.3	8.2	7.4	0.52	1.3	0.28	E5	Nice forested stream, few bankful features
06-L1M-03-17	1.13	10.6	1.0	142.7	13.5	10.7	10.5	0.87	1.2	0.27	E5	
06-L1M-04-17	0.39	6.9	0.5	48.6	7.1	13.8	3.4	0.08	1.2	0.16	E5	Adjusted W/D ratio -2.0
06-L2M-01-17	1.09	8.5	0.9	146.0	17.2	9.2	7.9	0.26	1.0	0.30	E5	No bed features upstream of xs
06-L2M-03-17	1.17	8.5	1.2	176.0	20.8	7.0	10.2	0.57	1.2	0.23	E5	Few good bankful features.
06-R3M-01-17	0.34	8.1	0.5	55.0	6.8	15.2	4.3	0.48	1.3	0.06	C6	Low gradient channel, not as well connected to the floodplain, more defined banks.
06-R3M-02-17	0.34	8.2	0.3	73.0	9.0	25.4	2.6	0.88	1.3	0.06	C5/6	Low gradient channel, well connected to the floodplain
06-R3M-08-17	0.38	9.1	0.7	143.0	15.7	13.8	6.0	0.88	1.4	0.18	E5	Site just downstream of a dam. Extensive downed wood in channel. No good bankful features observed other than low bank. Downstream end approaching confluence with trib/wetland.
09-L1M-01-17	4.15	18.3	1.8	101.0	5.5	10.4	32.1	0.73	1.4	9.40	E4/5	Unable to locate R1 cross section. Installed a new cross section.
09-L1M-02-17	4.29	24.6	1.3	28.7	1.2	19.4	31.1	0.27	1.1	0.28	F5	Only one riffle in site, 1/2 of riffle transverse
09-L2M-02-17	0.14	3.6	0.7	86.0	23.8	4.9	2.7	0.80	1.2	0.18	E5	Found both monuments. Bank height decreases moving downstream through site. No defined bed features in downstream 1/2 of site.
09-L2M-03-17	2.39	13.7	1.1	133.0	9.7	12.5	15.0	0.67	1.2	0.57	E5	Foumd right monument from old xs. Installed new left pin.
09-R3M-01-17	2.81	17.3	1.7	113.0	6.5	10.4	28.6	0.40	1.3	0.84	E5/4	Cross section taken in only straight riffle in reach.
09-R3M-03-17	0.18	7.3	0.7	83.0	11.4	11.2	4.8	1.50	1.2	0.06	ND	Highly modified system with large, gabion weirs installed across the floodplain for grade control. No Rosgen classification due to altered nature of system.
09-R3M-04-17	0.61	16.1	0.5	137.0	8.5	30.1	8.6	0.08	1.1	0.06	C6/5c-	No descernable bottom features. Well connected to its broad floodplain.
09-R3M-06-17	2.05	16.2	0.9	207.0	12.8	17.8	14.8	0.20	1.4	0.25	C5	
10-L1M-05-17	0.89	5.9	0.7	170.0	28.6	8.0	4.4	0.09	1.2	0.21	E5	Round 1 ID is 10-11A but cross sections were not installed during that year of monitoring. DS end of reach is well connected to FP with wetlands/seeps along floodplain, towards US end becomes slightly incised.
10-L1M-06-17	0.32	8.3	0.6	10.4	1.3	13.3	5.2	0.54	1.2	0.53	F5	Round 1 site ID is 10-09 but cross sections were not installed during that year of monitoring. Stream is entrenched with minor bank erosion in places.

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
10-L2M-01-17	0.70	16.9	0.2	160.0	9.5	86.6	3.3	2.00	1.1	0.55	DA5	R2-10-02 XS pins were located and resurveyed. Most of reach is multithread channel (one main channel) with connected wetlands. Dense vegetation. 30 m (98.4 ft) of stream were unsampleable due to underground flow, that length was added to US end of reach. DS underground section, channel is deeply incised and not connected to FP.
10-L2M-04-17	0.92	7.3	0.9	195.0	26.7	7.9	6.8	0.31	1.4	0.29	E5	R2-10-10. Located and resurveyed R2 XS pins. R2 notes still true. DS end of reach has better FP connection than US end. DA from R2 (2.13 sq mi) appears to include channel on opposite side of valley, though both are connected to the floodplain and flood flows may merge. Revised DA (in box above) is the area to this reach only.
10-R3M-01-17	0.54	10.6	0.7	98.0	9.2	15.8	7.1	0.45	1.2	0.13	C5	Stream against valley wall along right bank. Downstream half of site one long pool.
10-R3M-02-17	1.86	3.7	1.1	55.0	14.9	3.5	3.9	0.57	1.2	0.15	E5/6	Stream much smaller than drainage area suggests. Few bed features present. Surrounded by wetlands.
10-R3M-05-17	0.73	7.2	1.2	142.0	19.8	6.1	8.4	0.01	1.2	0.06	E6	Low gradient stream, downcut with near vertical banks. Bank height increases as you move downstream.
10-R3M-08-17	2.11	8.3	1.0	118.0	14.3	8.5	8.0	0.21	1.2	0.25	E5	Small stream surrounded by wetlands.
11-L1M-03-17	1.40	10.9	1.3	15.1	1.4	8.4	14.2	0.28	1.1	0.23	G5c	Round 1 site ID is 11-05. Located XS and resurveyed.
11-L1M-04-17	0.67	10.9	0.9	215.0	19.7	12.4	9.6	0.18	1.1	0.22	E5	Round 1 ID is 11-13A. XS was located and resurveyed but REP was replaced.
11-L2M-01-17	1.67	11.6	1.3	14.9	1.3	9.0	15.0	0.50	1.2	0.18	G5c	Round 2 site ID is 11-05
11-L2M-02-17	8.29	23.9	2.8	355.0	14.9	8.6	66.6	0.24	1.1	18.00	E4	Round 2 ID is 11-20A. Cross-section station not measured in the field. Approximated based on photos and relationship between cross-section and profile bankfull and water surface elevations.
11-R3M-02-17	1.16	17.1	0.5	19.8	1.2	31.9	9.2	0.36	1.1	0.33	F5	Incised channel with alternating depositional sand bars and vegetated low banks within a terrace. Moderate erosion throughout reach, especially where large trees on banks have fallen in.
11-R3M-03-17	6.46	15.2	1.6	255.0	16.8	9.3	24.8	0.38	1.1	0.14	E5	
11-R3M-07-17	2.23	6.0	0.9	24.6	4.1	6.9	5.3	0.25	1.1	0.25	E5	

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
11-R3M-08-17	0.60	12.2	0.8	15.0	1.2	15.0	9.8	0.25	1.2	0.30	F5	LB floodplain has significant sand deposition. Moderate to severe bank erosion throughout reach, very incised channel. XS area based on regional curve is small compared to field bankfull indicators and evidence that it gets out of bank
13-L1M-03-17	0.61	15.0	0.7	160.0	10.7	21.5	10.5	0.16	1.1	0.27	C5	Round 1 ID is 13-04
13-L1M-04-17	0.62	4.1	1.0	175.0	42.9	3.9	4.3	0.34	1.0	0.13	E5	Round 1 site 13-03. Located pins and resurveyed. XS located just DS of old wooden weir with sandbags on the banks (channel alteration) and stream gage. Stream has cut around weir.
13-L2M-03-17	0.72	14.4	0.5	165.0	11.5	30.2	6.8	0.25	1.0	0.06	C6	Revisit R2-13-08. Located XS pins and resurveyed. Two threads come together just upstream of cross section.
13-L2M-04-17	3.87	15.8	1.6	30.9	2.0	9.6	26.0	0.03	0.9	0.06	E6	Last 5m (upstream end) is under bridge. Approx. 1.5' drop off end of culvert
13-R3M-01-17	1.01	12.2	0.7	14.0	1.1	17.6	8.4	0.32	1.1	0.35	F5	Incised channel. Bank erosion in outer meanders, otherwise banks are steep but vegetated. Benches are developing throughout reach. Banks composed of unconsolidated sand. Rough DA is from Stream Stats.
13-R3M-03-17	0.27	6.1	0.7	185.0	30.5	8.4	4.4	0.51	1.1	0.11	E5	Majority of reach is backwatered, which continues at least 100' upstream of 75 m. Significant silt/fine sand deposition in backwater pool area.
13-R3M-05-17	0.68	9.5	0.7	12.8	1.3	14.1	6.5	0.28	1.0	0.22	F5	Bankfull for the cross section was changed in the office per comment responses so it does not match the profile bankfull calls.
13-R3M-33-17	3.90	19.2	2.4	250.0	13.1	8.0	45.8	0.00	1.1	0.06	E6	One long pool due to DS dams (1 human, 2 beaver)

Appendix B: Quality Control Summary

Appendix B: Quality Assurance/Quality Control Procedures and Results

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

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

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

Field Sampling

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

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 stratum (i.e., large streams, small streams) within each of the five primary sampling units (PSUs) sampled in 2017, for a total of 10 duplicates. These samples were collected just upstream of the original sampling location to determine the consistency and repeatability of the sampling procedures and the intra-team adherence to those protocols. The QC site was field-selected rather than randomly selected to ensure that the QC sites maintained similar habitat conditions to the original site, and no additional stressors or unusual conditions were present that may affect the biota. Duplicate

samples included collection and analysis of the benthic macroinvertebrate community, completion of the RBP and the PHI habitat assessments, 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:

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

Acceptable 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 high mRPD value for Number of EPT Taxa was due to relatively few EPT taxa present in the samples which tend to skew mRPD values upward when comparing small values as compared to large values. For example, a sample pair with 1 vs 2 taxa yielded an mRPD of 67, while a sample pair with 3 vs 4 taxa had an mRPD of 29, despite the same difference of only 1 taxon between sample pairs. The high mRPD for Percent Climbers was likely due to the variability within this metric between sites sampled in which values range from 0.0 percent to 65.7 percent for the sites analyzed for QC.

Three individual metrics, Percent Intolerant, Percent Ephemeroptera, and Scraper Taxa exceeded the MQO for RMSE, but passed for mRPD. The exceedance for Percent Intolerant was primarily due to the amount of variation between samples in which the percentages range from 0.0 percent to 81.6 percent for sites analyzed for QC. For Percent Ephemeroptera, the exceedances were primarily due to two outlier samples which had moderate differences between sample pairs, while all other samples had no Ephemeroptera present at all. Similarly,

for Scraper Taxa, the exceedances were primarily due to a few samples which had 4 or more taxa, while all other samples had only one or two taxa or no scrapers present at all.

Only one metric, Number of Scraper taxa, exceeded the MQO for CV. Seven of the 10 sample pairs had either zero or one scraper taxa, while the remaining samples had between one and eight taxa present. This resulted in both a skewed RMSE and average number of scrapers, which further skewed the CV value.

All other values were within acceptable ranges for the benthic metrics. All MQOs were within acceptable ranges for the BIBI index score.

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.

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
06-L2M-03-17	15	3	0	34.2	0.0	0	4.3	2.43	Poor
06-L2M-03QC-17	21	3	0	50.5	0.0	0	2.8	2.43	Poor
06-R3S-15-17	11	2	0	16.7	0.0	0	1.9	1.86	Very Poor
06-R3S-15QC-17	14	3	0	13.9	0.0	0	0.9	2.14	Poor
09-R3M-01-17	17	3	0	0.0	0.0	1	59.5	2.43	Poor
09-R3M-01QC-17	18	2	0	2.9	0.0	2	65.7	2.71	Poor
09-R3S-16-17	29	11	1	59.0	4.8	4	21.0	4.43	Good
09-R3S-16QC-17	22	7	2	81.6	2.6	8	7.9	4.43	Good
10-L1M-05-17	20	3	1	4.0	8.0	0	20.0	2.71	Poor
10-L1M-05QC-17	19	4	1	25.5	1.0	0	19.6	3.00	Fair
10-R3S-05-17	13	2	0	69.7	0.0	0	0.0	1.86	Very Poor
10-R3S-05QC-17	22	3	0	31.8	0.0	0	0.9	2.71	Poor
11-R3M-03-17	32	4	0	6.4	0.0	6	17.4	3.00	Fair
11-R3M-03QC-17	26	5	0	6.5	0.0	4	9.3	3.29	Fair
11-R3S-01-17	26	5	0	20.6	0.0	1	14.0	3.29	Fair
11-R3S-01QC-17	25	5	0	27.7	0.0	0	5.0	2.71	Poor
13-L2M-03-17	14	1	0	50.0	0.0	0	0.0	1.86	Very Poor
13-L2M-03QC-17	12	2	0	21.0	0.0	1	0.0	1.86	Very Poor
13-R3S-14-17	14	2	0	59.5	0.0	0	0.0	2.14	Poor
13-R3S-14QC-17	17	4	0	53.8	0.0	0	0.0	2.14	Poor
Median RPD	20.0	**40.0**	0.0	35.2	0.0	20.0	**52.3**	9.7	
RMSE	3.17	0.82	0.25	**18.76**	**0.62**	**1.66**	5.96	0.35	
CV	16.4	22.3	100.0	59.1	75.4	**123.1**	47.7	13.0	

Laboratory Sorting and Subsampling

Bias

All sorting was completed following the SOPs described in the QAPP. For these samples, 60 percent (54 samples) underwent quality control procedures for sorting, exceeding the ten percent requirement. Average percent sorting efficiency was 91.6% (n=54). All samples sorted by laboratory personnel in training (i.e., not consistently achieving >90% sorting efficiency) were checked, while ten percent of samples sorted by experienced laboratory personnel were also checked. This procedure ensures that all sorted samples either initially exceed the MQO of >90% for PSE, or will exceed the MQO following QC checks by experienced sorters.

Taxonomic Identification and Enumeration

Nine samples (06-R3S-02-17, 06-R3S-19-17, 09-R3S-04-17, 09-R3S-02-17, 09-R3S-16QC-17, 10-R3S-05-17, 10-R3S-05QC-17, 13-L1M-04-17, 13-R3S-02-17) were randomly selected for QC identification and enumeration by an independent lab. Initial identification was performed by EcoAnalysts[1] (ESC). Re-identification of the randomly selected samples was completed by the Maryland Department of Natural Resources[2]. Each sample was identified to the genus level where possible. Individuals that were not able to be identified to genus level were identified to the lowest possible level, usually family, but in some cases order. For Chironomidae, individuals not identifiable to genus may have been identified to subfamily or tribe level.

Precision

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

The PDE compares the final specimen counts between the two taxonomy labs, whereas PTD compares the number of agreements in final specimen identifications between the two taxonomic labs. To meet required MQOs set by the QAPP, the PDE for each sample must be equal to or less than 5%, and the PTD must be equal to or less than 15%. Results for the taxonomic comparison and resulting values for PDE and PTD for all nine samples are found in Table 6 through Table 14. Dashes shown in the '# of agreements' column signify hierarchical disagreements, which counts as an agreement for PTD calculations. For example, if the primary laboratory identified a specimen as Naididae and the secondary laboratory identified the same specimen as *Dero* (genus of the family Naididae) this would be considered a hierarchical disagreement.

All samples fell below the allowable thresholds for both PDE and PTD measures. The average PDE for all samples was 1.5% with a range between 0.4% and 2.5%. The average PTD was 8.7% with a range between 2.9% and 12.5%.

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

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). This analysis includes an evaluation of precision (repeatability) of water quality grab sampling.

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

- Median Relative Percent Difference (mRPD)

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.

For parameters that were below the method detection limit for one or both samples, mRPD could not be calculated and were considered to be not applicable. In 2017, only one parameter exceeded 20% mRPD (median RPD): Total Kjehldal Nitrogen. For individual duplicate sites, six out of eight pairs exceeded 20% mRPD for Total Kjehldal Nitrogen. Total Kjehldal Nitrogen values generally differed by <0.1 mg/L at duplicate sites, but because the values were very close to zero the mRPD was inflated. One duplicate site pair (13-R3S-14-17 and 13-R3S-14QC-17) had Total Kjehldal Nitrogen that differed by 0.21 mg/L. Nonetheless, these results are in line with those reported by MBSS in the 2001 Quality Assurance Report (Mercurio et al. 2003).

Field blanks containing deionized water were also collected at two sites during 2017. Results of individual parameter values for both field blank samples are presented in Table 4. At site 11-R3M-03QC-17, all individual parameter values fell below the method detection limit. At site 06-L2M-03QC-17, values for copper and zinc fell slightly above the method detection limit, with all other parameter values falling below.

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

Sample ID	Chloride	Total Phosphorus	Total Nitrogen	Ortho-phosphate	Total Ammonia Nitrogen	Nitrite-N	Nitrate-N	Total Kjehldal Nitrogen	Dissolved Organic Carbon
06-R3S-15-17	8.808	0.007	0.252	BDL	0.011	BDL	0.0760	0.1740	3.6231
06-R3S-15QC-17	8.937	0.008	0.311	BDL	0.012	BDL	0.0894	0.2189	3.4207
09-R3M-01-17	50.66	0.009	1.523	BDL	0.017	0.002	1.318	0.2019	1.5042
09-R3M-01QC-17	50.72	0.007	1.479	BDL	0.018	0.002	1.329	0.1479	1.5305
09-R3S-16-17	30.43	0.006	1.126	0.005	0.009	BDL	0.9507	0.1730	3.0828
09-R3S-16QC-17	30.08	0.010	1.113	0.003	0.008	BDL	0.9703	0.1403	3.1290
10-L1M-05-17	67.20	0.017	0.393	BDL	0.100	0.002	0.1969	0.1943	1.4849
10-L1M-05QC-17	68.43	0.019	0.415	BDL	0.104	0.003	0.1982	0.2143	1.6108
10-R3S-05-17	86.92	0.033	0.537	BDL	0.061	BDL	0.4308	0.1036	0.6162
10-R3S-05QC-17	93.64	0.018	0.597	BDL	0.059	BDL	0.5188	0.0764	0.5999
11-R3S-01-17	43.53	0.055	0.212	0.003	0.038	BDL	0.0819	0.1280	0.8098
11-R3S-01QC-17	43.51	0.052	0.268	0.003	0.036	BDL	0.0822	0.1831	0.7535
13-L2M-03-17	34.42	0.073	0.302	0.013	0.014	BDL	0.0746	0.2251	3.4965
13-L2M-03QC-17	34.50	0.064	0.328	0.014	0.013	BDL	0.0814	0.2446	3.6157
13-R3S-14-17	57.91	0.176	1.259	0.010	0.058	BDL	0.6610	0.5959	2.1372
13-R3S-14QC-17	58.09	0.194	1.236	0.010	0.059	0.002	0.8499	0.3840	2.3832
Median RPD	1	18	7	10	5	14	5	27	5

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)
06-R3S-15-17	3.6808	2.212	3.666	18.26	0.794	16.21	0.324	4.0
06-R3S-15QC-17	3.4669	2.167	3.662	18.07	0.777	19.54	0.221	4.1
09-R3M-01-17	1.5644	3.052	12.57	43.96	1.57	16.31	0.213	1.7
09-R3M-01QC-17	1.5590	3.009	12.16	42.75	1.61	16.48	0.232	2.0
09-R3S-16-17	3.1170	3.664	6.495	31.31	1.43	3.801	0.139	5.4
09-R3S-16QC-17	3.1384	3.625	6.435	31.00	1.45	3.351	0.135	4.5
10-L1M-05-17	1.6243	3.822	10.75	42.58	0.278	10.73	0.087	6.9
10-L1M-05QC-17	1.6246	4.064	11.84	46.30	0.223	9.645	0.100	9.9
10-R3S-05-17	0.9283	7.798	13.56	65.97	0.160	24.06	0.239	12.3
10-R3S-05QC-17	0.8789	7.718	13.65	65.87	0.128	19.39	0.196	12.8
11-R3S-01-17	0.9049	3.472	13.88	48.96	0.055	8.234	0.033	21.4
11-R3S-01QC-17	0.8757	3.503	14.04	49.48	0.042	8.060	0.022	19.5
13-L2M-03-17	3.5649	3.634	12.31	45.70	0.543	17.29	0.274	7.5
13-L2M-03QC-17	3.6136	3.701	11.74	44.56	0.522	16.33	0.240	5.4
13-R3S-14-17	3.4529	4.554	17.75	63.08	0.466	20.95	0.529	19.3
13-R3S-14QC-17	2.6292	4.483	18.09	63.63	0.633	21.66	0.918	21.0
Median RPD	2	1	2	1	13	8	17	14

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	06-L2M-03QC-17	11-R3M-03QC-17	Parameter	06-L2M-03QC-17	11-R3M-03QC-17
Chloride	BDL	BDL	Total Organic Carbon	BDL	BDL
Total Phosphorus	BDL	BDL	Magnesium	BDL	BDL
Total Nitrogen	BDL	BDL	Calcium	BDL	BDL
Orthophosphate	BDL	BDL	Hardness	BDL	BDL
Total Ammonia Nitrogen	BDL	BDL	Total Copper (µg/L)	0.093	BDL
Nitrite-N	BDL	BDL	Total Zinc (µg/L)	0.483	BDL
Nitrate-N	BDL	BDL	Total Lead (µg/L)	BDL	BDL
Total Kjelhal Nitrogen	BDL	BDL	Turbidity (NTU)	BDL	BDL
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 6. Although several individual metrics had exceeded measures for mRPD, RMSE and CV, the overall BIBI was within the proposed MQO limits for mRPD and RMSE demonstrating acceptable precision for field sampling. Laboratory sorting and subsampling measures indicated acceptable levels of bias, while taxonomic identification measures demonstrated acceptable precision. Furthermore, the overall sensitivity of the site assessment was within the desired 90% confidence interval for the BIBI.

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

All remaining MQOs were met during the 2017 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	2017 Results
Field Sampling	Precision	mRPD (BIBI)	<20	9.7
		RMSE (BIBI)	<0.6	0.35
Laboratory Sorting/Subsampling	Bias	PSE	>90	91.6
Taxonomic Identification	Precision	PDE	<5	1.5
		PTD	<15	8.7
Site Assessment	Sensitivity	90% CI (BIBI)	≤0.96	0.57

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

Table 6 - Taxonomic Identification and Enumeration Results: 06-R3S-19-17

Order	Family	Tribe	Sample ID	06-R3S-19-17		
				Taxonomist 1	Taxonomist 2	# of agreements
Diptera	Ceratopogonidae	-	Bezzia/Palpomyia sp.	3	2	2
	Chironomidae	-	Corynoneura	2	1	1
	Chironomidae	-	Limnophyes	3	3	3
	Chironomidae	Tanytarsini	Micropsectra	1	1	1
	Chironomidae	Chironomini	Polypedilum	2	2	2
	Chironomidae	-	Pseudorthocladius	4	4	4
	Chironomidae	-	Rheocricotopus	14	14	14
	Chironomidae	-	Thienemannimyia group	7	6	6
		-	Thienemanniella		1	0
	Chironomidae	Pentaneurini	Zavrelimyia	1	1	1
		-	Tanypodinae		1	0
	Simuliidae	-	Simuliidae	2	1	1
	Simuliidae	Simuliini	Simulium	19	19	19
Haplotaxida	Enchytraeidae	-	Enchytraeidae	14	8	8
	Naididae	-	Naididae	11	0	11
		-	Tubificidae	0	11	-
Lumbriculida	Lumbriculidae	-	Lumbriculidae	4	15	4
Plecoptera	Leuctridae	-	Leuctra	25	25	25
	Nemouridae	-	Nemouridae	7	6	6
Trichoptera	Philopotamidae	-	Wormaldia	13	12	12
Diptera	Ceratopogonidae	-	Bezzia/Palpomyia sp.	3	2	2
	Chironomidae	-	Corynoneura	2	1	1
	Tubificidae	-	Spirosperma	25	22	22
Veneroida	Pisidiidae	-	Pisidium	14	11	14
	Pisidiidae	-	Sphaeriidae	0	3	-
			Total	132	133	120
			PDE			0.38
			PTD			9.09

Table 7 - Taxonomic Identification and Enumeration Results: 09-R3S-04-17

Order	Family	Tribe	Sample ID	09-R3S-04-17		
				Taxonomist 1	Taxonomist 2	# of agreements
Coleoptera	Elmidae	-	Stenelmis	8	7	7
	Hydrophilidae	-	Cymbiodyta	1	0	0
Diptera	Chironomidae	-	Brillia	1	1	1
	Chironomidae	-	Corynoneura	3	3	3
	Chironomidae	-	Orthocladius	3	3	3
		-	Orthocladiinae pupae	0	2	-
	Chironomidae	-	Parakiefferiella	2	1	1
	Chironomidae	-	Parametriocnemus	9	8	8
	Chironomidae	Chironomini	Polypedilum	5	5	5
	Chironomidae	Diamesini	Potthastia	2	2	2
	Chironomidae	-	Rheocricotopus	2	3	2
	Chironomidae	Chironomini	Stenochironomus	1	1	1
	Chironomidae	Chironomini	Stictochironomus	1	1	1
	Chironomidae	-	Thienemannimyia group	4	3	3
		-	Tanypodinae	0	1	-
	Ephydridae	-	Ephydridae	1	1	1
Haplotaxida	Enchytraeidae	-	Enchytraeidae	1	1	1
	Naididae	-	Naididae	45	45	45
		-	Tubificidae	0	10	0
Isopoda	Asellidae	-	Caecidotea	2	2	2
Megaloptera	Corydalidae	-	Nigronia	1	1	1
not identified	not identified	-	Nematoda	3	3	3
Odonata	Calopterygidae	-	Calopteryx	3	3	3
Plecoptera	Leuctridae	-	Leuctra	9	0	9
		-	Leuctridae	0	10	-
Trichoptera	Hydropsychidae	-	Cheumatopsyche	1	1	1
	Hydropsychidae	-	Hydropsyche	1	1	1
	Limnephilidae	-	Ironoquia	1	1	1
	Limnephilidae	-	Limnephilidae	1	1	1

Order	Family	Tribe	Sample ID	09-R3S-04-17 Taxonomist 1	Taxonomist 2	# of agreements
	Polycentropodidae	-	Polycentropus	1	1	1
Veneroida	Pisidiidae	-	Pisidium	4	0	4
		-	Sphaeriidae (Pisidiidae)	0	4	-
			Total	116	126	111
			PDE			4.13
			PTD			11.90

Table 8 - Taxonomic Identification and Enumeration Results: 10-R3S-05QC-17

Order	Family	Tribe	Sample ID	10-R3S-05QC-17 Taxonomist 1	Taxonomist 2	# of agreements
Amphipoda	Crangonyctidae	-	Crangonyctidae	2	3	2
	Crangonyctidae	-	Synurella	21	24	21
	not identified	-	Amphipoda	20	12	12
Coleoptera	Ptilodactylidae	-	Anchytarsus	2	2	2
Diptera	Ceratopogonidae	-	Bezzia/Palpomyia sp.	1	1	1
	Chironomidae	Chironomini	Cryptochironomus	1	1	1
	Chironomidae	Pentaneurini	Larsia	1	1	1
	Chironomidae	Natarsiini	Natarsia	6	2	2
	Chironomidae	-	Pentaneura	0	4	0
	Chironomidae	Chironomini	Paralauterborniella	1	1	1
	Chironomidae	-	Parametriocnemus	6	5	5
	Chironomidae	-	Paraphaenocladius	0	1	1
	Chironomidae	-	Prodiamesa	2	2	2
	Chironomidae	-	Thienemannimyia group	2	2	2
	Tipulidae	-	Erioptera	1	0	0
	Tipulidae	-	Molophilus	0	1	0

Order	Family	Tribe	Sample ID	10-R3S-05QC-17		
				Taxonomist 1	Taxonomist 2	# of agreements
	Tipulidae	-	Tipulidae	1	1	1
	Tipulidae	-	Pseudolimnophila	1	1	1
	Tipulidae	-	Tipula	1	1	1
Haplotaxida	Enchytraeidae	-	Enchytraeidae	1	1	1
	Naididae	-	Naididae	38	0	38
		-	Tubificidae	0	42	-
Hoplonemertea	Tetrastemmatidae	-	Prostoma	1	1	1
Isopoda	Asellidae	-	Caecidotea	4	4	4
Lumbriculida	Lumbriculidae	-	Lumbriculidae	1	1	1
Megaloptera	Corydalidae	-	Chauliodes	1	1	1
Odonata	Cordulegastridae	-	Cordulegaster	1	1	1
Plecoptera	Leuctridae	-	Leuctra	2	0	2
		-	Leuctridae	0	2	-
Trichoptera	Polycentropodidae	-	Polycentropus	8	8	8
	Sericostomatidae	-	Agarodes	3	2	2
Veneroida	Pisidiidae	-	Pisidium	1	1	1
			Total	130	129	116
			PDE			0.39
			PTD			10.77

Table 9 - Taxonomic Identification and Enumeration Results: 06-R3S-02-17

Order	Family	Tribe	Sample ID	06-R3S-02-17		
				Taxonomist 1	Taxonomist 2	# of agreements
Amphipoda	Crangonyctidae	-	Synurella	4	4	4
	Gammaridae	-	Gammarus	8	8	8
Basommatophora	Physidae	-	Physa	3	3	3

Order	Family	Tribe	Sample ID	06-R3S-02-17 Taxonomist 1	Taxonomist 2	# of agreements
	Planorbidae	-	Menetus	2	0	0
Diptera	Ceratopogonidae	-	Bezzia/Palpomyia	1	1	1
	Chironomidae	-	Corynoneura	1	1	1
	Chironomidae	-	Parametriocnemus	2	2	2
	Chironomidae	-	Paraphaenocladius	2	2	2
	Chironomidae	-	Rheocricotopus	18	16	16
	Chironomidae	-	Thienemannimyia group	4	0	0
		-	Orthocladinae	0	1	0
Haplotaxida	Naididae	-	Naididae	2	0	2
		-	Tubificidae	0	4	-
Isopoda	Asellidae	-	Caecidotea	6	6	6
Lumbriculida	Lumbriculidae	-	Lumbriculidae	16	26	16
Odonata	Calopterygidae	-	Calopteryx	2	2	2
Trichoptera	Calamoceratidae	-	Heteroplectron	9	9	9
	Lepidostomatidae	-	Lepidostoma	1	1	1
	Limnephilidae	-	Ironoquia	5	5	5
	Polycentropodidae	-	Polycentropodidae	1	1	5
Veneroida	Pisidiidae	-	Sphaeriidae	1	51	-
	Pisidiidae	-	Pisidium	49	0	49
			Total	137	143	132
			PDE			2.14
			PTD			7.69

Table 10 - Taxonomic Identification and Enumeration Results: 09-R3S-02-17

Order	Family	Tribe	Sample ID	09-R3S-02-17 Taxonomist 1	Taxonomist 2	# of agreements
Amphipoda	Crangonyctidae	-	Crangonyctidae	2	2	2

Order	Family	Tribe	Sample ID	09-R3S-02-17		
				Taxonomist 1	Taxonomist 2	# of agreements
	Crangonyctidae	-	Synurella	31	31	31
	not identified	-	Amphipoda	24	23	23
Coleoptera	Ptilodactylidae	-	Anchytarsus	7	7	7
Diptera	Chironomidae	Macropelopiini	Apsectrotanypus	1	1	1
	Chironomidae	-	Cricotopus/Orthocladius	1	0	1
		-	Orthocladius sp.	0	2	-
	Chironomidae	Tanytarsini	Micropsectra	6	6	6
	Chironomidae	-	Parametriocnemus	2	2	2
	Chironomidae	-	Parametriocnemus	1	0	0
	Chironomidae	-	Paraphaenocladius	1	1	1
	Chironomidae	Chironomini	Paratendipes	2	1	1
		-	Chironomini	0	1	-
	Chironomidae	Chironomini	Polypedilum	2	2	2
	Chironomidae	Diamesini	Potthastia	1	1	1
	Chironomidae	-	Rheocricotopus	4	3	3
	Chironomidae	-	Thienemannimyia group	3	3	3
	Chironomidae	-	Thienemannimyia group	1	0	-
	Chironomidae	-	Tvetenia	2	1	1
		-	Orthocladiinae pupae	0	3	-
	Tipulidae	-	Dicranota	1	1	1
	Tipulidae	-	Pseudolimnophila	2	2	2
	Tipulidae	-	Tipula	1	1	1
Haplotaxida	Naididae	-	Naididae	1	0	1
		-	Tubificidae	0	1	-
Isopoda	Asellidae	-	Caecidotea	6	6	6
Lumbriculida	Lumbriculidae	-	Lumbriculidae	2	1	1
Plecoptera	Leuctridae	-	Leuctra	3	3	3
	Nemouridae	-	Amphinemura	1	1	1
Trichoptera	Hydropsychidae	-	Diplectrona	1	1	1
	Lepidostomatidae	-	Lepidostoma	3	3	3

Order	Family	Tribe	Sample ID	09-R3S-02-17 Taxonomist 1	Taxonomist 2	# of agreements
	Limnephilidae	Stenophylacini	Pycnopsyche	2	2	2
	Philopotamidae	-	Philopotamidae	2	0	-
	Philopotamidae	-	Wormaldia	4	2	2
	Psychomyiidae	-	Lype	1	1	1
Veneroida	Pisidiidae	-	Sphaeriidae	1	1	1
			Total	122	116	111
			PDE			2.52
			PTD			9.02

Table 11 - Taxonomic Identification and Enumeration Results: 09-R3S-16QC-17

Order	Family	Tribe	Sample ID	09-R3S-16-QC-17 Taxonomist 1	Taxonomist 2	# of agreements
Basommatophora	Physidae	-	Physa	1	1	1
Coleoptera	Dryopidae	-	Helichus	2	2	2
	Elmidae	-	Ancyronyx	1	1	1
	Elmidae	-	Macronychus	2	2	2
	Elmidae	-	Optioservus	2	2	2
	Elmidae	-	Oulimnius	56	57	56
	Elmidae	-	Stenelmis	1	1	1
Diptera	Ceratopogonidae	-	Bezzia/Palpomyia sp.	2	2	2
	Chironomidae	-	Parametriocnemus	1	1	1
	Chironomidae	Chironomini	Polypedilum	5	5	5
	Simuliidae	Simuliini	Simulium	2	2	2
	Tipulidae	-	Pseudolimnophila	1	1	1
	Tipulidae	-	Tipula	1	1	1
Ephemeroptera	Baetidae	-	Acerpenna	4	4	4
	Ephemerellidae	-	Eurylophella	1	1	1
Haplotaxida	Naididae	-	Naididae	1	0	1

Order	Family	Tribe	Sample ID	09-R3S-16-QC-17		
				Taxonomist 1	Taxonomist 2	# of agreements
		-	Tubificidae	0	2	
Lumbricina	not identified	-	Lumbricina	2	0	0
Lumbriculida	Lumbriculidae	-	Lumbriculidae	1	2	1
Megaloptera	Corydalidae	-	Nigronia	1	1	1
Odonata	Aeshnidae	-	Boyeria	1	1	1
Plecoptera	Chloroperlidae	-	Haploperla	25	25	25
	Chloroperlidae	-	Chloroperlidae	3	3	3
	Nemouridae	-	Amphinemura	6	6	6
		Acroneuriini	Eccoptura	2	1	1
		-	Perlidae	0	1	1
Trichoptera	Hydropsychidae	-	Diplectrona	12	12	12
	Lepidostomatidae	-	Lepidostoma	2	2	2
Veneroida	Pisidiidae	-	Pisidium	1	0	0
		-	Sphaeriidae	0	1	0
			Total	139	140	136
			PDE			0.36
			PTD			2.86

Table 12 - Taxonomic Identification and Enumeration Results: 10-R3S-05-17

Order	Family	Tribe	Sample ID	10-R3S-05-17		
				Taxonomist 1	Taxonomist 2	# of agreements
Amphipoda	Crangonyctidae	-	Synurella	70	68	68
	not identified	-	Amphipoda	19	19	19
Diptera	Chironomidae	-	Heterotrissocladius	1	1	1
	Chironomidae	Natarsiini	Natarsia	6	4	4
			Tanypodinae	0	2	-
	Chironomidae	-	Parametriocnemus	2	2	2
	Chironomidae	-	Pseudorthocladius	1	1	1

Order	Family	Tribe	Sample ID	10-R3S-05-17 Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	-	Thienemannimyia group	2	3	2
	Chironomidae	Pentaneurini	Zavrelimyia	1	0	0
	not identified	-	Diptera	1	0	0
	Tipulidae	-	Dicranota	2	2	2
	Tipulidae	-	Pilaria	1	1	1
Haplotaxida	Naididae	-	Naididae	2	0	2
		-	Tubificidae	0	2	-
Isopoda	Asellidae	-	Caecidotea	8	7	7
Lumbricina	not identified	-	Lumbricina	2	0	0
		-	Lumbriculidae	0	2	0
Odonata	Cordulegastridae	-	Cordulegaster	1	2	1
Trichoptera	Hydropsychidae	-	Diplectrona	1	1	1
	Polycentropodidae	-	Polycentropus	1	1	1
			Total	121	118	112
			PDE			1.26
			PTD			5.08

Table 13 - Taxonomic Identification and Enumeration Results: 13-L1M-04-17

Order	Family	Tribe	Sample ID	13-L1M-04-17 Taxonomist 1	Taxonomist 2	# of agreements
Amphipoda	Crangonyctidae	-	Crangonyctidae	1	1	1
	Crangonyctidae	-	Synurella	11	11	11
Basommatophora	Planorbidae	-	Planorbella	1	1	1
Coleoptera	Dytiscidae	-	Colymbetinae	3	0	0
		-	Dytiscidae	0	3	0
Diptera	Ceratopogonidae	-	Ceratopogonidae	1	1	1
	Ceratopogonidae	-	Bezzia/Palpomyia	1	1	1
	Chironomidae	-	Cricotopus	2	0	0

Order	Family	Tribe	Sample ID	13-L1M-04-17 Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	-	Hydrobaenus	10	11	10
	Chironomidae	-	Limnophyes	2	2	2
	Chironomidae	-	Orthocladius	39	37	37
	Chironomidae	-	Rheocricotopus	11	10	10
	Chironomidae	Pentaneurini	Zavrelimyia	4	4	4
			Orthocladiinae pupae	0	4	-
	Simuliidae	Simuliini	Simulium	13	13	13
	Simuliidae	Prosimuliini	Stegopterna	2	2	2
Hoplonemertea	Tetrastemmatidae	-	Prostoma	1	1	1
Isopoda	Asellidae	-	Caecidotea	13	12	12
	not identified	-	Turbellaria	1	0	0
		-	Dugesiidae	0	1	0
Plecoptera	Nemouridae	-	Amphinemura	1	1	1
Trichoptera	Limnephilidae	-	Ironoquia	3	3	3
Veneroida	Pisidiidae	-	Pisidium	2	0	0
		-	Musculium sp.	0	2	0
			Total	122	121	110
			PDE			0.41
			PTD			9.09

Table 14 - Taxonimic Identification and Enumeration Results: 13-R3S-02-17

Order	Family	Tribe	Sample ID	13-R3S-02-17 Taxonomist 1	Taxonomist 2	# of agreements
Diptera	Ceratopogonidae	-	Ceratopogonidae	1	1	1
	Chironomidae	Chironomini	Chironomus	9	9	9
	Chironomidae	-	Corynoneura	12	0	0
		-	Hydrobaenus sp.	0	12	0

Order	Family	Tribe	Sample ID	13-R3S-02-17		
				Taxonomist 1	Taxonomist 2	# of agreements
	Chironomidae	-	Diplocladius	2	2	2
	Chironomidae	-	Rheocricotopus	70	69	69
	Chironomidae	Pentaneurini	Zavrelimyia	15	15	15
	Culicidae	-	Culicidae	7	0	7
		-	Aedes sp.	0	7	-
		-	Orthocladiinae pupae	0	1	0
		-	Tipula sp.	0	1	0
Amphipoda		-	Amphipoda	0	4	0
Haplotaxida	Naididae	-	Naididae	10	0	10
		-	Tubificidae	0	10	-
Isopoda	Asellidae	-	Caecidotea	9	9	9
Plecoptera	Nemouridae	-	Nemouridae	1	1	1
Veneroida	Pisidiidae	-	Pisidium	3	3	3
			Total	139	144	126
			PDE			1.77
			PTD			12.50

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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	Polypedilum	Polypedilum	Shredder	cb, cn	6.3	569	12.86%	34	85.0%
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6	373	8.43%	20	50.0%
Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	Collector	sp	6.2	370	8.36%	35	87.5%
Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	Collector	sp	4.6	255	5.76%	24	60.0%
Amphipoda	Gammaridae	Gammarus	Gammarus	Shredder	sp	6.7	202	4.57%	8	20.0%
Diptera	Chironomidae	Orthocladius	Orthocladius	Collector	sp, bu	9.2	201	4.54%	29	72.5%
Haplotaxida	Naididae	not identified	Naididae	Collector	bu	8.5	134	3.03%	22	55.0%
Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	Predator	sp	5.3	122	2.76%	24	60.0%
Diptera	Chironomidae	Diplocladius	Diplocladius	Collector	sp	5.9	115	2.60%	20	50.0%
Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia group	Predator	sp	8.2	103	2.33%	23	57.5%
Coleoptera	Ptilodactylidae	Anchytarsus	Anchytarsus	Shredder	cn	3.1	98	2.22%	6	15.0%
Diptera	Simuliidae	Simulium	Simulium	Filterer	cn	5.7	98	2.22%	15	37.5%
Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	Scraper	sp	7.2	89	2.01%	6	15.0%
Amphipoda	Crangonyctidae	Synurella	Synurella	0	0	0.4	88	1.99%	17	42.5%
Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	Filterer	cn	6.5	82	1.85%	8	20.0%
Diptera	Chironomidae	Chironomus	Chironomus	Collector	bu	4.6	76	1.72%	5	12.5%
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7	75	1.70%	17	42.5%
Diptera	Simuliidae	Stegopterna	Stegopterna	Filterer	cn	2.4	58	1.31%	12	30.0%
Diptera	Chironomidae	Parakiefferiella	Parakiefferiella	Collector	sp	2.1	51	1.15%	11	27.5%
Diptera	Chironomidae	Tanytarsus	Tanytarsus	Filterer	cb, cn	4.9	44	0.99%	14	35.0%
Diptera	Chironomidae	Chaetocladius	Chaetocladius	Collector	sp	7	41	0.93%	10	25.0%
Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	Filterer	cn	1.1	41	0.93%	12	30.0%
Diptera	Chironomidae	Apsectrotanypus	Apsectrotanypus	Predator	bu, sp	6.6	39	0.88%	8	20.0%
Amphipoda	not identified	not identified	Amphipoda	0	sp	6	38	0.86%	10	25.0%
Plecoptera	Nemouridae	Amphinemura	Amphinemura	Shredder	sp, cn	3	37	0.84%	11	27.5%
Mesogastropoda	Hydrobiidae	not identified	Hydrobiidae	Scraper	cb	8	35	0.79%	1	2.5%
Veneroida	Pisidiidae	not identified	Sphaeriidae	Filterer	bu	6.5	35	0.79%	10	25.0%
Coleoptera	Elmidae	Stenelmis	Stenelmis	Scraper	cn	7.1	34	0.77%	9	22.5%
Diptera	Tipulidae	Tipula	Tipula	Shredder	bu	6.7	34	0.77%	13	32.5%
Diptera	Chironomidae	Corynoneura	Corynoneura	Collector	sp	4.1	33	0.75%	18	45.0%
Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	Filterer	cn	2.7	29	0.66%	7	17.5%
Trichoptera	Limnephilidae	Ironoquia	Ironoquia	Shredder	sp	4.9	28	0.63%	10	25.0%
Lumbriculida	Lumbriculidae	not identified	Lumbriculidae	Collector	bu	6.6	28	0.63%	7	17.5%
Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	Filterer	cn	7.2	28	0.63%	9	22.5%
Diptera	Chironomidae	Thienemanniella	Thienemanniella	Collector	sp	5.1	26	0.59%	10	25.0%
Plecoptera	Leuctridae	Leuctra	Leuctra	Shredder	cn	0.4	25	0.57%	7	17.5%
Diptera	Ceratopogonidae	not identified	Ceratopogonidae	Predator	sp, bu	3.6	22	0.50%	15	37.5%
Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	Collector	sp	6.7	21	0.47%	4	10.0%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	Filterer	cn	7.5	21	0.47%	6	15.0%
Trichoptera	Polycentropodidae	not identified	Polycentropodidae	0	cn	0.2	20	0.45%	7	17.5%
not identified	not identified	not identified	Turbellaria	Predator	sp	4	20	0.45%	8	20.0%
Diptera	Ceratopogonidae	Bezzia	Bezzia	Predator	bu	3.3	19	0.43%	5	12.5%
Odonata	Calopterygidae	Calopteryx	Calopteryx	Predator	cb	8.3	19	0.43%	9	22.5%
Diptera	Ceratopogonidae	not identified	Bezzia/Palpomyia	0	0	na	16	0.36%	8	20.0%
Hoplonemertea	Tetrastemmatidae	Prostoma	Prostoma	Predator	0	7.3	16	0.36%	7	17.5%
Diptera	Chironomidae	Brillia	Brillia	Shredder	bu, sp	7.4	15	0.34%	4	10.0%
Megaloptera	Corydalidae	Nigronia	Nigronia	Predator	cn, cb	1.4	15	0.34%	10	25.0%
Basommatophora	Planorbidae	Menetus	Menetus	Scraper	cb	7.6	14	0.32%	4	10.0%
Coleoptera	Dytiscidae	not identified	Dytiscidae	Predator	sw, dv	5.4	13	0.29%	9	22.5%
Trichoptera	Philopotamidae	Chimarra	Chimarra	Filterer	cn	4.4	12	0.27%	4	10.0%
Amphipoda	Crangonyctidae	not identified	Crangonyctidae	Collector	sp	6.5	12	0.27%	5	12.5%
Diptera	Chironomidae	Cricotopus	Cricotopus	Shredder	cn, bu	9.6	12	0.27%	8	20.0%
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7	12	0.27%	8	20.0%
Trichoptera	Uenoidae	Neophylax	Neophylax	Scraper	cn	2.7	11	0.25%	2	5.0%
Diptera	Chironomidae	Tvetenia	Tvetenia	Collector	sp	5.1	11	0.25%	7	17.5%
Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	Collector	bu	9.1	10	0.23%	8	20.0%
Diptera	Tipulidae	Erioptera	Erioptera	Collector	bu	4.8	10	0.23%	4	10.0%
Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	Collector	sp	7.7	10	0.23%	1	2.5%
Ephemeroptera	Heptageniidae	Maccaffertium	Maccaffertium	Scraper	cn	3	9	0.20%	1	2.5%
Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	Collector	cn	8.7	9	0.20%	7	17.5%
Diptera	Chironomidae	Ablabesmyia	Ablabesmyia	Predator	sp	8.1	8	0.18%	4	10.0%
Coleoptera	Elmidae	Dubiraphia	Dubiraphia	Scraper	cn, cb	5.7	8	0.18%	3	7.5%
Plecoptera	Chloroperlidae	Haploperla	Haploperla	Predator	cn	1.6	8	0.18%	1	2.5%
Diptera	Chironomidae	Micropsectra	Micropsectra	Collector	cb, sp	2.1	8	0.18%	7	17.5%
Diptera	Chironomidae	Odontomesa	Odontomesa	Collector	sp	6.6	8	0.18%	3	7.5%
Diptera	Chironomidae	Prodiamesa	Prodiamesa	Collector	bu, sp	6.6	8	0.18%	1	2.5%
Ephemeroptera	Siphlonuridae	Siphlonurus	Siphlonurus	Collector	sw, cb	7	8	0.18%	1	2.5%
Lumbricina	not identified	not identified	Lumbricina	Collector	bu	na	7	0.16%	5	12.5%
Diptera	Chironomidae	Natarsia	Natarsia	Predator	sp	6.6	7	0.16%	3	7.5%
Diptera	Chironomidae	Potthastia	Potthastia	Collector	sp	0.01	7	0.16%	6	15.0%
Diptera	Chironomidae	Pseudorthocladius	Pseudorthocladius	Collector	sp	6	7	0.16%	4	10.0%
Trichoptera	Leptoceridae	Triaenodes	Triaenodes	Shredder	sw, cb	5	7	0.16%	4	10.0%
Ephemeroptera	Baetidae	Acerpenna	Acerpenna	Collector	sw, cn	2.6	6	0.14%	3	7.5%
Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	Shredder	0	7.7	6	0.14%	3	7.5%
Diptera	Chironomidae	Limnophyes	Limnophyes	Collector	sp	8.6	6	0.14%	4	10.0%
Trichoptera	Psychomyiidae	Lype	Lype	Scraper	cn	4.7	6	0.14%	4	10.0%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Coleoptera	Elmidae	Macronychus	Macronychus	Scraper	cn	6.8	6	0.14%	4	10.0%
Diptera	Chironomidae	Stilocladius	Stilocladius	Collector	sp	6.6	6	0.14%	3	7.5%
Odonata	Aeshnidae	Boyeria	Boyeria	Predator	cb, sp	6.3	5	0.11%	3	7.5%
Plecoptera	Chloroperlidae	not identified	Chloroperlidae	Predator	cn	1.6	5	0.11%	1	2.5%
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9	5	0.11%	4	10.0%
Diptera	Chironomidae	Heterotrissocladius	Heterotrissocladius	Collector	sp, bu	2	5	0.11%	4	10.0%
Diptera	Tipulidae	Hexatoma	Hexatoma	Predator	bu, sp	1.5	5	0.11%	3	7.5%
Trichoptera	Hydroptilidae	Hydroptila	Hydroptila	Scraper	cn	6	5	0.11%	1	2.5%
Trichoptera	Limnephilidae	not identified	Limnephilidae	Shredder	cb, sp, cn	3.4	5	0.11%	5	12.5%
Coleoptera	Elmidae	Oulimnius	Oulimnius	Scraper	cn	2.7	5	0.11%	2	5.0%
Diptera	Chironomidae	Paratendipes	Paratendipes	Collector	bu	6.6	5	0.11%	4	10.0%
Trichoptera	Phryganeidae	Ptilostomis	Ptilostomis	Shredder	cb	4.3	5	0.11%	5	12.5%
Trichoptera	Limnephilidae	Pycnopsyche	Pycnopsyche	Shredder	sp, cb, cn	3.1	5	0.11%	2	5.0%
Diptera	Chironomidae	Stenochironomus	Stenochironomus	Shredder	bu	7.9	5	0.11%	4	10.0%
Coleoptera	Elmidae	Ancyronyx	Ancyronyx	Scraper	cn, sp	7.8	4	0.09%	4	10.0%
Diptera	Tabanidae	Chrysops	Chrysops	Predator	sp, bu	2.9	4	0.09%	2	5.0%
Odonata	Cordulegastridae	Cordulegaster	Cordulegaster	Predator	bu	2.4	4	0.09%	4	10.0%
Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	Collector	bu	9	4	0.09%	4	10.0%
Coleoptera	Dryopidae	Helichus	Helichus	Scraper	cn	6.4	4	0.09%	4	10.0%
Trichoptera	Calamoceratidae	Heteroplectron	Heteroplectron	Shredder	sp	3	4	0.09%	3	7.5%
Ephemeroptera	Leptophlebiidae	not identified	Leptophlebiidae	Collector	sw, cn	1.7	4	0.09%	1	2.5%
Plecoptera	Nemouridae	not identified	Nemouridae	Shredder	sp, cn	2.9	4	0.09%	2	5.0%
Coleoptera	Dytiscidae	Neoporus	Neoporus	Predator	0	na	4	0.09%	3	7.5%
Diptera	Chironomidae	not identified	Tanypodinae	Predator	0	7.5	4	0.09%	3	7.5%
Diptera	Tipulidae	not identified	Tipulidae	Predator	bu, sp	4.8	4	0.09%	3	7.5%
Diptera	Chironomidae	Alotanypus	Alotanypus	0	0	6.6	3	0.07%	2	5.0%
Diptera	Chironomidae	Chironomini	Chironomini	0	0	5.9	3	0.07%	2	5.0%
Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	Predator	sp, bu	7.6	3	0.07%	3	7.5%
Coleoptera	Hydrophilidae	Cymbiodyta	Cymbiodyta	Collector	bu	4.1	3	0.07%	2	5.0%
Diptera	Tipulidae	Dicranota	Dicranota	Predator	sp, bu	1.1	3	0.07%	3	7.5%
Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	Collector	sp	6.1	3	0.07%	2	5.0%
Ephemeroptera	Ephemerellidae	Eurylophella	Eurylophella	Scraper	cn, sp	4.5	3	0.07%	1	2.5%
Trichoptera	Lepidostomatidae	Lepidostoma	Lepidostoma	Shredder	cb, sp, cn	0.01	3	0.07%	3	7.5%
Basommatophora	Lymnaeidae	not identified	Lymnaeidae	Scraper	cb	6.9	3	0.07%	3	7.5%
Diptera	Chironomidae	Microtendipes	Microtendipes	Filterer	cn	4.9	3	0.07%	2	5.0%
Diptera	Chironomidae	Nanocladius	Nanocladius	Collector	sp	7.6	3	0.07%	3	7.5%
not identified	not identified	not identified	Nemata	0	0	na	3	0.07%	3	7.5%
Diptera	Chironomidae	not identified	Orthocladiinae	Collector	0	7.6	3	0.07%	3	7.5%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Diptera	Chironomidae	Paracladopelma	Paracladopelma	Collector	sp	6.6	3	0.07%	3	7.5%
Diptera	Chironomidae	Paraphaenocladius	Paraphaenocladius	Collector	sp	4	3	0.07%	3	7.5%
Diptera	Simuliidae	not identified	Simuliidae	Filterer	cn	3.2	3	0.07%	2	5.0%
Diptera	Ceratopogonidae	Dasyhelea	Dasyhelea	Collector	sp	3.6	2	0.05%	2	5.0%
Coleoptera	Gyrinidae	Gyrinus	Gyrinus	Predator	sw, dv	4	2	0.05%	1	2.5%
Diptera	Chironomidae	Larsia	Larsia	Predator	sp	8.5	2	0.05%	2	5.0%
Lepidoptera	not identified	not identified	Lepidoptera	0	0	6.7	2	0.05%	2	5.0%
Coleoptera	Elmidae	Microcylloepus	Microcylloepus	Collector	0	4.8	2	0.05%	2	5.0%
Diptera	Tipulidae	Molophilus	Molophilus	0	bu	4.8	2	0.05%	2	5.0%
Diptera	Empididae	Neoplasta	Neoplasta	Predator	0	na	2	0.05%	2	5.0%
Trichoptera	Leptoceridae	Oecetis	Oecetis	Predator	cn, sp, cb	4.7	2	0.05%	2	5.0%
Coleoptera	Elmidae	Optioservus	Optioservus	Scraper	cn	5.4	2	0.05%	1	2.5%
Plecoptera	Perlidae	Perlesta	Perlesta	Predator	cn	1.6	2	0.05%	1	2.5%
Diptera	Chironomidae	Procladius	Procladius	Predator	sp	1.2	2	0.05%	1	2.5%
Megaloptera	Sialidae	Sialis	Sialis	Predator	bu, cb, cn	1.9	2	0.05%	2	5.0%
Diptera	Chironomidae	Stempellinella	Stempellinella	Collector	cb, sp, cn	4.2	2	0.05%	1	2.5%
Diptera	Chironomidae	Stictochironomus	Stictochironomus	Collector	bu	9.2	2	0.05%	2	5.0%
Diptera	Chironomidae	not identified	Tanytarsini	Collector	0	3.5	2	0.05%	2	5.0%
Diptera	Chironomidae	Tribelos	Tribelos	Collector	bu	7	2	0.05%	2	5.0%
Diptera	Ptychopteridae	Bittacomorpha	Bittacomorpha	Collector	bu	4	1	0.02%	1	2.5%
Decapoda	Cambaridae	not identified	Cambaridae	Shredder	sp	2.8	1	0.02%	1	2.5%
Decapoda	Cambaridae	Cambarus	Cambarus	Collector	sp	0.4	1	0.02%	1	2.5%
Diptera	Chironomidae	not identified	Chironominae	Collector	0	6.6	1	0.02%	1	2.5%
Veneroida	Corbiculidae	Corbicula	Corbicula	Filterer	bu	6	1	0.02%	1	2.5%
Odonata	Corduliidae	not identified	Corduliidae	Predator	sp, cb	2	1	0.02%	1	2.5%
Coleoptera	Gyrinidae	Dineutus	Dineutus	Predator	sw, dv	4	1	0.02%	1	2.5%
Diptera	Dixidae	Dixa	Dixa	Predator	sw, cb	5.8	1	0.02%	1	2.5%
Diptera	Dolichopodidae	not identified	Dolichopodidae	Predator	sp, bu	7.5	1	0.02%	1	2.5%
Odonata	Coenagrionidae	Enallagma	Enallagma	Predator	cb	9	1	0.02%	1	2.5%
Diptera	Ephydridae	not identified	Ephydridae	Collector	bu, sp	na	1	0.02%	1	2.5%
Basommatophora	Ancylidae	Ferrissia	Ferrissia	Scraper	cb	7	1	0.02%	1	2.5%
Odonata	Gomphidae	not identified	Gomphidae	Predator	bu	2.2	1	0.02%	1	2.5%
Trichoptera	Limnephilidae	Hydatophylax	Hydatophylax	Shredder	sp, cb	3.4	1	0.02%	1	2.5%
Trichoptera	Hydropsychidae	not identified	Hydropsychidae	Filterer	cn	5.7	1	0.02%	1	2.5%
Ephemeroptera	Leptophlebiidae	Leptophlebia	Leptophlebia	Collector	sw, cn, sp	1.8	1	0.02%	1	2.5%
Odonata	Libellulidae	not identified	Libellulidae	Predator	0	9	1	0.02%	1	2.5%
Diptera	Chironomidae	Metriocnemus	Metriocnemus	0	0	na	1	0.02%	1	2.5%
Odonata	not identified	not identified	Odonata	Predator	0	6.6	1	0.02%	1	2.5%

Order	Family	Genus	Final ID	Functional Feeding Group	Habit[1]	Tolerance Value[2]	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Diptera	Chironomidae	Paralauterborniella	Paralauterborniella	Collector	cn	6.6	1	0.02%	1	2.5%
Diptera	Psychodidae	Pericoma	Pericoma	Collector	0	4	1	0.02%	1	2.5%
Diptera	Tipulidae	Pilaria	Pilaria	Predator	bu	4.8	1	0.02%	1	2.5%
Tipulidae	Tipulidae	Pseudolimnophila	Pseudolimnophila	Predator	bu	2.8	1	0.02%	1	2.5%
Diptera	Psychodidae	not identified	Psychodidae	0	0	4	1	0.02%	1	2.5%
Diptera	Chironomidae	Saetheria	Saetheria	Collector	bu	6.6	1	0.02%	1	2.5%
Diptera	Sciomyzidae	not identified	Sciomyzidae	Predator	bu	6	1	0.02%	1	2.5%
Odonata	Corduliidae	Somatochlora	Somatochlora	Predator	sp	1	1	0.02%	1	2.5%
Amphipoda	Crangonyctidae	Stygobromus	Stygobromus	Collector	0	4	1	0.02%	1	2.5%
Diptera	Tabanidae	not identified	Tabanidae	Predator	0	2.8	1	0.02%	1	2.5%
Trichoptera	not identified	not identified	Trichoptera	0	0	4.6	1	0.02%	1	2.5%

1) Habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer
2) Tolerance Values, based on Hilsenhoff, modified for Maryland (Bressler et al., 2004)
An entry of "0" indicates information was not available in the MBSS Master Taxa List

Common Name	Scientific Name	Tolerance	Trophic Status	Lithophilic Spawner	Composition	Total Number of Organisms	% of Total Organisms	Total Number of Sites	% of Sites
Eastern Mudminnow	*Umbra pygmaea*	T	IV	N	NOTYPE	1067	30.3%	25	78%
Blacknose Dace	*Rhinichthys atratulus*	T	OM	N	NOTYPE	710	20.1%	10	31%
American Eel	*Anguilla rostrata*	NOTYPE	GE	N	NOTYPE	421	11.9%	24	75%
Bluegill	*Lepomis macrochirus*	T	IV	N	NOTYPE	248	7.0%	13	41%
Tessellated darter	*Etheostoma olmstedi*	T	IV	N	B	210	6.0%	11	34%
Green sunfish	*Lepomis cyanellus*	T	GE	N	NOTYPE	162	4.6%	11	34%
Least brook lamprey	*Lampetra aepyptera*	NOTYPE	FF	N	B	138	3.9%	5	16%
Eastern Mosquitofish	*Gambusia holbrooki*	NOTYPE	IV	N	NOTYPE	105	3.0%	5	16%
Golden Shiner	*Notemigonus crysoleucas*	T	OM	N	NOTYPE	85	2.4%	8	25%
Brown Bullhead	*Ameiurus nebulosus*	T	OM	N	NOTYPE	63	1.8%	6	19%
Creek chubsucker	*Erimyzon oblongus*	NOTYPE	IV	N	R	54	1.5%	2	6%
Pumpkinseed	*Lepomis gibbosus*	T	IV	N	NOTYPE	44	1.2%	6	19%
Banded Killifish	*Fundulus diaphanus*	NOTYPE	IV	N	NOTYPE	34	1.0%	7	22%
Mummichog	*Fundulus heteroclitus*	NOTYPE	IV	N	NOTYPE	35	1.0%	6	19%
White Sucker	*Catostomus commersonii*	T	OM	Y	NOTYPE	37	1.0%	4	13%
Bluespotted sunfish	*Enneacanthus gloriosus*	NOTYPE	IV	N	NOTYPE	26	0.7%	2	6%
Fallfish	*Semotilus corporalis*	I	GE	Y	NOTYPE	18	0.5%	3	9%
Largemouth Bass	*Mictopterus salmoides*	T	TP	N	NOTYPE	18	0.5%	3	9%
Rosyside dace	*Clinostomus funduloides*	NOTYPE	IV	Y	NOTYPE	14	0.4%	2	6%
Redfin Pickerel	*Esox americanus*	T	TP	N	NOTYPE	9	0.3%	1	3%
Swallowtail Shiner	*Notropis procne*	NOTYPE	IV	Y	NOTYPE	9	0.3%	1	3%
Chain pickerel	*Esox niger*	NOTYPE	TP	N	NOTYPE	7	0.2%	2	6%
Lepomis hybrid	*Lepomis sp.*	NOTYPE	NOTYPE	NOTYPE	NOTYPE	6	0.2%	2	6%
Tadpole madtom	*Noturus gyrinus*	NOTYPE	IV	N	B	4	0.1%	2	6%
Brook Trout	*Salvelinus fontinalis*	I	GE	Y	NOTYPE	1	0.0%	1	3%
Warmouth	*Lepomis gulosus*	NOTYPE	GE	N	NOTYPE	1	0.0%	1	3%

Note: Total number of sites is 32 as 8 of the 40 sites were found dry and not sampled

Tolerance: I = intolerant, T = tolerant; NOTYPE = no category assigned
Trophic groups: FF = filter feeder, TP = top predator, GE = generalist, IV = invertivore, IS = insectivore, OM = omnivore, AL = algivore, HE = herbivore
Lithophilic spawner: Y = Yes, N = No, NOTYPE = no categopry assigned
Composition: B = Benthic, R = Round-Bodied Sucker, NOTYPE = no category assigned

Crayfish

Common Name	Scientific Name	Total Number of Sites	% of Sites
Devil Crawfish	*Cambarus diogenes*	6	7%
Spinycheek Crayfish	*Orconectes limosus*	5	6%
n/a	*Procambarus sp.*	3	3%
Red Swamp Crawfish	*Procambarus clarkii*	1	1%

Freshwater Mussels/Corbicula

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

Herpetofauna

Common Name	Scientific Name	Total Number of Sites	% of Sites
Northern Green Frog	*Lithobates clamitans*	54	60%
Pickerel Frog	*Lithobates palustris*	21	23%
Northern Two-lined Salamander	*Eurycea bislineata*	11	12%
American Bullfrog	*Lithobates catesbeianus*	10	11%
Northern Spring Peeper	*Pseudacris crucifer*	9	10%
Cope's Gray Treefrog	*Hyla chrysoscelis*	7	8%
Eastern American Toad	*Anaxyrus americanus*	6	7%
Eastern Cricket Frog	*Acris crepitans*	5	6%
Gray Treefrog	*Hyla versicolor*	5	6%
n/a	*Pseudotriton sp.* [1]	5	6%
Wood Frog	*Lithobates sylvaticus*	4	4%
Southern Leopard Frog	*Lithobates sphenocephalus*	3	3%
Fowler's Toad	*Anaxyrus fowleri*	2	2%
Eastern Mud Salamander	*Pseudotriton montanus montanus*	1	1%
Four-toed Salamander	*Hemidactylium scutatum*	1	1%
Northern Red Salamander	*Pseudotriton ruber ruber*	1	1%
Spotted Salamander	*Ambystoma maculatum*	1	1%
Eastern Gartersnake	*Thamnophis sirtalis sirtalis*	1	1%
Eastern Wormsnake	*Carphophis amoenus amoenus*	1	1%
Northern Water Snake	*Nerodia sipedon sipedon*	1	1%
Eastern Mud Turtle	*Kinosternon subrurum*	1	1%
Eastern Painted Turtle	*Chrysemys picta picta*	1	1%

Non-native Riparian Plants

Common Name	Scientific Name	Total Number of Sites	% of Sites
Japanese Stiltgrass	*Microstegium vimineum*	32	80%
Oriental Bittersweet	*Celastrus orbiculatus*	15	38%
Japanese barberry	*Berberis thunbergii*	13	33%
Multiflora Rose	*Rosa multiflora*	13	33%
Japanese Honeysuckle	*Lonicera japonica*	12	30%
Mile-a-minute	*Persicaria perfoliata*	11	28%
Privet sp.	*Ligustrum sp.*	4	10%
Wineberry	*Rubus phoenicolasius*	4	10%
Garlic Mustard	*Alliaria petiolata*	3	8%
Japanese Knotweed	*Fallopia japonica*	1	3%
Phragmites	*Phragmites australis*	1	3%
Vinca	*Vinca minor*	1	3%

1) Unknown Pseudotriton species, commonly referred to as red or mud salamanders

Appendix D: Individual Site Summaries

Site ID 06-L1M-02-17

Revist of site R1-06-08

Upstream View - 2017

Downstream View - 2017

Upstream View - 2006

Downstream View - 2006

Summary Results

	2017 Data	2006 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Comparable to Reference	Supporting
MPHI Habitat Condition	Minimally Degraded	Minimally Degraded
Water Quality Conditions	Elevated nitrogen	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 271.20

Land Cover	2017 Acres	2006 Acres	2017 % Area	2006 % Area
Developed Land	167.84	199.05	61.89	57.48
Forested Land	61.55	107.01	22.70	30.90
Open Land	39.43	40.24	14.54	11.62
Agricultural Land	2.38	0.00	0.88	0.00

Impervious Surface	2017 Acres	2006 Acres	2017 % Area	2006 % Area
Impervious Land	37.79	40.63	13.93	11.73

Site ID 06-L1M-02-17

Revist of site R1-06-08

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2006 Spring
Dissolved Oxygen (mg/L)	9.44	6.52	9.31
Turbidity (NTU)	4.06	3.8	n/a
Temperature (°C)	9.8	22	10.65
pH (Standard Units)	7.79	7.5	5.8
Specific Conductivity (µS/cm)	370.6	319.8	207

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.014	Chloride (mg/L)	78.921
Total Nitrogen (mg/L)	0.934	Magnesium (mg/L)	4.504
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	12.33
Total Ammonia N (mg/L)	0.091	Total Copper (µg/L)	0.938
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	17.357
Nitrate-N (mg/L)	0.551	Total Lead (µg/L)	0.528
Total Kjehldal N (mg/L)	0.380	Turbidity (NTU)	2.3
Dissolved Organic C (mg/L)	2.918		
Total Organic C (mg/L)	3.236		
Hardness (mg eq. $CaCO_3$/L)	49.34		

Geomorphic Assessment

Rosgen Level II Classification Data

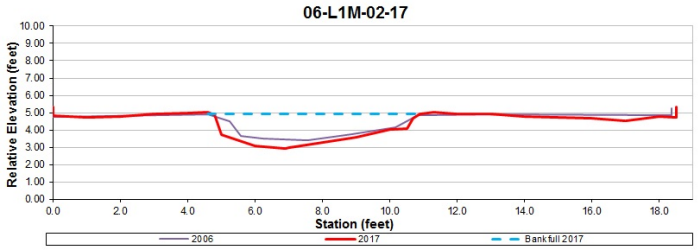
	2017	2006
Drainage Area (mi²)	0.42	
Bankfull Width (ft)	7.8	6.2
Mean Bankfull Depth (ft)	0.9	1.0
Floodprone Width (ft)	103.0	131.0
Entrenchment Ratio	13.3	21.0
Width to Depth Ratio	8.2	6.0
Cross Sectional Area (ft²)	7.4	6.4
Water Surface Slope (%)	0.520	0.190

	2017	2006
Sinuosity	1.32	1.10
D50 (mm)	0.28	0.16
Adjustments?	None	Increased Sinuosity

Rosgen Stream Type

2017	2006
E5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2006 Spring Value	2006 Spring Score
Remoteness	10.98	59.13	12.00	64.62
Shading	95	99.94	95	99.94
Epifaunal Substrate	14	100.00	12	87.83
Instream Habitat	14	100.00	9	70.78
Instream Woody Debris	11	90.82	9	82.14
Bank Stability	19.80	99.50	16.00	89.45

	2017 Score	2006 Score
MPHI Habitat Score	91.57	82.46
MPHI Rating	Minimally Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2017 Score	2006 Score		2017 Score	2006 Score
Epifaunal Substrate/Available Cover	16	12	Bank Stability - Right Bank	9	8
Pool Substrate Characterization	17	10	Bank Stability - Left Bank	9	8
Pool Variability	4	9	Vegetative Protection - Right Bank	10	10
Sediment Deposition	19	10	Vegetative Protection - Left Bank	10	10
Channel Flow Status	18	18	Riparian Veg. Zone Width - Right Bank	10	8
Channel Alteration	20	18	Riparian Veg. Zone Width - Left Bank	10	8
Channel Sinuosity	9	11			

	2017 Score	2006 Score
RBP Habitat Score	161	140
RBP Rating	Comparable to Reference	Supporting

Site ID 06-L1M-02-17

Revist of site R1-06-08

Biological Assessments

BIBI Metric Values	2017	2006
Total Taxa	16	37
EPT Taxa	2	5
Ephemeroptera Taxa	0	0
% Intolerant to Urban	77.59	17.31
% Ephemeroptera	0.00	0.00
Scraper Taxa	2	0
% Climbers	1.72	8.65

FIBI Metric Values (2017 only)	
Abundance per m²	1.00
Adj. No. of Benthic Species	0.00
% Tolerant	84.04
% Gen., Omni., Invert.	97.87
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	30.85

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

FIBI Metric Scores (2017 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.00	3.00
BIBI Rating	Fair	Fair

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
American Eel	4
Banded Killifish	2
Bluegill	29
Brown Bullhead	15
Eastern Mosquitofish	1
Eastern Mudminnow	5
Golden Shiner	10
Green Sunfish	17
Largemouth Bass	2
Mummichog	8
Pumpkinseed	1

Benthic Macroinvertebrate Taxa

2017	Number
Caecidotea	84
Corynoneura	1
Dytiscidae	1
Gomphidae	1
Lepidostoma	1
Lumbriculidae	13
Macronychus	2
Macronychus	1
Naididae	1
Nanocladius	1
Orthocladius	1
Prostoma	1
Pycnopsyche	1
Stegopterna	4
Stenelmis	1
Stenochironomus	1
Turbellaria	1

Original Visit	Number
Apsectrotanypus	5
Bethbilbeckia	2
Bezzia/Palpomyia	5
Ceratopogon	6
Chrysops	1
Corethrella	1
Corynoneura	1
Enallagma	1
Heteroplectron	1
Heterotrissocladius	2
Ischnura	1
Lepidostoma	1
Limnophyes	4
Micropsectra	2
Microtendipes	1
Nanocladius	1
Neoporus	3
Orthocladius	1
Parametriocnemus	1
Paraphaenocladius	6
Paratendipes	1
Polycentropus	1
Polypedilum	1
Pseudolimnophila	1
Pseudorthocladius	2
Pseudosmittia	2
Ptilostomis	3
Pycnopsyche	2
Sialis	1
Sphaeriidae (Mollusca)	2
Stegopterna	2
Stenochironomus	2
Tanypodinae	2
Thienemannimyia	19
Tipula	1
Tribelos	8
Zavrelimyia	8

Site ID 06-L1M-03-17

Revist of site R1-06-09

Upstream View - 2017

Downstream View - 2017

Upstream View - 2006

Downstream View - 2006

Summary Results

	2017 Data	2006 Data
Benthic Macroinvertebrate Community	Fair	Very Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Comparable to Reference
MPHI Habitat Condition	Minimally Degraded	Minimally Degraded
Water Quality Conditions	Within acceptable ranges	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 760.63

Land Cover	2017 Acres	2006 Acres	2017 % Area	2006 % Area
Developed Land	313.57	276.51	41.22	38.24
Forested Land	314.77	317.75	41.38	43.94
Open Land	118.64	124.99	15.60	17.29
Agricultural Land	13.66	3.85	1.80	0.53

Impervious Surface	2017 Acres	2006 Acres	2017 % Area	2006 % Area
Impervious Land	80.34	87.58	10.56	12.11

Site ID 06-L1M-03-17

Revist of site R1-06-09

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2006 Spring
Dissolved Oxygen (mg/L)	9.22	7.15	9.94
Turbidity (NTU)	3.86	4.41	n/a
Temperature (°C)	9.3	18.7	12.78
pH (Standard Units)	7.08	5.25	5.16
Specific Conductivity (µS/cm)	283.8	326.7	172

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.008	Chloride (mg/L)	65.701
Total Nitrogen (mg/L)	0.613	Magnesium (mg/L)	2.968
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	5.54
Total Ammonia N (mg/L)	0.018	Total Copper (µg/L)	1.174
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	15.436
Nitrate-N (mg/L)	0.461	Total Lead (µg/L)	0.281
Total Kjehldal N (mg/L)	0.151	Turbidity (NTU)	3.1
Dissolved Organic C (mg/L)	1.465		
Total Organic C (mg/L)	1.614		
Hardness (mg eq. $CaCO_3$/L)	26.07		

Geomorphic Assessment

Rosgen Level II Classification Data

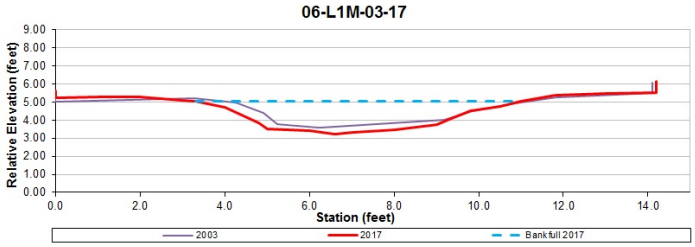
	2017	2006
Drainage Area (mi²)	1.19	
Bankfull Width (ft)	10.6	8.4
Mean Bankfull Depth (ft)	1.0	0.9
Floodprone Width (ft)	142.7	98.0
Entrenchment Ratio	13.5	11.6
Width to Depth Ratio	10.7	9.2
Cross Sectional Area (ft²)	10.5	7.7
Water Surface Slope (%)	0.870	0.910

	2017	2006
Sinuosity	1.17	1.10
D50 (mm)	0.27	0.25
Adjustments?	None	Increased Sinuosity

Rosgen Stream Type

2017	2006
E5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2006 Spring Value	2006 Spring Score
Remoteness	15.28	82.26	16.00	86.16
Shading	80	78.67	95	99.94
Epifaunal Substrate	13	88.52	15	100.00
Instream Habitat	16	100.00	15	96.54
Instream Woody Debris	21	100.00	10	76.76
Bank Stability	10.40	72.11	17.00	92.20

	2017 Score	2006 Score
MPHI Habitat Score	86.93	91.93
MPHI Rating	Minimally Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2017 Score	2006 Score		2017 Score	2006 Score
Epifaunal Substrate/Available Cover	16	15	Bank Stability - Right Bank	7	9
Pool Substrate Characterization	14	11	Bank Stability - Left Bank	7	9
Pool Variability	6	10	Vegetative Protection - Right Bank	10	10
Sediment Deposition	16	10	Vegetative Protection - Left Bank	10	9
Channel Flow Status	14	19	Riparian Veg. Zone Width - Right Bank	10	9
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	9
Channel Sinuosity	8	17			

	2017 Score	2006 Score
RBP Habitat Score	148	156
RBP Rating	Supporting	Comparable to Reference

Site ID 06-L1M-03-17

Revist of site R1-06-09

Biological Assessments

BIBI Metric Values	2017	2006
Total Taxa	29	21
EPT Taxa	6	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	30.70	8.26
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	7.89	4.59

FIBI Metric Values (2017 only)	
Abundance per m²	1.91
Adj. No. of Benthic Species	0.00
% Tolerant	86.03
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	43.38

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

FIBI Metric Scores (2017 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	3.29	1.86
BIBI Rating	Fair	Very Poor

FIBI Score	2.33
FIBI Rating	Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Pickerel Frog

Fish Taxa	Number
American Eel	18
Banded Killifish	1
Bluegill	23
Eastern Mudminnow	59
Golden Shiner	1
Green Sunfish	34

Benthic Macroinvertebrate Taxa

2017	Number
Ablabesmyia	5
Alotanypus	1
Amphipoda	1
Anchytarsus	1
Caecidotea	10
Calopteryx	1
Corynoneura	1
Dasyhelea	1
Diplectrona	3
Diplocladius	1
Heteroplectron	2
Leuctra	2
Lype	2
Micropsectra	1
Nigronia	2
Parametriocnemus	28
Pisidium	1
Polycentropodidae	5
Polycentropus	2
Polypedilum	2
Rheotanytarsus	2
Simulium	15
Sphaeriidae	2
Stegopterna	7
Synurella	1
Tanytarsus	2
Thienemanniella	2
Thienemannimyia group	5
Thienemannimyia group	1
Triaenodes	1
Tribelos	1
Turbellaria	2
Zavrelimyia	1

Original Visit	Number
Ablabesmyia	6
Apsectrotanypus	2
Cryptochironomus	4
Dineutus	1
Diplectrona	1
Diplocladius	2
Heteroplectron	2
Natarsia	5
Nigronia	2
Paracladopelma	2
Parametriocnemus	3
Paraphaenocladius	4
Paratendipes	42
Phaenopsectra	7
Polycentropus	1
Polypedilum	5
Rheotanytarsus	8
Sialis	3
Thienemannimyia	6
Tribelos	2
Zavrelimyia	1

Site ID 06-L1M-04-17

Revist of site R1-06-10

Upstream View - 2017

Downstream View - 2017

Upstream View - 2006

Downstream View - 2006

Summary Results

	2017 Data	2006 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Elevated nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 240.90

Land Cover	2017 Acres	2006 Acres	2017 % Area	2006 % Area
Developed Land	155.90	130.49	64.71	52.20
Forested Land	73.57	107.77	30.54	43.11
Open Land	3.90	5.82	1.62	2.33
Agricultural Land	7.53	5.92	3.13	2.37

Impervious Surface	2017 Acres	2006 Acres	2017 % Area	2006 % Area
Impervious Land	30.09	23.78	12.49	9.51

Site ID 06-L1M-04-17

Revist of site R1-06-10

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2006 Spring
Dissolved Oxygen (mg/L)	6.88	n/a	9.31
Turbidity (NTU)	4.63	n/a	n/a
Temperature (°C)	13.6	n/a	14.04
pH (Standard Units)	7.14	n/a	5.36
Specific Conductivity (µS/cm)	154.5	n/a	79

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.083	Chloride (mg/L)	17.515
Total Nitrogen (mg/L)	1.924	Magnesium (mg/L)	3.538
Orthophosphate (mg/L)	0.008	Calcium (mg/L)	7.38
Total Ammonia N (mg/L)	0.058	Total Copper (µg/L)	3.851
Nitrite-N (mg/L)	0.007	Total Zinc (µg/L)	10.439
Nitrate-N (mg/L)	0.884	Total Lead (µg/L)	1.311
Total Kjehldal N (mg/L)	1.033	Turbidity (NTU)	32.8
Dissolved Organic C (mg/L)	10.021		
Total Organic C (mg/L)	10.389		
Hardness (mg eq. $CaCO_3$/L)	32.99		

Geomorphic Assessment

Rosgen Level II Classification Data

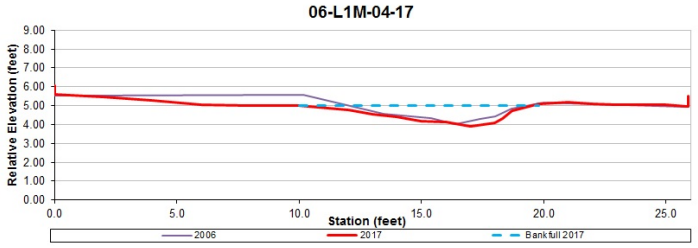
	2017	2006
Drainage Area (mi²)	0.38	
Bankfull Width (ft)	6.9	8.4
Mean Bankfull Depth (ft)	0.5	0.6
Floodprone Width (ft)	48.6	69.0
Entrenchment Ratio	7.1	8.2
Width to Depth Ratio	13.8	14.7
Cross Sectional Area (ft²)	3.4	4.8
Water Surface Slope (%)	0.078	0.670

	2017	2006
Sinuosity	1.20	1.30
D50 (mm)	0.16	0.13
Adjustments?	Adjusted W/D ratio -2.0	None

Rosgen Stream Type

2017	2006
E5	**C5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2006 Spring Value	2006 Spring Score
Remoteness	7.95	42.78	8.00	43.08
Shading	90	91.34	95	99.94
Epifaunal Substrate	12	90.20	5	49.29
Instream Habitat	12	91.14	6	57.47
Instream Woody Debris	11	92.16	1	62.16
Bank Stability	11.20	74.84	17.00	92.20

	2017 Score	2006 Score
MPHI Habitat Score	80.41	67.36
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2017 Score	2006 Score		2017 Score	2006 Score
Epifaunal Substrate/Available Cover	9	7	Bank Stability - Right Bank	8	7
Pool Substrate Characterization	7	7	Bank Stability - Left Bank	8	7
Pool Variability	5	6	Vegetative Protection - Right Bank	9	10
Sediment Deposition	12	8	Vegetative Protection - Left Bank	9	9
Channel Flow Status	16	15	Riparian Veg. Zone Width - Right Bank	10	7
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	7
Channel Sinuosity	7	12			

	2017 Score	2006 Score
RBP Habitat Score	130	121
RBP Rating	Supporting	Partially Supporting

Site ID 06-L1M-04-17

Revist of site R1-06-10

Biological Assessments

BIBI Metric Values	2017	2006
Total Taxa	30	32
EPT Taxa	0	4
Ephemeroptera Taxa	0	0
% Intolerant to Urban	4.67	24.35
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	1
% Climbers	12.15	7.83

FIBI Metric Values (2017 only)	
Abundance per m²	3.26
Adj. No. of Benthic Species	0.00
% Tolerant	99.12
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	92.48

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

FIBI Metric Scores (2017 only)	
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	2.14	2.71
BIBI Rating	Poor	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Flora and Fauna (2017 only)

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
American Eel	2
Eastern Mudminnow	209
Green Sunfish	15

Benthic Macroinvertebrate Taxa

2017	Number
Anchytarsus	1
Apsectrotanypus	2
Calopteryx	9
Ceratopogonidae	2
Cheumatopsyche	4
Chironomus	1
Corynoneura	1
Crangonyctidae	1
Cryptochironomus	1
Diplectrona	2
Diplocladius	1
Enchytraeidae	1
Lumbricina	2
Lumbricina	1
Micropsectra	1
Naididae	1
Natarsia	2
Nigronia	1
Orthocladius	2
Parametriocnemus	1
Pisidium	3
Polypedilum	2
Prodiamesa	8
Pseudolimnophila	1
Rheocricotopus	25
Simulium	1
Thienemanniella	1
Thienemannimyia group	22
Thienemannimyia group	1
Tipulidae	1
Tribelos	1
Zavrelimyia	4

Original Visit	Number
Ablabesmyia	2
Apsectrotanypus	7
Bethbilbeckia	2
Bezzia/Palpomyia	3
Caecidotea	1
Calopteryx	4
Ceratopogon	1
Cryptochironomus	3
Diplectrona	2
Heteroplectron	7
Heterotrissocladius	2
Lype	1
Mallochohelea	2
Micropsectra	1
Natarsia	4
Orthocladius	1
Parametriocnemus	9
Paraphaenocladius	7
Paratendipes	1
Pilaria	2
Polycentropus	7
Polypedilum	3
Prionocyphon	1
Pseudolimnophila	1
Rheocricotopus	1
Rheotanytarsus	4
Stegopterna	1
Synurella	5
Thienemannimyia	19
Tipula	1
Tubificidae	5
Zavrelimyia	5

Site ID 06-L2M-01-17

Revist of site R2-06-19A

Upstream View - 2017

Downstream View - 2017

Upstream View - 2011

Downstream View - 2011

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 721.37

Land Cover	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Developed Land	313.57	304.40	43.47	43.50
Forested Land	280.22	265.90	38.85	38.00
Open Land	114.33	127.50	15.85	18.20
Agricultural Land	13.25	1.70	1.84	0.20

Impervious Surface	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Impervious Land	80.03	89.20	11.09	12.80

Site ID 06-L2M-01-17

Revist of site R2-06-19A

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2011 Spring
Dissolved Oxygen (mg/L)	9.46	4.26	9.89
Turbidity (NTU)	7.96	10.7	7.11
Temperature (°C)	8.7	16.9	12.93
pH (Standard Units)	5.85	6.98	5.97
Specific Conductivity (µS/cm)	249.4	323.9	336.9

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.018	Chloride (mg/L)	60.118
Total Nitrogen (mg/L)	0.489	Magnesium (mg/L)	2.504
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	5.53
Total Ammonia N (mg/L)	0.062	Total Copper (µg/L)	0.865
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	10.689
Nitrate-N (mg/L)	0.278	Total Lead (µg/L)	0.314
Total Kjehldal N (mg/L)	0.208	Turbidity (NTU)	6.4
Dissolved Organic C (mg/L)	2.006		
Total Organic C (mg/L)	2.256		
Hardness (mg eq. $CaCO_3$/L)	24.12		

Geomorphic Assessment

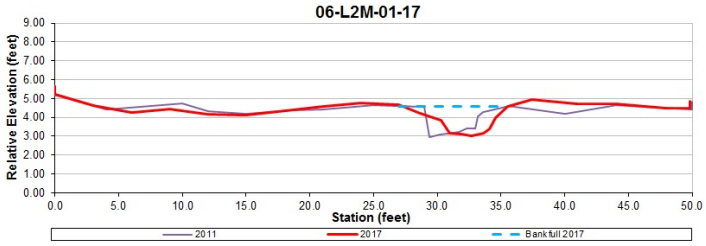
Rosgen Level II Classification Data

	2017	2011		2017	2011
Drainage Area (mi²)	1.13		Sinuosity	1.04	1.20
Bankfull Width (ft)	8.5	6.4	D50 (mm)	0.30	0.40
Mean Bankfull Depth (ft)	0.9	0.9	Adjustments?	None	None
Floodprone Width (ft)	146.0	145.0			
Entrenchment Ratio	17.2	22.7			
Width to Depth Ratio	9.2	7.1			
Cross Sectional Area (ft²)	7.9	5.7			
Water Surface Slope (%)	0.260	0.740			

Rosgen Stream Type

2017	2011
E5	**E5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2011 Spring Value	2011 Spring Score
Remoteness	12.20	65.72	7.00	37.70
Shading	65	63.55	60	58.94
Epifaunal Substrate	12	83.05	8	60.01
Instream Habitat	16	100.00	8	58.04
Instream Woody Debris	20	100.00	2	53.47
Bank Stability	10.40	72.11	15.00	86.61

	2017 Score	2011 Score
MPHI Habitat Score	80.74	59.13
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2017 Score	2011 Score		2017 Score	2011 Score
Epifaunal Substrate/Available Cover	11	8	Bank Stability - Right Bank	4	8
Pool Substrate Characterization	8	8	Bank Stability - Left Bank	3	7
Pool Variability	11	11	Vegetative Protection - Right Bank	9	8
Sediment Deposition	15	13	Vegetative Protection - Left Bank	9	7
Channel Flow Status	12	19	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	8	6
Channel Sinuosity	7	13			

	2017 Score	2011 Score
RBP Habitat Score	127	137
RBP Rating	Supporting	Supporting

Site ID 06-L2M-01-17

Revist of site R2-06-19A

Biological Assessments

BIBI Metric Values	2017	2011
Total Taxa	16	6
EPT Taxa	2	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	49.55	0.90
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	1
% Climbers	1.80	0.90

FIBI Metric Values (2017 only)	
Abundance per m²	1.42
Adj. No. of Benthic Species	0.00
% Tolerant	92.71
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	45.83

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

FIBI Metric Scores (2017 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	2.43	1.29
BIBI Rating	Poor	Very Poor

FIBI Score	2.33
FIBI Rating	Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
American Eel	5
Bluegill	28
Eastern Mosquitofish	2
Eastern Mudminnow	44
Green Sunfish	15
Pumpkinseed	2

Benthic Macroinvertebrate Taxa

2017	Number
Caecidotea	42
Cheumatopsyche	1
Libellulidae	1
Naididae	2
Orthocladius	1
Parametriocnemus	17
ParaphaenocladiuS	1
Pisidium	10
Polycentropodidae	1
Procladius	2
Prostoma	5
Rheocricotopus	4
Sphaeriidae	5
Stegopterna	10
Tanytarsus	2
Thienemanniella	1
Thienemannimyia group	6

Original Visit	Number
Gastropoda	1
Parametriocnemus	1
Phaenopsectra	1
Rheocricotopus	20
Simulium	90
Stegopterna	1

Site ID 06-L2M-03-17

Revist of site R2-06-11A

Upstream View - 2017

Downstream View - 2017

Upstream View - 2011

Downstream View - 2011

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 749.93

Land Cover	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Developed Land	313.57	304.40	41.81	40.50
Forested Land	304.06	308.40	40.54	41.00
Open Land	118.64	134.80	15.82	17.90
Agricultural Land	13.66	4.30	1.82	0.60

Impervious Surface	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Impervious Land	80.26	89.50	10.70	11.90

Site ID 06-L2M-03-17

Revist of site R2-06-11A

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2011 Spring
Dissolved Oxygen (mg/L)	10.02	6.77	9.84
Turbidity (NTU)	3.48	3.5	4.29
Temperature (°C)	7.3	20.3	7.97
pH (Standard Units)	6	5.02	5.64
Specific Conductivity (µS/cm)	364.3	364.3	263.7

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.009	Chloride (mg/L)	80.097
Total Nitrogen (mg/L)	0.668	Magnesium (mg/L)	3.341
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	6.15
Total Ammonia N (mg/L)	0.026	Total Copper (µg/L)	1.182
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	15.375
Nitrate-N (mg/L)	0.540	Total Lead (µg/L)	0.209
Total Kjehldal N (mg/L)	0.126	Turbidity (NTU)	2.9
Dissolved Organic C (mg/L)	1.357		
Total Organic C (mg/L)	1.421		
Hardness (mg eq. $CaCO_3$/L)	29.12		

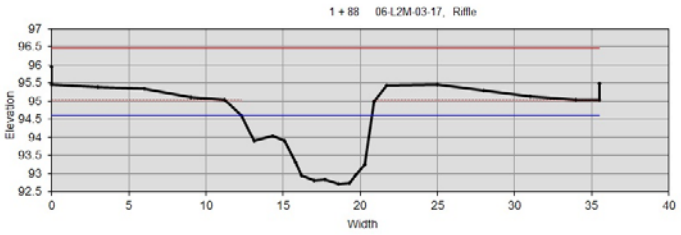
Geomorphic Assessment

Rosgen Level II Classification Data

	2017	2011		2017	2011
Drainage Area (mi²)	1.17		Sinuosity	1.17	1.26
Bankfull Width (ft)	8.5	29.6	D50 (mm)	0.22	0.50
Mean Bankfull Depth (ft)	1.2	0.7	Adjustments?	None	None
Floodprone Width (ft)	176.0	106.0			
Entrenchment Ratio	20.8	3.6			
Width to Depth Ratio	7.0	39.7			
Cross Sectional Area (ft²)	10.2	22.0			
Water Surface Slope (%)	0.570	0.730			

Rosgen Stream Type	
2017	2011
E5	**DA5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2011 Spring Value	2011 Spring Score
Remoteness	14.33	77.16	13.00	70.01
Shading	85	84.56	80	78.67
Epifaunal Substrate	12	82.80	13	88.59
Instream Habitat	15	96.17	14	90.59
Instream Woody Debris	13	85.22	6	64.49
Bank Stability	5.70	53.39	16.00	89.45

	2017 Score	2011 Score
MPHI Habitat Score	79.88	80.30
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2017 Score	2011 Score		2017 Score	2011 Score
Epifaunal Substrate/Available Cover	17	13	Bank Stability - Right Bank	2	8
Pool Substrate Characterization	14	13	Bank Stability - Left Bank	3	8
Pool Variability	10	13	Vegetative Protection - Right Bank	9	8
Sediment Deposition	17	15	Vegetative Protection - Left Bank	9	8
Channel Flow Status	15	20	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	18	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	14			

	2017 Score	2011 Score
RBP Habitat Score	142	160
RBP Rating	Supporting	Comparable to Reference

Site ID 06-L2M-03-17

Revist of site R2-06-11A

Biological Assessments

BIBI Metric Values	2017	2011
Total Taxa	15	28
EPT Taxa	3	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	34.19	23.10
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	1
% Climbers	4.27	7.70

FIBI Metric Values (2017 only)	
Abundance per m²	1.09
Adj. No. of Benthic Species	0.00
% Tolerant	88.54
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	35.42

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

FIBI Metric Scores (2017 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	2.43	2.71
BIBI Rating	Poor	Poor

FIBI Score	2.67
FIBI Rating	Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Pickerel Frog

Fish Taxa	Number
American Eel	10
Banded Killifish	1
Bluegill	34
Eastern Mudminnow	26
Golden Shiner	1
Green Sunfish	23
Pumpkinseed	1

Benthic Macroinvertebrate Taxa

2017	Number
Caecidotea	2
Ceratopogonidae	1
Diplectrona	14
Naididae	1
Nigronia	3
Parametriocnemus	40
Polycentropodidae	2
Polypedilum	1
Simulium	23
Stegopterna	18
Synurella	1
Thienemanniella	1
Thienemannimyia group	7
Thienemannimyia group	1
Triaenodes	1
Turbellaria	1

Original Visit	Number
Ablabesmyia	1
Amphipoda	6
Anchytarsus	1
Bezzia/Palpomyia	1
Caecidotea	4
Chironominae	1
Chironomini	2
Corynoneura	1
Heterotrissocladius	1
Hydrobaenus	1
Micropsectra	1
Naididae	1
Natarsia	1
Nectopsyche	1
Nigronia	1
Orthocladiinae	1
Parametriocnemus	16
Paratendipes	1
Pisidiidae	9
Pisidium	5
Plecoptera	1
Polycentropus	6
Rheocricotopus	13
Rheotanytarsus	2
Sialis	2
Simuliidae	4
Simulium	3
Stegopterna	10
Synurella	2
Tabanidae	1
Tanytarsus	7
Thienemannimyia group	4
Tubificidae	2
Zavrelimyia	4

Site ID: 06-R3M-01-17

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	Low pH; Low D.O.; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 218.64

Land Cover	Acres	% Area
Developed Land	138.70	63.44
Forested Land	68.51	31.33
Open Land	3.90	1.78
Agricultural Land	7.53	3.44

Impervious Surface	Acres	% Area
Impervious Land	26.27	12.02

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	3.78
Turbidity (NTU)	5.3
Temperature (°C)	14.3
pH (Standard Units)	6.3
Specific Conductivity (µS/cm)	104.3

Laboratory Measurements

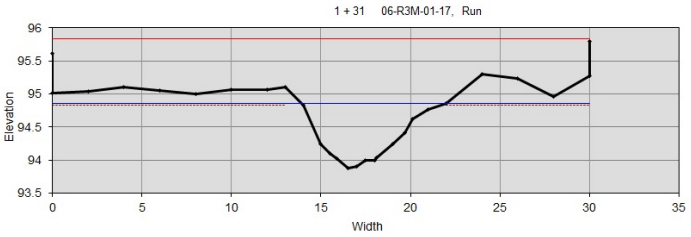
Total Phosphorus (mg/L)	0.056	Chloride (mg/L)	9.701
Total Nitrogen (mg/L)	1.010	Magnesium (mg/L)	2.804
Orthophosphate (mg/L)	0.011	Calcium (mg/L)	4.55
Total Ammonia N (mg/L)	0.110	Total Copper (µg/L)	3.941
Nitrite-N (mg/L)	0.007	Total Zinc (µg/L)	8.037
Nitrate-N (mg/L)	0.196	Total Lead (µg/L)	1.478
Total Kjehldal N (mg/L)	0.807	Turbidity (NTU)	14.5
Dissolved Organic C (mg/L)	12.023		
Total Organic C (mg/L)	12.226		
Hardness (mg eq. $CaCO_3$/L)	22.92		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.34	Sinuosity	1.27
Bankfull Width (ft)	8.1	D50 (mm)	0.06
Mean Bankfull Depth (ft)	0.5	Adjustments?	None
Floodprone Width (ft)	55.0		
Entrenchment Ratio	6.8		
Width to Depth Ratio	15.2	**Rosgen Stream Type**	**C6**
Cross Sectional Area (ft²)	4.3		
Water Surface Slope (%)	0.48		

Cross-sectional Survey



Site ID: 06-R3M-01-17

Biological Assessments

BIBI Metric Values

Total Taxa	15
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	3.54

FIBI Metric Values

Abundance per m²	5.07
Adj. No. of Benthic Species	0.00
% Tolerant	98.95
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	96.49

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Apsectrotanypus	1
Bezzia	3
Bittacomorpha	1
Ceratopogonidae	1
Ceratopogonidae	1
Chironomus	37
Cymbiodyta	2
Dytiscidae	1
Limnophyes	1
Lype	1
Menetus	3
Naididae	3
Pisidium	4
Polypedilum	1
Rheocricotopus	37
Rheocricotopus	3
Sphaeriidae	7
Thienemanniella group	2
Zavrelimyia	4

Fish Taxa

American Eel	3
Eastern Mudminnow	275
Green Sunfish	7

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	124
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.59	51.66
Shading	80	78.67
Epifaunal Substrate	5	50.16
Instream Habitat	5	53.30
Instream Woody Debris	11	93.26
Bank Stability	19.33	98.32

MPHI Habitat Score	70.90
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

American Bullfrog

Northern Green Frog

Mussels

None Observed

Site ID: 06-R3M-02-17

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Very Poor
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Low pH; Low D.O.; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 214.72

Land Cover

	Acres	% Area
Developed Land	136.92	63.77
Forested Land	66.36	30.91
Open Land	3.90	1.82
Agricultural Land	7.53	3.51

Impervious Surface

	Acres	% Area
Impervious Land	26.07	12.14

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	3.98
Turbidity (NTU)	5.04
Temperature (°C)	15.3
pH (Standard Units)	6.07
Specific Conductivity (µS/cm)	131.9

Laboratory Measurements

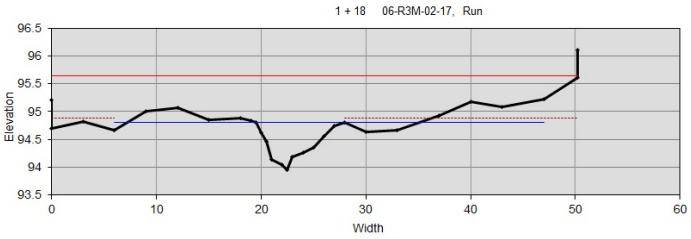
Total Phosphorus (mg/L)	0.052	Chloride (mg/L)	12.921
Total Nitrogen (mg/L)	0.780	Magnesium (mg/L)	3.231
Orthophosphate (mg/L)	0.014	Calcium (mg/L)	6.51
Total Ammonia N (mg/L)	0.150	Total Copper (µg/L)	3.519
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	14.242
Nitrate-N (mg/L)	0.039	Total Lead (µg/L)	1.115
Total Kjehldal N (mg/L)	0.736	Turbidity (NTU)	4.5
Dissolved Organic C (mg/L)	12.238		
Total Organic C (mg/L)	12.619		
Hardness (mg eq. $CaCO_3$/L)	29.55		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.34	Sinuosity	1.27
Bankfull Width (ft)	8.2	D50 (mm)	0.06
Mean Bankfull Depth (ft)	0.3	Adjustments?	None
Floodprone Width (ft)	73.0		
Entrenchment Ratio	9.0		
Width to Depth Ratio	25.4	**Rosgen Stream Type**	**C5/6**
Cross Sectional Area (ft²)	2.6		
Water Surface Slope (%)	0.88		

Cross-sectional Survey



Site ID: 06-R3M-02-17

Biological Assessments

BIBI Metric Values

Total Taxa	14
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	4.11
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	1.37

FIBI Metric Values

Abundance per m²	3.15
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	100.00

BIBI Metric Scores

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

FIBI Metric Scores

Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	1
% 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

Apsectrotanypus	1
Apsectrotanypus	1
Chironomus	3
Chironomus	34
Cymbiodyta	1
Larsia	1
Menetus	1
Metriocnemus	1
Neoporus	1
Pisidium	7
Rheocricotopus	9
Sciomyzidae	1
Stygobromus	1
Synurella	3
Thienemannimyia group	2
Zavrelimyia	6

Fish Taxa

Eastern Mudminnow	59

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	3
Pool Substrate Characterization	6
Pool Variability	6
Sediment Deposition	14
Channel Flow Status	17
Channel Alteration	20
Channel Sinuosity	9
Bank Stability - Right Bank	10
Bank Stability - Left Bank	10
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	131
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	8.44	45.46
Shading	85	84.56
Epifaunal Substrate	3	38.66
Instream Habitat	2	36.84
Instream Woody Debris	4	72.76
Bank Stability	16.10	89.72

MPHI Habitat Score	61.33
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

American Bullfrog

Northern Green Frog

Mussels

None Observed

Site ID: 06-R3M-08-17

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Fair
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Minimally Degraded
Water Quality Conditions	Low pH; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 245.12

Land Cover	Acres	% Area
Developed Land	149.76	61.10
Forested Land	53.56	21.85
Open Land	39.43	16.09
Agricultural Land	2.38	0.97

Impervious Surface	Acres	% Area
Impervious Land	34.63	14.13

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	5.66
Turbidity (NTU)	2.96
Temperature (°C)	16.3
pH (Standard Units)	6.28
Specific Conductivity (µS/cm)	388.7

Laboratory Measurements

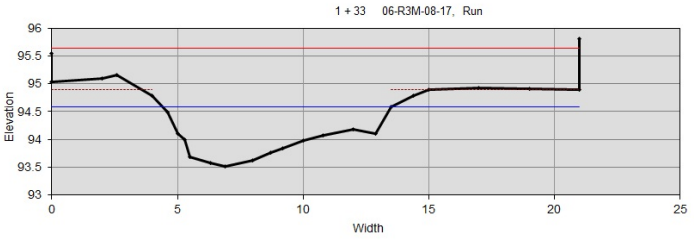
Total Phosphorus (mg/L)	0.017	Chloride (mg/L)	80.192
Total Nitrogen (mg/L)	0.653	Magnesium (mg/L)	3.854
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	14.96
Total Ammonia N (mg/L)	0.064	Total Copper (µg/L)	2.574
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	10.646
Nitrate-N (mg/L)	0.193	Total Lead (µg/L)	3.189
Total Kjehldal N (mg/L)	0.457	Turbidity (NTU)	2.2
Dissolved Organic C (mg/L)	3.712		
Total Organic C (mg/L)	3.786		
Hardness (mg eq. $CaCO_3$/L)	53.23		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.38	Sinuosity	1.45
Bankfull Width (ft)	9.1	D50 (mm)	0.18
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	143.0		
Entrenchment Ratio	15.7		
Width to Depth Ratio	13.8	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	6.0		
Water Surface Slope (%)	0.88		

Cross-sectional Survey



Site ID: 06-R3M-08-17

Biological Assessments

BIBI Metric Values

Total Taxa	22
EPT Taxa	3
Ephemeroptera Taxa	0
% Intolerant to Urban	24.53
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	3.77

FIBI Metric Values

Abundance per m²	1.37
Adj. No. of Benthic Species	0.00
% Tolerant	89.06
% Gen., Omni., Invert.	98.44
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	28.91

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	3.00
BIBI Rating	Fair

FIBI Score	3.00
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Bezzia	1
Caecidotea	24
Chaetocladius	1
Cheumatopsyche	35
Chimarra	2
Dytiscidae	1
Enchytraeidae	1
Ironoquia	3
Lumbriculidae	1
Macronychus	1
Microcylloepus	1
Naididae	9
Nanocladius	1
Physa	2
Pisidium	1
Rheotanytarsus	1
Simuliidae	1
Simulium	3
Stegopterna	1
Stegopterna	1
Tanytarsus	2
Thienemanniella	1
Turbellaria	11
Zavrelimyia	1

Fish Taxa

American Eel	5
Banded Killifish	1
Bluegill	31
Brown Bullhead	37
Eastern Mosquitofish	3
Eastern Mudminnow	7
Green Sunfish	37
Largemouth Bass	2
Mummichog	5

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	14
Pool Substrate Characterization	16
Pool Variability	6
Sediment Deposition	15
Channel Flow Status	14
Channel Alteration	17
Channel Sinuosity	10
Bank Stability - Right Bank	9
Bank Stability - Left Bank	9
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	9
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	8

RBP Habitat Score	146
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.59	51.66
Shading	90	91.34
Epifaunal Substrate	11	84.27
Instream Habitat	12	90.96
Instream Woody Debris	18	100.00
Bank Stability	20.00	100.00

MPHI Habitat Score	86.37
MPHI Rating	Minimally Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

American Bullfrog

Pickerel Frog

Mussels

None Observed

Site ID 09-L1M-01-17

Revist of site R1-09-08

Upstream View - 2017

Downstream View - 2017

Upstream View - 2004

Downstream View - 2004

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2618.25

Land Cover	2017 Acres	2004 Acres	2017 % Area	2004 % Area
Developed Land	1701.85	1590.71	65.00	60.00
Forested Land	715.00	885.49	27.31	33.40
Open Land	190.70	159.07	7.28	6.00
Agricultural Land	10.71	7.95	0.41	0.30

Impervious Surface	2017 Acres	2004 Acres	2017 % Area	2004 % Area
Impervious Land	727.71	837.77	27.79	31.60

Site ID 09-L1M-01-17

Revist of site R1-09-08

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2004 Spring
Dissolved Oxygen (mg/L)	6.19	9.36	8.57
Turbidity (NTU)	6.43	17.4	19.9
Temperature (°C)	17.4	19.7	8.54
pH (Standard Units)	6.93	6.85	7.3
Specific Conductivity (µS/cm)	270.5	238.3	266.4

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.018	Chloride (mg/L)	46.309
Total Nitrogen (mg/L)	1.226	Magnesium (mg/L)	3.158
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	13.43
Total Ammonia N (mg/L)	0.019	Total Copper (µg/L)	1.991
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	13.874
Nitrate-N (mg/L)	1.040	Total Lead (µg/L)	0.354
Total Kjehldal N (mg/L)	0.183	Turbidity (NTU)	3.8
Dissolved Organic C (mg/L)	3.162		
Total Organic C (mg/L)	3.184		
Hardness (mg eq. $CaCO_3$/L)	46.54		

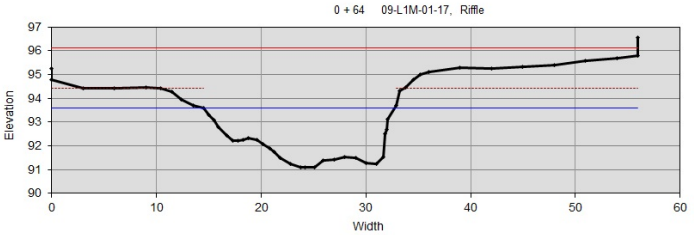
Geomorphic Assessment

Rosgen Level II Classification Data

	2017	2004		2017	2004
Drainage Area (mi²)	4.09		Sinuosity	1.44	n/a
Bankfull Width (ft)	18.3	n/a	D50 (mm)	9.40	n/a
Mean Bankfull Depth (ft)	1.8	n/a	Adjustments?	None	n/a
Floodprone Width (ft)	101.0	n/a			
Entrenchment Ratio	5.5	n/a			
Width to Depth Ratio	10.4	n/a			
Cross Sectional Area (ft²)	32.1	n/a			
Water Surface Slope (%)	0.730	n/a			

Rosgen Stream Type	
2017	2004
E4/5	**n/a**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2004 Spring Value	2004 Spring Score
Remoteness	6.00	32.32	2.00	10.77
Shading	85	84.56	95	99.94
Epifaunal Substrate	14	86.27	15	92.00
Instream Habitat	12	66.72	15	83.24
Instream Woody Debris	20	91.78	11	65.01
Bank Stability	6.80	58.31	16.00	89.45

	2017 Score	2004 Score
MPHI Habitat Score	69.99	73.40
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2017 Score	2004 Score		2017 Score	2004 Score
Epifaunal Substrate/Available Cover	15	15	Bank Stability - Right Bank	4	8
Pool Substrate Characterization	17	12	Bank Stability - Left Bank	4	8
Pool Variability	10	16	Vegetative Protection - Right Bank	7	5
Sediment Deposition	12	11	Vegetative Protection - Left Bank	9	7
Channel Flow Status	12	18	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	18	17	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	10	13			

	2017 Score	2004 Score
RBP Habitat Score	138	150
RBP Rating	Supporting	Supporting

Site ID 09-L1M-01-17

Revist of site R1-09-08

Biological Assessments

BIBI Metric Values	2017	2004
Total Taxa	21	21
EPT Taxa	3	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	2.80	2.86
% Ephemeroptera	0.00	0.00
Scraper Taxa	3	4
% Climbers	54.21	29.52

FIBI Metric Values (2017 only)	
Abundance per m²	1.17
Adj. No. of Benthic Species	0.52
% Tolerant	92.36
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	78.66

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

FIBI Metric Scores (2017 only)	
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	2.71	2.43
BIBI Rating	Poor	Poor

FIBI Score	2.67
FIBI Rating	Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

Orconectes limosus

Procambarus acutus/zonangulus

Mussels

None Observed

Herpetofauna

Pickerel Frog

Northern Two-lined Sal

Fish Taxa	Number
American Eel	24
Blacknose Dace	247
Bluegill	1
Pumpkinseed	2
Tessellated Darter	35
White Sucker	5

Benthic Macroinvertebrate Taxa

2017	Number
Calopteryx	1
Chimarra	6
Crangonyx	13
Cricotopus	3
Dicrotendipes	1
Diplocladius	1
Hydropsyche	6
Hydropsychidae	1
Lumbricina	2
Microtendipes	2
Orthocladius	2
Oulimnius	2
Parakiefferiella	1
Parametriocnemus	1
Phaenopsectra	1
Physa	1
Polypedilum	46
Sphaeriidae	2
Stenelmis	2
Tanytarsini	1
Tanytarsus	3
Triaenodes	4
Trichoptera	1
Tvetenia	1

Original Visit	Number
Sphaeriidae	4
Physidae	1
Lumbricidae	1
Tubificidae	3
Crangonyx	16
Copelatus	1
Elmidae	1
Dubiraphia	4
Oulimnius	2
Stenelmis	3
Gyrinus	1
Dineutus	2
Bezzia/Palpomyia	1
Chironomidae	5
Brillia	5
Hydrobaenus	9
Phaenopsectra	12
Polypedilum	12
Prodiamesia	1
Stenochironomus	5
Tanytarsus	28
Thienemannimyia	16
Calopteryx	1
Gomphidae	1
Cheumatopsyche	2

Site ID 09-L1M-02-17

Revist of site R1-09-09

Upstream View - 2017

Downstream View - 2017

Upstream View - 2004

Downstream View - 2004

Summary Results

	2017 Data	2004 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Comparable to Reference
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Within acceptable ranges	Elevated conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2728.46

Land Cover	2017 Acres	2004 Acres	2017 % Area	2004 % Area
Developed Land	1738.95	1626.55	63.73	59.30
Forested Land	771.59	929.85	28.28	33.90
Open Land	207.21	170.06	7.59	6.20
Agricultural Land	10.71	13.71	0.39	0.50

Impervious Surface	2017 Acres	2004 Acres	2017 % Area	2004 % Area
Impervious Land	751.54	853.05	27.54	31.10

Site ID 09-L1M-02-17

Revist of site R1-09-09

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2004 Spring
Dissolved Oxygen (mg/L)	8.95	10.34	8.69
Turbidity (NTU)	1.04	6.97	26
Temperature (°C)	13.2	18.4	8.12
pH (Standard Units)	7.13	7.47	7.2
Specific Conductivity (µS/cm)	326.7	261.8	311.7

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.021	Chloride (mg/L)	58.460
Total Nitrogen (mg/L)	1.170	Magnesium (mg/L)	3.353
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	15.55
Total Ammonia N (mg/L)	0.024	Total Copper (µg/L)	2.123
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	13.747
Nitrate-N (mg/L)	0.924	Total Lead (µg/L)	0.411
Total Kjehldal N (mg/L)	0.243	Turbidity (NTU)	8.1
Dissolved Organic C (mg/L)	3.532		
Total Organic C (mg/L)	3.610		
Hardness (mg eq. $CaCO_3$/L)	52.64		

Geomorphic Assessment

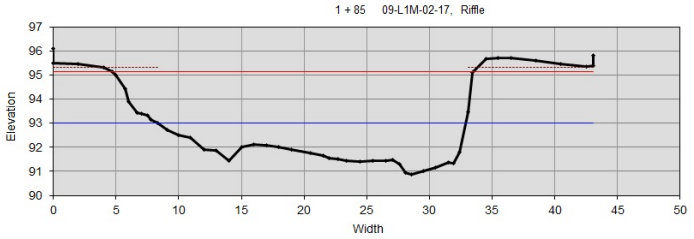
Rosgen Level II Classification Data

	2017	2004		2017	2004
Drainage Area (mi²)	4.26		Sinuosity	1.07	n/a
Bankfull Width (ft)	24.6	n/a	D50 (mm)	0.28	n/a
Mean Bankfull Depth (ft)	1.3	n/a	Adjustments?	None	n/a
Floodprone Width (ft)	28.7	n/a			
Entrenchment Ratio	1.2	n/a			
Width to Depth Ratio	19.4	n/a			
Cross Sectional Area (ft²)	31.1	n/a			
Water Surface Slope (%)	0.270	n/a			

Rosgen Stream Type

2017	2004
F5	**n/a**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2004 Spring Value	2004 Spring Score
Remoteness	6.15	33.11	3.00	16.16
Shading	85	84.56	95	99.94
Epifaunal Substrate	12	74.38	15	91.78
Instream Habitat	12	66.30	17	93.99
Instream Woody Debris	16	79.48	17	82.38
Bank Stability	10.00	70.71	14.00	83.67

	2017 Score	2004 Score
MPHI Habitat Score	68.09	77.98
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2017 Score	2004 Score		2017 Score	2004 Score
Epifaunal Substrate/Available Cover	13	15	Bank Stability - Right Bank	2	7
Pool Substrate Characterization	9	17	Bank Stability - Left Bank	6	7
Pool Variability	9	17	Vegetative Protection - Right Bank	10	9
Sediment Deposition	7	12	Vegetative Protection - Left Bank	10	7
Channel Flow Status	8	18	Riparian Veg. Zone Width - Right Bank	9	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	9
Channel Sinuosity	7	9			

	2017 Score	2004 Score
RBP Habitat Score	120	157
RBP Rating	Partially Supporting	Comparable to Reference

Site ID 09-L1M-02-17

Revist of site R1-09-09

Biological Assessments

BIBI Metric Values	2017	2004
Total Taxa	21	29
EPT Taxa	3	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.00	4.50
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	5
% Climbers	68.81	24.32

FIBI Metric Values (2017 only)	
Abundance per m²	0.78
Adj. No. of Benthic Species	0.52
% Tolerant	86.61
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	25.89

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

FIBI Metric Scores (2017 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	2.14	2.71
BIBI Rating	Poor	Poor

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Flora and Fauna (2017 only)

Crayfish

Orconectes limosus

Procambarus sp

Mussels

None Observed

Herpetofauna

Northern Two-lined Sal

Northern Green Frog

American Bullfrog

Fish Taxa	Number
American Eel	21
Blacknose Dace	58
Bluegill	50
Eastern Mudminnow	8
Pumpkinseed	18
Swallowtail Shiner	9
Tessellated Darter	41
White Sucker	19

Benthic Macroinvertebrate Taxa

2017	Number
Ablabesmyia	1
Caloptervx	1
Cheumatopsyche	5
Crangonyx	1
Cricotopus	2
Cricotopus/Orthocladius	1
Cryptochironomus	1
Dicrotendipes	1
Diplocladius	1
Hydropsyche	2
Microtendipes	1
Orthocladius	6
Parametriocnemus	2
Phaenopsectra	3
Polypedilum	66
Rheotanytarsus	2
Saetheria	1
Tanytarsus	7
Thienemannimyia group	3
Triaenodes	1
Tvetenia	1

Original Visit	Number
Sphaeriidae	5
Physella	3
Tubificidae	3
Lumbricidae	3
Crangonyx	29
Elmidae	1
Optioservus	3
Stenelmis	1
Gyrinus	1
Peltodytes	1
Hydrobius	2
Chironomidae	8
Diplocladius	1
Eurvhapsis	1
Larsia	1
Orthocladiinae	3
Orthocladius	3
Phaenopsectra	1
Polypedilum	3
Tanytarsus	8
Thienemannimyia	11
Dolichopodidae	1
Allognosta	1
Tipula	1
Lepidoptera	1
Boveria	3
Caloptervx	6
Ischnura	1
Hagenius	1
Erythemis	1
Macromia	1
Cheumatopsyche	2

Site ID 09-L2M-02-17

Revist of site R2-09-05

Upstream View - 2017

Downstream View - 2017

Upstream View - 2011

Downstream View - 2011

Summary Results

	2017 Data	2011 Data
Benthic Macroinvertebrate Community	Very Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Supporting
MPHI Habitat Condition	Dry Site	Partially Degraded
Water Quality Conditions	Elevated nitrogen	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 150.50

Land Cover	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Developed Land	120.17	52.00	79.85	57.50
Forested Land	24.37	34.60	16.19	38.20
Open Land	5.96	3.80	3.96	4.30
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Impervious Land	35.39	12.50	23.51	13.80

Site ID 09-L2M-02-17

Revist of site R2-09-05

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2011 Spring
Dissolved Oxygen (mg/L)	7.56	0	12
Turbidity (NTU)	7.43	0	36.3
Temperature (°C)	14.1	0	9.96
pH (Standard Units)	7.32	0	5.58
Specific Conductivity (µS/cm)	211.9	0	144.5

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.020	Chloride (mg/L)	26.751
Total Nitrogen (mg/L)	0.854	Magnesium (mg/L)	3.105
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	14.13
Total Ammonia N (mg/L)	0.058	Total Copper (µg/L)	1.352
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	5.113
Nitrate-N (mg/L)	0.274	Total Lead (µg/L)	0.738
Total Kjehldal N (mg/L)	0.576	Turbidity (NTU)	4.2
Dissolved Organic C (mg/L)	8.660		
Total Organic C (mg/L)	8.799		
Hardness (mg eq. $CaCO_3$/L)	48.07		

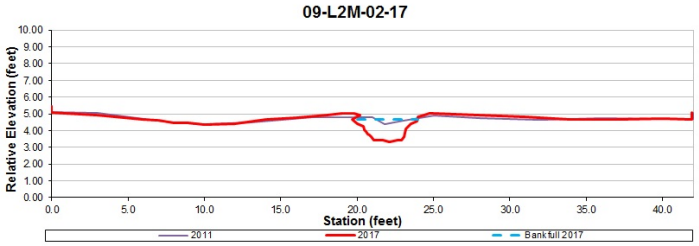
Geomorphic Assessment

Rosgen Level II Classification Data

	2017	2011		2017	2011
Drainage Area (mi²)	0.24		Sinuosity	1.18	1.27
Bankfull Width (ft)	3.6	20.7	D50 (mm)	0.18	0.17
Mean Bankfull Depth (ft)	0.7	0.3	Adjustments?	None	None
Floodprone Width (ft)	86.0	73.0			
Entrenchment Ratio	23.8	3.5			
Width to Depth Ratio	4.9	76.7			
Cross Sectional Area (ft²)	2.7	5.6			
Water Surface Slope (%)	0.800	1.600			

Rosgen Stream Type	
2017	2011
E5	**DA5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2011 Spring Value	2011 Spring Score
Remoteness	Dry Site	No PHI	7.00	37.70
Shading			55	54.42
Epifaunal Substrate			7	67.53
Instream Habitat			7	73.43
Instream Woody Debris			5	85.51
Bank Stability			16.00	89.45

	2017 Score	2011 Score
MPHI Habitat Score	No PHI	68.01
MPHI Rating	Dry Site	Partially Degraded

Rapid Bioassessment Protocol

	2017 Score	2011 Score		2017 Score	2011 Score
Epifaunal Substrate/Available Cover	4	7	Bank Stability - Right Bank	3	8
Pool Substrate Characterization	6	8	Bank Stability - Left Bank	3	8
Pool Variability	3	7	Vegetative Protection - Right Bank	7	8
Sediment Deposition	11	12	Vegetative Protection - Left Bank	7	8
Channel Flow Status	13	20	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	14			

	2017 Score	2011 Score
RBP Habitat Score	105	140
RBP Rating	Partially Supporting	Supporting

Site ID 09-L2M-02-17

Revist of site R2-09-05

Biological Assessments

BIBI Metric Values	2017	2011
Total Taxa	14	14
EPT Taxa	0	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	0.00	23.60
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	2
% Climbers	0.00	2.70

FIBI Metric Values (2017 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	3
EPT Taxa	1	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	3
% Ephemeroptera	1	1
Scraper Taxa	1	5
% Climbers	1	3

FIBI Metric Scores (2017 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	1.29	2.71
BIBI Rating	Very Poor	Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

None Observed

Fish Taxa — Number

Dry Site

Benthic Macroinvertebrate Taxa

2017	Number
Chaetocladius	2
Corynoneura	3
Diplocladius	69
Erioptera	1
Eukiefferiella	2
Ironoquia	4
Lumbriculidae	6
Molophilus	1
Naididae	1
Orthocladius	2
Rheocricotopus	1
Simulium	6
Thienemanniella	8
Tvetenia	2

Original Visit	Number
Cheumatopsyche	1
Chironomidae	1
Corynoneura	2
Fossaria	1
Hydrobaenus	34
Limnephilidae	1
Lumbriculidae	1
Orthocladiinae	1
Orthocladius	9
Prostoma	1
Pyralidae	1
Rheocricotopus	6
Simulium	17
Stegopterna	26
Taeniopteryx	1
Thienemanniella	3
Trichoptera	4

Site ID 09-L2M-03-17

Revist of site R2-09-03

Upstream View - 2017

Downstream View - 2017

Upstream View - 2011

Downstream View - 2011

Summary Results

	2017 Data	2011 Data
Benthic Macroinvertebrate Community	Good	Fair
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	Elevated nitrogen	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1355.48

Land Cover	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Developed Land	541.65	583.60	39.96	38.90
Forested Land	603.49	693.30	44.52	45.30
Open Land	79.31	60.10	5.85	3.90
Agricultural Land	131.04	182.00	9.67	11.90

Impervious Surface	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Impervious Land	181.32	201.60	13.38	13.20

Site ID 09-L2M-03-17

Revist of site R2-09-03

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2011 Spring
Dissolved Oxygen (mg/L)	9.55	7.61	11.43
Turbidity (NTU)	4.27	5.14	5.2
Temperature (°C)	16.8	20.6	6.52
pH (Standard Units)	6.74	6.5	5.95
Specific Conductivity (µS/cm)	256	254.5	221.5

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.013	Chloride (mg/L)	57.305
Total Nitrogen (mg/L)	1.705	Magnesium (mg/L)	2.775
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	5.19
Total Ammonia N (mg/L)	0.107	Total Copper (µg/L)	0.499
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	6.025
Nitrate-N (mg/L)	1.237	Total Lead (µg/L)	0.188
Total Kjehldal N (mg/L)	0.466	Turbidity (NTU)	3.8
Dissolved Organic C (mg/L)	2.289		
Total Organic C (mg/L)	2.304		
Hardness (mg eq. $CaCO_3$/L)	24.38		

Geomorphic Assessment

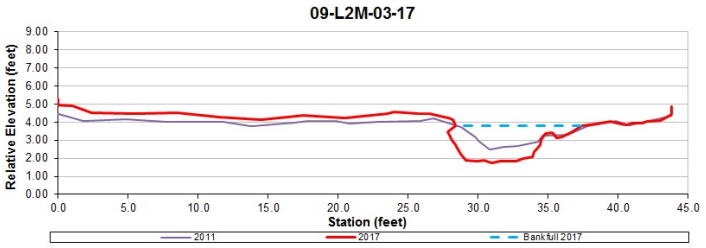
Rosgen Level II Classification Data

	2017	2011		2017	2011
Drainage Area (mi²)	2.12		Sinuosity	1.17	1.08
Bankfull Width (ft)	13.7	12.4	D50 (mm)	0.58	0.29
Mean Bankfull Depth (ft)	1.1	0.8	Adjustments?	None	None
Floodprone Width (ft)	133.0	280.0			
Entrenchment Ratio	9.7	22.5			
Width to Depth Ratio	12.5	16.1			
Cross Sectional Area (ft²)	15.0	9.6			
Water Surface Slope (%)	0.670	0.860			

Rosgen Stream Type

2017	2011
E5	**C5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2011 Spring Value	2011 Spring Score
Remoteness	6.96	37.50	10.00	53.85
Shading	35	36.34	40	40.96
Epifaunal Substrate	14	90.56	10	66.53
Instream Habitat	15	90.11	13	77.76
Instream Woody Debris	13	78.52	5	53.47
Bank Stability	11.03	74.28	15.00	86.61

	2017 Score	2011 Score
MPHI Habitat Score	67.88	63.19
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2017 Score	2011 Score		2017 Score	2011 Score
Epifaunal Substrate/Available Cover	13	11	Bank Stability - Right Bank	5	8
Pool Substrate Characterization	11	12	Bank Stability - Left Bank	3	7
Pool Variability	7	13	Vegetative Protection - Right Bank	8	8
Sediment Deposition	9	11	Vegetative Protection - Left Bank	5	6
Channel Flow Status	15	19	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	19	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	12			

	2017 Score	2011 Score
RBP Habitat Score	124	146
RBP Rating	Partially Supporting	Supporting

Site ID 09-L2M-03-17

Revist of site R2-09-03

Biological Assessments

BIBI Metric Values	2017	2011
Total Taxa	30	38
EPT Taxa	7	9
Ephemeroptera Taxa	2	1
% Intolerant to Urban	31.36	21.10
% Ephemeroptera	5.93	1.80
Scraper Taxa	4	4
% Climbers	11.86	2.80

FIBI Metric Values (2017 only)	
Abundance per m²	3.16
Adj. No. of Benthic Species	0.00
% Tolerant	96.35
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	77.17

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

FIBI Metric Scores (2017 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	4.71	3.86
BIBI Rating	Good	Fair

FIBI Score	2.00
FIBI Rating	Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

Cambarus diogenes

Mussels

None Observed

Herpetofauna

Cope's Gray Treefrog

Northern Green Frog

Fish Taxa	Number
American Eel	7
Blacknose Dace	169
Brook Trout	1
Eastern Mudminnow	34
White Sucker	8

Benthic Macroinvertebrate Taxa

2017	Number
Acerpenna	4
Bezzia	9
Chaetocladius	1
Chloroperlidae	5
Dicrotendipes	1
Diplectrona	4
Eukiefferiella	1
Eurylophella	3
Haploperla	8
Helichus	1
Hydropsyche	4
Leuctra	10
Micropsectra	2
Nigronia	1
Orthocladiinae	1
Orthocladius	23
Paracladopelma	1
Parametriocnemus	1
Physa	1
Polycentropus	1
Polypedilum	9
Potthastia	2
Psychodidae	1
Rheocricotopus	8
Rheotanytarsus	1
Simulium	5
Stenelmis	2
Stictochironomus	1
Tipula	5
Tvetenia	1

Original Visit	Number
Bezzia/Palpomyia	1
Brillia	2
Caecidotea	1
Cheumatopsyche	1
Chironomini	1
Corynoneura	1
Dicrotendipes	1
Diplectrona	1
Diplocladius	1
Eccoptura	1
Eurylophella	2
Haploperla	10
Hydrobaenus	1
Leuctra	1
Limnophyes	2
Lumbricina	1
Lumbriculidae	2
Lype	6
Microtendipes	1
Naididae	3
Neoporus	1
Orthocladiinae	1
Orthocladius	7
Parametriocnemus	12
Pisidiidae	1
Polycentropus	4
Polypedilum	2
Prosimulium	4
Prostoma	1
Rheotanytarsus	11
Simulium	2
Stegopterna	1
Stenelmis	5
Tanytarsus	1
Thienemanniella	2
Thienemannimyia group	3
Triaenodes	1
Tubificidae	4
Tvetenia	5
Zavrelimyia	1

Site ID: 09-R3M-01-17

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1792.70

Land Cover

	Acres	% Area
Developed Land	1128.52	62.95
Forested Land	516.16	28.79
Open Land	137.32	7.66
Agricultural Land	10.71	0.60

Impervious Surface

	Acres	% Area
Impervious Land	447.34	24.95

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.27
Turbidity (NTU)	2.52
Temperature (°C)	11.1
pH (Standard Units)	6.73
Specific Conductivity (µS/cm)	266

Laboratory Measurements

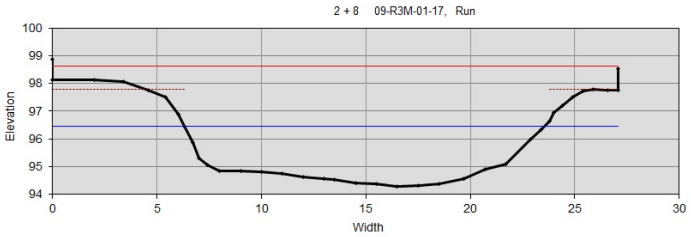
Total Phosphorus (mg/L)	0.009	Chloride (mg/L)	50.660
Total Nitrogen (mg/L)	1.523	Magnesium (mg/L)	3.052
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	12.57
Total Ammonia N (mg/L)	0.017	Total Copper (µg/L)	1.569
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	16.305
Nitrate-N (mg/L)	1.318	Total Lead (µg/L)	0.213
Total Kjehldal N (mg/L)	0.202	Turbidity (NTU)	1.7
Dissolved Organic C (mg/L)	1.504		
Total Organic C (mg/L)	1.564		
Hardness (mg eq. $CaCO_3$/L)	43.96		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	2.80	Sinuosity	1.27
Bankfull Width (ft)	17.3	D50 (mm)	0.84
Mean Bankfull Depth (ft)	1.7	Adjustments?	None
Floodprone Width (ft)	113.0		
Entrenchment Ratio	6.5		
Width to Depth Ratio	10.4	**Rosgen Stream Type**	**E5/4**
Cross Sectional Area (ft²)	28.6		
Water Surface Slope (%)	0.4		

Cross-sectional Survey



Site ID: 09-R3M-01-17

Biological Assessments

BIBI Metric Values

Total Taxa	17
EPT Taxa	3
Ephemeroptera Taxa	0
% Intolerant to Urban	0.00
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	59.46

FIBI Metric Values

Abundance per m²	0.68
Adj. No. of Benthic Species	0.59
% Tolerant	92.65
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	73.04

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

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Chaetocladius	2
Cheumatopsyche	15
Chimarra	3
Chironominae	1
Cryptochironomus	1
Enchytraeidae	2
Hydropsyche	5
Lumbriculidae	1
Neoplasta	1
Orthocladius	6
Polypedilum	65
Rheotanytarsus	1
Stenelmis	1
Tanytarsus	1
Thienemannimyia group	4
Tipula	1
Tvetenia	1

Fish Taxa

American Eel	15
Blacknose Dace	149
Bluegill	8
Eastern Mudminnow	9
Tessellated Darter	18
White Sucker	5

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	124
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	12.20	65.72
Shading	70	68.32
Epifaunal Substrate	10	65.50
Instream Habitat	13	76.15
Instream Woody Debris	22	100.00
Bank Stability	11.33	75.28

MPHI Habitat Score	75.16
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

Orconectes limosus

Herpetofauna

Northern Green Frog

Northern Two-lined Sal

Mussels

None Observed

Site ID: 09-R3M-03-17

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Very Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 111.56

Land Cover	Acres	% Area
Developed Land	42.44	38.04
Forested Land	61.42	55.06
Open Land	7.70	6.90
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	16.48	14.77

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.57
Turbidity (NTU)	0
Temperature (°C)	5.6
pH (Standard Units)	7.83
Specific Conductivity (µS/cm)	552.2

Laboratory Measurements

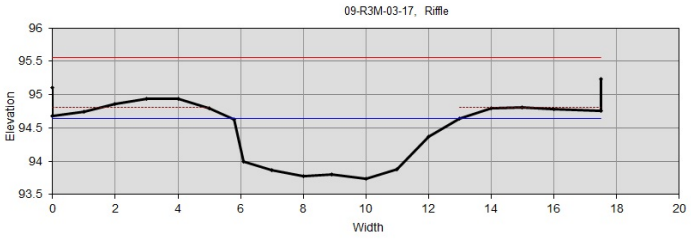
Total Phosphorus (mg/L)	0.018	Chloride (mg/L)	79.414
Total Nitrogen (mg/L)	0.361	Magnesium (mg/L)	3.441
Orthophosphate (mg/L)	0.005	Calcium (mg/L)	23.13
Total Ammonia N (mg/L)	0.008	Total Copper (µg/L)	2.746
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	7.552
Nitrate-N (mg/L)	0.025	Total Lead (µg/L)	0.342
Total Kjehldal N (mg/L)	0.334	Turbidity (NTU)	1.6
Dissolved Organic C (mg/L)	5.362		
Total Organic C (mg/L)	5.443		
Hardness (mg eq. $CaCO_3$/L)	71.93		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.17	Sinuosity	1.18
Bankfull Width (ft)	7.3	D50 (mm)	0.06
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	83.0		
Entrenchment Ratio	11.4		
Width to Depth Ratio	11.2	**Rosgen Stream Type**	**ND**
Cross Sectional Area (ft²)	4.8		
Water Surface Slope (%)	1.5		

Cross-sectional Survey



Site ID: 09-R3M-03-17

Biological Assessments

BIBI Metric Values

Total Taxa	16
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	3.54
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	1.77

FIBI Metric Values

Abundance per m²	1.60
Adj. No. of Benthic Species	0.00
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	100.00

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	1.67
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Chaetocladius	19
Diplocladius	5
Hydrobaenus	1
Ironoquia	5
Limnephilidae	1
Lumbricina	1
Lymnaeidae	1
Naididae	62
Nemata	1
Orthocladiinae	1
Parakiefferiella	3
Pisidium	3
Prostoma	2
Pseudorthocladius	2
Rheocricotopus	1
Stegopterna	1
Tipulidae	2
Turbellaria	2

Fish Taxa

Eastern Mudminnow	3

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	122
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	6.96	37.50
Shading	80	78.67
Epifaunal Substrate	1	31.31
Instream Habitat	1	37.99
Instream Woody Debris	0	68.34
Bank Stability	16.10	89.72

MPHI Habitat Score	57.25
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Pickerel Frog

Northern Green Frog

Mussels

None Observed

Site ID: 09-R3M-04-17

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Very Poor
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Dry Site
Water Quality Conditions	Low pH; Low D.O.; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 389.87

Land Cover	Acres	% Area
Developed Land	217.20	55.71
Forested Land	156.47	40.13
Open Land	16.20	4.15
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	51.77	13.28

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	4.3
Turbidity (NTU)	8.05
Temperature (°C)	20.1
pH (Standard Units)	6.26
Specific Conductivity (µS/cm)	166.1

Laboratory Measurements

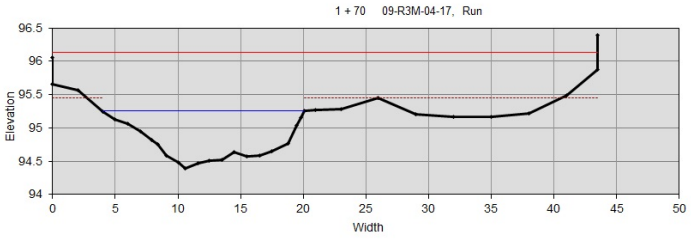
Total Phosphorus (mg/L)	0.025	Chloride (mg/L)	23.837
Total Nitrogen (mg/L)	0.724	Magnesium (mg/L)	2.215
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	11.09
Total Ammonia N (mg/L)	0.038	Total Copper (µg/L)	2.620
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	14.395
Nitrate-N (mg/L)	0.149	Total Lead (µg/L)	1.212
Total Kjehldal N (mg/L)	0.572	Turbidity (NTU)	9.7
Dissolved Organic C (mg/L)	12.293		
Total Organic C (mg/L)	12.472		
Hardness (mg eq. $CaCO_3$/L)	36.81		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.61	Sinuosity	1.09
Bankfull Width (ft)	16.1	D50 (mm)	0.06
Mean Bankfull Depth (ft)	0.5	Adjustments?	None
Floodprone Width (ft)	137.0		
Entrenchment Ratio	8.5		
Width to Depth Ratio	30.1	**Rosgen Stream Type**	**C6/5c-**
Cross Sectional Area (ft²)	8.6		
Water Surface Slope (%)	0.08		

Cross-sectional Survey



Site ID: 09-R3M-04-17

Biological Assessments

BIBI Metric Values

Total Taxa	18
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	6.31
% Ephemeroptera	0.00
Scraper Taxa	3
% Climbers	10.81

FIBI Metric Values

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

FIBI Metric Scores

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

BIBI Score	2.71
BIBI Rating	Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Amphinemura	5
Amphipoda	7
Ceratopogonidae	1
Corduliidae	1
Diplocladius	8
Dytiscidae	1
Enchytraeidae	1
Ferrissia	1
Hydrobaenus	1
Ironoquia	2
Menetus	3
Naididae	4
Odonata	1
Orthocladius	3
Orthocladius	1
Pisidium	5
Polypedilum	7
Rheocricotopus	52
Rheocricotopus	1
Simulium	2
Sphaeriidae	2
Synurella	1
Tipula	1

Fish Taxa

Dry Site

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	138
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	Dry Site	No PHI
Shading		
Epifaunal Substrate		
Instream Habitat		
Instream Woody Debris		
Bank Stability		

MPHI Habitat Score	
MPHI Rating	Dry Site

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Gray Treefrog

Northern Green Frog

Mussels

None Observed

Site ID: 09-R3M-06-17

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Good
Fish Community	Fair
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Degraded
Water Quality Conditions	Low D.O.; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1313.61

Land Cover	Acres	% Area
Developed Land	933.40	71.06
Forested Land	294.17	22.39
Open Land	77.42	5.89
Agricultural Land	8.61	0.66

Impervious Surface	Acres	% Area
Impervious Land	278.13	21.17

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	4.68
Turbidity (NTU)	6.01
Temperature (°C)	15.3
pH (Standard Units)	6.72
Specific Conductivity (µS/cm)	186.5

Laboratory Measurements

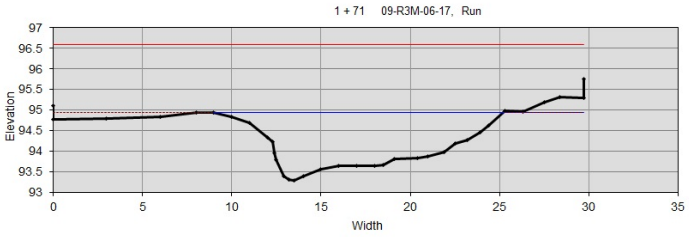
Total Phosphorus (mg/L)	0.028	Chloride (mg/L)	21.341
Total Nitrogen (mg/L)	0.830	Magnesium (mg/L)	2.880
Orthophosphate (mg/L)	0.007	Calcium (mg/L)	15.78
Total Ammonia N (mg/L)	0.022	Total Copper (µg/L)	2.270
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	10.722
Nitrate-N (mg/L)	0.338	Total Lead (µg/L)	0.968
Total Kjehldal N (mg/L)	0.489	Turbidity (NTU)	3.4
Dissolved Organic C (mg/L)	11.056		
Total Organic C (mg/L)	11.076		
Hardness (mg eq. $CaCO_3$/L)	51.26		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	2.05	Sinuosity	1.38
Bankfull Width (ft)	16.2	D50 (mm)	0.25
Mean Bankfull Depth (ft)	0.9	Adjustments?	None
Floodprone Width (ft)	207.0		
Entrenchment Ratio	12.8		
Width to Depth Ratio	17.8	**Rosgen Stream Type**	**C5**
Cross Sectional Area (ft²)	14.8		
Water Surface Slope (%)	0.2		

Cross-sectional Survey



Site ID: 09-R3M-06-17

Biological Assessments

BIBI Metric Values

Total Taxa	31
EPT Taxa	7
Ephemeroptera Taxa	2
% Intolerant to Urban	27.78
% Ephemeroptera	9.26
Scraper Taxa	7
% Climbers	12.96

FIBI Metric Values

Abundance per m²	0.51
Adj. No. of Benthic Species	0.65
% Tolerant	84.78
% Gen., Omni., Invert.	80.43
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	58.70

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	4.43
BIBI Rating	Good

FIBI Score	3.33
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Acerpenna	1
Amphinemura	5
Amphipoda	3
Ancyronyx	1
Caloptervx	1
Cheumatopsyche	15
Chimarra	1
Corvnoneura	1
Cricotopus/Orthocladius	1
Diplocladius	2
Dubiraphia	2
Maccaffertium	9
Micropsectra	1
Naididae	3
Optioservus	2
Orthocladius	13
Oulimnius	3
Parakiefferiella	3
Parametriocnemus	2
Perlesta	2
Phaenopsectra	1
Physa	1
Pisidium	3
Polycentropus	1
Polypedilum	9

Fish Taxa

American Eel	7
Blacknose Dace	2
Eastern Mudminnow	1
Redfin Pickerel	9
Tessellated Darter	27

Benthics Continued

Potthastia	1
Simulium	1
Sphaeriidae	2
Stenelmis	8
Synurella	4
Thienemanniella	1
Tipula	1
Tvetenia	4

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	15
Pool Substrate Characterization	12
Pool Variability	4
Sediment Deposition	16
Channel Flow Status	18
Channel Alteration	18
Channel Sinuosity	10
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	10

RBP Habitat Score	149
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	1.88	10.15
Shading	90	91.34
Epifaunal Substrate	4	32.67
Instream Habitat	7	46.04
Instream Woody Debris	5	55.21
Bank Stability	13.87	83.27

MPHI Habitat Score	53.11
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

Cambarus diogenes

Herpetofauna

Fowler's Toad

Gray Treefrog

Pickerel Frog

Northern Green Frog

Mussels

None Observed

Site ID 10-L1M-05-17

Revist of site R1-10-11A

Upstream View - 2017

Downstream View - 2017

Upstream View - 2004

Downstream View - 2004

Summary Results

	2017 Data	2004 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Comparable to Reference
MPHI Habitat Condition	Dry Site	Partially Degraded
Water Quality Conditions	Elevated nitrogen	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 569.04

Land Cover	2017 Acres	2004 Acres	2017 % Area	2004 % Area
Developed Land	205.01	497.92	36.03	34.90
Forested Land	357.48	914.51	62.82	64.10
Open Land	2.74	0.00	0.48	0.00
Agricultural Land	3.80	15.69	0.67	1.10

Impervious Surface	2017 Acres	2004 Acres	2017 % Area	2004 % Area
Impervious Land	40.45	108.43	7.11	7.60

Site ID 10-L1M-05-17

Revist of site R1-10-11A

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2004 Spring
Dissolved Oxygen (mg/L)	10.85	n/a	8.59
Turbidity (NTU)	3.4	n/a	6.7
Temperature (°C)	8.5	n/a	9.8
pH (Standard Units)	6.88	n/a	6.1
Specific Conductivity (µS/cm)	290	n/a	162.6

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.017	Chloride (mg/L)	67.200
Total Nitrogen (mg/L)	0.393	Magnesium (mg/L)	3.822
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	10.75
Total Ammonia N (mg/L)	0.100	Total Copper (µg/L)	0.278
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	10.725
Nitrate-N (mg/L)	0.197	Total Lead (µg/L)	0.087
Total Kjehldal N (mg/L)	0.194	Turbidity (NTU)	6.9
Dissolved Organic C (mg/L)	1.485		
Total Organic C (mg/L)	1.624		
Hardness (mg eq. $CaCO_3$/L)	42.58		

Geomorphic Assessment

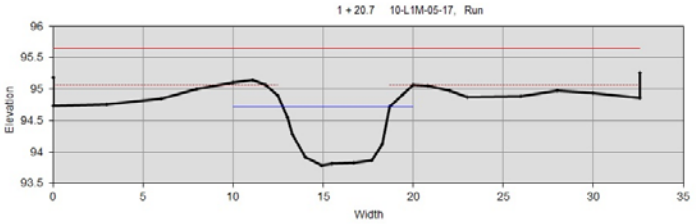
Rosgen Level II Classification Data

	2017	2004		2017	2004
Drainage Area (mi²)	0.89		Sinuosity	1.17	n/a
Bankfull Width (ft)	5.9	n/a	D50 (mm)	0.21	n/a
Mean Bankfull Depth (ft)	0.7	n/a	Adjustments?	None	n/a
Floodprone Width (ft)	170.0	n/a			
Entrenchment Ratio	28.6	n/a			
Width to Depth Ratio	8.0	n/a			
Cross Sectional Area (ft²)	4.4	n/a			
Water Surface Slope (%)	0.093	n/a			

Rosgen Stream Type

2017	2004
E5	**n/a**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2004 Spring Value	2004 Spring Score
Remoteness	Dry Site	No PHI	8.00	43.08
Shading			90	91.34
Epifaunal Substrate			13	84.42
Instream Habitat			11	67.39
Instream Woody Debris			5	54.28
Bank Stability			20.00	100.00

	2017 Score	2004 Score
MPHI Habitat Score	No PHI	73.42
MPHI Rating	Dry Site	Partially Degraded

Rapid Bioassessment Protocol

	2017 Score	2004 Score		2017 Score	2004 Score
Epifaunal Substrate/Available Cover	11	13	Bank Stability - Right Bank	8	10
Pool Substrate Characterization	9	14	Bank Stability - Left Bank	9	10
Pool Variability	8	5	Vegetative Protection - Right Bank	9	9
Sediment Deposition	4	17	Vegetative Protection - Left Bank	9	9
Channel Flow Status	15	19	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	10	14			

	2017 Score	2004 Score
RBP Habitat Score	132	160
RBP Rating	Supporting	Comparable to Reference

Site ID 10-L1M-05-17

Revist of site R1-10-11A

Biological Assessments

BIBI Metric Values	2017	2004
Total Taxa	20	14
EPT Taxa	3	2
Ephemeroptera Taxa	1	1
% Intolerant to Urban	4.00	0.00
% Ephemeroptera	8.00	1.05
Scraper Taxa	0	1
% Climbers	20.00	3.09

FIBI Metric Values (2017 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	3
EPT Taxa	3	3
Ephemeroptera Taxa	3	3
% Intolerant to Urban	1	1
% Ephemeroptera	3	3
Scraper Taxa	1	3
% Climbers	5	3

FIBI Metric Scores (2017 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 Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Northern Spring Peepe

Fish Taxa	Number
Dry Site	

Benthic Macroinvertebrate Taxa

2017	Number
Amphinemura	1
Apsectrotanypus	1
Caecidotea	1
Calopteryx	1
Corynoneura	2
Crangonyx	1
Diplocladius	1
Diplocladius	1
Ironoquia	1
Neoporus	1
Nigronia	2
Orthocladius	4
Parametriocnemus	5
Polypedilum	8
Pseudorthocladius	2
Rheocricotopus	33
Simulium	2
Siphlonurus	8
Tanypodinae	2
Tanytarsus	1
Zavrelimyia	27
Zavrelimyia	1

Original Visit	Number
Sphaeriidae	24
Lumbriculidae	1
Crangonyx	9
Caecidotea	13
Ostracoda	1
Apsectrotanypus	1
Larsia	2
Parametriocnemus	2
Phaenopsectra	1
Polypedilum	3
Thienemannimyia	2
Hemerodromia	1
Simulium	70
Chrysops	1
Leptophlebia	1
Limnephilidae	3

Site ID 10-L1M-06-17

Revist of site R1-10-09

Upstream View - 2017

Downstream View - 2017

Upstream View - 2004

Downstream View - 2004

Summary Results

	2017 Data	2004 Data
Benthic Macroinvertebrate Community	Poor	Fair
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Comparable to Reference
MPHI Habitat Condition	Partially Degraded	Minimally Degraded
Water Quality Conditions	Low pH; Elevated nitrogen	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 203.17

Land Cover	2017 Acres	2004 Acres	2017 % Area	2004 % Area
Developed Land	130.96	105.66	64.46	50.20
Forested Land	70.13	101.87	34.52	48.40
Open Land	2.08	2.74	1.02	1.30
Agricultural Land	0.00	0.00	0.00	0.00

Impervious Surface	2017 Acres	2004 Acres	2017 % Area	2004 % Area
Impervious Land	30.91	37.25	15.21	17.70

Site ID 10-L1M-06-17

Revist of site R1-10-09

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2004 Spring
Dissolved Oxygen (mg/L)	8.83	4.97	9.07
Turbidity (NTU)	0.8	0.6	3.5
Temperature (°C)	14.5	21.1	6.38
pH (Standard Units)	6.04	6.34	6.6
Specific Conductivity (µS/cm)	400	394	235.3

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.018	Chloride (mg/L)	95.913
Total Nitrogen (mg/L)	0.552	Magnesium (mg/L)	6.485
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	17.97
Total Ammonia N (mg/L)	0.060	Total Copper (µg/L)	0.458
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	31.033
Nitrate-N (mg/L)	0.413	Total Lead (µg/L)	0.073
Total Kjehldal N (mg/L)	0.136	Turbidity (NTU)	7.6
Dissolved Organic C (mg/L)	0.690		
Total Organic C (mg/L)	0.751		
Hardness (mg eq. $CaCO_3$/L)	71.58		

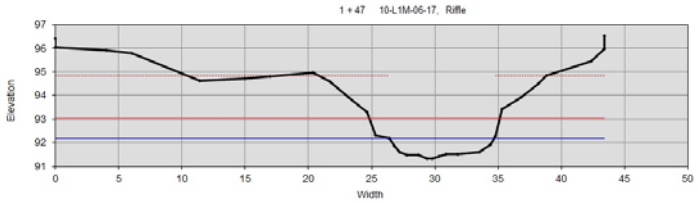
Geomorphic Assessment

Rosgen Level II Classification Data

	2017	2004		2017	2004
Drainage Area (mi²)	0.32		Sinuosity	1.19	n/a
Bankfull Width (ft)	8.3	n/a	D50 (mm)	0.53	n/a
Mean Bankfull Depth (ft)	0.6	n/a	Adjustments?	None	n/a
Floodprone Width (ft)	10.4	n/a			
Entrenchment Ratio	1.3	n/a			
Width to Depth Ratio	13.3	n/a			
Cross Sectional Area (ft²)	5.2	n/a			
Water Surface Slope (%)	0.540	n/a			

Rosgen Stream Type	
2017	2004
F5	**n/a**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2004 Spring Value	2004 Spring Score
Remoteness	11.85	63.82	14.00	75.39
Shading	98	100.00	90	91.34
Epifaunal Substrate	10	79.46	13	96.89
Instream Habitat	7	64.78	17	100.00
Instream Woody Debris	6	78.90	7	81.86
Bank Stability	11.20	74.84	18.00	94.87

	2017 Score	2004 Score
MPHI Habitat Score	76.97	90.06
MPHI Rating	Partially Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2017 Score	2004 Score		2017 Score	2004 Score
Epifaunal Substrate/Available Cover	11	13	Bank Stability - Right Bank	7	9
Pool Substrate Characterization	9	14	Bank Stability - Left Bank	6	9
Pool Variability	8	10	Vegetative Protection - Right Bank	5	9
Sediment Deposition	8	16	Vegetative Protection - Left Bank	7	9
Channel Flow Status	14	15	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	7	11			

	2017 Score	2004 Score
RBP Habitat Score	122	155
RBP Rating	Partially Supporting	Comparable to Reference

Site ID 10-L1M-06-17

Revist of site R1-10-09

Biological Assessments

BIBI Metric Values	2017	2004
Total Taxa	15	18
EPT Taxa	3	4
Ephemeroptera Taxa	0	1
% Intolerant to Urban	3.81	2.80
% Ephemeroptera	0.00	3.74
Scraper Taxa	0	1
% Climbers	46.67	12.15

FIBI Metric Values (2017 only)	
Abundance per m²	0.08
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	3
EPT Taxa	3	3
Ephemeroptera Taxa	1	3
% Intolerant to Urban	1	1
% Ephemeroptera	1	3
Scraper Taxa	1	3
% Climbers	5	5

FIBI Metric Scores (2017 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.14	3.00
BIBI Rating	Poor	Fair

FIBI Score	1.67
FIBI Rating	Very Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
American Eel	5

Benthic Macroinvertebrate Taxa

2017	Number
Amphinemura	1
Amphipoda	1
Chaetocladius	7
Cordulegaster	1
Diplocladius	2
Diplocladius	1
Erioptera	1
Ironoquia	2
Leuctra	2
Limnephilidae	1
Molophilus	1
Parametriocnemus	1
Parametriocnemus	17
Paratendipes	1
Polypedilum	48
Rheocricotopus	9
Thienemanniella	2
Tipula	7

Original Visit	Number
Hoplonemertea	1
Tubificidae	4
Crangonyx	17
Hydrobius	3
Haliplus	1
Anchytarsus	17
Chironomidae	3
Larsia	15
Parametriocnemus	15
Phaenopsectra	2
Polypedilum	3
Thienemannimyia	10
Ptychoptera	1
Hexatoma	2
Leptophlebia	4
Sialis	1
Leuctra	2
Diplectrona	1
Limnephilidae	3
Pycnopsyche	2

Site ID 10-L2M-01-17

Revist of site R2-10-02

Upstream View - 2017

Downstream View - 2017

Upstream View - 2013

Downstream View - 2013

Summary Results

	2017 Data	2013 Data
Benthic Macroinvertebrate Community	Fair	Fair
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Comparable to Reference	Comparable to Reference
MPHI Habitat Condition	Minimally Degraded	Minimally Degraded
Water Quality Conditions	Low pH	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 445.32

Land Cover	2017 Acres	2013 Acres	2017 % Area	2013 % Area
Developed Land	158.22	155.69	35.53	35.68
Forested Land	241.54	237.22	54.24	54.37
Open Land	15.81	13.12	3.55	3.01
Agricultural Land	29.75	30.31	6.68	6.95

Impervious Surface	2017 Acres	2013 Acres	2017 % Area	2013 % Area
Impervious Land	41.83	38.20	9.39	8.75

Site ID 10-L2M-01-17

Revist of site R2-10-02

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2013 Spring
Dissolved Oxygen (mg/L)	6.68	6.1	11.72
Turbidity (NTU)	9	0.8	2.64
Temperature (°C)	12.8	20.6	6.9
pH (Standard Units)	6.13	6.02	5.57
Specific Conductivity (µS/cm)	50	52	63.8

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.023	Chloride (mg/L)	8.031
Total Nitrogen (mg/L)	0.370	Magnesium (mg/L)	1.227
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	1.43
Total Ammonia N (mg/L)	0.008	Total Copper (µg/L)	0.961
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	5.703
Nitrate-N (mg/L)	0.100	Total Lead (µg/L)	0.877
Total Kjehldal N (mg/L)	0.268	Turbidity (NTU)	7.1
Dissolved Organic C (mg/L)	2.342		
Total Organic C (mg/L)	3.519		
Hardness (mg eq. $CaCO_3$/L)	8.62		

Geomorphic Assessment

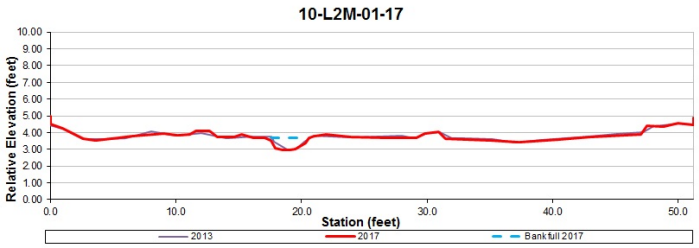
Rosgen Level II Classification Data

	2017	2013		2017	2013
Drainage Area (mi²)	0.70		Sinuosity	1.14	1.20
Bankfull Width (ft)	16.9	26.5	D50 (mm)	0.55	0.09
Mean Bankfull Depth (ft)	0.2	0.2	Adjustments?	None	None
Floodprone Width (ft)	160.0	160.0			
Entrenchment Ratio	9.5	6.0			
Width to Depth Ratio	86.6	155.8			
Cross Sectional Area (ft²)	3.3	4.5			
Water Surface Slope (%)	2.000	1.900			

Rosgen Stream Type

2017	2013
DA5	**DA5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2013 Spring Value	2013 Spring Score
Remoteness	15.02	80.86	19.00	100.00
Shading	98	100.00	96	100.00
Epifaunal Substrate	15	100.00	13	92.14
Instream Habitat	6	51.77	10	73.97
Instream Woody Debris	2	58.81	9	79.52
Bank Stability	19.60	99.00	20.00	100.00

	2017 Score	2013 Score
MPHI Habitat Score	81.74	90.94
MPHI Rating	Minimally Degraded	Minimally Degraded

Rapid Bioassessment Protocol

	2017 Score	2013 Score		2017 Score	2013 Score
Epifaunal Substrate/Available Cover	18	12	Bank Stability - Right Bank	10	10
Pool Substrate Characterization	15	11	Bank Stability - Left Bank	10	10
Pool Variability	5	11	Vegetative Protection - Right Bank	10	10
Sediment Deposition	20	16	Vegetative Protection - Left Bank	10	10
Channel Flow Status	19	16	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	14			

	2017 Score	2013 Score
RBP Habitat Score	165	160
RBP Rating	Comparable to Reference	Comparable to Reference

Site ID 10-L2M-01-17

Revist of site R2-10-02

Biological Assessments

BIBI Metric Values	2017	2013
Total Taxa	23	23
EPT Taxa	6	5
Ephemeroptera Taxa	0	0
% Intolerant to Urban	34.55	46.50
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	1
% Climbers	8.18	21.78

FIBI Metric Values (2017 only)	
Abundance per m²	0.54
Adj. No. of Benthic Species	1.05
% Tolerant	37.93
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	62.07

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

FIBI Metric Scores (2017 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	3.57	3.57
BIBI Rating	Fair	Fair

FIBI Score	3.00
FIBI Rating	Fair

Supplemental Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Northern Green Frog

Eastern American Toad

Eastern Mud Salamand

Northern Red Salaman

Northern Green Frog

Fish Taxa	Number
American Eel	18
Eastern Mudminnow	10
Tessellated Darter	1

Benthic Macroinvertebrate Taxa

2017	Number
Alotanypus	2
Apsectrotanypus	26
Cordulegaster	1
Corynoneura	1
Diplectrona	1
Heteroplectron	1
Lepidostoma	1
Leuctra	1
Natarsia	4
Nigronia	1
Parametriocnemus	7
Polycentropus	12
Pycnopsyche	4
Rheocricotopus	4
Sialis	1
Simulium	2
Stegopterna	10
Stegopterna	2
Stempellinella	2
Stenelmis	1
Stictochironomus	1
Synurella	7
Thienemannimyia group	17
Zavrelimyia	1

Original Visit	Number
Agapetus	2
Apsectrotanypus	3
Calopteryx	2
Cheumatopsyche	1
Chrysops	1
Conchapelopia	1
Heterotrissocladius	8
Lepidostoma	1
Leuctra	6
Micropsectra	8
Microtendipes	2
Natarsia	2
Parametriocnemus	7
Phaenopsectra/Tribelos	1
Pisidium	1
Plecoptera	6
Polycentropus	5
Polypedilum	1
Pseudolimnophila	1
Rheotanytarsus	2
Sialis	3
Stegopterna	1
Synurella	5
Tanytarsini	18
Tanytarsus	7
Thienemannimyia group	6

Site ID 10-L2M-04-17

Revist of site R2-10-10

Upstream View - 2017

Downstream View - 2017

Upstream View - 2013

Downstream View - 2013

Summary Results

	2017 Data	2013 Data
Benthic Macroinvertebrate Community	Poor	Fair
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	Low pH; Elevated nitrogen	Low pH; Elevated conductivity

Land Use/Land Cover Analysis

Total Drainage Area (acres) 586.16

Land Cover	2017 Acres	2013 Acres	2017 % Area	2013 % Area
Developed Land	207.82	476.04	35.46	34.90
Forested Land	371.79	756.48	63.43	55.45
Open Land	2.74	80.35	0.47	5.89
Agricultural Land	3.80	51.30	0.65	3.76

Impervious Surface	2017 Acres	2013 Acres	2017 % Area	2013 % Area
Impervious Land	41.20	87.81	7.03	6.44

Site ID 10-L2M-04-17

Revist of site R2-10-10

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2013 Spring
Dissolved Oxygen (mg/L)	9.12	1.92	13.33
Turbidity (NTU)	3.6	66.4	5.98
Temperature (°C)	16.2	21.9	2.1
pH (Standard Units)	6.24	6.8	6.15
Specific Conductivity (µS/cm)	100	125	292.13

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.023	Chloride (mg/L)	64.137
Total Nitrogen (mg/L)	0.374	Magnesium (mg/L)	3.860
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	10.92
Total Ammonia N (mg/L)	0.070	Total Copper (µg/L)	0.356
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	11.035
Nitrate-N (mg/L)	0.168	Total Lead (µg/L)	0.146
Total Kjehldal N (mg/L)	0.203	Turbidity (NTU)	7.4
Dissolved Organic C (mg/L)	2.030		
Total Organic C (mg/L)	2.159		
Hardness (mg eq. $CaCO_3$/L)	43.16		

Geomorphic Assessment

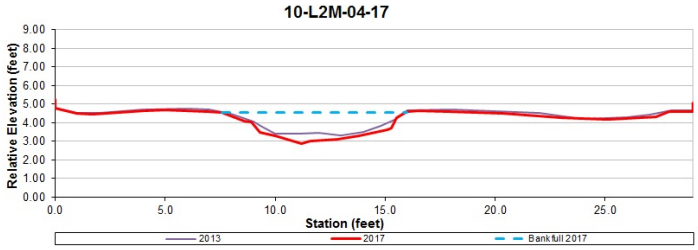
Rosgen Level II Classification Data

	2017	2013		2017	2013
Drainage Area (mi²)	0.92		Sinuosity	1.42	1.10
Bankfull Width (ft)	7.3	8.8	D50 (mm)	0.29	0.06
Mean Bankfull Depth (ft)	0.9	0.9	Adjustments?	None	None
Floodprone Width (ft)	195.0	195.0			
Entrenchment Ratio	26.7	22.3			
Width to Depth Ratio	7.9	10.0			
Cross Sectional Area (ft²)	6.8	7.7			
Water Surface Slope (%)	0.310	0.520			

Rosgen Stream Type

2017	2013
E5	**E6**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2013 Spring Value	2013 Spring Score
Remoteness	6.34	34.14	9.00	48.47
Shading	95	99.94	90	91.34
Epifaunal Substrate	4	32.42	7	49.85
Instream Habitat	3	23.46	8	51.20
Instream Woody Debris	6	57.74	3	48.87
Bank Stability	16.00	89.45	18.00	94.87

	2017 Score	2013 Score
MPHI Habitat Score	56.19	64.10
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2017 Score	2013 Score		2017 Score	2013 Score
Epifaunal Substrate/Available Cover	14	8	Bank Stability - Right Bank	8	9
Pool Substrate Characterization	12	13	Bank Stability - Left Bank	8	9
Pool Variability	5	10	Vegetative Protection - Right Bank	8	9
Sediment Deposition	19	13	Vegetative Protection - Left Bank	8	9
Channel Flow Status	19	20	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	19	18	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	9	10			

	2017 Score	2013 Score
RBP Habitat Score	149	148
RBP Rating	Supporting	Supporting

Site ID 10-L2M-04-17

Revist of site R2-10-10

Biological Assessments

BIBI Metric Values	2017	2013
Total Taxa	24	19
EPT Taxa	1	5
Ephemeroptera Taxa	0	1
% Intolerant to Urban	14.29	69.50
% Ephemeroptera	0.00	1.90
Scraper Taxa	0	1
% Climbers	8.04	2.86

FIBI Metric Values (2017 only)	
Abundance per m²	0.81
Adj. No. of Benthic Species	0.00
% Tolerant	95.24
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	85.71

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

FIBI Metric Scores (2017 only)	
Abundance per m²	5
Adj. No. of Benthic Species	1
% Tolerant	3
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43	3.57
BIBI Rating	Poor	Fair

FIBI Score	2.00
FIBI Rating	Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

Cambarus diogenes

Mussels

None Observed

Herpetofauna

Northern Green Frog

Fish Taxa	Number
Bluegill	4
Eastern Mudminnow	36
Mummichog	2

Benthic Macroinvertebrate Taxa

2017	Number
Ablabesmyia	1
Amphinemura	11
Bezzia/Palpomyia	1
Calopteryx	1
Cambarus	1
Corynoneura	1
Crangonyx	6
Dasyhelea	1
Diplocladius	4
Larsia	1
Lepidoptera	1
Micropsectra	1
Nigronia	1
Parakiefferiella	1
Parametriocnemus	13
Parametriocnemus	2
Paraphaenocladius	1
Phaenopsectra	1
Polypedilum	5
Rheocricotopus	20
Simuliidae	2
Simulium	19
Stegopterna	1
Tanytarsus	1
Tipula	1
Zavrelimyia	14

Original Visit	Number
Amphinemura	3
Caecidotea	2
Cloeon	2
Culicoides	9
Hydrobaenus	3
Ironoquia	1
Leuctra	3
Limonia	1
Orthocladius	1
Paraphaenocladius	6
Polypedilum	1
Ptilostomis	1
Rheocricotopus	1
Simuliidae	1
Stegopterna	65
Stenochironomus	1
Tanytarsus	1
Thienemanniella	1
Thienemannimyia group	1
Zavrelimyia	1

Site ID: 10-R3M-01-17

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 342.45

Land Cover	Acres	% Area
Developed Land	190.88	55.74
Forested Land	129.48	37.81
Open Land	22.09	6.45
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	82.89	24.21

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	6.17
Turbidity (NTU)	7.65
Temperature (°C)	18.2
pH (Standard Units)	6.99
Specific Conductivity (µS/cm)	247

Laboratory Measurements

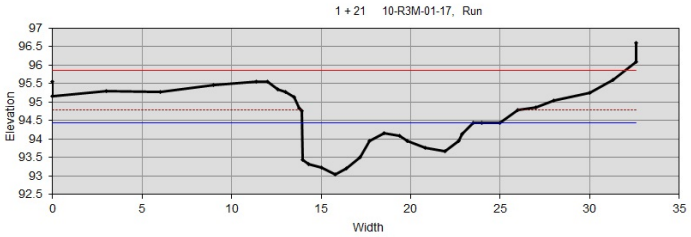
Total Phosphorus (mg/L)	0.026	Chloride (mg/L)	51.627
Total Nitrogen (mg/L)	0.671	Magnesium (mg/L)	5.667
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	18.18
Total Ammonia N (mg/L)	0.034	Total Copper (µg/L)	0.150
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	6.402
Nitrate-N (mg/L)	0.535	Total Lead (µg/L)	0.059
Total Kjehldal N (mg/L)	0.134	Turbidity (NTU)	5.4
Dissolved Organic C (mg/L)	1.325		
Total Organic C (mg/L)	1.356		
Hardness (mg eq. $CaCO_3$/L)	68.73		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.54	Sinuosity	1.19
Bankfull Width (ft)	10.6	D50 (mm)	0.13
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	98.0		
Entrenchment Ratio	9.2		
Width to Depth Ratio	15.8	**Rosgen Stream Type**	**C5**
Cross Sectional Area (ft²)	7.1		
Water Surface Slope (%)	0.45		

Cross-sectional Survey



Site ID: 10-R3M-01-17

Biological Assessments

BIBI Metric Values

Total Taxa	11
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	46.96
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	7.83

FIBI Metric Values

Abundance per m²	1.31
Adj. No. of Benthic Species	0.00
% Tolerant	37.29
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	52.54

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	2.43
BIBI Rating	Poor

FIBI Score	2.67
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Ancyronyx	1
Boveria	3
Caecidotea	54
Calopteryx	3
Cricotopus	1
Gammarus	30
Orthocladius	2
Physa	3
Pisidium	3
Rheocricotopus	1
Rheocricotopus	11
Thienemannimyia group	3

Fish Taxa

American Eel	93
Banded Killifish	3
Eastern Mudminnow	56
Golden Shiner	10
Mummichog	15

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	15
Pool Substrate Characterization	13
Pool Variability	9
Sediment Deposition	12
Channel Flow Status	18
Channel Alteration	19
Channel Sinuosity	7
Bank Stability - Right Bank	4
Bank Stability - Left Bank	7
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	142
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	10.03	54.01
Shading	75	73.32
Epifaunal Substrate	13	93.71
Instream Habitat	14	98.64
Instream Woody Debris	17	100.00
Bank Stability	15.60	88.32

MPHI Habitat Score	84.67
MPHI Rating	Minimally Degraded

Supplemental Flora and Fauna

Crayfish

Procambarus acutus/zonangulus

Herpetofauna

Northern Green Frog

Pickerel Frog

Cope's Gray Treefrog

Mussels

None Observed

Site ID: 10-R3M-02-17

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Very Poor
Fish Community	Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Partially Degraded
Water Quality Conditions	Low pH; Low D.O.; Elevated nitrogen

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1193.17

Land Cover

	Acres	% Area
Developed Land	544.77	45.66
Forested Land	469.49	39.35
Open Land	71.63	6.00
Agricultural Land	107.27	8.99

Impervious Surface

	Acres	% Area
Impervious Land	118.53	9.93

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	4.13
Turbidity (NTU)	4.45
Temperature (°C)	17.2
pH (Standard Units)	5.73
Specific Conductivity (µS/cm)	162.9

Laboratory Measurements

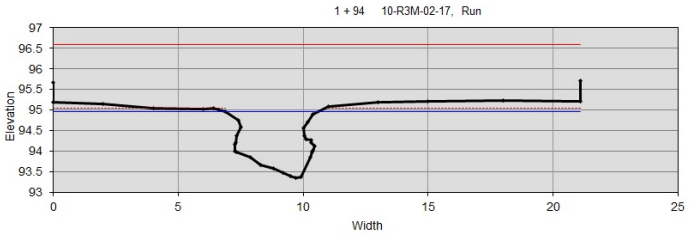
Total Phosphorus (mg/L)	0.014	Chloride (mg/L)	32.965
Total Nitrogen (mg/L)	0.560	Magnesium (mg/L)	3.043
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	2.98
Total Ammonia N (mg/L)	0.158	Total Copper (µg/L)	0.724
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	4.789
Nitrate-N (mg/L)	0.320	Total Lead (µg/L)	0.069
Total Kjehldal N (mg/L)	0.238	Turbidity (NTU)	9.9
Dissolved Organic C (mg/L)	1.438		
Total Organic C (mg/L)	1.632		
Hardness (mg eq. $CaCO_3$/L)	19.97		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.86	Sinuosity	1.24
Bankfull Width (ft)	3.7	D50 (mm)	0.15
Mean Bankfull Depth (ft)	1.1	Adjustments?	None
Floodprone Width (ft)	55.0		
Entrenchment Ratio	14.9		
Width to Depth Ratio	3.5	**Rosgen Stream Type**	**E5/6**
Cross Sectional Area (ft²)	3.9		
Water Surface Slope (%)	0.57		

Cross-sectional Survey



Site ID: 10-R3M-02-17

Biological Assessments

BIBI Metric Values

Total Taxa	15
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	11.71
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	0.00

FIBI Metric Values

Abundance per m²	1.12
Adj. No. of Benthic Species	0.00
% Tolerant	85.07
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	85.07

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	1.86
BIBI Rating	Very Poor

FIBI Score	2.00
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Anchytarsus	65
Apsectrotanypus	3
Bezzia	1
Ceratopogonidae	1
Diplectrona	1
Hexatoma	3
Lumbricina	1
Lumbriculidae	3
Naididae	2
Parametriocnemus	2
Pisidium	6
Polycentropodidae	6
Polycentropus	1
Prostoma	5
Rheocricotopus	2
Sphaeriidae	2
Synurella	2
Thienemannimyia group	5

Fish Taxa

American Eel	10
Eastern Mudminnow	57

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	3
Pool Substrate Characterization	8
Pool Variability	4
Sediment Deposition	13
Channel Flow Status	16
Channel Alteration	16
Channel Sinuosity	8
Bank Stability - Right Bank	5
Bank Stability - Left Bank	5
Vegetative Protection - Right Bank	8
Vegetative Protection - Left Bank	8
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	114
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	15.64	84.21
Shading	90	91.34
Epifaunal Substrate	8	56.53
Instream Habitat	7	47.02
Instream Woody Debris	17	91.80
Bank Stability	10.00	70.71

MPHI Habitat Score	73.60
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Cope's Gray Treefrog

Northern Green Frog

Pseudotriton sp

Pickerel Frog

Mussels

None Observed

Site ID: 10-R3M-05-17

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 467.58

Land Cover	Acres	% Area
Developed Land	262.67	56.18
Forested Land	197.73	42.29
Open Land	7.18	1.54
Agricultural Land	0.00	0.00

Impervious Surface	Acres	% Area
Impervious Land	51.31	10.97

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	6.28
Turbidity (NTU)	7.19
Temperature (°C)	16.1
pH (Standard Units)	6.82
Specific Conductivity (µS/cm)	308.2

Laboratory Measurements

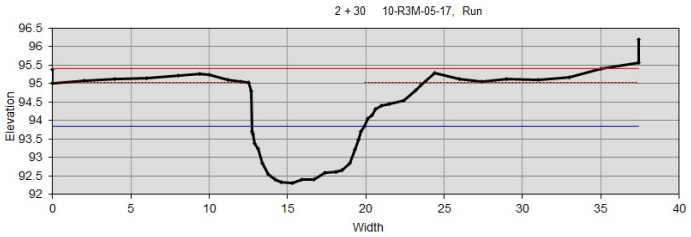
Total Phosphorus (mg/L)	0.022	Chloride (mg/L)	77.819
Total Nitrogen (mg/L)	0.593	Magnesium (mg/L)	6.240
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	15.10
Total Ammonia N (mg/L)	0.156	Total Copper (µg/L)	0.129
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	22.508
Nitrate-N (mg/L)	0.348	Total Lead (µg/L)	0.050
Total Kjehldal N (mg/L)	0.242	Turbidity (NTU)	6.9
Dissolved Organic C (mg/L)	1.468		
Total Organic C (mg/L)	1.649		
Hardness (mg eq. $CaCO_3$/L)	63.40		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.73	Sinuosity	1.22
Bankfull Width (ft)	7.2	D50 (mm)	0.06
Mean Bankfull Depth (ft)	1.2	Adjustments?	None
Floodprone Width (ft)	142.0		
Entrenchment Ratio	19.8		
Width to Depth Ratio	6.1	**Rosgen Stream Type**	**E6**
Cross Sectional Area (ft²)	8.4		
Water Surface Slope (%)	0.01		

Cross-sectional Survey



Site ID: 10-R3M-05-17

Biological Assessments

BIBI Metric Values

Total Taxa	20
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	78.10
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	6.67

FIBI Metric Values

Abundance per m²	0.69
Adj. No. of Benthic Species	0.00
% Tolerant	36.67
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	63.33

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	2.71
BIBI Rating	Poor

FIBI Score	2.33
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Ancyronyx	1
Boveria	1
Brillia	1
Caecidotea	69
Calopteryx	1
Ceratopogonidae	1
Corynoneura	1
Dytiscidae	2
Gammarus	1
Heteroplectron	1
Macronychus	2
Naididae	1
Nigronia	1
Polycentropodidae	1
Polycentropus	3
Polypedilum	4
Rheocricotopus	4
Synurella	7
Thienemannimyia group	1
Turbellaria	1
Zavrelimyia	1

Fish Taxa

American Eel	57
Brown Bullhead	2
Eastern Mudminnow	31

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	117
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	9.44	50.84
Shading	80	78.67
Epifaunal Substrate	8	62.64
Instream Habitat	11	78.81
Instream Woody Debris	8	75.78
Bank Stability	8.80	66.33

MPHI Habitat Score	68.85
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Pickerel Frog

Northern Green Frog

Pickerel Frog

Mussels

None Observed

Site ID: 10-R3M-08-17

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1352.94

Land Cover

	Acres	% Area
Developed Land	612.59	45.28
Forested Land	551.94	40.80
Open Land	77.52	5.73
Agricultural Land	110.90	8.20

Impervious Surface

	Acres	% Area
Impervious Land	130.62	9.65

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	5.5
Turbidity (NTU)	3.13
Temperature (°C)	12.8
pH (Standard Units)	6.46
Specific Conductivity (µS/cm)	108.8

Laboratory Measurements

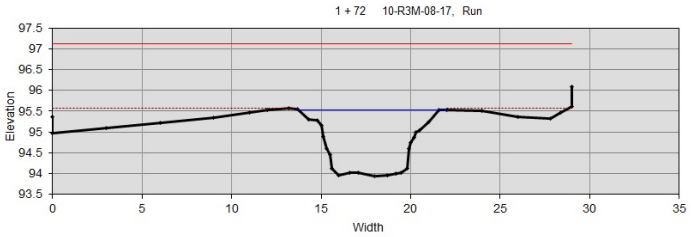
Total Phosphorus (mg/L)	0.008	Chloride (mg/L)	19.825
Total Nitrogen (mg/L)	0.555	Magnesium (mg/L)	2.892
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	2.82
Total Ammonia N (mg/L)	0.095	Total Copper (µg/L)	5.421
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	12.542
Nitrate-N (mg/L)	0.396	Total Lead (µg/L)	0.054
Total Kjehldal N (mg/L)	0.157	Turbidity (NTU)	3.9
Dissolved Organic C (mg/L)	1.167		
Total Organic C (mg/L)	1.333		
Hardness (mg eq. $CaCO_3$/L)	18.94		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	2.11	Sinuosity	1.18
Bankfull Width (ft)	8.3	D50 (mm)	0.25
Mean Bankfull Depth (ft)	1.0	Adjustments?	None
Floodprone Width (ft)	118.0		
Entrenchment Ratio	14.3		
Width to Depth Ratio	8.5	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	8.0		
Water Surface Slope (%)			

Cross-sectional Survey



Site ID: 10-R3M-08-17

Biological Assessments

BIBI Metric Values

Total Taxa	24
EPT Taxa	3
Ephemeroptera Taxa	0
% Intolerant to Urban	30.56
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	6.48

FIBI Metric Values

Abundance per m²	1.87
Adj. No. of Benthic Species	0.00
% Tolerant	80.65
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	80.65

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	2.71
BIBI Rating	Poor

FIBI Score	2.00
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Amphipoda	6
Anchytarsus	20
Apsectrotanypus	4
Bezzia	5
Caecidotea	1
Ceratopogonidae	1
Chironomus	1
Crangonyctidae	3
Dicranota	1
Enchytraeidae	2
Heterotrissocladius	1
Hexatoma	1
Lepidostoma	1
Leuctra	5
Lumbriculidae	1
Micropsectra	1
Paralauterborniella	1
Parametriocnemus	1
Pisidium	11
Polycentropodidae	4
Polycentropus	6
Prostoma	1
Rheocricotopus	5
Sialis	1
Sphaeriidae	4

Fish Taxa

American Eel	12
Eastern Mudminnow	50

Benthics Continued

Synurella	11
Tanytarsus	4
Thienemannimyia group	4
Tipula	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	7
Pool Substrate Characterization	12
Pool Variability	4
Sediment Deposition	17
Channel Flow Status	17
Channel Alteration	20
Channel Sinuosity	8
Bank Stability - Right Bank	2
Bank Stability - Left Bank	2
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	10.58	57.00
Shading	90	91.34
Epifaunal Substrate	10	67.34
Instream Habitat	9	56.84
Instream Woody Debris	11	72.63
Bank Stability	10.47	72.34

MPHI Habitat Score	69.58
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Pickerel Frog

Pseudotriton sp

Mussels

None Observed

Site ID 11-L1M-03-17

Revist of site R1-11-05

Upstream View - 2017

Downstream View - 2017

Upstream View - 2005

Downstream View - 2005

Summary Results

	2017 Data	2005 Data
Benthic Macroinvertebrate Community	Fair	Good
Fish Community	Fair	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Degraded	Degraded
Water Quality Conditions	Elevated nitrogen	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 896.92

Land Cover	2017 Acres	2005 Acres	2017 % Area	2005 % Area
Developed Land	272.19	247.99	30.35	23.90
Forested Land	379.14	532.29	42.27	51.30
Open Land	21.30	11.41	2.37	1.10
Agricultural Land	224.30	246.95	25.01	23.80

Impervious Surface	2017 Acres	2005 Acres	2017 % Area	2005 % Area
Impervious Land	42.71	48.77	4.76	4.70

Site ID 11-L1M-03-17

Revist of site R1-11-05

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2005 Spring
Dissolved Oxygen (mg/L)	10.99	8.55	5.41
Turbidity (NTU)	3.7	23.2	47.9
Temperature (°C)	9.9	20.6	10.43
pH (Standard Units)	6.5	6.86	5.8
Specific Conductivity (µS/cm)	170	168	113

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.024	Chloride (mg/L)	27.399
Total Nitrogen (mg/L)	0.319	Magnesium (mg/L)	2.920
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	13.33
Total Ammonia N (mg/L)	0.091	Total Copper (µg/L)	0.083
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	29.870
Nitrate-N (mg/L)	0.174	Total Lead (µg/L)	0.061
Total Kjehldal N (mg/L)	0.144	Turbidity (NTU)	9.0
Dissolved Organic C (mg/L)	0.770		
Total Organic C (mg/L)	0.883		
Hardness (mg eq. $CaCO_3$/L)	45.31		

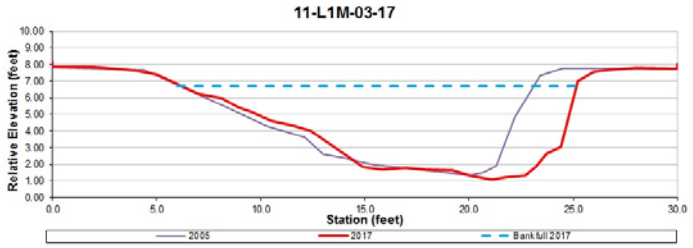
Geomorphic Assessment

Rosgen Level II Classification Data

	2017	2005		2017	2005
Drainage Area (mi²)	1.40		Sinuosity	1.06	1.05
Bankfull Width (ft)	10.9	9.7	D50 (mm)	0.23	0.30
Mean Bankfull Depth (ft)	1.3	1.6	Adjustments?	None	None
Floodprone Width (ft)	15.1	15.2			
Entrenchment Ratio	1.4	1.6			
Width to Depth Ratio	8.4	6.0			
Cross Sectional Area (ft²)	14.2	15.8			
Water Surface Slope (%)	0.280	0.500			

Rosgen Stream Type	
2017	2005
G5c	**B 5c**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2005 Spring Value	2005 Spring Score
Remoteness	12.59	67.81	n/a	71.68
Shading	85	84.56	80	78.67
Epifaunal Substrate	8	57.35	3	28.40
Instream Habitat	7	48.31	5	37.36
Instream Woody Debris	12	78.43	11	75.63
Bank Stability	4.10	45.28	n/a	61.24

	2017 Score	2005 Score
MPHI Habitat Score	63.62	58.83
MPHI Rating	Degraded	Degraded

Rapid Bioassessment Protocol

	2017 Score	2005 Score		2017 Score	2005 Score
Epifaunal Substrate/Available Cover	6	3	Bank Stability - Right Bank	3	2
Pool Substrate Characterization	7	7	Bank Stability - Left Bank	3	2
Pool Variability	5	11	Vegetative Protection - Right Bank	8	7
Sediment Deposition	5	2	Vegetative Protection - Left Bank	8	7
Channel Flow Status	16	16	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	19	18	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	6	6			

	2017 Score	2005 Score
RBP Habitat Score	106	101
RBP Rating	Partially Supporting	Partially Supporting

Site ID 11-L1M-03-17

Revist of site R1-11-05

Biological Assessments

BIBI Metric Values	2017	2005
Total Taxa	29	31
EPT Taxa	7	7
Ephemeroptera Taxa	1	1
% Intolerant to Urban	15.79	48.45
% Ephemeroptera	0.88	1.03
Scraper Taxa	1	1
% Climbers	17.54	8.20

FIBI Metric Values (2017 only)	
Abundance per m²	0.23
Adj. No. of Benthic Species	1.50
% Tolerant	34.69
% Gen., Omni., Invert.	36.73
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	63.27

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

FIBI Metric Scores (2017 only)	
Abundance per m²	1
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	3

BIBI Score	3.86	4.14
BIBI Rating	Fair	Good

FIBI Score	3.33
FIBI Rating	Fair

Supplemental Flora and Fauna (2017 only)

Crayfish

Cambarus diogenes

Mussels

None Observed

Herpetofauna

Eastern Wormsnake

Wood Frog

Northern Green Frog

Northern Two-lined Sal

Eastern American Toad

Fish Taxa	Number
American Eel	1
Blacknose Dace	10
Eastern Mudminnow	1
Least Brook Lamprey	31
Tessellated Darter	6

Benthic Macroinvertebrate Taxa

2017	Number
Acerpenna	1
Amphinemura	1
Amphipoda	2
Anchytarsus	1
Brillia	3
Caecidotea	1
Chaetocladius	1
Corynoneura	2
Diplectrona	4
Diplocladius	1
Hemerodromia	1
Leuctra	2
Lype	2
Micropsectra	1
Odontomesa	3
Orthocladius	4
Paracladopelma	1
Parakiefferiella	1
Parametriocnemus	30
Polycentropus	1
Polypedilum	18
Potthastia	1
Ptilostomis	1
Rheotanytarsus	10
Stilocladius	1
Synurella	5
Thienemanniella	4
Thienemannimyia group	7
Tipula	1
Zavrelimyia	3

Original Visit	Number
Leptophlebia	1
Caloptervx	2
Anchytarsus	2
Nigronia	2
Diplocladius	1
Limnophyes	2
Natarsia	1
Parakiefferiella	1
Parametriocnemus	7
Polypedilum	1
Pseudorthocladius	3
Rheocricotopus	1
Rheotanytarsus	1
Thienemannimyia	2
Xylotopus	1
Bezzia	1
Hemerodromia	2
Pilaria	1
Probezzia	1
Pseudolimnophila	1
Tipula	6
Diplectrona	29
Hydropsyche	2
Limnephilidae	2
Lype	1
Polycentropus	1
Ptilostomis	1
Oligochaeta	9
Caecidotea	6
Synurella	5
Pedicia	1

Site ID 11-L1M-04-17

Revist of site R1-11-13A

Upstream View - 2017

Downstream View - 2017

Upstream View - 2005

Downstream View - 2005

Summary Results

	2017 Data	2005 Data
Benthic Macroinvertebrate Community	Poor	Fair
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Non Supporting
MPHI Habitat Condition	Dry Site	Partially Degraded
Water Quality Conditions	Elevated nitrogen	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 426.97

Land Cover	2017 Acres	2005 Acres	2017 % Area	2005 % Area
Developed Land	108.15	58.30	25.33	14.10
Forested Land	296.67	330.39	69.48	79.90
Open Land	3.41	14.06	0.80	3.40
Agricultural Land	18.75	10.34	4.39	2.50

Impervious Surface	2017 Acres	2005 Acres	2017 % Area	2005 % Area
Impervious Land	13.42	13.23	3.14	3.20

Site ID 11-L1M-04-17

Revist of site R1-11-13A

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2005 Spring
Dissolved Oxygen (mg/L)	9.97	n/a	5.37
Turbidity (NTU)	1.7	n/a	9.4
Temperature (°C)	11.7	n/a	8.7
pH (Standard Units)	6.55	n/a	5.53
Specific Conductivity (µS/cm)	120	n/a	71

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.020	Chloride (mg/L)	19.060
Total Nitrogen (mg/L)	0.361	Magnesium (mg/L)	2.917
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	6.86
Total Ammonia N (mg/L)	0.088	Total Copper (µg/L)	0.137
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	6.421
Nitrate-N (mg/L)	0.177	Total Lead (µg/L)	0.047
Total Kjehldal N (mg/L)	0.180	Turbidity (NTU)	6.0
Dissolved Organic C (mg/L)	1.818		
Total Organic C (mg/L)	1.948		
Hardness (mg eq. $CaCO_3$/L)	29.14		

Geomorphic Assessment

Rosgen Level II Classification Data

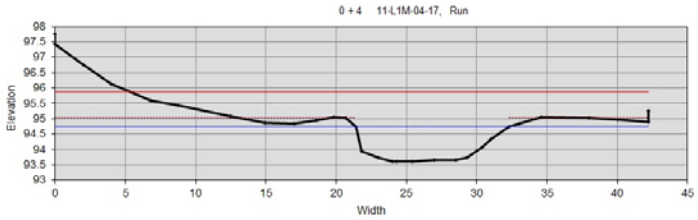
	2017	2005
Drainage Area (mi²)	0.67	
Bankfull Width (ft)	10.9	20.2
Mean Bankfull Depth (ft)	0.9	0.4
Floodprone Width (ft)	215.0	200.0
Entrenchment Ratio	19.7	9.9
Width to Depth Ratio	12.4	48.1
Cross Sectional Area (ft²)	9.6	8.5
Water Surface Slope (%)	0.180	0.500

	2017	2005
Sinuosity	1.11	1.05
D50 (mm)	0.22	0.19
Adjustments?	None	Increased Sinuosity

Rosgen Stream Type

2017	2005
E5	**C 5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2005 Spring Value	2005 Spring Score
Remoteness	Dry Site	No PHI	n/a	100.00
Shading			90	91.34
Epifaunal Substrate			3	34.39
Instream Habitat			6	52.32
Instream Woody Debris			9	80.13
Bank Stability			n/a	98.32

	2017 Score	2005 Score
MPHI Habitat Score	No PHI	76.08
MPHI Rating	Dry Site	Partially Degraded

Rapid Bioassessment Protocol

	2017 Score	2005 Score		2017 Score	2005 Score
Epifaunal Substrate/Available Cover	14	3	Bank Stability - Right Bank	9	6
Pool Substrate Characterization	12	4	Bank Stability - Left Bank	8	6
Pool Variability	9	5	Vegetative Protection - Right Bank	8	8
Sediment Deposition	8	5	Vegetative Protection - Left Bank	8	8
Channel Flow Status	17	11	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	16	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	10	4			

	2017 Score	2005 Score
RBP Habitat Score	143	96
RBP Rating	Supporting	Non-supporting

Site ID 11-L1M-04-17

Revist of site R1-11-13A

Biological Assessments

BIBI Metric Values	2017	2005
Total Taxa	20	19
EPT Taxa	4	6
Ephemeroptera Taxa	1	1
% Intolerant to Urban	7.50	33.66
% Ephemeroptera	3.33	1.98
Scraper Taxa	0	1
% Climbers	5.83	13.90

FIBI Metric Values (2017 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	3
EPT Taxa	3	5
Ephemeroptera Taxa	3	3
% Intolerant to Urban	1	5
% Ephemeroptera	3	3
Scraper Taxa	1	3
% Climbers	3	5

FIBI Metric Scores (2017 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.43	3.86
BIBI Rating	Poor	Fair

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

None Observed

Fish Taxa	Number
Dry Site	

Benthic Macroinvertebrate Taxa

2017	Number
Corydalidae	5
Dytiscidae	1
Heterotrissocladius	1
Leptophlebiidae	4
Leuctra	3
Limnephilidae	1
Lumbriculidae	3
Naididae	2
Natarsia	1
Orthocladius	1
Parametriocnemus	41
Phaenopsectra	1
Pilaria	1
Pisidium	1
Polypedilum	5
Ptilostomis	1
Synurella	1
Tanypodinae	1
Thienemanniyia group	5
Tipula	4
Zavrelimyia	37

Original Visit	Number
Leptophlebia	2
Leuctra	21
Diamesa	1
Cricotopus/Orthocladius	15
Parametriocnemus	6
Phaenopsectra	1
Polypedilum	5
Thienemanniyia Grou	1
Stegopterna	4
Tipula	5
Diplectrona	1
Hydatophylax	8
Limnephilidae	1
Lype	1
Pisidium	1
Oligochaeta	20
Caecidotea	1
Crangonyx	2
Synurella	5

Site ID 11-L2M-01-17

Revist of site R2-11-05

Upstream View - 2017

Downstream View - 2017

Upstream View - 2011

Downstream View - 2011

Summary Results

	2017 Data	2011 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Partially Supporting
MPHI Habitat Condition	Partially Degraded	Partially Degraded
Water Quality Conditions	Elevated nitrogen	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1069.42

Land Cover	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Developed Land	388.96	198.20	36.37	18.20
Forested Land	422.87	618.40	39.54	56.90
Open Land	22.60	12.50	2.11	1.20
Agricultural Land	234.99	257.70	21.97	23.70

Impervious Surface	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Impervious Land	54.82	55.50	5.13	5.10

Site ID 11-L2M-01-17

Revist of site R2-11-05

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2011 Spring
Dissolved Oxygen (mg/L)	11.52	8.77	13.07
Turbidity (NTU)	2.7	20.7	4.76
Temperature (°C)	7.3	18.8	3.43
pH (Standard Units)	7.2	6.92	6.53
Specific Conductivity (µS/cm)	190	190	169.9

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.021	Chloride (mg/L)	32.433
Total Nitrogen (mg/L)	0.404	Magnesium (mg/L)	3.288
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	13.40
Total Ammonia N (mg/L)	0.101	Total Copper (µg/L)	0.097
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	25.787
Nitrate-N (mg/L)	0.200	Total Lead (µg/L)	0.052
Total Kjehldal N (mg/L)	0.202	Turbidity (NTU)	7.8
Dissolved Organic C (mg/L)	0.770		
Total Organic C (mg/L)	0.911		
Hardness (mg eq. $CaCO_3$/L)	47.00		

Geomorphic Assessment

Rosgen Level II Classification Data

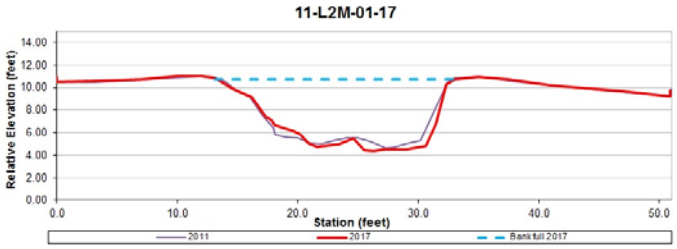
	2017	2011
Drainage Area (mi^2)	1.67	
Bankfull Width (ft)	11.6	12.7
Mean Bankfull Depth (ft)	1.3	1.1
Floodprone Width (ft)	14.9	14.7
Entrenchment Ratio	1.3	1.2
Width to Depth Ratio	9.0	11.1
Cross Sectional Area (ft^2)	15.0	14.5
Water Surface Slope (%)	0.500	0.540

	2017	2011
Sinuosity	1.25	1.25
D50 (mm)	0.18	0.32
Adjustments?	None	Yes, WD +1.0

Rosgen Stream Type

2017	2011
F5/G5c	**F5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2011 Spring Value	2011 Spring Score
Remoteness	10.26	55.23	14.00	75.39
Shading	95	99.94	95	99.94
Epifaunal Substrate	10	68.76	11	74.57
Instream Habitat	9	59.08	12	75.72
Instream Woody Debris	15	86.94	5	57.36
Bank Stability	8.60	65.58	4.00	44.72

	2017 Score	2011 Score
MPHI Habitat Score	72.59	71.28
MPHI Rating	Partially Degraded	Partially Degraded

Rapid Bioassessment Protocol

	2017 Score	2011 Score		2017 Score	2011 Score
Epifaunal Substrate/Available Cover	9	11	Bank Stability - Right Bank	3	2
Pool Substrate Characterization	10	7	Bank Stability - Left Bank	4	2
Pool Variability	8	15	Vegetative Protection - Right Bank	9	3
Sediment Deposition	5	10	Vegetative Protection - Left Bank	9	2
Channel Flow Status	18	15	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	19	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	11			

	2017 Score	2011 Score
RBP Habitat Score	122	118
RBP Rating	Partially Supporting	Partially Supporting

Site ID 11-L2M-01-17

Revist of site R2-11-05

Biological Assessments

BIBI Metric Values	2017	2011
Total Taxa	20	23
EPT Taxa	4	4
Ephemeroptera Taxa	1	0
% Intolerant to Urban	10.28	12.70
% Ephemeroptera	0.93	0.00
Scraper Taxa	0	0
% Climbers	49.53	7.30

FIBI Metric Values (2017 only)	
Abundance per m²	0.54
Adj. No. of Benthic Species	1.40
% Tolerant	51.19
% Gen., Omni., Invert.	65.48
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	34.52

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

FIBI Metric Scores (2017 only)	
Abundance per m²	3
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	5
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	3.00	2.43
BIBI Rating	Fair	Poor

FIBI Score	4.00
FIBI Rating	Good

Supplemental Flora and Fauna (2017 only)

Crayfish

Cambarus diogenes

Mussels

None Observed

Herpetofauna

Northern Two-lined Sal

American Bullfrog

Northern Green Frog

Eastern American Toad

Wood Frog

Fish Taxa	Number
Blacknose Dace	27
Bluegill	2
Eastern Mudminnow	7
Fallfish	1
Least Brook Lamprey	29
Rosyside Dace	11
Tessellated Darter	7

Benthic Macroinvertebrate Taxa

2017	Number
Anchytarsus	10
Brillia	5
Cordulegaster	1
Diplocladius	1
Hemerodromia	1
Heterotrissocladius	1
Hydatophylax	1
Leptophlebia	1
Odontomesa	2
Parametriocnemus	4
Phaenopsectra	1
Polycentropus	7
Polypedilum	51
Potthastia	1
Ptilostomis	1
Rheocricotopus	1
Rheotanytarsus	7
Stilocladius	4
Thienemanniella	5
Thienemannimyia group	2

Original Visit	Number
Alotanypus	1
Amphinemura	2
Anchytarsus	7
Bezzia/Palpomyia	1
Brillia	4
Chironomini	1
Corynoneura	1
Diplectrona	1
Hemerodromia	2
Heterotrissocladius	1
Leuctra	2
Limnophyes	1
Nemata	1
Nigronia	3
Orthocladius	2
Paralauterborniella	1
Parametriocnemus	38
Plecoptera	3
Polycentropus	2
Polypedilum	8
Rheocricotopus	1
Rheotanytarsus	17
Thienemanniella	1
Thienemannimyia group	8
Tipula	1

Site ID 11-L2M-02-17

Revist of site R2-11-20A

Upstream View - 2017

Downstream View - 2017

Upstream View - 2011

Downstream View - 2011

Summary Results

	2017 Data	2011 Data
Benthic Macroinvertebrate Community	Fair	Poor
Fish Community	Good	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Supporting
MPHI Habitat Condition	Partially Degraded	Degraded
Water Quality Conditions	Elevated nutrients	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 5305.80

Land Cover	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Developed Land	2252.75	1384.70	42.46	24.60
Forested Land	2412.93	3629.50	45.48	64.10
Open Land	196.75	129.50	3.71	2.30
Agricultural Land	443.37	512.60	8.36	9.00

Impervious Surface	2017 Acres	2011 Acres	2017 % Area	2011 % Area
Impervious Land	355.97	450.70	6.71	8.00

Site ID 11-L2M-02-17

Revist of site R2-11-20A

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2011 Spring
Dissolved Oxygen (mg/L)	8.06	3.36	11.21
Turbidity (NTU)	5.6	5.4	10.2
Temperature (°C)	13.7	23	9.3
pH (Standard Units)	6.56	6.12	6.48
Specific Conductivity (µS/cm)	220	248	194.6

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.030	Chloride (mg/L)	48.178
Total Nitrogen (mg/L)	0.473	Magnesium (mg/L)	3.729
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	11.99
Total Ammonia N (mg/L)	0.132	Total Copper (µg/L)	0.201
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	12.608
Nitrate-N (mg/L)	0.183	Total Lead (µg/L)	0.192
Total Kjehldal N (mg/L)	0.287	Turbidity (NTU)	11.6
Dissolved Organic C (mg/L)	1.909		
Total Organic C (mg/L)	2.130		
Hardness (mg eq. $CaCO_3$/L)	45.30		

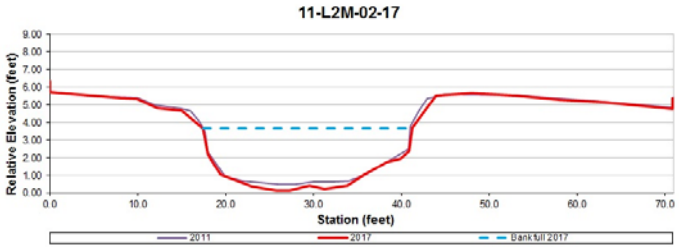
Geomorphic Assessment

Rosgen Level II Classification Data

	2017	2011		2017	2011
Drainage Area (mi²)	8.29		Sinuosity	1.07	1.09
Bankfull Width (ft)	23.9	23.3	D50 (mm)	18.00	4.10
Mean Bankfull Depth (ft)	2.8	2.5	Adjustments?	None	None
Floodprone Width (ft)	355.0	240.0			
Entrenchment Ratio	14.9	10.3			
Width to Depth Ratio	8.6	9.3			
Cross Sectional Area (ft²)	66.6	57.9			
Water Surface Slope (%)	0.240	0.005			

Rosgen Stream Type	
2017	2011
E4	**ND**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2011 Spring Value	2011 Spring Score
Remoteness	2.25	12.14	2.00	10.77
Shading	70	68.32	60	58.94
Epifaunal Substrate	15	87.05	11	63.81
Instream Habitat	16	81.02	14	69.92
Instream Woody Debris	17	74.16	8	47.54
Bank Stability	17.53	93.63	17.00	92.20

	2017 Score	2011 Score
MPHI Habitat Score	69.39	57.20
MPHI Rating	Partially Degraded	Degraded

Rapid Bioassessment Protocol

	2017 Score	2011 Score		2017 Score	2011 Score
Epifaunal Substrate/Available Cover	16	11	Bank Stability - Right Bank	8	8
Pool Substrate Characterization	14	14	Bank Stability - Left Bank	9	9
Pool Variability	14	13	Vegetative Protection - Right Bank	7	7
Sediment Deposition	13	14	Vegetative Protection - Left Bank	8	5
Channel Flow Status	16	20	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	12	7	Riparian Veg. Zone Width - Left Bank	2	4
Channel Sinuosity	6	5			

	2017 Score	2011 Score
RBP Habitat Score	135	127
RBP Rating	Supporting	Supporting

Site ID 11-L2M-02-17

Revist of site R2-11-20A

Biological Assessments

BIBI Metric Values	2017	2011
Total Taxa	25	21
EPT Taxa	5	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	5.26	1.90
% Ephemeroptera	0.00	0.00
Scraper Taxa	4	1
% Climbers	42.98	26.40

FIBI Metric Values (2017 only)	
Abundance per m²	0.86
Adj. No. of Benthic Species	1.31
% Tolerant	50.69
% Gen., Omni., Invert.	89.24
% Round-bodied Suckers	12.85
% Abund. Dominant Taxon	20.83

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

FIBI Metric Scores (2017 only)	
Abundance per m²	5
Adj. No. of Benthic Species	5
% Tolerant	5
% Gen., Omni., Invert.	5
% Round-bodied Suckers	5
% Abund. Dominant Taxon	5

BIBI Score	3.29	2.14
BIBI Rating	Fair	Poor

FIBI Score	5.00
FIBI Rating	Good

Supplemental Flora and Fauna (2017 only)

Crayfish

Orconectes limosus

Mussels

Corbicula sp.

Herpetofauna

Northern Two-lined Sal

Eastern American Toad

Northern Green Frog

Northern Two-lined Sal

Northern Green Frog

Pickerel Frog

Northern Water Snake

Fish Taxa	Number
American Eel	60
Blacknose Dace	1
Bluegill	15
Bluespotted Sunfish	13
Brown Bullhead	5
Chain Pickerel	3
Creek Chubsucker	37
Eastern Mudminnow	12
Fallfish	13
Golden Shiner	50
Green Sunfish	1
Largemouth Bass	14
Least Brook Lamprey	14
Pumpkinseed	20
Tadpole Madtom	1
Tessellated Darter	28
Warmouth	1

Benthic Macroinvertebrate Taxa

2017	Number
Amphipoda	2
Boveria	1
Caecidotea	2
Cheumatopsyche	4
Corbicula	1
Cricotopus	1
Cricotopus/Orthocladius	4
Dicrotendipes	1
Gammarus	1
Hemerodromia	2
Hydrobiidae	35
Hydropsyche	3
Hydroptila	5
Lymnaeidae	1
Microcylloepus	1
Naididae	1
Oecetis	1
Orthocladius	8
Parakiefferiella	1
Polycentropodidae	1
Polycentropus	2
Polypedilum	1
Rheocricotopus	2
Rheotanytarsus	2
Simulium	2
Sphaeriidae	4
Stenelmis	15
Tanytarsus	10

Original Visit	Number
Amphipoda	1
Bezzia/Palpomyia	1
Caecidotea	1
Chironomini	1
Cricotopus	1
Cryptochironomus	1
Dicrotendipes	26
Gammarus	3
Helichus	1
Larsia	1
Odontomesa	1
Orthocladius	3
Parakiefferiella	1
Paratanytarsus	21
Paratendipes	6
Phaenopsectra	3
Pisidium	1
Polypedilum	16
Psectrocladius	1
Rheotanytarsus	2
Saetheria	2
Stempellinella	1
Tanytarsus	11

Site ID: 11-R3M-02-17

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 744.00

Land Cover	Acres	% Area
Developed Land	280.17	37.66
Forested Land	395.75	53.19
Open Land	47.93	6.44
Agricultural Land	20.16	2.71

Impervious Surface	Acres	% Area
Impervious Land	65.62	8.82

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	
Turbidity (NTU)	
Temperature (°C)	
pH (Standard Units)	
Specific Conductivity (µS/cm)	223

Laboratory Measurements

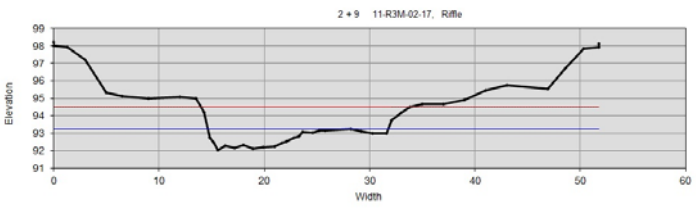
Total Phosphorus (mg/L)	0.021	Chloride (mg/L)	56.561
Total Nitrogen (mg/L)	0.582	Magnesium (mg/L)	5.302
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	13.20
Total Ammonia N (mg/L)	0.208	Total Copper (µg/L)	0.110
Nitrite-N (mg/L)	0.007	Total Zinc (µg/L)	15.478
Nitrate-N (mg/L)	0.304	Total Lead (µg/L)	0.067
Total Kjehldal N (mg/L)	0.272	Turbidity (NTU)	8.9
Dissolved Organic C (mg/L)	1.346		
Total Organic C (mg/L)	1.442		
Hardness (mg eq. $CaCO_3$/L)	54.79		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.16	Sinuosity	1.15
Bankfull Width (ft)	17.1	D50 (mm)	0.33
Mean Bankfull Depth (ft)	0.5	Adjustments?	None
Floodprone Width (ft)	19.8		
Entrenchment Ratio	1.2		
Width to Depth Ratio	31.9	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	9.2		
Water Surface Slope (%)	0.36		

Cross-sectional Survey



Site ID: 11-R3M-02-17

Biological Assessments

BIBI Metric Values

Total Taxa	18
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	3.33
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	44.17

FIBI Metric Values

Abundance per m²	0.65
Adj. No. of Benthic Species	1.63
% Tolerant	48.80
% Gen., Omni., Invert.	49.60
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	50.40

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	3.67
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Brillia	6
Chaetocladius	1
Chironomini	1
Chironomini	2
Dicranota	1
Erioptera	1
Ironoquia	6
Limnophyes	1
Odontomesa	3
Paracladopelma	1
Paratendipes	1
Phaenopsectra	1
Polycentropus	2
Polypedilum	2
Polypedilum	50
Potthastia	1
Rheocricotopus	35
Stilocladius	1
Tanytarsus	1
Thienemannimyia group	2
Tipula	1

Fish Taxa

American Eel	1
Blacknose Dace	43
Eastern Mudminnow	16
Least Brook Lamprey	63
Tessellated Darter	2

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	111
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	15.02	80.86
Shading	70	68.32
Epifaunal Substrate	10	71.23
Instream Habitat	9	62.96
Instream Woody Debris	10	76.44
Bank Stability	14.40	84.86

MPHI Habitat Score	74.11
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Northern Two-lined Sal

Northern Green Frog

Mussels

None Observed

Site ID: 11-R3M-03-17

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Fair
Fish Community	Good
RBP Habitat Condition	Supporting
MPHI Habitat Condition	Minimally Degraded
Water Quality Conditions	Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 4134.93

Land Cover

	Acres	% Area
Developed Land	1311.46	31.72
Forested Land	2158.79	52.21
Open Land	194.83	4.71
Agricultural Land	469.85	11.36

Impervious Surface

	Acres	% Area
Impervious Land	275.93	6.67

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.05
Turbidity (NTU)	12.5
Temperature (°C)	7.9
pH (Standard Units)	6.85
Specific Conductivity (µS/cm)	280

Laboratory Measurements

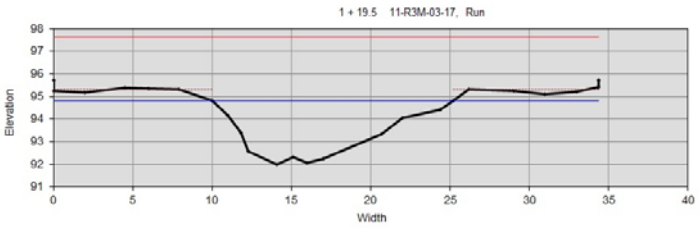
Total Phosphorus (mg/L)	0.085	Chloride (mg/L)	58.289
Total Nitrogen (mg/L)	0.651	Magnesium (mg/L)	4.802
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	12.92
Total Ammonia N (mg/L)	0.197	Total Copper (µg/L)	0.615
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	19.446
Nitrate-N (mg/L)	0.216	Total Lead (µg/L)	0.637
Total Kjehldal N (mg/L)	0.431	Turbidity (NTU)	28.3
Dissolved Organic C (mg/L)	1.969		
Total Organic C (mg/L)	2.180		
Hardness (mg eq. $CaCO_3$/L)	52.04		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	6.46	Sinuosity	1.13
Bankfull Width (ft)	15.2	D50 (mm)	0.14
Mean Bankfull Depth (ft)	1.6	Adjustments?	None
Floodprone Width (ft)	255.0		
Entrenchment Ratio	16.8		
Width to Depth Ratio	9.3	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	24.8		
Water Surface Slope (%)	0.38		

Cross-sectional Survey



Site ID: 11-R3M-03-17

Biological Assessments

BIBI Metric Values

Total Taxa	32
EPT Taxa	4
Ephemeroptera Taxa	0
% Intolerant to Urban	6.42
% Ephemeroptera	0.00
Scraper Taxa	6
% Climbers	17.43

FIBI Metric Values

Abundance per m²	1.49
Adj. No. of Benthic Species	1.39
% Tolerant	56.36
% Gen., Omni., Invert.	96.97
% Round-bodied Suckers	10.30
% Abund. Dominant Taxon	26.67

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	3.00
BIBI Rating	Fair

FIBI Score	4.67
FIBI Rating	Good

Benthic Macroinvertebrate Taxa

Ablabesmyia	1
Ancyronyx	1
Caecidotea	1
Cheumatopsyche	3
Corynoneura	1
Dineutus	1
Diplocladius	3
Dubiraphia	5
Dubiraphia	1
Enallagma	1
Gammarus	26
Gyrinus	2
Helichus	1
Limnephilidae	1
Lymnaeidae	1
Naididae	1
Nanocladius	1
Nigronia	1
Oecetis	1
Orthocladius	9
Parametriocnemus	4
Paratanytarsus	10
Physa	1
Polycentropus	3
Pseudorthocladius	1

Fish Taxa

American Eel	27
Bluespotted Sunfish	13
Chain Pickerel	4
Creek Chubsucker	17
Eastern Mudminnow	42
Fallfish	4
Golden Shiner	5
Green Sunfish	2
Least Brook Lamprey	1
Rosyside Dace	3
Tadpole Madtom	3
Tessellated Darter	44

Benthics Continued

Rheocricotopus	7
Rheotanytarsus	2
Simulium	4
Stenelmis	2
Synurella	2
Tanytarsini	1
Tanytarsus	7
Thienemannimyia group	2
Zavrelimyia	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	147
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	20.00	100.00
Shading	60	58.94
Epifaunal Substrate	16	94.95
Instream Habitat	16	84.30
Instream Woody Debris	10	57.09
Bank Stability	16.80	91.65

MPHI Habitat Score	81.16
MPHI Rating	Minimally Degraded

Supplemental Flora and Fauna

Crayfish

Orconectes limosus

Herpetofauna

Northern Green Frog

Southern Leopard Frog

Mussels

None Observed

Site ID: 11-R3M-07-17

Upstream View

Downstream View

Summary Results

Benthic Macroinvertebrate Community	Poor
Fish Community	Very Poor
RBP Habitat Condition	Partially Supporting
MPHI Habitat Condition	Dry Site
Water Quality Conditions	Low pH; Low D.O.; Elevated nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 1428.26

Land Cover	Acres	% Area
Developed Land	597.57	41.84
Forested Land	501.38	35.10
Open Land	43.53	3.05
Agricultural Land	285.79	20.01

Impervious Surface	Acres	% Area
Impervious Land	113.59	7.95

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	4.31
Turbidity (NTU)	0.9
Temperature (°C)	8.5
pH (Standard Units)	5.33
Specific Conductivity (µS/cm)	100

Laboratory Measurements

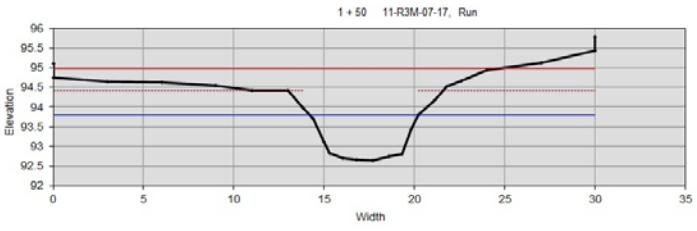
Total Phosphorus (mg/L)	0.028	Chloride (mg/L)	20.242
Total Nitrogen (mg/L)	0.193	Magnesium (mg/L)	2.183
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	5.06
Total Ammonia N (mg/L)	0.015	Total Copper (µg/L)	0.500
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	25.215
Nitrate-N (mg/L)	0.088	Total Lead (µg/L)	0.531
Total Kjehldal N (mg/L)	0.102	Turbidity (NTU)	3.8
Dissolved Organic C (mg/L)	0.848		
Total Organic C (mg/L)	0.893		
Hardness (mg eq. $CaCO_3$/L)	21.63		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	2.23	Sinuosity	1.07
Bankfull Width (ft)	6.0	D50 (mm)	0.25
Mean Bankfull Depth (ft)	0.9	Adjustments?	None
Floodprone Width (ft)	24.6		
Entrenchment Ratio	4.1		
Width to Depth Ratio	6.9	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	5.3		
Water Surface Slope (%)	0.25		

Cross-sectional Survey



Site ID: 11-R3M-07-17

Biological Assessments

BIBI Metric Values

Total Taxa	21
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	10.00
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	0.83

FIBI Metric Values

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
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	3
% Ephemeroptera	1
Scraper Taxa	3
% 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	2.14
BIBI Rating	Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Bezzia/Palpomyia	2
Caecidotea	2
Ceratopogonidae	2
Chaetocladius	6
Chrysops	3
Cordulegaster	1
Crangonyctidae	1
Diplocladius	2
Dytiscidae	1
Enchytraeidae	1
Erioptera	7
Hydrobaenus	73
Naididae	1
Nemouridae	3
Paratendipes	1
Pseudorthocladius	2
Ptilostomis	1
Rheocricotopus	3
Stenochironomus	2
Synurella	2
Tabanidae	1
Zavrelimyia	3

Fish Taxa

Dry Site

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	101
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	Dry Site	No PHI
Shading		
Epifaunal Substrate		
Instream Habitat		
Instream Woody Debris		
Bank Stability		

MPHI Habitat Score	
MPHI Rating	Dry Site

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Spring Peepe

Eastern American Toad

Mussels

None Observed

Site ID: 11-R3M-08-17

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 381.12

Land Cover

	Acres	% Area
Developed Land	162.07	42.52
Forested Land	198.69	52.13
Open Land	8.95	2.35
Agricultural Land	11.41	2.99

Impervious Surface

	Acres	% Area
Impervious Land	37.12	9.74

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	9.23
Turbidity (NTU)	1.7
Temperature (°C)	15.3
pH (Standard Units)	6.11
Specific Conductivity (µS/cm)	430

Laboratory Measurements

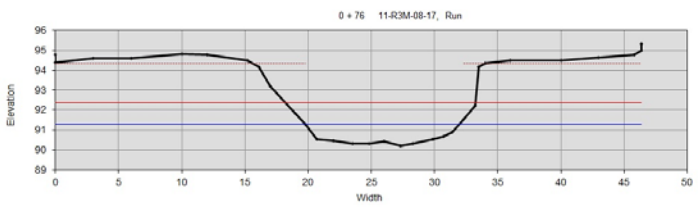
Total Phosphorus (mg/L)	0.020	Chloride (mg/L)	117.124
Total Nitrogen (mg/L)	0.566	Magnesium (mg/L)	6.513
Orthophosphate (mg/L)	0.003	Calcium (mg/L)	16.02
Total Ammonia N (mg/L)	0.273	Total Copper (µg/L)	0.157
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	30.126
Nitrate-N (mg/L)	0.234	Total Lead (µg/L)	0.103
Total Kjehldal N (mg/L)	0.330	Turbidity (NTU)	24.5
Dissolved Organic C (mg/L)	0.679		
Total Organic C (mg/L)	0.726		
Hardness (mg eq. $CaCO_3$/L)	66.82		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.60	Sinuosity	1.22
Bankfull Width (ft)	12.2	D50 (mm)	0.30
Mean Bankfull Depth (ft)	0.8	Adjustments?	None
Floodprone Width (ft)	15.0		
Entrenchment Ratio	1.2		
Width to Depth Ratio	15.0	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	9.8		
Water Surface Slope (%)	0.25		

Cross-sectional Survey



Site ID: 11-R3M-08-17

Biological Assessments

BIBI Metric Values

Total Taxa	12
EPT Taxa	0
Ephemeroptera Taxa	0
% Intolerant to Urban	2.54
% Ephemeroptera	0.00
Scraper Taxa	0
% Climbers	64.41

FIBI Metric Values

Abundance per m²	0.18
Adj. No. of Benthic Species	1.47
% Tolerant	100.00
% Gen., Omni., Invert.	100.00
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	66.67

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	1.57
BIBI Rating	Very Poor

FIBI Score	2.00
FIBI Rating	Poor

Benthic Macroinvertebrate Taxa

Bezzia/Palpomyia	1
Heterotrissocladius	2
Hexatoma	1
Naididae	15
Nemata	1
Orthocladiinae	1
Parametriocnemus	11
Paraphaenocladius	1
Paratendipes	2
Polypedilum	76
Tipula	6
Tipulidae	1

Fish Taxa

Blacknose Dace	4
Eastern Mudminnow	10
Tessellated Darter	1

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	6
Pool Substrate Characterization	5
Pool Variability	4
Sediment Deposition	6
Channel Flow Status	8
Channel Alteration	18
Channel Sinuosity	8
Bank Stability - Right Bank	2
Bank Stability - Left Bank	1
Vegetative Protection - Right Bank	7
Vegetative Protection - Left Bank	7
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	5

RBP Habitat Score	87
RBP Rating	Non Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	5.80	31.22
Shading	88	88.49
Epifaunal Substrate	6	54.57
Instream Habitat	3	39.99
Instream Woody Debris	3	67.15
Bank Stability	11.20	74.84

MPHI Habitat Score	59.38
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Southern Leopard Frog

Eastern Gartersnake

Mussels

None Observed

Site ID 13-L1M-03-17

Revist of site R1-13-04

Upstream View - 2017

Downstream View - 2017

Upstream View - 2008

Downstream View - 2008

Summary Results

	2017 Data	2008 Data
Benthic Macroinvertebrate Community	Very Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Non Supporting
MPHI Habitat Condition	Dry Site	Degraded
Water Quality Conditions	Low pH; Elevated nutrients	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 389.32

Land Cover	2017 Acres	2008 Acres	2017 % Area	2008 % Area
Developed Land	150.91	139.80	38.76	34.69
Forested Land	162.55	180.89	41.75	44.89
Open Land	13.86	46.48	3.56	11.53
Agricultural Land	61.99	35.79	15.92	8.88

Impervious Surface	2017 Acres	2008 Acres	2017 % Area	2008 % Area
Impervious Land	17.21	21.76	4.42	5.40

Site ID 13-L1M-03-17

Revist of site R1-13-04

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2008 Spring
Dissolved Oxygen (mg/L)	12.24	n/a	12.06
Turbidity (NTU)	3	n/a	n/a
Temperature (°C)	16.1	n/a	6.94
pH (Standard Units)	6.38	n/a	5.91
Specific Conductivity (µS/cm)	206	n/a	197

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.064	Chloride (mg/L)	41.244
Total Nitrogen (mg/L)	0.564	Magnesium (mg/L)	4.088
Orthophosphate (mg/L)	0.011	Calcium (mg/L)	14.51
Total Ammonia N (mg/L)	0.012	Total Copper (µg/L)	0.374
Nitrite-N (mg/L)	0.003	Total Zinc (µg/L)	11.219
Nitrate-N (mg/L)	0.280	Total Lead (µg/L)	0.150
Total Kjehldal N (mg/L)	0.281	Turbidity (NTU)	4.8
Dissolved Organic C (mg/L)	2.721		
Total Organic C (mg/L)	2.790		
Hardness (mg eq. $CaCO_3$/L)	53.07		

Geomorphic Assessment

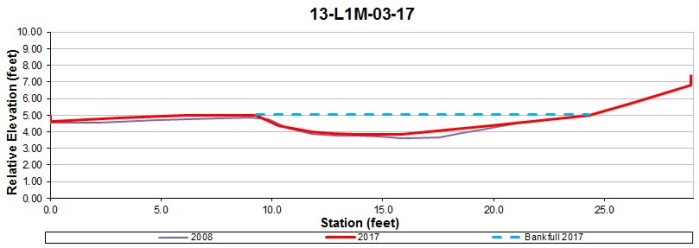
Rosgen Level II Classification Data

	2017	2008		2017	2008
Drainage Area (mi²)	0.61		Sinuosity	1.07	1.10
Bankfull Width (ft)	n/a	13.8	D50 (mm)	0.27	0.25
Mean Bankfull Depth (ft)	n/a	0.8	Adjustments?	None	Increased Sinuosity
Floodprone Width (ft)	n/a	106.0			
Entrenchment Ratio	n/a	7.6			
Width to Depth Ratio	n/a	16.7			
Cross Sectional Area (ft²)	n/a	11.4			
Water Surface Slope (%)	0.160	0.096			

Rosgen Stream Type

2017	2008
E5	**C5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2008 Spring Value	2008 Spring Score
Remoteness	Dry Site	No PHI	5.00	26.93
Shading			100	100.00
Epifaunal Substrate			2	28.75
Instream Habitat			6	52.59
Instream Woody Debris			6	71.55
Bank Stability			6.00	54.77

	2017 Score	2008 Score
MPHI Habitat Score	No PHI	55.76
MPHI Rating	Dry Site	Degraded

Rapid Bioassessment Protocol

	2017 Score	2008 Score		2017 Score	2008 Score
Epifaunal Substrate/Available Cover	11	6	Bank Stability - Right Bank	10	3
Pool Substrate Characterization	9	8	Bank Stability - Left Bank	10	3
Pool Variability	9	5	Vegetative Protection - Right Bank	6	3
Sediment Deposition	12	5	Vegetative Protection - Left Bank	7	3
Channel Flow Status	18	19	Riparian Veg. Zone Width - Right Bank	6	4
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	8	3			

	2017 Score	2008 Score
RBP Habitat Score	136	92
RBP Rating	Supporting	Non Supporting

Site ID 13-L1M-03-17

Revist of site R1-13-04

Biological Assessments

BIBI Metric Values	2017	2008
Total Taxa	19	17
EPT Taxa	0	3
Ephemeroptera Taxa	0	0
% Intolerant to Urban	5.56	37.14
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	0
% Climbers	5.56	0.95

FIBI Metric Values (2017 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	3
EPT Taxa	1	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	1	5
% Ephemeroptera	1	1
Scraper Taxa	1	1
% Climbers	3	3

FIBI Metric Scores (2017 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	1.57	2.43
BIBI Rating	Very Poor	Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

Cambarus diogenes

Mussels

None Observed

Herpetofauna

Eastern Cricket Frog

Pickerel Frog

Northern Green Frog

Cope's Gray Treefrog

Northern Green Frog

Fish Taxa — Number

Dry Site

Benthic Macroinvertebrate Taxa

2017	Number
Bezzia/Palpomyia	1
Caecidotea	2
Ceratopogonidae	1
Chaetocladius	1
Corynoneura	1
Crangonyctidae	6
Cricotopus	1
Diplocladius	7
Enchytraeidae	1
Naididae	9
Nigronia	2
Orthocladius	3
Orthocladius	26
Pisidium	10
Polypedilum	2
Polypedilum	2
Rheocricotopus	22
Simulium	1
Stenochironomus	1
Synurella	2
Thienemanniyia group	1
Tipula	3
Zavrelimyia	3

Original Visit	Number
Hydrobaenus	30
Limnephilidae	1
Nanocladius	3
Nemouridae	10
Orthocladius/Cricotopus	5
Gonomyia	1
Stegopterna	17
Pilaria	1
Synurella	1
Tanytarsus	1
Paranemoura	8
Tubificinae	13
Pisidiidae	1
Enchytraeidae	2
Caecidotea	3
Spirosperma	1
Diplocladius	7

Site ID 13-L1M-04-17

Revist of site R1-13-03

Upstream View - 2017

Downstream View - 2017

Upstream View - 2008

Downstream View - 2008

Summary Results

	2017 Data	2008 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Partially Supporting
MPHI Habitat Condition	Dry Site	Partially Degraded
Water Quality Conditions	Low pH; Elevated phosphorus	Low pH

Land Use/Land Cover Analysis

Total Drainage Area (acres) 393.88

Land Cover	2017 Acres	2008 Acres	2017 % Area	2008 % Area
Developed Land	158.60	122.01	40.27	25.34
Forested Land	179.58	283.86	45.59	58.96
Open Land	15.49	63.07	3.93	13.10
Agricultural Land	40.20	12.51	10.21	2.60

Impervious Surface	2017 Acres	2008 Acres	2017 % Area	2008 % Area
Impervious Land	20.60	23.59	5.23	4.90

Site ID 13-L1M-04-17

Revist of site R1-13-03

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2008 Spring
Dissolved Oxygen (mg/L)	11.1	n/a	13.81
Turbidity (NTU)	3.9	n/a	n/a
Temperature (°C)	15.2	n/a	9.53
pH (Standard Units)	6.11	n/a	5.78
Specific Conductivity (µS/cm)	200	n/a	113

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.053	Chloride (mg/L)	43.557
Total Nitrogen (mg/L)	0.377	Magnesium (mg/L)	4.368
Orthophosphate (mg/L)	0.007	Calcium (mg/L)	12.78
Total Ammonia N (mg/L)	0.020	Total Copper (µg/L)	0.460
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	14.028
Nitrate-N (mg/L)	0.044	Total Lead (µg/L)	0.085
Total Kjehldal N (mg/L)	0.331	Turbidity (NTU)	4.6
Dissolved Organic C (mg/L)	4.257		
Total Organic C (mg/L)	4.459		
Hardness (mg eq. $CaCO_3$/L)	49.90		

Geomorphic Assessment

Rosgen Level II Classification Data

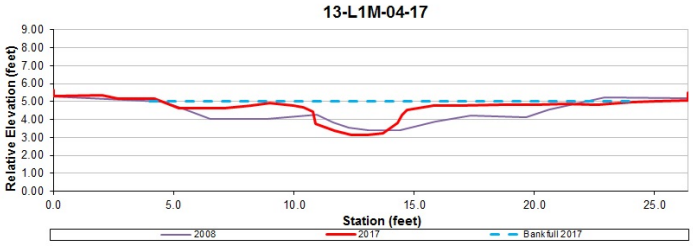
	2017	2008
Drainage Area (mi²)	0.62	
Bankfull Width (ft)	n/a	15.2
Mean Bankfull Depth (ft)	n/a	0.6
Floodprone Width (ft)	n/a	115.0
Entrenchment Ratio	n/a	7.5
Width to Depth Ratio	n/a	25.8
Cross Sectional Area (ft²)	n/a	8.9
Water Surface Slope (%)	0.340	0.099

	2017	2008
Sinuosity	1.01	1.10
D50 (mm)	0.13	0.25
Adjustments?	None	Increased Sinuosity

Rosgen Stream Type

2017	2008
E5	**C5**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2008 Spring Value	2008 Spring Score
Remoteness	Dry Site	No PHI	13.00	70.01
Shading			85	84.56
Epifaunal Substrate			3	33.40
Instream Habitat			11	78.51
Instream Woody Debris			5	66.58
Bank Stability			16.00	89.45

	2017 Score	2008 Score
MPHI Habitat Score	No PHI	70.42
MPHI Rating	Dry Site	Partially Degraded

Rapid Bioassessment Protocol

	2017 Score	2008 Score		2017 Score	2008 Score
Epifaunal Substrate/Available Cover	16	11	Bank Stability - Right Bank	10	8
Pool Substrate Characterization	13	9	Bank Stability - Left Bank	10	8
Pool Variability	9	7	Vegetative Protection - Right Bank	10	8
Sediment Deposition	12	7	Vegetative Protection - Left Bank	10	8
Channel Flow Status	20	16	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	17	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	3	2			

	2017 Score	2008 Score
RBP Habitat Score	150	124
RBP Rating	Supporting	Partially Supporting

Site ID 13-L1M-04-17

Revist of site R1-13-03

Biological Assessments

BIBI Metric Values	2017	2008
Total Taxa	17	19
EPT Taxa	2	2
Ephemeroptera Taxa	0	0
% Intolerant to Urban	23.42	64.08
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	0
% Climbers	0.00	0.00

FIBI Metric Values (2017 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	3
EPT Taxa	3	3
Ephemeroptera Taxa	1	1
% Intolerant to Urban	3	5
% Ephemeroptera	1	1
Scraper Taxa	3	1
% Climbers	1	1

FIBI Metric Scores (2017 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	1
% Gen., Omni., Invert.	1
% Round-bodied Suckers	1
% Abund. Dominant Taxon	1

BIBI Score	2.14	2.14
BIBI Rating	Poor	Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

American Bullfrog

Eastern Cricket Frog

Gray Treefrog

Pickerel Frog

Spotted Salamander

Northern Spring Peepe

Northern Green Frog

Fish Taxa	Number
Dry Site	

Benthic Macroinvertebrate Taxa

2017	Number
Amphinemura	1
Bezzia/Palpomyia	1
Caecidotea	13
Ceratopogonidae	1
Crangonyctidae	1
Cricotopus	1
Cricotopus	1
Dytiscidae	3
Hydrobaenus	10
Ironoquia	2
Limnophyes	2
Orthocladius	2
Orthocladius	33
Pisidium	2
Prostoma	1
Rheocricotopus	1
Rheocricotopus	8
Simulium	12
Stegopterna	2
Synurella	10
Turbellaria	1
Zavrelimyia	3

Original Visit	Number
Paraphaenocladius	1
Tubificinae	8
Limnodrilus	1
Paranemoura	34
Synurella	8
Stegopterna	4
Pisidiidae	1
Simuliidae	1
Pseudosmittia	2
Orthocladius/Cricotopus	3
Orthocladiinae	2
Hydrobaenus	1
Fossaria	1
Sciaridae	1
Nemata	1
Enchytraeidae	5
Caecidotea	15
Amphinemura	5
Diplocladius	9

Site ID 13-L2M-03-17

Revist of site R2-13-08

Upstream View - 2017

Downstream View - 2017

Upstream View - 2012

Downstream View - 2012

Summary Results

	2017 Data	2012 Data
Benthic Macroinvertebrate Community	Very Poor	Very Poor
Fish Community	Very Poor	Not sampled prior to 2017
RBP Habitat Condition	Supporting	Comparable to Reference
MPHI Habitat Condition	Dry Site	Degraded
Water Quality Conditions	Low pH; Elevated phosphorus	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 458.54

Land Cover	2017 Acres	2012 Acres	2017 % Area	2012 % Area
Developed Land	153.51	135.89	33.48	29.27
Forested Land	229.21	248.12	49.99	53.45
Open Land	13.86	44.39	3.02	9.56
Agricultural Land	61.96	35.84	13.51	7.72

Impervious Surface	2017 Acres	2012 Acres	2017 % Area	2012 % Area
Impervious Land	18.93	21.90	4.13	4.70

Site ID 13-L2M-03-17

Revist of site R2-13-08

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2012 Spring
Dissolved Oxygen (mg/L)	9.34	n/a	10.81
Turbidity (NTU)	6.5	n/a	6.62
Temperature (°C)	11.1	n/a	15.2
pH (Standard Units)	6.27	n/a	6.56
Specific Conductivity (µS/cm)	172	n/a	225.8

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.073	Chloride (mg/L)	34.417
Total Nitrogen (mg/L)	0.302	Magnesium (mg/L)	3.634
Orthophosphate (mg/L)	0.013	Calcium (mg/L)	12.31
Total Ammonia N (mg/L)	0.014	Total Copper (µg/L)	0.543
Nitrite-N (mg/L)	0.002	Total Zinc (µg/L)	17.286
Nitrate-N (mg/L)	0.075	Total Lead (µg/L)	0.274
Total Kjehldal N (mg/L)	0.225	Turbidity (NTU)	7.5
Dissolved Organic C (mg/L)	3.497		
Total Organic C (mg/L)	3.565		
Hardness (mg eq. $CaCO_3$/L)	45.70		

Geomorphic Assessment

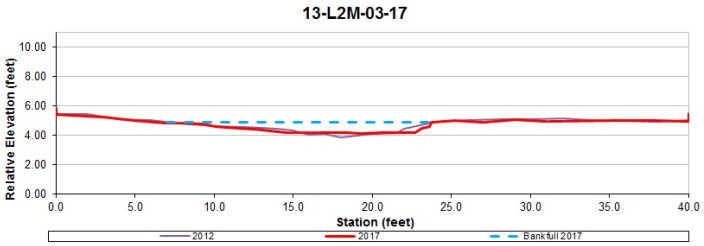
Rosgen Level II Classification Data

	2017	2012		2017	2012
Drainage Area (mi²)	0.72		Sinuosity	1.05	1.20
Bankfull Width (ft)	14.4	17.0	D50 (mm)	0.06	0.06
Mean Bankfull Depth (ft)	0.5	0.5	Adjustments?	None	None
Floodprone Width (ft)	165.0	165.0			
Entrenchment Ratio	11.5	9.7			
Width to Depth Ratio	30.2	32.6			
Cross Sectional Area (ft²)	6.8	8.9			
Water Surface Slope (%)	0.250	0.250			

Rosgen Stream Type

2017	2012
C6	**C6**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2012 Spring Value	2012 Spring Score
Remoteness	Dry Site	No PHI	10.00	53.85
Shading			40	40.96
Epifaunal Substrate			7	56.88
Instream Habitat			7	56.69
Instream Woody Debris			5	66.99
Bank Stability			20.00	100.00

	2017 Score	2012 Score
MPHI Habitat Score	No PHI	62.56
MPHI Rating	Dry Site	Degraded

Rapid Bioassessment Protocol

	2017 Score	2012 Score		2017 Score	2012 Score
Epifaunal Substrate/Available Cover	12	7	Bank Stability - Right Bank	10	10
Pool Substrate Characterization	4	13	Bank Stability - Left Bank	10	10
Pool Variability	3	10	Vegetative Protection - Right Bank	8	10
Sediment Deposition	4	15	Vegetative Protection - Left Bank	10	10
Channel Flow Status	20	20	Riparian Veg. Zone Width - Right Bank	10	10
Channel Alteration	20	20	Riparian Veg. Zone Width - Left Bank	10	10
Channel Sinuosity	6	12			

	2017 Score	2012 Score
RBP Habitat Score	127	157
RBP Rating	Supporting	Comparable to Reference

Site ID 13-L2M-03-17

Revist of site R2-13-08

Biological Assessments

BIBI Metric Values	2017	2012
Total Taxa	14	10
EPT Taxa	1	0
Ephemeroptera Taxa	0	0
% Intolerant to Urban	50.00	16.50
% Ephemeroptera	0.00	0.00
Scraper Taxa	0	0
% Climbers	0.00	35.00

FIBI Metric Values (2017 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	1
EPT Taxa	1	1
Ephemeroptera Taxa	1	1
% Intolerant to Urban	5	3
% Ephemeroptera	1	1
Scraper Taxa	1	1
% Climbers	1	5

FIBI Metric Scores (2017 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 Flora and Fauna (2017 only)

Crayfish

None Observed

Mussels

None Observed

Herpetofauna

Pickerel Frog

Fish Taxa	Number
Dry Site	

Benthic Macroinvertebrate Taxa

2017	Number
Amphinemura	1
Amphipoda	10
Caecidotea	32
Ceratopogonidae	6
Cricotopus	2
Dolichopodidae	1
Naididae	8
Orthocladius	2
Orthocladius	6
Pericoma	1
Pisidium	3
Rheocricotopus	16
Somatochlora	1
Synurella	23
Tvetenia	1
Zavrelimyia	1

Original Visit	Number
Asellidae	20
Bivalvia	3
Caecidotea	17
Ceratopogonidae	1
Chironomidae	1
Chironomini	4
Chironomus	2
Cricotopus/Orthocladius	4
Orthocladius	2
Phaenopsectra/Tribelos	1
Pisidium	4
Polypedilum	36
Rheocricotopus	5
Thienemanniella	1
Thienemannimyia group	1
Tubificidae	1

Site ID 13-L2M-04-17

Revist of site R2-13-22A

Upstream View - 2017

Downstream View - 2017

Upstream View - 2012

Downstream View - 2012

Summary Results

	2017 Data	2012 Data
Benthic Macroinvertebrate Community	Poor	Poor
Fish Community	Poor	Not sampled prior to 2017
RBP Habitat Condition	Partially Supporting	Non Supporting
MPHI Habitat Condition	Degraded	Severely Degraded
Water Quality Conditions	Elevated nutrients	Within acceptable ranges

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2478.36

Land Cover	2017 Acres	2012 Acres	2017 % Area	2012 % Area
Developed Land	594.51	569.39	23.99	19.86
Forested Land	1258.35	1639.45	50.77	57.20
Open Land	129.64	154.22	5.23	5.38
Agricultural Land	495.87	503.32	20.01	17.56

Impervious Surface	2017 Acres	2012 Acres	2017 % Area	2012 % Area
Impervious Land	85.19	98.90	3.44	3.50

Site ID 13-L2M-04-17

Revist of site R2-13-22A

Water Chemistry

In Situ Measurements

	2017 Spring	2017 Summer	2012 Spring
Dissolved Oxygen (mg/L)	10.72	5.14	11.85
Turbidity (NTU)	9.4	21.4	16.1
Temperature (°C)	16.2	22.7	11
pH (Standard Units)	7.01	7.05	6.56
Specific Conductivity (µS/cm)	172	202	180.5

Laboratory Measurements (collected 2017 only)

Total Phosphorus (mg/L)	0.133	Chloride (mg/L)	26.434
Total Nitrogen (mg/L)	0.500	Magnesium (mg/L)	2.571
Orthophosphate (mg/L)	0.021	Calcium (mg/L)	17.85
Total Ammonia N (mg/L)	0.024	Total Copper (µg/L)	0.524
Nitrite-N (mg/L)	0.004	Total Zinc (µg/L)	5.023
Nitrate-N (mg/L)	0.191	Total Lead (µg/L)	0.231
Total Kjehldal N (mg/L)	0.305	Turbidity (NTU)	12.3
Dissolved Organic C (mg/L)	4.225		
Total Organic C (mg/L)	4.409		
Hardness (mg eq. $CaCO_3$/L)	55.16		

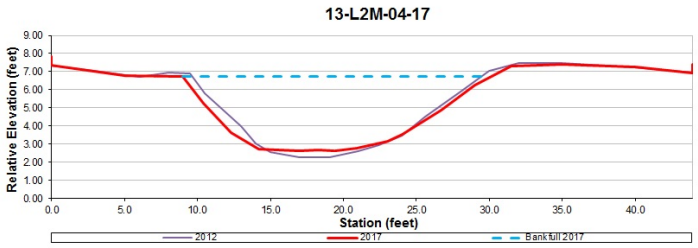
Geomorphic Assessment

Rosgen Level II Classification Data

	2017	2012		2017	2012
Drainage Area (mi²)	3.87		Sinuosity	0.95	1.00
Bankfull Width (ft)	15.8	13.3	D50 (mm)	0.06	0.06
Mean Bankfull Depth (ft)	1.6	1.6	Adjustments?	None	None
Floodprone Width (ft)	30.9	21.4			
Entrenchment Ratio	2.0	1.6			
Width to Depth Ratio	9.6	8.3			
Cross Sectional Area (ft²)	26.0	21.3			
Water Surface Slope (%)	0.025	0.046			

Rosgen Stream Type	
2017	2012
E6	**ND**

Cross-sectional Survey



Habitat Assessments

MBSS Physical Habitat Index

	2017 Summer Value	2017 Summer Score	2012 Spring Value	2012 Spring Score
Remoteness	4.83	25.99	0.00	0.00
Shading	90	91.34	85	84.56
Epifaunal Substrate	5	34.34	8	50.83
Instream Habitat	6	33.99	9	49.15
Instream Woody Debris	8	56.90	4	43.42
Bank Stability	11.60	76.16	6.00	54.77

	2017 Score	2012 Score
MPHI Habitat Score	53.12	47.12
MPHI Rating	Degraded	Severely Degraded

Rapid Bioassessment Protocol

	2017 Score	2012 Score		2017 Score	2012 Score
Epifaunal Substrate/Available Cover	8	8	Bank Stability - Right Bank	8	3
Pool Substrate Characterization	8	8	Bank Stability - Left Bank	6	3
Pool Variability	7	9	Vegetative Protection - Right Bank	7	2
Sediment Deposition	12	12	Vegetative Protection - Left Bank	9	2
Channel Flow Status	17	19	Riparian Veg. Zone Width - Right Bank	9	8
Channel Alteration	14	11	Riparian Veg. Zone Width - Left Bank	9	8
Channel Sinuosity	6	7			

	2017 Score	2012 Score
RBP Habitat Score	120	100
RBP Rating	Partially Supporting	Non Supporting

Site ID 13-L2M-04-17

Revist of site R2-13-22A

Biological Assessments

BIBI Metric Values	2017	2012
Total Taxa	20	18
EPT Taxa	1	1
Ephemeroptera Taxa	0	0
% Intolerant to Urban	38.39	17.40
% Ephemeroptera	0.00	0.00
Scraper Taxa	1	1
% Climbers	5.36	22.80

FIBI Metric Values (2017 only)	
Abundance per m²	0.28
Adj. No. of Benthic Species	0.00
% Tolerant	32.35
% Gen., Omni., Invert.	97.06
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	32.35

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

FIBI Metric Scores (2017 only)	
Abundance per m²	1
Adj. No. of Benthic Species	1
% Tolerant	5
% Gen., Omni., Invert.	3
% Round-bodied Suckers	1
% Abund. Dominant Taxon	5

BIBI Score	2.43	2.43
BIBI Rating	Poor	Poor

FIBI Score	2.67
FIBI Rating	Poor

Supplemental Flora and Fauna (2017 only)

Crayfish

Procambarus clarkii

Mussels

None Observed

Herpetofauna

American Bullfrog

Northern Green Frog

Southern Leopard Frog

Fish Taxa	Number
American Eel	3
Banded Killifish	6
Bluegill	3
Brown Bullhead	2
Eastern Mosquitofish	11
Golden Shiner	1
Green Sunfish	5
Lepomis Hybrid	1
Mummichog	2

Benthic Macroinvertebrate Taxa

2017	Number
Bezzia/Palpomyia	1
Caecidotea	16
Ceratopogonidae	1
Corynoneura	1
Dixa	1
Dytiscidae	2
Enchytraeidae	1
Ephydridae	1
Gammarus	3
Hydrobaenus	3
Naididae	2
Nemouridae	1
Neoplasta	1
Orthocladius	26
Orthocladius	1
Parakiefferiella	1
Parakiefferiella	24
Polypedilum	1
Polypedilum	3
Potthastia	1
Rheocricotopus	16
Rheocricotopus	1
Stenochironomus	1
Tanytarsus	1
Zavrelimyia	2

Original Visit	Number
Ablabesmyia	1
Amphinemura	6
Amphipoda	3
Caecidotea	10
Calopteryx	1
Chironomini	1
Conchapelopia	1
Cricotopus	15
Cricotopus/Orthocladius	10
Eukiefferiella	1
Hydrobaenus	1
Microtendipes	2
Orthocladiinae	8
Parametriocnemus	1
Paratanytarsus	2
Polypedilum	20
Rheocricotopus	1
Tanytarsini	2
Thienemanniella	3
Thienemannimyia group	1
Tubificidae	1
Zavrelimyia	1

Site ID: 13-R3M-01-17

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 nutrients

Land Use/Land Cover Analysis

Total Drainage Area (acres) 644.76

Land Cover	Acres	% Area
Developed Land	307.51	47.69
Forested Land	262.46	40.71
Open Land	31.56	4.90
Agricultural Land	43.23	6.70

Impervious Surface	Acres	% Area
Impervious Land	35.96	5.58

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.12
Turbidity (NTU)	4.6
Temperature (°C)	16.9
pH (Standard Units)	6.93
Specific Conductivity (µS/cm)	249

Laboratory Measurements

Total Phosphorus (mg/L)	0.150	Chloride (mg/L)	45.691
Total Nitrogen (mg/L)	0.447	Magnesium (mg/L)	2.865
Orthophosphate (mg/L)	0.048	Calcium (mg/L)	23.70
Total Ammonia N (mg/L)	0.028	Total Copper (µg/L)	0.297
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	2.633
Nitrate-N (mg/L)	0.237	Total Lead (µg/L)	0.083
Total Kjehldal N (mg/L)	0.205	Turbidity (NTU)	6.5
Dissolved Organic C (mg/L)	2.869		
Total Organic C (mg/L)	2.921		
Hardness (mg eq. $CaCO_3$/L)	70.98		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	1.01	Sinuosity	1.06
Bankfull Width (ft)	12.2	D50 (mm)	0.35
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	14.0		
Entrenchment Ratio	1.1		
Width to Depth Ratio	17.6	**Rosgen Stream Type**	**F5**
Cross Sectional Area (ft²)	8.4		
Water Surface Slope (%)	0.32		

Cross-sectional Survey

Site ID: 13-R3M-01-17

Biological Assessments

BIBI Metric Values

Total Taxa	20
EPT Taxa	4
Ephemeroptera Taxa	0
% Intolerant to Urban	18.92
% Ephemeroptera	0.00
Scraper Taxa	4
% Climbers	33.33

FIBI Metric Values

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
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	3
% Ephemeroptera	1
Scraper Taxa	5
% 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	3.00
BIBI Rating	Fair

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Amphinemura	9
Corynoneura	5
Dicranota	1
Diplocladius	1
Diplocladius	3
Gammarus	21
Helichus	1
Ironoquia	1
Limnephilidae	1
Lype	1
Naididae	4
Neophylax	9
Orthocladius	4
Parakiefferiella	1
Physa	2
Polypedilum	1
Polypedilum	33
Prostoma	1
Rheocricotopus	7
Stegopterna	1
Tipula	2
Turbellaria	1
Zavrelimyia	1

Fish Taxa

None Observed

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	130
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	17.09	92.01
Shading	88	88.49
Epifaunal Substrate	10	72.16
Instream Habitat	7	53.32
Instream Woody Debris	6	66.23
Bank Stability	10.93	73.94

MPHI Habitat Score	74.36
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Wood Frog

Northern Green Frog

Northern Two-lined Sal

American Bullfrog

Mussels

None Observed

Site ID: 13-R3M-03-17

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 175.29

Land Cover	Acres	% Area
Developed Land	80.66	46.01
Forested Land	80.11	45.70
Open Land	6.47	3.69
Agricultural Land	8.06	4.60

Impervious Surface	Acres	% Area
Impervious Land	11.66	6.65

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	8.63
Turbidity (NTU)	11.1
Temperature (°C)	18.5
pH (Standard Units)	7.1
Specific Conductivity (µS/cm)	308

Laboratory Measurements

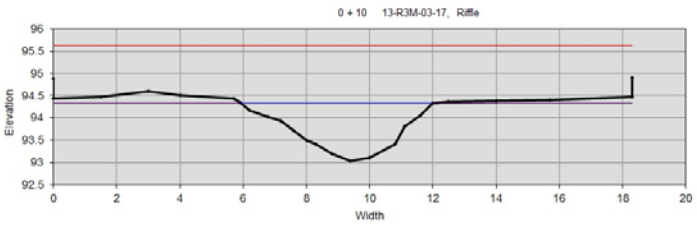
Total Phosphorus (mg/L)	0.114	Chloride (mg/L)	60.515
Total Nitrogen (mg/L)	0.491	Magnesium (mg/L)	4.052
Orthophosphate (mg/L)	0.021	Calcium (mg/L)	31.09
Total Ammonia N (mg/L)	0.037	Total Copper (µg/L)	0.478
Nitrite-N (mg/L)	0.009	Total Zinc (µg/L)	6.730
Nitrate-N (mg/L)	0.088	Total Lead (µg/L)	0.169
Total Kjehldal N (mg/L)	0.395	Turbidity (NTU)	10.8
Dissolved Organic C (mg/L)	4.126		
Total Organic C (mg/L)	4.232		
Hardness (mg eq. $CaCO_3$/L)	94.32		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.27	Sinuosity	1.13
Bankfull Width (ft)	6.1	D50 (mm)	0.11
Mean Bankfull Depth (ft)	0.7	Adjustments?	None
Floodprone Width (ft)	185.0		
Entrenchment Ratio	30.5		
Width to Depth Ratio	8.4	**Rosgen Stream Type**	**E5**
Cross Sectional Area (ft²)	4.4		
Water Surface Slope (%)	0.51		

Cross-sectional Survey



Site ID: 13-R3M-03-17

Biological Assessments

BIBI Metric Values

Total Taxa	15
EPT Taxa	2
Ephemeroptera Taxa	0
% Intolerant to Urban	18.42
% Ephemeroptera	0.00
Scraper Taxa	2
% Climbers	35.09

FIBI Metric Values

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
EPT Taxa	3
Ephemeroptera Taxa	1
% Intolerant to Urban	3
% Ephemeroptera	1
Scraper Taxa	5
% 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	3.00
BIBI Rating	Fair

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Amphinemura	1
Amphipoda	4
Bezzia/Palpomyia	7
Caecidotea	13
Ceratopogonidae	1
Chrysops	1
Corynoneura	4
Corynoneura	1
Helichus	1
Ironoquia	2
Menetus	7
Parametriocnemus	10
Pisidium	2
Polypedilum	2
Polypedilum	31
Rheocricotopus	14
Sphaeriidae	5
Synurella	6
Zavrelimyia	1
Zavrelimyia	1

Fish Taxa

None Observed

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	12
Pool Substrate Characterization	9
Pool Variability	8
Sediment Deposition	10
Channel Flow Status	16
Channel Alteration	20
Channel Sinuosity	7
Bank Stability - Right Bank	9
Bank Stability - Left Bank	9
Vegetative Protection - Right Bank	9
Vegetative Protection - Left Bank	10
Riparian Veg. Zone Width - Right Bank	10
Riparian Veg. Zone Width - Left Bank	10

RBP Habitat Score	139
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	10.72	57.72
Shading	90	91.34
Epifaunal Substrate	13	98.08
Instream Habitat	7	66.65
Instream Woody Debris	9	89.85
Bank Stability	19.93	99.84

MPHI Habitat Score	83.91
MPHI Rating	Minimally Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Eastern Cricket Frog

Northern Green Frog

Cope's Gray Treefrog

Northern Green Frog

Northern Leopard Frog

American Bullfrog

Mussels

None Observed

Site ID: 13-R3M-05-17

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) 435.82

Land Cover	Acres	% Area
Developed Land	215.75	49.51
Forested Land	174.97	40.15
Open Land	21.36	4.90
Agricultural Land	23.74	5.45

Impervious Surface	Acres	% Area
Impervious Land	23.93	5.49

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.91
Turbidity (NTU)	8.8
Temperature (°C)	8.1
pH (Standard Units)	6.75
Specific Conductivity (µS/cm)	265

Laboratory Measurements

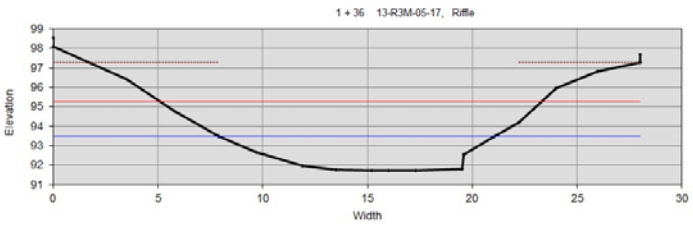
Total Phosphorus (mg/L)	0.327	Chloride (mg/L)	43.943
Total Nitrogen (mg/L)	0.691	Magnesium (mg/L)	2.767
Orthophosphate (mg/L)	0.030	Calcium (mg/L)	26.86
Total Ammonia N (mg/L)	0.078	Total Copper (µg/L)	0.450
Nitrite-N (mg/L)	0.006	Total Zinc (µg/L)	5.274
Nitrate-N (mg/L)	0.295	Total Lead (µg/L)	0.356
Total Kjehldal N (mg/L)	0.390	Turbidity (NTU)	16.6
Dissolved Organic C (mg/L)	2.425		
Total Organic C (mg/L)	2.444		
Hardness (mg eq. $CaCO_3$/L)	78.46		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	0.68	Sinuosity	1.04
Bankfull Width (ft)	13.1	D50 (mm)	0.22
Mean Bankfull Depth (ft)	1.3	Adjustments?	None
Floodprone Width (ft)	18.1		
Entrenchment Ratio	1.4		
Width to Depth Ratio	10.1	**Rosgen Stream Type**	**G5c**
Cross Sectional Area (ft²)	17.1		
Water Surface Slope (%)	0.28		

Cross-sectional Survey



Site ID: 13-R3M-05-17

Biological Assessments

BIBI Metric Values

Total Taxa	17
EPT Taxa	3
Ephemeroptera Taxa	0
% Intolerant to Urban	3.81
% Ephemeroptera	0.00
Scraper Taxa	3
% Climbers	9.52

FIBI Metric Values

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

FIBI Metric Scores

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

BIBI Score	2.71
BIBI Rating	Poor

FIBI Score	1.00
FIBI Rating	Very Poor

Benthic Macroinvertebrate Taxa

Amphinemura	1
Amphipoda	2
Bezzia/Palpomyia	2
Caecidotea	1
Corynoneura	1
Gammarus	62
Hemerodromia	1
Hydropsyche	1
Naididae	1
Nemata	1
Neophylax	2
Orthocladius	1
Parametriocnemus	2
Parametriocnemus	13
Physa	1
Polypedilum	9
Rheocricotopus	1
Stenelmis	2
Zavrelimyia	1

Fish Taxa

None Observed

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

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

RBP Habitat Score	122
RBP Rating	Partially Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	12.25	65.97
Shading	95	99.94
Epifaunal Substrate	12	86.33
Instream Habitat	8	62.88
Instream Woody Debris	4	64.74
Bank Stability	17.80	94.34

MPHI Habitat Score	79.04
MPHI Rating	Partially Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Pickerel Frog

Northern Green Frog

Northern Two-lined Sal

Mussels

None Observed

Site ID: 13-R3M-33-17

Upstream View

Downstream View

Summary Results

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

Land Use/Land Cover Analysis

Total Drainage Area (acres) 2497.36

Land Cover

	Acres	% Area
Developed Land	597.22	23.91
Forested Land	1273.25	50.98
Open Land	131.02	5.25
Agricultural Land	495.87	19.86

Impervious Surface

	Acres	% Area
Impervious Land	85.45	3.42

Water Chemistry

In Situ Measurements

Dissolved Oxygen (mg/L)	10.36
Turbidity (NTU)	9.8
Temperature (°C)	14.6
pH (Standard Units)	7.08
Specific Conductivity (µS/cm)	183

Laboratory Measurements

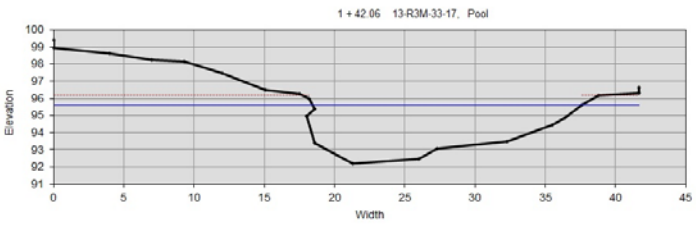
Total Phosphorus (mg/L)	0.196	Chloride (mg/L)	29.845
Total Nitrogen (mg/L)	0.480	Magnesium (mg/L)	2.990
Orthophosphate (mg/L)	0.019	Calcium (mg/L)	17.60
Total Ammonia N (mg/L)	0.033	Total Copper (µg/L)	0.450
Nitrite-N (mg/L)	0.005	Total Zinc (µg/L)	5.274
Nitrate-N (mg/L)	0.194	Total Lead (µg/L)	0.356
Total Kjehldal N (mg/L)	0.281	Turbidity (NTU)	9.3
Dissolved Organic C (mg/L)	3.565		
Total Organic C (mg/L)	3.717		
Hardness (mg eq. $CaCO_3$/L)	56.26		

Geomorphic Assessment

Rosgen Level II Classification Data

Drainage Area (mi²)	3.90	Sinuosity	1.10
Bankfull Width (ft)		D50 (mm)	0.06
Mean Bankfull Depth (ft)		Adjustments?	None
Floodprone Width (ft)			
Entrenchment Ratio			
Width to Depth Ratio		**Rosgen Stream Type**	**E6**
Cross Sectional Area (ft²)			
Water Surface Slope (%)	6.1E-15		

Cross-sectional Survey



Site ID: 13-R3M-33-17

Biological Assessments

BIBI Metric Values

Total Taxa	14
EPT Taxa	1
Ephemeroptera Taxa	0
% Intolerant to Urban	16.81
% Ephemeroptera	0.00
Scraper Taxa	1
% Climbers	7.08

FIBI Metric Values

Abundance per m²	0.74
Adj. No. of Benthic Species	0.00
% Tolerant	21.34
% Gen., Omni., Invert.	96.95
% Round-bodied Suckers	0.00
% Abund. Dominant Taxon	53.66

BIBI Metric Scores

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

FIBI Metric Scores

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

BIBI Score	2.14
BIBI Rating	Poor

FIBI Score	3.00
FIBI Rating	Fair

Benthic Macroinvertebrate Taxa

Caecidotea	3
Cambaridae	1
Ceratopogonidae	1
Gammarus	58
Hydrobaenus	1
Lepidoptera	1
Limnophyes	2
Neoporus	2
Orthocladius	8
Orthocladius	1
Parakiefferiella	1
Parakiefferiella	14
Polypedilum	1
Polypedilum	6
Ptilostomis	1
Rheocricotopus	5
Rheocricotopus	1
Tanypodinae	1
Zavrelimyia	1
Zavrelimyia	4

Fish Taxa

American Eel	13
Banded Killifish	20
Bluegill	20
Brown Bullhead	2
Eastern Mosquitofish	88
Golden Shiner	7
Green Sunfish	6
Lepomis Hybrid	5
Mummichog	3

Habitat Assessments

Rapid Bioassessment Protocol (RBP)

	Spring Score
Epifaunal Substrate/Available Cover	10
Pool Substrate Characterization	7
Pool Variability	14
Sediment Deposition	13
Channel Flow Status	20
Channel Alteration	20
Channel Sinuosity	10
Bank Stability - Right Bank	7
Bank Stability - Left Bank	7
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	146
RBP Rating	Supporting

MBSS Physical Habitat Index

	Summer Value	Summer Score
Remoteness	11.08	59.69
Shading	90	91.34
Epifaunal Substrate	7	45.91
Instream Habitat	9	50.56
Instream Woody Debris	10	62.73
Bank Stability	11.40	75.50

MPHI Habitat Score	64.29
MPHI Rating	Degraded

Supplemental Flora and Fauna

Crayfish

None Observed

Herpetofauna

Northern Green Frog

Pickerel Frog

Mussels

None Observed

Appendix E: Water Quality Data

Sampling Unit	Sample ID	Date Collected	Time Collected	Chloride (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Ortho-phosphate (mg/L)	Total Ammonia Nitrogen (mg/L)	Nitrite-N (mg/L)	Nitrate-N (mg/L)	Total Kjehldal Nitrogen (mg/L)	Dissolved Organic Carbon (mg/L)	Total Organic Carbon (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Hardness (mg equivalent $CaCO_3$/L)	Total Copper (µg/L)	Total Zinc (µg/L)	Total Lead (µg/L)	Turbidity (NTU)
Bodkin Creek	06-L1M-02-17	03/21/17	10:50	78.92	0.014	0.934	< 0.003	0.091	< 0.002	0.551	0.380	2.918	3.236	4.504	12.33	49.34	0.938	17.36	0.528	2.3
	06-L1M-03-17	03/22/17	10:45	65.70	0.008	0.613	< 0.003	0.018	< 0.002	0.461	0.151	1.465	1.614	2.968	5.54	26.07	1.174	15.44	0.281	3.1
	06-L1M-04-17	04/26/17	9:30	17.52	0.083	1.924	0.008	0.058	0.007	0.884	1.033	10.021	10.389	3.538	7.38	32.99	3.851	10.44	1.311	32.8
	06-L2M-01-17	03/23/17	13:45	60.12	0.018	0.489	< 0.003	0.062	< 0.002	0.278	0.208	2.006	2.256	2.504	5.53	24.12	0.865	10.69	0.314	6.4
	06-L2M-03-17	03/23/17	9:20	80.10	0.009	0.668	< 0.003	0.026	< 0.002	0.540	0.126	1.357	1.421	3.341	6.15	29.12	1.182	15.38	0.209	2.9
	06-R3M-01-17	04/26/17	11:30	9.70	0.056	1.010	0.011	0.110	0.007	0.196	0.807	12.023	12.226	2.804	4.55	22.92	3.941	8.04	1.478	14.5
	06-R3M-02-17	04/26/17	13:00	12.92	0.052	0.780	0.014	0.150	0.005	0.039	0.736	12.238	12.619	3.231	6.51	29.55	3.519	14.24	1.115	4.5
	06-R3M-08-17	03/29/17	16:30	80.19	0.017	0.653	< 0.003	0.064	0.003	0.193	0.457	3.712	3.786	3.854	14.96	53.23	2.574	10.65	3.189	2.2
Severn Run	09-L1M-01-17	04/05/17	14:30	46.31	0.018	1.226	< 0.003	0.019	0.002	1.040	0.183	3.162	3.184	3.158	13.43	46.54	1.991	13.87	0.354	3.8
	09-L1M-02-17	04/05/17	9:00	58.46	0.021	1.170	0.003	0.024	< 0.002	0.924	0.243	3.532	3.610	3.353	15.55	52.64	2.123	13.75	0.411	8.1
	09-L2M-02-17	04/11/17	9:00	26.75	0.020	0.854	0.003	0.058	0.004	0.274	0.576	8.660	8.799	3.105	14.13	48.07	1.352	5.11	0.738	4.2
	09-L2M-03-17	04/10/17	14:00	57.30	0.013	1.705	< 0.003	0.107	0.002	1.237	0.466	2.289	2.304	2.775	5.19	24.38	0.499	6.03	0.188	3.8
	09-R3M-01-17	03/30/17	12:30	50.66	0.009	1.523	< 0.003	0.017	0.002	1.318	0.202	1.504	1.564	3.052	12.57	43.96	1.569	16.31	0.213	1.7
	09-R3M-03-17	03/30/17	8:55	79.41	0.018	0.361	0.005	0.008	< 0.002	0.025	0.334	5.362	5.443	3.441	23.13	71.93	2.746	7.55	0.342	1.6
	09-R3M-04-17	04/11/17	13:30	23.84	0.025	0.724	0.003	0.038	0.003	0.149	0.572	12.293	12.472	2.215	11.09	36.81	2.620	14.40	1.212	9.7
	09-R3M-06-17	04/11/17	11:30	21.34	0.028	0.830	0.007	0.022	0.003	0.338	0.489	11.056	11.076	2.880	15.78	51.26	2.270	10.72	0.968	3.4
Severn River	10-L1M-05-17	04/03/17	8:30	67.20	0.017	0.393	< 0.003	0.100	0.002	0.197	0.194	1.485	1.624	3.822	10.75	42.58	0.278	10.73	0.087	6.9
	10-L1M-06-17	04/03/17	14:50	95.91	0.018	0.552	< 0.003	0.060	< 0.002	0.413	0.136	0.690	0.751	6.485	17.97	71.58	0.458	31.03	0.073	7.6
	10-L2M-01-17	04/04/17	8:30	8.03	0.023	0.370	< 0.003	0.008	< 0.002	0.100	0.268	2.342	3.519	1.227	1.43	8.62	0.961	5.70	0.877	7.1
	10-L2M-04-17	04/04/17	12:45	64.14	0.023	0.374	< 0.003	0.070	0.002	0.168	0.203	2.030	2.159	3.860	10.92	43.16	0.356	11.04	0.146	7.4
	10-R3M-01-17	04/18/17	14:30	51.63	0.026	0.671	0.003	0.034	0.003	0.535	0.134	1.325	1.356	5.667	18.18	68.73	0.150	6.40	0.059	5.4
	10-R3M-02-17	04/13/17	14:30	32.97	0.014	0.560	< 0.003	0.158	< 0.002	0.320	0.238	1.438	1.632	3.043	2.98	19.97	0.724	4.79	0.069	9.9
	10-R3M-05-17	04/17/17	9:15	77.82	0.022	0.593	0.003	0.156	0.003	0.348	0.242	1.468	1.649	6.240	15.10	63.40	0.129	22.51	0.050	6.9
	10-R3M-08-17	04/19/17	10:45	19.83	0.008	0.555	< 0.003	0.095	< 0.002	0.396	0.157	1.167	1.333	2.892	2.82	18.94	5.421	12.54	0.054	3.9
Upper North River	11-L1M-03-17	03/22/17	12:25	27.40	0.024	0.319	< 0.003	0.091	< 0.002	0.174	0.144	0.770	0.883	2.920	13.33	45.31	0.083	29.87	0.061	9.0
	11-L1M-04-17	03/27/17	10:30	19.06	0.020	0.361	< 0.003	0.088	0.004	0.177	0.180	1.818	1.948	2.917	6.86	29.14	0.137	6.42	0.047	6.0
	11-L2M-01-17	03/22/17	9:05	32.43	0.021	0.404	< 0.003	0.101	< 0.002	0.200	0.202	0.770	0.911	3.288	13.40	47.00	0.097	25.79	0.052	7.8
	11-L2M-02-17	03/29/17	7:45	48.18	0.030	0.473	< 0.003	0.132	0.003	0.183	0.287	1.909	2.130	3.729	11.99	45.30	0.201	12.61	0.192	11.6
	11-R3M-02-17	04/19/17	10:45	56.56	0.021	0.582	< 0.003	0.208	0.007	0.304	0.272	1.346	1.442	5.302	13.20	54.79	0.110	15.48	0.067	8.9
	11-R3M-03-17	03/21/17	8:30	58.29	0.085	0.651	< 0.003	0.197	0.004	0.216	0.431	1.969	2.180	4.802	12.92	52.04	0.615	19.45	0.637	28.3
	11-R3M-07-17	03/27/17	9:15	20.24	0.028	0.193	< 0.003	0.015	< 0.002	0.088	0.102	0.848	0.893	2.183	5.06	21.63	0.500	25.22	0.531	3.8
	11-R3M-08-17	03/27/17	15:00	117.12	0.020	0.566	< 0.003	0.273	< 0.002	0.234	0.330	0.679	0.726	6.513	16.02	66.82	0.157	30.13	0.103	24.5
Rhode River	13-L1M-03-17	04/10/17	13:00	41.24	0.064	0.564	0.011	0.012	0.003	0.280	0.281	2.721	2.790	4.088	14.51	53.07	0.374	11.22	0.150	4.8
	13-L1M-04-17	04/13/17	11:15	43.56	0.053	0.377	0.007	0.020	< 0.002	0.044	0.331	4.257	4.459	4.368	12.78	49.90	0.460	14.03	0.085	4.6
	13-L2M-03-17	04/13/17	8:00	34.42	0.073	0.302	0.013	0.014	< 0.002	0.075	0.225	3.497	3.565	3.634	12.31	45.70	0.543	17.29	0.274	7.5
	13-L2M-04-17	04/12/17	12:30	26.43	0.133	0.500	0.021	0.024	0.004	0.191	0.305	4.225	4.409	2.571	17.85	55.16	0.524	5.02	0.231	12.3
	13-R3M-01-17	04/13/17	14:15	45.69	0.150	0.447	0.048	0.028	0.005	0.237	0.205	2.869	2.921	2.865	23.70	70.98	0.297	2.63	0.083	6.5
	13-R3M-03-17	04/18/17	13:45	60.51	0.114	0.491	0.021	0.037	0.009	0.088	0.395	4.126	4.232	4.052	31.09	94.32	0.478	6.73	0.169	10.8
	13-R3M-05-17	04/10/17	8:35	43.94	0.327	0.691	0.030	0.078	0.006	0.295	0.390	2.425	2.444	2.767	26.86	78.46	0.450	5.27	0.356	16.6
	13-R3M-33-17	04/12/17	9:30	29.85	0.196	0.480	0.019	0.033	0.005	0.194	0.281	3.565	3.717	2.990	17.60	56.26	0.450	5.27	0.356	9.3