



**BIOLOGICAL AND
GEOMORPHOLOGICAL CONDITION
IN THE PICTURE SPRING BRANCH
SUBWATERSHED, SEVERN RIVER
WATERSHED, ANNE ARUNDEL COUNTY,
MARYLAND: 2016 - 2017**



FINAL REPORT

Prepared for

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1.0 INTRODUCTION

Anne Arundel County is required to perform physical stream monitoring in the Picture Spring Branch Subwatershed in accordance with their National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System Discharge Permit (NPDES permit number MD0068306). The goal of this monitoring effort is to assess the implementation of best management practice (BMP) design criteria from the *2000 Maryland Stormwater Design Manual* approved by Maryland Department of the Environment (MDE). The BMP design criteria were applied to the stormwater management system constructed at the West County Library site, located in Odenton, Maryland, just west of the intersection of State Highways 170 (Telegraph Road) and 175 (Annapolis Road). Specifically, bioretention areas and dry swale structural BMPs, and the nonstructural credit “sheetflow to buffer” were incorporated into the library site development in order to mitigate the effects of stormwater runoff on Picture Spring Branch.

In addition, there are four other BMPs within the watershed that are providing detention for stormwater that are impacting the flows through the study reach. These include a dry detention pond, a retention pond, and two other detention ponds with shallow wetlands. Baseline conditions within the watershed, for both land use and BMP functionality, were developed as part of this long-term study. These conditions are monitored periodically to determine if changes within the watershed affect the conditions found in the stream channel. Stormwater facility locations within the watershed were verified for this 2017 report.

To monitor the effectiveness of these BMPs on stream channel protection, the County has implemented a monitoring program to characterize the biological and geomorphological conditions of the Picture Spring Branch Subwatershed, located within the Severn River Watershed, in the vicinity of the Odenton/West County Library. Physical condition and habitat monitoring for Picture Spring Branch began in 2003 and is conducted on an annual basis. Biological monitoring to measure overall stream health is also performed.

This report summarizes the results of biological, geomorphological, and physical habitat assessments performed in 2017 with comparisons to previous years’ conditions, and discusses the current watershed conditions.

2.0 METHODS

2.1 SAMPLING LOCATIONS

The study area is located in the southwestern portion of the Picture Spring Branch Subwatershed, within the Severn River Watershed in Anne Arundel County, Maryland (Figure 2-1). The study area consists of the North Tributary and South Tributary and encompasses approximately 155 acres of drainage. The land use within the study area is dominated by developed land, with approximately 56% in residential, commercial, and industrial uses (Table 2-1). Less than one-third of the subwatershed (31.6%) is open space or wooded land cover, most of which surrounds the stream valley.

Three biological monitoring locations are located within the study area, which were selected by County staff in 2006 (see Figure 2-1). Two sites were placed on the North Tributary and one site was placed downstream of the confluence with the South Tributary and below Piney Orchard Parkway (MD State Highway 170). Sites were marked in the field using silver tree tags labeled with the site name located at the upstream and downstream ends of each 75-meter sampling segment.

Table 2-1. Summary of land use in the Picture Spring Branch Subwatershed, Anne Arundel County		
Land Use	Acres	% of Watershed Area
Commercial	15.6	10.0%
Industrial	16.3	10.5%
Open Space	6.0	3.9%
Residential	56.0	36.1%
Transportation	16.8	10.8%
Utility	1.6	1.0%
Forest	43.0	27.7%
Total	155.3	
Source: Anne Arundel County Department of Public Works		

Five previously established cross-sections were remeasured in 2017 as part of the annual geomorphological assessment. Three cross-sections are located along the North Tributary, one is located on the South Tributary, and another is located downstream of Piney Orchard Parkway (see Figure 2-1). Permanent cross-section monuments are located on each bank and consist of iron bolts set in concrete flush to the ground surface.

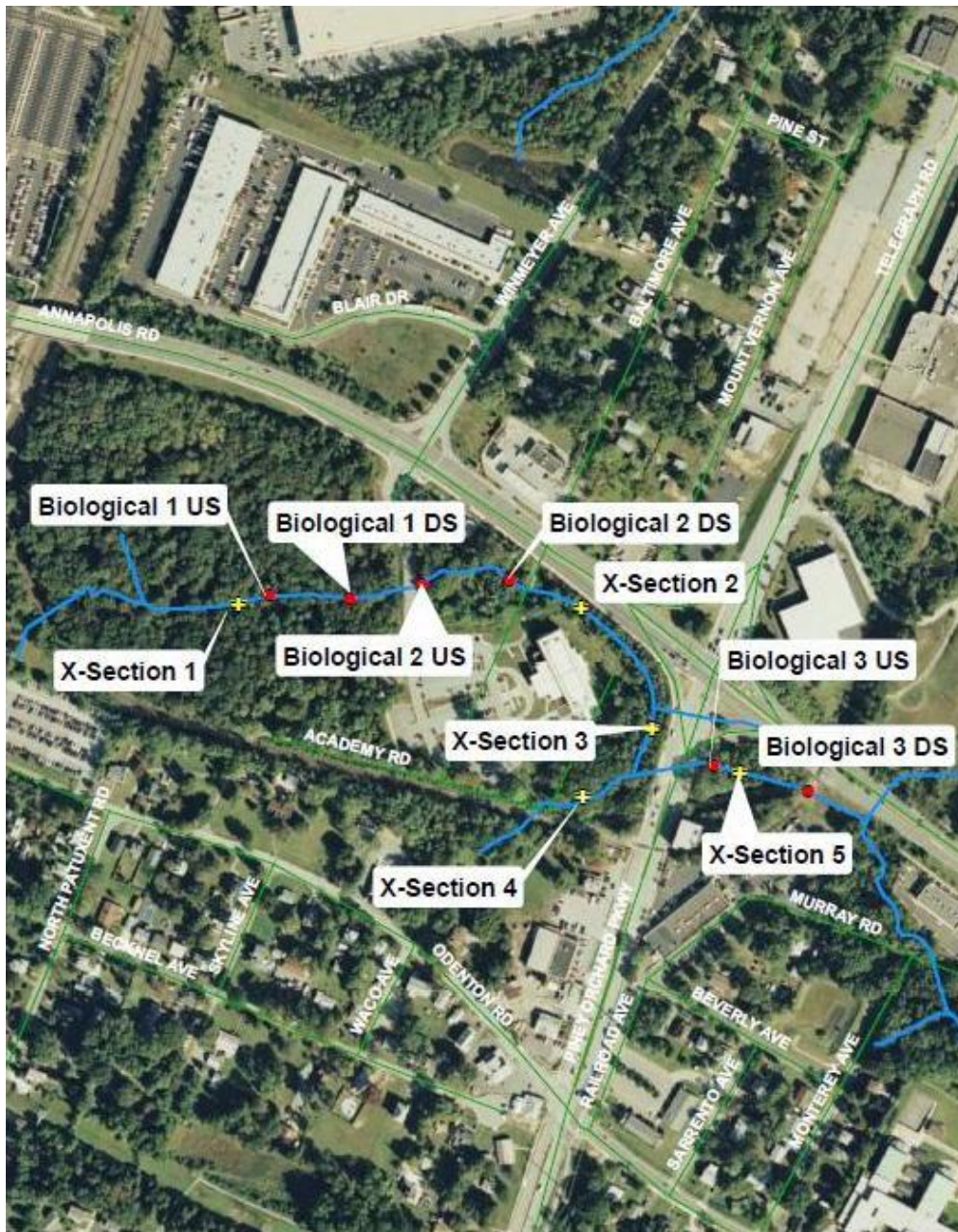


Figure 2-1. Picture Spring Branch study area stream monitoring locations

2.2 FIELD METHODS

All biological assessment data were collected in accordance with the *Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan* (Anne Arundel County 2010), which incorporates many elements of Maryland Department of Natural Resources' Maryland Biological Stream Survey (MBSS). Geomorphic assessment data were

collected in accordance with the standard operating procedures (SOPs) approved for the County's NPDES Program. All methods are consistent with previous years' methods (with applicable updates) to ensure data comparability between years. Collection methods are summarized below. Field data were collected in 2017 by Versar, Inc., a consultant to Anne Arundel County.

2.2.1 Stream Habitat

To support the biological monitoring, a visual assessment of physical habitat was completed at each monitoring site to evaluate the reach's ability to support aquatic life. Both the MBSS Physical Habitat Index (PHI; Paul et al. 2003) and the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al. 1999) were used to visually assess the physical habitat at each site in conjunction with the spring benthic monitoring. Both habitat assessments consist of a review of biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health.

2.2.2 Benthic Macroinvertebrates

Benthic macroinvertebrate samples were collected in April 2017 following the MBSS Spring index period protocols (MD DNR 2017) and consistent with the methods specified in *Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan* (QAPP; Anne Arundel County 2010). This methodology emphasizes the community composition and relative abundance of benthic macroinvertebrates inhabiting the most taxonomically diverse, or productive, instream habitats. In this sampling approach, a total of twenty jabs are distributed among the most productive habitats present within the 75-meter reach and sampled in proportion to their dominance within the segment. 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. Other less preferred habitats include gravel, broken peat, clay lumps and detrital or sand areas in runs; however, of the aforementioned habitat types, those that are located within moving water are preferred over those in still water.

2.2.3 Water Quality

To supplement the biological and physical sampling, *in situ* water quality was measured at each site. Field tested parameters include pH, specific conductivity, dissolved oxygen, temperature, and turbidity. With the exception of turbidity, which was measured once at the upstream end of the site, all measurements were collected from three locations within each sampling reach (upstream end, midpoint, and downstream end) and results were averaged to minimize variability and better represent water quality conditions throughout the entire sampling reach. All *in situ* parameters were measured with a YSI 6820 multiparameter water quality sonde.

2.2.4 Geomorphic Assessment

Geomorphic assessments included a survey of the longitudinal profile, measurement of permanent cross-sections, and representative pebble counts. Data from these measurements were used to determine the stream type of each reach as categorized by the Rosgen Stream Classification (Rosgen 1996), which can be found in Appendix A.

The longitudinal profile was performed throughout the entire study area, totaling 1,968 linear feet along the North Tributary and continuing below Telegraph Road (Maryland Route 170 and 356 linear feet along the South Tributary). The goal of the longitudinal profile was to identify indicators and elevations of the bankfull discharge (i.e., bankfull indicators) and to determine the bankfull water surface slope throughout the study reach. Once the bankfull indicators were identified, elevation data on the channel thalweg, water surface, and bankfull indicators were also collected.

The cross-section surveys were performed at the five permanent cross-section locations (Figure 2-1). Photos were taken of upstream, downstream, left bank, and right bank views at each cross-section location. Photographs are included in Appendix B. Cross-section surveys consisted of measuring the topographic variability of the associated stream bed, floodplains, and terraces, including:

- Monument elevations
- Changes in topography
- Top of each channel bank
- Elevations of bankfull indicators
- Edge of water during the time of survey
- Thalweg or deepest elevation along active channel
- Depositional and erosional features within the channel

During the cross-sectional survey, the following measurements and calculations of the bankfull channel, which are critical for determining the Rosgen stream type of each reach, were also collected:

- Bankfull Width (Wbkf): the width of the channel at the elevation of bankfull discharge or at the stage that defines the bankfull channel.
- Mean Depth (dbkf): the mean depth of the bankfull channel.
- Bankfull Cross-sectional Area (Abkf): the area of the bankfull channel, estimated as the product of bankfull width and mean depth.
- Width Depth Ratio (Wbkf/dbkf): the ratio of the bankfull width to mean depth.
- Maximum Depth (dmbkf): the maximum depth of the bankfull channel, or the difference between the thalweg elevation and the bankfull discharge elevation.

- Width of Floodprone Area (Wfpa): the width of the channel at a stage of twice the maximum depth. If the width of the floodprone area was far outside of the channel, its value was visually estimated or paced off.
- Entrenchment Ratio (ER): the ratio of the width of the floodprone area versus bankfull width.
- Sinuosity (K): ratio of the stream length versus the valley length or the valley slope divided by the channel slope. Sinuosity was visually estimated or the valley length was paced off so that an estimate could be calculated.

To quantify the distribution of channel substrate particle sizes within the study area, a modified Wolman pebble count (Rosgen 1996) was performed at each cross-section location. Reach-wide proportional counts were used. Each pebble count consists of stratifying the reach based on the frequency of channel features in that reach (e.g., riffle, run, pool, glide) and measuring 100 particles across ten transects (i.e., 10 particles in each of 10 transects). The transects are allocated across all feature types in the proportion at which they occur within the reach. The intermediate axis of each measured pebble is recorded. The goal of the pebble count is to measure 100 particles across the bankfull width of the channel and calculate the median substrate particle size (i.e., D50) of the reach. This value is used for categorizing the sites into the Rosgen Stream Classification (Rosgen 1996). If a channel was clearly a sand or silt bed channel with no distinct variation in material size, the pebble count was not performed, and the D50 was visually estimated. However, if the channel did have variation in bed material size from feature to feature, a full pebble count was performed.

2.3 DATA ANALYSIS

2.3.1 Aquatic Habitat

At each monitoring site, stream physical habitat was visually assessed utilizing the Maryland Biological Stream Survey (MBSS) Physical Habitat Index (PHI; Paul et al. 2003). The PHI was developed in part based on the EPA's Rapid Bioassessment Protocol (RBP; Barbour et al. 1999), and has been specifically calibrated to each of Maryland's physiographic regions. The habitat metrics for coastal plain streams include epifaunal substrate, percent shading, remoteness (i.e., distance to the nearest road), instream habitat, bank stability, and instream woody debris and rootwads. The metrics selected represent a mixture of physical habitat characteristics including geomorphology, habitat complexity for aquatic biota, riparian condition, and surrounding land use.

To calculate PHI at each site, six parameters were given a numerical score and a categorical rating. The raw scores are then transformed into a scaled score (0-100 scale) as described in Paul et al. (2003), and the six scaled scores are averaged into an aggregate final PHI score. Narrative condition descriptions and scoring ranges for the PHI are displayed in Table 2-2.

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: Epifaunal substrate/available cover, Embeddedness, Velocity/depth regime, Sediment deposition, Channel flow status, Channel alteration, Frequency of riffles/bends, Bank stability, Vegetative protection, and Riparian vegetative zone width (Barbour et al. 1999). In the field, each parameter was 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 individual RBP habitat parameters for each reach were summed to obtain an overall RBP assessment score. Because adequate reference conditions currently do not exist for Anne Arundel County, the percent comparability was calculated based on western coastal plain reference site conditions obtained from work done in Prince George’s County streams (Stribling et al. 1999). The percent of reference score, or percent comparability score, was then used to place each site into corresponding narrative rating categories. The ranges are shown in Table 2-3.

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

Percent of Reference Score	Narrative
90-100	Comparable to Reference
75.1-89.9	Supporting
60.1-75	Partially Supporting
0-60	Non-Supporting

2.3.2 Benthic Macroinvertebrates

Benthic macroinvertebrate samples were processed and subsampled according to MBSS methods described in the MBSS laboratory methods manual (Boward and Freidman, 2000) and as briefly summarized in the *Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan* (Anne Arundel County 2010). Subsampling is conducted to standardize the sample size and reduce variation caused by field collection methods. In brief, the sample was washed of preservative in a 0.595mm screen and spread evenly across a tray comprised of 100 numbered 5cm x 5cm grids. A random number between one and 100 was selected and the selected grid was picked entirely of macroinvertebrates under a bright light source. This process was repeated until a count of 120 organisms was reached. The 120

organism target was used following MBSS methods to allow for specimens that are missing parts or are early instars, which cannot be properly identified.

The samples were taxonomically identified by Versar taxonomists certified by the Society for Freshwater Science (SFS) (formerly known as the North American Benthological Society, NABS). The taxonomic level for most organisms was genus level when possible, with the exception of Oligochaeta which were identified to the family level. Early instars or damaged specimens were identified to the lowest possible level. Oligochaeta and Chironomidae specimens were permanently slide mounted for identification. Counts and identifications were recorded on a laboratory bench sheet and entered into a master database for analysis. A list of all taxa identified is provided in Appendix C: Master Taxa List.

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. Tolerance values were obtained from Bressler et al. (2005).

Raw values from each metric are given a score of 1, 3, or 5 based on ranges of values developed for each metric. The results are combined into a scaled BIBI score ranging from 1.0 to 5.0 and a corresponding narrative rating is assigned. Three sets of metric calculations have been developed for Maryland streams based on broad physiographic regions: Coastal Plain, Piedmont and Combined Highlands. The Coastal Plain, and Piedmont regions are divided by the Fall Line. The current study area is located within the Coastal Plain region. Table 2-4 shows the thresholds for the determination of the metric scoring. The metrics calculated for Coastal Plain streams are as follows:

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.

Number of EPT Taxa – Equals the richness of genera within the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). EPT taxa are generally considered pollution sensitive, thus higher levels of EPT taxa would be indicative of higher water quality.

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.

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 out of 10. As impairment increases the percent of intolerant taxa decreases.

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.

Number Scraper Taxa – Equals the number of taxa in the sample that have evolved to scrape their food from the substrate in their environment. As the levels of stressors or pollution rise, there is an expected decrease in the numbers of Scraper taxa.

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.

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	1.9-1.0	< 1.0
Percent Intolerant Urban	≥ 28	10-27	< 10
Percent Ephemeroptera	≥ 11	0.8-10.9	< 0.8
Number Scraper Taxa	≥ 2	1.9-1.0	< 1.0
Percent Climbers	≥ 8.0	0.9-7.9	< 0.9

All of the metric scores are summed and then averaged to obtain the final BIBI score. Table 2-5 shows the scores and narrative rankings of the MBSS BIBI. The QA/QC information for these calculations is included in Appendix D.

BIBI Score	Narrative Ranking	Characteristics
4.0-5.0	Good	Comparable to reference conditions, stream considered to be minimally impacted, biological metrics fall within upper 50th percentile of reference site conditions.
3.0-3.9	Fair	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of minimally impacted streams.
2.0-2.9	Poor	Significant deviation from reference conditions, indicating some degradation. On average, biological metrics fall below the 10th percentile of reference site values.
1.0-1.9	Very Poor	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of minimally impacted streams, indicating severe degradation. On average, most or all metrics fall below the 10th percentile of reference site values.

2.3.3 Water Quality

Data were compared to the standards for Use I streams listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-3 Water Quality* and shown in Table 2-6.

Table 2-6. Maryland COMAR water quality standards for Use I streams	
Parameter	Standard
pH	6.5 to 8.5
Dissolved Oxygen (mg/L)	Minimum of 5 mg/L
Conductivity (µS/cm)	No existing standard
Turbidity (NTU)	Maximum of 150 NTU and maximum monthly average of 50 NTU
Total Dissolved Solids (mg/L)	No existing standard
Temperature (C)	Maximum of 32 °C (90 °F) or ambient temperature, whichever is greater
Source: Code of Maryland Regulations (COMAR) 26.08.02.03-3 Water Quality	

2.3.4 Geomorphic Assessment

Geomorphic field data were compared to regional relationships of bankfull channel geometry developed by the USFWS for streams in the Maryland Coastal Plain (McCandless 2003) and by Anne Arundel County Department of Public Works (AADPW 2002) for urban streams within the County. Estimates of the bankfull channel parameters, the longitudinal profile survey, the cross-section survey, and the pebble count data were entered into *The Reference Reach Spreadsheet* (Mecklenburg 2006) and analyzed for each assessment site. These data were used to identify each stream reach as one of the stream types categorized by the Rosgen Stream Classification (Rosgen 1996). In the Rosgen Classification methodology, streams are categorized based on their measured field values of entrenchment ratio, width/depth ratio, sinuosity, water surface slope, and channel materials according to the table in Appendix A: Rosgen Stream Classification. As illustrated in Appendix A, the Rosgen Stream Classification categorizes streams into broad stream types, which are identified by the letters Aa, A, B, C, D, DA, E, F, and G. Table 2-7 includes general descriptions of each Rosgen stream type. A summary of the stream types identified for the streams in this study is included in Appendix B: Geomorphic Assessment Results.

Channel Type	General Description
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.
A	Steep, entrenched, confined, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.
B	Moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools. Moderate width/depth ratio. Narrow, gently sloping valleys. Very stable plan and profile. Stable banks.
C	Low gradient, meandering, slightly entrenched, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks. Active lateral adjustment, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well-vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.
E	Low gradient, Highly sinuous, riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander/width ratio.
F	Entrenched, meandering riffle/pool channel on low gradients with high width/depth ratio and high bank erosion rates.
G	Entrenched “gully” step/pool and low width/depth ratio on moderate gradients. Narrow valleys. Unstable, with grade control problems and high bank erosion rates.

Source: Rosgen (1996).

2.4 LAND USE AND STORMWATER MANAGEMENT ASSESSMENT

2.4.1 Picture Spring Branch Watershed Land Use

A previous report (Versar 2013) provided information on land use, based on field reconnaissance conducted during 2013. As seen in an aerial photograph and stormwater best management practice (BMP) facilities map (Figure 2-2), the watershed is a mix of commercial and residential land uses, with a large block of forest adjacent to the stream channels and smaller fragments of forest interspersed with the other land uses.

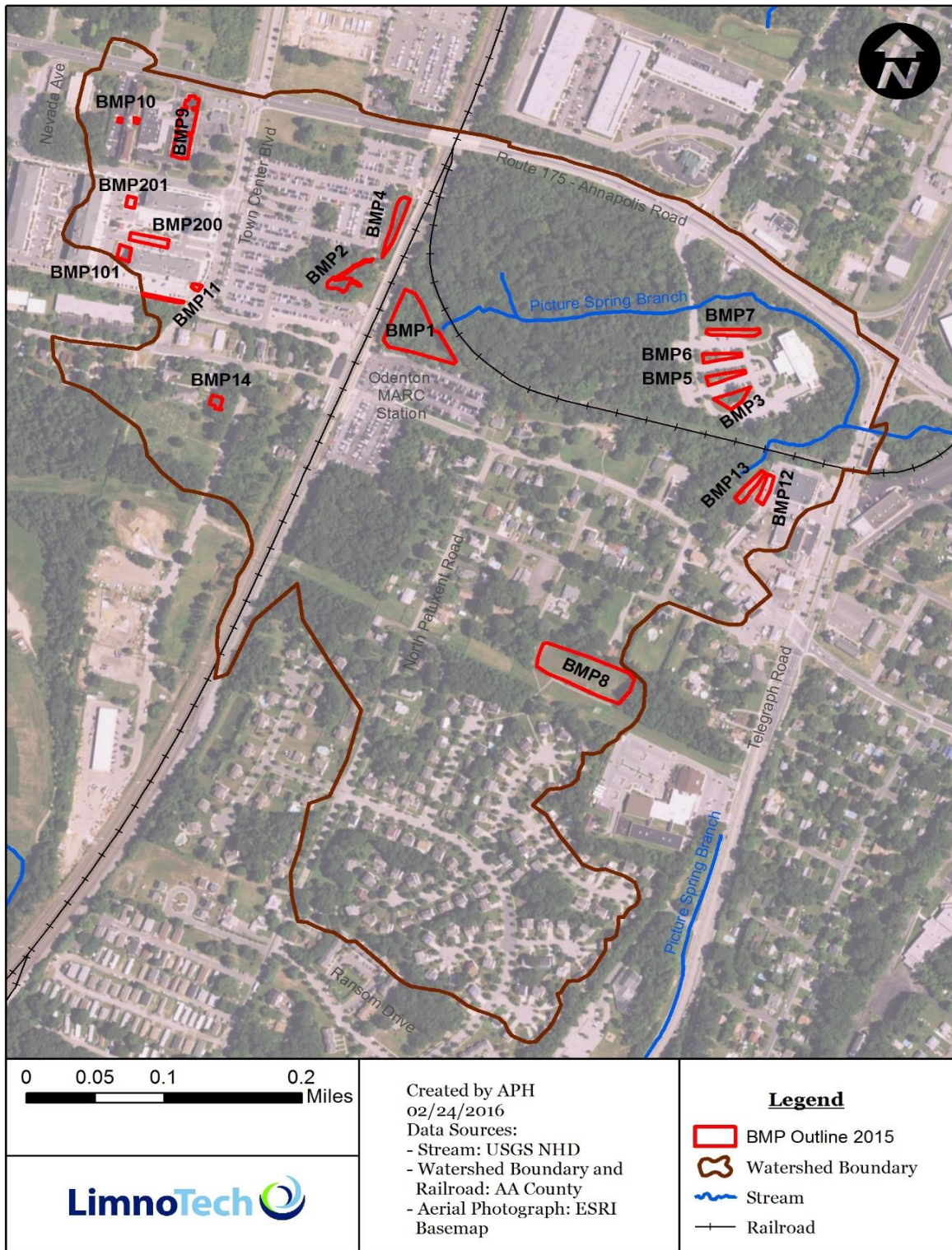


Figure 2-2. Picture Spring Branch BMPs

2.4.2 Picture Spring Branch Watershed BMP Inspections

The Picture Spring Branch watershed contains 17 BMPs, as shown in Figure 2-2 and Table 2-8. Inspections were conducted on November 16, 2015 and January 13, 2016 (hereafter termed the “2015/2016 inspections”). Inspections at BMPs under the County’s jurisdiction are carried out regularly and the records are maintained at the County offices. Each BMP was inspected during dry weather conditions (defined as a minimum 48 hours of dry weather since the last rain event).

Picture Spring Branch BMP	AA County Urban BMP Database ID ^(a)	Current BMP Type in Database ^(b)	Recommended Updated BMP Type	Drainage Area (acres) ^(c)	Location	Address	Presumed Owner	County Follow-up Completed
1	AA004443	IBAS	IBAS	2.1	Odenton MARC Station Parking Lot	Odenton MARC Station	MTA	---
2	Not found in 2015 database	N/A	WP	-	Odenton MARC Station Parking Lot	Odenton MARC Station	MTA	---
3	AA012420	FBIO	FBIO	3	West County Library Parking Lot	1325 Annapolis Road	County	Feature moved to correct location
4	Not found in 2015 database	N/A	WP	-	Odenton MARC Station Parking Lot	Odenton MARC Station	MTA	---
5	AA012419	FBIO	FBIO	3	West County Library Parking Lot	1325 Annapolis Road	County	Feature moved to correct location
6	AA012418	FBIO	FBIO	3	West County Library Parking Lot	1325 Annapolis Road	County	Feature moved to correct location
7	AA012421	ODSW	ODSW	3	West County Library Parking Lot	1325 Annapolis Road	County	Feature moved to correct location
8	AA002445	PWED	XDED	36.86	Peach Tree East Neighborhood	Peach Leaf Court	County	---
9	AA004558	XDPD	XDED	2	Donaldson Funeral Home Parking Lot	1411 Annapolis Road	County	---
10	AA000692	ITRN	ITRN and FBIO	-	Odenton Commerce Center Parking Lot (aka Goodman Office Building)	1413A Annapolis Road	County	---
11	AA009980	ITRN	FBIO (2 BMPs)	0.67	The Village at Odenton Parking Lot	Town Center Boulevard	County	Features moved to the correct location, will be separated and the correct BMP type assigned next year
12	AA012190	XDPD	XDED	1.9	Walgreens Parking Lot	8374 Piney Orchard Parkway	County	---

Table2-8. (Continued)								
Picture Spring Branch BMP	AA County Urban BMP Database ID ^(a)	Current BMP Type in Database ^(b)	Recommended Updated BMP Type	Drainage Area (acres) ^(c)	Location	Address	Presumed Owner	County Follow-up Completed
13	AA012189	FSND	FSND	1.9	Walgreens Parking Lot	8374 Piney Orchard Parkway	County	---
14	AA004926	ITRN	ITRN	2.97	Epiphany Episcopal Church Playground	1419 Odenton Road	Private	---
101	AA009978	ITRN	ITRN	0.51	The Village at Odenton Station	360 Morgan Road	Unknown	Feature moved to the correct location
200	AA009979	ITRN	ITRN	0.70	The Village at Odenton Station	360 Morgan Road	Unknown	Feature moved to the correct location
201	AA009976 AA009977	ITRN	ITRN	3	The Village at Odenton Station	360 Morgan Road	Unknown	Feature moved to the correct location

(a) Numbering system carried over from the 2013 BMP inspection report.

(b) The 2015 Anne Arundel County Urban BMP database was used to identify the BMP type data for the 2015/2016 inspections (See List of Acronyms in Appendix A). Thus BMP type data may be different from the 2013 BMP type data for the same BMP. In addition, LimnoTech has recommended that some of these BMP types be changed based on what was observed in the field.

(c) The 2015 Anne Arundel County Urban BMP database was used to update drainage areas for the 2015/2016 inspections. Some drainage areas are missing in the Urban BMP database.

3.0 RESULTS

3.1 AQUATIC HABITAT

Physical habitat quality within the Picture Spring Branch study area was primarily rated as “Partially Degraded” by the Maryland PHI. The most upstream reach, PSB-01, received the highest score (81.07). Remoteness rated very low at all sites due to proximity to roads and parking lots surrounding the stream reach, however, banks exhibited only minor erosion, and woody debris and rootwads were present in sufficient amounts for colonization of benthic macroinvertebrates. At site PSB-01, there was substantial riparian buffer and well-vegetated banks throughout this reach providing adequate shading. Site PSB-02, located between the Winnemeyer Avenue and Baltimore Avenue culverts, received a PHI score of 71.50. The site downstream of Maryland Route 170 (PSB-03) received a PHI score of 71.21. Lower PHI scores at Sites PSB-02 and PSB-03 were primarily driven by lower remoteness and shading scores than PSB-01. Table 3-1 shows the PHI scores for the sampling sites within the Picture Spring Branch study area. Data for individual parameters are listed in Appendix F.

Physical habitat quality was also evaluated with the RBP and rated “Supporting” for all three sites (Table 3-1). Index scores varied somewhat and ranged from a low of 76 at PSB-02 to a high of 86 at PSB-01. All sites had low scores for velocity/depth regime and sediment deposition metrics.

Site	PHI Score	PHI Narrative Rating	RBP Score	RBP Narrative Rating
PSB-01	81.07	Minimally Degraded	86	Supporting
PSB-02	71.50	Partially Degraded	76	Supporting
PSB-03	71.21	Partially Degraded	79	Supporting

3.2 BENTHIC MACROINVERTEBRATES

Biological condition was rated as “Fair” at all sites. Table 3-2 contains the BIBI scores and corresponding narrative condition ratings for each sampling location. Detailed data on each site can be found in Appendix F: Biological Assessment Results.

The most upstream site within the North Tributary (PSB-01) had a BIBI score of 3.57. This site is buffered by a young deciduous forest. The macroinvertebrate community was represented by 28 taxa, 39.5% of which were urban intolerant taxa. The sample was dominated by individuals of the family Polycentropus, a predator and part of the tube-making caddisfly family. However, the absence of Ephemeroptera taxa in the subsample may indicate that

stressors such as sedimentation could be affecting the biological community. Climbers made up 2.6% of the sample.

Site	BIBI Score	Narrative Rating
PSB-01	3.57	Fair
PSB-02	3.57	Fair
PSB-03	3.00	Fair

Site PSB-02, also located on the North Tributary, received a BIBI score of 3.57. Of the 34 taxa present in the subsample, 37.5% were intolerant to urban stressors, and six were EPT taxa. Dominant taxa at this site were the shredding stonefly taxa *Leuctra*, followed by the non-biting midge genus *Rheocricotopus* in the Chironomid family. This site lacked Ephemeroptera taxa but had five Scrapper taxa.

Downstream of State Highway 170, site PSB-03 received a BIBI score of 3.00. Overall, this site had a total of 34 taxa identified, including three sensitive EPT taxa, and 38.9% Clingers, with four Scrapper taxa. Ephemeroptera taxa were absent from the subsample, and 6.2% of the individuals present were intolerant to urban stressors. The benthic community was dominated by the taxa Tubificidae, a family of oligochaete worms, and the genus *Physa* which is comprised of freshwater snails.

3.3 WATER QUALITY

With the exception of low pH at PSB-01 and PSB-02, all water quality measurements met Maryland's water quality standards for Use I streams (Table 3-3). Conductivity values were relatively high compared to most coastal plain streams, but are within the range of those found in other urban, or highly impervious, drainage areas in Maryland (MD DNR, 2001, 2003, 2005; KCI, 2009; Hill and Crunkleton, 2009). Stream conductivity is affected by inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations, many of which are generally found at elevated concentrations in urban streams (Paul and Meyer 2001). Increased stream ion concentrations (measured as conductivity) in urban systems typically result from runoff over impervious surfaces, passage through pipes, and exposure to other infrastructure (Cushman 2006).

Site	pH SU	Temperature °C	Dissolved Oxygen mg/L	Conductivity µS/cm	Turbidity NTU
PSB-01	6.26	16.3	7.19	1510	2.2
PSB-02	6.35	13.2	7.01	1313	0.2
PSB-03	6.90	12.1	9.86	1140	-1.4

3.4 GEOMORPHIC ASSESSMENT

The geomorphic assessment field data were compared to both the Maryland Coastal Plain (MCP) regional relationships of bankfull channel geometry (McCandless 2003) and relationships for gaged urban Coastal Plain streams developed specifically for Anne Arundel County (AADPW 2002) to determine how bankfull characteristics observed in the field compared to those predicted by the MCP and urban relationships. Comparisons of bankfull width, bankfull cross-sectional area, and mean bankfull depth are shown in Figures 3-1, 3-2, and 3-3, respectively. Bankfull width values tended to loosely fit the predictions of the urban curve, with some points wider than predicted due to the engineered channel design. All bankfull cross-section area field data values fell between the MCP curve and urban curve predictions. Field data for mean bankfull depth mainly fell between the MCP curve and urban curve predictions, with one site falling just below the MCP curve. Overall, it appears that some of the field data were not consistent with the MCP relationships; however, it should be noted that the regional curves were developed using streams with drainage areas ranging from 0.3 to 89.7 square miles, with the majority of the data collected in watersheds greater than one square-mile with low (zero to three percent) imperviousness. Thus, it is possible that stream channels with smaller drainage areas, such as those studied in this assessment (ranging from 0.07 to 0.23 square miles), exhibit greater variability in channel dimensions when compared to the MCP relationships. Additionally, the Rosgen method is best used on streams that are free to adjust their lateral boundaries under the current discharge regime experienced by the system (Rosgen 1996), conditions which do not necessarily exist in the study area. For example, cross-sections 2, 3, and 5 are underlain by concrete trapezoidal channels, possibly making the accurate determination of the bankfull indicators in the field at these locations problematic. Regardless, given the high imperviousness of the study drainage area and the modified nature of the channel, it is not surprising that the field data deviated in many cases from the MCP curve and were more closely matched to urban curve predictions for bankfull width.

Based on the Rosgen Classification scheme, two sites were classified as E channels, two sites as F channels, and one site was classified as a C channel (Table 3-4). Water surface slopes along the study area ranged from 0.0018 ft/ft to 0.015 ft/ft. D50's ranged from 0.11 mm to 1.1 mm, meaning all five sites had channel substrates dominated by sand. Detailed summaries of the geomorphic data and stream types are included in Appendix B: Geomorphic Assessment Results.

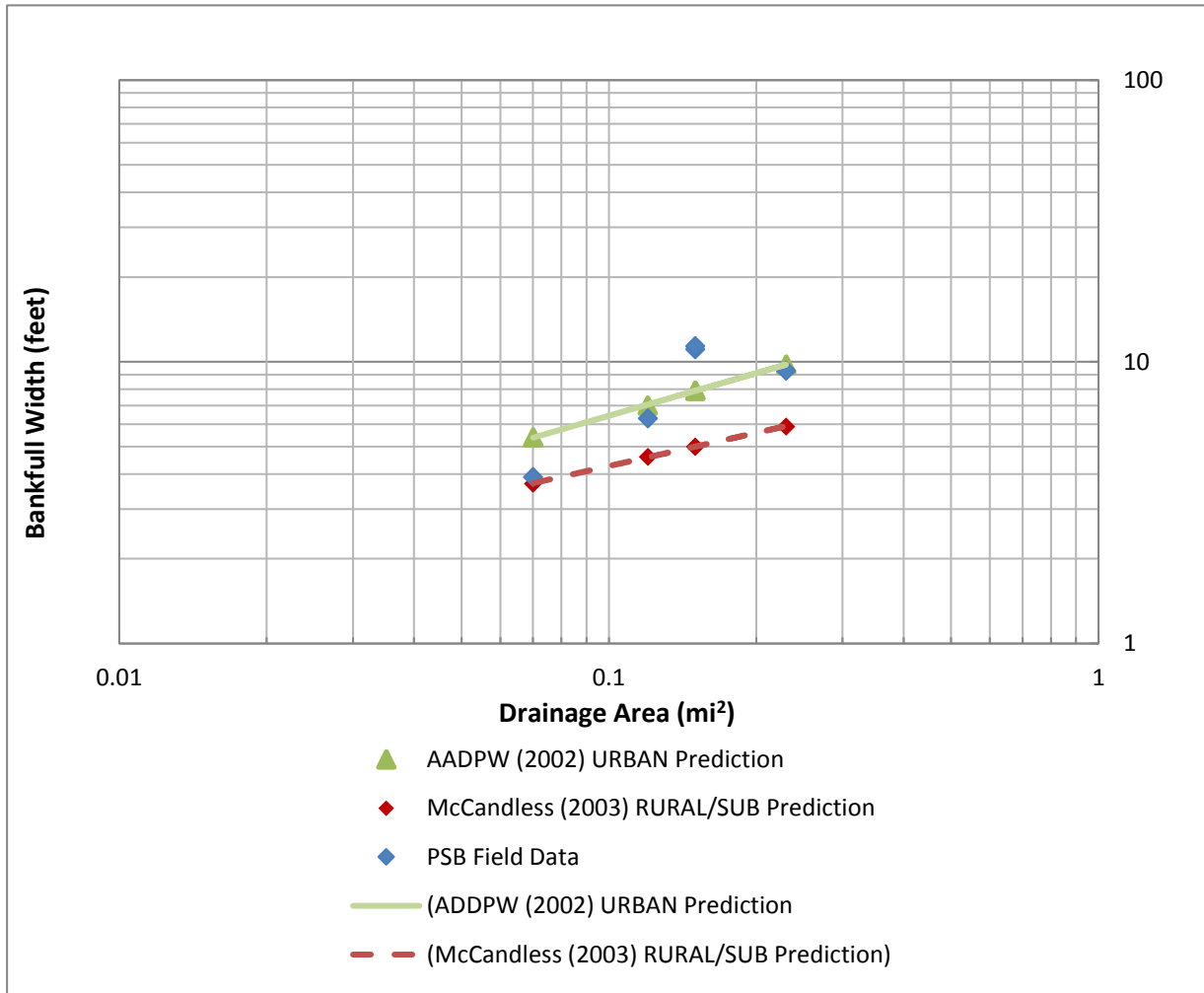


Figure 3-1. Comparison of the bankfull width drainage area relationship between Picture Spring Branch (PSB) 2017 field data and regional relationship curve data

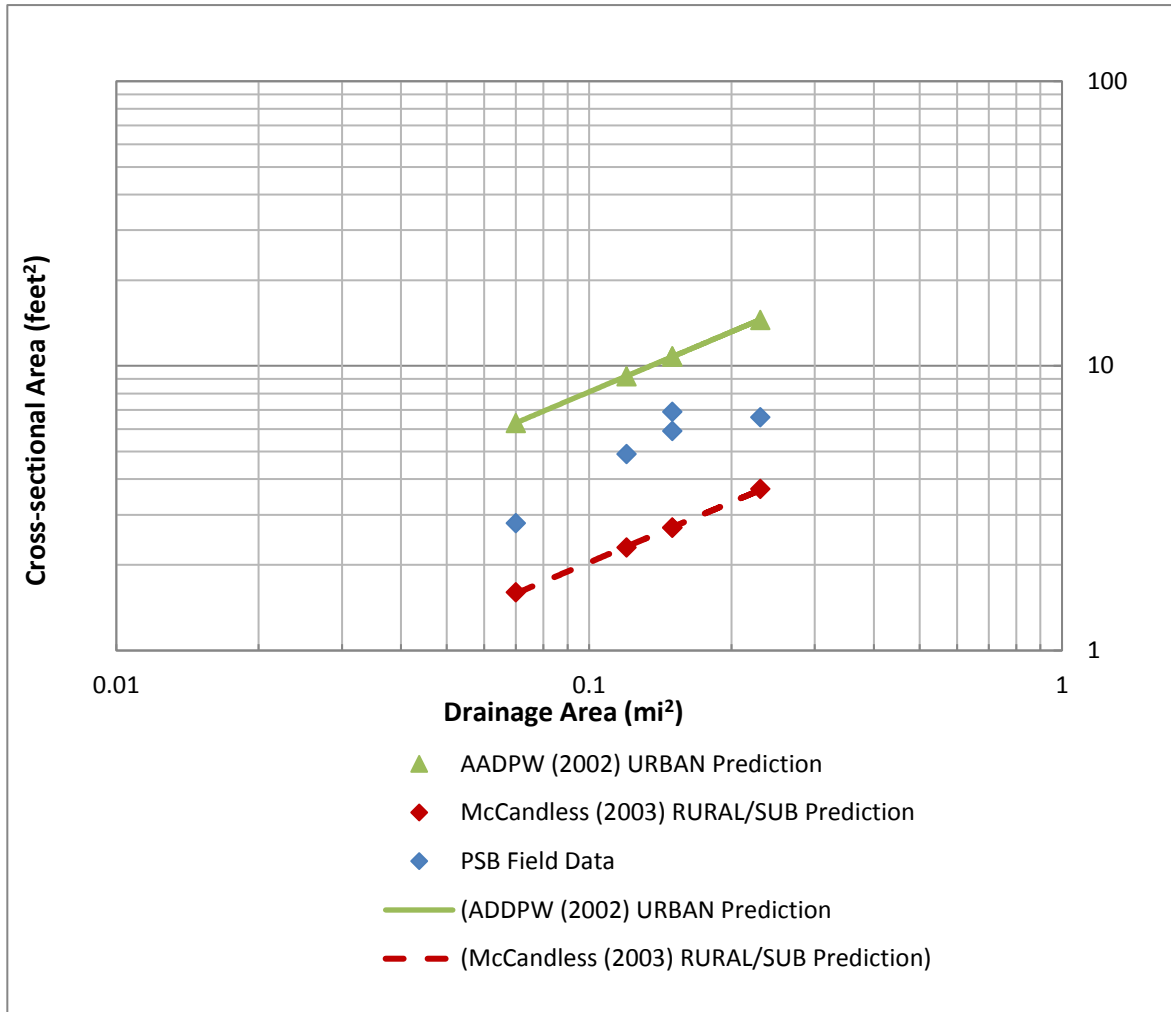


Figure 3-2. Comparison of the bankfull cross-sectional area drainage area relationship between Picture Spring Branch (PSB) 2017 field data and regional relationship curve data

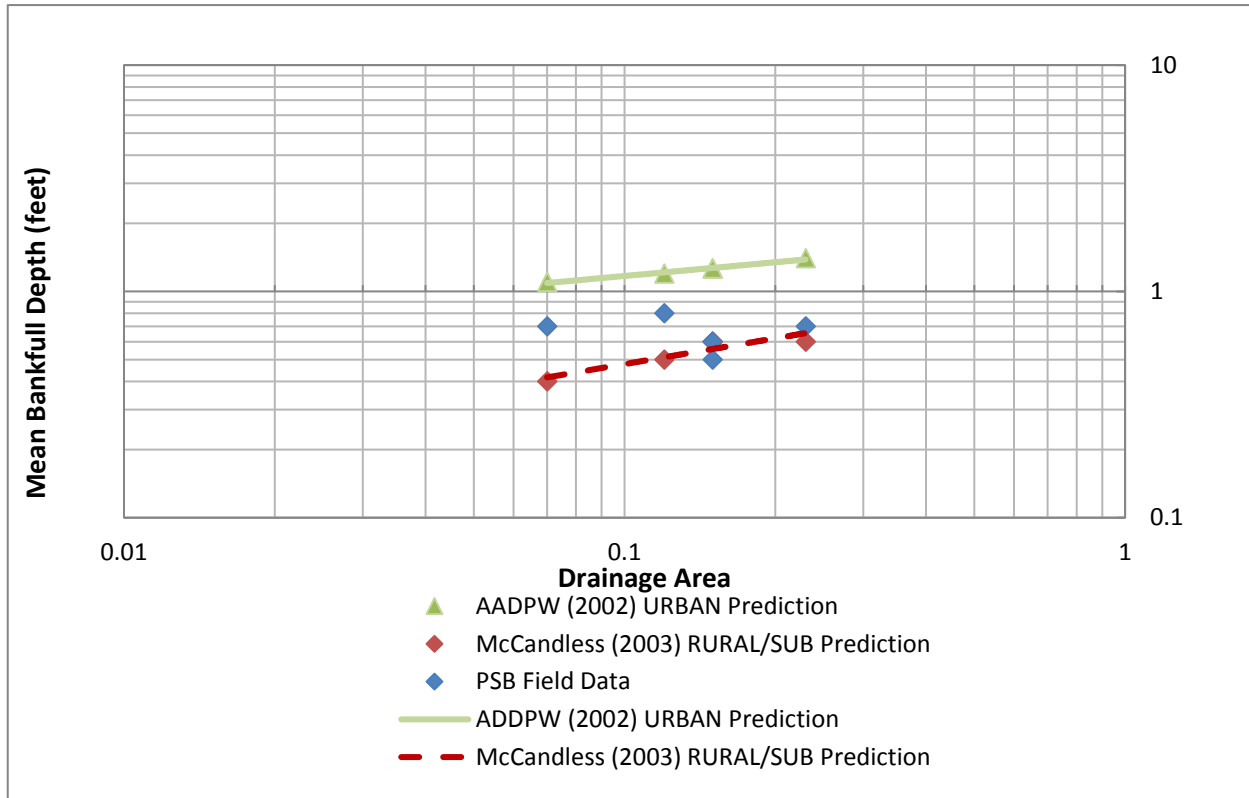


Figure 3-3. Comparison of the mean bankfull depth drainage area relationship between Picture Spring Branch (PSB) 2017 field data and regional relationship curve data

Cross-section	Classification	D50 (mm)	Water Surface Slope (ft/ft)
XS-1	E5	0.11	0.011
XS-2	F5	0.30	0.0018
XS-3	F5	0.35	0.0048
XS-4	E5	0.31	0.015
XS-5	C5	1.10	0.003

The channel located in the well-forested, upper portion of the North Tributary at cross-section 1 exhibited characteristics typical of both C and E type channels, as well as some characteristics that fit neither. For example, E channels are typically very sinuous; however, this reach had very little sinuosity. Likewise, C channels often have numerous point bars, which were not common along this reach. As a result, best professional judgment was applied and the final decision was to change the classification from a C5 to an E5 given the decreased entrenchment and width/depth ratio. F channels were identified at cross-sections 2 and 3, which had been altered in the past with concrete trapezoidal channels. The channel along this segment of the

North Tributary and downstream of Maryland State Highway 170 was over-widened as a result of the channelization. However, it continues to adjust by filling with sediment and woody debris, thus establishing a more “natural” stream channel within the man-made, engineered channel. Cross-section 5 remains classified as a C5 channel with comparable entrenchment and width/depth ratios measured in 2016. The Rosgen classification at this cross-section previously changed from an F5 in 2014, to a C5 in 2015.

An E channel was identified at cross-section 4 on the South Tributary, which appeared to have been channelized in the past and is piped underground for a significant distance upstream, further modifying its hydrology. However, the South Tributary is not overwidened and is significantly steeper than the North Tributary. Indicators were observed that show some limited floodplain connectivity along the upstream portion of the tributary where the cross-section is located. However, just downstream of the cross-section location, the channel became noticeably entrenched and showed signs of active downcutting. While it is possible that this reach may exhibit both B and E characteristics along different portions of the reach, it was assigned an E5 classification primarily based on the entrenchment and width/depth ratios measured at the cross-section location. Evidence of recent downcutting (e.g., nick points) suggests that the reach is unstable and is likely shifting from an E channel to a B channel. Significant changes in the shape of this cross-section were observed during the 2013 survey, as the channel had noticeably deepened and widened since the 2012 survey (Appendix B). Over the next year, as seen in the 2014 survey, aggradation occurred affecting the bed level by raising it approximately 0.5 feet. From 2014 to 2015, the channel has shifted slightly, but has remained stable in terms of aggradation or deepening. Noticeable aggradation occurred again in 2016 by an approximate 0.5-foot rise in bed elevation but the bed was stable between the 2016 and 2017 surveys. Analysis of the longitudinal profile overlay from 2007 through 2017 shows considerable downcutting between stations 1+00 and 2+20 (Appendix B). However, during 2014 the pool near station 2+00 has mostly filled in. This trend continued in 2015, with the pool working its way up the reach to station 1+80. In 2016, the pool remained at station 1+80 but deepened by almost a foot with no additional changes occurring in 2017. The headcut and large scour pool between stations 2+68 and 2+90 just downstream from this eroded section have not worsened. However, in 2016 this scour pool shifted downstream by a few feet. It is recommended that this area continue to be monitored, since further erosion could eventually lead to undermining of the concrete-lined channel just downstream.

An overlay of North Tributary longitudinal profiles shows little change occurring to this reach from 2007 through 2017 (Appendix B). Numerous man-made structures (i.e., culverts, concrete-lined channel) throughout this reach appear to be providing adequate grade control, preventing substantial channel degradation.

4.0 SUMMARY AND CONCLUSIONS

4.1 BIOLOGICAL ASSESSMENT SUMMARY

Water quality measurements showed all parameters near or within COMAR standards. pH values were low at both PSB-01 and PSB-02, but do not considerably deviate from past records at the sites. Conductivity levels at all of the sampling sites continue to be elevated, which is likely due to the high percent of impervious surfaces within the drainage area and the resulting stormwater runoff. In urban systems, high conductivity may be an indicator of road salt usage (Morgan et al. 2012, Southerland et al. 2007, Kaushal et al. 2005); however, chloride concentrations are often necessary to confirm whether road salts are a primary source. Given the presence in the watershed of the large MARC train station Park & Ride lots, which likely receive large quantities of de-icing salts, and two adjacent detention/shallow wetland ponds, which may accumulate the salts and slowly release them through the groundwater, it is plausible that road salt application is responsible, at least in part, for the observed elevated conductivity.

Physical habitat was rated “Minimally Degraded” or “Partially Degraded” at all sites throughout the study area, which is a slight improvement over the scores from 2016 (Table 4-1). The increase in scores are primarily a result of small increases in instream woody debris, and consequently, an increase in epifaunal substrate scores as well as instream habitat scores. PSB-01 is located along the wooded upper reach of the North Tributary, which had a substantial riparian buffer, adequate shading, minor bank erosion, and sufficient instream woody debris and rootwads. These factors increase the potential of the stream to support a diverse macroinvertebrate community. Sites PSB-02 and PSB-03 had some improvement in their physical habitat. While these two sites still had marginal riparian buffers and scored very low for remoteness, they too exhibited an increase in instream woody debris. The resulting improvement in epifaunal substrate and instream habitat moved these two sites into the “Partially Degraded” category for 2016 and 2017, despite their proximity to routes 170 and 175.

During the past five years of monitoring, PHI scores have fluctuated slightly from year to year (Figure 4-1). Fluctuations in annual physical habitat scores may be attributed to two primary factors: 1) changes in habitat suitable for colonization (i.e., changes in substrate/embeddedness and changes in the quantity of woody debris) affects direct scoring of this parameter, and also indirectly influences scoring for epifaunal substrate and instream habitat; and 2) variability in qualitative visual assessment scoring between field crews.

In 2013, the updated MBSS PHI methods (Paul et al. 2003) were used to calculate PHI instead of the original MBSS methods (Hall et al. 2002) which had been used in the Picture Spring Branch watershed reports from prior years. Scores for 2006-2012 shown in Table 4-1 and Figure 4-1 were calculated using the original method, while the scores for 2013-2017 were calculated using the updated method.

Table 4-1. PHI scores from 2006 to 2017				
	Site	PSB-01	PSB-02	PSB-03
2006	PHI Score	66.0	60.1	50.9
	Rating	Degraded	Degraded	Severely Degraded
2007	PHI Score	79.6	69.5	69.5
	Rating	Partially Degraded	Partially Degraded	Partially Degraded
2008	PHI Score	84.5	73.0	73.3
	Rating	Minimally Degraded	Partially Degraded	Partially Degraded
2009	PHI Score	76.4	65.9	58.6
	Rating	Partially Degraded	Degraded	Degraded
2010	PHI Score	84.3	72.4	73.8
	Rating	Minimally Degraded	Partially Degraded	Partially Degraded
2011	PHI Score	83.3	73.4	71.9
	Rating	Minimally Degraded	Partially Degraded	Partially Degraded
2012	PHI Score	83.9	74.8	73.2
	Rating	Minimally Degraded	Partially Degraded	Partially Degraded
2013	PHI Score	77.2	62.6	57.2
	Rating	Partially Degraded	Degraded	Degraded
2014	PHI Score	77.7	64.7	65.7
	Rating	Partially Degraded	Degraded	Degraded
2015	PHI Score	72.1	64.4	60.5
	Rating	Partially Degraded	Degraded	Degraded
2016	PHI Score	79.0	67.8	68.0
	Rating	Partially Degraded	Partially Degraded	Partially Degraded
2017	PHI Score	81.1	71.5	71.2
	Rating	Minimally Degraded	Partially Degraded	Partially Degraded

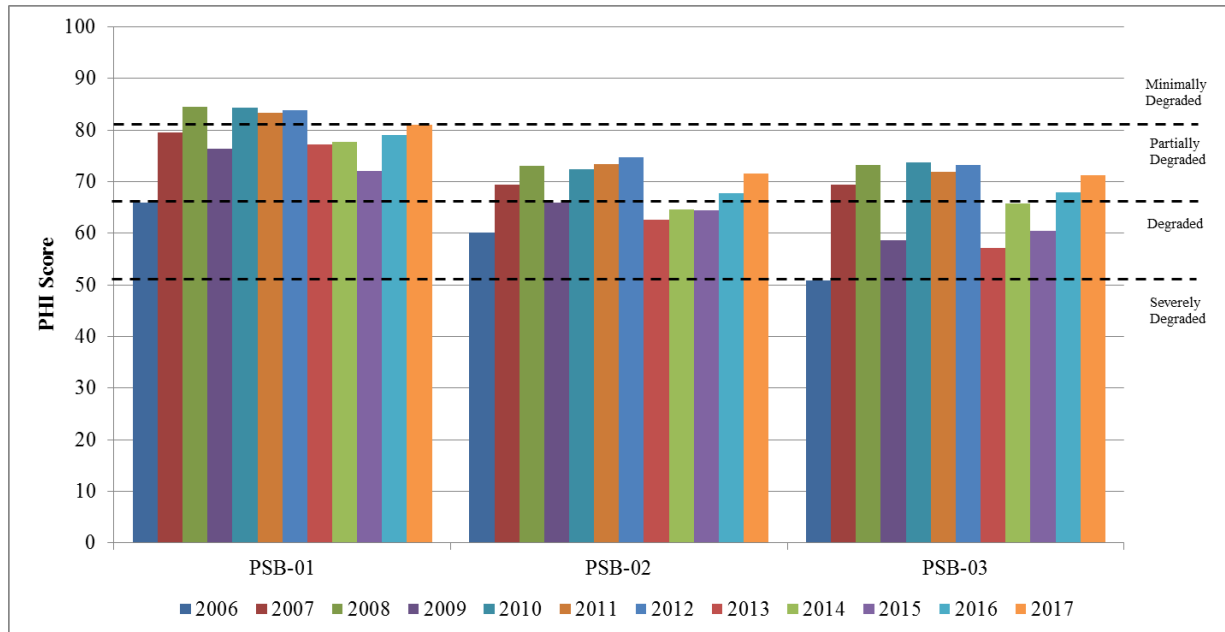


Figure 4-1. Comparison of PHI Habitat Scores from 2006 through 2017

In 2016 and 2017, the benthic macroinvertebrate community at all three sites within the Picture Spring Branch study area were rated as “Fair”. These BIBI scores are higher than in 2014 and 2015, and rank in the “Fair” category for the first time since 2012. A variety of the individual BIBI metrics have shown steady increases over this time period. For example, taxa diversity as measured by total taxa has increased at all three sites every year since 2014. Percentage of sample intolerant to urban stressors at sites showed improvement as well and increased in percentage of sub-sample for the last three years. In 2017, these individuals ranged from 3.4% (PSB-03) to 26.1% (PSB-01) of the total specimens. Percentages of climbers also increased at all three sites. No Ephemeroptera taxa were found at any site during this sampling period. Figure 4-2 provides a visual comparison of BIBI scores over time.

Site		PSB-01	PSB-02	PSB-03
2006	BIBI Score	3.00	2.71	2.43
	Rating	Fair	Poor	Poor
2007	BIBI Score	3.29	3.00	3.57
	Rating	Fair	Fair	Fair
2008	BIBI Score	3.86	3.00	2.71
	Rating	Fair	Fair	Poor
2009	BIBI Score	2.43	2.71	1.86
	Rating	Poor	Poor	Very Poor

Site		PSB-01	PSB-02	PSB-03
2010	BIBI Score	2.71	3.00	2.43
	Rating	Poor	Fair	Poor
2011	BIBI Score	3.29	3.29	2.71
	Rating	Fair	Fair	Poor
2012	BIBI Score	3.29	3.00	3.00
	Rating	Fair	Fair	Fair
2013	BIBI Score	2.71	3.29	3.00
	Rating	Poor	Fair	Fair
2014	BIBI Score	2.43	2.71	2.43
	Rating	Poor	Poor	Poor
2015	BIBI Score	2.43	2.71	3.00
	Rating	Poor	Poor	Fair
2016	BIBI Score	3.29	3.0	3.29
	Rating	Fair	Fair	Fair
2017	BIBI Score	3.57	3.57	3
	Rating	Fair	Fair	Fair

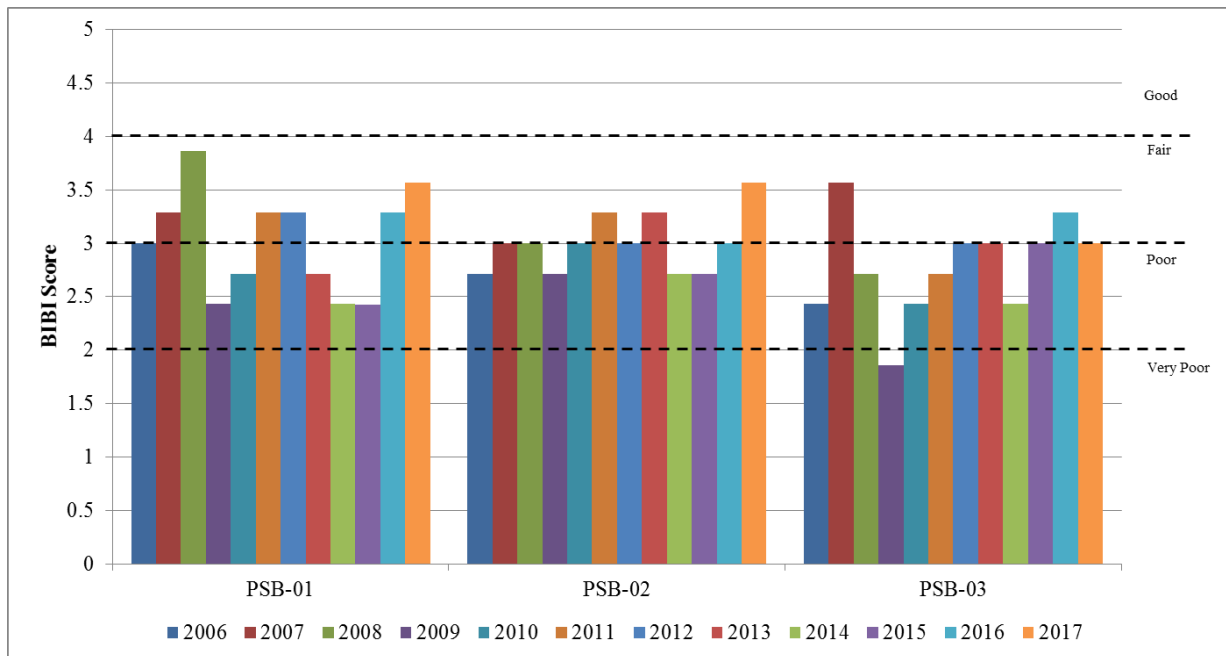


Figure 4-2. Comparison of BIBI Scores from 2006 through 2017

4.2 GEOMORPHIC ASSESSMENT SURVEY

The majority of the streams within the Picture Spring Branch study area have been altered by past channelization and the installation of concrete-lined channels, resulting from modifications made to accommodate runoff from Maryland State Highways 170 and 175, running both parallel and adjacent to the stream channel. Consequently, stream reaches in the vicinity of cross-sections XS-2, XS-3, and XS-5, on the North Tributary and mainstem were overwidened resulting in F channels at these locations. A notable amount of sediment has deposited in these concrete channels in the past, and it appears as though these channels have become naturalized, especially below Route 170 where a more natural stream pattern is emerging, resulting in a C channel forming within the larger channel at XS-5. These cross-sections also appeared quite stable during recent years, having shown very little change from previous surveys, with the exception of XS-5 which experienced notable aggradation across its total width between 2011 and 2012. Between 2012 and 2013 the right-side stream bed at XS-5 eroded slightly while the left side had no change. From 2014 to 2017, surveys continued to show minor erosion at the bottom of the left bank. Past channelization also appears to have occurred on the South Tributary in the vicinity of cross-section XS-4. The slope of the South Tributary is much greater than that of the North Tributary, and the channel is showing signs of active downcutting. Historically, the reach of stream in the Picture Spring Branch study area which appeared to be least disturbed was in the vicinity of XS-1. This section of stream is in a forested upper portion of the North Tributary and is classified as an E5 channel in 2017.

To compare changes in cross-sectional area over time, cross-sectional area from 2011 through 2017 was calculated using the top of bank elevation from the baseline survey in order to standardize comparisons and reduce variability among more subjective bankfull elevation reference points, or even changes that can occur to top of bank elevations from year to year. It is important to note that calculations prior to 2011 did not use the baseline reference elevation, instead they used the corresponding years top of bank elevation for calculating cross-sectional area, and consequently these values are not directly comparable to the cross-sectional areas reported in 2011 through 2017. Comparison of baseline cross-sectional area is however comparable from 2011 through 2017 since all calculations are made using the same top of bank elevation. Channel dimensions appear moderately constant for three out of the five cross-sections, compared to baseline conditions (Table 4-3). The stream channel at XS-2, XS-3, and XS-5 has remained relatively stable from 2011 to 2017, with cross-sectional area increasing 0.3% at XS-2 and decreasing 4.0% and 6.0% at XS-3 and XS-5, respectively, and decreasing only 1.8%, 7.0%, and 7.9%, respectively, since 2003. In contrast, significant increases in cross-sectional areas have occurred at XS-1 and XS-4 from baseline conditions. Due to channel deepening, cross-sectional area at XS-1 has increased 59.4% from baseline conditions (2005) and XS-4 has had cross-sectional area increase 22.4% from baseline conditions (2003). While overall cross-sectional areas have increased substantially at these two locations, cross-sectional areas over the past six years have stabilized, with only a 5.2% increase at XS-1 and no increase, 0.0%, at XS-4. Unsurprisingly, XS-1 and XS-4 are located in portions of stream where there has been no engineering or armoring of the stream channel, while the other three cross-sections have been channelized.

Cross-section^(a)	XS-1	XS-2	XS-3	XS-4	XS-5
July 2003	ND	146.0	84.5	7.6	35.5
Jan 2005	6.4	164.4	83.2	5.5	35.2
March 2006	7.6	143.9	81.0	7.6	34.0
March 2007	6.8	142.6	81.1	7.6	32.9
May 2008	6.3	141.5	81.5	7.4	34.9
July 2009	6.8	142.8	80.8	8.4	33.4
May 2010	6.0	145.2	80.5	9.7	34.5
July 2011^(b)	9.7	143.0	81.9	9.3	34.8
April 2012^(b)	8.0	143.1	81.8	9.2	28.4
July 2013^(b)	8.6	142.8	80.4	10.5	30.9
June 2014^(b)	8.8	141.9	77.4	10.0	32.6
June 2015^(b)	10.2	143.0	80.9	10.3	31.6
March 2016^(b)	9.8	144.7	75.4	9.6	33.2
February 2017^(b)	10.2	143.3	78.6	9.3	32.7
% Change 2003-2017	59.4 ^(c)	-1.8	-7.0	22.4	-7.9
% Change 2011-2017	5.2	0.3	-4.0	0.0	-6.0

^(a) All values listed here are for top of bank area
^(b) Values obtained using reference elevations (top of bank) from baseline measurements
^(c) % change from 2005
 ND = No Data

4.3 GENERAL CONCLUSIONS

Based upon the data collected over the course of this study, it appears that the development of the West County Library site has not accelerated the degradation of this system. While physical habitat and biological conditions have fluctuated slightly from year to year, the overall conditions have changed minimally when compared to baseline data. It is likely that the best management practices installed within the watershed have reduced the impact of some stressors affecting the stream (i.e., hydrologic alteration) such that the system has begun to stabilize from past alteration and land use modifications (i.e., extensive channelization).

5.0 REFERENCES

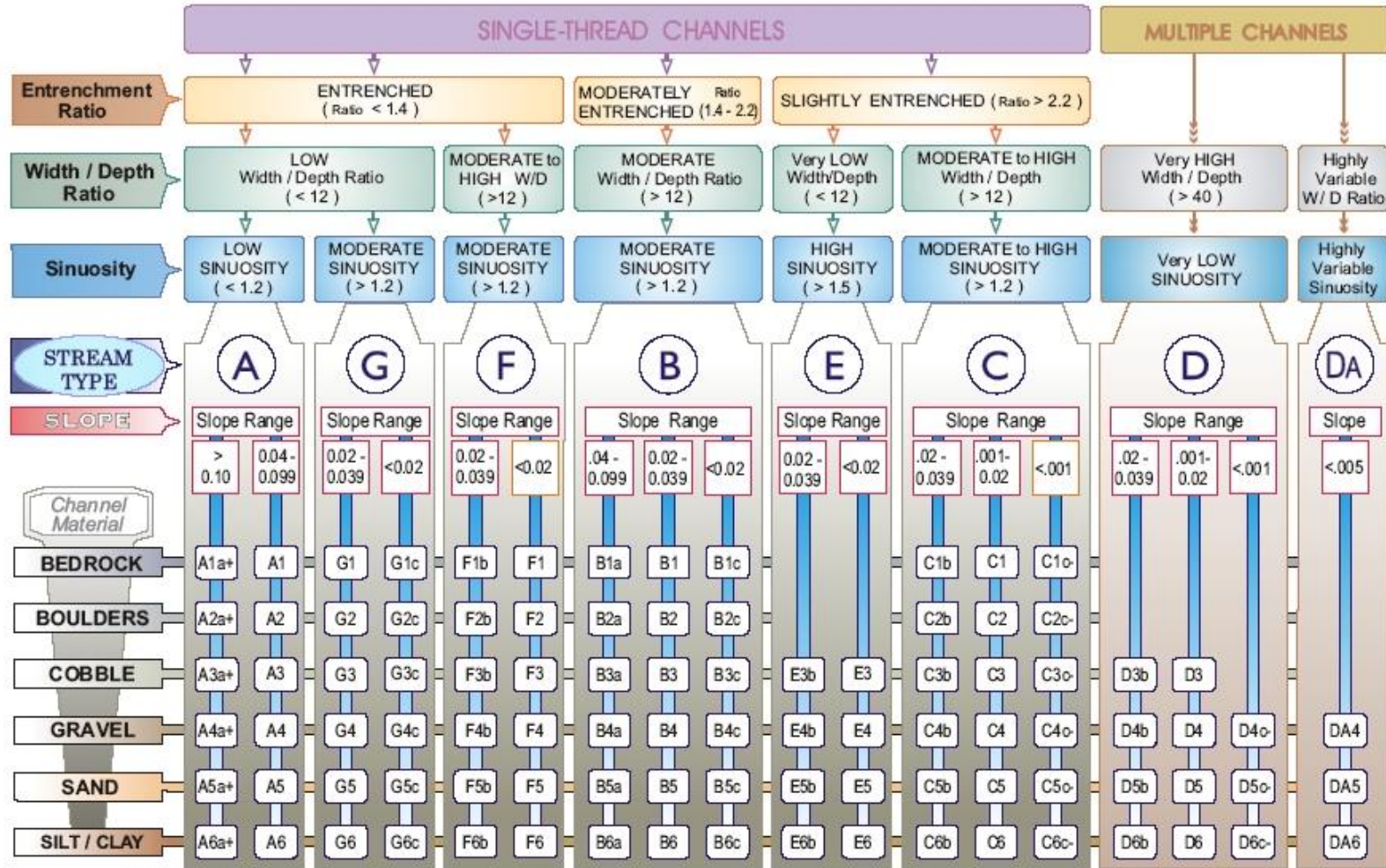
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APPENDIX A
ROSGEN STREAM CLASSIFICATION

The Key to the Rosgen Classification of Natural Rivers



A-3

KEY to the **ROSGEN** CLASSIFICATION of NATURAL RIVERS. As a function of the "continuum of physical variables" within stream reaches, values of **Entrenchment** and **Sinuosity** ratios can vary by +/- 0.2 units; while values for **Width / Depth** ratios can vary by +/- 2.0 units.

Source: Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

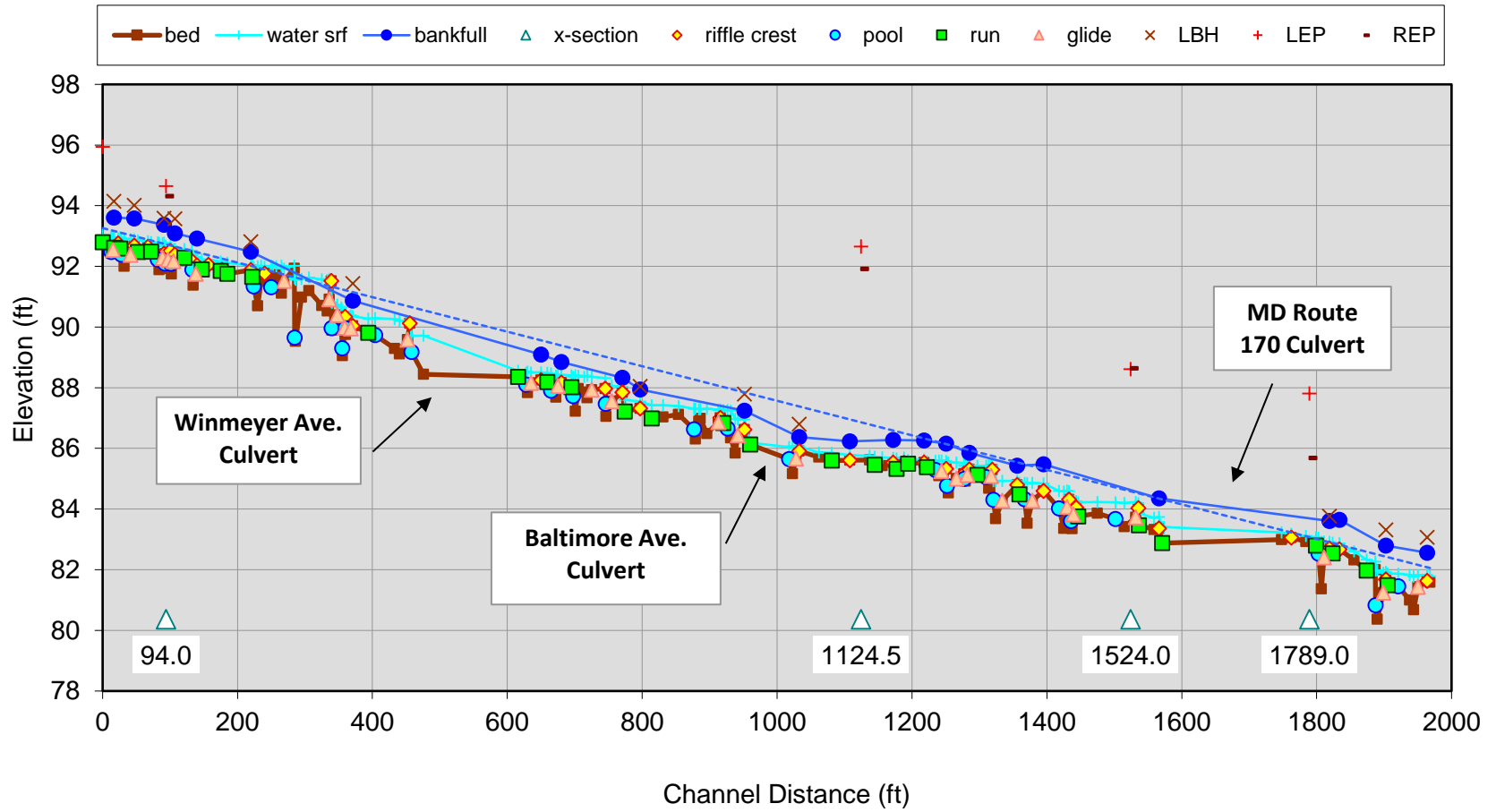
APPENDIX B
GEOMORPHIC ASSESSMENT RESULTS

Picture Spring Branch 2017 Geomorphic Assessment Results Summary

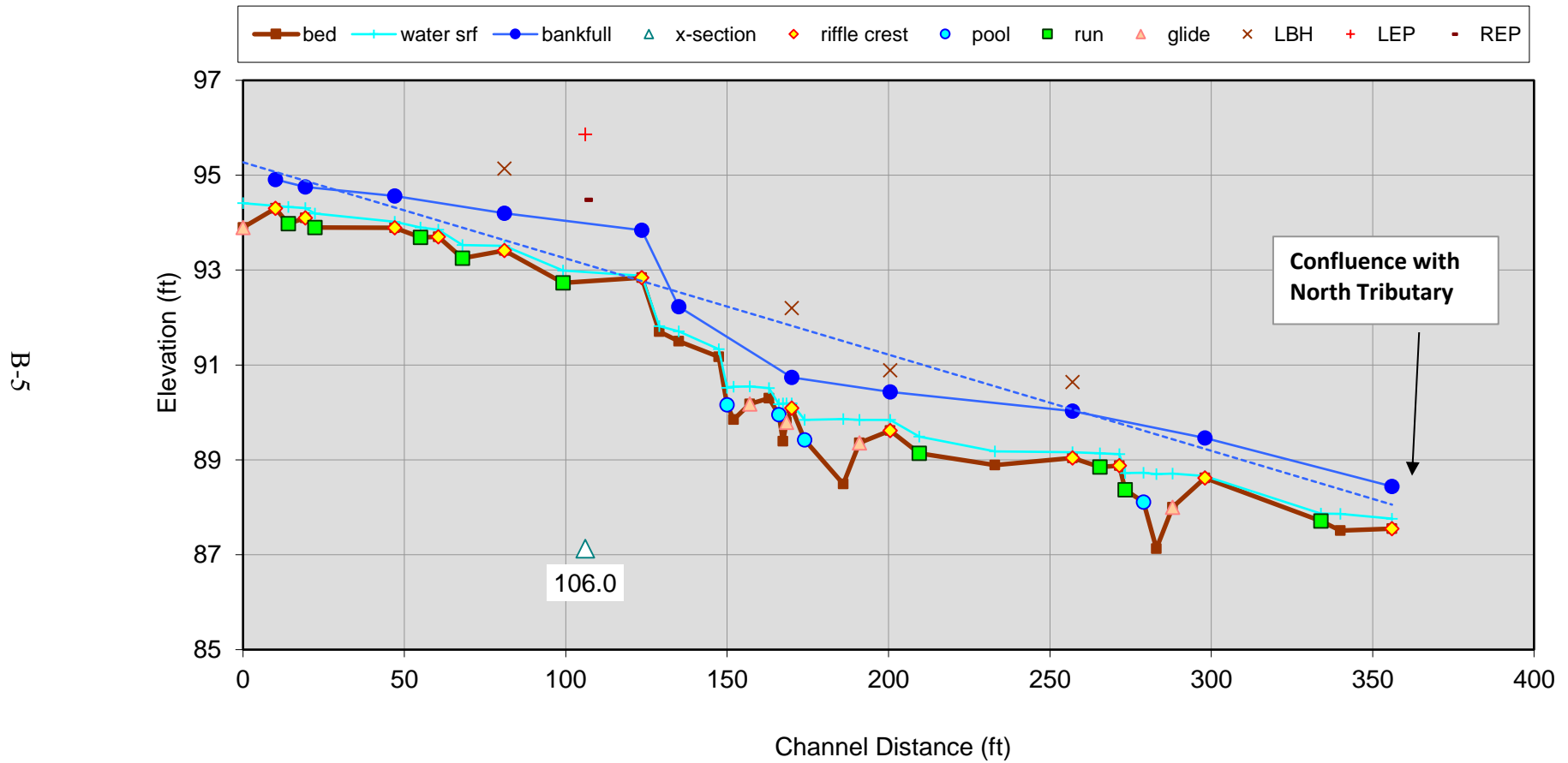
Assessment Parameter	Cross-section				
	XS-1 Pool @ Sta. 0+94	XS-2 Run @ Sta. 11+26	XS-3 Pool @ Sta. 15+24	XS-4 Run @ Sta. 1+06 on South Tributary	XS-5 Riffle @ Sta. 17+89
Classification	E5	F5	F5	E5	C5
Bankfull Width (ft)	6.3	11.1	11.4	3.9	9.3
Mean Depth (ft)	0.8	0.6	0.5	0.7	0.7
Bankfull X-Sec Area (sq ft)	4.9	6.9	5.9	2.8	6.6
Width:Depth Ratio	8.2	18.0	21.9	5.3	13.1
Flood-Prone Width (ft)	35.0	13.5	14.2	22.9	22.3
Entrenchment Ratio	5.5	1.2	1.2	5.9	2.4
D50(mm)	0.11	0.30	0.35	0.31	1.1
Water Surface Slope (ft/ft)	0.011	0.0018	0.0048	0.015	0.003
Sinuosity	<1.2	<1.2	<1.2	<1.2	<1.2
Drainage Area (mi²)	0.12	0.15	0.15	0.07	0.23
Adjustments?	Sin ↑	Sin ↑	Sin ↑	Sin ↑	Sin ↑

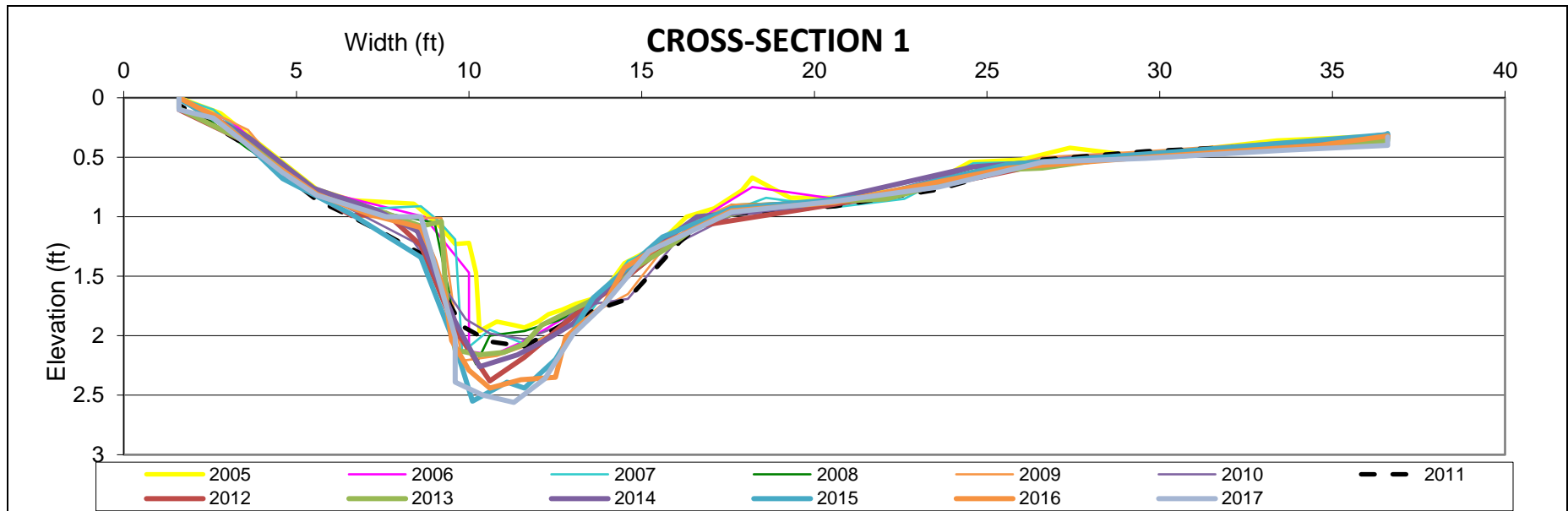
Picture Spring Branch North Tributary Longitudinal Profile

B-4







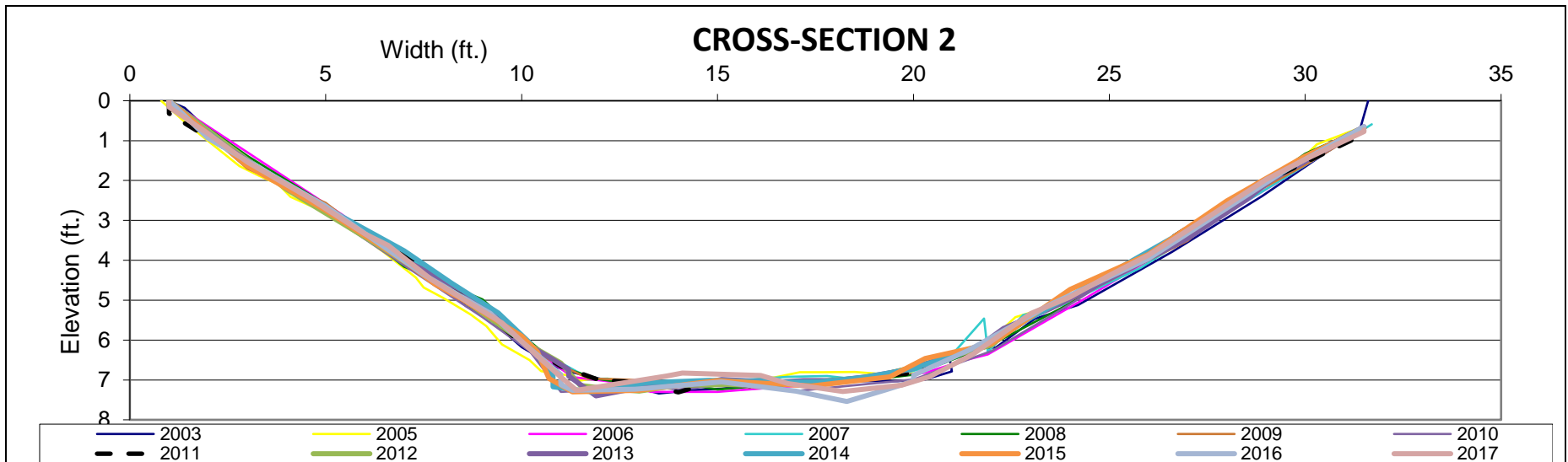
Picture Spring Branch South Tributary Longitudinal Profile





B-6

		2017 Geomorphic Assessment Results	
			
		Mean Depth (d_{bkt}) (feet)	0.8
		Bankfull Cross-sectional Area (A_{bkt}) (feet ²)	4.9
		Width/Depth Ratio (W_{bkt}/d_{bkt})	8.2
Upstream View	Downstream View	Width of Flood-prone Area (W_{fpa}) (feet)	35.0
		Entrenchment Ratio (ER) = W_{fpa}/W_{bkt}	5.5
		Channel Materials D_{50} (millimeters)	0.11
		Water Surface Slope (S)	0.012
		Sinuosity (K) = stream length/valley length	<1.2
		Adjustments?	Sin ↑
Left Bank View	Right Bank View	STREAM TYPE	E5



B-7



2017 Geomorphic Assessment Results

Bankfull Width (W_{bkt}) (feet)	11.1
Mean Depth (d_{bkt}) (feet)	0.6
Bankfull Cross-sectional Area (A_{bkt}) (feet ²)	6.9
Width/Depth Ratio (W_{bkt}/d_{bkt})	18.0
Width of Flood-prone Area (W_{fpa}) (feet)	13.5
Entrenchment Ratio (ER) = W_{fpa}/W_{bkt}	1.2
Channel Materials D_{50} (millimeters)	0.30
Water Surface Slope (S)	0.0027
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑

Upstream View

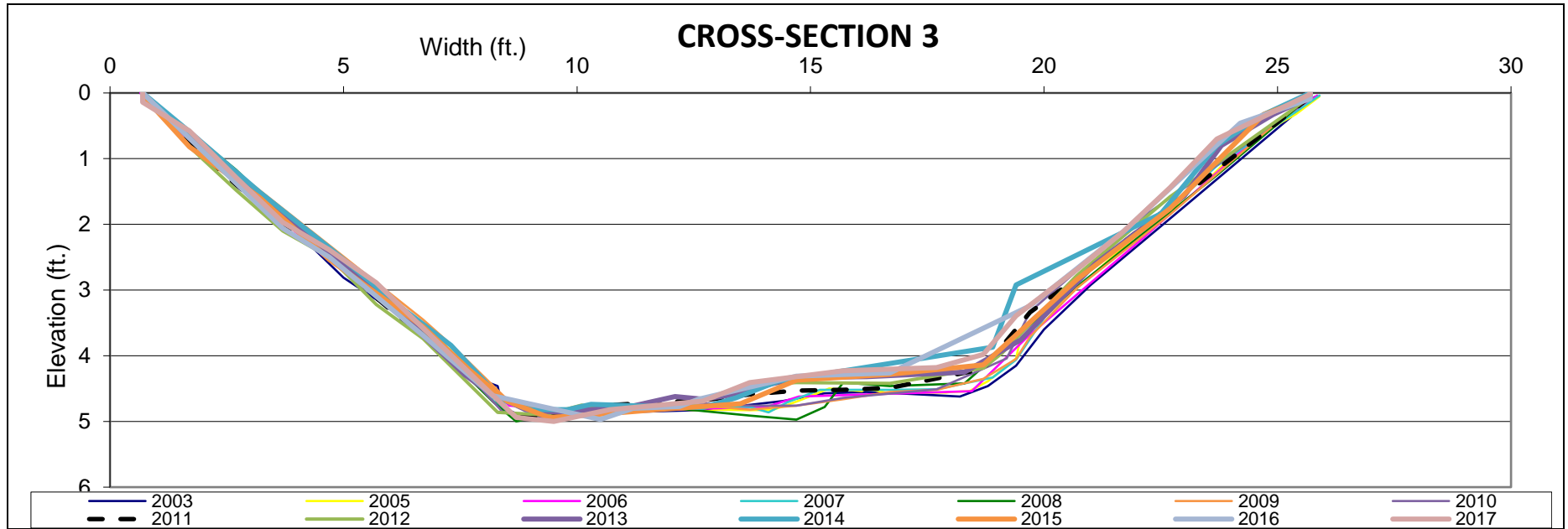
Downstream View

Left Bank View

Right Bank View

STREAM TYPE

F5



B-8



Upstream View



Downstream View

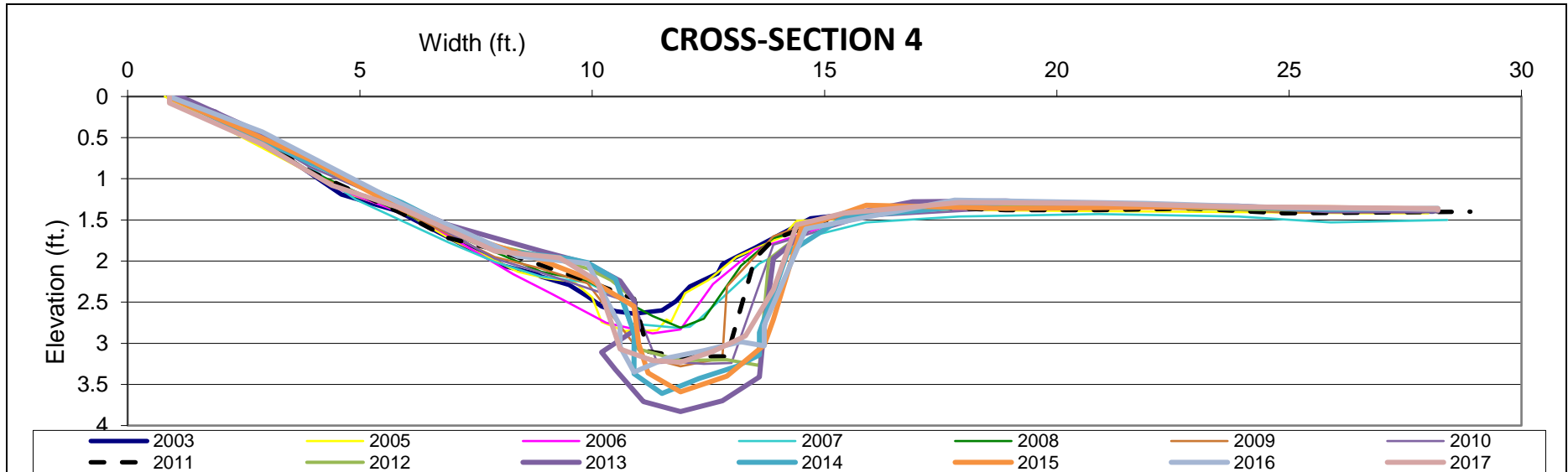


Left Bank View



Right Bank View

2017 Geomorphic Assessment Results	
Bankfull Width (W_{bkt}) (feet)	11.4
Mean Depth (d_{bkt}) (feet)	0.5
Bankfull Cross-sectional Area (A_{bkt}) (feet ²)	5.9
Width/Depth Ratio (W_{bkt}/d_{bkt})	21.9
Width of Flood-prone Area (W_{fpa}) (feet)	14.2
Entrenchment Ratio (ER) = W_{fpa}/W_{bkt}	1.2
Channel Materials D_{50} (millimeters)	0.35
Water Surface Slope (S)	0.0039
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	F5



B-9



Upstream View



Downstream View



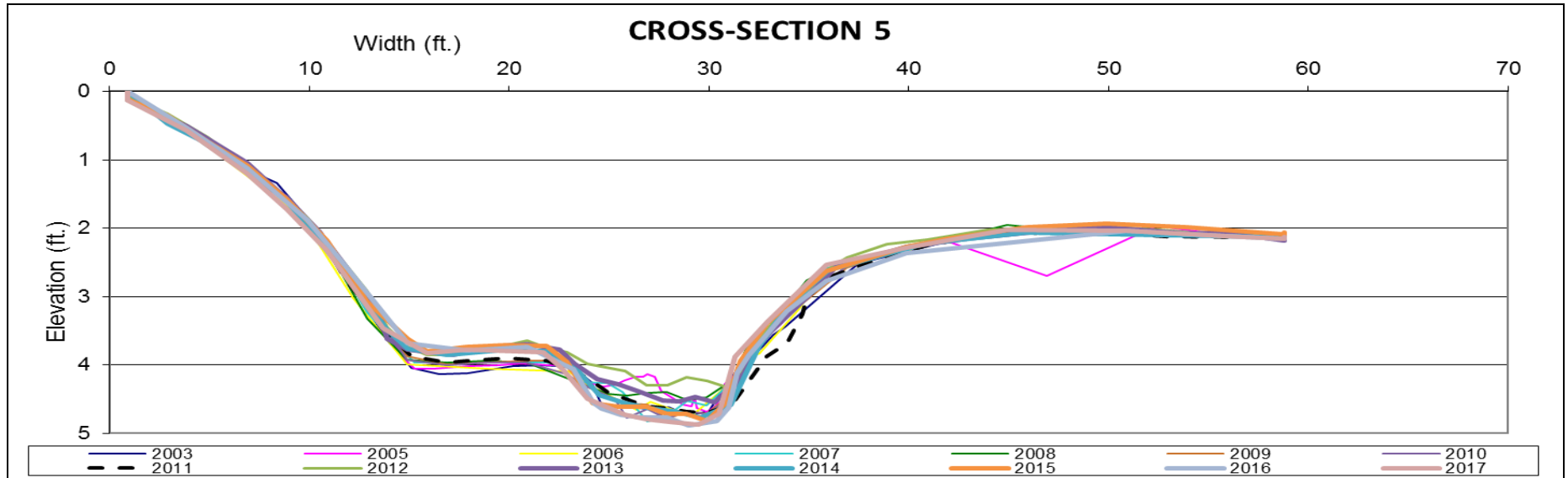
Left Bank View



Right Bank View

2017 Geomorphic Assessment Results

Bankfull Width (W_{bkf}) (feet)	3.9
Mean Depth (d_{bkf}) (feet)	0.7
Bankfull Cross-sectional Area (A_{bkf}) (feet ²)	2.8
Width/Depth Ratio (W_{bkf}/d_{bkf})	5.3
Width of Flood-prone Area (W_{fpa}) (feet)	22.9
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	5.9
Channel Materials D_{50} (millimeters)	0.31
Water Surface Slope (S)	0.015
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	E5



Upstream View

Downstream View

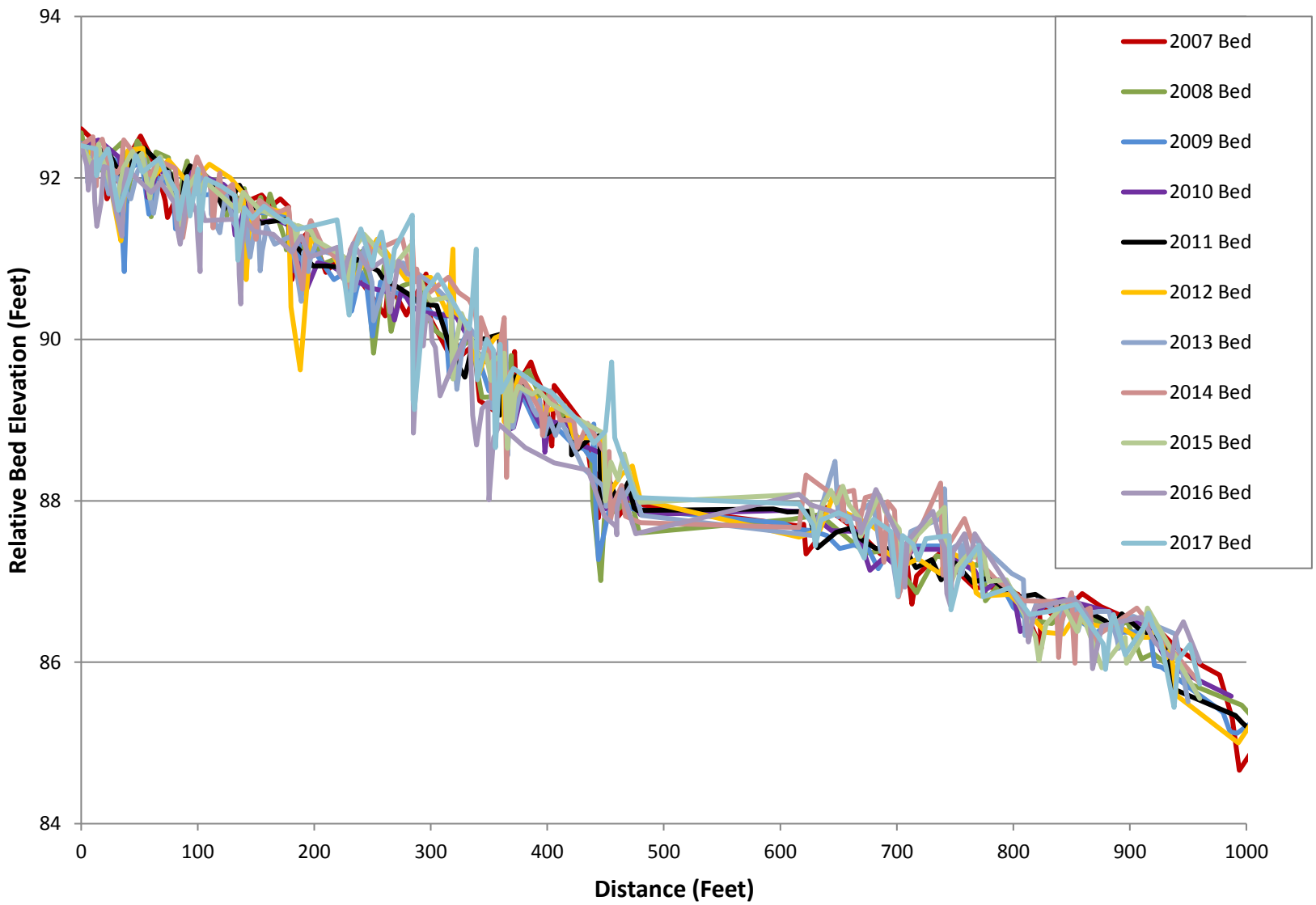


Left Bank View

Right Bank View

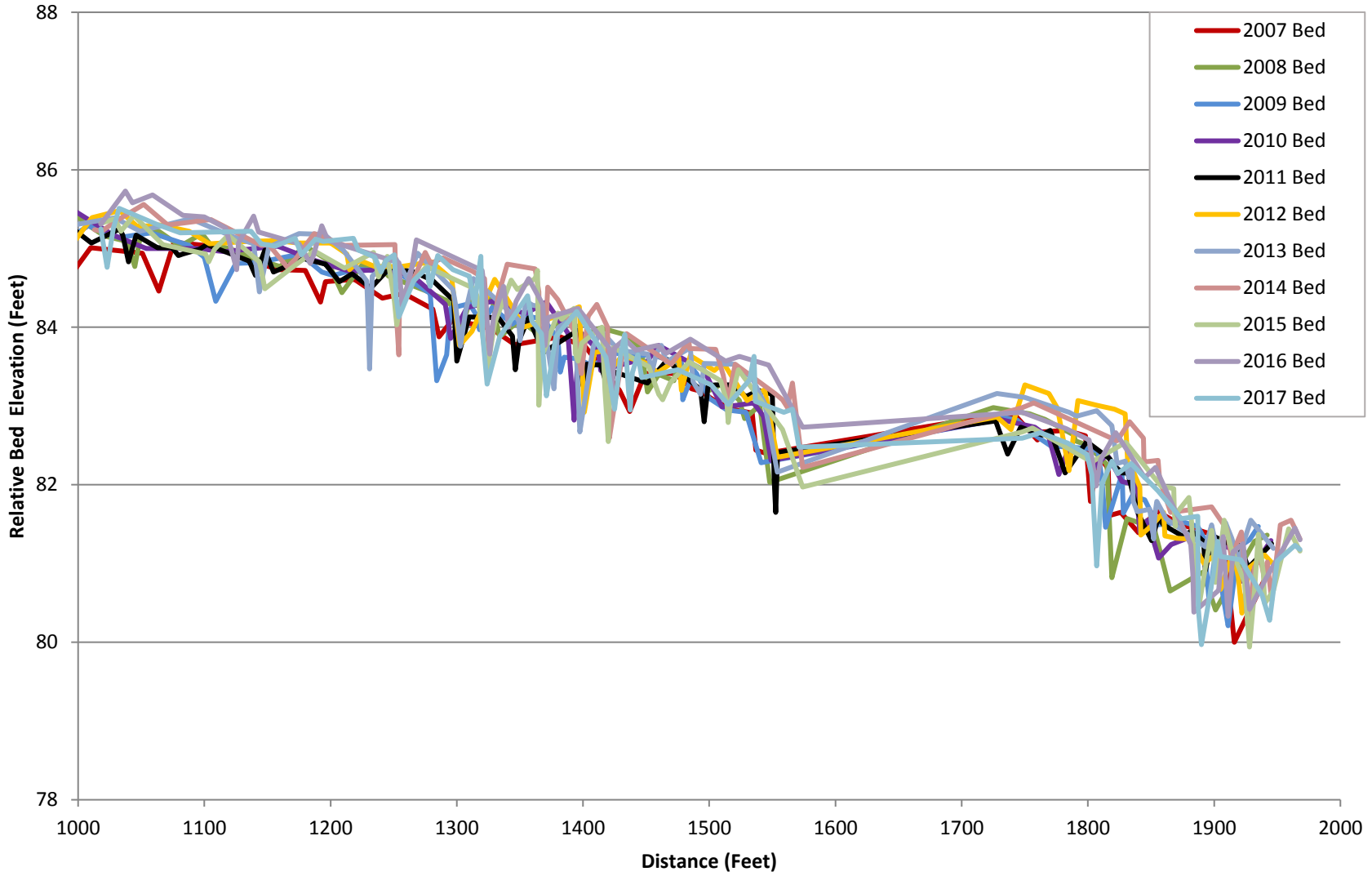
2017 Geomorphic Assessment Results	
Bankfull Width (W_{bkt}) (feet)	9.3
Mean Depth (d_{bkt}) (feet)	0.7
Bankfull Cross-sectional Area (A_{bkt}) (feetz)	6.6
Width/Depth Ratio (W_{bkt}/d_{bkt})	13.1
Width of Flood-prone Area (W_{fpa}) (feet)	22.3
Entrenchment Ratio (ER) = W_{fpa}/W_{bkt}	2.4
Channel Materials D_{50} (millimeters)	1.1
Water Surface Slope (S)	0.0046
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	C5

North Tributary Profile Overlay 2007-2017



B-11

North Tributary Profile Overlay 2007-2017 (Continued)



B-12

APPENDIX C
MASTER BENTHIC MACROINVERTEBRATE TAXA LIST

Order	Family	Genus	Taxon	FFG ^(a)	Habit ^(b)	Tolerance Value ^(c)
Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	Collector	sp	6.7
Amphipoda	Crangonyctidae	Stygonectes	Stygonectes	Collector		8
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7
Basommatophora	Planorbidae	Menetus	Menetus	Scraper	cb	7.6
Coleoptera	Dryopidae	Helichus	Helichus	Scraper	cn	6.4
Coleoptera	Dytiscidae		Dytiscidae	Predator	sw, dv	5.4
Coleoptera	Elmidae	Macronychus	Macronychus	Scraper	cn	6.8
Coleoptera	Elmidae	Stenelmis	Stenelmis	Scraper	cn	7.1
Coleoptera	Halipidae	Peltodytes	Peltodytes	Shredder	cb, cn	8.9
Coleoptera	Hydrophilidae	Hydrobius	Hydrobius	Collector	cb, cn, sp	4.1
Diptera	Chironomidae		Bryophaenocladus	Collector		6
Diptera	Chironomidae	Ablabesmyia	Ablabesmyia	Predator	sp	8.1
Diptera	Chironomidae	Chaetocladus	Chaetocladus	Collector	sp	7
Diptera	Chironomidae	Conchapelopia	Conchapelopia	Predator	sp	6.1
Diptera	Chironomidae	Corynoneura	Corynoneura	Collector	sp	4.1
Diptera	Chironomidae	Limnophyes	Limnophyes	Collector	sp	8.6
Diptera	Chironomidae	Micropsectra	Micropsectra	Collector	cb, sp	2.1
Diptera	Chironomidae	Natarsia	Natarsia	Predator	sp	6.6
Diptera	Chironomidae	Orthocladus	Orthocladus	Collector	sp, bu	9.2
Diptera	Chironomidae	Paracricotopus	Paracricotopus	Collector		6
Diptera	Chironomidae	Parakiefferiella	Parakiefferiella	Collector	sp	2.1
Diptera	Chironomidae	Parametricnemus	Parametricnemus	Collector	sp	4.6
Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	Collector	sp	7.7
Diptera	Chironomidae	Paratendipes	Paratendipes	Collector	bu	6.6
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3
Diptera	Chironomidae	Potthastia	Potthastia	Collector	sp	0
Diptera	Chironomidae	Prodiamesa	Prodiamesa	Collector	bu, sp	6.6
Diptera	Chironomidae	Pseudorthocladus	Pseudorthocladus	Collector	sp	6
Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	Collector	sp	6.2
Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	Filterer	cn	7.2
Diptera	Chironomidae	Smittia	Smittia	Collector	bu	6.6
Diptera	Chironomidae	Stenochironomus	Stenochironomus	Shredder	bu	7.9
Diptera	Chironomidae	Tanytarsus	Tanytarsus	Filterer	cb, cn	4.9
Diptera	Chironomidae	Thienemanniella	Thienemanniella	Collector	sp	5.1
Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia group	Predator	sp	8.2
Diptera	Chironomidae	Tvetenia	Tvetenia	Collector	sp	5.1
Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	Predator	sp	5.3
Diptera	Empididae		Empididae	Predator	sp, bu	7.5
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9
Diptera	Simuliidae	Simulium	Simulium	Filterer	cn	5.7
Diptera	Tabanidae	Chrysops	Chrysops	Predator	sp, bu	2.9
Diptera	Tipulidae	Dicranota	Dicranota	Predator	sp, bu	1.1
Diptera	Tipulidae	Tipula	Tipula	Shredder	bu	6.7
Haplotaxida	Naididae		Naididae	Collector	bu	8.5

Order	Family	Genus	Taxon	FFG ^(a)	Habit ^(b)	Tolerance Value ^(c)
Hemiptera	Gerridae	Trepobates	Trepobates	Predator	sk	6
Hemiptera	Veliidae	Microvelia	Microvelia	Predator	sk	6
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6
Lumbriculida	Lumbriculidae		Lumbriculidae	Collector	bu	6.6
Odonata	Aeshnidae	Boyeria	Boyeria	Predator	cb, sp	6.3
Odonata	Calopterygidae	Calopteryx	Calopteryx	Predator	cb	8.3
Odonata	Coenagrionidae	Argia	Argia	Predator	cn, cb, sp	9.3
Odonata	Coenagrionidae	Ischnura	Ischnura	Predator	cb	9
Plecoptera	Leuctridae	Leuctra	Leuctra	Shredder	cn	0.4
Trichoptera			Trichoptera			4.6
Trichoptera	Hydropsychidae		Hydropsychidae	Filterer	cn	5.7
Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	Filterer	cn	6.5
Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	Filterer	cn	2.7
Trichoptera	Lepidostomatidae	Lepidostoma	Lepidostoma	Shredder	cb, sp, cn	0
Trichoptera	Limnephilidae	Ironoquia	Ironoquia	Shredder	sp	4.9
Trichoptera	Philopotamidae	Chimarra	Chimarra	Filterer	cn	4.4
Trichoptera	Polycentropodidae		Polycentropodidae		cn	0.2
Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	Filterer	cn	1.1
Tricladida	Dugesidae	Girardia	Girardia	Predator	sp	9.3
Tubificida	Tubificidae		Tubificidae	Collector	cn	8.4
Veneroida	Pisidiidae		Sphaeriidae	Filterer	bu	6.5
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7

^(a) Functional Feeding Group
^(b) Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer
Some information for the particular taxa was not available
^(c) Tolerance Values, based on Hilsenhoff, modified for Maryland

APPENDIX D
QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance/Quality Control Summary for NPDES Monitoring Activities

This section describes all Quality Assurance/Quality Control (QA/QC) procedures implemented for this project including field sampling, laboratory sorting and subsampling, data entry, metric calculation, final IBI calculation, geomorphic field sampling, and classification of stream types.

Field Sampling

Initial QA/QC procedures for benthic macroinvertebrate field sampling included formal training for field crew leaders in MBSS Sampling Protocols. All field crew members have attended at least one MBSS Spring Index Period Training. At least one crew member extensively trained and certified in MBSS sampling protocols was present for each field sampling day. Also during field sampling, each data sheet was double checked for completeness and sample bottle labels were double checked for accuracy. Geomorphic assessment field crews have more than one year of experience conducting similar assessment using the Rosgen Stream Classification Methodology, and the Geomorphic Field Leader has completed two or more levels of Rosgen training.

Geomorphic assessment survey equipment is calibrated annually and regularly inspected to ensure proper functioning. Cross-section and profile data were digitally plotted and analyzed in Ohio Department of Natural Resources (ODNR) Reference Reach Spreadsheet Version 4.3L for accuracy.

Water quality QA/QC procedures included calibration of the YSI multiprobe meter daily during the sampling season. Dissolved oxygen probe membranes were inspected regularly and replaced when dirty or damaged.

Laboratory Sorting and Subsampling

Sorting QA/QC was conducted on one sample since only seven samples were collected for this survey (the three samples from Picture Spring Branch are analyzed concurrently with three samples taken in Church Creek). This check consisted of entirely resorting the sorted grid cells of one randomly selected sample. This QC met the sorting efficiency criterion of 90%, so no further action was required. As a taxonomic QC, one sample was re-identified completely by another Versar SFS-certified taxonomist following the same identification methods stated above. The Percent Difference in Enumeration (PDE) and the Percent Taxonomic Disagreement (PTD) were calculated, and no further action was required since both the PDE and PTD met MBSS and County MQO requirements.

Data Entry

All data entered were double checked by someone other than the person who performed the initial data entry. Any errors found during QA/QC were corrected to ensure 100% accuracy of the data.

Metric and IBI Calculations

Ten percent of metric and IBI calculations were checked by hand using a calculator to ensure correct calculation by the Access database. Any discrepancies were addressed at that time.

Identification of Stream Types

All stream types were determined by hand based on the methods of the Rosgen Stream Classification (Rosgen 1996). Due to the natural variability, or continuum, of streams, adjustments in the values of Width Depth Ratio (+/- 2.0) and Entrenchment Ratio (+/- 0.2) are allowed, which may result in assigning a different stream type. Therefore, all stream types assigned were checked by a second person and any necessary adjustments were made.

APPENDIX E
BMP CODES

MDE Approved BMP Classifications

ESD BMPs		
Category	Code	Code Description
Alternative Surfaces (A)		
E	AGRE	Green Roof - Extensive
E	AGRI	Green Roof - Intensive
E	APRP	Permeable Pavements
E	ARTF	Reinforced Turf
Nonstructural Techniques (N)		
E	NDRR	Disconnection of Rooftop Runoff
E	NDNR	Disconnection of Non-Rooftop Runoff
E	NSCA	Sheetflow to Conservation Areas
Micro-Scale Practices (M)		
E	MRWH	Rainwater Harvesting
E	MSGW	Submerged Gravel Wetlands
E	MILS	Landscape Infiltration
E	MIBR	Infiltration Berms
E	MIDW	Dry Wells
E	MMBR	Micro-Bioretention
E	MRNG	Rain Gardens
E	MSWG	Grass Swale
E	MSWW	Wet Swale
E	MSWB	Bio-Swale
E	MENF	Enhanced Filters
Structural BMPs		
Ponds (P)		
S	PWED	Extended Detention Structure, Wet
S	PWET	Retention Pond (Wet Pond)
S	PMPS	Multiple Pond System
S	PPKT	Pocket Pond
S	PMED	Micropool Extended Detention Pond
Wetlands (W)		
S	WSHW	Shallow Marsh
S	WEDW	ED - Wetland
S	WPWS	Wet Pond - Wetland
S	WPKT	Pocket Wetland
Infiltration (I)		
S	IBAS	Infiltration Basin
S	ITRN	Infiltration Trench

MDE Approved BMP Classifications

Structural BMPs		
Filtering Systems (F)		
S	FBIO	Bioretention
S	FSND	Sand Filter
S	FUND	Underground Filter
S	FPER	Perimeter (Sand) Filter
S	FORG	Organic Filter (Peat Filter)
S	FBIO	Bioretention
Open Channels (O)		
S	ODSW	Dry Swale
S	OWSW	Wet Swale
Other Practices (X)		
S	XDPD	Detention Structure (Dry Pond)
S	XDED	Extended Detention Structure, Dry
S	XFLD	Flood Management Area
S	XOGS	Oil Grit Separator
S	XOTH	Other

MDE Approved Alternative BMP Classifications

Alt. BMPs (A)	Code	Code Description
A	MSS	Mechanical Street Sweeping
A	VSS	Regenerative/Vacuum Street Sweeping
A	IMPP	Impervious Surface Elimination (to pervious)
A	IMPF	Impervious Surface Elimination (to forest)
A	FPU	Planting Trees or Forestation on Pervious Urban
A	CBC	Catch Basin Cleaning
A	SDV	Storm Drain Vacuuming
A	STRE	Stream Restoration
A	OUT	Outfall Stabilization
A	SPSC	Regenerative Step Pool Storm Conveyance
A	SHST	Shoreline Management
A	SEPP	Septic Pumping
A	SEPD	Septic Denitrification
A	SEPC	Septic Connections to WWTP

APPENDIX F
BIOLOGICAL ASSESSMENT RESULTS

Picture Spring Branch Site PSB-01

Sampled: 4/13/2017

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Fair
BIBI Score	3.57

Metric	Value	Score
Total Taxa	28	5
EPT Taxa	5	5
Number Ephemeroptera	0	1
% Intolerant to Urban	39.47	5
% Ephemeroptera	0	1
Scraper Taxa	2	5
% Climbers	2.63	3

Benthic Macroinvertebrate Taxa List

Taxa	Count
Ablabesmyia	1
Bryophaenocladus	1
Caecidotea	1
Conchelopodia	1
Crangonyx	1
Diplectrona	1
Dytiscidae	6
Helichus	3
Hydrobius	1
Ironoquia	3
Lepidostoma	1
Leuctra	12
Limnophyes	1
Lumbriculidae	1
Macronychus	1
Microvelia	2
Parametriocnemus	1
Pisidium	11
Polycentropus	30
Polypedilum	1
Prodiamesa	3
Pseudorthocladus	1
Rheocricotopus	12
Stenochironomus	1
Stygonectes	1
Trepobates	1
Tubificidae	8
Zavrelimyia	7

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Minimally Degraded
PHI Score	81.07

Metric	Score
Drainage area (acres)	76.80
Remoteness	42.78
Percent Shading	73.32
Epifaunal Substrate	100.00
Instream Habitat	97.29
Instream Wood Debris	100.00
Bank Stability	73.04

Rapid Bioassessment Protocol

Narrative Rating	Supporting
RBP Score	86

Metric	Score
Epifaunal Substrate / Cover	14
Embeddedness	12
Velocity / Depth Regime	9
Sediment Deposition	11
Channel Flow Status	15
Channel Alteration	20
Frequency of Riffles	16
Bank Stability	8(Left)/8(Right)
Vegetative Protection	6(Left)/7(Right)
Riparian Veg Zone Width	9(Left)/9(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	7.19
pH	6.26
Specific Conductance (µS/cm)	1510
Temperature (°C)	16.3
Turbidity (NTUs)	2.2

Picture Spring Branch Site PSB-02

Sampled: 4/13/2017

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Fair
IBI Score	3.57

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	71.50

Metric	Value	Score
Total Taxa	34	5
EPT Taxa	6	5
Number Ephemeroptera	0	1
% Intolerant to Urban	37.50	5
% Ephemeroptera	0	1
Scraper Taxa	5	5
% Climbers	4.69	3

Metric	Score
Drainage area (acres)	96.00
Remoteness	15.79
Percent Shading	63.55
Epifaunal Substrate	84.57
Instream Habitat	89.46
Instream Wood Debris	100.00
Bank Stability	75.62

Benthic Macroinvertebrate Taxa List

Taxa	Count
Caecidotea	6
Calopteryx	2
Cheumatopsyche	1
Chimarra	1
Chrysops	1
Conchapelopia	3
Conchapelopia	1
Corynoneura	1
Dicranota	4
Dipletrona	1
Empididae	1
Girardia	1
Helichus	1
Ironoquia	2
Leuctra	25
Limnophyes	2
Lumbriculidae	1
Macronychus	1
Menetus	1
Naididae	8
Natarsia	1
Paracricotopus	1
Parakiefferiella	4
Parametriocnemus	1
Parametriocnemus	4
Paratendipes	1
Physa	2
Pisidium	5
Polycentropus	6
Polypedilum	1
Potthastia	1
Prodiamesa	1
Rheocricotopus	17
Sphaeriidae	2
Stenelmis	4
Thienemannimyia group	1
Trichoptera	1
Tubificidae	6
Zavrelimyia	5

Rapid Bioassessment Protocol

Narrative Rating	Supporting
RBP Score	76

Metric	Score
Epifaunal Substrate / Cover	10
Embeddedness	10
Velocity / Depth Regime	4
Sediment Deposition	11
Channel Flow Status	16
Channel Alteration	17
Frequency of Riffles	17
Bank Stability	9(Left)/10(Right)
Vegetative Protection	6(Left)/6(Right)
Riparian Veg Zone Width	6(Left)/6(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	7.01
pH	6.35
Specific Conductance (µS/cm)	1313
Temperature (°C)	13.2
Turbidity (NTUs)	0.2

Picture Spring Branch Site PSB-03

Sampled: 4/13/2017

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Fair
BIBI Score	3.00

Metric	Value	Score
Total Taxa	34	5
EPT Taxa	3	3
Number Ephemeroptera	0	1
% Intolerant to Urban	6.19	1
% Ephemeroptera	0	1
Scraper Taxa	4	5
% Climbers	30.09	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	1
Boyeria	5
Calopteryx	2
Chaetocladius	1
Cheumatopsyche	1
Conchapelopia	5
Corynoneura	2
Cranganox	11
Helichus	6
Hemerodromia	1
Hydropsychidae	1
Ironoquia	1
Ischnura	1
Lumbriculidae	3
Macronychus	1
Macronychus	1
Micropsectra	3
Naididae	4
Orthocladius	1
Orthocladius	4
Parakiefferiella	3
Paratanytarsus	1
Paratendipes	1
Peltodytes	1
Physa	14
Polycentropodidae	1
Polypedilum	5
Polypedilum	1
Rheotanytarsus	1
Simulium	1
Smittia	1
Stenelmis	2
Stenelmis	1
Tanytarsus	1
Thienemanniella	1
Tipula	1
Tubificidae	19
Tvetenia	1
Tvetenia	1
Zavrelimyia	1

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	71.21

Metric	Score
Drainage area (acres)	147.20
Remoteness	15.79
Percent Shading	49.95
Epifaunal Substrate	87.60
Instream Habitat	100.00
Instream Wood Debris	100.00
Bank Stability	73.91

Rapid Bioassessment Protocol

Narrative Rating	Supporting
RBP Score	79

Metric	Score
Epifaunal Substrate / Cover	14
Embeddedness	16
Velocity / Depth Regime	10
Sediment Deposition	10
Channel Flow Status	13
Channel Alteration	15
Frequency of Riffles	10
Bank Stability	8(Left)/8(Right)
Vegetative Protection	7(Left)/7(Right)
Riparian Veg Zone Width	6(Left)/8(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	9.86
pH	6.9
Specific Conductance (μ S/cm)	1140
Temperature ($^{\circ}$ C)	12.1
Turbidity (NTUs)	-1.4

Select physical habitat parameters (raw scores) 2017			
Site	Epifaunal Substrate (0 – 20)	Instream Habitat (0-20)	Embeddedness (0 – 100%)
PSB-01	13	11	90
PSB-02	10	10	100
PSB-03	11	13	85