Appendix E2. b – Restoration Plans and TMDLs (Restoration Plans)

Maryland
Department of
the Environment

Larry Hogan, Governor
Boyd K. Rutherford, Lt. Governor

Ben Grumbles, Secretary
Horacio Tablada, Deputy Secretary

September 19, 2019

To: Harford County Watershed Protection and Restoration Office
From: Maryland Department of the Environment (MDE) – Integrated Water Planning Program (IWPP)
Subject: Approval of Harford County's Stormwater Wasteload Allocation (SW-WLA) Watershed Implementation Plan (WIP) for the Total Suspended Solids (TSS) impairment of Swan Creek

The Harford County SW-WLA implementation plan was initially submitted on September 29, 2017 and revised in the subsequent fiscal year 2018 municipal separate storm sewer system (MS4) annual report to address comments from MDE's IWPP. The revised plan is of sufficient quality to warrant MDE approval.

MDE's IWPP reviewed the plan for both its technical merits and watershed planning components. The comments the IWPP provided, both major and minor, asked for revisions to both small and large technical details of the modeling that the County conducted, which would affect potential implementation strategies and the tracking of pollutant load reductions in comparison to target reductions. The County has since made the technical fixes to the plan as requested by MDE's IWPP, or the County has responded to MDE's original comments providing an acceptable justification as to why revisions to the plan were not required.

Below are specific points that demonstrate why this plan is of sufficient quality to the IWPP:

- The County has provided reasonable end-dates for achieving the SW-WLA
- The County has provided detailed cost estimates for implementation
- The County used scientifically defensible modeling tools for estimating the watershed baseline load
- The County implementation plan incorporates elements of adaptive management, indicating that it will use water quality monitoring data to assess the effectiveness of implemented practices and adjust implementation strategies if data do not indicate positive trends
- The modeled baseline year is consistent with baseline conditions in the applicable total maximum daily load (TMDL)
- The County used SW-WLA reduction percentages rather than absolute loading targets from the TMDL in its implementation modeling to set loading targets in terms of its own modeling system
- The County outlined specific best management practices (BMPs) and the amounts of these control measures they plan to implement to meet the required loading reduction
- The County used scientifically defensible BMP reduction efficiencies in modeling the expected pollutant load reductions
- The County outlined a timeframe for achievement of the required pollutant load reduction

- The County discussed the mechanisms that it will employ for tracking progress towards the required load reductions

There is no information withheld from this plan at this point that should warrant it as being unacceptable per the IWPP's criteria for evaluation. However, the IWPP requests that comments provided to Harford County in the letter dated May 3, 2019 and subsequently discussed at the meeting between the IWPP and Harford County officials on Friday, July 26, 2019 be responded before January 26, 2019.

MDE IWPP Comments on Harford County Swan Creek TSS SW-WLA Implementation Plan

1. MDE would like to acknowledge that the absence of any required reductions for the agricultural sector in Swan Creek will make restoration in the watershed very difficult. MDE hopes to discuss this issue with Harford County at an in-person meeting in the near future.
2. Has Harford County attempted to coordinate with any of the other jurisdictions that have SW-WLAs in the Swan Creek watershed?
3. Has Harford County coordinated with the Soil Conservation District on any non-point source projects in the Swan Creek watershed (mentioned at the bottom of page 2-1) or only for property owner interactions?
4. Harford County should consider the Class II-P designated use mentioned on page 1-3 for purposes of coordination with other jurisdictions in the Swan Creek watershed. Drinking water designated uses should be given high priority for the purposes of restoration and planning.
5. In Section 2.1, Harford County describes how potential projects are prioritized and selected. MDE asks that the county provide a schematic illustrating this prioritization process, and explain if the process is quantifiable.
6. Figure 2-1 is excellent, can Harford County please compliment this figure with a prioritization schematic that contains a list of projects?
7. If Harford County is comfortable doing so, it would be useful for the preservation of data to mark on Figure 2-1 generally where site access is difficult/problematic so all records of efforts to implement are maintained
8. MDE requests that the County clarify the reason why only those sites mentioned in the sentence on page 2-3 will be addressed; "Only sites failing MBSS protocols will be pursued," will be pursued.
9. In reference to page 2-3, why are projects "with a minimum stream length of 1,000 linear feet" the only projects being considered? MDE recommends Harford County keep in mind that restoration is likely warranted throughout the watershed.
10. MDE recommends Harford County demonstrate that upstream jurisdictions and contributions tor the stream restoration projects they have decided to fund are being managed and stable prior to breaking ground on these projects to ensure proper return on investment in the restoration work and their longevity.

Maryland
Department of
the Environment

Larry Hogan, Governor
Boyd K. Rutherford, Lt. Governor

Ben Grumbles, Secretary
Horacio Tablada, Deputy Secretary

May 3, 2019

Ms. Christine Buckley
Harford County Department of Public Works
212 South Bond Street, 1st Floor
Bel Air, MD 21014

Dear Ms. Buckley:

The Maryland Department of the Environment (MDE) Water and Science Administration received Harford County's revised restoration implementation plans for the Bush River total maximum daily load (TMDL) stormwater wasteload allocation (SW-WLA) for PCBs and the Swan Creek TMDL SW-WLA for Sediment on December 17, 2018 and December 27, 2018, respectively. These plans were submitted as required per the County's National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit 11-DP-3310 (MD0068268).

Attached is a detailed review provided by MDE's Integrated Water Planning Program (IWPP). MDE requests a revised version of the Bush River PCB TMDL SW-WLA implementation plan with all comments addressed and changes integrated and finalized before November 30, 2019. This date is selected with the assumption that source tracking sampling data will become available during this time frame. Therefore, it is to Harford County's advantage to complete the implementation plan during the time that coincides with the approximate return of information from the County's data gathering efforts. In addition, having a plan in which data can be incorporated will provide the County more context for its work and also enable MDE to be of greater assistance during the planning process so that next-step management decisions can be made with confidence.

MDE would also like to request a meeting to discuss revisions needed for the Swan Creek sediment TMDL SW-WLA implementation plan. MDE recognizes the effort required in developing the restoration implementation plans and appreciates the County's commitment to improving these plans in collaboration with IWPP. To discuss this review, please contact Jonathan Leiman, IWPP, at 410-537-3169 or jonathan.leiman@maryland.gov. If you have any questions regarding the County's stormwater permit, please contact me at 410-537-3546 or christina.lyerly@maryland.gov.

Regards,

Christina M. Lyerly
Natural Resources Planner, Sediment, Stormwater, and Dam Safety Program

cc: Jeff White, MDE, IWPP
Stewart Comstock, MDE, Sediment, Stormwater, and Dam Safety Program

Enclosures

Attachment 1

Maryland Department of the Environment (MDE) Integrated Water Planning Program (IWPP) Review of Harford County Bush River PCB Total Maximum Daily Load (TMDL) Stormwater Wasteload Allocation (SW-WLA) Implementation Plan

MDE IWPP offers the following comments and requests for revisions:

1. MDE requests that the County add a map legend to Figure 2 and Figure 3 describing dashed lines and points on the map, respectively.
2. The first sentence on page 10 states, "The urban load for each watershed was further disaggregated for each MS4 jurisdiction with exception for MD State Highway Administration." MDE requests clarification on the reason why the Maryland Department of Transportation State Highway Administration (MDOT SHA) was not disaggregated.
3. MDE requests details with regard to the sentence on page 11, "Harford County will coordinate with MDE to determine if these sites are potential sources of PCBs." MDE requests clarification on what specifically Harford County wishes to coordinate on, so other parties can follow the process.
4. MDE would like to commend Harford County on the source identification efforts that have been made, particularly the following on page 13: "Within the Bush River watershed, this inventory includes twelve active permits and seven historic permits (Figure 4, Appendix A) with SIC codes from Table 17."
5. With regard to the first paragraph on page 15, MDE requests that a revised plan include more specific details about how Harford County staff and personnel will be trained on how to distribute and report information related to PCBs (e.g., who is the primary point of contact, is information reported on-line or in writing).
6. With regard to the last sentence on page 15, "Therefore, along with the implementation of the Bynum Run Sediment TMDL Restoration Plan, all dredge materials from stormwater management facilities retrofitted for restoration will be tested for PCBs using EPA Method 1668", MDE requests to be kept informed of these testing results to be able to share them with other jurisdictions.
7. MDE requests clarification on whether it will be included in the study being planned with the University of Maryland Baltimore County mentioned on page 16. Clarify in the plan so other parties can follow the process.
8. MDE requests that the sentence, "Additional locations will be sampled upstream of locations with results significantly over the water column criteria of 0.64 ng/L (i.e. over 2.0 ng/L)" be removed from the document, because of the arbitrary nature of this threshold given that the water quality standard (WQS) is derived from fish tissue concentrations and not ambient water quality.

9. With regard to the following sentence on page 16, "Since the PCB TMDL for Bush River is based on the presence of PCBs in fish tissue, the County will coordinate with MDE to determine if a schedule for future fish sampling in Bush River has been established", MDE requests that Harford County provide notes on these meetings past and current (e.g., who was there, what was discussed) in order to maintain high quality records of the work being done. These records should be included as appendices to the plan.
10. With regard to the following sentence on page 16, "In 2023, the County anticipates updating this plan and incorporating annual evaluations and any new developments or recommendations from the research community for PCB abatement", MDE requests that the County record specifically what management issues might need to be addressed in 2023 in order to provide internal guidance to adaptively manage information as it becomes available via research, sampling, etc.
11. With regard to the last paragraph of the plan on page 17, MDE would like to commend Harford County for attending these meetings, and request that for future meetings the County detail information that was acquired and where (if at all) it was integrated into the plan.
12. MDE has found that Comment #2 from the review dated May 31, 2018 has not been fully addressed: "*On Page 7, the first paragraph states that the "load from resuspension (3,328 g/year) is nearly 25 times greater than the contribution from the watershed (134.6 g/yr)." The load from resuspension is a gross load and does not consider exchanges between the water column and sediment through settling/deposition...The gross load from settling is 9,661 g/year resulting in a net load of 6,333 g/year from the water column to the sediment. Therefore the sediment is not a source of PCBs to the water column under baseline conditions. Also the load associated with resuspension will decrease over time as contaminated sediment is buried with new cleaner sediment as a result of reductions to watershed loads and Bay mainstem water column concentrations...[R]eductions are still required to the watershed in order to achieve water column and sediment TMDL endpoints.*" The County has removed language that the "load from resuspension is nearly 25 times greater than the watershed load", however, the County replaced this with language pulled directly from the TMDL stating that the gross load is the major source of PCBs to the River. MDE finds this language misleading, because net loading is from the water column to the sediment due to settling. MDE recognizes that the TMDL did not articulate this point, but still requests the County change the language.
13. The original Comment #3 was also not fully addressed: "*On Page 11, the first paragraph states that "in comparison to the resuspension loads for the Bush River (3,328 g/yr), a reduction by Harford County of 37.1 g/yr will be inconsequential in the reduction of PCBs in fish tissue..." As stated in the previous comment [comment #2], the load from resuspension is a gross load and does not take into consideration the gross load from settling/deposition which significantly decreases the overall net load from the sediment.*

The gross load from settling is 9,661 g/year resulting in a net load of 6,333 g/year from the water column to the sediment. Therefore the sediment is not a source of PCBs to the water column under baseline conditions. The load from the watershed is not inconsequential as the water column and sediment TMDL endpoints will never be achieved without a reduction to the watershed load. A TMDL modeling scenario demonstrated that if sediments within the Bush River were clean, current loads of suspended sediments contaminated with PCBs from the watershed and Chesapeake Bay main stem would bury the clean sediment over time with contaminated materials resulting in sediment concentrations that exceed the TMDL endpoints." MDE requests that Harford County readdress comment #3 and strike the sentence that the watershed load reductions will be inconsequential to reducing PCBs in fish. MDE requests clarification about the intent of the paragraph on page 11 that begins "Harford County's TMDL…", and whether the paragraph means to absolve Harford County of some responsibility. MDE requests that the County revise, with particular attention to the use of syntax like "inconsequential", which is open to a variety of interpretations.

Attachment 2

Maryland Department of the Environment (MDE) Integrated Water Planning Program (IWPP) Review of Harford County Swan Creek Sediment (TSS) Total Maximum Daily Load (TMDL) Stormwater Wasteload Allocation (SW-WLA) Implementation Plan

MDE IWPP offers the following comments and requests for revisions:

1. MDE would like to acknowledge that the absence of any required reductions for the agricultural sector in Swan Creek will make restoration in the watershed very difficult. MDE would like to discuss this issue with Harford County at an in-person meeting in the near future.
2. MDE requests clarification on whether the County has attempted to coordinate with any of the other jurisdictions that have SW-WLAs in the Swan Creek watershed.
3. MDE requests clarification on whether Harford County has coordinated with the Harford Soil Conservation District on any non-point source projects in the Swan Creek watershed (mentioned at the bottom of page 2-1) or only for property owner interactions.
4. Harford County should consider the Class II-P designated use mentioned on page 1-3 for purposes of coordination with other jurisdictions in the Swan Creek watershed. Drinking water designated uses should be given high priority for the purposes of restoration and planning.
5. In Section 2.1, Harford County described how potential projects are prioritized and selected. MDE asks that the County provide a schematic illustrating this prioritization process, and explain if the process is quantifiable.
6. Figure 2-1 is excellent and MDE requests that the County compliment this figure with a prioritization schematic that contains a list of projects.
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8. MDE requests that the County clarify the reason only those sites mentioned in the sentence on page 2-3 will be addressed: "Only sites failing MBSS protocols will be pursued."
9. In reference to page 2-3, MDE requests clarification on the reason projects "with a minimum stream length of 1,000 linear feet" are the only projects being considered. MDE recommends Harford County keep in mind that restoration is likely warranted throughout the watershed.
10. MDE recommends that Harford County demonstrate that upstream jurisdictions and contributions to the stream restoration projects the County has decided to fund are being managed and stable prior to breaking ground on these projects to ensure proper return on investment in the restoration work and their longevity.

Bush River TMDL Restoration Plan for PCBs

Bush River Watershed

Total Maximum Daily Load (TMDL)

Restoration Plan for PCBs

December 2019 (Update)
December 2018 (Update)
August 2017

Prepared by:

Harford County Department of Public Works
Watershed Protection and Restoration Office
212 South Bond Street, 1st Floor
Bel Air, Maryland 21014

Barry Glassman
County Executive

Bush River Watershed

Total Maximum Daily Load (TMDL)

Restoration Plan for PCBs

December 2019 (Update)

December 2018 (Update)

August 2017

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Prepared by:

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Harford County, Maryland
Bush River Watershed Total Maximum Daily Load (TMDL) for PCBs

Introduction

The Bush River Watershed Total Maximum Daily Loads (TMDL) for Polychlorinated Biphenyls (PCBs) (April 2016) was established by Maryland Department of Environment (MDE) and approved by the U.S. Environmental Protection Agency (EPA) on August 2, 2016.

On December 30, 2014, MDE reissued the Phase I National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit to Harford County (County). The permit has several new requirements, including stringent stormwater management criteria, implementation of strategies to reduce litter and floatables, and development of restoration plans. Part IV.E.2.b of the NPDES MS4 permit requires the County to develop restoration plans to address stormwater wasteload allocations (SW-WLAs) for the waterbodies in the County that have EPA-approved TMDLs. Additionally, the County is required to develop restoration plans for subsequent TMDL SW-WLAs within one year of EPA approval.

Bush River was identified as impaired by PCBs in the 2014 Integrated Report developed by MDE for Sections 305(b) and 303(d) of the Clean Water Act (CWA). The impairment is based on PCBs in fish tissue (2002). The designated use for the Bush River is Use II, or estuarine and marine aquatic life and shellfish harvesting.

PCBs are man-made chemical compounds mainly manufactured as an insulator and coolant in transformers and capacitors. The manufacturing of PCBs was banned in 1977 based on its carcinogenic properties and its persistence to readily breakdown in the environment.

Four 8-digit basins drain into the Bush River including Atkisson Reservoir (02130703), Lower Winters Run (02130702), Bynum Run (02130704), and Bush River (02130701) (Figure 1). A TMDL for sediment for the Bynum Run Watershed was approved in September 2011. The County completed the *Bynum Run Watershed Total Maximum Daily Load Restoration Plan for Sediment* in March 2016.

Watershed Description

The Bush River Watershed is located entirely within Harford County and receives drainage from the Town of Bel Air and portions of the City of Aberdeen, both of which are Phase II MS4 jurisdictions. Additionally, a majority of the Bush River tidal mainstem receives direct drainage from Aberdeen Proving Ground (APG), a Phase II MS4 federal jurisdiction. APG which dates

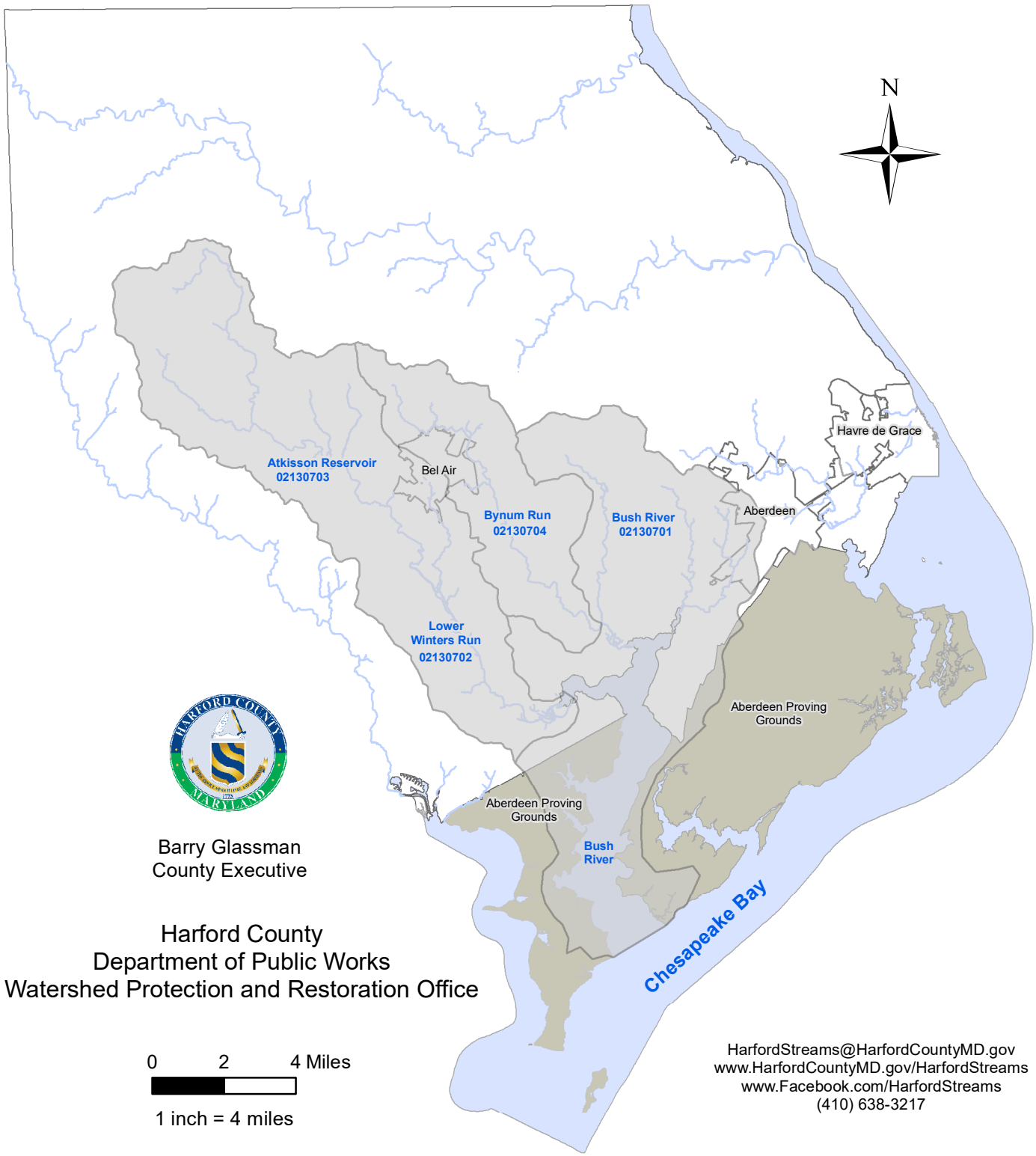

Figure 1: Bush River Watershed 8-digit Basins

back to World War I, is the U.S. Army's oldest active proving grounds. http://armyalliance.org/about-apg/history-of-apg/). The portion of APG located on the western shore of the Bush River focused on chemical weapons research and development.

Bush River Watershed begins near the intersection of Norrisville Road and Jarrettsville Pike and extends southeast to the confluence of the Bush River and Chesapeake Bay. The watershed is roughly bounded on the west by Maryland Route 152, the northeast by Maryland Route 22, and the northwest by Jarrettsville Road / Old Federal Hill Road (Figure 2).

Bush River Watershed is the most urban watershed in the County. Most of the County's Priority Funding Area or development envelope is located within this watershed. The development envelope spans north to south from Forest Hill to Edgewood along MD Route 24 and east to west Aberdeen to Joppa along US Route 40.

The major tributaries to the Bush River are Otter Point Creek, Church Creek and Bynum Creek. Their tributaries include Winters Run, Bynum Run, James Run and Grays Run.

TMDL Development

Bush River was first identified as impaired in MDE's 2002 Integrated Report based on fish tissue sampling. The criteria for impairments is based on concentration in the water column and concentration in fish tissue. The human health criterion is based on consumption of fish and their interaction with the water column and food chain. "Drinking water consumption does not pose any risk for cancer development at environmentally relevant levels." (TMDL, 2016)

Table 1: PCB Criteria for Impairment

	Concentration
Water Column for Human Health	0.64 ng/L
Fish Tissue	39 ng/g

In 2013 and 2014, MDE conducted PCB monitoring for the water column for six tidal and four non-tidal locations (Figure 3). The data used to develop the TMDL was collected on three dates as shown in Table 2. The six tidal locations exceeded the PCB criteria for human health for 2 of 3 sample dates. All four non-tidal locations were significantly below the PCB criteria for human health for 2 of 3 sample dates.

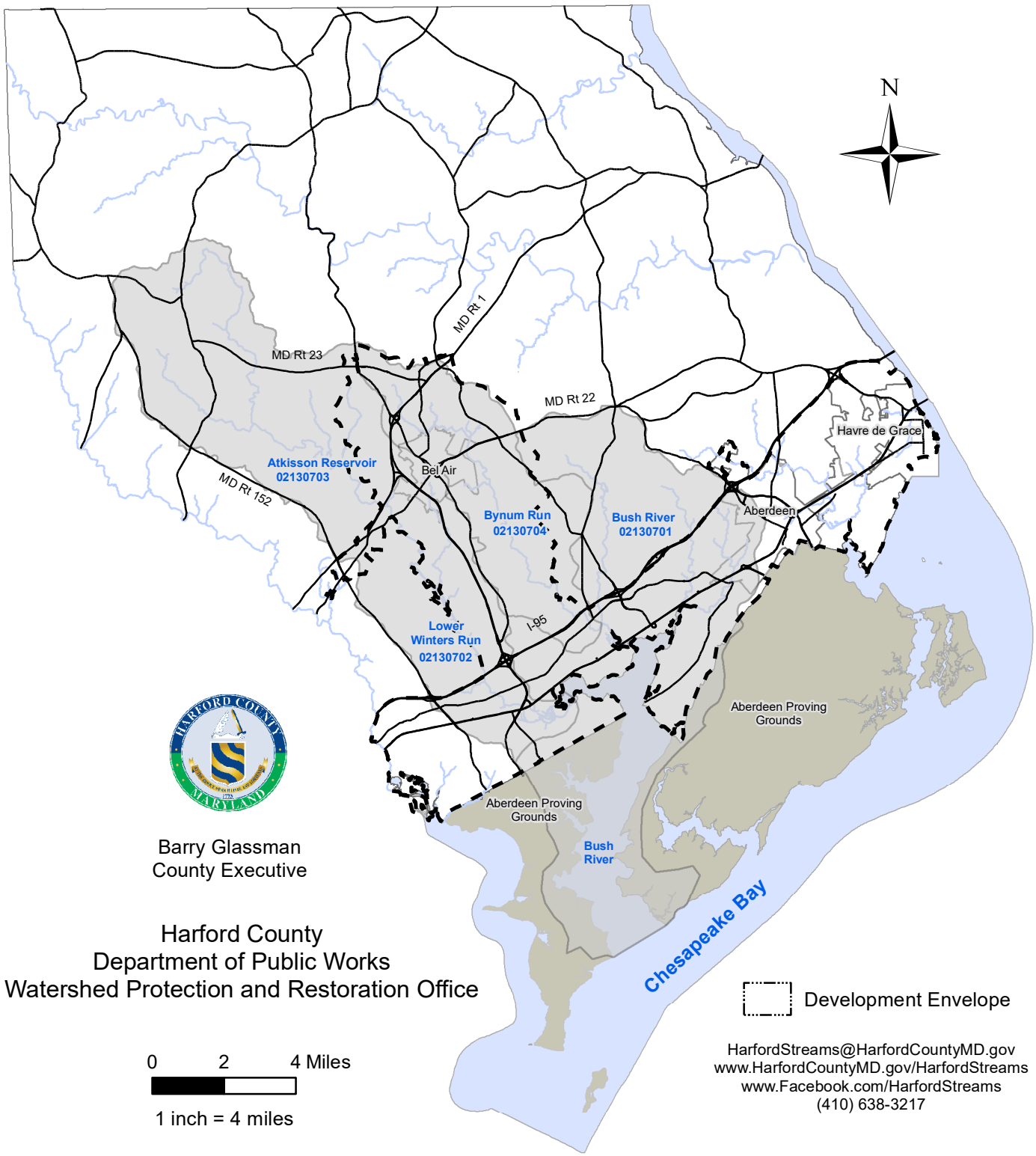

Figure 2: Bush River Watershed Location Map

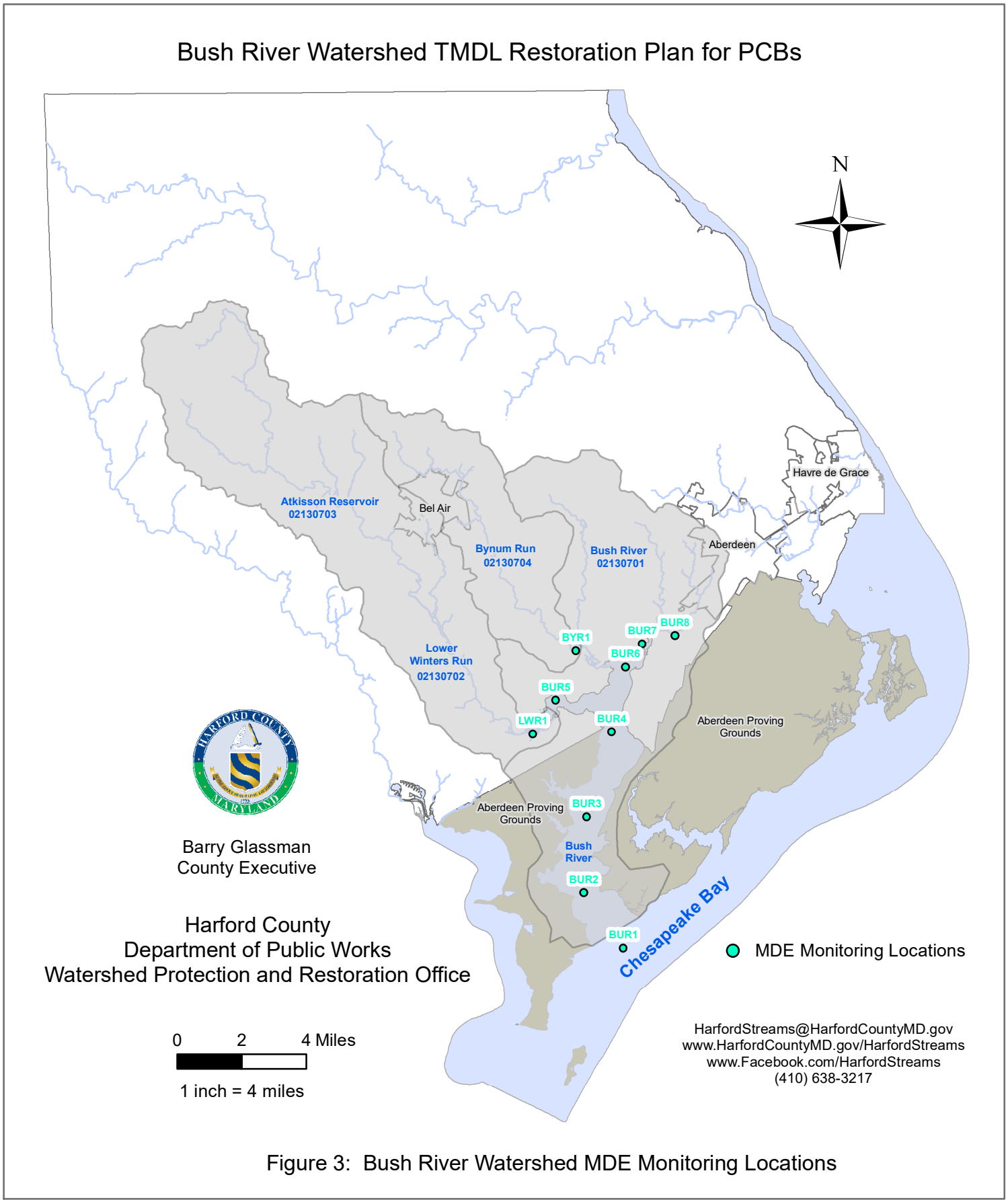

Figure 3: Bush River Watershed MDE Monitoring Locations

Table 2: MDE PCB Water Column Monitoring for Bush River TMDL (ng/L)

Station	Type	8/14/2013	10/30/2013	3/12/2014
BUR1	Tidal	0.90	0.35	1.20
BUR2	Tidal	1.34	0.51	4.64
BUR3	Tidal	2.02	0.37	4.00
BUR4	Tidal	2.15	0.87	5.19
BUR5	Tidal	0.80	0.33	1.56
BUR6	Tidal	1.46	1.16	8.43
BUR7	Non-tidal	0.01	0.03	1.15
BUR8	Non-tidal	0.00	0.03	1.72
BYR1	Non-tidal	0.02	0.01	7.20
LWR1	Non-tidal	0.02	0.03	0.44

In 2013 and 2014, MDE conducted PCB monitoring for sediment for five tidal locations (Figure 3). The data used to develop the TMDL was collected on two dates as shown in Table 3.

Table 3: MDE PCB Sediment Monitoring for Bush River TMDL (ng/g)

Station	Type	5/20/2013	10/3/2014
BUR2	Tidal	32.2	18.9
BUR3	Tidal	36.9	10.1
BUR4	Tidal	12.6	12.5
BUR5	Tidal	14.2	4.2
BUR6	Tidal	16.5	14.1

In 2014, MDE collected a total of thirty fish at BUR4 (Figure 3) for fish tissue sampling. The concentrations ranged from 54.22 ng/g to 658.96 ng/g which far exceed the impairment criterion of 39 ng/g. Therefore, demonstrating that a PCB impairment exists within the tidal mainstem of Bush River.

MDE used the Bush River Water Quality Model to calculate the PCB concentrations for the water column and sediment necessary to support fish tissue concentrations below the impairment criterion of 39 ng/g. Based on their analysis, the TMDL concentrations for the water column and sediment are listed in Table 4. Note, all four non-tidal locations were significantly below the TMDL concentration for 2 of the 3 sample dates.

Table 4: TMDL Concentrations for PCBs

	Concentration
Water Column	0.12 ng/L
Sediment	1.14 ng/g

Source Assessment

While PCBs are no longer manufactured, there are many sources for existing PCBs including 1) transformers still allowed to be in use 2) buildings constructed or renovated before 1979 which used PCB-containing materials such as caulks, paints, fireproofing materials, and fluorescent light ballasts 3) improper disposal 4) tidal influence from Chesapeake Bay and 5) atmospheric deposition. PCBs also bind strongly with sediment and can be introduced to the water column through erosion or resuspension of sediments.

MDE's Bush River Water Quality Model through observed PCB concentrations has determined the net PCB load transported into the Bay from the Bush River is 1,049 g/year.

Using concentration rates for urban areas from an atmospheric deposition study completed by the Chesapeake Bay Program, the PCB load from atmospheric deposition to the Bush River was calculated as 48.9 g/yr and the direct atmospheric deposition to the land surface of the Bush River Watershed as 538 g/year.

Likewise, MDE has identified one known PCB contaminated site (MD 446 Union Road Dump) which contributes 2.37 g/yr.

According to the TMDL document, "The water quality model, applying observed tPCB concentrations in the water column and sediment, predicts a gross tPCB load of 3,328 g/yr from bottom sediment to the water column through re-suspension and diffusion in the Bush River. Although the transport of PCBs to the river from bottom sediment via re-suspension and diffusion is currently estimated to be the major source of PCBs, this load contribution is resultant from other point and nonpoint source inputs (both historic and current) and is not considered to be directly controllable. Therefore, this load will not be assigned a baseline load or allocation."

Based on the average concentrations from the water column monitoring (Table 2) and stream flow from USGS stations within the watershed, loads for each of the non-tidal monitoring sites were calculated (Table 5). The total non-tidal load is 134.6 g/yr.

Table 5: MDE PCB Loads from Watershed Runoff

Watershed	Average Concentration (ng/L)	Load (g/yr)
Bush River	0.49	37.2
Bynum Run	2.41	85.3
Winters Run	0.16	12.1
		134.6

Stormwater Waste Load Allocation

The TMDL document calculates the stormwater waste load allocation (SW-WLA) for PCBs as the total contribution of urban land cover based on the 2006 USGS land cover data. The entire SW-WLA was collectively assigned to the regulated MS4 jurisdictions including Harford County, Town of Bel Air, City of Aberdeen, Aberdeen Proving Ground, and MD State Highway Administration. This analysis is based on MDE's expansive interpretation of the County's Permit Area in documents external to the County's current MS4 permit, which correctly defines the MS4 Permit Area in Part I.B. All rights noted above are reserved. This restoration plan develops strategies to reduce PCBs for the total urban loads within the physical boundaries of Harford County.

Using the 2006 USGS land cover data (downloaded from the TMDL Data Center), the County disaggregated the SW-WLA by calculating the urban land cover for each watershed (Table 6).

MDE did not calculate the urban load for each watershed. Instead, a total urban load was calculated as a percent of the total urban area or 36.9% of 134.6 g/yr, or 49.7 g/yr. The County calculated the baseline for each watershed based on the actual percent of urban land for each watershed. These values were then normalized using MDE's total urban load of 49.7 g/yr.

Table 6: PCB Loads by Watershed

	Bush River	Bynum Run	Winters Run	Total
Total (ac)	31,227	14,582	37,542	83,351
Urban (ac)	9,017	9,162	12,525	30,704
Urban (%)	28.9%	62.8%	33.4%	
Baseline (g/yr)	7.8	39.0	2.9	49.7
TMDL (g/yr)	3.0	14.8	1.1	18.9

Table 7: Town of Bel Air by Watershed

	Bush River	Bynum Run	Winters Run	Total
Total (ac)	0	1,084	830	1,914
Urban (ac)	0	982	773	1,755
Urban (%)	0	90.5%	93.1%	91.6%

Table 8: City of Aberdeen by Watershed

	Bush River	Bynum Run	Winters Run	Total
Total (ac)	1,115	0	0	1,115
Urban (ac)	874	0	0	874
Urban (%)	78.3%	0	0	78.3%

Table 9: Aberdeen Proving Ground by Watershed

	Bush River	Bynum Run	Winters Run	Total
Total (ac)	7,367	0	0	7,367
Urban (ac)	1,118	0	0	1,118
Urban (%)	15.1%	0	0	15.1%

Table 10: Harford County by Watershed

	Bush River	Bynum Run	Winters Run	Total
Total (ac)	22,534	13,391	36,440	72,365
Urban (ac)	6,844	8,082	11,520	26,446
Urban (%)	30.4%	60.3%	31.6%	36.5%

Table 10a: State Highway by Watershed

	Bush River	Bynum Run	Winters Run	Total
Total (ac)	211	107	272	590
Urban (ac)	181	98	232	511
Urban (%)	85.8%	91.6%	85.3%	86.6%

The urban load for each watershed was further disaggregated for each MS4 jurisdiction. Tables 7 through 10a provide a breakdown of urban acres by watershed for each MS4 jurisdiction.

Using the urban acres for each MS4 jurisdiction, the percent contribution from each was calculated and summarized in Table 11.

Table 11: Urban Acres by Watershed for each MS4 Jurisdiction

Jurisdiction	Bush River	Bynum Run	Winters Run	Total
Bel Air	0	982 (11%)	773 (6%)	1,755 (5.7%)
Aberdeen	874 (10%)	0	0	874 (2.8%)
APG	1,118 (12%)	0	0	1,118 (3.6%)
County	6,844 (76%)	8,082 (88%)	11,520 (92%)	26,446 (86.1%)
State Highway	181 (2%)	98 (1%)	232 (2%)	511 (1.7%)
	9,017 (100%)	9,162 (100%)	12,525 (100%)	30,704 (100%)

The County further disaggregated the baseline loads by watershed for each of the MS4 jurisdictions. The baseline loads by watershed for each jurisdiction was calculated as the product of the percent urban acres for each MS4 by watershed and the baseline watershed loads (Table 12).

Table 12: Baseline PCB Loads (g/yr) from Watershed Runoff by MS4 Jurisdiction

Jurisdiction	Bush River	Bynum Run	Winters Run	Total
Bel Air	0	4.2	0.2	4.4
Aberdeen	0.8	0	0	0.8
APG	1.0	0	0	1.0
County	5.9	34.4	2.7	43.0
State Highways	0.2	0.4	0.1	0.6
	7.8	39.0	2.9	49.7

MDE through modeling calculated a 62% reduction in baseline loads from the watershed runoff was necessary in combination with a measured 6.5% annual decrease in sediments within Chesapeake Bay. This scenario will take approximately 81 years to achieve the designated use for Bush River.

Using a 62% reduction from baseline loads, TMDL loads for each jurisdiction by watershed was calculated (Table 13).

Table 13: TMDL PCB Loads (g/yr) from Watershed Runoff by MS4 Jurisdiction

Jurisdiction	Bush River	Bynum Run	Winters Run	Total
Bel Air	0	1.6	0.1	1.7
Aberdeen	0.3	0	0	0.3
APG	0.4	0	0	0.4
County	2.25	13.06	1.03	16.34
State Highway	0.06	0.16	0.02	0.24
	3.0	14.8	1.1	18.9

Harford County's TMDL for PCBs in the Bush River Watershed is 16.3 g/yr.

Restoration Plan

Source Tracking

The County has identified several locations for further investigation as potential sources of PCBs.

A search of EPA's Superfund website (https://www.epa.gov/superfund/search-superfund-sites-where-you-live) lists three sites within Bush River Watershed (Table 14). Harford County will research these sites to determine if they are potential sources of PCBs.

Table 14: Superfund Sites within the Bush River Watershed

Site	Location
Aberdeen Proving Ground (Edgewood Area)	Edgewood, MD 21010
Aberdeen Proving Ground (Michaelsville Landfill)	Aberdeen, MD 21005
Bush Valley Landfill	Abingdon, MD 21009

According the Code of Federal Regulations any transformer that contains 500 ppm or greater PCB dielectric must be registered with EPA (https://www.epa.gov/pcbs/registering-transformers-containing-polychlorinated-biphenyls-pcbs. The registry includes three locations within Bush River Watershed (Table 15).

Table 15: PCB Registered Transformers within the Bush River Watershed

Site	Location
Aberdeen Proving Ground	Bldg E5863 Aberdeen, MD 21005
Aberdeen Proving Ground	Palmer & Access Road Aberdeen, MD 21005
Perryman Generating Station	900 Chelsea Road Aberdeen, MD 21001

All activities including the storage, transport, or disposal of PCBs must be reported to EPA (https://www.epa.gov/pcbs/notifications-polychlorinated-biphenyl-pcb-activities). The registry lists three locations within the Bush River Watershed (Table 16).

Table 16: PCB Activities within the Bush River Watershed

Site	Location	Activity
Aberdeen Proving Ground	Bldg E5850 Edgewood, MD 21010	Generator
City Light & Power EA Yard	Stokes and Hanlon Road Edgewood, MD 21040	Generator
City Light & Power EA Yard	3560 Crozier Loop Aberdeen, MD 21005	Generator

Under EPA's Toxics Release Inventory (TRI) Program (https://www.epa.gov/toxics-release-inventory-tri-program/tri-data-and-tools), PCBs are categorized as persistent bioaccumulative toxic (PBT) chemicals. The program tracks toxic releases through documentation required under the Emergency Planning and Community Right-to-Know Act (EPCRA). Eight facilities located within Bush River Watershed reported toxic releases within the preliminary inventory for 2016. None of the releases were for PCBs.

Virginia Department of Environmental Quality has well-established guidance for monitoring of point sources for PCBs (Guidance Memo No. 09-2001). This guidance provides a recommended list of Standard Industrial Classification (SIC) codes that are more likely to have impairments from PCBs (Table 17).

Table 17: SIC Codes for Industrial Facilities with Potential Impairments from PCBs

SIC Code	Code Operations	SIC Code	Code Operations
26 & 27	Paper and Allied Products	5093	Scrap Recycling
30	Rubber and Misc. Plastics	1221 & 1222	Bituminous Coal
33	Primary Metal Industries	3612	Transformers
34	Fabricated Metal Products	3731 & 3732	Ship / Boat Building / Repair
37	Transportation Equipment	4011	Railroad Transportation
49	Electrical, Gas and Sanitary Services	5015	Automobile Salvage Yards

Under EPA's National Pollutant Discharge Elimination System (NPDES) program, all industries that discharge process water or stormwater to surface or ground water must obtain an NPDES industrial permit. In Maryland, this program is administered through MDE. An inventory of these permits can be found at http://mes-mde.mde.state.md.us/WastewaterPermitPortal/

Within the Bush River watershed, this inventory includes twelve active permits and seven historic permits (Figure 4, Appendix A) with SIC codes from Table 17.

In addition to the locations listed above, several locations have been added for further investigation based on historic local knowledge (Table 18) and a list of properties constructed prior to 1980 with industrial landuse in the tax records (Table 19).

Table 18: Properties of Interest based on Historical Knowledge

Site	Location
Tollgate Landfill (Closed)	Tollgate Road Bel Air, MD 21014
Landfill (Closed)	Abingdon Road Abingdon, MD 21009
Bata (Redeveloped)	Pulaski Highway Belcamp, MD 21017
Landfill (Closed)	Philadelphia Road Abingdon, MD 21009

Table 19: Properties of Interest based on Industrial Landuse

Tax ID	Location	Tax ID	Location
03194418	Bynum Road Forest Hill, MD 21050	03194396	Melrose Lane Forest Hill, MD 21050
03040186	Calvary Road Churchville, MD 21028	02001209	Old Philadelphia Road Aberdeen, MD 21001
01030078	Edgewood Road Edgewood, MD 21040	02013878	Old Philadelphia Road Aberdeen, MD 21001
01055038	Edgewood Road Bel Air, MD 21014	01073621	Philadelphia Road Aberdeen, MD 21001
03086925	Industry Lane Forest Hill, MD 21050	03050955	Snake Lane Churchville, MD 21028
03052044	Jarrettsville Road Forest Hill, MD 21050		

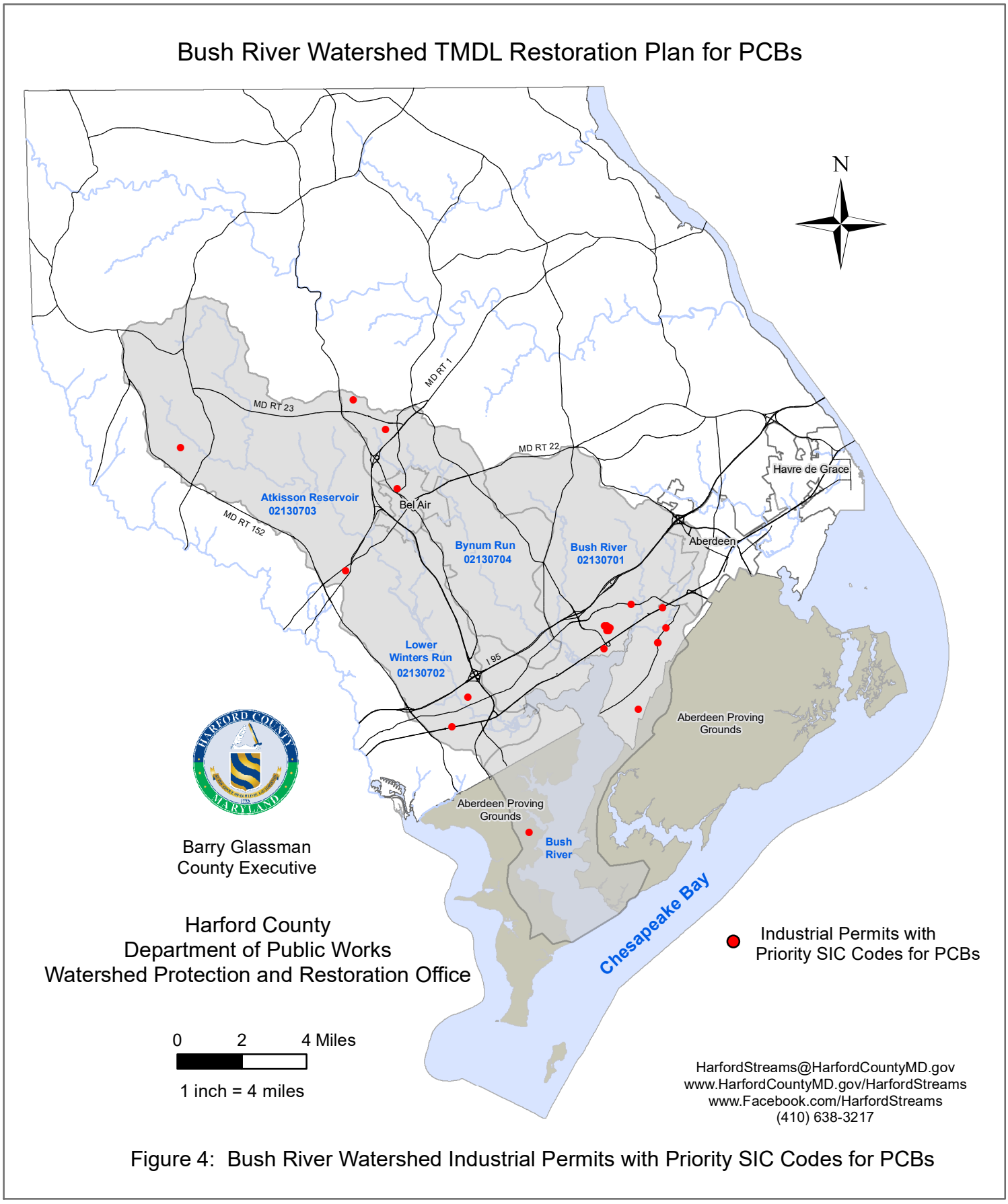

Figure 4: Bush River Watershed Industrial Permits with Priority SIC Codes for PCBs

In addition to industrial use of PCBs, through the 1970s, PCBs were also used in building material including caulks, paints, fireproofing materials, and fluorescent light ballasts. On an annual basis, the County's MS4 Office will distribute via email outreach materials to its own Facility Maintenance and Vertical Construction Engineering and Inspections Departments and Harford County Schools to ensure staff are familiar with potential existence of PCBs in older buildings considered for renovation or demolition. EPA's website provides a larger variety of educational materials (https://www.epa.gov/pcbs/polychlorinated-biphenyls-pcbs-building-materials). Additionally, on an annual basis, the County's MS4 Office will request each of the above referenced agencies provide documentation for all building renovations and demolitions including potential for PCBs.

Stormwater Management Facilities

According to the Toxics Work Group for the Chesapeake Bay Program, "Much of the PCB load moving through urban watersheds is potentially treatable by stormwater retrofits." They continue by noting that "Remarkably little monitoring has been conducted to assess whether urban stormwater BMPs can remove PCBs", and reference research conducted by Yee and Mckee (2010) which concluded that PCBs behaved very similar to sediments. Therefore, along with the implementation of the Bynum Run Sediment TMDL Restoration Plan, all dredge materials from stormwater management facilities retrofitted for restoration will be tested for PCBs using EPA Method 1668. Test results will be forwarded to MDE.

Monitoring Plan

The stormwater wasteload allocation developed by MDE was based on watershed runoff loads for a limited number of sample dates and results with considerable variability. Therefore, the County proposes to provide additional monitoring to better quantify the extent of the PCB loads prior to investing large quantities of funding for capital improvement projects.

The County is actively pursuing a partnership with University of Maryland Baltimore County (UMBC), with guidance from MDE, to develop and implement a monitoring plan using an integrative passive sampling approach. The monitoring plan will focus on a PCB source trackdown effort within the watershed to identify upland sources of PCBs. The County anticipates replicating the sampling initially conducted by MDE at each major non-tidal tributary in order to identify the subwatershed with the greatest relative PCB concentrations for source trackdown prioritization. (Figure 3). Based on the results, and guidance from MDE, the County will then develop a source trackdown monitoring plan within selected watersheds using a stream bracketing approach. The County will select stations covering the entire

subwatershed based on stream branching and target locations identified in the desktop analysis previously discussed. This subsequent sampling will refine the instream bracketing and focus the source trackdown effort isolating upland areas of concern. Once isolated, current and historic use of the properties will be investigated. The County will work with MDE Compliance as necessary to mitigate the PCB source.

Initial sampling is anticipated to take place in spring and fall 2020. For this proposed work, a recently published guidance document on passive sampling will be followed to measure freely dissolved concentrations of PCBs in surface water (U.S. EPA/SERDP/ESTCP. 2017). The analytical methods will follow those currently used for PCB measurements performed by UMBC for fish samples from MDE. These methods will include the analyses of commonly found congeners previously analyzed by MDE.

Since the PCB TMDL for Bush River is based on the presence of PCBs in fish tissue, the County will coordinate with MDE to obtain data results from future fish sampling in Bush River and include the results in the annual MS4 report.

Conclusion

The County will document in the annual MS4 report the monitoring results from the integrative passive samplers, status of source tracking and analytical results from materials dredged from stormwater retrofits.. This documentation will also include any new developments or recommendations from the research community in the areas of PCB sampling methodologies, analyses, and source tracking strategies. This information will be used to provide a structured approach to direct decision making and address specific management and monitoring issues in regards to the abatement of PCBs. By the end of the next MS4 permit term, the County will update this plan to adaptively manage these evaluations, developments and recommendations. The Toxics Work Group for the Chesapeake Bay Program has developed the "Toxic Contaminants Policy and Prevention Outcome, Management Strategy" that outlines specific approaches for regulations, education and awareness, voluntary programs, and science. By implementing these management approaches, federal, state, and local agencies can move forward in reducing toxic impacts within our waters in the most cost effective and beneficial manner.

Over the past year, Harford County has attended two workshops sponsored by the U.S. Geological Survey focused on toxics (8/3/2017) and PCBs (9/26/2018). The County appreciates the opportunity to interact with practitioners and researchers in this field and welcomes continued discussions into the future. Similar future meetings will be summarized and included within the appendices of this plan.

Appendix A: Industrial NPDES Permitted Sites with Priority SIC Codes in Bush River Watershed

Facility_N	Address	City_1	Zip_Code	State_Num_	Status_1	Status_Dat
Alcore, Inc	1502 Quarry Dr	Edgewood	21040	02SW1247	History	9/14/2014
Alcore, Inc	1502 Quarry Dr	Edgewood	21040	12NE1247	Issued	9/15/2014
American Color Graphics	1211 Belmar Dr	Belcamp	21017	02SW0164	History	6/15/2015
Bizerba Label Solutions	105 Industry Lane	Forest Hill	21050	02SW1827	History	3/8/2009
Bottcher America Corporation	4600 Mercedes Dr	Belcamp	21017	02SW0487	History	5/11/2015
Bottcher America Corporation	4600 Mercedes Dr	Belcamp	21017	12SR0487o	Issued	6/12/2015
Constellation Power - Perryman Generating Station	900 Chelsea Rd	Aberdeen	21001	06HT5131	History	8/15/2011
Constellation Power - Perryman Generating Station	900 Chelsea Rd	Aberdeen	21001	11HT5131	History	7/28/2014
Constellation Power - Perryman Generating Station	900 Chelsea Rd	Aberdeen	21001	11HT5131A	Issued	7/29/2014
Crown Speciality Packaging	4606 Richlynn Dr	Belcamp	21017	08NE1597	History	1/9/2013
Crown Speciality Packaging	4606 Richlynn Dr	Belcamp	21017	12NE1597o	History	9/8/2014
Crown Speciality Packaging	4606 Richlynn Dr	Belcamp	21017	12SW1597	Issued	9/9/2014
Greenridge Utilites, inc	506-A Fountain Green Rd	Bel Air	21015	06HT9526	History	3/31/2006
Greenridge Utilites, inc	506-A Fountain Green Rd	Bel Air	21015	11HT9526	Issued	8/2/2012
Independent Can Company	1300 Brass Mill Rd	Belcamp	21017	10DP2681	Issued	1/1/2012
Independent Can Company	1300 Brass Mill Rd	Belcamp	21017	17DP2681	Received	3/29/2017

Lifoam Industries, LLC	121 Bata Blvd	Belcamp	21017	02SW2347	History	9/7/2014
Lifoam Industries, LLC	121 Bata Blvd	Belcamp	21017	12SW2347	Issued	9/8/2014
LKQ Pick Your Part (1209)	1706 Pulaski Hwy	Edgewood	21040	02SW0539	History	12/23/2013
LKQ Pick Your Part (1209)	1706 Pulaski Hwy	Edgewood	21040	02SW2259	History	8/3/2011
LKQ Pick Your Part (1209)	1706 Pulaski Hwy	Edgewood	21040	12SR2259	Issued	3/30/2015
Mark/trece, Inc.	112 Connolly Rd	Fallston	21047	04NE3036	History	2/26/2015
Mark/trece, Inc.	112 Connolly Rd	Fallston	21047	12NE3036	Issued	2/27/2015
Maryland Used Auto Parts	1001-1009 Pulaski Hwy	Joppa	21085	12SR3120	Issued	6/8/2017
Master-Halco, Inc.	1720 Trimble Rd	Edgewood	21040	02SW1419	History	3/9/2006
Norman's New & Used Auto Parts, Inc	1301 S Philadelphia Blvd	Aberdeen	21001	12SW2279	History	12/8/2014
PS Publications Services	29 Ellendale St, Ste C	Bel Air	21014	02SW1354	History	4/12/2010
Sod Run WWTP	1212 Chelsea Rd	Perryman	21005	02SW1727	History	10/1/2014
Sod Run WWTP	1212 Chelsea Rd	Perryman	21005	12SW1727	Issued	10/2/2014
Sod Run WWTP	1212 Chelsea Rd	Perryman	21005	15DP1580	Issued	3/1/2016
WAVE - Worthington Armstrong Venture	1415 Perryman Rd	Aberdeen	21001	12NE1391	Issued	9/19/2014
WAVE - Worthington Armstrong Venture	1415 Perryman Rd	Aberdeen	21001	12NE1391o	History	9/18/2014

Bynum Run Watershed Total Maximum Daily Load Restoration Plan for Sediment

December 2019

Prepared for:
Harford County
Department of Public Works
212 South Bond Street
Bel Air, MD 21014

Prepared by:
URS Corporation
12420 Milestone Center Drive, Suite 150
Germantown, MD 20876

Revised by:
EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, MD 21031

BYNUM RUN WATERSHED
TOTAL MAXIMUM DAILY LOAD
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Total Maximum Daily Load Restoration Plan for Sediment

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12-SW	Industrial General Permit for Stormwater Discharges
BayFAST	Chesapeake Bay Facility Assessment Scenario Tool
BMP	best management practice
BSID	Biological Stress Identification
CAST	Chesapeake Assessment Scenario Tool
CBP	Chesapeake Bay Program
CIP	Capital Improvement Program
COMAR	Code of Maryland Regulations
County	Harford County
CWA	Clean Water Act
DPW	Harford County Department of Public Works
EA	EA Engineering, Science, and Technology, Inc. PBC
EOS	edge of stream
EPA	U.S. Environmental Protection Agency
ESC	Erosion and Sediment Control
ESD	environmental site design
GIS	geographic information system
HOA	Homeowners Association
HSG	Hydrologic Soil Group
lb	pound
MDE	Maryland Department of the Environment
MD SHA	Maryland State Highway Administration
MDRC	General Permit for Stormwater Discharges Associated with Construction Activity
MGD	millions of gallons per day
mg/l	milligrams per liter
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTU	Nephelometer Turbidity Unit
Plan	Bynum Run Watershed Total Maximum Daily Load Restoration Plan for Sediment
SPSC	step pool storm conveyance system
TMDL	Total Maximum Daily Load
TSS	total suspended solids
URS	URS Corporation

SECTION ONE: INTRODUCTION

The Bynum Run Watershed Total Maximum Daily Load (TMDL) Restoration Plan for Sediment (Plan) developed by the Harford County (County) Department of Public Works (DPW) will serve as a guidance document for the County to reduce sediment in the Bynum Run Watershed. This TMDL was established by Maryland Department of Environment (MDE) and approved by the U.S. Environmental Protection Agency (EPA) in September 2011.

On December 30, 2014, MDE reissued the Phase I National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit to the County. The permit has several new requirements, including stringent stormwater management criteria, implementation of strategies to reduce litter and floatables, and development of restoration plans. Part IV.E.2.b of the NPDES MS4 permit requires the County to develop restoration plans to address stormwater wasteload allocations (SW-WLAs) for the waterbodies in the County that have EPA-approved TMDLs. Attachment B of the County's NPDES MS4 permit lists eight waterbodies in the County that have TMDLs for various impairments. Table 1-1 lists the waterbodies, type of TMDL, and the impairment.

Table 1-1: EPA-Approved TMDLs in Harford County

Type of TMDL	Watershed	Impairment
Local	Bynum Run	Sediment
	Swan Creek	Nutrients
	Loch Raven Reservoir (Non-Tidal)	Bacteria
	Loch Raven Reservoir	Mercury
	Loch Raven Reservoir	Nutrients and Sediment
Chesapeake Bay	Bush River Oligohaline	Nutrients and Sediment
	Gunpowder River Oligohaline	Nutrients and Sediment
	Chesapeake Bay Mainstem 1 Tidal Fresh	Nutrients and Sediment
	Chesapeake Bay Mainstem 2 Oligohaline	Nutrients and Sediment

This Plan only addresses the Bynum Run TMDL. The Bynum Run Watershed (MDE 8-digit: 02130704), a subwatershed of Bush River Watershed (MDE 6-digit: 021307), lies entirely in Harford County and includes the Town of Bel Air, a Phase II NPDES MS4 community. The watershed also includes State-owned properties such as Bynum Run Park and Bynum Run Conservation area and State highways. Figure 1-1 shows the location of Bynum Run Watershed in Harford County, and where it overlaps the Town of Bel Air.

1.1 WATERSHED DESCRIPTION

Bynum Run Watershed is the most urban watershed in the County. The watershed is in the southeastern portion of Harford County. It begins at the intersection of Rock Spring Road and East Jarrettsville Road in Forest Hill and extends southeast to the confluence with James Run at Bush Declaration Natural Resources Management Area, north of Pulaski Highway. These streams converge and drain to Bush River. Approximately 50 percent of the Town of Bel Air, the portion of the town east of Main Street, is in the Bynum Run Watershed.

1.2 MDE-DESIGNATED USE OF SURFACE WATERS

MDE has classified all the waterbodies in the State including streams, impoundments, and tidal waters based on their designated use [Code of Maryland Regulations (COMAR) Section 26.08.02.08]. Table 1-2 identifies the use classes designated by MDE for surface waters.

Table 1-2: MDE-Designated Use Classes for Surface Waters

Class	Designated Use
I	Swimming, boating, fishing and other activities involving water contact, protection of aquatic life and wildlife (basic water use)
I-P	All basic water use and public water supply
II	All basic water uses and support estuarine and marine aquatic life and shellfish harvesting
II-P	All Use II and public water supply
III	All basic water uses and shellfish harvesting and propagation and growth of natural trout waters
III-P	All Use III and public water supply
IV	All basic water uses and recreational trout waters
IV-P	All Use IV and public water supply

Bynum Run and its tributaries are classified as Designated Use Class III waters, which support water contact recreation, and propagate growth of trout and other cold water aquatic life. There is one impoundment in the watershed, Bynum Run Community Lake located in Bynum Run Park which is also classified as Designated Use Class III.

1.3 DEVELOPMENT OF TMDL FOR BYNUM RUN

A TMDL is a calculation of the maximum amount of a pollutant a water body can receive and still meet the State water quality standards and designated uses. TMDLs are generally developed using pollutant load models or mathematical models that are calibrated using monitoring data.

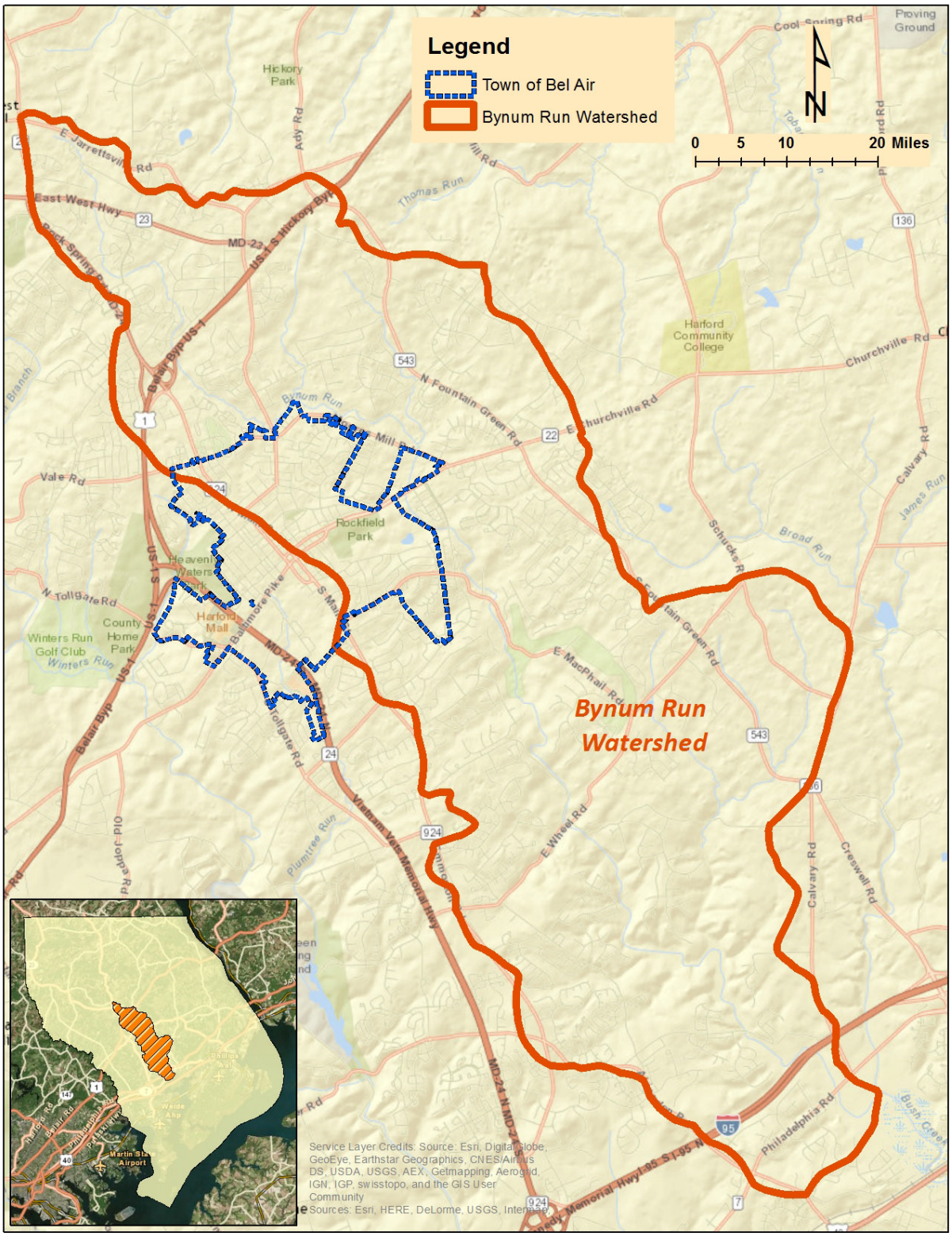


Figure 1-1: Location of Bynum Run Watershed and the Town of Bel Air

In general, a TMDL is made up of two major components:

- Wasteload allocation (WLA) includes point sources such as NPDES MS4-regulated urban stormwater (referred to as the SW-WLA) and industrial facilities that have permitted stormwater discharges and waste water treatment plants.
- Load allocation (LA) includes non-point sources such as unregulated stormwater from urban, agricultural, forested, and pasture areas.

In addition to these two components, TMDLs also include Margin of Safety (MOS), which accounts for any uncertainty in the TMDL analyses. A TMDL can be represented using the following equation:

$$\begin{aligned}&\textit{Total Maximum Daily Load}\\&\quad = \textit{Sum of Load Allocations} + \textit{Sum of Waste Load Allocations}\\&\quad + \textit{Margin of Saftey}\end{aligned}$$

$$TMDL = \sum LA + \sum WLA + MOS$$

Bynum Run Watershed was identified as impaired by sediment in the 2008 Integrated Report developed by MDE for Sections 305(b) and 303(d) of the Clean Water Act (CWA). To estimate the impact of sediment loads, MDE has used Biological Stressor Identification (BSID) methodology. Based on the results of the BSID analysis, MDE concluded that biological communities within the watershed were impacted by high flows and sediment-related stresses. To address the concerns about the sediment loads in the Bynum Run Watershed and to meet the requirements of the CWA, MDE developed a TMDL for sediment impairment for the watershed. Even though EPA approved the TMDL in 2011, MDE used 2005 data to develop it; therefore, 2005 is identified as the “baseline year” throughout this plan.

According to the TMDL Document for sediment impairment for Bynum Run Watershed (MDE, 2011a), sediment loads for the Bynum Run Watershed were estimated using the edge-of-stream (EOS) calibration target loading rates of the Chesapeake Bay Program (CBP) Phase 5.2 watershed model. Watershed-specific land use factors and erosion rates were used to calculate sediment loads from non-point sources as well as point sources such as the NPDES MS4 Phase I and II communities, which do not have limits for TSS concentrations. Sediment loads from point sources such as process water facilities that have TSS limits in their NPDES permits were calculated as a product of monthly or daily TSS concentration and corresponding flow rate.

1.4 SOURCES OF SEDIMENT IMPAIRMENT

The TMDL Document quantified sediment loads from point and non-point sources in the watershed. According to the *Total Maximum Daily Load of Sediment in the Bynum Run Watershed, Harford County, Maryland* (MDE, 2011a), "Urban land was identified as the only predominant controllable source in the watershed at 76.7 percent of the total watershed sediment load. Thus, reductions were only applied to this source." The report also states that MDE has expanded the watershed restoration component of the MS4 permits by stating "Theoretically extending these permitting requirements to all urban stormwater sources (i.e., not solely those sources regulated via Phase I MS4 permits) would require that all impervious areas developed prior to 1985 be retrofit at this pace." Part I.B of the County's MS4 permit correctly defines the MS4 Permit area. This plan is conservatively based on MDE's interpretation. However, the County expressly reserves its rights to reduce the load reduction goals for this plan to the minimum required by law.

1.4.1 Point Sources

Several permitted point sources in the watershed were identified as contributing sediment loads. These permitted sources are identified in Table 1-3.

Table 1-3: Point Sources in Bynum Run Watershed

Point Source	Permit Type	Contribution of Point Source Loads (%)
Harford County	NPDES MS4 Phase I (MD0068268)	68
Town of Bel Air	NPDES MS4 Phase II (MDR05550)	15
Maryland State Highway Administration (MD SHA)	NPDES MS4 Phase II (MD0068276)	6
Lafarge-Churchville Quarry	General Discharge Permit for Discharges from Mineral Quarries, Borrow Pits, and Concrete and Asphalt Plants (Permit No. 10-MM)	1
Other Regulated Stormwater	General Permit for Stormwater Discharges Associated with Industrial Activities (12-SW) General Permit for Stormwater Discharges Associated with Construction Activity (MDRC)	10
	Total	100

Of permitted sources, Lafarge-Churchville Quarry is identified as having a process water permit that has discharge limits for TSS as average daily or monthly concentrations and flows. Table 1-4 lists the TSS discharge permit limits for Lafarge-Churchville Quarry.

Table 1-4: TSS Discharge Permit Limits for Lafarge-Churchville Quarry

Point Source	Flow (MGD)	Permit Limits for Average Quarterly TSS Concentration (mg/l)	Permit Limits for Maximum Daily TSS Concentration (mg/l)
Lafarge-Churchville Quarry	0.9	30	66

MGD = millions of gallons a day mg/l = milligrams per liter

The other seven facilities that were identified as having stormwater discharge permits do not include limits for TSS concentration. Based on a review of the current General Permit for Stormwater Discharges Associated with Industrial Activity (12-SW) permit data available on the MDE website and a spatial analysis of facilities with 12-SW permits, it was also determined that the First Student Inc.-Harford County Garage Maintenance Facility, a County-owned facility, identified in the TMDL document, is not in the Bynum Run Watershed. It is in the Deer Creek Watershed, a subwatershed of the Lower Susquehanna River Watershed, and is therefore not included.

In addition to the above-mentioned point sources, the watershed includes seven sites that are covered under the General Permit for Discharges from Swimming Pools and Spas, including Baptismal Fonts (12-SI), which are insignificant point sources of sediment loads.

1.4.2 Non-Point Sources

Non-point sources of sediment loads include crop, extractive, forest, and pasture land uses. MDE's TMDL document identified that approximately 16.4 percent of the total sediment loads in the watershed are from agricultural areas, and that forest areas contribute approximately 5.4 percent of the total sediment loads. MDE's TMDL document also identifies stream bank erosion as a significant portion of the urban sediment load but has chosen to include this within the aggregate load for urban impervious loads.

1.5 TMDL TARGETS FOR HARFORD COUNTY SW-WLA

TMDL targets were only assigned to the urban sources in the watershed. No targets were assigned to the non-point sources.

The Bynum Run TMDL for sediment requires an overall 14 percent load reduction from the baseline. This load reduction was distributed among the stormwater point sources in the watershed. Table 1-5 lists the TMDL targets for the point sources in the watershed.

Table 1-5: TMDL WLAs for Stormwater Point Sources in Bynum Run

Facility Name	Permit Type	Sediment Load Reduction Target (%)
Harford County	NPDES MS4 Phase I (MD0068268)	19.7
Town of Bel Air	NPDES MS4 Phase II (MDR05550)	20.0
Maryland State Highway Administration	NPDES MS4 Phase II (MD0068276)	19.3
Other Regulated Stormwater	12-SW, MDRC	7.4

As discussed above, not all urban stormwater sources are regulated through the County's MS4 permit. Unregulated urban stormwater should have a separate target load (non-point) for the TMDL. The analysis within this Plan is based on MDE's expansive interpretation of the County's Permit Area in documents external to the County's current MS4 permit, which correctly defines the MS4 Permit Area. All rights noted above are reserved. This Plan therefore develops strategies to reduce sediment load in the portion of the watershed regulated by the County's MS4 permit (NPDES MS4 Phase I permit MD0068268) by 19.7 percent, which excludes the portion of the watershed within the Town of Bel Air.

1.6 REQUIREMENTS OF A TMDL RESTORATION PLAN

A TMDL restoration plan is a roadmap that identifies various water quality improvement strategies that a local jurisdiction can implement to reduce loadings of a particular pollutant in a specific impaired watershed. This graphic summarizes MDE's requirements for restoration plans as outlined within the County's MS4 permit. The County reserves the right to make arguments regarding the legality of the plan requirements notwithstanding their presentation in this plan. The Bynum Run TMDL focuses only on reducing sediment loads from the urban stormwater portion of the watershed.

The main objective of this TMDL Plan is to recommend a wide array of structural, non-structural, and programmatic management strategies that could be implemented at the watershed-scale level (rather than site specific).

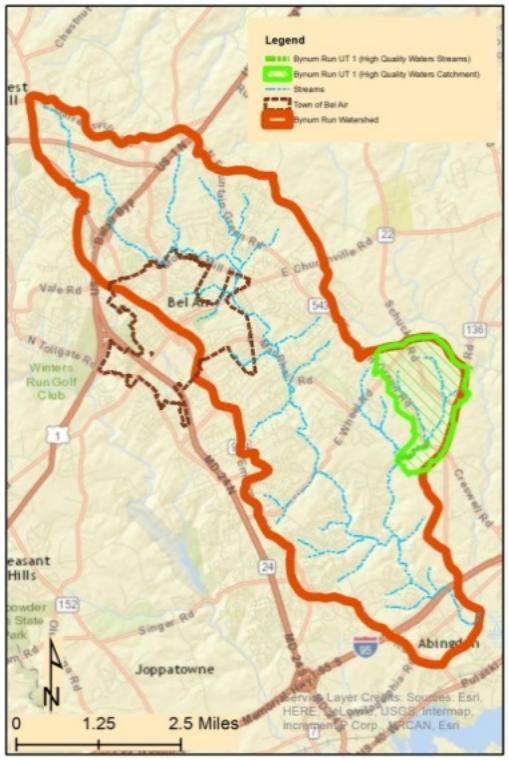
1.7 GOALS OF BYNUM RUN SEDIMENT TMDL RESTORATION PLAN

The goals for the Plan include:

- Baseline Load Conditions (2005) Scenario - Calculate sediment loads from the TMDL development baseline year based on County-level data.
- Proposed Restoration Strategies - Propose restoration measures, implementation costs, schedules and monitoring to address the TMDL goals.
- Proposed Load Conditions Scenario – Calculate the sediment load reductions that would be achieved by implementing the proposed restoration measures.

1.8 RESTORATION PLANNING IN TIER II WATERS

MDE data indicate that Tier II waters occur in one location in the Bynum Run Watershed, at Bynum Run Unnamed Tributary 1. The tributary extends from South Green Fountain Road to Creswell Road. The catchment to Bynum Run Unnamed Tributary 1 was identified based on the MDE data. This catchment primarily includes large tracts of forested areas with minimal development. Restoration projects have not been implemented in this area, nor are they planned for the future.



SECTION TWO: BYNUM RUN WATERSHED CHARACTERIZATION

This section summarizes the general conditions of the Bynum Run Watershed. The overall characterization of the Bynum Run Watershed was conducted using County-provided geographic information system (GIS) data and previous studies conducted by the County and MDE in the Bynum Run Watershed.

2.1 PHYSIOGRAPHY AND SOILS

The Bynum Run Watershed is primarily in the Piedmont Plateau province. This region of the watershed is characterized by crystalline igneous and metamorphic rocks of possible volcanic origin. Most piedmont streams are characterized by moderate slopes up to 15- percent with gravel and sand as bedrock material, which are to some degree resistant to erosion. These areas are characterized by rolling hills littered with ridges and valleys. The bedrock geology includes metamorphic rocks such as gneiss, marble, and phyllite in the upland areas, and sedimentary rocks such as limestone, sandstone, shale, conglomerate and quartz in the lowlands.

The portion of the watershed south of Interstate 95 is located in the Atlantic Coastal Plain province, which comprises primarily gravel, sand, silt, and clay from both terrain and marine origins. Streams in coastal zones have lower slopes compared to the streams in piedmont region, from 1 percent to 11 percent, and bedrock is made of sediment layers that are easily eroded and can contribute to sediment loads.

The soils data available for Harford County on the U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) website was used to evaluate the soil conditions in the Bynum Run Watershed. NRCS classifies soils into four Hydrologic Soil Groups (HSGs) (A, B, C, and D) based on factors such as runoff potential, soil texture, and infiltration rates. HSG A and B generally have sandy, loamy and silt textures and therefore they have high infiltration rates. HSG C and D have clay content and as a result have low infiltration rates and high runoff potential. Erodibility of soils increases with increase in silt and sand content. Soils with clay content are more stable and less susceptible to erosion due to the binding nature of the clay. Clay bonds with organic matter resulting in a more stable soil structure.

Table 2-1: Hydrologic Soil Group Distribution in the Bynum Run Watershed

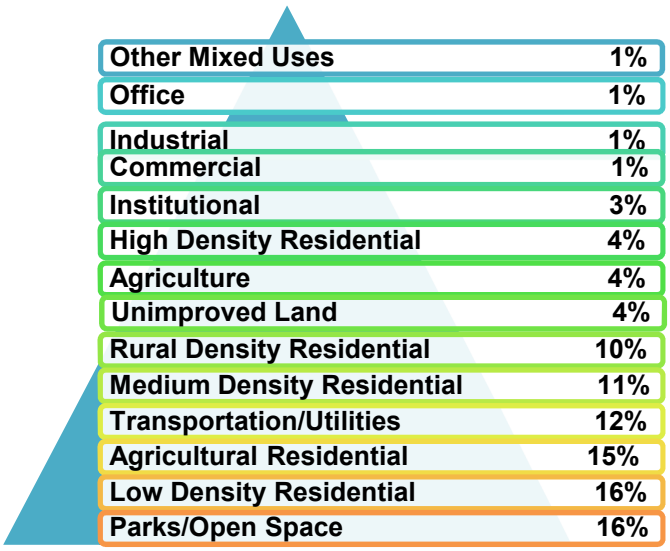
Hydrologic Soil Group	Percent (%)
A	2
B	58
C	25
D	15
Total	**100**

The majority of the soils in the Bynum Run Watershed are HSG B (58 percent) which are susceptible to erosion and therefore may contribute to some sediment loads in the watershed. Table 2-1 shows distribution of hydrologic soil groups in the watershed, and Figure 2-2 shows the physiographic regions in the watershed.

2.2 LAND USE AND IMPERVIOUS COVER

The distribution of land use and impervious cover has an impact on the amount of sediment load contributed to the streams. In general, land uses such as forest and open areas reduce the volume of runoff conveyed to the stream by promoting infiltration, thereby reducing the amount of sediment loads transported to streams. Increases in impervious cover due to development increase runoff, which may over time cause stream bank erosion and negatively impact aquatic and riparian habitat. Figure 2-1 shows in the land use distribution in Bynum Run Watershed.

Figure 2-1: 2014 Land use distribution in the Bynum Run Watershed



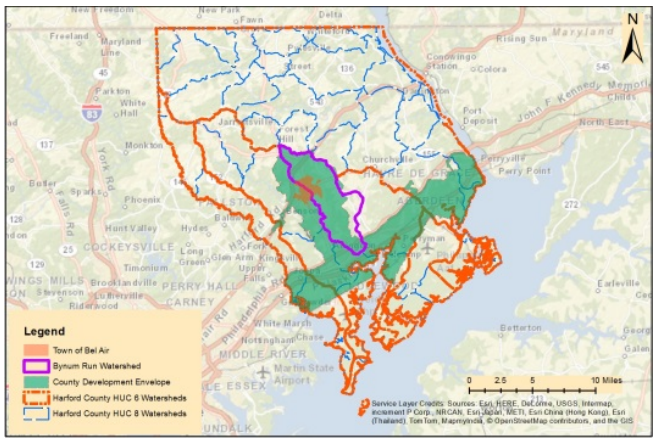
2.2.1 Land Use

Harford County has developed a robust GIS dataset reflecting the current land use conditions (2015) in Bynum Run Watershed. Residential low, medium and high density areas, including agricultural residential and rural residential areas, occupy approximately 56 percent of the watershed. Industrial areas in the watershed are concentrated along

Industry Lane and East Jarrettsville Road north of U.S. Route 1. Institutions in the watershed include County public schools, learning centers, churches and libraries. The Harford County Detention Center, on Rock Spring Road is also located in the watershed. Commercial areas are distributed throughout the watershed, with the majority located along U.S. Route 1, Churchville Road, and Rock Spring Road/North Main Street. Parks and recreational areas in the watershed include Bynum Run Park and Rockfield Park on East Churchville Road, Blake's Venture Park on Melrose Lane, Cedar Lane Sports Complex on Cedar Lane, Friends Park on East Jarrettsville Road, Maryland Golf and Country Club on East MacPhail Road, and Bush Declaration Natural Resources Management Area along Pulaski Highway. Figure 2-3 shows the land use distribution in the Bynum Run Watershed.

2.2.2 Impervious Cover

According to census data, four of the five fastest-growing areas in the County are in the Bynum Run Watershed and include Belcamp, Forest Hill, Bel Air, and Abingdon. Approximately 22 percent of the Bynum Run Watershed is currently impervious. As discussed below, nearly 86 percent of development occurred prior to 2002 when MDE adopted more stringent stormwater management regulations to protect water quality.



Bynum Run Watershed is located in the Priority Funding Area (PFA) or development envelope of the County (shown in the inset as the shaded green area). In 1997 Maryland adopted the Priority Funding Act to direct funding within designated growth areas or PFAs for programs such as public water and sewer and highways. Establishing designated growth areas fulfills the State's growth policy to concentrate development where public services such as water and sewer and public safety can more efficiently be provided to the community while directing growth away from rural areas.

The development trend in the watershed is likely to continue, resulting in additional impervious areas. The County has developed the *2012 Master Plan and Land Use Element Plan* (Harford County, 2012a), which aims to protect the natural and water resources and conserve forested and open areas.

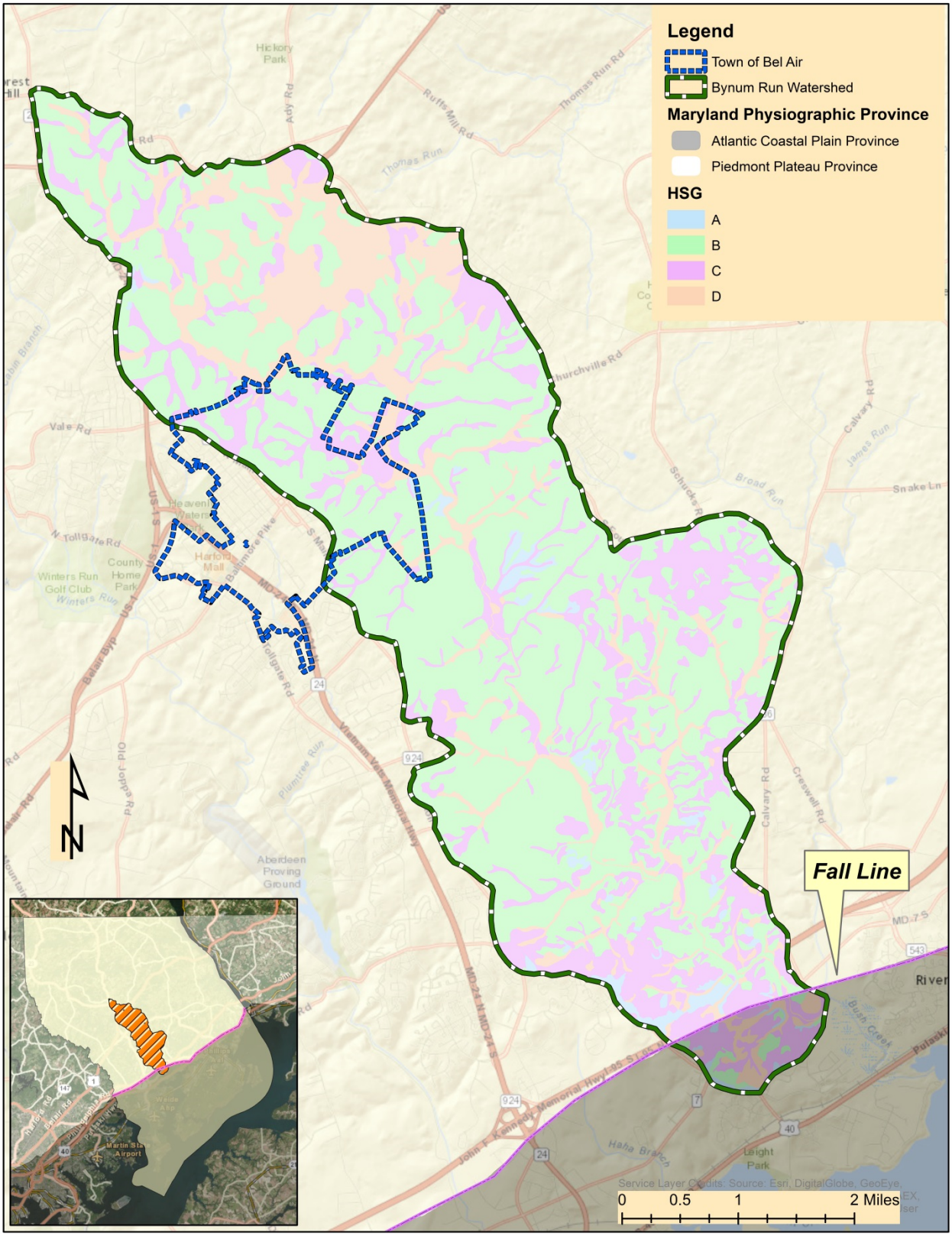


Figure 2-2: Physiographic setting and Hydrologic Soil Group distribution in the Bynum Run Watershed

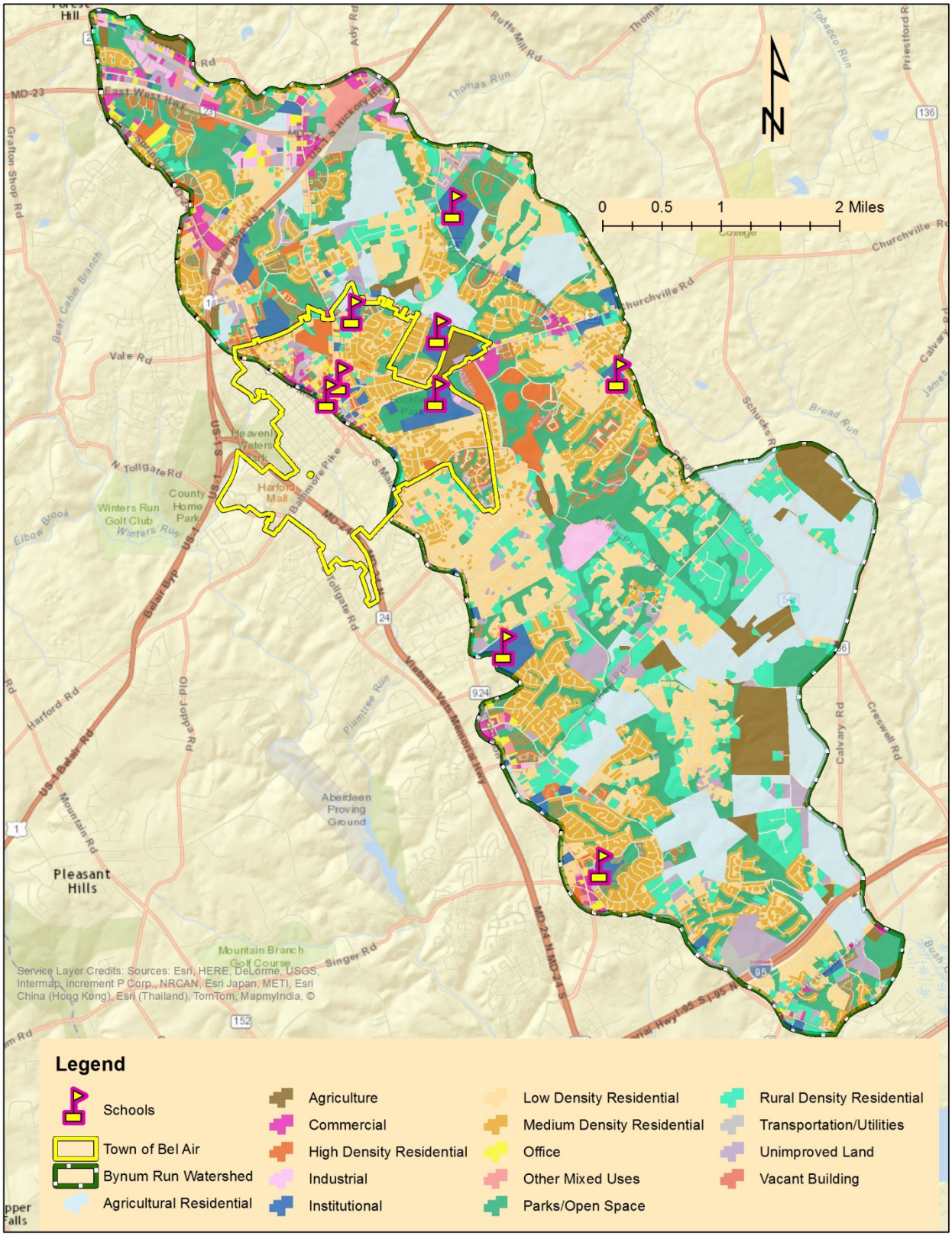


Figure 2-3: Land use distribution in the Bynum Run Watershed

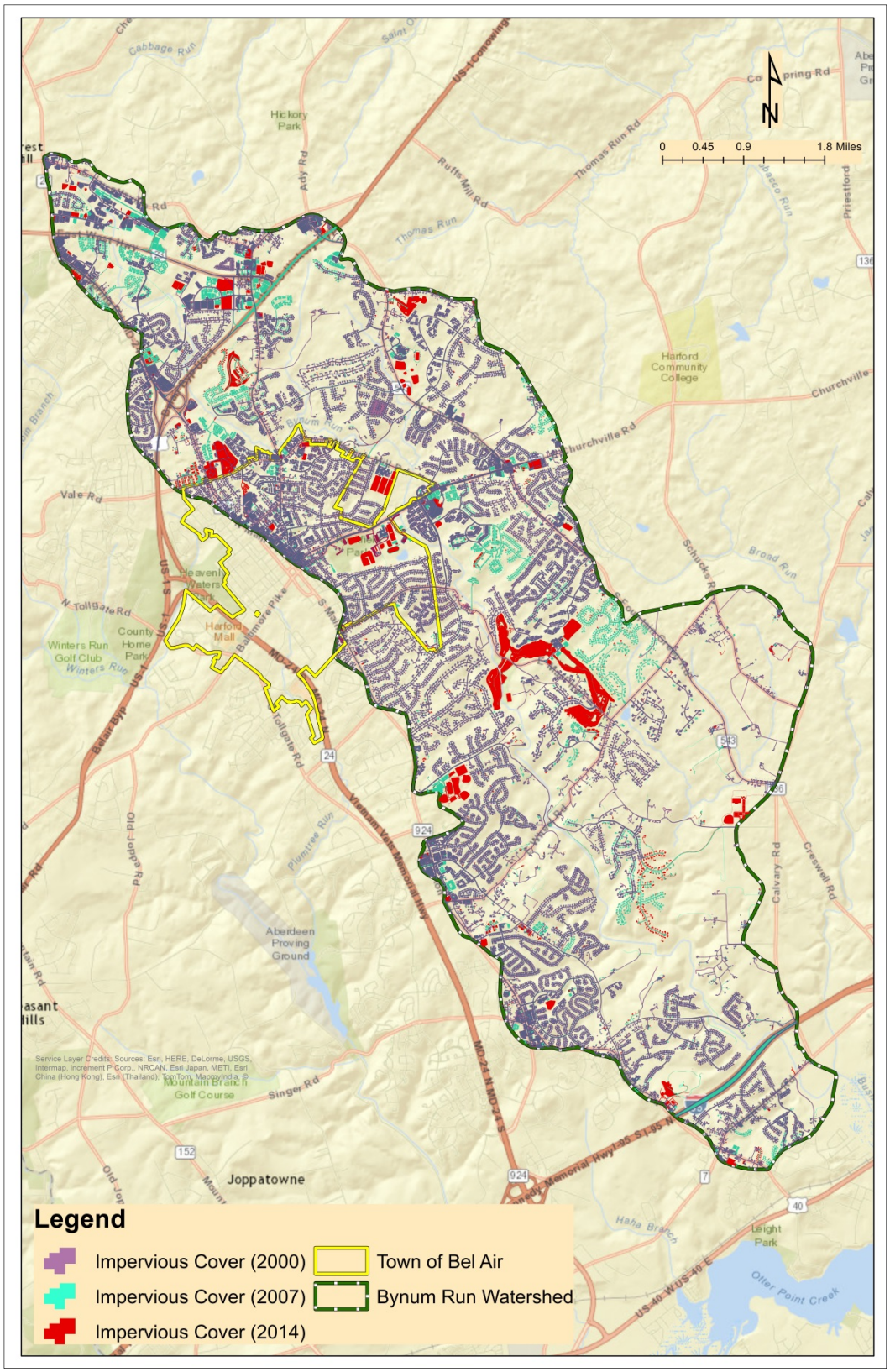


Figure 2-4: Impervious cover in the Bynum Run Watershed in 2000, 2007, and 2014

2.3 WATER QUALITY CONDITIONS

Previous studies conducted in the Bynum Run Watershed that evaluated the sediment conditions in the streams in the watershed were reviewed to analyze the health of the streams in the watershed over the years. The *Findings and Recommendations Report: Engineering Study for Bynum Run Watershed* (Harford County, 1999) and the *Watershed Report for Biological Impairment of the Bynum Run Watershed in Harford County Maryland, Biological Stress Identification Analysis Results (BSID) and Interpretations* (MDE, 2012) were conducted with a gap of 13 years and provide a good comparison of the change in stream water quality.

2.4 STORMWATER MANAGEMENT

Most areas developed prior to 1985 have no stormwater management associated with them because they were constructed before the State's stormwater management regulations were adopted.

Between 1985 and 2002, stormwater management in many jurisdictions in Maryland including Harford County, regulated only stormwater quantity. The stormwater management practices were designed to collect stormwater runoff from their drainage areas and release it at a controlled rate, providing limited water quality management.

In 2002, MDE required all jurisdictions to begin regulating stormwater quality management and increase stormwater quantity management. Stormwater management practices that provide quality treatment are designed to collect and treat rainfall through a combination of organic and inorganic filtering media such as sand, soil, gravel, and plants. Stormwater management practices that provide increased quantity management are designed to reduce stream bank erosion.

2.4.1 Structural Stormwater Controls

Approximately 86 percent of the parcels in Bynum Run Watershed were constructed prior to 2002 and as a result they do not have adequate controls for stormwater quality or quantity management to reduce stream bank erosion. The County's 2015 GIS data show that 337 stormwater management practices or BMPs (Table 2-2) have been constructed in Harford County portion of the Bynum Run Watershed. Approximately 5,813 acres of the Harford County portion of the Bynum Run Watershed is managed by these BMPs. The County continues to compile and refine historic BMP data that will be incorporated into future updates to this plan

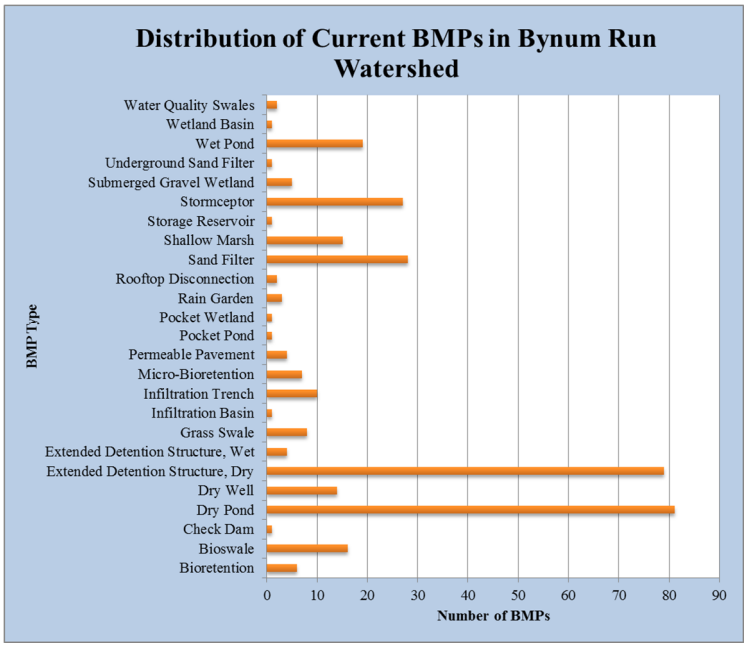


Table 2-2: Distribution of BMPs in Bynum Run from County GIS Data that meet MDE Design Standards (implemented 2002 to 2015)

Stormwater Management Era	Number of BMPs	Area Managed (acres)
1985-2001	175	4,852
2002-2009	109	876
2010-2015	47	85
Unknown	6	Unknown
Total	**337**	**5,813**

2.4.2 Non-structural Stormwater Controls

In 2002 MDE also approved the use of non-structural stormwater controls. These controls include disconnection of rooftop runoff, disconnection of non-roof top runoff, and sheetflow to conservation areas. Harford County has not inventoried non-structural stormwater controls. Therefore, non-structural stormwater controls are not included in this plan. The inclusion of this information into the plan will provide additional load reductions. The County will compile this historic data and incorporate the date into future updates to this plan.

2.5 ASSESSMENT OF SEDIMENT LOADS

As part of this Plan, sediment loads were quantified for the 2005 TMDL baseline year using County provided detailed data. The data used in the development of the Bynum Run TMDL by MDE were collected from the Maryland Department of Planning (MDP), which is a statewide broad scale view of land use conditions and therefore does not precisely capture detailed land use conditions. The sediment loads for this plan were calculated using an EPA-approved web-based tool called the "The Chesapeake Assessment Scenario Tool" (CAST). This tool was selected because its results are comparable to the CBP's Watershed Model, which MDE used to develop the sediment TMDL for Bynum Run. CAST is the successor to the now obsolete Maryland Scenario Assessment Tool (MAST) and the Chesapeake Bay Facility Assessment Scenario Tool (BayFAST), which were previously recommended by MDE (MDE, 2014c) for NPDES MS4 permittees for estimating nutrient and sediment loads for developing the restoration plans.

2.5.1 Defining the Harford County Urban Areas

To estimate the sediment loads, the Harford County urban areas in the watershed were defined using the statewide NPDES-Regulated Stormwater Area GIS data from MDE's TMDL data center, and County GIS data. The Town of Bel Air, Maryland SHA, State-owned properties and industrial properties with 12-SW permit coverage were excluded from this Plan.

The County portion of Bynum Run Watershed includes large portions of agricultural land that do not drain to the storm sewer system. These areas were identified from the County's agricultural land use GIS data and were excluded from the Harford County portion of the Bynum Run Watershed. County-owned properties within the Town of Bel Air were included in Harford County's jurisdiction such that restoration strategies could be implemented on those properties to address the TMDL. The County has included the properties in order to perform implementation on them, but the County does not concede they are properly part of the MS4 regulated Permit Area and it reserves the right to participate in any trading developed by the State.

Based on the 2005 progress year in CAST, approximately 5,549 acres are included in the Harford County (NPDES permit MD0068268) portion of the MS4 within the Bynum Run Watershed (Figure 2-5), which excludes the Town of Bel Air. The baseline and current load assessment scenarios were developed to estimate the sediment loads from these portions of the watershed. Similarly, the restoration strategies were also focused in these areas.

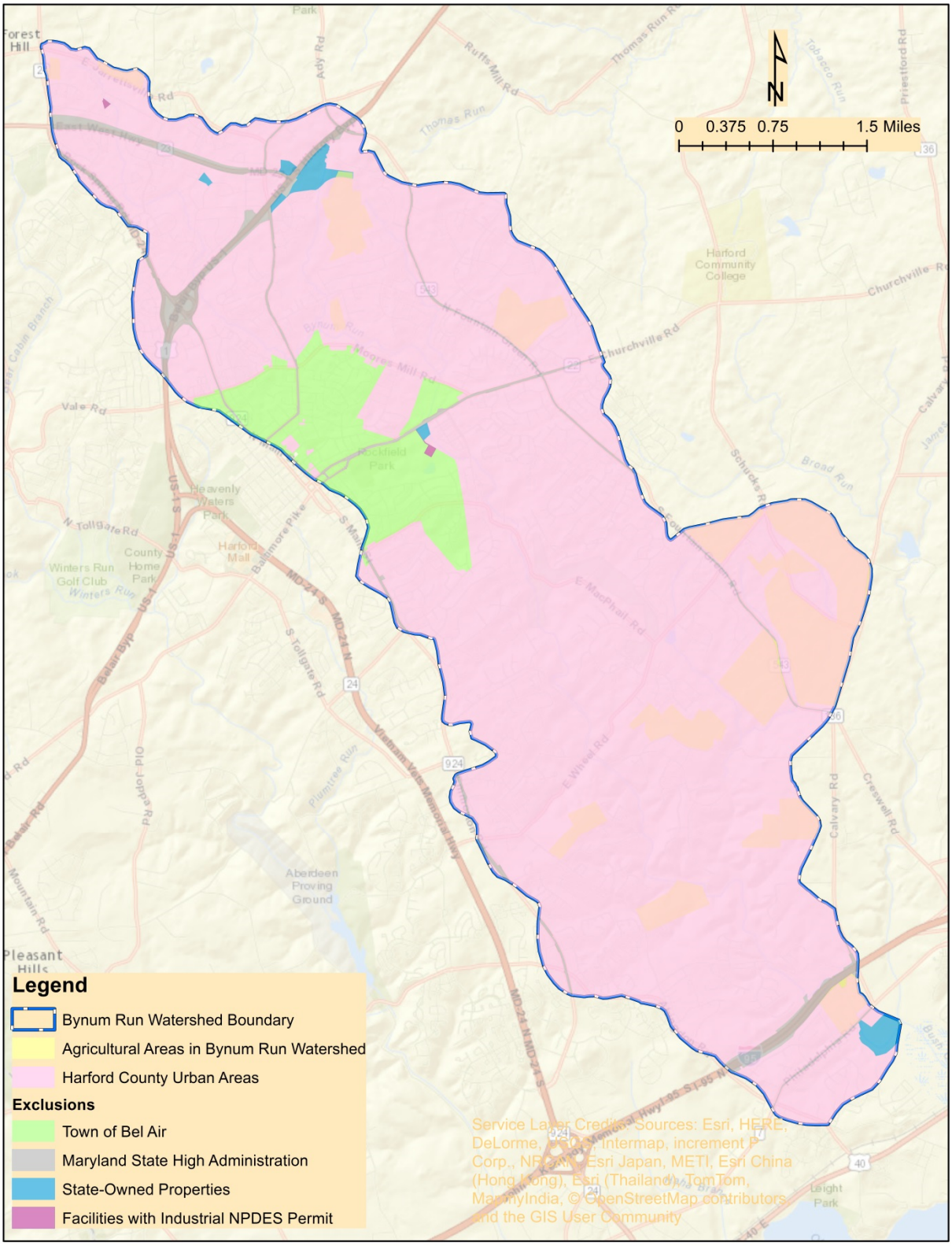


Figure 2-5: Harford County MS4 Areas in Bynum Run Watershed

2.5.2 Baseline Conditions (2005) Scenario using CAST

The previous version of this restoration plan utilized the Chesapeake Bay Program's BAYFAST (Chesapeake Bay Facility Assessment Scenario Tool) to assess sediment loads. The updates to the restoration plan for Bynum Run require the use of CAST (Chesapeake Assessment Scenario Tool) as BAYFAST is no longer available. CAST segments the loads by sources (i.e., agriculture, septic, developed) and agency (i.e., State, federal, non-federal). However, CAST does not separate the non-federal load between the county and the incorporated jurisdictions. Since both the Town of Bel Air and the County are located within the Bynum Run watershed, the total load must be disaggregated to determine the baseline load for Harford County.

The Chesapeake Bay Program Watershed Model (CBPWM) uses 2013 Phase 6 Land Use categories which differ from the land use categories within CAST (Table 2-3).

To correlate the land use categories between the 2013 CBPWM and CAST, a 2013 CAST scenario was run. The geographic area (land-river segment MD-N24025WU0_3250_0001 (CBWS)) of the Bynum Run Watershed was selected in CAST and the MS4 developed land use data populated in the baseline conditions CAST output report was used to compare to the CBPWM 2013 Phase 6 land uses to determine the correlation between land use categories (Table 2-3).

For example, the CBPWM 2013 Phase 6 Land Use class, MS4 Structures (881 acres) and Impervious Surfaces (1,160 acres) with a total acreage of 2,041 matched the closest to the CAST MS4 developed land use category of MS4 Buildings and Other with an acreage of 1,885.

The portion of the Bynum Run watershed within Harford County that excludes the Town of Bel Air was determined using the Phase 6 GIS layers and the computed percentages for each land use are shown in Table 2-4.

Table 2-3: Land Use Correlation Between CBPWM 2013 Phase 6 and CAST 2013

Bynum Run 2013 CBPWM[1] Phase 6		Bynum Run 2013 CAST	
Phase 6 Land Use Classes[2]	**Acres**	**Land Use Categories[3]**	**Acres**
MS4 Impervious Surfaces	1,160	MS4 Buildings and Other	1,885
MS4 Structures	881		
MS4 Impervious Roads	603	MS4 Roads	642
MS4 Tree Canopy over Impervious Roads	63	MS4 Tree Canopy over Impervious	352
MS4 Tree Canopy over Impervious Surfaces	120		
MS4 Canopy over Structures	44		
MS4 Tree Canopy over Turf	1,502	MS4 Tree Canopy over Turf Grass	1,776
MS4 Turf	3,003	MS4 Turf Grass	2,897
Total	**7,414**		**7,552**

1. CBPWM: Chesapeake Bay Program Watershed Model (Phase 6)
2. Phase 6 Land Use Categories sourced from Phase 6 2013 Land Use GIS Layers
3. Comparison of areas between Phase 6 2013 and CAST MS4 Land Use Categories resulted in the correlated pairings

Table 2-4: Bynum Run CBPWM Phase 6 Land Use (2013)

		Harford County (excluding Town of Bel Air)	
Phase 6 Land Use Classes	**Total Land Use Acres**	**Land Use Acres (2013)**	**%Land Use (2013)**
MS4 Impervious Surfaces	2,041	1,799	88.1%
MS4 Structures			
MS4 Impervious Roads	603	537	89.1%
MS4 Tree Canopy over Impervious Roads	265	227	85.7%
MS4 Tree Canopy over Impervious Surfaces			
MS4 Canopy over Structures			
MS4 Tree Canopy over Turf	1,502	1,278	85.1%
MS4 Turf	3,003	2,779	92.5%
Total	**7,414**	**6,621**	

The results of the baseline conditions (Progress 2005-CBP Admin) scenario are listed in Table 2-5. This reflects the 116 Developed BMPs that were functioning in 2005, as reported by the state to the Chesapeake Bay Program for annual progress and uses 2005 historic trends base conditions. According to the Bynum Run TMDL document, Harford County must reduce the stormwater loads by 19.7 percent from the baseline year.

Table 2-5: Sediment Loads from the Baseline Conditions (Progress 2005-CBP Admin) Scenario

CAST Load Source	CAST Total Watershed Sediment Loads (lbs/year)	County Portion (NPDES Permit MD0068268)	
		Percent	Sediment Loads (lbs/year)
MS4 Buildings and Other	3,154,206	88.1%	2,778,856
MS4 Roads	1,069,964	89.1%	953,338
MS4 Tree Canopy over Impervious	585,374	85.7%	501,666
MS4 Tree Canopy over Turf Grass	716,314	85.1%	609,583
MS4 Turf Grass	1,657,564	92.5%	1,533,247
Total	**7,183,422**		**6,376,689**

SECTION THREE: RESTORATION STRATEGIES

This section discusses the proposed restoration strategies to address the sediment TMDL load reduction and to improve the water quality in the streams in Bynum Run Watershed. These strategies were evaluated using existing County GIS data, reports such as the Bynum Run Engineering Study (Harford County, 1999), Harford County, Maryland *Phase II Watershed Implementation Plan (Phase II WIP) for the Chesapeake Bay TMDL* (Harford County, 2012b), the County's Capital Improvement Program (CIP), the *Accounting Document for Stormwater Wasteload Allocations and Impervious Area Credits* (MDE, 2014b) and other relevant data and resources. This section also includes the planning-level implementation costs for the proposed restoration projects along with the potential load reductions that are estimated using CAST. The proposed strategies can be broadly categorized as follows:

- **Structural Stormwater Management Strategies:** These include retrofits or new BMPs that are designed to the current MDE stormwater management standards to collect and treat stormwater runoff and remove sediment through processes such as filtration and infiltration. The proposed BMPs include ESD and traditional structural practices.

- **Alternative Urban Strategies:** Alternative urban strategies in general do not require detailed design like the structural BMPs and are aimed at conservation of natural resources through adoption of techniques such as tree planting and converting existing impervious areas to pervious areas. These strategies are approved by MDE and can provide flexibility for jurisdictions to address their NPDES MS4 and TMDL goals.

- **Programmatic Strategies:** These include recommendations to enhance the County's existing programs as well as potential new programs that could be adopted by the County and may include educating residents on pollution prevention and natural resources conservation practices.

3.1 STRUCTURAL STORMWATER MANAGEMENT STRATEGIES

New and retrofit BMP opportunities in the watershed were identified using the existing County GIS data such as parcels information, existing BMPs, and storm drain network.

The County CIP projects in the Bynum Run Watershed that are currently in the design phase are included as a part of this strategy. Implementation of new filtration, infiltration practices, retrofits of pre-2002 stormwater management facilities to current MDE standards, and storm drain outfall retrofits are examples of proposed structural BMPs. Urban stream restoration and step pool storm conveyance systems (SPSCs), which are classified as Alternative Urban BMPs by MDE, were included as a part of structural BMP restoration strategies in this restoration plan, as they include

detailed design development for implementation. The identified structural BMPs were categorized into High Priority, Medium Priority, and Low Priority Projects.

3.1.1 Completed and High Priority Proposed Projects

Completed structural, stream restoration, and urban tree planting restoration projects are included in Table 3-1a, 3-1b and 3-1c, respectively. Table 3-1a provides a summary of the completed structural BMPs projects including the project type, drainage area, impervious acres credited, implementation costs and sediment removal. Table 3-1b provides a summary of the completed stream restoration projects including the project name, length of stream, implementation costs, impervious acres credited, sediment removal efficiency, and sediment removal. Table 3-1c provides a summary of the completed urban tree planting projects including the project name, load sources, impervious acres credited, implementation costs, and sediment removal.

High priority proposed projects include all the restoration options identified on the County-owned properties. These were given high priority because of the relative ease of their implementation; the County does not need to develop any agreements to implement these projects and the projects would be easily accessible for maintenance. Approximately 75 County-owned properties in the watershed were evaluated for potential restoration projects. Thirty-eight projects were identified at schools, fire stations, and offices. The two County stream restoration CIP projects in the Bynum Run Watershed (Sunnyview Drive Stream Restoration – Farnandis Branch and Bynum Run at St. Andrews Way) were also included in the high priority projects because they are currently in design phase.Table 3-2 provides a summary of the high priority structural BMPs proposed projects including the project type, anticipated drainage, impervious area to be treated, planning-level costs and sediment removal. These high priority BMPs are proposed projects included in the previous version of this restoration plan (URS, March 2016). Table 3-3a provides a summary of the high priority structural BMPs that were included in the previous version of this restoration plan (URS, March 2016) as medium or low proposed projects. Additional high priority structural BMP restoration projects are provided in Table 3-3b. These additional high priority BMPs are newly proposed projects not included in the previous version of this restoration plan (URS, March 2016). These projects were identified in the Upper Bynum Run Small Watershed Assessment (2018) and include both publicly and privately owned properties. Planning-level cost calculations for the high priority projects are based on C*osts of Stormwater Management Practices in Maryland Counties* (King and Hagan, 2011). A contingency of 35 percent was added to these costs to account for increases in design, erosion and sediment control, permitting, and construction costs since the publication of the document. Figure 3-1 shows the locations of the proposed high priority structural BMPs. Table 3-4 provides a summary

of the stream restoration proposed projects including the project name, length of stream, impervious area to be treated, planning-level costs, sediment removal efficiency, and sediment removal. Details of the proposed high priority projects are included in Appendix A.

Table 3-1a: Completed Structural Post-Baseline BMP Restoration Projects

Completed Structural BMP	BMP Shortname	Drainage Area (acres)	Impervious Area (acres)	Total Costs ($)	Sediment Removal (lbs/yr)[1]
Friends Pond Stormwater Retrofit	st	36	11.5	$986,339	32,112
Total		**36**	**11.5**	**$986,339**	**32,112**

1. Includes all MS4 load sources, but not reductions to the stream bed and bank load source.

Table 3-1b: Completed Post-Baseline BMP Stream Restoration Projects

Completed Stream Restoration Project	BMP Shortname	Length of Stream Restoration (ft)	Total Costs ($)	Impervious Area Credits (acres)[1]	Sediment Removal Efficiency (lbs/ft)[2]	Sediment Removal (lbs/yr)[2]
Bynum Ridge Road and Bowles Terrace	urbstrmrest	465	$1,203,764	13.95	248	115,320
Total		**465**	**$1,203,764**	**13.95**	**NA**	**115,320**

NA = Not Applicable

1. Impervious acre credit calculated as 0.03 (or 0.02) * linear feet of stream restored piedmont (or coastal plain) (MDE 2019)
2. Sediment removal rate used by CAST (2017d). CAST applies load reduction from stream restoration to the Stream Bed and Bank load source; however, the County is claiming credit toward the MS4 WLA.

Table 3-1c: Completed Urban Tree Planting Post-Baseline BMP Restoration Projects

Completed BMP	BMP Shortname	From Load Source	To Load Source	Acres Planted	Impervious Acres Credited	Total Costs ($)	Sediment Removal (lbs/yr)
Urban Tree Planting	urbantreeplant	MS4 Turf Grass	MS4 Tree Canopy over Turf Grass	2.15	1.33	$94,920	517
Urban Tree Planting	urbantreeplant	MS4 Turf Grass	MS4 Tree Canopy over Turf Grass	3.20	1.98	$141,277	770
Total				**5.35**	**3.32**	**$236,197**	**1,287**

Table 3-2: High Priority Structural BMP Restoration Projects

Proposed Structural BMP	BMP Shortname	Drainage Area (acres)	Impervious Area (acres)[1]	Planning-Level Implementation Costs ($)[2]	Sediment Removal (lbs/yr)
Bioretention/Rain Gardens – A/B soils, underdrain	bioretudab	61.1	24.6	$6,047,416	64,609
Bioretention/Rain Gardens – C/D soils, underdrain	bioretudcd	3.3	2.4	$589,992	3,328
Bioswale	Bioswale	6.7	4.7	$264,092	9,611
Stormwater Management Retrofit to Upgrade to Current MDE Standards [1]	st	25.0	5.6	$479,470	21,636
Permeable Pavement without Sand, Vegetation – A/B Soils	permpavnosvudab	2.7	2.5	$801,305	4,058
Permeable Pavement wo/Sand, Vegetation – C/D Soils	permpavnosvudcd	0.8	0.7	$224,365	909
Urban Filtering Practices	filter	19.6	7.9	$517,882	20,736
Urban Infiltration Practices with Sand and Vegetation – A/B Soils, no underdrain	infiltwithsv	0.9	0.5	$40,972	1,336
Total		**120**	**48.9**	**$8,965,494**	**126,225**

1. Assumes 1-inch runoff depth treated
2. All costs in 2011 dollars using King and Hagen (2011) initial costs with a 0.991 County index and a 35% contingency factor.

Table 3-3a: Updated High Priority Structural BMP Restoration Projects

Proposed Structural BMP	BMP Shortname	Drainage Area (acres)	Impervious Area (acres)[1]	Planning-Level Implementation Costs ($)[2]	Sediment Removal (lbs/yr)
Bioretention/Rain Gardens – A/B soils, underdrain	BioRetUDAB	75.5	13.5	$3,308,871	58,458
Bioretention/Rain Gardens – C/D soils, underdrain	BioRetUDCD	2.03	0.36	$88,499	1,081
Filtering practices	Filter	49	9.99	$654,891	39,506
WetPondWetland	WetPondWetland	401	69.3	$2,234,806	230,984
Total		**528**	**93.1**	**$6,287,067**	**330,029**

1. Assumes 1-inch runoff depth treated
2. All costs in 2011 dollars using King and Hagen (2011) initial costs with a 0.991 County index and a 35% contingency factor.

Table 3-3b: Additional High Priority Structural BMP Restoration Projects

Proposed Structural BMP	BMP Shortname	Drainage Area (acres)	Impervious Area (acres)[1]	Planning-Level Implementation Costs ($)[2]	Sediment Removal (lbs/yr)
Bioretention/Rain Gardens – A/B soils, underdrain	BioRetUDAB	31.2	15.9	$3,901,321	37,188
Bioretention/Rain Gardens – C/D soils, underdrain	BioRetUDCD	4.2	0.81	$199,122	2,288
Filtering practices	Filter	23.8	3.75	$245,830	17,827
WetPondWetland	WetPondWetland	359	106	$3,405,603	247,848
Bioswale	Bioswale	28	9.89	$555,716	27,840
Total		**446**	**136**	**$8,307,593**	**332,990**

1. Assumes 1-inch runoff depth treated
2. All costs in 2011 dollars using King and Hagen (2011) initial costs with a 0.991 County index and a 35% contingency factor.

Table 3-4: High Priority Stream Restoration Projects

Proposed Stream Restoration Project	Length of Stream Restoration (ft)	Planning-Level Implementation Costs	Impervious Area Credits (acres)[1]	Sediment Removal Efficiency (lbs/ft/yr)[2]	Sediment Removal (lbs/yr)[2]
Sunnyview Drive Stream Restoration – Farnandis Branch	3,000	$7,766,219[3]	90	248	744,000
Bynum Run at St. Andrews Way Stream Restoration	3,000	$7,766,219[3]	90	248	744,000
Additional Bynum Run Stream Restoration Projects	40,775	$32,934,844	1,223	248	10,112,200
Total	**46,775**	**$48,467,282**	**1,403**	**NA**	**11,600,200**

NA = Not Applicable

1. Impervious acre credit calculated as 0.03 (or 0.02) * linear feet of stream restored piedmont (or coastal plain) (MDE 2019)
2. Sediment removal rate used by CAST (2017d). CAST applies load reduction from stream restoration to the Stream Bed and Bank load source; however, the County is claiming credit toward the MS4 WLA.
3. Costs in 2011 dollars using King and Hagen (2011) initial costs with a 0.991 County index and a 35% contingency factor.

The baseline load conditions (2005) scenario input data, and all the identified high priority projects were input in CAST to estimate the potential sediment load reductions. A load reduction of 14.7 percent (469 tons/year) was estimated from the implementation of all completed projects and the high priority structural restoration projects. The additional high priority stream restoration projects would yield 5,056 tons/year of sediment reduction, which far exceeds the MS4 TMDL reduction requirements of 19.7% (628 tons).

Approximately 28.8 impervious acre credits have been achieved by post-baseline completed projects, with approximately 278 additional impervious acre credits available by implementing the proposed high priority structural restoration projects. An additional 1,403 impervious acre credits could be achieved by implementing all of the proposed high priority stream restoration projects.

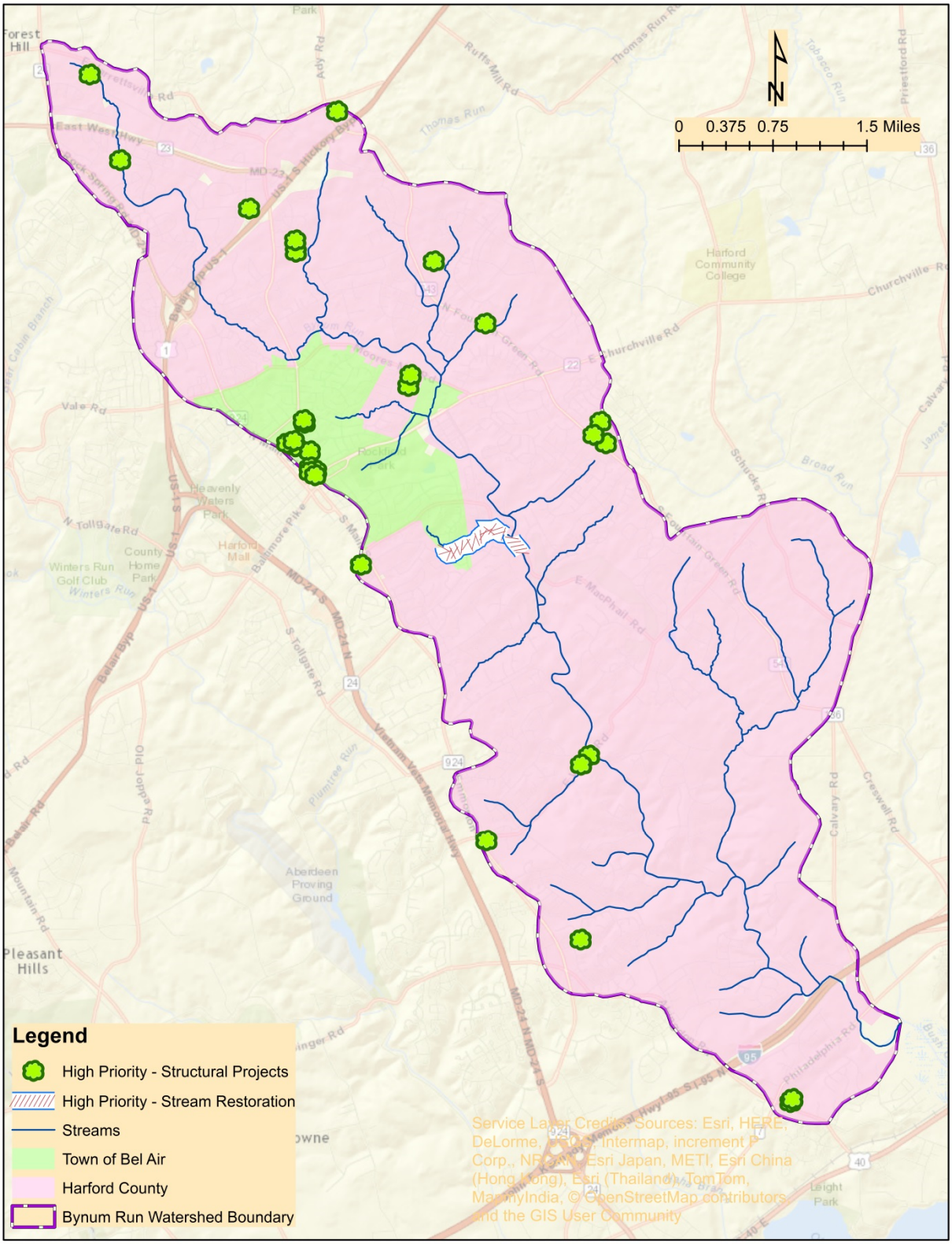


Figure 3-1: Locations of proposed high priority projects

3.1.2 Medium Priority Projects

Medium priority proposed projects include stormwater retrofits and new storm drain outfall retrofit projects on HOA-owned properties. The County has established a solid relationship with the various HOAs in Harford County by implementing various stormwater management projects and through public education and outreach. It is generally feasible to implement new and retrofit projects on HOA-owned areas through agreements, so the proposed restoration strategies on HOA-owned properties were given a medium priority.

Approximately 96 pre-2002 BMPs are located on HOA-owned properties and have the potential to be upgraded to the current MDE standards. Ideal retrofit options for dry ponds and extended detention dry ponds with drainage areas of less than 10 acres include converting them to a filtering system such as bioretention or sand filter to enhance the pollutant uptake. This option was proposed for approximately 15 dry ponds and extended detention dry ponds.

For the remaining 81 pre-2002 BMPs with drainage areas greater than 10 acres, upgrading the facility by modifying the outflow structure, increasing the flow path, and adding forebays and micropools was recommended. These include dry ponds, extended detention dry ponds; extended detention wet ponds, shallow marshes and wet ponds. The County's BMP GIS database was used to estimate the contributing drainage area for these BMPs. The impervious area captured is currently not populated in the BMP database; however, it was assumed that 22.5 percent of the drainage area was impervious based on the County's GIS data.

Additionally, storm drain outfalls that convey flow directly to the streams were evaluated for retrofit potential. Approximately 59 outfalls were identified where a BMP such as SPSC can be implemented to capture and treat the stormwater runoff before it discharges into the streams. Typically SPSCs are best suited to be implemented downstream of the outfall if the grade is less than 10 percent. Forty-nine of the 59 potential outfall retrofits are located on HOA-owned open areas.

A feasibility assessment was conducted using the County's water and sewer GIS layers to identify potential utility impacts. Forty-seven outfalls that did not have major utility impacts were categorized as medium priority, and two outfalls where potential water and sewer impacts were observed were given a low priority. Drainage areas and impervious area captured by the outfalls were delineated using the County's contour, storm drain, and 2014 impervious cover data. Implementation of SPSCs, and filtration practices such as bioretention and sand filters were proposed as outfall retrofits. Table 3-5 summarizes the proposed medium priority structural BMPs including the project type, anticipated drainage, impervious areas to be treated, planning-level costs and sediment removal.

Planning-level cost calculations for the medium priority projects are based on the *Cost of Stormwater Management Practices in Maryland Counties* (King and Hagan, 2011). A contingency of 35 percent was added to these costs to account for increases in design, erosion and sediment control, permitting, and construction costs since the publication of the document. Figure 3-2 shows the locations of the proposed medium priority structural BMPs. Details of the medium priority projects are included in Appendix A.

Table 3-5: Medium Priority Structural BMP Restoration Projects

Proposed Structural BMP	BMP Shortname	Drainage Area (acres)	Impervious Area (Acres)[1]	Planning Level Implementation Costs[2]	Sediment Removal (lbs/year)
Bioretention/Rain Gardens – A/B soils, underdrain	bioretudab	49.9	30	$7,374,898	65,268
Bioretention/Rain Gardens – C/D soils, underdrain	bioretudcd	118	47.1	$11,578,590	85,467
Stormwater Management Retrofit to Upgrade to Current MDE Standards[1]	st	1,353	305	$26,122,578	1,731,886
Urban Filtering Practices	filter	112	36.1	$2,366,523	107,030
Total		**1,633**	**418**	**$47,442,589**	**1,989,651**

1. Assumes 1-inch runoff depth treated
2. All costs in 2011 dollars

From the set the medium priority projects, retrofitting 81 pre-2002 BMPs with drainage areas greater than 10 acres will generate impervious area restoration credits of approximately 418 acres and help the County in addressing the NPDES MS4 permit's impervious area restoration requirements for the Bynum Run Watershed, as well as TMDL goals for the watershed.

A proposed scenario was developed in CAST using the current load conditions scenario input data, the identified high priority projects and the subset of medium priority projects that included upgrades of 81 pre-2002 BMPs to current MDE Stormwater Management standards. In addition to the 14.7% (469 ton/year) load reduction from the completed and high priority structural projects, an additional load reduction of 31.2 percent (995 tons/year) was estimated from the implementation of the proposed medium priority, for a total reduction of 45.9 %.

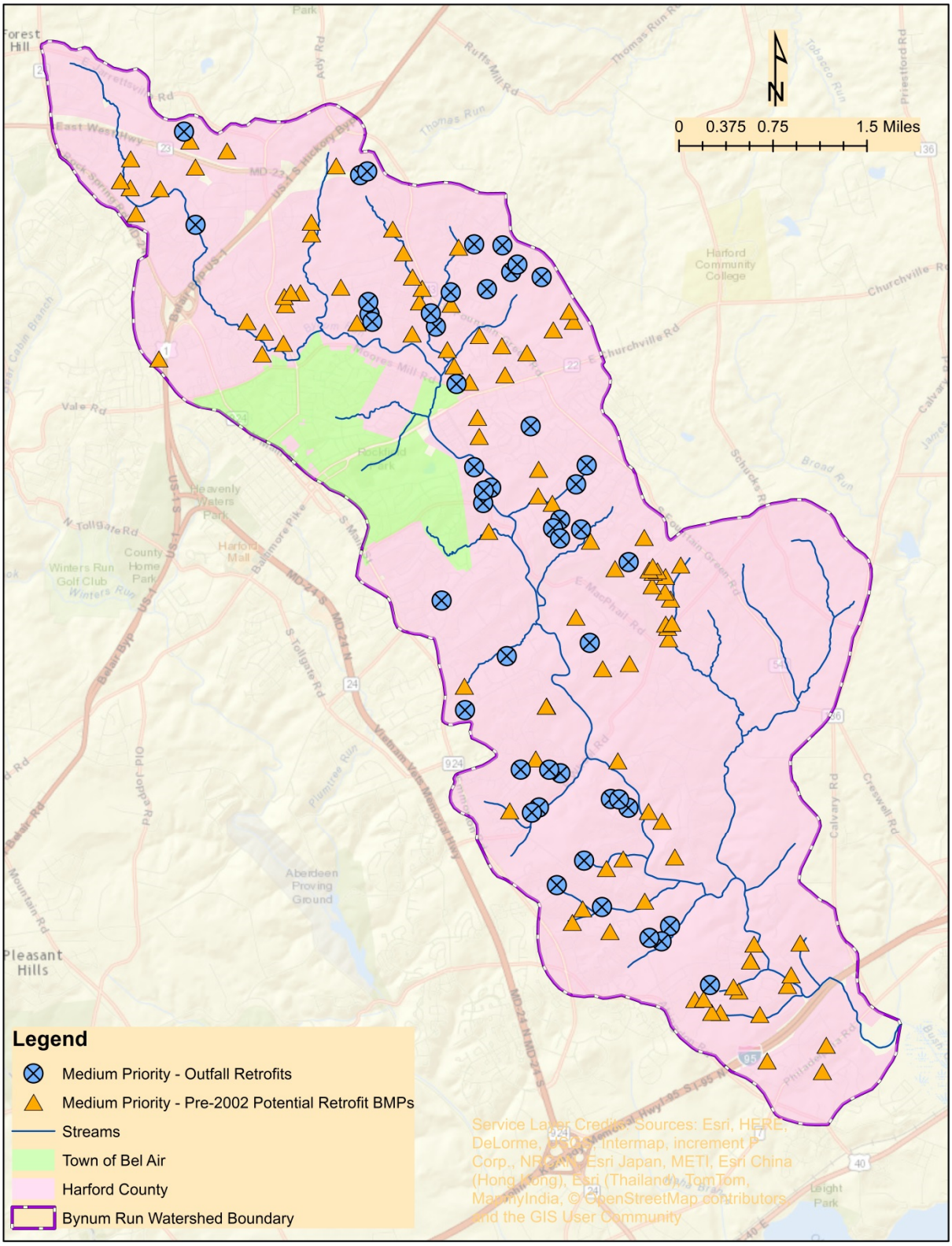


Figure 3-2: Locations of proposed medium priority projects

3.1.3 Low Priority Projects

The proposed projects on privately owned properties such as commercial and industrial areas were given low priority. These projects include retrofit of pre-2002 BMPs including dry ponds, extended detention dry ponds, shallow marshes and wet ponds, and of outfall retrofits on privately owned areas. Outfall retrofits on HOA-owned properties that have potential utility conflicts were also categorized as low priority. Projects in County-owned right-of-way were also categorized as low priority, as the County would not be implementing these projects immediately but will consider implementation as part of road improvement projects in the watershed. Even though the sediment TMDL goals can be addressed by the implementation of high and medium priority projects, these low priority projects would provide additional options to the County if any of the proposed high and medium priority projects are deemed not feasible.

Approximately 22 pre-2002 BMP retrofits, 6 outfall retrofits, and 20 right-of-way restoration projects, as shown on Figure 3-3, were considered low priority projects. Table 3-6 summarizes the proposed low priority structural BMPs including the project type, anticipated drainage, impervious area to be treated, planning-level costs and sediment removal.

Table 3-6: Low Priority Structural BMP Restoration Projects

Proposed Structural BMP	BMP Shortname	Drainage Area (acres)	Impervious Area (Acres)[1]	Planning-Level Implementation Costs[2]	Sediment Removal (lbs/yr)
Bioretention/Rain Gardens – A/B soils, underdrain	bioretudab	101	34.3	$8,431,967	98,935
Bioretention/Rain Gardens – C/D soils, underdrain	bioretudcd	68.5	25.9	$6,366,995	48,341
Stormwater Management Retrofit to Upgrade to Current MDE Standards[1]	st	89.9	20.3	$1,738,080	663,706
Urban Filtering Practices	filter	140	53.3	$3,494,063	144,280
Total		**400**	**134**	**$20,031,105**	**955,263**

1. Assumes 1-inch runoff depth treated
2. All costs in 2011 dollars

Planning-level cost calculations for the low priority projects are based on the *Cost of Stormwater Management Practices in Maryland Counties* (King and Hagan, 2011). A contingency of 35 percent was added to these costs to account for increases in design, erosion and control, permitting, and construction costs since the publication of the document.

A proposed scenario was developed in CAST using the target load assessment land uses to compute the sediment load reductions that could be achieved by implementing these identified

low priority projects. Implementing these low priority projects would further reduce sediment loads by approximately 478 tons/year (15 percent). Details of the low priority projects are included in Appendix A.

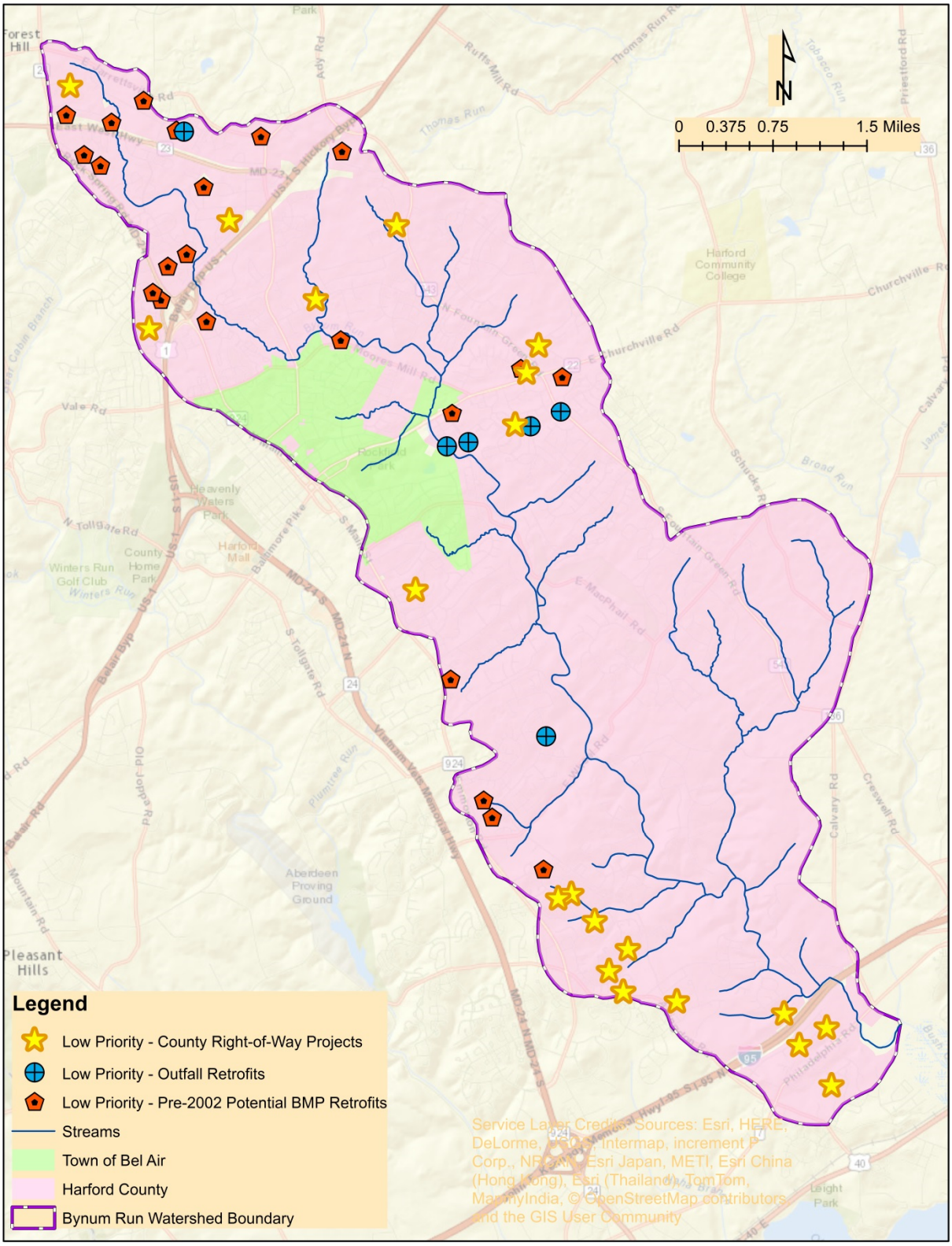


Figure 3-3: Locations of proposed low priority projects

3.2 ALTERNATIVE URBAN BMPS

In addition to the structural BMPs, MDE-approved Alternative Urban BMPs can be important options for the County to address sediment TMDL targets. The County has already adopted some of these alternative urban strategies. Expansion or modification of these strategies is proposed to receive credits from MDE as an approved Alternative Urban BMP.

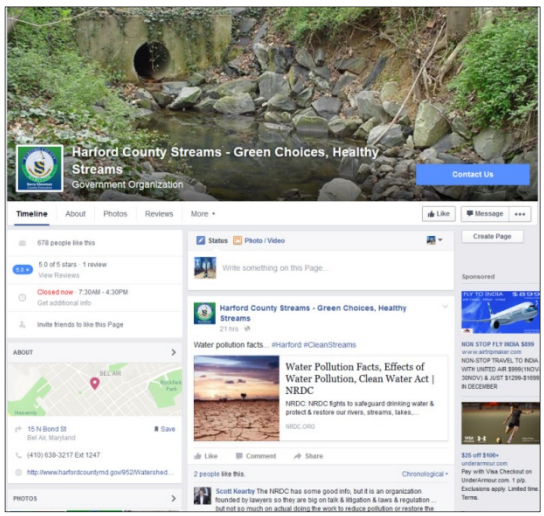
- **Urban Tree Planting:** The County is already implementing tree planting as a part of its stormwater management program on several schools and libraries. As an expansion to this program, six properties with available open area for tree planting were identified in the Bynum Run Watershed. Approximately 14.14 acres of open area are available for tree planting. To receive credits from MDE for tree buffers, a survival rate of at least 100 trees per acre is necessary, and 50 percent of the trees must be at least 2 inches in diameter and have a 4.5-foot-tall trunk. Assuming a load source conversion from MS4 Turf Grass to MS4 Tree Canopy over Turf Grass, could result in reduction of sediment loads by 3,379 lbs/year. Appendix B identifies the locations of the County properties in Bynum Run Watershed with available area for tree planting. Planning-level implementation costs of $624,000 (does not include land costs) are estimated for this strategy based on *Costs of Stormwater Management Practices in Maryland Counties* (King and Hogan, 2011). A contingency of 35 percent was applied to account for increases in unit costs for trees and resources required for tree planting since the publication of this document. Using the 0.38 impervious acre equivalent recommended by MDE (2014b), an impervious area credit of approximately 8.8 acres would be received from the implementation of the proposed tree planting projects.

- **Catch Basin Cleaning and Street Sweeping:** The County is currently not planning on expanding these programs to address TMDLs. The potential benefits from these programs will be evaluated by the County once all the restoration options are exhausted.

3.3 PROGRAMMATIC STRATEGIES

Public participation and stakeholder engagement are essential to the successful implementation of a TMDL restoration plan. Part IV.E.3 of the County's NPDES MS4 Permit requires the County to engage the public to solicit their input for potential program developments that could help the County in addressing applicable TMDLs. Most of the land in the Bynum Run Watershed is privately owned. Developing programs to promote education and outreach to these private property owners, including homeowners and businesses, on pollution prevention and good housekeeping would encourage their participation as environmental stewards.

The County currently uses Harford County's website http://www.harfordcountymd.gov and Facebook page at Harford County Streams – Green Choices, Healthy Streams to promote various education and outreach programs. The County participates in outreach events such as Earth Day and the Wade-In. The County also conducts programs at County schools annually to educate students on effective stormwater management.



In addition to the existing County programs, below are some potential programmatic strategies the County can consider to inform residents on the impacts of sediment pollution.

- **Education and Outreach Program for Erosion and Sediment Control (ESC):** Currently, the County requires implementation of ESC practices for all new development that disturb more than 5,000 square feet of area using the MDE approved ESC practices. A County inspector inspects all the sites and requires installation and maintenance of proper ESC practices. The County's ESC webpage currently has the list of sediment control practices that can be used. As Bynum Run Watershed is one of the fastest growing areas in the County, new development is anticipated to continue to increase. An education and outreach program for builders, contractors, and construction workers on the site could be developed on strategies for proper use of sediment control practices to reduce sediment pollution. The EPA-developed poster, available at http://water.epa.gov/polwaste/npdes/stormwater/upload/posterside1.pdf, can be used as one of the readily available outreach materials for the construction industry. In addition, the County can increase awareness of the readily available resources such as the County ESC webpage.

- **Education and Outreach Program for Home Owners:** The County posts several related messages on their Facebook page such as the importance of tree planting, pollution from stormwater runoff, and ongoing stormwater restoration projects throughout the County,

which increase awareness among residents about stormwater pollution. Incentive programs could be developed at the County level to promote installation of rain barrels, rain gardens, and other techniques to capture stormwater in residential areas. The EPA-developed material available at http://water.epa.gov/polwaste/npdes/stormwater/upload/solution_to_pollution.pdf could be used as potential outreach material for educating the home owners on pollution prevention. Additional resources are also available on one of Maryland's Phase I NPDES MS4 community's, Montgomery County's RainScapes website at http://www.montgomerycountymd.gov/DEP/water/rainscapes.html#resources.

- **Expansion of County's Current Urban Nutrient Management:** The County has adopted a nutrient management program at schools. This program promotes no-mow or low-mow areas throughout the property and reduction of stormwater runoff through infiltration, along with restriction on the use of any fertilizers. This program can be expanded to County properties so that concentrated runoff from impervious areas can be captured by the filter strips, thereby reducing the sediment loads.

- **Expansion of Stormwater Management Facility Maintenance Workshop Program:** The County's DPW currently conducts an annual workshop for the HOAs, businesses, and contractors on the maintenance of stormwater management facilities. Expansion of this program by conducting it bi-annually and adding more participants can increase awareness of the importance of maintaining stormwater management facilities.

3.4 SUMMARY

The TMDL goal of a 19.7 percent reduction in sediment load from the baseline load conditions is planned based upon implementing a subset of high and medium priority projects. The County has flexibility to select restoration projects from the set of high, medium, low and alternative urban BMPs to address the TMDL. Table 3-7 provides a summary of sediment load reductions, impervious credits and implementation cost of high, medium, and low priority restoration projects.

Table 3-7: Bynum Run Sediment Load Reductions based on Proposed Restoration Projects

Priority	Sediment Load Reductions from 2005 Baseline Load Conditions (tons/yr)	Sediment Load Reductions from Baseline Conditions (%)	Impervious Credits (acres)	Implementation Costs (millions)
Completed	74	2.33%	28.8	NA
High: Structural	63	1.98%	48.9	$8.97
High: Structural Updated	165	5.18%	93.1	$6.29
High: Structural Additional	166	5.22%	136	$8.31
High: Stream Restoration	5,056	159%	1,403	$32.9
Medium	995	31.2%	418	$47.4
Low	478	15%	134	$20.0
Totals	**6,998**	**219%**	**2,262**	**$124**
TMDL Goals	**628[1]**	**19.7**	**NA**	**NA**

NA = Not Applicable

1. 19.7% of estimated baseline load from CAST excluding Town of Bel Air.

SECTION FOUR: FUNDING AND TECHNICAL ASSISTANCE

4.1 POTENTIAL FUNDING SOURCES

The proposed restoration projects require funding for their successful implementation and continued maintenance. Funding is needed for the project implementation, operational expenditure, administrative costs, and for education and outreach program development. The County's CIP projects are funded through several sources such as bonds, recordation tax, and State and Federal grants. While these funds may be adequate to implement some of the proposed restoration strategies as a part of the CIP projects, additional funds will be needed to implement the other restoration strategies, and to expand educational and outreach programs. Table 4-1 identifies potential State and Federal funding, non-profit grants and loans that may be appropriate for the proposed restoration strategies.

4.2 TECHNICAL ASSISTANCE

Various documents, including *Guidance for Developing Stormwater Wasteload Allocation Implementation Plans for Nutrient and Sediment Total Maximum Daily Loads* (MDE, 2014a) and *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE, 2014b), provide guidance on the development of restoration plans and restoration strategies to address applicable TMDLs. In addition, MDE has conducted webinars and workshops to train the staff of NPDES MS4 jurisdictions on different tools and technologies developed by MDE. Technical guidance is also available for educators through MD DNR's "Resources for Educators" at http://dnr2.maryland.gov/Education/Pages/programs.aspx.

Table 4-1: Potentially Available Funding Sources for the Implementation of Restoration Strategies

Funding Source	Funding Agency	Funding Type	Restoration Measure Type Supported
Federal	National Fish and Wildlife Foundation (NFWF)/EPA	Matching Funds/Grants	• Stream restoration • Water quality improvement
Federal	EPA 319 Funds	Matching Funds/Grants	• Restoration of impaired waters by implementing watershed plans
Federal	EPA Urban Waters Small Grants	Matching Funds/Grants	• Projects that address urban pollution through outreach
State	Maryland Department of Natural Resources (MD DNR) – Chesapeake Bay Implementation Grants	Grant	• Watershed assistance • Natural filters • Innovative technology • Maryland agriculture cost-share
State	MD DNR – Natural Filters	Technical Assistance/ Funding	• Forest buffers • Wetlands
State	MDE – The Maryland Stormwater Pollution Prevention Cost-Share Program	Cost-Share	• Stormwater Management Retrofits
State	State Water Quality Revolving Loan Fund	Loan	• Point source pollution prevention • Non-point source pollution prevention
State	Bay Restoration Funds	Grant	• Failing/non-conforming onsite sewage disposal system • Upgrade of wastewater treatment plants
Non-Profit	Chesapeake Bay Trust	Grants	• Environmental education • Outreach • Water quality improvement through restoration and retrofits

SECTION FIVE: IMPLEMENTATION SCHEDULE

On February 17, 2015, the Harford County Council approved Resolution 005-15 which dedicates a portion of the recordation tax toward watershed protection and restoration improvement projects. The projected $2M per year will be used to pay for debt services for future bonds and / or loans. Harford County's projected annual budget for the implementation of the MS4 permit including capital improvement projects, watershed assessments and plans, water quality monitoring, etc. is $10 M. Harford County projects $2.5 M per year will be available for restoration projects in Bynum Run.

In 2018, Harford County completed a watershed assessment for the Upper Bynum Run, from the headwaters downstream to the crossing at Maryland Route 22, or 20% of the watershed. The data was incorporated into this updated plan. An existing USGS flow gage is located here and will assist in long term monitoring discussed in the next section. The watershed assessment will provides field collected survey data of the stream conditions and identifies additional restoration opportunities such as stream restoration that could provide lower costs per unit of sediment removal. An assessment of the Lower Bynum Run was completed in 2019 and will be incorporated into future updates to this plan.

The following table lists projected expenditures and sediment load reductions through 2019 which accounts for 40 tons or 20% of the load reduction.

Having prioritized the restoration strategies developed to address the sediment TMDL, the County will begin implementing high priority projects. Urban tree planting on school and County-owned property that is part of the restoration strategy will also be given high priority and combined with the existing tree planting program for other County-owned properties.

The County will also evaluate the medium priority projects. These projects will likely take longer to implement, as they are located on HOA properties, and agreements may need to be developed to initiate them. During the implementation process, if any of the high and medium priority projects are considered not feasible, then alternative options can be selected from the low priority projects.

As noted above, the County reserves the right, because the availability of resources is dependent on several factors, and because new technologies continuously emerge, to re-evaluate the implementation plan annually and update the plan based upon the feasibility of the proposed BMPs and the implementation schedule. As noted above, compliance with the County's MS4 permit is based upon an MEP level-of-effort as determined by the County.

SECTION SIX: MONITORING AND EVALUATION

6.1 EVALUATING PROGRESS OF PROPOSED RESTORATION STRATEGIES

Documentation regarding the County's progress on restoration is to be submitted in the County's annual reports due on December 30 each year and will include net changes in pollutant load reductions, and costs for completed projects. Pollutant load reductions will be calculated for each individual project constructed. Progress towards addressing the TMDL stormwater WLA will be calculated as a reduction in the current sediment load target of 1,222 tons per year. Updated CAST modeling occurred in 2019 to incorporate a completed historical review of BMPs and refinements to the 2014 impervious cover GIS layer. This is an updated current load scenario for 2015. Additionally, Harford County anticipates updating the planimetric GIS data in 2019. An updated CAST current load scenario will be completed with this data.

6.2 WATER QUALITY MONITORING

One method to determine the effectiveness of restoration strategies is to conduct a combination of physical, chemical, and biological monitoring. Improvements to biological communities are not instantaneous. Reducing sediment loads does not guarantee the return of a healthy biological community because it may be impacted by yet to be determined stressors. In addition, monitoring is costly. This plan, and the underlying County review, focuses on sediment load reduction and recognizes the impact flow has on sediment loading. The flow itself within the stream can also be a biological stressor. Therefore, load reductions should be credited towards for both TMDLs and impervious area restoration for managing the channel protection volume.

Harford County has collaborated with U.S. Geological Survey (USGS) to operate a flow gage on Bynum Run (USGS 01581500) since 1999. The gage is located on the main stem of Bynum Run at MD Route 22. Approximately 20% of the drainage area flows through the gage. Adding a turbidity probe at this location may be a cost effective method to measure sediment, but would only capture a portion of the watershed. To monitor turbidity effectively, a second USGS flow gage and turbidity probe could be installed lower in the watershed. The annual cost for a second flow gage and turbidity probe is estimated as $40,000.

Since this TMDL was established based on the BSID, the County intends to conduct biological monitoring using similar methods. Harford County anticipates initiating biological monitoring in the Bynum Run Watershed in spring 2017 using standard MBSS protocols. The monitoring methods will be established and presented to MD DNR for approval prior to monitoring. Harford County's goal is to collect scientifically defensible data.

This proposed monitoring program aligns with the County's current watershed monitoring strategy. Watershed based monitoring programs have been established in the Plumtree Run and Foster Branch watershed including USGS gages for flow and water quality. The purpose of this watershed-based approach is to utilize this data to demonstrate water quality improvements on a watershed level. Conducting site specific monitoring as generally required through wetland permitting by MDE and / or U.S. Army Corp of Engineers is very costly, labor intensive, and does not provide useful data for restoration planning at the local level.

6.3 INSPECTION AND MAINTENANCE

Maintenance is a key component for the success of any proposed or existing BMP to maintain the design level of treatment of runoff. Inspectors are important because they provide guidance for BMP operators to ensure they are following maintenance consistent with BMP design. Chapter 3 and Chapter 5 of the Maryland Stormwater Design Manual (MDE, 2000) describe maintenance requirements for conventional stormwater BMPs and for ESD practices, respectively.

Maintenance can be broken up into three general categories: routine, structural, and emergency. Routine maintenance should be the most frequent and does not require any structural changes to an existing stormwater practice (e.g., mowing, weeding, and removing trash from an existing stormwater practice). Structural maintenance is less frequent and involves replacing or repairing structural features of an existing practice (e.g., replacing broken storm drain pipes, repairing riser structures, replacing filter media). Emergency maintenance is the least common, and is required when an existing structure has failed or is about to fail (e.g., emergency spillway failure, flooding at an existing BMP).

Typical maintenance practices for stormwater BMPs include removal of invasive vegetation, mowing grass, removing sediment from pretreatment forebays, and replacing structural features (e.g., weirs, storm drain pipes, overflow structures). Wetlands require additional maintenance, as wetland plantings may be required if vegetation cover requirements are not met. Infiltration (e.g., infiltration trenches, infiltration basins, dry wells) and filtering practices (sand filters, bioretentions, micro-bioretentions, submerged gravel wetlands, and rain gardens) require additional inspection and maintenance considerations related to the filtering media, which may need to be replaced if clogged with sediments.

Inspectors must understand the unique design considerations and maintenance needs of each type of stormwater BMP. For example, wet swales and bio-swales do not require mowing, a dry swale should have grass heights in the 4 to 6 inch range, and a surface sand filter should have grass heights of less than 12 inches. While these slight differences may seem trivial, incorrect

maintenance can substantially reduce pollutant removal effectiveness. Qualified inspectors are therefore an important element in enforcing proper maintenance practices.

MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE, 2014a) indicates that:

> *Regular maintenance shall occur for all BMPs once every 3 years and each jurisdiction shall implement appropriate actions and document that any deficiencies are rectified. Otherwise, the credits will be removed until proper performance is verified.*

Harford County is responsible for conducting triennial inspections for all stormwater management facilities. Most stormwater management facilities are privately owned, typically by homeowner associations, individual businesses or business parks. These owners are required to provide preventative and long-term maintenance as outlined within a maintenance agreement and / or maintenance schedules included within approved design plans. Ensuring these facilities are functioning properly is important in maintaining load reductions for Bynum Run. Harford County anticipates reviewing the status of all existing stormwater management facilities within the Bynum Run watershed. All maintenance records will be associated with plans review records, and an inspection and outreach program will be developed. Restoration that includes retrofitting existing stormwater management facilities and constructing new stormwater management facilities are included in the inventory for triennial inspections.

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APPENDIX A:
Proposed Restoration Strategies for the Bynum Run Watershed Total Maximum Daily Load Restoration Plan for Sediment

Structural Stormwater Best Management Practices (BMPs)

Table A1: High Priority – Structural BMPs

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
CP-1	Board of Education	William S. James Elementary School	Tree Box Filter	0.85	0.78	Two inlets at the northwestern parking lot can be retrofitted with tree box filters to treat the stormwater runoff from the parking lot and the driveways at the northern and western ends of the property.	$51,132.63
CP-3	Board of Education	East of Forest Hill Annex	Bioretention	0.78	0.59	A bioretention can be implemented in the open area east of the parking lot.	$145,039.66
CP-5	Board of Education	C. Milton Wright High School	Step Pool Storm Conveyance System (SPSC)	20.29	8.86	Majority of the property drains to the outfall on the southwestern corner. A channel runs downstream from the outfall until confluence with the stream. The area is a good place to implement SPSC at OF001309.	$2,178,053.25
CP-6	Harford County	Abingdon Fire Company	Bioretention	1.34	0.80	A bioretention to treat rooftop runoff and parking lot in front of the building can be implemented. The grass area in front of the building is available for implementation.	$196,663.95

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
CP-6A	Harford County	Abingdon Fire Company	Permeable Pavement	0.66	0.64	Parking lot can be converted to permeable pavement to treat stormwater runoff.	$205,134.15
CP-7	Board of Education	Southampton Middle School	Bioretention	1.10	0.37	A bioretention can be implemented to treat stormwater runoff from parking lot south of Moores Mill Road. Open area is available to implement the bioretention.	$90,957.08
CP-7A	Board of Education	Southampton Middle School	Bioretention	6.03	4.33	Multiple bio-filtering practices can be implemented in the open area around the building to treat rooftop runoff and parking lot runoff.	$1,064,443.63
CP-9	Harford County	County Property on 45 E. Gordon Street	Micro-Bioretention	0.28	0.12	Micro-bioretention to treat a portion of the roof can be implemented in the open area available southeast of the property.	$29,499.59
CP-10	Harford County	County Property on 503 Bynum Road	Bioretention/ Sand Filter	0.11	0.05	A filtration practice can be implemented to treat runoff from the entire building and a portion of the driveway in the open area west of the property.	$12,291.50

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
CP-11	Harford County	Harford County Animal Control Division	Bioswale	3.61	2.01	Almost half of the property currently drains to a grass area along the road. A bioswale can be implemented in the grass area.	$112,941.297
CP-12	Harford County	County Property on 621A Hickory Overlook Drive	Bioretention	0.28	0.13	A bioretention to treat half of driveway and the buildings can be implemented in the open area south of the property. Infiltration not possible because is the open area has C/D soils.	$31,957.89
CP-12A	Harford County	County Property on 621A Hickory Overlook Drive	Permeable Pavement	0.16	0.08	The lower portion of the driveway drains to the wooded area on the east. Potential for permeable pavement or infiltration practice to treat runoff from the northern half of the driveway.	$25,641.77
CP-13	Harford County	County Property on Wright Street	Micro-bioretention	0.25	0.18	County parking lot can be treated by adding a micro-bioretention at the eastern corner next to the entrance.	$44,249.39

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
CP-14	Board of Education	Bel Air Elementary School	Bioretention	3.40	2.0	A flow splitter can be added to the inlet near the median to divert the flow to the open area southeast of the property where a bioretention can be implemented.	$491,659.88
CP-14A	Board of Education	Bel Air Elementary School	Downspout Disconnection and Micro-Bioretention	0.16	0.14	Downspouts from the rooftop of eastern building can be disconnected, and a micro-bioretention can be implemented in the open area next to it.	$34,416.19
CP-15	Board of Education	Wakefield Elementary School	Downspout Disconnection and Landscape Infiltration	0.37	0.35	Hydrologic soil group (HSG) B in the area, so runoff can be treated by downspout disconnection and landscape infiltration at the main building.	$28,680.16
CP-16	Board of Education	County Property on S. Conowingo Road	Bioswale	3.04	2.69	A bioswale can be implemented downstream of the existing outfall. Topo looks suitable for implementation of a bioswale.	$151,150.29
CP-17	Harford County Commissioners	County Property on Courtland & Burns Alley	Permeable Pavements	0.22	0.19	Permeable pavement is a possible option for the area because there is not much open area available for other practices.	$60,899.20

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
CP-18	Harford County	County Property on 11 W. Courtland Street	Permeable Pavements	0.11	0.11	Permeable pavements possible option because there is not much open area available for other practices.	$35,257.43
CP-19	Harford County	County Property on 112 S. Hickory Avenue	Permeable Pavements	0.19	0.19	Permeable pavements possible option because there is not much open area available for other practices.	$60,899.20
CP-20	Harford County	County Property on Wheel and Old Emmorton Road	Bioretention	0.24	0.18	Bioretention can be implemented to treat portion of Old Emmorton Road, which is a County-owned road.	$44,249.39
CP-21	Harford County	County Property off Mardic Drive	Infiltration Trenches	0.56	0.18	Possibility to treat the road parcel using infiltration practices because the soils are HSG B in the area.	$14,749.80
CP-22	Harford County	Fountain Green Elementary School	Retrofit of Pond to Filtering Practice	3.62	1.95	Portion of parking lot drains to this unidentified pond. Potential to retrofit the stormwater pond to a filtering practice to provide water quality.	$127,831.57
CP-25	Harford County	County Senior Citizen Center	Micro-Bioretention	0.60	0.29	Micro-bioretention can be implemented to treat a portion of the property in the open area northeast of the property.	$71,290.68

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
CP-26	Harford County Commissioners	County Public Library –Bel Air	Permeable Pavement	0.52	0.41	Potential to convert parking lot to permeable pavement to treat portion of rooftop and parking lot runoff as well.	$131,414.06
CP-27	Harford County	County Property on 611 E. Wheel Road	Sand Filter	0.57	0.37	A filtration practice can be implemented in the County open area to treat a portion of Wheel Road, which is County owned.	$24,255.22
CP-28	Harford County	County Property on 703 Wheel Road	Sand Filter	0.19	0.16	A filtration practice can be implemented in the County open area to treat a portion of Wheel Road, which is County owned.	$10,488.74
CP-30	Board of Education	Fountain Green Elementary School	Micro-Bioretention	0.44	0.41	A micro-bioretention can be implemented in the open to treat portion of roof top in the open area east of the building.	$100,790.27
CP-30A	Board of Education	Fountain Green Elementary School	Micro-Bioretention	0.45	0.38	A micro-bioretention can be implemented to treat runoff from parking lot west of the property.	$93,415.38
CP-31	Harford County	County Property on 121 S. Main Street	Permeable Pavements	1.68	1.56	Permeable pavements are potential option at this property as there is not much open area available for other practices.	$500,014.48

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
SWM000164	Board of Education	Fountain Green Elementary School	MS4 Permit Required Stormwater Retrofit	25.0	5.6	The existing pre-2002 wet pond is proposed to be upgraded to the current MDE standards.	479,470.46
OF-17	Board of Education	C. Milton Wright High School	Bioretention	1.55	1.04	A filtering practice can be implemented at the outfall to treat the runoff before it is conveyed to the stream.	$255,663.14
OF-18	County	County Property South of Malku's Way	SPSC	4.71	2.02	The outfall can be retrofitted with an SPSC to treat runoff from May Court and Malku's Way neighborhood.	$496,576.47
OF-19	County	County Property North of East Broadway	Sand Filter	6.61	2.16	A sand filter can be implemented at the outfall to treat runoff from East Broadway and Ardmore Way neighborhood.	$141,598.04
OF-33	County	County Property East of Briarcliff Lane across Rolling Place	SPSC	10.00	2.25	The outfall can be retrofitted with an SPSC to treat a portion of runoff from Saratoga Drive and Briarcliff Lane neighborhood.	$553,117.36
OF-35	County	County Property South of Glenangus Drive	Sand Filter	7.79	2.46	A sand filter can be implemented at the outfall to treat a portion of runoff from Glenangus Drive.	$161,264.44

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
OF-49	County	County Property End of Brewster Drive	SPSC	5.26	1.61	The outfall can be retrofitted with a SPSC to treat a portion of runoff from Parliamentary Drive and Brewster Lane neighborhood.	$395,786.20
SWM000097(1)	Private - Residential	Behind 1204 Bancroft Court	Sandfilter	7	1.6		$65,555
SWM000116	Private - Residential	Behind 1357 Crofton Drive	Stormwater Wetland	18.9	4.3		$85,620
SWM000099	Private - Residential	Behind 1200 Gyros Court	Sandfilter	16.4	3.7		$65,555
SWM000210	Private - Residential	Behind 1203 Hampton Ridge Lane	Stormwater Wetland	25	5.6		$85,620
SWM000070	Private - Residential	Intersection Route 543 and Thomas Run Road	Stormwater Wetland	25	5.6		$85,620
SWM000014	Private - Residential	Behind 1013 Shaffner Drive	Stormwater Wetland	5.3	1.2		$85,620
SWM000011	Private - Residential	Behind 1315 Cheshire Lane	Bioretention	11.9	2.7		$245,830
SWM000012	Private - Residential	Behind 1339 Cheshire Lane	Bioretention	5.1	1.1		$245,830
SWM000281	Private - Residential	Next to 1344 Agora Place	Sandfilter	11.5	2.6		$65,555
SWM000064	Private - Residential	Next to 1411 Banstead Court	Stormwater Wetland	24	5.4		$85,620
SWM000322	Private - Residential	Behind 904 Felicia Court	Stormwater Wetland	6.3	1.4		$85,620
SWM000100	Private - Residential	Behind 318 Sparta Court	Sandfilter	5.3	1.2		$65,555

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
SWM000543	Private - Residential	Next to 1015 Henderson Manor Court	Bioretention	12.1	2.7		$245,830
SWM000208(1)	Private - Residential	Behind 1219 Cheshire Lane	Bioretention	25	5.6		$245,830
SWM000401	Private - Residential	Next to 616 Loring Avenue	Stormwater Wetland	5.5	1.2		$85,620
SWM000329	Private - Residential	Across from 1733 Chrisara Court on Spenceola Parkway	Sandfilter	20.4	4.6		$65,555
SWM000025	Private - Residential	Md. Rt. 23 and Aster La West of Melrose Lane	Bioretention	1.2	0.3		$245,830
SWM000335	Private - Residential	Behind 1011 Saddleback Way	Stormwater Wetland	9.5	2.1		$85,620
SWM000240	Private - Residential	Behind 2195 Sewanee Drive	Stormwater Wetland	16.6	3.7		$85,620
SWM000254	Private - Residential	Across from 1320 Valley Oak Way	Stormwater Wetland	25	5.6		$85,620
SWM000207	Private - Residential	Next to 905 Hnderson Road	Stormwater Wetland	25	5.6		$85,620
SWM000023	Private - Commercial	1 Red Pump Road	Bioretention	0.3	0.1		$245,830
SWM000168	Private - Commercial	Behind 1503 Rock Spring Road	Bioretention	2.1	0.5		$245,830
SWM000232	Private - Commercial	804 Moores Mill Road	Submerged Gravel Wetland	2	0.5		$245,830
SWM000202(1)	Private - Commercial	Next to 1631 Robin Hill Circle	Stormwater Wetland	25	5.6		$85,620

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
SWM000053	Private	1 Colgate Drive	Stormwater Wetland	6	1.4		$85,620
SWM000157	Private - Commercial	Next to 23 Newport Drive	Stormwater Wetland	25	5.6		$85,620
SWM000227	Private	209 E Jarrettsville Road	Bioretention	1.3	0.3		$245,830

Table A2: Additional High Priority – Structural Restoration Projects

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
UB-35			Bioretention	1.94	0.90	New	$17,245
SWM000927			Bioretention	2.15	0.93	New	$121,308
UB-195			Bioretention	0.61	0.11	New	$20,218
UB-N101			Bioretention	0.44	0.46	New	$68,925
UB-N105			Bioretention	1.36	1.02	New	$35,841
UB-N112			Bioretention	0.58	0.39	New	$35,841
UB-N115			Bioretention	2.00	1.25	New	$206,775
UB-N116			Bioretention	1.48	0.88	New	$82,710
UB-N117			Bioretention	3.31	1.18	New	$110,280
UB-N119			Bioretention	0.44	0.21	New	$22,056
UB-N123			Bioretention	6.28	2.99	New	$54,715
UB-N128			Bioretention	0.74	0.53	New	$36,760
UB-N130			Bioretention	1.59	0.90	New	$91,900

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
UB-N132			Bioretention	2.72	1.40	New	$128,660
UB-N138			Bioretention	1.67	0.87	New	$82,710
UB-N141			Bioretention	0.40	0.33	New	$45,491
UB-N142			Bioretention	1.59	0.54	New	$45,950
UB-N143			Bioretention	1.91	0.98	New	$102,928
UB-N102			Bioswale	9.31	4.15	New	$65,599
UB-N107			Bioswale	4.77	1.90	New	$98,384
UB-N109			Bioswale	4.06	0.78	New	$43,726
UB-N113			Bioswale	2.93	1.23	New	$18,987
UB-N114			Bioswale	6.89	1.83	New	$109,315
SWM000098			Sandfilter	23.83	3.75	Retrofit	$91,864
UB-N110			Step Pool Stormwater Conveyance	7.46	4.75	New	$351,000
SWM000018			Stormwater Wetland	45.95	7.89	Retrofit	$191,048
SWM000379			Stormwater Wetland	55.67	13.95	Retrofit	$323,091
SWM000921			Stormwater Wetland	14.62	1.64	Retrofit	$42,520
SWM000931			Stormwater Wetland	35.13	6.18	Retrofit	$149,149
SWM000932			Stormwater Wetland	10.28	2.47	Retrofit	$57,442
UB-N202			Stormwater Wetland	11.07	1.94	New	$46,748

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
UB-N103			Stormwater Wetland	2.54	1.96	New	$31,236
UB-N104			Stormwater Wetland	6.50	3.94	New	$44,507
UB-N106			Stormwater Wetland	2.83	1.02	New	$18,834
UB-N108			Stormwater Wetland	23.60	7.34	New	$136,889
UB-N118			Stormwater Wetland	65.89	23.25	New	$341,675
UB-N120			Stormwater Wetland	2.94	1.66	New	$22,687
UB-N121			Stormwater Wetland	7.15	3.62	New	$41,189
UB-N124			Stormwater Wetland	11.90	3.94	New	$86,870
UB-N125			Stormwater Wetland	24.90	7.37	New	$91,145
UB-N126			Stormwater Wetland	3.68	1.84	New	$39,639
UB-N127			Stormwater Wetland	18.14	6.14	New	$74,110
UB-N129			Stormwater Wetland	2.36	1.78	New	$76,152
UB-N131			Stormwater Wetland	6.28	4.11	New	$71,775
UB-N137			Stormwater Wetland	7.63	3.52	New	$59,053

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
Bynum Run @ Blake's Venture Park			Stream Restoration		25.00		$1,925,820
Bynum Run @ Harford Detention Center			Stream Restoration		8.00		$567,060
Bynum Run @ MD-23			Stream Restoration		21.00		$1,663,740
Bynum Run @ Moores Mill Road			Stream Restoration		23.00		$1,818,180
Bynum Run @ Newport Drive			Stream Restoration		5.00		$405,600
Unnamed Trbutary @ Switchman Drive			Stream Restoration		4.00		$334,620
Unnamed Triburtay @ MD 543			Stream Restoration		37.00		$2,903,160
Unnamed Tributary @ Bel Air Bypass			Stream Restoration		23.00		$1,798,680
Unnamed Tributary @ Broadway			Stream Restoration		23.00		$1,792,440
Unnamed Tributary @ Centreville Way			Stream Restoration		20.00		$1,540,500

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Proposed Restoration	Planning Level Cost
Unnamed Tributary @ Frogleap Way			Stream Restoration		8.00		$608,400
Unnamed Tributary @ MD-22			Stream Restoration		12.00		$953,940
Unnamed Tributary @ Melrose Lane			Stream Restoration		22.00		$1,752,660
Unnamed Tributary @ Pipercove Way			Stream Restoration		11.00		$811,200
Unnamed Tributary @ Rockfield Park			Stream Restoration		25.00		$1,913,340
SWM000222			Submerged Gravel Wetland	4.20	0.81	New	$19,326

Table A3: High Priority – Stream Restoration Projects

Project Name	Owner	Location	Proposed Project Type	Length of Restoration (feet)	Impervious Area (acres)	Proposed Restoration	Planning Level Cost
Sunnyview Drive Stream Restoration – Farnandis Branch	Private / Home Owners Association (HOA)	Sunnyview Drive and Ring Factory Road	Stream Restoration	3,000	90	Stabilize stream to reduce sediment loads using various restoration techniques.	$1,000,000
Bynum Run at St. Andrews Way Stream Restoration	County	Woodland Drive	Stream Restoration	3,000	90	Stabilize stream to reduce sediment loads using various restoration techniques.	$1,500,000

Table A3: Medium Priority – Structural BMPs

Project Name	Owner	Location	Proposed Project Type	Drainage Area (acres)	Impervious Area (acres)	Planning Level Cost
SWM000223	Private – Residential	Next to 1318 Hidden Stream Drive	Retrofit	25.0	5.6	$479,470.46
SWM000089	Private – Residential	Between 3723 and 3715 Federal Lane	Retrofit	12.8	2.9	$248,297.20
SWM000287	Private – Residential	End of Gittings Court	Sand Filter	7.6	1.7	$111,442.91
SWM000085	Private –- Residential	Next to 3120 Birchbrook Lane	Retrofit	25.0	5.6	$479,470.46
SWM000084	Private – Residential	Next to 321 Eastbend Court	Retrofit	25.0	5.6	$479,470.46

Project Name	Owner	Location	Proposed Project Type	Drainage Area (acres)	Impervious Area (acres)	Planning Level Cost
SWM000359	Private – Residential	Eastbend Court	Retrofit	25.0	5.6	$479,470.461
SWM000415	Private – Residential	Next to 805 Tiffany Terrace	Retrofit	19.7	4.4	$376,726.79
SWM000286	Private – Residential	End of Towson Drive	Retrofit	20.3	4.6	$393,850.73
SWM000126	Private – Residential	Next to 911 Deer Court	Retrofit	25.0	5.6	$479,470.46
SWM000118	Private – Residential	Behind 34 Mitchell Drive	Sand Filter	7.4	1.7	$111,442.91
SWM000040	Private – Residential	Behind 305 Lindsay Court	Retrofit	25.0	5.6	$479,470.46
SWM000039	Private – Residential	Behind 2603 Smallwood Court	Sand Filter	6.3	1.4	$91,776.51
SWM000229	Private – Residential	Next to 368 Hunters Run Drive	Retrofit	25.0	5.6	$479,470.46
SWM000363	Private – Residential	Next to 540 David Drive	Retrofit	25.0	5.6	$479,470.46
SWM000006	Private – Residential	N.S. David Dr. E. of Rambler Road	Retrofit	25.0	5.6	$479,470.46
SWM000259	Private – Residential	Behind 1504 Parkland Drive	Retrofit	25.0	5.6	$479,470.46
SWM000295	Private – Residential	Across from 1500 Dunkeld Way	Retrofit	25.0	5.6	$479,470.46
SWM000198	Private – Residential	Behind 1402 Royal Troon Court	Retrofit	25.0	5.6	$479,470.46
SWM000685	Private – Residential	Next to 1307 Forest Oak Court	Retrofit	25.0	5.6	$479,470.46
SWM000166	Private – Residential	N.S. Foxborough D. West of Bennett Place	Retrofit	25.0	5.6	$479,470.46

Project Name	Owner	Location	Proposed Project Type	Drainage Area (acres)	Impervious Area (acres)	Planning Level Cost
SWM000199	Private – Residential	S. Macphail Road at Ring Factory Road	Retrofit	25.0	5.6	$479,470.46
SWM000163	Private – Residential	Fountain Glen Drive	Retrofit	25.0	5.6	$479,470.46
SWM000203(1)	Private – Residential	West of Vanguard S. of Royston Place	Retrofit	16.2	3.6	$308,231.01
SWM000338	Private – Residential	Todd Rd and Treadmore Road	Retrofit	25.0	5.6	$479,470.46
SWM000096	Private – Residential	Across from 1302 Beckett Court	Retrofit	10.4	2.3	$196,925.37
SWM000037(2)	Private – Residential	Across from 438 Ellis Lane	Retrofit	25.0	5.6	$479,470.46
SWM000260	Private – Residential	Behind 1100 Runnymede Lane	Retrofit	25.0	5.6	$479,470.46
SWM000209	Private – Residential	N.S. Henderson Rd W. Of Md. Route. 543	Retrofit	25.0	5.6	$479,470.46
SWM000073	Private – Residential	Behind 1800 Queen Anne Square	Retrofit	25.0	5.6	$479,470.46
SWM000382	Private – Residential	Behind 721 Hickory Limb Circle	Retrofit	24.8	5.6	$479,470.46
SWM000428	Private – Residential	East Side of Birch Brook Lane	Sand Filter	5.8	1.3	$85,221.05
SWM000416	Private – Residential	Behind 4001 off Andrew Court	Retrofit	10.9	2.5	$214,049.31
SWM000125	Private – Residential	Across from Bynum Overlook Drive on Hookers Mill Rd	Retrofit	13.8	3.1	$265,421.15
SWM000332	Private – Residential	Off Hookers Mill Rd	Retrofit	25.0	5.6	$479,470.46

Project Name	Owner	Location	Proposed Project Type	Drainage Area (acres)	Impervious Area (acres)	Planning Level Cost
SWM000347	Private – Residential	Clarkson Drive	Retrofit	11.0	2.5	$214,049.31
SWM000333	Private – Residential	Off Oak Mill Court	Sand Filter	6.8	1.5	$98,331.98
SWM000041	Private – Residential	Behind 2608 Rhododendron Drive	Retrofit	24.1	5.4	$462,346.51
SWM000453	Private – Residential	Behind 925 Sidehill Drive	Retrofit	16.2	3.7	$316,792.98
SWM000257	Private – Residential	Behind 803 Deep Wood Court	Retrofit	22.2	5.0	$428,098.62
SWM000342	Private – Residential	Behind 511 Cedar Hill Court	Retrofit	12.7	2.9	$248,297.20
SWM000058	Private – Residential	Behind 1704 Sable Court	Retrofit	25.0	5.6	$479,470.46
SWM000621	Private – Residential	Behind 1200 Sparrow Mill Way	Retrofit	25.0	5.6	$479,470.46
SWM000455	Private – Residential	Behind 1302 Streamview Court	Retrofit	12.6	2.8	$239,735.23
SWM000469	Private – Residential	Behind 1301 Harling Court	Retrofit	17.7	4.0	$342,478.90
SWM000290(1)	Private – Residential	Northeast Corner of Amyclae Drive and Md 543	Retrofit	25.0	5.6	$479,470.46
SWM000321	Private – Residential	Behind 589 Henderson Road	Retrofit	10.3	2.3	$1,969,25.37
SWM000337	Private – Residential	Next to 1712 Amyclae Drive	Sand Filter	8.0	1.8	$117,998.37
SWM000458	Private – Residential	Next to 569 Henderson Road	Retrofit	25.0	5.6	$479,470.46

Project Name	Owner	Location	Proposed Project Type	Drainage Area (acres)	Impervious Area (acres)	Planning Level Cost
SWM000447	Private – Residential	Across from 303 Wagner Road	Retrofit	14.7	3.3	$282,545.09
SWM000449	Private – Residential	Next to 1806 Amyclae Drive	Retrofit	25.0	5.6	$479,470.46
SWM000320	Private – Residential	Behind 733 Hickory Limb Circle	Retrofit	25.0	5.6	$479,470.46
SWM000408	Private – Residential	Behind 327 Donald Circle	Retrofit	14.2	3.2	$273,983.12
SWM000476	Private – Residential	Next to 101 Wagner Way	Sand Filter	7.5	1.7	$111,442.91
SWM000475	Private – Residential	Next to 16 Wagner Way	Retrofit	25.0	5.6	$479,470.46
SWM000409	Private – Residential	Next to 2046 Mardic Drive	Retrofit	21.3	4.8	$410,974.68
SWM000348	Private – Residential	Behind 2290 Howland Drive	Retrofit	25.0	5.6	$479,470.46
SWM000256(1)	Private – Residential	Behind 812 Bynum Run Court	Retrofit	25.0	5.6	$479,470.46
SWM000419	Private – Residential	Northwest Corner Wheel Rd and Willow Chase Drive	Retrofit	1.4	0.3	$25,685.92
SWM000421	Private – Residential	West Side of Willow Chase Drive Adjacent to Lot 45	Retrofit	5.5	1.2	$102,743.67
SWM000420	Private – Residential	Northeast Corner of Wheel Rd and Willow Chase Drive	Retrofit	2.0	0.4	$34,247.89
SWM000422	Private – Residential	East Side of Willow Chase Drive Behind Lot 5	Retrofit	8.3	1.9	$162,677.48
SWM000423	Private – Residential	East Side of Willow Chase Drive Behind Lot 8	Retrofit	7.1	1.6	$136,991.56

Project Name	Owner	Location	Proposed Project Type	Drainage Area (acres)	Impervious Area (acres)	Planning Level Cost
SWM000430	Private – Residential	East Side of Springvale Court Behind Lots 13 and 14	Retrofit	4.0	0.9	$77,057.75
SWM000429	Private – Residential	East Side Of Springvale Court Behind Lot 20 and 21	Retrofit	4.0	0.9	$77,057.75
SWM000425	Private – Residential	South Side of Springvale Court adjacent to Lot 17	Retrofit	1.1	0.2	$17,123.94
SWM000427	Private – Residential	South Side of Springvale Court adjacent to Lot 18	Retrofit	1.6	0.4	$34,247.89
SWM000424	Private – Residential	North Side of Springvale Court adjacent to Lot 28	Retrofit	1.9	0.4	$34,247.89
SWM000426	Private – Residential	North Side of Springvale Court adjacent to Lot 27	Retrofit	4.4	1.0	$85,619.72
SWM000045	Private – Residential	Behind 1400 Federal Garth	Retrofit	25.0	5.6	$479,470.46
SWM000117	Private – Residential	Across from 52 Laurentum Parkway	Retrofit	25.0	5.6	$479,470.46
SWM000009	Private – Residential	Merrick Way Cul-De-Sac	Retrofit	25.0	5.6	$479,470.46
SWM000230	Private – Residential	N.E. Corner Laurel Bush Road and Point to Point	Retrofit	25.0	5.6	$479,470.46
SWM000069	Private – Residential	S.S. Wheel Rd W. of Md. Route 543	Retrofit	25.0	5.6	$479,470.46
SWM000620	Private – Residential	Behind 1502 Stone Post Court	Retrofit	17.7	4.0	$342,478.90
SWM000402	Private – Residential	Behind 616 Loring Avenue	Retrofit	18.2	4.1	$351,040.87
OF-10	HOA – Private	West of Bramble Court	Bioretention/Sand Filter	1.0	0.5	$122,914.97
OF-11	HOA – Private	West of Othello Court	Bioretention/Sand Filter	3.2	1.5	$368,744.91

Project Name	Owner	Location	Proposed Project Type	Drainage Area (acres)	Impervious Area (acres)	Planning Level Cost
OF-12	HOA – Private	East of Fallstaff Road	Bioretention/Sand Filter	1.0	0.4	$98,331.98
OF-13	HOA – Private	North of Shakespeare Drive	Bioretention/Sand Filter	5.4	2.3	$150,775.70
OF-14	HOA – Private	End of Fall Staff Court	SPSC	5.0	1.9	$467,076.88
OF-15	HOA – Private	South of Greenwood Drive	SPSC	10.7	3.1	$762,072.81
OF-16	HOA – Private	West of Thomas Run Road	SPSC	13.1	3.8	$934,153.76
OF-2	HOA – Private	South of Saddleback Way	SPSC	2.6	1.5	$368,744.91
OF-20	HOA – Private	End of Beckett Court	Bioretention/Sand Filter	1.6	0.8	$196,663.95
OF-23	HOA – Private	End of Clifton Terrace	SPSC	9.0	3.5	$860,404.78
OF-24	HOA – Private	North end of Ellicott Drive	SPSC	2.3	1.1	$270,412.93
OF-25	HOA – Private	East of Ellicott Drive	SPSC	2.9	0.9	$221,246.94
OF-26	HOA – Private	North of East Mcphail Road, across Ellicott Drive	SPSC	13.8	4.6	$1,130,817.71
OF-27	HOA – Private	Fountain Glen Drive across Sandy Ray Terrace	SPSC	3.6	1.9	$467,076.88
OF-28	HOA – Private	West end of Lochern Terrace	Bioretention/Sand Filter	4.6	2.2	$540,825.86
OF-29	HOA – Private	Fountain Glen Drive next to Loch Carron Way	SPSC	2.4	1.3	$319,578.92
OF-3	HOA – Private	End of Oakville Court	SPSC	1.1	0.5	$122,914.97
OF-30	HOA – Private	End of Loch Carron Way	SPSC	2.0	1.1	$270,412.93
OF-31	HOA – Private	West end of Brierhill Estates	SPSC	3.0	1.6	$393,327.90
OF-32	HOA – Private	West end of Stone Ridge Way	Bioretention/Sand Filter	2.4	1.2	$294,995.93

Project Name	Owner	Location	Proposed Project Type	Drainage Area (acres)	Impervious Area (acres)	Planning Level Cost
OF-34	HOA – Private	West of Ring Factory Road across Colony Place	Bioretention/Sand Filter	12.7	3.9	$255,663.14
OF-36	HOA – Private	East of Glenangus Drive next to Lytham Court	SPSC	5.5	2.0	$491,659.88
OF-38	HOA – Private	Patterson Mill Road across Patterson Mill Middle School	SPSC	3.9	2.1	$516,242.87
OF-4	HOA – Private	South of Montgomery Drive	SPSC	24.1	9.2	$2,261,635.43
OF-40	HOA – Private	North of Sand Park Court	Bioretention/Sand Filter	18.1	5.5	$360,550.58
OF-41	HOA – Private	End of Fox Hunt Court	SPSC	1.1	0.5	$122,914.97
OF-42	HOA – Private	End of Kempton Park Circle	SPSC	12.0	5.2	$1278,315.68
OF-43	HOA – Private	End of Sedgefield Court	Bioretention/Sand Filter	17.5	7.3	$478,548.95
OF-44	HOA – Private	East of Chantaway Court	SPSC	4.2	1.9	$467,076.88
OF-45	HOA – Private	End of Abbey Circle	SPSC	1.7	0.9	$221,246.94
OF-46	HOA – Private	End of Sutton Place	SPSC	4.4	1.4	$344,161.91
OF-47	HOA – Private/County	East of Abbey Circle across Parliament Drive	SPSC	4.7	1.9	$467,076.88
OF-48	HOA – Private	End of Butterfield Drive	SPSC	1.4	0.7	$172,080.96
OF-5	HOA – Private	End of Brighton Court	Bioretention/Sand Filter	4.5	1.4	$344,161.91
OF-50	HOA – Private	End of Millwright Circle	Bioretention/Sand Filter	3.9	2.3	$565,408.86
OF-51	HOA – Private	East of Parallel Path	SPSC	12.4	4.9	$1,204,566.69
OF-52	HOA – Private	Northeast of Burgh-Westra Way	SPSC	2.3	1.1	$270,412.93
OF-53	HOA – Private	End of Toddsbury Court	Bioretention/Sand Filter	1.6	0.9	$221,246.94

Project Name	Owner	Location	Proposed Project Type	Drainage Area (acres)	Impervious Area (acres)	Planning Level Cost
OF-54	HOA – Private	At the intersection of Burgh-Westra Court and Laurel Bush Road	SPSC	3.4	1.0	$245,829.94
OF-55	HOA – Private	End of Clarkson Drive	Bioretention/Sand Filter	2.1	1.0	$245,829.94
OF-56	HOA – Private	South of Laurel Valley Court between Long Meadow Drive and Parallel Path	SPSC	34.7	12.9	$3,171,206.19
OF-57	HOA – Private	End of Lynndale Court and Waterbury Court	Bioretention/Sand Filter	11.7	4.2	$275,329.53
OF-59	HOA – Private	East of Brierhill Estates Drive next to Briergreen Court	Bioretention/Sand Filter	3.9	2.0	$491,659.88
OF-6	HOA – Private	End of Manchester Court	Bioretention/Sand Filter	2.1	0.9	$221,246.94
OF-7	HOA – Private	End of Midwood Court	SPSC	1.7	0.7	$172,080.96
OF-8	HOA – Private	West of Crescent Knoll Drive	Bioretention/Sand Filter	13.7	5.5	$360,550.58
OF-9	HOA – Private	End of Dulwich Lane	Bioretention/Sand Filter	1.3	0.7	$172,080.96

Table A4: Low Priority – Structural BMPs

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Planning Level Cost
SWM000029	Private – Commercial	128 St Mary' s Church Road	Bioretention	4.3	1.0	$245,829.94
SWM000393	Private	2225 and 2227 Old Emmorton Road	Bioretention	4.6	1.0	$245,829.94
SWM000123(1)	Private	Next to 2100 Laurel Bush Road	Retrofit	25.0	5.6	$479,470.46
SWM000122	Private – Commercial	Southeast Corner Md Route 22 and Brierhill Drive	Bioretention	0.9	0.2	$49,165.99

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Planning Level Cost
SWM000007(1)	Private – Commercial	5 Maurice Drive	Retrofit	17.7	4.0	$342,478.90
SWM000222(1)	Private – Commercial	534 E Jarrettsville Road	Bioretention	3.2	0.7	$172,080.96
SWM000231	Private – Commercial	1515 Emmorton Road	Bioretention	2.5	0.6	$147,497.96
SWM000245	Private – Commercial	1645 E. Churchville Road	Sand Filter	5.2	1.2	$78,665.58
SWM000280	Private – Commercial	1203 Agora Drive	Bioretention	1.2	0.3	$73,748.98
SWM000033	Private – Commercial	Northeast corner of Md.Route 924 and North Ave	Sand Filter	9.2	2.1	$137,664.77
SWM000461	Private – Commercial	207 Bynum Road	Bioretention	1.1	0.3	$73,748.98
SWM000353	Private – Commercial	Behind 1303 Enterprise Court	Retrofit	25.0	5.6	$479,470.46
SWM000379	Private – Commercial	Behind 2209 Commerce Road	Retrofit	25.0	5.6	$479,470.46
SWM000156	Private – Commercial	5 Newport Drive	Bioretention	1.3	0.3	$73,748.98
SWM000588	Private – Commercial	St Francis Road	Retrofit	3.2	0.7	$59,933.81
OF-1	HOA – Private	End of Duffy Court	Bioretention/Sand Filter	1.6	0.9	$221,246.94
OF-39	HOA – Private/Private	North of Fox Catcher Road	SPSC	2.3	1.2	$294,995.93
OF-58	HOA – Private	End of Umbarger Drive	Bioretention/Sand Filter	1.5	0.6	$147,497.96
ROW-1	County	Agora Drive	Tree Box Filters	0.5	0.4	$26,221.86
ROW-2	County	Alconbury Court, Brighwater Lane, Ruskin Court, Salford Drive and Meredith Court	Bioretention	29.8	11.0	$2,704,129.31
ROW-3	County	Harrogate Way, Dumbarton Drive, Colchester Court, Hastings Court, Taunton Court, and Greenock Court	Bioretention	21.8	8.3	$2,040,388.48
ROW-4	County	Academy Garth and Federal Lane	Bioretention	10.6	4.8	$1,179,983.70

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Planning Level Cost
ROW-5	County	Andreas Drive, Andreas Court and Parthenon Court	Tree Box Filter	6.9	3.8	$249,107.67
ROW-6	County	Frogleay Way	Bioretention	0.7	0.0	$9,833.20
ROW-7	County	North Forest Drive, Tory Way and Issacs Way	Tree Box Filters	17.3	7.9	$517,881.74
ROW-9	County	Hidden Stream Court and Swift Run Court	Tree Box Filter	6.4	3.0	$196,663.95
ROW-10	County	My Lady's Drive	Tree Box Filter	4.0	1.8	$117,998.37
ROW-11	County	Pouska Road	Tree Box Filter	5.6	2.6	$170,442.09
ROW-12	County	Jourdan Court	Tree Box Filter	1.6	0.9	$58,999.19
ROW-13	County	Parallel Path	Tree Box Filter	8.9	3.0	$196,663.95
ROW-14	County	Kensington Parkway, Strathaven Lane, Craigston Lane, Sunderland Court and Maidstone Lane	Tree Box Filter	34.7	13.4	$878,432.31
ROW-15	County	Lynnbrook Place, Fairmont Drive, and Sherwood Place	Tree Box Filter	27.6	8.9	$583,436.39
ROW-16	County	Boxthorn Road, Bluebell Court, White Rose Court and Red Rose Court	Tree Box Filter	6.2	2.9	$190,108.49
ROW-17	County	Longstream Court, Henderson Road, and Autumn View Court	Bioretention	10.5	4.8	$1,179,983.70
ROW-18	County	Bynum Ridge Road, Montgomery Court, Carrolton Court	Bioretention	20.0	4.9	$1,204,566.69
ROW-19	County	Marston Court	Bioretention	1.4	0.7	$172,080.96
ROW-20	County	Long Meadow Drive, Edith Stone Drive, Cinnamon Tree Drive, and Whisper Wood Court	Bioretention/Tree Box Filters	16.1	6.8	$1,671,643.58

Project Name	Owner	Location	Proposed Project Type	Drainage Area (Acres)	Impervious Area (Acres)	Planning Level Cost
ROW-21	County	Fordham Court, Princeton Lane, Saint Francis Road and Marywood Drive	Bioretention/Tree Box Filters	34.3	12.1	$2,974,542.24

Alternative Urban BMPs

Table A5: High Priority – Alternative Urban BMPS

Project Name	Owner	Location	Proposed Project Type	Area (Acres)	Proposed Restoration	Planning Level Cost ($2011)
CP-2	Board of Education	William S. James Elementary School	Tree Planting	1.71	Open area at the northwestern part of the property along Laurentum Parkway is available for tree planting.	$75,495
CP-4	Harford County	County Property on 1200 Macphail Road	Tree Planting	1.40	Bynum Run Restoration at St. Andrews is planned in the same area. As a part of the project this open area can be converted to a tree planting area.	$61,809
CP-8	Harford County	County Property on 2213 Old Emmorton Road	Tree Planting	0.18	The entire property drains to a large pond behind the property. Potential for tree planting in the available open space.	$7,947
CP-23	Harford County	County Property on E Route 1	Tree Planting	0.32	Stream buffer area. Tree planting recommended.	$14,128
CP-24	Harford County	County Property Off Bynum Road	Tree Planting	9.31	Tree planting along with outfall retrofit.	$411,028
CP-29	Harford County	County Property on 702 Wheel Road	Tree Planting	1.22	Potential for tree planting in the open area.	$53,862

Watershed Restoration Monitoring

Foster Branch

Year 4 Monitoring Results

December | 2019

Prepared For

Harford County
Watershed Protection and Restoration
Department of Public Works
212 South Bond Street, 1st Floor
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Prepared By

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Appendix D – Supplemental Flora/Fauna

Background and Objectives

Harford County Department of Public Works (DPW) commissioned a watershed action plan for the Foster Branch watershed. The Foster Branch Small Watershed Action Plan (BayLand 2013) was completed in January of 2013. The plan outlines restoration projects and storm-water retrofits throughout this approximately 1,400 acre watershed. In anticipation of the permit conditions which may be placed on these restoration projects by Maryland Department of the Environment (MDE) and the U.S. Army Corps of Engineers (USACE), a monitoring plan was developed for the Foster Branch watershed. KCI Technologies, Inc. (KCI) developed the *Foster Branch Monitoring Plan* (Harford County 2016) with sites located generally upstream and downstream of proposed or constructed restoration projects.

KCI Technologies, Inc. completed the fourth year of chemical, physical, and biological stream sampling in spring and summer of 2019 at the five stream sites described in the plan. This technical memorandum describes the methods and results of the four years of sampling conducted at the Foster Branch sites.

The primary goal of this effort is to characterize baseline stream conditions (biological, physical habitat, and *in situ* chemical) prior to additional restoration project/BMP implementation. A secondary goal is to conduct monitoring in Foster Branch that can be used to document ecological uplift and habitat improvement as projects are completed within this watershed.

1 Methods

The monitoring effort includes chemical (*in situ* water quality), physical (habitat assessment), and biological (benthic macroinvertebrate, fish, herpetofauna, freshwater mussels, and crayfish) assessments conducted at each of the selected sites. The sampling methods used are consistent with Maryland Department of Natural Resources' (DNR) Maryland Biological Stream Survey (MBSS). The methods have been developed locally and are calibrated specifically to Maryland's ecophysiographic regions and stream types.

1.1 Sampling Sites

Five sampling sites were selected within the Foster Branch watershed (**Error! Reference source not found.**) to characterize baseline stream conditions and to assess the effect of planned restoration on the ecological health of the watershed. A brief description of sites follows, for more detailed information about each site see the *Foster Branch Monitoring Plan* (Harford County 2016).

1.1.1 Fost-1

Site Fost-1 is located close to the head-of-tide near the downstream most point in the Foster Branch watershed. This site is co-located with the USGS stream gage on Foster Branch (01585075). A stream restoration was previously completed by Harford County at this location and Fost-1 is located wholly within the restored reach. The land use upstream of Fost-1 is mostly urban (65.7%) with most of the remaining portion in forest (31.3%). This site will integrate the effects of all future restoration projects in the watershed.

1.1.2 Fost-2

Fost-2 is located on east branch of Foster Branch a short distance upstream of Trimble Rd and the confluence with the west branch. This site is located within a future planned stream restoration project. This site is the most urban of the Foster Branch sites, with 77.4% of the upstream watershed in urban and 22.1% in forest categories. This site will measure ecological response to all restoration projects on the east branch as they are implemented.

1.1.3 Fost-3

The site Fost-3 is located on the west branch of Foster Branch in a similar relative position as Fost-2, a short distance upstream of Trimble Rd and the confluence with the east branch. The west branch is the larger of the two branches of Foster Branch. This site is located a short distance downstream of both a planned stream restoration project and a planned sediment removal project. This site will integrate and assess the ecological benefit of all implemented restoration projects in the west branch.

1.1.4 Fost-4

This site is located on an unnamed tributary to the west branch, primarily draining forested (65.5%) land. This site has the smallest amount of urbanization (19.7% urban, approximately 2% impervious)) in its upstream drainage. Two large stream restoration projects are planned for the headwaters of this unnamed tributary. This site will measure ecological lift possibly attributable to stream restoration in a minimally developed subwatershed. Due to this site's small drainage area (approx. 100 acres) a Maryland-specific species-area curve suggests that very few, if any, fish species are expected to be observed; therefore fish community may not be a useful indicator of stream condition. Since fish community will not be a useful indicator, this site will only be sampled for fish in Year 1 and Year 4 of sampling.

1.1.5 Fost-5

This site is located on an unnamed tributary to the west branch, primarily draining urban (55.2%) land. This site is much more urban than Fost-4, with approximately 29% of the upstream area in impervious land cover. This site is downstream of two planned stream restoration projects and one new stormwater BMP. This site will assess the ecological benefit of planned restoration in a heavily urbanized subwatershed. Similarly to Fost-4, this site is of small drainage area and will only be sampled for fish in Year 1 and Year 4

1.2 Water Quality Sampling

Water quality conditions were measured *in situ* during the summer sampling visits at all Foster Branch sites. Currently the MBSS does not measure *in situ* water quality at sites, but did so in the past. *In situ* water quality methods used were consistent with those in DNR, 2010. Field measured parameters include temperature, dissolved oxygen, pH, specific conductance, and turbidity. Measurements at each site were made at the upstream end of the 75-meter long site. *In situ* measurements were made before any sampling activities started to avoid sampling water disturbed by other activities. Most *in situ* parameters (i.e., temperature, pH, specific conductivity, and dissolved oxygen) were measured using a multiparameter sonde (YSI Professional Plus), while turbidity was measured with a Hach 2100 Turbidimeter. Water quality meters are regularly inspected and maintained and were calibrated immediately prior to sampling to ensure proper usage and accuracy of the readings.

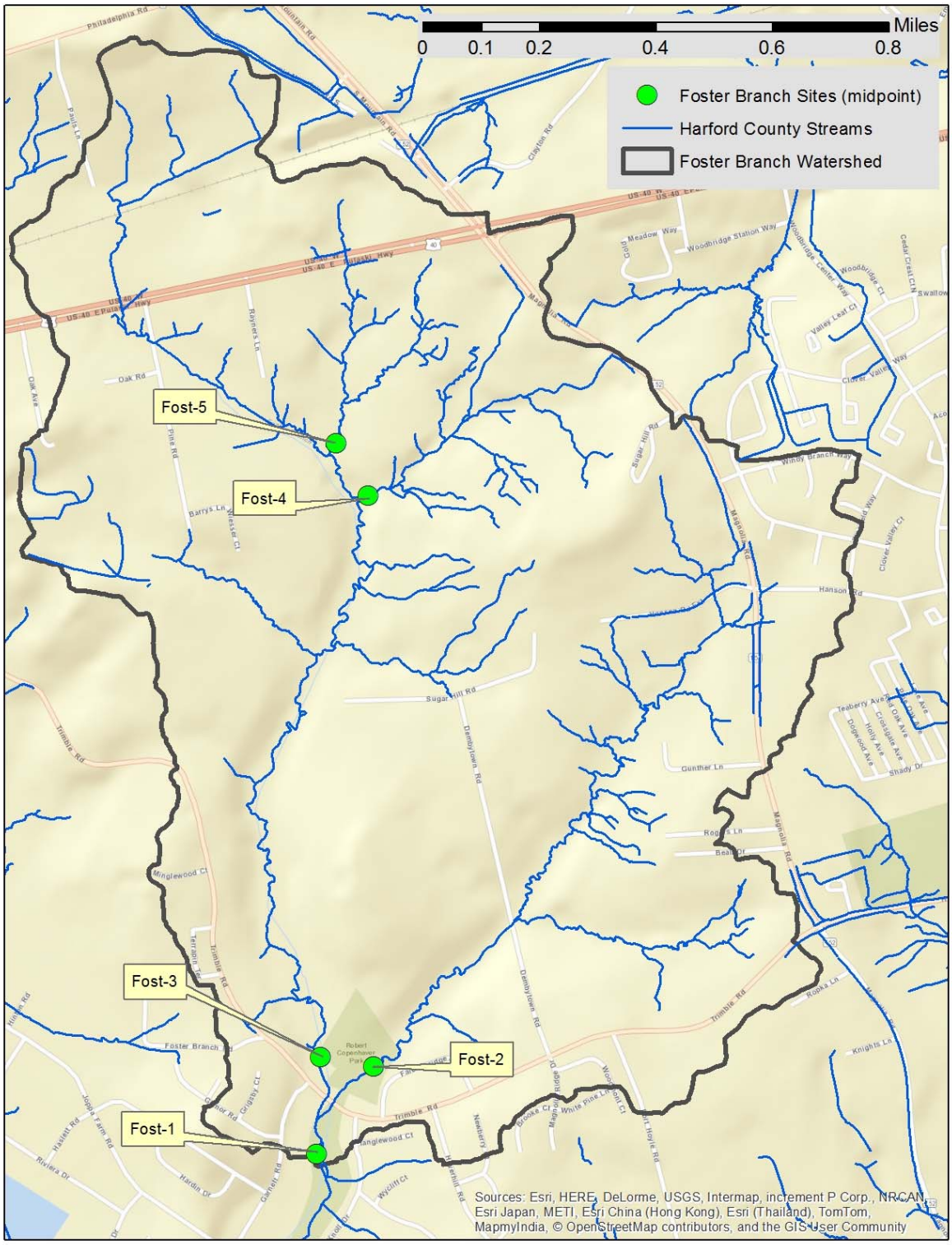

Figure 1 – Location of Sampling Sites

1.3 Physical Habitat Assessment

Each stream site was characterized based on visual observations of physical characteristics and various habitat parameters. The Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI; Paul et al., 2002) was used to assess the physical habitat at the site.

To reduce individual sampler bias, assessments were completed as a team with discussion and agreement of the scoring for each parameter. In addition to the visual habitat assessments, photographs were taken from three locations within each sampling reach (downstream end, midpoint, and upstream end) facing in the upstream and downstream direction, for a total of six (6) photographs per site.

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 were used to develop the PHI score for these sites because the Foster Branch watershed is located in Maryland's coastal plain ecophysiographic region. In developing the PHI, MBSS identified eight parameters that have the most discriminatory power for the coastal plain streams. These parameters are used in calculating the PHI (Table 1). Several of the parameters have been found to be drainage area dependent and are scaled accordingly. The drainage area to each site was calculated in GIS using the GPS-collected location of each site, streams and 2-foot contour data from Harford County.

Table 1 – PHI Coastal Plain Parameters

Coastal Plain Stream Parameters	
Instream Habitat	Epibenthic Substrate
Bank Stability	Percent Shading
Remoteness	Number Woody Debris/Root wads

Each habitat parameter is given an assessment score ranging from 0-20, with the exception of shading (percentage 0-100%) and woody debris and root wads (total count). A prepared score and scaled score (0-100) are then calculated. The average of these scores yields the final PHI score. The final scores are then ranked according to the ranges shown in Table 2 and assigned corresponding narrative ratings, which allows for a score that can be compared to habitat assessments performed statewide.

Table 2 – PHI Score and Ratings

PHI Score	Narrative Rating
81.0 – 100.0	Minimally Degraded
66.0 – 80.9	Partially Degraded
51.0 – 65.9	Degraded
0.0 – 50.9	Severely Degraded

1.4 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate collection strictly followed MBSS procedures (Stranko et al., 2015). Sampling occurred during the Spring Index Period (March 1 – April 30), samples were collected from all five Foster Branch sites on April 24, 2019. The monitoring sites consist of a 75-meter reach and benthic macroinvertebrate sampling is conducted once per year. The sampling methods utilize semi-quantitative field collections of the benthic macroinvertebrate community. The multi-habitat D-frame net approach is used to sample a range of the most productive habitat types present within the reach. Best available habitats include riffles, stable woody debris, root wads, root mats, leaf packs, aquatic

macrophytes, and undercut banks. In this sampling approach, a total of twenty jabs (each approximately one square foot) are distributed proportionally among all best available habitats within the stream site and combined into a single composite sample and preserved in 95 percent ethanol. The composite sample contains material collected from approximately 20 square feet of habitat.

MBSS specifies that a minimum of 5% (1 in 20) of sites are selected for a duplicate sample (Stranko et al., 2015). Because the total number of samples in this project (5) is well below 20, Foster Branch samples were pooled with other County monitoring project samples from Plumtree Run (5) to meet the field sampling QC objective (1 in 10, or 10.0%). The randomly selected QC site for 2019 was taken at a site in the Plumtree Run watershed, Plum-2.

1.4.1 Benthic Macroinvertebrate Sample Processing and Laboratory Identification

Benthic macroinvertebrate samples were processed and subsampled according to methods described in the MBSS Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy (Boward and Friedman 2011). Subsampling was conducted to standardize the sample size and reduce variation caused by samples of different size. In this method, the sample was spread evenly across a numbered, gridded tray (100 total grids), and a grid was picked at random and picked clean of organisms. If the organism count was 100 or more, then the subsampling was complete. If the organism count was less than 100, then another grid was selected at random and picked clean of organisms. This repeated until the organism count reached 100 to 120 organisms. The 100 (plus 20 percent) organism target is used to allow for specimens that are missing parts or are not mature enough for proper identification, are terrestrial, or meiofauna. Identification of the subsampled specimens was conducted by Environmental Services and Consulting, Inc. Taxa were identified to the genus level for most organisms. Groups including Oligochaeta and Nematomorpha were identified to the family level while Nematomorpha was left at phylum. Individuals of early instars or those that were damaged were identified to the lowest possible level, which could be phylum or order, but in most cases was family. Chironomidae could be 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 viewed with a compound microscope were used to identify Oligochaeta to family and for Chironomid sorting to subfamily and tribe. Permanent slide mounts were then used for Chironomid genus level identification. Results were logged on a bench sheet and entered into a spreadsheet for analysis.

1.4.2 Benthic Macroinvertebrate Data Analysis

Benthic macroinvertebrate data were analyzed by KCI 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 were given a score of 1, 3 or 5 based on ranges of values developed for each metric. The results were combined into a scaled IBI score from 1.0 to 5.0, and a corresponding narrative biological condition rating was applied.

Three sets of metric calculations have been developed for Maryland streams based on broad eco-physiographic regions. These include the Coastal Plain, Piedmont and combined Highlands. The study area is located in the Coastal Plain region therefore the following metrics (Table 3) and IBI scoring (Table 4) were used for the analysis.

Table 3 – Benthic Macroinvertebrate Metric Scoring for the Coastal Plain BIBI

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
% Intolerant to Urban	≥ 28	10 - 27	< 10
% Ephemeroptera	≥ 11	0.8 – 10.9	< 0.8
Number of Scraper Taxa	≥ 2	1 - 1	< 1
% Climbers	≥ 8	0.9 – 7.9	< 0.9

*Adjusted for catchment size

Table 4 – BIBI 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

1.5 Fish Sampling

The fish community at each of the five Foster Branch sites was sampled 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., 2015). 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., 2015). 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 voucher specimens.

1.5.1 Fish Data Analysis

Fish data for Foster Branch sites were analyzed using methods developed by MBSS as outlined in the *New Biological Indicators to Better Assess the Condition of Maryland Streams* (DNR, 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 1, 3 or 5 based on ranges of values developed for each metric. The results were combined into a scaled FIBI score, ranging from 1.0 to 5.0, 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 based on DNR, 2005. These include the Coastal Plain, Eastern Piedmont, and warmwater and coldwater Highlands. Foster Branch is located in the Coastal Plain region, therefore, the following metrics listed in Table 5 were used for the FIBI scoring (Table 6) and analysis.

Table 5 – 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 Taxa	≤ 40	41 - 69	< > 69

*Adjusted for catchment size

Table 6 – 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

1.6 Herpetofauna Survey

Herpetofauna (i.e., reptiles and amphibians) were surveyed at each of the five Foster Branch sites using methods following MBSS protocols (Stranko et al., 2015); 1) incidental collection, and 2) a search within all suitable stream salamander habitats within the 75-meter site. 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.

1.7 Freshwater Mussel Survey

A survey of freshwater mussels was conducted at each site using MBSS protocols (Stranko et al., 2015). A search for freshwater mussels was conducted at each site. 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 were retained as voucher specimens.

1.8 Crayfish Survey

Crayfish were surveyed for at each site using MBSS protocols (Stranko et al., 2015). 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.

1.9 Invasive Plant Survey

A survey of invasive plants was performed at each site during the Summer Index Period following MBSS protocols (Stranko et al., 2015). 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.

1.10 Quality Assurance and Quality Control

All work was conducted with thorough quality assurance and quality control. Biological assessment methods have been designed to be consistent and comparable with the methods used by MBSS (Stranko et al., 2015). Field crews receive yearly training in MBSS protocols and certification by DNR to perform benthic macroinvertebrate and fish sampling procedures. The Certified Fish Sampling Field Crew Leader and Fish Taxonomist for this project was Andy Becker. All field forms are checked and signed by the Crew Leader before leaving the site. Digital data entry is also checked for accuracy. Field equipment are checked regularly and calibrated as necessary prior to use. Calculation of metric scores and IBIs are completed using KCI's controlled and verified spreadsheet and each site undergoes a documented quality control check.

2 Results and Discussion

Biological monitoring and water quality sampling were conducted to assess the conditions in the Foster Branch watershed. Presented below are the summary results for each monitoring component.

2.1 Water Quality

Water quality measurements were collected during the Summer Index Period sampling visit at each of the five Foster Branch sites. Table 7 presents the results of the *in situ* water quality measurements for Year 1 (summer 2015), Year 2 (summer 2016), Year 3 (summer 2017), and Year 4 (summer 2019).

Table 7 – In Situ Water Quality Measurement Results

Site	Year	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Fost-1	1 (Summer 2015)	19.0	8.46	6.96	269.0	3.88
Fost-1	2 (Summer 2016)	22.0	8.86	6.92	325.6	20.9
Fost-1	3 (Summer 2017)	21.9	7.4	7.26	257.9	17.7
Fost-1	4 (Summer 2019)	23.3	8.4	7.41	263.6	13.7
Fost-2	1 (Summer 2015)	17.2	2.13	6.57	224.2	6.47
Fost-2	2 (Summer 2016)	20.0	1.24	6.39	282.3	10.4
Fost-2	3 (Summer 2017)	20.8	5.96	6.87	222.8	66.2
Fost-2	4 (Summer 2019)	22.3	4.22	6.94	244.7	4.26
Fost-3	1 (Summer 2015)	19.4	8.36	6.86	260.4	4.63
Fost-3	2 (Summer 2016)	18.2	7.91	6.90	247.5	4.82
Fost-3	3 (Summer 2017)	20.1	7.29	7.12	292.9	6.45

Fost-3	4 (Summer 2019)	22.0	8.26	6.82	281.6	4.91
Fost-4	1 (Summer 2015)	18.0	6.35	6.83	112.4	10.1
Fost-4	4 (Summer 2019)	21.9	6.6	6.15	83.1	18.7
Fost-5	1 (Summer 2015)	17.1	8.76	7.48	617.0	1.44
Fost-5	4 (Summer 2019)	21.7	8.21	7.37	586.0	3.97

Shaded cells indicate values exceeding either water quality criteria or published values

MDE has established acceptable water quality standards for each designated Stream Use Classification, which are listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality*. Foster Branch is covered in *COMAR* in Sub-Basin 02-13-08: Gunpowder River Area as Use I waters. Specific designated uses for Use I streams include growth and propagation of fish and aquatic life, water supply for industrial and agricultural use, water contact sports, fishing, and leisure activities involving direct water contact.

The acceptable criteria for Use I waters are as follows:

- pH - 6.5 to 8.5
- DO - may not be less than 5 mg/l at any time
- Turbidity - maximum of 150 Nephelometric Turbidity Units (NTU's) and maximum monthly average of 50 NTU
- Temperature - maximum of 90°F (32°C) or ambient temperature of the surface water, whichever is greater

In situ water quality measurements for temperature, pH, and turbidity for 2015, 2016, 2017 and 2019 were within COMAR standards for Use I streams with the exception of Fost-2 in 2016 with a pH value of 6.39 and Fost-4 in 2019 with a pH value of 6.15. Measurement of dissolved oxygen at Fost-2 was 2.13 mg/L during the 2015 visit 1.24 mg/L during the 2016 visit and 4.22 mg/L in 2019, below the Use I instantaneous criterion of 5.0 mg/L. The cause of the low dissolved oxygen measurement was likely due to the flow at this site being greatly reduced. The site was reduced to standing pools at the time of sampling during both 2015 and 2016. In 2017 the stream was flowing and the dissolved oxygen was measured at 5.96 mg/L. With no flow to bring oxygenated water into the site in 2015- 2016, biological processes had likely reduced the dissolved oxygen available in what little water existed in the site.

Although MDE does not have a water quality standard for specific conductivity, Morgan and others (Morgan et al, 2007; Morgan et al, 2012) have reported critical values for specific conductance in Maryland streams, above which there is a potential for detrimental effects on the stream biological communities. For the benthic macroinvertebrate community that critical value is 247 µS/cm, and for the fish community it is 171 µS/cm. Four of the five Foster Branch stream sites had specific conductivity values exceeding the threshold for fish community impairment, and exceedances were measured at these four sites during all *in situ* sampling events. Four of the five also had values exceeding the benthic macroinvertebrate threshold, with Fost-1 and Fost-3 exceeding during all sampling years, Fost-2 exceeding only during 2016, and Fost-5 exceeding during sampling events in 2015 and 2019. Only Fost-4 had specific conductivity below both thresholds. Conductivity levels in this watershed are likely influenced by runoff from impervious surfaces (i.e., roads, sidewalks, parking lots, roof tops). Increased stream inorganic ion concentrations (i.e., conductivity) in urban systems typically results from paved surface de-icing, accumulations in storm-water management facilities (Casey et al., 2013), runoff from impervious surfaces, passage through pipes, and exposure to other infrastructure (Cushman, 2006).

While elevated conductivity may not directly affect stream biota, its constituents (e.g., chloride, metals, and nutrients) may be present at levels that can cause biological impairment.

2.2 Physical Habitat Assessment

The summary results of the PHI habitat assessments are presented in Table 8. Fost-1, Fost-2 and Fost-3 all have compromised physical habitat, with PHI ratings of either 'Degraded' or 'Severely Degraded' with the exception of Fost-3 during Summer 2016 being rated as 'Partially Degraded'. Fost-4 and Fost-5 have had the best habitat scores of the five sites scoring 'Partially Degraded' and 'Minimally Degraded', respectively in 2015 and both 'Partially Degraded in 2019), reflecting their location in a minimally-disturbed tract of forest. The relatively low habitat scores at Fost-1, Fost-2 and Fost-3 are likely due to urbanization effects on streams. Complete physical habitat data for each site are included in Appendix A.

Table 8 – PHI Habitat Assessment Results

Site	Year	PHI Score	PHI Narrative Rating
Fost-1	1 (Summer 2015)	50.0	Severely Degraded
Fost-1	2 (Summer 2016)	58.1	Degraded
Fost-1	3 (Summer 2017)	58.9	Degraded
Fost-1	4 (Summer 2019)	61.12	Degraded
Fost-2	1 (Summer 2015)	53.3	Degraded
Fost-2	2 (Summer 2016)	54.8	Degraded
Fost-2	3 (Summer 2017)	64.5	Degraded
Fost-2	4 (Summer 2019)	63.12	Degraded
Fost-3	1 (Summer 2015)	60.1	Degraded
Fost-3	2 (Summer 2016)	74.8	Partially Degraded
Fost-3	3 (Summer 2017)	63.1	Degraded
Fost-3	4 (Summer 2019)	58.79	Degraded
Fost-4	1 (Summer 2015)	78.6	Partially Degraded
Fost-4	4 (Summer 2019)	74.90	Partially Degraded
Fost-5	1 (Summer 2015)	84.9	Minimally Degraded
Fost-5	4 (Summer 2019)	78.04	Partially Degraded

2.3 Benthic Macroinvertebrate Community

The results of benthic macroinvertebrate community assessments for Year 4 are presented in Table 9. Complete benthic macroinvertebrate data for each site are included in Appendix B.

Table 9 – Benthic Index of Biotic Integrity (BIBI) Summary Data – Year 4

Metric	Fost-1	Fost-2	Fost-3	Fost-4	Fost-5
Metric Values					
Total Number of Taxa	24	23	35	25	18
Number of EPT Taxa	3	0	2	4	4
Number of Ephemeroptera Taxa	0	0	0	0	1
% Intolerant to Urban	4.90	2.14	4.55	18.75	0.00
% Ephemeroptera	0.00	0.00	0.00	0.00	0.66
Number of Scraper Taxa	3	0	5	0	1
% Climbers	6.29	24.29	21.21	3.13	1.32
Metric Scores					
Total Number of Taxa	5	5	5	5	3
Number of EPT Taxa	3	1	3	3	3
Number of Ephemeroptera Taxa	1	1	1	1	3
% Intolerant to Urban	1	1	1	3	1
% Ephemeroptera	1	1	1	1	1
Number of Scraper Taxa	5	1	5	1	3
% Climbers	3	5	5	3	3
BIBI Score	**2.71**	**2.14**	**3.00**	**2.43**	**2.43**
Narrative Rating	**Poor**	**Poor**	**Fair**	**Poor**	**Poor**

Foster Branch sites had BIBI ratings for Year 4 ranging from the 'Poor' to 'Fair' category. Fost-3 had the highest score of 3.00 resulting in a 'Fair' rating. Fost-1 had the next highest score of 2.71 resulting in a 'Poor' rating. Fost-2 received the lowest score of 2.14 resulting in a rating of 'Poor'. Fost-4 and Fost-5 were both rated as 'Poor' with scores of 2.43. During Year 1, all sites except for Fost-4 had measured specific conductivity values greater than the published impairment threshold for benthic macroinvertebrates. Conversely, Fost-4 had the lowest measured specific conductivity and the highest proportion of organisms intolerant to urbanization. That pattern held true for Years 2 and 3 as well. A comparison of BIBI scores across the four years of monitoring is presented in Table 10 and Figure 2. BIBI scores in Year 4 were higher at Fost-2 and Fost-5, the same at Fost-3 and then lower at Fost-1 and Fost-4 when compared to Year 3.

Table 10 – BIBI Scores and Narrative Rating for all Years

Site	Year	BIBI Score	Narrative Rating
Fost-1	1 (Spring 2016)	2.14	Poor
Fost-1	2 (Spring 2017)	2.71	Poor
Fost-1	3 (Spring 2018)	3.00	Fair
Fost-1	4 (Spring 2019)	2.71	Poor
Fost-2	1 (Spring 2016)	2.14	Poor
Fost-2	2 (Spring 2017)	2.14	Poor
Fost-2	3 (Spring 2018)	1.86	Very Poor
Fost-2	4 (Spring 2019)	2.14	Poor
Fost-3	1 (Spring 2016)	3.00	Fair
Fost-3	2 (Spring 2017)	2.71	Poor
Fost-3	3 (Spring 2018)	3.00	Fair
Fost-3	4 (Spring 2019)	3.00	Fair
Fost-4	1 (Spring 2016)	2.43	Poor
Fost-4	2 (Spring 2017)	2.71	Poor
Fost-4	3 (Spring 2018)	2.71	Poor
Fost-4	4 (Spring 2019)	2.43	Poor
Fost-5	1 (Spring 2016)	1.86	Very Poor
Fost-5	2 (Spring 2017)	2.71	Poor
Fost-5	3 (Spring 2018)	2.14	Poor
Fost-5	4 (Spring 2019)	2.43	Poor

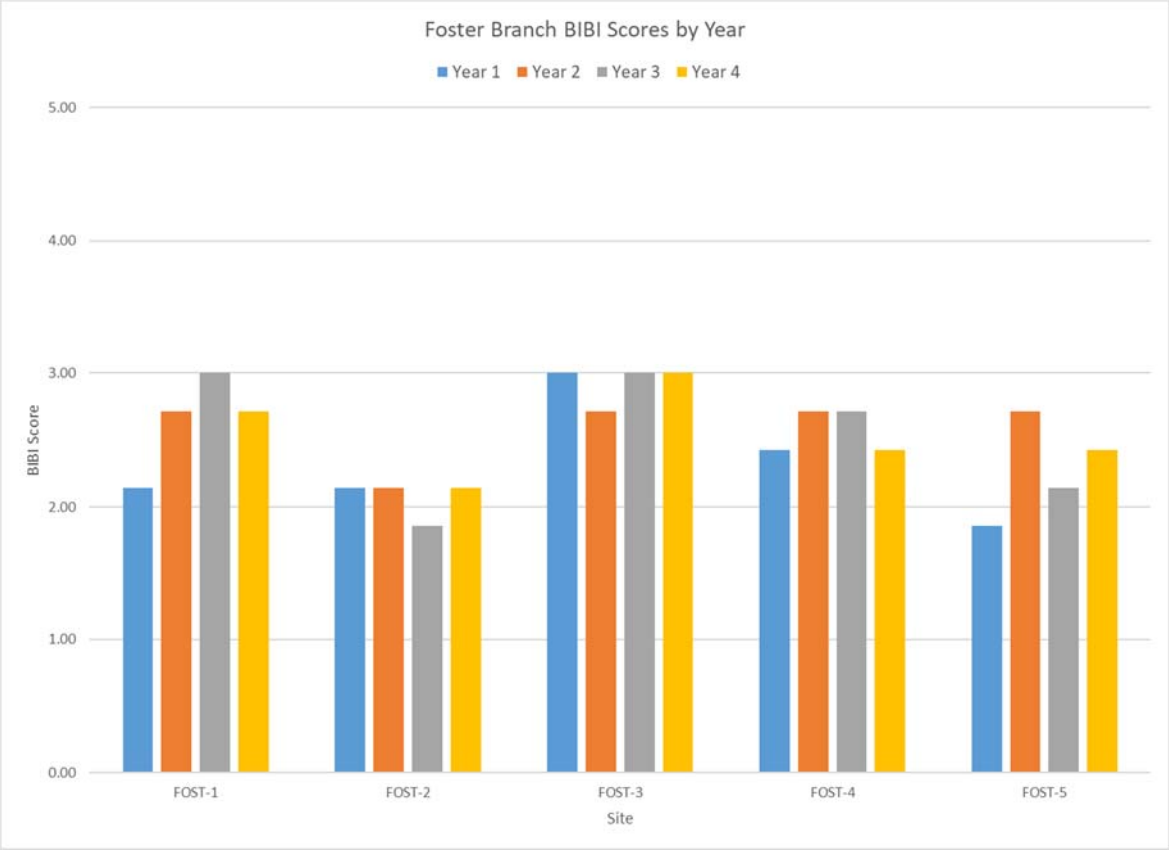

Figure 2 – BIBI Scores by Year

2.4 Fish Community

The results of the fish community assessments are presented in Table 11 and a cumulative list of species collected at each site for all years sampled can be found in Table 12. Complete fish community data for each site are included in Appendix C.

The Foster Branch sites had FIBI ratings ranging across the entire spectrum from 'Very Poor' to 'Good'. As noted before, sites Fost-4 and Fost-5 were only sampled in Year 1 and Year 4 as per the Foster Branch Monitoring Plan. These two sites are sufficiently small enough in contributing drainage area (each approx. 100 acres) that a Maryland-specific species-area curve suggests that very few, if any, fish species are expected to be observed; therefore fish community may not be a useful indicator of stream condition.

Table 11 – Fish Index of Biotic Integrity (FIBI) Summary Data – Year 4

Metric	Fost-1	Fost-2	Fost-3	Fost-4	Fost-5
Metric Values					
Abundance per square meter	1.82	1.48	2.15	1.76	0.99
Adjusted Number of Benthic species	1.37	1.12	1.67	0.00	0.00
% Tolerant	76.19	96.14	79.60	100.00	76.12
% Generalist, Omnivores, Invertivores	97.62	100.00	94.40	100.00	100.00
% Round-bodied Suckers	8.33	0.00	0.00	0.00	0.00
% Abundance of Dominant Taxon	38.33	0.00	50.40	88.16	67.16
Metric Scores					
Abundance per square meter	5	5	5	5	5
Adjusted Number of Benthic species	5	5	5	1	1
% Tolerant	3	3	3	1	3
% Generalist, Omnivores, Invertivores	3	1	3	1	1
% Round-bodied Suckers	5	1	1	1	1
% Lithophilic Spawners	5	5	3	1	3
FIBI Score	***4.33***	***3.33***	***3.33***	***1.67***	***2.33***
Narrative Rating	***Good***	***Fair***	***Fair***	***Very Poor***	***Poor***

Table 12 – Cumulative List of Fish Species Collected at Foster Branch Sites

Common Name	Scientific Name	Fost-1	Fost-2	Fost-3	Fost-4	Fost-5
Least Brook Lamprey	*Lampetra aepyptera*	X		X		
Sea Lamprey	*Petromyzon marinus*			X		
American Eel	*Anguilla rostrata*	X		X		X
Eastern Mosquitofish	*Gambusia holbrooki*	X				
Yellow Bullhead	*Ameiurus natalis*	X				
Brown Bullhead	*Ameiurus nebulosus*	X				
Creek Chubsucker	*Erimyzon oblongus*	X	X			
Northern Hogsucker	*Hypentelium nigricans*	X				
White Sucker	*Catostomus commersonii*	X	X	X		
Goldfish	*Carassius auratus*	X				

Common Name	Scientific Name	Fost-1	Fost-2	Fost-3	Fost-4	Fost-5
Eastern Silvery Minnow	*Hybognathus regius*	X				
Rosyside Dace	*Clinostomus funduloides*	X	X	X		X
Satinfin Shiner	*Cyprinella analostana*	X		X		
Spottail Shiner	*Notropis hudsonius*	X				
Swallowtail Shiner	*Notropis procne*	X				
Creek Chub	*Semotilus atromaculatus*	X	X	X	X	X
Blacknose Dace	*Rhinichthys atratulus*	X	X	X	X	X
Banded Killifish	*Fundulus diaphanus*	X		X		
Mummichog	*Fundulus heteroclitus*	X	X	X		X
Tessellated Darter	*Etheostoma olmstedi*	X	X	X		
Largemouth Bass	*Micropterus salmoides*	X		X		
Bluespotted Sunfish	*Enneacanthus gloriosus*	X				
Lepomis sp.	*Lepomis sp.*	X				
Redbreast Sunfish	*Lepomis auritus*	X		X		
Bluegill	*Lepomis machrochirus*	X		X		
Pumpkinseed	*Lepomis gibbosus*	X	X	X		
Northern Snakehead	*Esox lucius*	X				

Site Fost-1 had the highest FIBI score of all sites with, 4.33 which rated 'Good'. Sixteen species of fish were collected during Year 4 at Fost-1, the highest diversity of the five sites. The diversity of fish collected at this site helped to drive the FIBI score into the 'Good' category. Larger stream sites along the Fall Line between Maryland's Piedmont and Coastal Plain have a larger potential pool of species, possibly being occupied by species more commonly associated with one or the other physiographic provinces.

Fost-2 had a FIBI score of 3.33 in Year 4 which was in the 'Fair' category. Seven species were collected during Year 4 sampling, the most of all sampling years. This site was previously only standing pools during both the summer of 2015 and 2016, which reducing greatly the space and resources available to stream fish. In 2017 the entire site had flow going through it which aided in the increase in FIBI score. This site also had flow going through it in 2019 and a stream restoration project (Dembytown) upstream of the sampling site had been completed within the prior two years and has since become more established which could aide in the increase in FIBI score.

Site Fost-3 scored a 3.33 which was in the 'Fair' category. This site had ten species collected during sampling. While less diverse than Fost-1, the metrics scored well because of the smaller drainage area.

At site Fost-4, two species were collected resulting in the lowest score of all sites with 1.67 and a rating of 'Very Poor'.

Site Fost-5 scored a 2.33 which was in the 'Poor' category. This site had five species collected during sampling.

A comparison of FIBI scores across the four years of monitoring is presented in Table 13 and Figure 3. Fost-1 had the same FIBI score in Year 4 as Year 3, a 4.3. Fost-2 scored a 3.33, an increase of (+1.66) from Year 3. During the first two years of sampling at Fost-2 the site was reduced to standing pools. This lack of water and habitat space likely is the cause of the low FIBI scores during those years. Site

Fost-3 had a lower FIBI score (-0.34) in Year 4 than in Year 3, a 3.33 vs a 3.67. Sites Fost-4 and Fost-5 were only sampled during Years 1 and 4. These sites are small headwater streams which were outlined in the Foster Branch Monitoring Plan as being sampled less frequently as the rest of the Foster Branch sites. Fost-4 remained the same between the four years at 1.67. Fost-5 decreased by (-0.34) in Year 4 compared to Year 1.

Table 13 – FIBI Scores and Narrative Rating Across Years

Site	Year	FIBI Score	Narrative Rating
Fost-1	1 (Summer 2015)	4.67	Good
Fost-1	2 (Summer 2016)	5.00	Good
Fost-1	3 (Summer 2017)	4.33	Good
Fost-1	4 (Summer 2019)	4.33	Good
Fost-2	1 (Summer 2015)	1.00	Very Poor
Fost-2	2 (Summer 2016)	1.00	Very Poor
Fost-2	3 (Summer 2017)	1.67	Very Poor
Fost-2	4 (Summer 2019)	3.33	Fair
Fost-3	1 (Summer 2015)	4.33	Good
Fost-3	2 (Summer 2016)	3.33	Fair
Fost-3	3 (Summer 2017)	3.67	Fair
Fost-3	4 (Summer 2019)	3.33	Fair
Fost-4	1 (Summer 2015)	1.67	Very Poor
Fost-4	4 (Summer 2019)	1.67	Very Poor
Fost-5	1 (Summer 2015)	2.67	Poor
Fost-5	4 (Summer 2019)	2.33	Poor

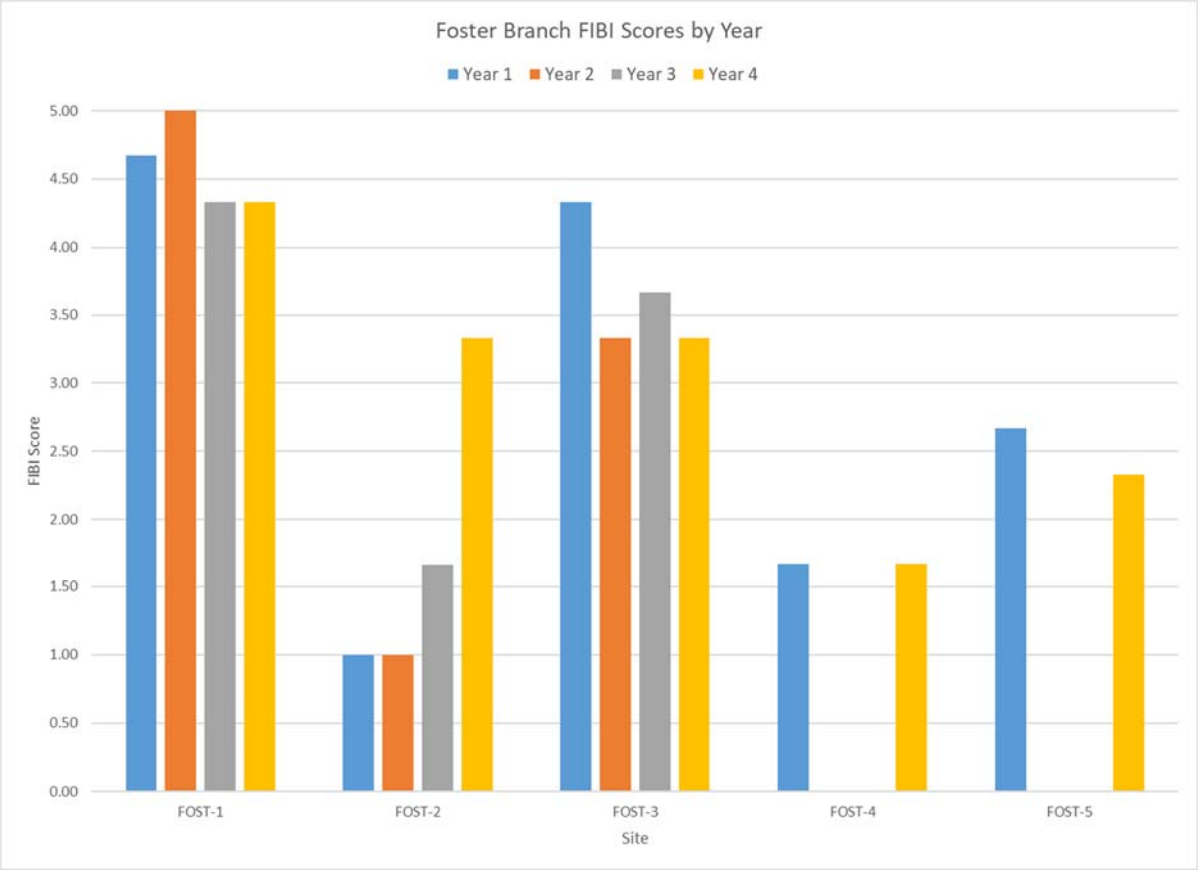

Figure 3 – FIBI Scores by Year

2.5 Herpetofauna

At least two amphibian species have been documented at each of the sites over the four year sampling period. Table 14 Shows the cumulative presence of herpetofauna over all four years of sampling. Fost-1 has the highest diversity with five species present at the site. The most widely distributed species was Northern Green Frog, which was present at all five of the Foster Branch sites. Stream salamander species were observed at three of the five sites during the stream salamander search or incidentally during other sampling activities. Northern Two-lined Salamander was observed at Fost-2 during the summer 2015 field visit, at Fost-1 during the summer 2016 visit, and at Fost-5 during both summer 2015 and summer 2016. At Fost-1 and Fost-2 a single individual was captured during electrofishing activities, but none were observed during the targeted stream salamander search. At Fost-5 one individual was observed while electrofishing during the summer 2015 sampling event but no salamanders were encountered during the targeted stream salamander search. During summer of 2016 no electrofishing took place at Fost-5 but one individual was encountered during the stream salamander search. During summer 2017 and 2019, no salamanders were encountered incidentally or during the stream salamander search.

Table 14 – Cumulative Herpetofauna Presence at Foster Branch Sites

Common Name	Scientific Name	Fost-1	Fost-2	Fost-3	Fost-4	Fost-5
Cope's Gray Treefrog	*Hyla chrysoscelis*			X	X	
American Bullfrog	*Lithobates catesbeianus*	X	X			
Northern Green Frog	*Lithobates clamitans melanota*	X	X	X	X	X
Pickerel Frog	*Lithobates palustris*	X	X	X		
Northern Spring Peeper	*Pseudacris crucifer*	X				
Stream Salamanders						
Northern Two-lined Salamander	*Eurycea bislineata*	X	X			X

The low density of stream salamanders at three sites, and lack of stream salamanders at two of the five sites is likely due to a combination of habitat degradation and water quality impairment. There was very little suitable stream salamander habitat present at those sites for the field crew to search. The restoration reach (Fost-1) contained several areas of armored banks and rock structures in the stream. Those areas are not preferred habitat for stream salamanders. The non-restored sites had a dominant substrate of sand which is not a preferred habitat of stream salamanders. Stream salamanders generally prefer large cover objects over loose cobble and gravel, creating a moist microclimate and many interstices for shelter and foraging. Stream salamanders breathe through their highly permeable skin and are therefore particularly sensitive to water quality impairments. The high conductivity values suggest that salamanders would experience osmotic difficulties in these conditions.

2.6 Freshwater Mussels

No freshwater mussels were observed at any Foster Branch site during either year of sampling. The lack of freshwater mussels at these sites is likely due to a combination of habitat degradation and water quality impairment. Freshwater mussels are relatively sessile organisms which live partially embedded within the stream substrates. The flashy hydrology characteristic of urban streams like Foster Branch create habitat conditions unsuitable for freshwater mussels. Also, it is likely that water quality conditions in urban streams are outside the range of tolerance of these sensitive organisms.

2.7 Crayfish

No crayfish were observed at three of the five Foster Branch sites. *Faxonius limosus*, a native species, was the only crayfish species observed at these sites and was observed at Fost-1 during electrofishing in all four years and at Fost-3 during Year 2 and Year 3. In 2019, *Procambarus sp.* was found at both Fost-1 and Fost-2. Crayfish burrows were observed at all of the Foster Branch sites during all four years of sampling. These burrows most likely were dug by *Cambarus diogenes*, but no specimens were collected to confirm. *Cambarus diogenes* is the most likely species as it is the only burrowing species collected by MD DNR in Harford County. The lack of crayfish may be due to habitat degradation. Both Fost-2 and Fost-3 had evidence of high flows, suggesting that flashy urban hydrology may frequently disturb cover objects reducing the availability of suitable crayfish habitat at those sites. Water quality conditions may also be impacting crayfish, but currently the water quality requirements for crayfish in Maryland are poorly understood.

2.8 Invasive Plant Species

Invasive plant species were present at all of the Foster Branch sites. Table 15 presents all invasive species found at each monitoring site cumulatively for all sampling visits. Fost-2 has the most invasive

plant species with seven, and Fost-4 had the least with two. Japanese stiltgrass was the most widely distributed invasive plant, found at all five sites. Oriental bittersweet and Multiflora rose were the next most widely distributed species, each being found at four sites.

Table 15 – Cumulative Invasive Plant Species Presence at Foster Branch Sites

Common Name	Scientific Name	Fost-1	Fost-2	Fost-3	Fost-4	Fost-5
Garlic mustard	*Alliaria petiolata*		X			
Japanese barberry	*Berberis thunbergii*					X
Oriental bittersweet	*Celastrus orbiculatus*		X	X	X	X
Autumn olive	*Elaeagnus umbellata*			X		
American wintergreen	*Gaultheria procumbens*		X			
Ground Ivy	*Glechoma hederacea*	X	X			
Chinese Lespedeza	*Lespedeza cuneata*	X				
Japanese honeysuckle	*Lonicera japonica*		X			X
Japanese stiltgrass	*Microstegium vimineum*	X	X	X	X	X
Mile-a-minute	*Persicaria perfoilata*					X
Phragmites	*Phragmites sp.*	X				
Multiflora rose	*Rosa multiflora*	X	X	X		X

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Appendix A: Physical Habitat Data

Project Name: Foster's Branch Biological Monitoring
Project Number: 161602035.03
Prepared by: SKB
Prepared date: 8/26/2019

PHI_Coastal_Plain_v2_Fosters_2019_v2.xlsx

		Raw Data											Scaled Metrics						Rating	
Site	Subshed Area (acres)	Instream Habitat	Epibenthic Substrate	Velocity Depth Diversity	Pool Glide Eddy Quality	Bank Stab (0-20)	Embeddedness	Percent Shading	Aesthetics (Trash)	Remoteness Score	# Woody Debris/ Rootwads	Max Depth	Instream Habitat	Epibenthic Substrate	Bank Stability	Shading	Remoteness	# Woody Debris/ Rootwads	PHI	PHI Rating
FOST-1	1137.51	12	12	13	12	20	15	25	13	7	2	75	75.26	80.08	99.17	26.57	37.70	47.97	61.12	Degraded
FOST-2	398.06	9	7	6	11	13	50	65	12	3	13	54	69.36	57.88	79.37	63.55	16.16	92.39	63.12	Degraded
FOST-3	701.98	7	6	7	8	6	100	90	12	5	10	43	52.45	48.37	56.57	91.34	26.93	77.10	58.79	Degraded
FOST-4	107.82	5	4	6	7	13	45	90	14	13	9	39	60.53	48.96	80.63	91.34	72.59	95.35	74.90	Partially Degraded
FOST-5	73.56	6	6	9	9	13	40	85	13	13	14	43	69.99	63.07	81.86	84.56	68.77	100.00	78.04	Partially Degraded

Score	Narrative Rating
81-100	Minimally Degraded
66.0-80.9	Partially Degraded
51.0-65.9	Degraded
0-50.9	Severely Degraded

Appendix B: Benthic Macroinvertebrate Data

Project Name:	Foster Branch		
Project Number:	161602035.03		Foster_2019_BIBI_Coastal_Plain_v4.xlsx
Prepared by:	SKB	Checked by: RAO	Version: 4
Prepared date:	8/29/2019	Checked date: 12/17/2019	

Metric	Fost-1	Fost-2	Fost-3	Fost-4	Fost-5
Raw Scores	**Raw Scores**				
Total Number of Taxa	24	23	35	25	18
Number of EPT Taxa	3	0	2	4	4
Number Ephemeroptera Taxa	0	0	0	0	1
Percent Intolerant Urban	4.90	2.14	4.55	18.75	0.00
Percent Ephemeroptera	0.00	0.00	0.00	0.00	0.66
Number Scraper Taxa	3	0	5	0	1
Percent Climbers	6.29	24.29	21.21	3.13	1.32
BIBI Scores	**BIBI Scores**				
Total Number of Taxa	5	5	5	5	3
Number of EPT Taxa	3	1	3	3	3
Number Ephemeroptera Taxa	1	1	1	1	3
Percent Intolerant Urban	1	1	1	3	1
Percent Ephemeroptera	1	1	1	1	1
Number Scraper Taxa	5	1	5	1	3
Percent Climbers	3	5	5	3	3
BIBI Score	***2.71***	***2.14***	***3.00***	***2.43***	***2.43***
Narrative Rating	***Poor***	***Poor***	***Fair***	***Poor***	***Poor***

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

Notes on use and calculations:
Raw scores should be linked to the sheets for each individual site.
These cannot be copied across but should be linked to the formulas calculated in columns R-X on each individual sampling site tab.

Project Name: Foster Branch
Project Number: 161602035.03
Prepared by: SKB
Prepared date: 8/29/2019
Checked by: RAO
Checked date: 12/17/2019

Foster_2019_BIBI_Coastal_Plain_v4.xlsx
Version: 4
Site Name: FOST-1

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Plecoptera	Nemouridae	Amphinemura	Amphinemura	I	1	Shredder	sp, cn	3
Insecta	Coleoptera	Elmidae	Ancyronyx	Ancyronyx	I	2	Scraper	cn, sp	7.8
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	1	Filterer	cn	6.5
Insecta	Diptera	Chironomidae	Chironomus	Chironomus	I	1	Collector	bu	4.6
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	10	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	I	5	Shredder	0	7.7
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I	1	Collector	sp	8.5
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	15	Collector	sp	6.1
Insecta	Diptera	Empididae	Hemerodromia	Hemerodromia	I	1	Predator	sp, bu	7.9
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	1	Scraper	sp	7.2
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	I	6	Filterer	cn	7.5
Insecta	Trichoptera	Hydropsychidae	not identified	Hydropsychidae	P	2	Filterer	cn	5.7
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	6	Collector	sp	8.6
Oligochaeta	Lumbricina	not identified	not identified	Lumbricina	U	1	Collector	bu	na
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	3	Collector	cb, sp	2.1
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	2	Collector	bu	8.5
0	0	0	not identified	Nematoda	U	3	0	0	na
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	48	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	6	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Potthastia	Potthastia	I	3	Collector	sp	0.01
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	8	Filterer	cn	5.7
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	I	1	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella	I	1	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia Group	I	2	Predator	sp	8.2
Oligochaeta	Tubificida	Tubificidae	not identified	Tubificidae	U	3	Collector	cn	8.4
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	10	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Project Name: Foster Branch
Project Number: 161602035.03
Prepared by: SKB
Prepared date: 8/29/2019
Checked by: RAO
Checked date: 12/17/2019

Foster_2019_BIBI_Coastal_Plain_v4.xlsx
Version: 4
Site Name: FOST-2

KCI TECHNOLOGIES

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Diptera	Chironomidae	Brillia	Brillia	I	1	Shredder	bu, sp	7.4
Insecta	Diptera	Chironomidae	Chaetocladius	Chaetocladius	I	1	Collector	sp	7
Insecta	Diptera	Chironomidae	Corynoneura	Corynoneura	I	1	Collector	sp	4.1
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	3	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	I	1	Shredder	0	7.7
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	2	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Krenosmittia	Krenosmittia	I	11	Collector	sp	na
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	21	Collector	sp	8.6
Oligochaeta	Lumbricina	not identified	not identified	Lumbricina	U	1	Collector	bu	na
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	3	Collector	cb, sp	2.1
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	6	Collector	bu	8.5
Insecta	Diptera	Chironomidae	Natarsia	Natarsia	I/P	2	Predator	sp	6.6
Insecta	Diptera	Chironomidae	not identified	Orthocladiinae	I	3	Collector	0	7.6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	2	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	1	Collector	sp	4.6
Insecta	Diptera	Tipulidae	Pilaria	Pilaria	I	1	Predator	bu	4.8
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	31	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	I	1	Collector	sp	6.2
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	I	10	Filterer	cn	7.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I/P	13	Filterer	cn	5.7
Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella	I	5	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia Group	I	4	Predator	sp	8.2
Oligochaeta	Tubificida	Tubificidae	not identified	Tubificidae	U	1	Collector	cn	8.4
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	15	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Project Name: Foster Branch
Project Number: 161602035.03
Prepared by: SKB
Prepared date: 8/29/2019
Checked by: RAO
Checked date: 12/17/2019

Foster_2019_BIBI_Coastal_Plain_v4.xlsx
Version: 4
Site Name: FOST-3

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Coleoptera	Elmidae	Ancyronyx	Ancyronyx	I/A	4	Scraper	cn, sp	7.8
Insecta	Odonata	Coenagrionidae	Argia	Argia	I	1	Predator	cn, cb, sp	9.3
Insecta	Odonata	Calopterygidae	Calopteryx	Calopteryx	I	1	Predator	cb	8.3
Malacostraca	Decapoda	Cambaridae	not identified	Cambaridae	I	1	Shredder	sp	2.8
Insecta	Plecoptera	Capniidae	not identified	Capniidae	I	8	Shredder	sp, cn	3.7
Insecta	Diptera	Chironomidae	Chironomus	Chironomus	I	1	Collector	bu	4.6
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	2	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Diplocladius	Diplocladius	I	3	Collector	sp	5.9
Oligochaeta	Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	U	1	Collector	bu	9.1
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	2	Collector	sp	6.1
Insecta	Coleoptera	Dryopidae	Helichus	Helichus	A	1	Scraper	cn	6.4
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	10	Scraper	sp	7.2
Insecta	Trichoptera	Limnephilidae	Ironoquia	Ironoquia	I	2	Shredder	sp	4.9
Insecta	Collembola	Isotomidae	not identified	Isotomidae	U	1	0	0	4.8
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	12	Collector	sp	8.6
Oligochaeta	Lumbriculida	Lumbriculidae	not identified	Lumbriculidae	U	2	Collector	bu	6.6
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	5	Collector	bu	8.5
Insecta	Odonata	not identified	not identified	Odonata	I	5	Predator	0	6.6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	11	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Paracladopelma	Paracladopelma	I	1	Collector	sp	6.6
Insecta	Diptera	Chironomidae	Parakiefferiella	Parakiefferiella	I	1	Collector	sp	2.1
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	P	1	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	I	1	Collector	sp	7.7
Gastropoda	Basommatophor	Physidae	Physella	Physella	U	1	Scraper	cb	8
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	6	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Potthastia	Potthastia	I	4	Collector	sp	0.01
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	I	1	Collector	sp	6.2
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	I/P	3	Filterer	cn	7.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	5	Filterer	cn	5.7
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	A	1	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	I	19	Filterer	cb, cn	4.9
Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella	I	6	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia Group	I	3	Predator	sp	8.2
Insecta	Diptera	Tipulidae	Tipula	Tipula	I	1	Shredder	bu	6.7
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	5	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Project Name: Foster Branch
Project Number: 161602035.03
Prepared by: SKB Checked by: RAO
Prepared date: 8/29/2019 Checked date: 12/17/2019

Foster_2019_BIBI_Coastal_Plain_v4.xlsx
Version: 4
Site Name: FOST-4

KCI TECHNOLOGIES

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Plecoptera	Nemouridae	Amphinemura	Amphinemura	I	1	Shredder	sp, cn	3
Insecta	Diptera	Culicidae	ANOPHELES	Anopheles	I	1	Collector	sw	na
Insecta	Odonata	Coenagrionidae	Argia	Argia	I	1	Predator	cn, cb, sp	9.3
Insecta	Odonata	Calopterygidae	Calopteryx	Calopteryx	I	1	Predator	cb	8.3
Insecta	Plecoptera	Capniidae	not identified	Capniidae	I	1	Shredder	sp, cn	3.7
Insecta	Diptera	Ceratopogonidae	not identified	Ceratopogonidae	I	6	Predator	sp, bu	3.6
Insecta	Diptera	Chironomidae	Chironomus	Chironomus	I	1	Collector	bu	4.6
Insecta	Odonata	Cordulegastridae	Cordulegaster	Cordulegaster	I	1	Predator	bu	2.4
Insecta	Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	I	3	Filterer	cn	2.7
Insecta	Diptera	Chironomidae	Diplocladius	Diplocladius	I	3	Collector	sp	5.9
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	2	Collector	sp	6.1
Insecta	Collembola	Isotomidae	not identified	Isotomidae	U	1	0	0	4.8
Insecta	Diptera	Chironomidae	Krenosmittia	Krenosmittia	I	2	Collector	sp	na
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	9	Collector	sp	8.6
Oligochaeta	Lumbriculida	Lumbriculidae	not identified	Lumbriculidae	U	1	Collector	bu	6.6
Insecta	Diptera	Chironomidae	Natarsia	Natarsia	P	2	Predator	sp	6.6
Insecta	Coleoptera	Dytiscidae	Neoporus	Neoporous	A	1	Predator	sw,cb	5
Insecta	Odonata	not identified	not identified	Odonata	I	3	Predator	0	6.6
Insecta	Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	I	1	Filterer	cn	1.1
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	1	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	I	2	Collector	sp	6.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	60	Filterer	cn	5.7
Bivalvia	Veneroida	Pisidiidae	not identified	Sphaeriidae	I	1	Filterer	bu	6.5
Insecta	Diptera	Simuliidae	Stegopterna	Stegopterna	I/P	18	Filterer	cn	2.4
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	A	3	Scraper	cn	7.1
Insecta	Diptera	Tipulidae	Tipula	Tipula	I	1	Shredder	bu	6.7
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	1	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa

Project Name: Foster Branch
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Prepared by: SKB
Prepared date: 8/29/2019
Checked by: RAO
Checked date: 12/17/2019

Foster_2019_BIBI_Coastal_Plain_v4.xlsx
Version: 4
Site Name: FOST-5

KCI TECHNOLOGIES

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis	I	1	Collector	sw, cb, cn	3.9
Insecta	Plecoptera	Capniidae	not identified	Capniidae	I	4	Shredder	sp, cn	3.7
Insecta	Diptera	Ceratopogonidae	not identified	Ceratopogonidae	I	2	Predator	sp, bu	3.6
Insecta	Diptera	Chironomidae	Chaetocladius	Chaetocladius	I	2	Collector	sp	7
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	1	Filterer	cn	6.5
Insecta	Diptera	Chironomidae	Corynoneura	Corynoneura	I	1	Collector	sp	4.1
Insecta	Diptera	Chironomidae	Diplocladius	Diplocladius	I	1	Collector	sp	5.9
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	13	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	1	Scraper	sp	7.2
Insecta	Coleoptera	Hydrophilidae	Hydrobius	Hydrobius	I	1	Collector	cb, cn, sp	4.1
Insecta	Trichoptera	Limnephilidae	Ironoquia	Ironoquia	I	1	Shredder	sp	4.9
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	5	Collector	sp	8.6
Oligochaeta	Lumbriculida	Lumbriculidae	not identified	Lumbriculidae	U	1	Collector	bu	6.6
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	109	Collector	bu	8.5
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	2	Collector	sp, bu	9.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	4	Filterer	cn	5.7
Insecta	Diptera	Chironomidae	Thienemannimyia gr	Thienemannimyia Group	I	1	Predator	sp	8.2
Oligochaeta	Tubificida	Tubificidae	not identified	Tubificidae	U	2	Collector	cn	8.4

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Appendix C: Fish Data

Project Name: Foster Branch Monitoring 2019
Project Number: 161602035.03
Prepared by: JSM
Prepared date: 6/27/2019

Checked by: RAO
Checked date: 12/17/2019

FIBI_Fosters_2019_CoastalPlain_v1.xlsx
Version: 1

KCI TECHNOLOGIES

Metric	Fost 1	Fost 2	Fost 3	Fost 4	Fost 5
Raw Scores	**Raw Scores**				
Abundance per square meter	1.82	1.48	2.15	1.76	0.99
Adjusted Number of Benthic species	1.37	1.12	1.67	0.00	0.00
% Tolerant	76.19	96.14	79.60	100.00	76.12
% Generalist, Omnivores, Invertivores	97.62	100.00	94.40	100.00	100.00
% Round Bodied Suckers	8.33	0.00	0.00	0.00	0.00
% Abundance of Dominant Taxon	38.33	0.00	50.40	88.16	67.16
FIBI Scores	**FIBI Scores**				
Abundance per square meter	5	5	5	5	5
Adjusted Number of Benthic species	5	5	5	1	1
% Tolerant	3	3	3	1	3
% Generalist, Omnivores, Invertivores	3	1	3	1	1
% Round Bodied Suckers	5	1	1	1	1
% Abundance of Dominant Taxon	5	5	3	1	3
FIBI Score	***4.33***	***3.33***	***3.33***	***1.67***	***2.33***
Narrative Rating	***Good***	***Fair***	***Fair***	***Very Poor***	***Poor***

Coastal Plain	**Score**			
Metric	**5**	**3**	**1**	
Abundance per square meter	≥ 0.72	0.45 – 0.71	< 0.45	
Adjusted Number of Benthic species	≥ 0.22	0.01 – 0.21	0	
% Tolerant	≤ 68	69 –97	> 97	68.9
% Generalist, Omnivores, Invertivores	≤ 92	93 - 99	100	92.3
% Round Bodied Suckers	≥ 2	1	0	0.9
% Abundance of Dominant Taxon	≤ 40	41 - 69	> 69	40.1

Project Name: Foster Branch Monitoring 2019
Project Number: 161602035.03
Prepared by: JSM Checked by: RAO
Prepared date: 6/27/2019 Checked date: 12/17/2019

FIBI_Fosters_2019_CoastalPlain_v1.xlsx

Site Name: Fost 1

Final ID	Scientific Name	Number of Organisms	Tolerance	Trophic Status	Lithophilic Spawner	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	Lithophilic Spawner	Adjusted No. Benthic Species	% Dominant Taxa	Abundance per Square Meter	Biomass per Square Meter	% Round Bodied Suckers
American Eel	*Anguilla rostrata*	23	NOTYPE	GE	N	NOTYPE	0	23	0	0	0	0.10		0
Tessellated Darter	*Etheostoma olmstedi*	44	T	IV	N	B	44	44	0	1	0	0.19		0
Brown Bullhead	*Ameiurus nebulosus*	44	T	OM	N	NOTYPE	44	44	0	0	0	0.19		0
Creek Chub	*Semotilus atromaculatus*	161	T	GE	Y	NOTYPE	161	161	161	0	161	0.70		0
Rosyside Dace	*Clinostomus funduloides*	7	NOTYPE	IV	Y	NOTYPE	0	7	7	0	0	0.03		0
Blacknose Dace	*Rhinichthys atratulus*	3	T	OM	N	NOTYPE	3	3	0	0	0	0.01		0
Redbreast Sunfish	*Lepomis auritus*	12	NOTYPE	GE	N	NOTYPE	0	12	0	0	0	0.05		0
Yellow Bullhead	*Ameiurus natalis*	1	NOTYPE	OM	N	NOTYPE	0	1	0	0	0	0.00		0
Pumpkinseed	*Lepomis gibbosus*	22	T	IV	N	NOTYPE	22	22	0	0	0	0.10		0
Least Brook Lamprey	*Lampetra aepyptera*	9	NOTYPE	FF	N	B	0	0	0	1	0	0.04		0
White Sucker	*Catostomus commersonii*	46	T	OM	Y	NOTYPE	46	46	46	0	0	0.20		0
Creek Chubsucker	*Erimyzon oblongus*	35	NOTYPE	IV	N	R	0	35	0	0	0	0.15		35
Mummichog	*Fundulus heteroclitus*	6	NOTYPE	IV	N	NOTYPE	0	6	0	0	0	0.03		0
Northern Snakehead	*Esox lucius*	1	NOTYPE	TP	N	NOTYPE	0	0	0	0	0	0.00		0
Swallowtail Shiner	*Notropis procne*	5	NOTYPE	IV	Y	NOTYPE	0	5	5	0	0	0.02		0
Goldfish	*Carassius auratus*	1	NOTYPE	OM	N	NOTYPE	0	1	0	0	0	0.00		0
	Total Count	*420*					*76.19*	*97.62*	*52.14*	*1.4*	*38.33*	1.82	*13.39*	*8.33*
	Total Biomass (g)	*3088*												

Project Name: Foster Branch Monitoring 2019
Project Number: 161602035.03
Prepared by: JSM Checked by: RAO
Prepared date: 6/27/2019 Checked date: 12/17/2019

FIBI_Fosters_2019_CoastalPlain_v1.xlsx

Site Name: Fost 2

Final ID	Scientific Name	Number of Organisms	Tolerance	Trophic Status	Lithophilic Spawner	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	Lithophilic Spawner	Adjusted No. Benthic Species	% Dominant Taxa	Abundance per Square Meter	Biomass per Square Meter	% Round Bodied Suckers
Creek Chub	*Semotilus atromaculatus*	192	T	GE	Y	NOTYPE	192	192	192	0	0	1.22		
Blacknose Dace	*Rhinichthys atratulus*	18	T	OM	N	NOTYPE	18	18	0	0	0	0.11		
Tessellated Darter	*Etheostoma olmstedi*	4	T	IV	N	B	4	4	0	1	0	0.03		
White Sucker	*Catostomus commersonii*	8	T	OM	Y	NOTYPE	8	8	8	0	0	0.05		
Rosyside Dace	*Clinostomus funduloides*	7	NOTYPE	IV	Y	NOTYPE	0	7	7	0	0	0.04		
Creek Chubsucker	*Erimyzon oblongus*	2	NOTYPE	IV	N	R	0	2	0	0	0	0.01		
Pumpkinseed	*Lepomis gibbosus*	2	T	IV	N	NOTYPE	2	2	0	0	0	0.01		
	Total Count	*233*					*96.14*	*100.00*	*88.84*	*1.1*	*0.00*	1.48	*6.72*	*0.00*
	Total Biomass (g)	*1058*												

Project Name: Foster Branch Monitoring 2019
Project Number: 161602035.03
Prepared by: JSM Checked by: RAO
Prepared date: 8/19/2019 Checked date: 12/17/2019

FIBI_Fosters_2019_CoastalPlain_v1.xlsx

Site Name: Fost 3

Final ID	Scientific Name	Number of Organisms	Tolerance	Trophic Status	Lithophilic Spawner	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	Lithophilic Spawner	Adjusted No. Benthic Species	% Dominant Taxa	Abundance per Square Meter	Biomass per Square Meter	% Round Bodied Suckers
Creek Chub	*Semotilus atromaculatus*	126	T	GE	Y	NOTYPE	126	126	126	0	126	1.08		0
Blacknose Dace	*Rhinichthys atratulus*	49	T	OM	N	NOTYPE	49	49	0	0	0	0.42		0
Rosyside Dace	*Clinostomus funduloides*	24	NOTYPE	IV	Y	NOTYPE	0	24	24	0	0	0.21		0
American Eel	*Anguilla rostrata*	10	NOTYPE	GE	N	NOTYPE	0	10	0	0	0	0.09		0
Tessellated Darter	*Etheostoma olmstedi*	6	T	IV	N	B	6	6	0	1	0	0.05		0
White Sucker	*Catostomus commersonii*	15	T	OM	Y	NOTYPE	15	15	15	0	0	0.13		0
Pumpkinseed	*Lepomis gibbosus*	2	T	IV	N	NOTYPE	2	2	0	0	0	0.02		0
Redbreast Sunfish	*Lepomis auritus*	3	NOTYPE	GE	N	NOTYPE	0	3	0	0	0	0.03		0
Least Brook Lamprey	*Lampetra aepyptera*	14	NOTYPE	FF	N	B	0	0	0	1	0	0.12		0
Bluegill	*Lepomis macrochirus*	1	T	IV	N	NOTYPE	1	1	0	0	0	0.01		0
	Total Count	*250*					*79.60*	*94.40*	*66.00*	*1.7*	*50.40*	2.15	*5.94*	*0.00*
	Total Biomass (g)	*691*												

Project Name: Foster Branch Monitoring 2019
Project Number: 161602035.03
Prepared by: JSM Checked by: RAO
Prepared date: 8/19/2019 Checked date: 12/17/2019

FIBI_Fosters_2019_CoastalPlain_v1.xlsx

Site Name: Fost 4

Final ID	Scientific Name	Number of Organisms	Tolerance	Trophic Status	Lithophilic Spawner	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	Lithophilic Spawner	Adjusted No. Benthic Species	% Dominant Taxa	Abundance per Square Meter	Biomass per Square Meter	% Round Bodied Suckers
Creek Chub	*Semotilus atromaculatus*	67	T	GE	Y	NOTYPE	67	67	67	0	67	1.55		0
Blacknose Dace	*Rhinichthys atratulus*	9	T	OM	N	NOTYPE	9	9	0	0	0	0.21		0
	Total Count	*76*					*100.00*	*100.00*	*88.16*	*0.0*	*88.16*	1.76	*7.47*	*0.00*
	Total Biomass (g)	*322*												

Project Name: Foster Branch Monitoring 2019
Project Number: 161602035.03
Prepared by: JSM Checked by: RAO
Prepared date: 8/19/2019 Checked date: 12/17/2019

FIBI_Fosters_2019_CoastalPlain_v1.xlsx

Site Name: Fost 5

Final ID	Scientific Name	Number of Organisms	Tolerance	Trophic Status	Lithophilic Spawner	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	Lithophilic Spawner	Adjusted No. Benthic Species	% Dominant Taxa	Abundance per Square Meter	Biomass per Square Meter	% Round Bodied Suckers
Creek Chub	*Semotilus atromaculatus*	45	T	GE	Y	NOTYPE	45	45	45	0	45	0.67		0
Mummichog	*Fundulus heteroclitus*	10	NOTYPE	IV	N	NOTYPE	0	10	0	0	0	0.15		0
Blacknose Dace	*Rhinichthys atratulus*	6	T	OM	N	NOTYPE	6	6	0	0	0	0.09		0
Rosyside Dace	*Clinostomus funduloides*	4	NOTYPE	IV	Y	NOTYPE	0	4	4	0	0	0.06		0
American Eel	*Anguilla rostrata*	2	NOTYPE	GE	N	NOTYPE	0	2	0	0	0	0.03		0
	Total Count	*67*					*76.12*	*100.00*	*73.13*	*0.0*	*67.16*	0.99	*2.30*	*0.00*
	Total Biomass (g)	*155*												

Appendix D: Supplemental Flora/Fauana Data

Fost-1

Invasive Plants	Relative Abundance
multiflora rose	Present
Japanese stiltgrass	Present
Phragmites	Present
ground ivy	Present

Stream Salamanders
None observed

Other Herpetofauna
American Bullfrog

Crayfish
Faxonius limosus
Procambarus sp.

Fost-2

Invasive Plants	Relative Abundance
Japanese stiltgrass	Present
multiflora rose	Present
ground ivy	Present
oriental bittersweet	Present
creeping wintergreen	Present
Japanese honeysuckle	Present
garlic mustard	Present

Stream Salamanders
None observed

Other Herpetofauna
American bullfrog
northern green frog

Crayfish
Procambarus sp.

Fost-3

Invasive Plants	Relative Abundance
oriental bittersweet	Present
Japanese stiltgrass	Present
multiflora rose	Present

Stream Salamanders
None Observed

Other Herpetofauna
Northern green frog
pickerel frog

Crayfish
None Observed

Fost-4

Invasive Plants	Relative Abundance
None Observed	n/a

Stream Salamanders
None Observed

Other Herpetofauna
Northern green frog

Crayfish
None observed

Fost-5

Invasive Plants	Relative Abundance
mile-a-minute	Present
Japanese stiltgrass	Extrensive
multiflora rose	Present

Stream Salamanders
None observed

Other Herpetofauna
Northern green frog

Crayfish
None observed

Plumtree Run

Year 4 Monitoring Results

December | 2019

Prepared For

Harford County
Watershed Protection and Restoration
Department of Public Works
212 South Bond Street, 1st Floor
Bel Air, Maryland 21014

Prepared By

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Background and Objectives

Harford County Department of Public Works (DPW) commissioned a watershed action plan for the Plumtree Run watershed. The Plumtree Run Small Watershed Action Plan (BayLand 2011) was completed in June of 2011. The plan outlines restoration projects and storm-water retrofits throughout this approximately 1,650 acre watershed. In anticipation of the permit conditions which may be placed on these restoration projects by Maryland Department of the Environment (MDE) and the U.S. Army Corps of Engineers (USACE), a monitoring plan was developed for the Plumtree watershed.

KCI Technologies, Inc. completed the fourth year of chemical, physical, and biological stream sampling in spring and summer of 2019 at the five stream sites described in the plan. This technical memorandum describes the methods and results of the four years of sampling conducted at those sites in the Plumtree Run watershed.

The primary goal of this effort is to characterize baseline stream conditions (biological, physical habitat, and *in situ* chemical) prior to additional restoration project/BMP implementation. A secondary goal is to conduct monitoring in Plumtree Run that can be used to document ecological uplift and habitat improvement as projects are completed within this watershed.

1 Methods

The monitoring effort includes chemical (*in situ* water quality), physical (habitat assessment), and biological (benthic macroinvertebrate, fish, herpetofauna, freshwater mussels, and crayfish) assessments conducted at each of the selected sites. The sampling methods used are consistent with Maryland Department of Natural Resources' (DNR) Maryland Biological Stream Survey (MBSS). The methods have been developed locally and are calibrated specifically to Maryland's ecophysiographic regions and stream types.

1.1 Sampling Sites

Five sampling sites were selected within the Plumtree Run watershed (Figure 1) to characterize baseline stream conditions and to assess the effect of planned restoration on the ecological health of the watershed. A brief description of sites follows, for more detailed information about each site see the *Plumtree Run Monitoring Plan* (Harford County 2016).

1.1.1 Plum-1

Site Plum-1 is the downstream-most site in the Plumtree Run watershed. This site is located on the mainstem of Plumtree Run in the area of the USGS gage at Plumtree Road. This site will be used to measure overall watershed response to the restoration treatments implemented within the watershed. Since this site is located so close to the USGS gage on Plumtree Run, future analysis of the relationships between biological parameters, stream flow, and water quality may be possible. The land use upstream of Plum-1 is mostly urban and suburban (87.9%) with the remaining portion in agriculture (7.2%) and forest (4.8%). This site will integrate the effects of all future restoration projects in the watershed.

1.1.2 Plum-2

Plum-2 is located on the mainstem of Plumtree Run downstream of Tollgate Road within a previously completed stream restoration reach. The catchment upstream of this site is mostly urban and suburban land (90.4%) with the remaining land classified as agriculture (5.8%) and forest (3.8%). This site will measure ecological response to all restoration projects upstream of this point as those projects are implemented. This site will also directly measure habitat and ecological lift at the previously restored reach. This site is located approximately 420 meters downstream of a MBSS site (HA-P-151-10-96) sampled in 1996.

1.1.3 Plum-3

Plum-3 is located on the mainstem of Plumtree Run downstream of the political boundary of the Town of Bel Air. The upstream catchment to this site is mostly urban (93.5%) with the remaining land classified as agriculture (6.5%). This site will assess the ecological health of Plumtree Run as it enters Harford County's jurisdiction. It will also measure ecological response to future restoration as projects are implemented within the Town of Bel Air.

1.1.4 Plum-4

This site is located on an unnamed tributary to Plumtree Run, primarily draining urban (71.3%) land. The Plumtree Run plan identified extensive stream restoration and stormwater retrofit projects upstream of the site. This site will measure ecological lift possibly attributable to the planned restoration in this urbanized part of the Plumtree Run watershed. The benthic macroinvertebrate community at Plum-4 was sampled each of the four monitoring years, while the fish community was sampled only in Years 1 and 4.

1.1.5 Plum-5

This site is located on an unnamed tributary to Plumtree Run, primarily draining urban (98.7%) land. This site is downstream of two planned stream restoration projects and one stormwater BMP retrofit. This site will assess the ecological benefit of planned restoration in a heavily urbanized subwatershed. The benthic macroinvertebrate community at Plum-5 was sampled each of the four monitoring years, while the fish community was sampled only in Years 1 and 4.

1.2 Water Quality Sampling

Water quality conditions were measured *in situ* during the summer 2019 sampling visits at all Plumtree Run sites. Currently the MBSS does not measure *in situ* water quality at sites, but did so in the past. *In situ* water quality methods used were consistent with those in DNR, 2010. Field measured parameters include temperature, dissolved oxygen, pH, specific conductance, and turbidity. Measurements at each site were made at the upstream end of the 75-meter long site. *In situ* measurements were made before any sampling activities started to avoid sampling water disturbed by other activities. Most *in situ* parameters (i.e., temperature, pH, specific conductivity, and dissolved oxygen) were measured using a multiparameter sonde (YSI Professional Plus), while turbidity was measured with a Hach 2100 Turbidimeter. Water quality meters are regularly inspected and maintained and were calibrated immediately prior to sampling to ensure proper usage and accuracy of the readings.

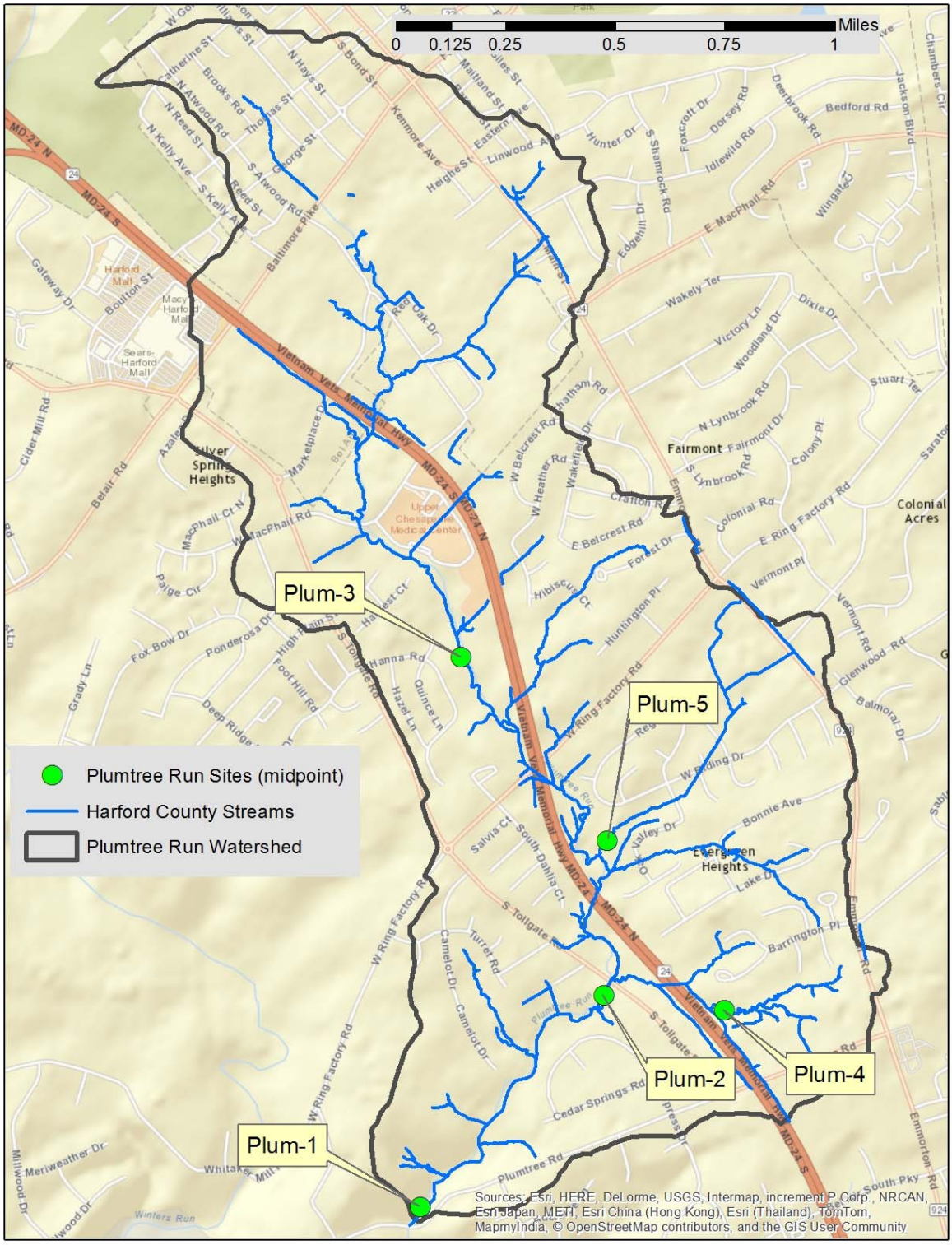

Figure 1 – Location of Sampling Sites

1.3 Physical Habitat Assessment

Each stream site was characterized based on visual observations of physical characteristics and various habitat parameters. The Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI; Paul et al. 2002) was used to assess the physical habitat at the site.

To reduce individual sampler bias, assessments were completed as a team with discussion and agreement of the scoring for each parameter. In addition to the visual assessments, photographs were taken from three locations within each sampling reach (downstream end, midpoint, and upstream end) facing in the upstream and downstream direction, for a total of six (6) photographs per site.

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 Piedmont parameters were used to develop the PHI score for these sites because the Plumtree Run watershed is located in Maryland's Piedmont ecophysiographic region. In developing the PHI, MBSS identified eight parameters that have the most discriminatory power for the Piedmont streams. These parameters are used in calculating the PHI (Table 1). Several of the parameters have been found to be drainage area dependent and are scaled accordingly. The drainage area to each site was calculated in GIS using the GPS-collected location of each site, streams and 2-foot contour data from Harford County.

Table 1 – PHI Piedmont Parameters

Piedmont Stream Parameters	
Instream Habitat	Epifaunal Substrate
Bank Stability	Percent Shading
Remoteness	Number Woody Debris/Root wads

Each habitat parameter is given an assessment score ranging from 0-20, with the exception of shading (percentage 0-100%) and woody debris and root wads (total count). A prepared score and scaled score (0-100) are then calculated. The average of these scores yields the final PHI score. The final scores are then ranked according to the ranges shown in Table 2 and assigned corresponding narrative ratings, which allows for a score that can be compared to habitat assessments performed statewide.

Table 2 – PHI Score and Ratings

PHI Score	Narrative Rating
81.0 – 100.0	Minimally Degraded
66.0 – 80.9	Partially Degraded
51.0 – 65.9	Degraded
0.0 – 50.9	Severely Degraded

1.4 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate collection strictly followed MBSS procedures (Stranko et al. 2015). Sampling occurred during the Spring Index Period (March 1 – April 30), samples were collected from all five Plumtree Run sites on April 23, 2019. The monitoring sites consist of a 75-meter reach and benthic macroinvertebrate sampling is conducted once per year. The sampling methods utilize semi-quantitative field collections of the benthic macroinvertebrate community. The multi-habitat D-frame net approach is used to sample a range of the most productive habitat types present within the reach. Best available habitats include riffles, stable woody debris, root wads, root mats, leaf packs, aquatic macrophytes, and undercut banks. In this sampling approach, a total of twenty kicks or jabs (each

approximately one square foot) are distributed proportionally among all best available habitats within the stream site and combined into a single composite sample and preserved in 95 percent ethanol. The composite sample contains material collected from approximately 20 square feet of habitat.

MBSS specifies that a minimum of 5% (1 in 20) of sites are selected for a duplicate sample (Stranko et al. 2015). Because the total number of samples in this project (5) is well below 20, Plumtree Run samples were pooled with other County monitoring project samples from Foster Branch (5) to meet the field sampling QC objective (1 in 10, or 10.0%). The randomly selected QC site for 2019 was taken at Plum-2.

1.4.1 Benthic Macroinvertebrate Sample Processing and Laboratory Identification

Benthic macroinvertebrate samples were processed and subsampled according to methods described in the MBSS Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy (Boward and Friedman 2011). Subsampling was conducted to standardize the sample size and reduce variation caused by samples of different size. In this method, the sample was spread evenly across a numbered, gridded tray (100 total grids), and a grid was picked at random and picked clean of organisms. If the organism count was 100 or more, then the subsampling was complete. If the organism count was less than 100, then another grid was selected at random and picked clean of organisms. This repeated until the organism count reached 100 to 120 organisms. The 100 (plus 20 percent) organism target is used to allow for specimens that are missing parts or are not mature enough for proper identification, are terrestrial, or meiofauna. Identification of the subsampled specimens was conducted by Environmental Services and Consulting, Inc. Taxa were identified to the genus level for most organisms. Groups including Oligochaeta and Nematomorpha were identified to the family level while Nematomorpha was left at phylum. Individuals of early instars or those that were damaged were identified to the lowest possible level, which could be phylum or order, but in most cases was family. Chironomidae could be 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 viewed with a compound microscope were used to identify Oligochaeta to family and for Chironomid sorting to subfamily and tribe. Permanent slide mounts were then used for Chironomid genus level identification. Results were logged on a bench sheet and entered into a spreadsheet for analysis.

Benthic macroinvertebrate lab quality control procedures followed those used by the MBSS (Boward and Friedman 2011). Because the total number of samples in this project (5) is well below 20, Plumtree Run samples were pooled with samples from Foster Branch (5) to meet the laboratory QC objective (1 in 10, or 10.0%). The lab QC samples were selected at random from either Foster Branch or Plumtree Run samples. One (1) sample was randomly selected for QC re-identification by an independent lab.

1.4.2 Benthic Macroinvertebrate Data Analysis

Benthic macroinvertebrate data were analyzed by KCI 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 were given a score of 1, 3 or 5 based on ranges of values developed for each metric. The results were combined into a scaled IBI score from 1.0 to 5.0, and a corresponding narrative biological condition rating was applied.

Three sets of metric calculations have been developed for Maryland streams based on broad eco-physiographic regions. These include the Coastal Plain, Piedmont and combined Highlands. The study area is located in the Piedmont region therefore the following metrics (Table 3) and IBI scoring (Table 4) were used for the analysis.

Table 3 – Benthic Macroinvertebrate Metric Scoring for the Piedmont BIBI

Metric	Score		
	5	3	1
Total Number of Taxa	≥ 25	15 – 24	< 15
Number of EPT Taxa	≥ 11	5 – 10	< 5
Number of Ephemeroptera Taxa	≥ 4	2 – 3	< 2
% Intolerant to Urban	≥ 51	12 – 50	< 12
% Chironomidae	≤ 24	24 – 63	> 63
% Clingers	≥ 74	31 – 73	< 31

*Adjusted for catchment size

Table 4 – BIBI 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

1.5 Fish Sampling

The fish community at each of the five Plumtree Run sites was sampled 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. 2015). 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. 2015). 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 voucher specimens.

1.5.1 Fish Data Analysis

Fish data for Plumtree Run 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 1, 3 or 5 based on ranges of values developed for each metric. The results were combined into a scaled FIBI score, ranging from 1.0 to 5.0, 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. Plumtree Run is located in the Eastern Piedmont region, therefore, the following metrics listed in Table 5 were used for the FIBI scoring (Table 6) and analysis.

Table 5 – Fish Metric Scoring for the Piedmont FIBI

Metric	Score		
	5	3	1
Abundance per Square Meter	≥ 1.25	0.25 – 1.24	< 0.25
Number of Benthic species *	≥ 0.26	0.09 – 0.25	< 0.09
% Tolerant	≤ 45	46 – 68	> 68
% Generalist, Omnivores, Invertivores	≤ 80	81 – 99	100
Biomass per Square Meter	≥ 8.6	4.0 – 8.5	< 4.0
% Lithophilic Spawners	≥ 61	32 – 60	< 32

*Adjusted for catchment size

Table 6 – 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

1.6 Herpetofauna Survey

Herpetofauna (i.e., reptiles and amphibians) were surveyed at each of the five Plumtree Run sites using methods following MBSS protocols (Stranko et al. 2015); 1) incidental collection, and 2) a search within all suitable stream salamander habitats within the 75-meter site. 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.

1.7 Freshwater Mussel Survey

A survey of freshwater mussels was conducted at each site using MBSS protocols (Stranko et al. 2015). A search for freshwater mussels was conducted at each site. 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 were retained as voucher specimens.

1.8 Crayfish Survey

Crayfish were surveyed for at each site using MBSS protocols (Stranko et al. 2015). 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.

1.9 Invasive Plant Survey

A survey of invasive plants was performed at each site during the Summer Index Period following MBSS protocols (Stranko et al. 2015). 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.

1.10 Quality Assurance and Quality Control

All work was conducted with thorough quality assurance and quality control. Biological assessment methods have been designed to be consistent and comparable with the methods used by MBSS (Stranko et al. 2015). Field crews receive yearly training in MBSS protocols and certification by DNR to perform benthic macroinvertebrate and fish sampling procedures. The Certified Fish Sampling Field Crew Leader and Fish Taxonomists for this project was Andy Becker and Rob Owen. All field forms are checked and signed by the Crew Leader before leaving the site. Digital data entry is also checked for accuracy. Field equipment are checked regularly and calibrated as necessary prior to use. Calculation of metric scores and IBIs are completed using KCI's controlled and verified spreadsheet and each site undergoes a documented quality control check.

2 Results and Discussion

Biological monitoring and water quality sampling were conducted to assess the conditions in the Plumtree Run watershed. Presented below are the summary results for each monitoring component.

2.1 Water Quality

Water quality measurements were collected during the Summer Index Period sampling visit during all four years at each of the five Plumtree Run sites. Table 7 presents the results of the *in situ* water quality measurements.

Table 7 – In Situ Water Quality Measurement Results

Site	Season	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (Units)	Specific Conductance (µS/cm)	Turbidity (NTU)
Plum-1	Summer 2015	15.1	9.92	7.52	596.7	0.89
Plum-1	Summer 2016	19.4	9.01	7.41	332.2	2.23
Plum-1	Summer 2017	21.0	8.75	7.82	436.9	7.89
Plum-1	Summer 2019	20.7	7.77	7.69	514.6	2.05
Plum-2	Summer 2015	17.6	9.94	7.22	672.0	4.95
Plum-2	Summer 2016	21.7	7.41	6.98	357.9	3.67
Plum-2	Summer 2017	23.2	7.14	8.98	482.8	8.93
Plum-2	Summer 2019	22.9	8.22	7.08	599.0	4.99
Plum-3	Summer 2015	16.5	8.54	7.18	887.0	1.72
Plum-3	Summer 2016	22.6	8.36	6.92	726.0	1.30
Plum-3	Summer 2017	22.0	6.41	7.22	589.0	5.08
Plum-3	Summer 2019	24.4	8.03	7.13	937.0	1.38
Plum-4	Summer 2015	15.4	7.01	6.81	384.2	1.13
Plum-4	Summer 2019	14	9.73	6.99	446.4	1.33
Plum-5	Summer 2015	17.8	7.22	7.12	433.9	1.40
Plum-5	Summer 2019	17.7	9.51	7.26	417.7	1.61

Shaded cells indicate values exceeding either water quality criteria or published values

MDE has established acceptable water quality standards for each designated Stream Use Classification, which are listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality*. Plumtree Run is covered in *COMAR* in Sub-Basin 02-13-07: Bush River Area as Use IV-P waters. Specific designated uses for Use IV-P streams include public water supply, supporting adult trout for put-and-take fishing, growth and propagation of fish and aquatic life, water supply for industrial and agricultural use, water contact sports, fishing, and leisure activities involving direct water contact.

The acceptable criteria for Use IV-P waters are as follows:

- pH - 6.5 to 8.5
- DO - may not be less than 5 mg/l at any time
- Turbidity - maximum of 150 Nephelometric Turbidity Units (NTU's) and maximum monthly average of 50 NTU
- Temperature - maximum of 75°F (23.9°C) or ambient temperature of the surface water, whichever is greater

In situ water quality measurements for temperature, dissolved oxygen, and turbidity were within COMAR standards for Use IV-P streams. At Plum-2 during Year 3/Summer of 2017 the pH was 8.98, exceeding the COMAR criteria. All other pH values fell within the criteria. Although MDE does not have a water quality standard for specific conductivity, Morgan and others (Morgan et al, 2007; Morgan et al, 2012) have reported critical values for specific conductance in Maryland streams, above which there is a potential for detrimental effects on the stream biological communities. For the benthic macroinvertebrate community that critical value is 247 µS/cm, and for the fish community it is 171 µS/cm. Each of the five Plumtree Run stream sites had specific conductivity values far exceeding the threshold for both benthic macroinvertebrate and fish community impairments for all water

quality sampling events. Conductivity levels in this watershed are likely influenced by runoff from impervious surfaces (i.e., roads, sidewalks, parking lots, roof tops). Increased stream inorganic ion concentrations (i.e., conductivity) in urban systems typically results from paved surface de-icing, accumulations in storm-water management facilities (Casey et al. 2013), runoff over impervious surfaces, passage through pipes, and exposure to other infrastructure (Cushman 2006). While elevated conductivity may not directly affect stream biota, its constituents (e.g., chloride, metals, and nutrients) may be present at levels that can cause biological impairment.

2.2 Physical Habitat Assessment

The summary results of the PHI habitat assessments for Years 1, 2, 3 and 4 are presented in Table 8. All Plumtree Run sites have compromised physical habitat, with PHI ratings of 'Degraded' for all sites in Year 1 and all sites in Year 2 except Plum-1. Plum-1 had the best habitat scores of the five sites with a 'Partially Degraded' in Year 2. Year 3 had the same results as Year 2 with Plum-1 receiving a rating of 'Partially Degraded' while the other sites both received ratings of 'Degraded'. Year 4 had similar results with all sites scoring as 'Degraded' except Plum-4 which received a rating of 'Partially Degraded'. The relatively low habitat scores are likely due to urbanization effects on streams. Complete physical habitat data for each site are included in Appendix A.

Table 8 – RBP and PHI Habitat Assessment Results

Site	Season	PHI Score	PHI Narrative Rating
Plum-1	Summer 2015	64.6	Degraded
Plum-1	Summer 2016	71.2	Partially Degraded
Plum-1	Summer 2017	66.4	Partially Degraded
Plum-1	Summer 2019	58.3	Degraded
Plum-2	Summer 2015	54.0	Degraded
Plum-2	Summer 2016	58.5	Degraded
Plum-2	Summer 2017	58.2	Degraded
Plum-2	Summer 2019	51.3	Degraded
Plum-3	Summer 2015	59.0	Degraded
Plum-3	Summer 2016	64.1	Degraded
Plum-3	Summer 2017	60.4	Degraded
Plum-3	Summer 2019	54.1	Degraded
Plum-4	Summer 2015	59.5	Degraded
Plum-4	Summer 2019	69.0	Partially Degraded
Plum-5	Summer 2015	54.2	Degraded
Plum-5	Summer 2019	52.1	Degraded

2.3 Benthic Macroinvertebrate Community

The results of Year 4 benthic macroinvertebrate community assessments are presented in Table 9. Complete benthic macroinvertebrate data for each site are included in Appendix B.

Table 9 – Benthic Index of Biotic Integrity (BIBI) Summary Data – Year 4

Metric	Plum-1	Plum-2	Plum-3	Plum-4	Plum-5	Plum-2 QC
Metric Values						
Total Number of Taxa	18	17	17	21	19	17
Number of EPT Taxa	5	3	3	4	5	2
Number of Ephemeroptera Taxa	2	2	1	0	1	1
% Intolerant to Urban	5.51	2.31	0.00	9.09	6.58	5.67
% Chironomidae	70	62.31	51.85	87.41	50.00	78.01
% Clingers	0.00	8.46	18.52	15.38	22.37	7.80
Metric Scores						
Total Number of Taxa	3	3	3	3	3	3
Number of EPT Taxa	3	1	1	1	3	1
Number of Ephemeroptera Taxa	3	3	1	1	1	1
% Intolerant to Urban	1	1	1	1	1	1
% Chironomidae	1	3	3	1	3	1
% Clingers	1	1	1	1	1	1
BIBI Score	***2.00***	***2.00***	***1.67***	***1.33***	***2.00***	***1.33***
Narrative Rating	**Poor**	**Poor**	**Very Poor**	**Very Poor**	**Poor**	***Very Poor***

For Year 4 benthic macroinvertebrate sampling, all five Plumtree Run sites had BIBI ratings in the 'Poor' or 'Very Poor' category, with Plum-4 scoring 1.33, the lowest score.

At the Plumtree Run sites BIBI scores ranged from 1.33 to 2.00. The individual metrics scored consistently low across all sites with none of the site receiving a score of 5 for any metrics. Two metrics, Percent Intolerant to Urban, and Percent Clingers scored consistently low across all five sites with each site scoring the lowest possible '1' for these two metrics. Minor differences in the other four metrics (Total Number of Taxa, Number of EPT Taxa, Number of Ephemeroptera Taxa, and Percent Chironomidae) accounted for the variation in BIBI scores. These low BIBI scores are possibly due to poor habitat and water quality. All sites had measured specific conductivity values greater than the published impairment threshold for benthic macroinvertebrates.

The QC sample from Plum-2 slightly lower than the non-QC sample, in the 'Very Poor' category. The QC sample had smaller Number of Ephemeroptera Taxa and Percent Clingers, driving the BIBI lower than the non-QC sample. This is most likely due to the naturally-occurring patchy distribution of benthic macroinvertebrates.

A comparison of BIBI scores across the three years of monitoring is presented in Table 10 and Figure 2. Four of the five Plumtree Run sites had BIBI scores that were higher in Year 4 than in Year 3 (Plum-1, Plum-2, Plum-4 and Plum-5), while Plum-3 remained the same between years. Sites Plum-1 and Plum-2 had the largest BIBI score difference (+0.67), scoring a 1.33 in Year 3 and a 2.00 in Year 4. Sites Plum-4, and Plum-5, had the smallest BIBI score differences (-0.33), and Plum-3 had no change between years.

Table 10 – BIBI Scores and Narrative Rating for all Years

Site	Year	BIBI Score	Narrative Rating
Plum-1	1 (Spring 2016)	2.67	Poor
Plum-1	2 (Spring 2017)	1.00	Very Poor
Plum-1	3 (Spring 2018)	1.33	Very Poor
Plum-1	4 (Spring 2019)	2.00	Poor
Plum-2	1 (Spring 2016)	2.00	Poor
Plum-2	2 (Spring 2017)	1.00	Very Poor
Plum-2	3 (Spring 2018)	1.33	Very Poor
Plum-2	4 (Spring 2019)	2.00	Poor
Plum-3	1 (Spring 2016)	2.00	Poor
Plum-3	2 (Spring 2017)	1.33	Very Poor
Plum-3	3 (Spring 2018)	1.67	Very Poor
Plum-3	4 (Spring 2019)	1.67	Very Poor
Plum-4	1 (Spring 2016)	2.33	Poor
Plum-4	2 (Spring 2017)	2.00	Poor
Plum-4	3 (Spring 2018)	1.00	Very Poor
Plum-4	4 (Spring 2019)	1.33	Very Poor
Plum-5	1 (Spring 2016)	2.00	Poor
Plum-5	2 (Spring 2017)	1.67	Very Poor
Plum-5	3 (Spring 2018)	1.67	Very Poor
Plum-5	4 (Spring 2019)	2.00	Poor

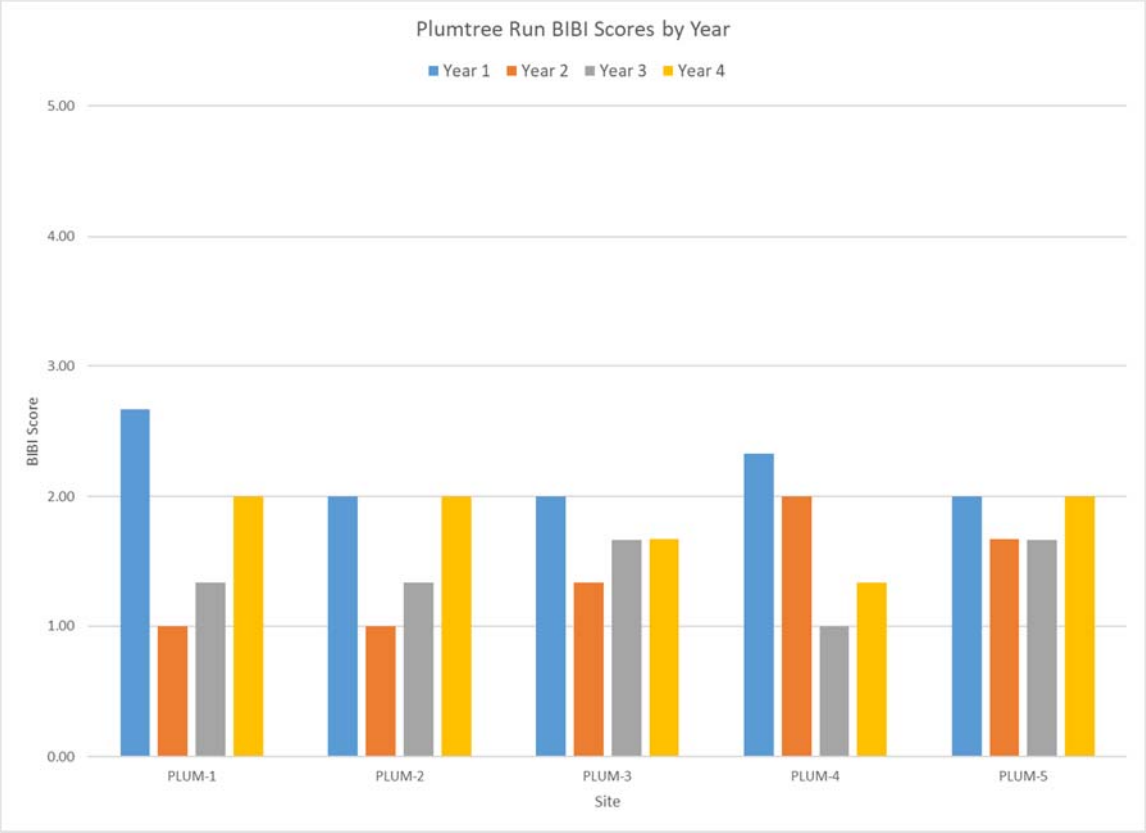

Figure 2 – BIBI Scores by Year

2.4 Fish Community

The results of the Year 4 fish community assessments are presented in Table 11 and a list of species collected over all four sampling years at each site can be found in Table 12. Complete fish community data for each site are included in Appendix C.

The Plumtree Run sites had FIBI ratings ranging from 'Poor' to 'Good'. Sites Plum-4 and Plum-5 were only sampled in Year 1 and Year 4 as per the Plumtree Run Monitoring Plan. These two sites are sufficiently small enough in contributing drainage area (each approx. 100 acres) that a Maryland-specific species-area curve suggests that very few, if any, fish species are expected to be observed; therefore fish community may not be a useful indicator of stream condition.

Table 11 – Fish Index of Biotic Integrity (FIBI) Summary Data – Year 4

Metric	Plum-1	Plum-2	Plum-3	Plum-4	Plum-5
Metric Values					
Abundance per Square Meter	1.29	3.21	2.91	2.43	1.52
Adjusted Number of Benthic Species	0.62	0.65	0.84	0.00	3.70
% Tolerant	54.15%	72.30%	80.51%	100.00%	84.73%
% Generalist, Omnivores, Invertivores	67.47%	88.85%	91.18%	100.00%	93.10%
Biomass per Square Meter	4.73	17.96	4.81	7.83	3.49
% Lithophilic Spawners	54.15%	36.19%	39.68%	65.56%	48.28%
Metric Scores					
Abundance per Square Meter	5	5	5	5	5
Adjusted Number of Benthic Species	5	5	5	1	5
% Tolerant	3	1	1	1	1
% Generalist, Omnivores, Invertivores	5	3	3	1	3
Biomass per Square Meter	3	5	3	3	1
% Lithophilic Spawners	3	3	3	5	3
FIBI Score	***4.00***	***3.67***	***3.33***	***2.67***	***3.00***
Narrative Rating	***Good***	***Fair***	***Fair***	***Poor***	***Fair***

Table 12 – Cumulative List of Fish Species Collected at Plumtree Run Sites

Common Name	Scientific Name	Plum-1	Plum-2	Plum-3	Plum-4	Plum-5
White Sucker	*Catostomus commersonii*	X	X	X		
Bluntnose Minnow	*Pimephales notatus*	X	X	X		
Fathead Minnow	*Pimephales promelas*	X	X	X		
Cutlip Minnow	*Exoglossum maxillingua*		X			
Satinfin Shiner	*Cyprinella analostana*		X			
Common Shiner	*Luxilus cornutus*	X	X			
Rosyside Dace	*Clinostomus funduloides*	X	X	X		X
Creek Chub	*Semotilus atromaculatus*	X	X	X	X	X
Fallfish	*Semotilus corporalis*	X	X			
Blacknose Dace	*Rhinichthys atratulus*	X	X	X	X	X
Longnose Dace	*Rhinichthys cataractae*	X	X	X	X	X

Common Name	Scientific Name	Plum-1	Plum-2	Plum-3	Plum-4	Plum-5
Eastern Mosquitofish	*Gambusia holbrooki*		X			
Blue Ridge Sculpin	*Cottus caeruleomentum*	X	X	X		X
Brown Bullhead	*Ameiurus nebulosus*		X			
Tessellated Darter	*Etheostoma olmstedi*		X			
Redbreast Sunfish	*Lepomis auritus*	X	X	X		
Bluegill	*Lepomis macrochirus*			X		
Pumplkinseed	*Lepomis gibbosus*		X			
Green Sunfish	*Lepomis cyanellus*			X		
Hybrid Sunfish	*Lepomis sp.*		X			

Site Plum-1 had the highest FIBI score, 4.00 which rated 'Good'. Sites Plum-2, Plum-3 and Plum-5 all received a rating of 'Fair', with scores of 3.67, 3.33 and 3.00 respectively. Plum-4 was rated as 'Poor' with a score of 2.67. This low rating was due to only two species being present during Year 4 sampling. Five species of fish have been collected at Plum-5, ten species collected at Plum-1, ten species collected at Plum-3 and 16 species collected at Plum-2 (the restored site) which had the highest diversity of the five sites. Metrics for Adjusted Number of Benthic Species, and Percent Lithophilic Spawners were consistent between the four sites. Biomass per Square Meter varied the most between the sites, with Plum-2 scoring a '5', Plum-1, Plum-3 and Plum-4 scoring a '3', and Plum-5 scoring a '1'. Minor differences in the other three metrics between sites accounted for the minor variability in FIBI scores between sites

A comparison of FIBI scores across the three years of monitoring is presented in Table 13 and Figure 3. Overall, FIBI scores at the three Plumtree Run sites monitoring in the three years varied slightly. Plum-3 scored a 3.33 all four years, Plum-1 had a slightly lower FIBI score (-0.33) in Year 2, but then increased to 4.00 in Year 3 and remained at 4.00 in Year 4. Plum-2 had a slightly higher FIBI scoreof 4.00 in Year 2, but then has remained in the 'Fair' rating in Years 3 and 4 (3.33, 3.67 respectively). Plum-4 remained the same with a 'Poor' rating in both Year 1 and Year 4 while Plum-5 increased to 'Fair' in Year 4 from a rating of 'Poor' in Year 1.

Table 13 – FIBI Scores and Narrative Rating Across Years

Site	Year	FIBI Score	Narrative Rating
Plum-1	1 (Summer 2015)	3.67	Fair
Plum-1	2 (Summer 2016)	3.33	Fair
Plum-1	3 (Summer 2017)	4.00	Good
Plum-1	4 (Summer 2019)	4.00	Good
Plum-2	1 (Summer 2015)	3.67	Fair
Plum-2	2 (Summer 2016)	4.00	Good
Plum-2	3 (Summer 2017)	3.33	Fair
Plum-2	4 (Summer 2019)	3.67	Fair
Plum-3	1 (Summer 2015)	3.33	Fair
Plum-3	2 (Summer 2016)	3.33	Fair
Plum-3	3 (Summer 2017)	3.33	Fair
Plum-3	4 (Summer 2019)	3.33	Fair
Plum-4	1 (Summer 2015)	2.67	Poor
Plum-4	4 (Summer 2019)	2.67	Poor
Plum-5	1 (Summer 2015)	2.67	Poor
Plum-5	4 (Summer 2019)	3.00	Fair

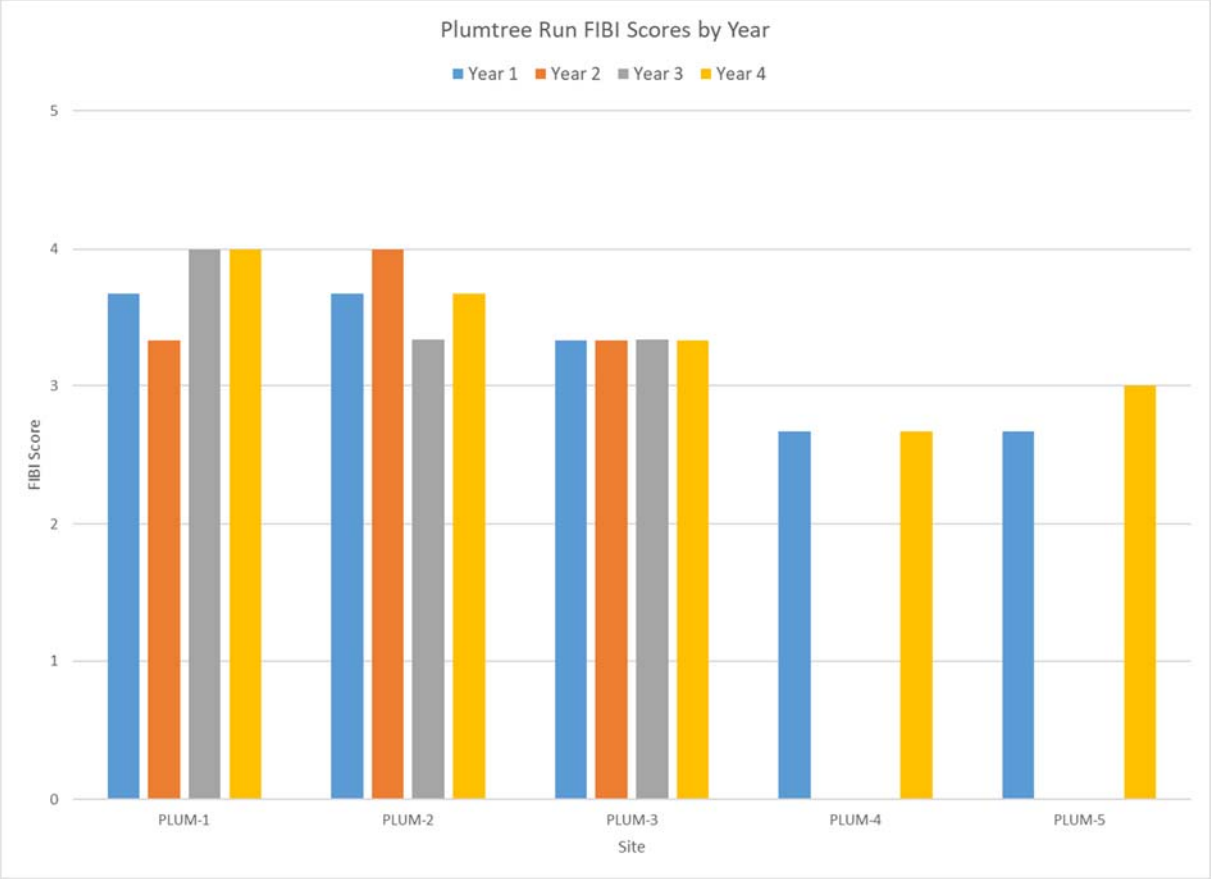

Figure 3 – FIBI Scores by Year

2.5 Herpetofauna

At least two reptile or amphibian species were collected at each of the sites, as presented in Table 14 which represents all species found at each monitoring site across all sampling visits. Plum-2 had the highest diversity with five species present at the site. The most widely distributed species was Northern Two-lined Salamander, which was present at each of the five Plumtree Run sites. Numbers of stream salamander individuals were low at all sites where they were observed; one or two Northern Two-lined Salamander individuals were observed at most sites, Plum-4 and Plum-5 had the greatest stream salamander diversity with both Northern Two-lined Salamanders and Northern Dusky observed during summer of 2019

Table 14 – Cumulative Herpetofauna Presence at Plumtree Run Sites

Common Name	Scientific Name	Plum-1	Plum-2	Plum-3	Plum-4	Plum-5
American Toad	*Anaxyrus americanus*	X		X		
Northern Green Frog	*Lithobates clamitans melanota*	X	X	X	X	X
Northern Spring Peeper	*Pseudacris crucifer*		X			
Northern Watersnake	*Nerodia sipedon sipedon*		X			
Stream Salamanders						
Northern Dusky Salamander	*Desmognathus fuscus*				X	X
Northern Two-lined Salamander	*Eurycea bislineata*	X	X	X	X	X

The low density of stream salamanders at all sites is likely due to a combination of habitat degradation and water quality impairment. There was very little suitable stream salamander habitat present at Plum-2 during all four years for the field crew to search. Stream salamanders generally prefer large cover objects over loose cobble and gravel, creating a moist microclimate and many interstices for shelter and foraging. The restoration reach (Plum-2) contained several areas of armored banks and rock structures in the stream. Water quality may be influencing the distribution of stream salamanders in the Plumtree Run watershed. Measured specific conductivity was high at all five sites, ranging from 332 to 937 µS/cm. Stream salamanders breathe through their skins, and because of their highly permeable skin are particularly sensitive to water quality impairments. The high conductivity values suggest that salamanders would experience osmotic difficulties in these conditions.

2.6 Freshwater Mussels

No freshwater mussels were observed at any Plumtree Run site during the four years of monitoring. The lack of freshwater mussels at these sites is likely due to a combination of habitat degradation and water quality impairment. Freshwater mussels are relatively sessile organisms which live partially embedded within the stream substrates. The flashy hydrology characteristic of urban streams like Plumtree Run create habitat conditions unsuitable for freshwater mussels. Also, it is likely that water quality conditions in urban streams are outside the range of tolerance of these sensitive organisms.

2.7 Crayfish

Crayfish were observed at each of the five Plumtree Run sites. *Faxonius virilis*, a non-native species, was the only crayfish species observed at these sites. *F. virilis* was observed during electrofishing in Year 1, Year 2, Year 3 and Year 4 sampling efforts at all five sites. Crayfish burrows were not observed at any of the Plumtree Run sites. The lack of native crayfish is most likely due to competition with non-

native crayfish. In the Patapsco River watershed, *Faxonius virilis* has displaced the native *Faxonius limosus* from the entire watershed (Kilian et al. 2010). It is likely that a similar species displacement has occurred in the Winters Run watershed. Water quality conditions may also be impacting crayfish, but currently the water quality requirements for crayfish in Maryland are poorly understood.

2.8 Invasive Plant Species

Invasive plant species were present at each of the five Plumtree Run sites. Table 15 presents all invasive species found at each monitoring site across all sampling visits. Plum-2 has the most invasive plant species with 13, and Plum-4 had the least with four. Japanese stiltgrass and Mulitflora rose were the most widely distributed invasive plant, each found at all five sites.

Table 15 – Cumulative Invasive Plant Species Presence at Plumtree Run Sites

Common Name	Scientific Name	Plum-1	Plum-2	Plum-3	Plum-4	Plum-5
Garlic Mustard	*Allaria petiolata*	X	X			X
Common ragweed	*Ambrosia artemisiifolia*		X			X
Japanese barberry	*Berberis thunbergii*	X			X	
Oriental bittersweet	*Celastrus orbiculatus*	X	X	X		X
Fireweed	*Chamerion angustifolium*			X		
Autumn Clematis	*Clematis terniflora*	X	X			
Ground ivy	*Glechoma hederacea*		X			
English ivy	*Hedera helix*	X	X			
Chinese Lespedeza	*Lespedeza cuneata*		X			
Japanese honeysuckle	*Lonicera japonica*	X		X		X
Japanese stiltgrass	*Microstegium vimineum*	X	X	X	X	X
Mile-a-minute	*Persicaria perfoilata*		X	X		X
Mimosa tree	*Albizia julibrissin*		X			
Multiflora rose	*Rosa multiflora*	X	X	X	X	X
Wineberry	*Rubus phoenicolasius*		X	X	X	X
Vinca vine	*Vinca sp.*		X			

3 References

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Appendix A: Physical Habitat Data

Project Name: Plumtree Run Monitoring Plan and Biological Monitoring
Project Number: 161602035.02
Prepared by: SKB
Prepared date: 8/23/2019

PHI_Piedmont_v3_2019.xlsx

		RAW DATA								SCALED METRICS								SCORES	
Site	Subshed Area (ac)*	Instream Habitat	Epibenthic Substrate	Embeddedness	Percent Shading	# Woody Debris/ Rootwads	Riffle Quality	Bank Stability	Remoteness Score	Instream Habitat	Epibenthic Substrate	Embeddedness	Percent Shading	# Woody Debris/ Rootwads	Riffle Quality	Bank Stability	Remoteness	PHI	PHI Rating
Plum 1	1527.06	14	13	60	80	0	13	16	3	75.52	70.59	44.44	80.42	0.00	80.16	93.53	21.59	58.3	Degraded
Plum 2	1317.81	9	8	40	35	1	14	20	3	44.39	41.18	66.67	45.77	8.33	86.03	100.00	18.33	51.3	Degraded
Plum 3	692.32	12	11	40	65	3	11	8	3	66.19	58.82	66.67	63.50	25.00	74.18	56.92	21.59	54.1	Degraded
Plum 4	58.85	11	10	35	95	10	7	16	6	70.36	52.94	72.22	77.34	83.33	66.94	92.51	36.24	69.0	Partially Degraded
Plum 5	127.11	7	8	0	75	0	12	5	8	41.67	41.18	100.00	60.86	0.00	88.30	37.65	47.31	52.1	Degraded

Score	Narrative Rating
81-100	Minimally Degraded
66.0-80.9	Partially Degraded
51.0-65.9	Degraded
0-50.9	Severely Degraded

Appendix B: Benthic Macroinvertebrate Data

Project Name: Plumtree Run Monitoring
Project Number: 161602035.02
Prepared by: SKB Checked by: RAO
Prepared date: 8/23/2019 Checked date: 12/17/2019

2019Plum_BIBI_Piedmont.xlsx
Version: 1

KCI TECHNOLOGIES

Metric	Plum 1	Plum 2	Plum 3	Plum 4	Plum 5	Plum 2 QC
Raw Scores						
Total Number of Taxa	18	17	17	21	19	17
Number of EPT Taxa	5	3	3	4	5	2
Number of Ephemeroptera Taxa	2	2	1	0	1	1
Percent Intolerant Urban	5.51	2.31	0.00	9.09	6.58	5.67
Percent Chironomidae	70	62.31	51.85	87.41	50.00	78.01
Percent Clingers	0.00	8.46	18.52	15.38	22.37	7.80
BIBI Scores						
Total Number of Taxa	3	3	3	3	3	3
Number of EPT Taxa	3	1	1	1	3	1
Number of Ephemeroptera Taxa	3	3	1	1	1	1
Percent Intolerant Urban	1	1	1	1	1	1
Percent Chironomidae	1	3	3	1	3	1
Percent Clingers	1	1	1	1	1	1
BIBI Score	***2.00***	***2.00***	***1.67***	***1.33***	***2.00***	***1.33***
Narrative Rating	***Poor***	***Poor***	***Very Poor***	***Very Poor***	***Poor***	***Very Poor***

1.33
audit sample

Piedmont		Score	
Metric	**5**	**3**	**1**
Total Number of Taxa	≥25	15 - 24	<15
Number of EPT Taxa	≥11	5 - 10	<5
Number Ephemeroptera Taxa	≥4	2 - 3	<2
Percent Intolerant Urban	≥51	12 - 50	<12
Percent Chironomidae	<24	24 - 63	>63
Percent Clingers	≥74	31 - 73	<31

Project Name: Plumtree Run Monitoring
Project Number: 161602035.02
Prepared by: SKB Checked by: RAO
Prepared date: 8/23/2019 Checked date: 12/17/2019

2019Plum_BIBI_Piedmont.xlsx
Version: 1
Site Name: Plum 1

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Oligochaeta	Lumbriculida	Lumbriculidae	not identified	Lumbriculidae		1	Collector	bu	6.6
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae		7	Collector	bu	8.5
Insecta	Ephemeroptera	Baetidae	Acentrella	Acentrella		7	Collector	sw, cn	4.9
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis		2	Collector	sw, cb, cn	3.9
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche		1	Filterer	cn	7.5
Insecta	Trichoptera	Philopotamidae	Chimarra	Chimarra		5	Filterer	cn	4.4
Insecta	Trichoptera	Philopotamidae	Dolophilodes	Dolophilodes		4	Filterer	cn	1.7
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis		2	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum		5	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra		3	Collector	cb, sp	2.1
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus		1	Filterer	cn	7.2
Insecta	Diptera	Chironomidae	not identified	Orthocladiinae		16	Collector	0	7.6
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella		3	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes		2	Collector	sp	8.6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius		53	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	not identified	Diamesinae		3	Collector	0	7.1
Insecta	Diptera	Chironomidae	Diamesa	Diamesa		3	Collector	sp	8.5
Insecta	Diptera	Simuliidae	Simulium	Simulium		8	Filterer	cn	5.7
Insecta	Diptera	Tipulidae	Antocha	Antocha		1	Collector	cn	8

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Project Name: Plumtree Run Monitoring
Project Number: 161602035.02
Prepared by: SKB Checked by: RAO
Prepared date: 8/29/2019 Checked date: 12/17/2019

2019Plum_BIBI_Piedmont.xlsx
Version: 1
Site Name: Plum 2

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Ephemeroptera	Baetidae	Acentrella	Acentrella	I	1	Collector	sw, cn	4.9
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis	I	1	Collector	sw, cb, cn	3.9
Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	U	1	Collector	sp	6.7
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	4	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I/P	5	Collector	sp	8.5
Insecta	Diptera	Empididae	not identified	Empididae	P	1	Predator	sp, bu	7.5
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I/P	3	Collector	sp	6.1
Insecta	Diptera	Empididae	Hemerodromia	Hemerodromia	I	1	Predator	sp, bu	7.9
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	I	1	Filterer	cn	7.5
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	2	Collector	sp	8.6
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	2	Collector	cb, sp	2.1
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	39	Collector	bu	8.5
0	0	0	not identified	Nematoda	U	1	0	0	na
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	62	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	1	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Potthastia	Potthastia	I	1	Collector	sp	0.01
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	I	1	Filterer	cn	7.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	3	Filterer	cn	5.7

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Project Name: Plumtree Run Monitoring
Project Number: 161602035.02
Prepared by: SKB Checked by: RAO
Prepared date: 8/29/2019 Checked date: 12/17/2019

2019Plum_BIBI_Piedmont.xlsx
Version: 1
Site Name: Plum 3

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Diptera	Tipulidae	Antocha	Antocha	I	2	Collector	cn	8
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis	I	2	Collector	sw, cb, cn	3.9
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	2	Filterer	cn	6.5
Insecta	Trichoptera	Philopotamidae	Chimarra	Chimarra	I	1	Filterer	cn	4.4
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I/P	13	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	I	1	Shredder	0	7.7
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I	1	Collector	sp	8.5
Insecta	Diptera	Empididae	not identified	Empididae	P	1	Predator	sp, bu	7.5
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I/P	17	Collector	sp	6.1
Insecta	Diptera	Empididae	Hemerodromia	Hemerodromia	I	1	Predator	sp, bu	7.9
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	4	Collector	sp	8.6
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	52	Collector	bu	8.5
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	22	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	5	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	1	Shredder	cb, cn	6.3
Enopla	Hoplonemertea	Tetrastemmatidae	Prostoma	Prostoma	U	1	Predator	0	7.3
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	I	1	Filterer	cn	7.2
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	I/A	3	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I/P	5	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Project Name: Plumtree Run Monitoring
Project Number: 161602035.02
Prepared by: SKB Checked by: RAO
Prepared date: 8/29/2019 Checked date: 12/17/2019

2019Plum_BIBI_Piedmont.xlsx
Version: 1
Site Name: Plum 4

KCI TECHNOLOGIES

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Plecoptera	Nemouridae	Amphinemura	Amphinemura	I	5	Shredder	sp, cn	3
Insecta	Diptera	Chironomidae	Chaetocladius	Chaetocladius	I	4	Collector	sp	7
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	2	Filterer	cn	6.5
Insecta	Trichoptera	Philopotamidae	Chimarra	Chimarra	I	2	Filterer	cn	4.4
Insecta	Diptera	Chironomidae	Corynoneura	Corynoneura	I	5	Collector	sp	4.1
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	4	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	I	3	Shredder	0	7.7
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I	1	Collector	sp	8.5
Insecta	Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	I	1	Filterer	cn	2.7
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	25	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Krenosmittia	Krenosmittia	I	1	Collector	sp	na
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	4	Collector	sp	8.6
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	6	Collector	cb, sp	2.1
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	6	Collector	bu	8.5
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	42	Collector	sp, bu	9.2
Insecta	Coleoptera	Elmidae	Oulimnius	Oulimnius	I	1	Scraper	cn	2.7
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	4	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I/P	6	Shredder	cb, cn	6.3
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	1	Filterer	cn	5.7
Insecta	Diptera	Chironomidae	Sympotthastia	Sympotthastia	I	1	Collector	sp	8.2
Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella	I	17	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	2	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Project Name: Plumtree Run Monitoring
Project Number: 161602035.02
Prepared by: SKB Checked by: RAO
Prepared date: 8/29/2019 Checked date: 12/17/2019

2019Plum_BIBI_Piedmont.xlsx
Version: 1
Site Name: Plum 5

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Plecoptera	Nemouridae	Amphinemura	Amphinemura	I	1	Shredder	sp, cn	3
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis	I	22	Collector	sw, cb, cn	3.9
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	2	Filterer	cn	6.5
Insecta	Trichoptera	Philopotamidae	Chimarra	Chimarra	I	3	Filterer	cn	4.4
Insecta	Diptera	Chironomidae	Corynoneura	Corynoneura	I	1	Collector	sp	4.1
Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	U	1	Collector	sp	6.7
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	4	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	I	1	Shredder	0	7.7
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I	5	Collector	sp	8.5
Insecta	Trichoptera	Philopotamidae	Dolophilodes	Dolophilodes	I	4	Filterer	cn	1.7
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I/P	24	Collector	sp	6.1
Insecta	Trichoptera	Hydropsychidae	not identified	Hydropsychidae	P	1	Filterer	cn	5.7
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	4	Collector	sp	8.6
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	5	Collector	cb, sp	2.1
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	37	Collector	bu	8.5
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	12	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	8	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	5	Shredder	cb, cn	6.3
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	4	Filterer	cn	5.7
Turbellaria	not identified	not identified	not identified	Turbellaria	I	1	Predator	sp	4
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I/P	7	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Project Name: Plumtree Run Monitoring
Project Number: 161602035.02
Prepared by: SKB Checked by: RAO
Prepared date: 8/29/2019 Checked date: 12/17/2019

2019Plum_BIBI_Piedmont.xlsx
Version: 1
Site Name: Plum 2 QC

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis	I	2	Collector	sw, cb, cn	3.9
Insecta	Diptera	Chironomidae	Chaetocladius	Chaetocladius	I	1	Collector	sp	7
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	4	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I/P	3	Collector	sp	8.5
Insecta	Diptera	Empididae	not identified	Empididae	P	1	Predator	sp, bu	7.5
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	6	Collector	sp	6.1
Insecta	Diptera	Empididae	Hemerodromia	Hemerodromia	I	1	Predator	sp, bu	7.9
Insecta	Trichoptera	Hydropsychidae	not identified	Hydropsychidae	P	1	Filterer	cn	5.7
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	7	Collector	cb, sp	2.1
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	21	Collector	bu	8.5
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	87	Collector	sp, bu	9.2
Insecta	Coleoptera	Elmidae	Oulimnius	Oulimnius	I	1	Scraper	cn	2.7
Enopla	Hoplonemertea	Tetrastemmatidae	Prostoma	Prostoma	U	1	Predator	0	7.3
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	2	Filterer	cn	5.7
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	I	1	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	not identified	Tanypodinae	P	1	Predator	0	7.5
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	1	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Appendix C: Fish Data

Project Name: Plumtree Run Monitoring 2019 - 2021
Project Number: 161602035.02
Prepared by: JSM
Prepared date: 8/19/2019

Checked by: SKB
Checked date: 8/23/2019

FIBI_Plumtree_2019.xlsx

KCI TECHNOLOGIES

Metric	Plum-1	Plum-2	Plum-3	Plum-4	Plum-5
Raw Scores	**Raw Scores**				
Abundance per square meter	1.29	3.21	2.91	2.43	1.52
Adjusted Number of Benthic species	0.62	0.65	0.84	0.00	3.70
% Tolerant	54.15%	72.30%	80.51%	100.00%	84.73%
% Generalist, Omnivores, Invertivores	67.47%	88.85%	91.18%	100.00%	93.10%
Biomass per square meter	4.73	17.96	4.81	7.83	3.49
% Lithophilic Spawners	54.15%	36.19%	39.68%	65.56%	48.28%
FIBI Scores	**FIBI Scores**				
Abundance per square meter	5	5	5	5	5
Adjusted Number of Benthic species	5	5	5	1	5
% Tolerant	3	1	1	1	1
% Generalist, Omnivores, Invertivores	5	3	3	1	3
Biomass per square meter	3	5	3	3	1
% Lithophilic Spawners	3	3	3	5	3
FIBI Score	***4.00***	***3.67***	***3.33***	***2.67***	***3.00***
Narrative Rating	***Good***	***Fair***	***Fair***	***Poor***	***Fair***

Eastern Piedmont	**Score**		
Metric	**5**	**3**	**1**
Abundance per square meter	≥ 1.25	0.25 – 1.24	< 0.25
Adjusted Number of Benthic species	≥ 0.26	0.09 – 0.25	< 0.09
% Tolerant	≤ 45	46 – 68	> 68
% Generalist, Omnivores, Invertivores	≤ 80	81 - 99	100
Biomass per square meter	≥ 8.6	4.0 – 8.5	< 4.0
% Lithophilic Spawners	≥ 61	32 - 60	< 32

Project Name: Plumtree Run Monitoring Plan and Biological Monitoring
Project Number: 161602035.02
Prepared by: JSM Checked by: SKB
Prepared date: 7/11/2019 Checked date: 8/23/2019

FIBI_Plumtree_2019.xlsx

Site Name: Plum 1

Final ID	Scientific Name	Number of Organisms	Type	Tolerance	Trophic Status	Lithophilic Spawner	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	Lithophilic Spawner	Adjusted No. Benthic Species	Abundance per Square Meter	Biomass per Square Meter
Blue Ridge Sculpin	*Cottus caeruleomentum*	188	SCULPIN	I	IS	Y	B	0	0	188	1	0.42	
Creek Chub	*Semotilus atromaculatus*	106	OTHRCYPR	T	GE	Y	NOTYPE	106	106	106	0	0.24	
Blacknose Dace	*Rhinichthys atratulus*	198	OTHRCYPR	T	OM	N	NOTYPE	198	198	0	0	0.44	
Rosyside Dace	*Clinostomus funduloides*	12	OTHRCYPR	NOTYPE	IV	Y	NOTYPE	0	12	12	0	0.03	
White Sucker	*Catostomus commersonii*	7	SUCKER	T	OM	Y	NOTYPE	7	7	7	0	0.02	
Redbreast Sunfish	*Lepomis auritus*	4	SUNFISH	NOTYPE	GE	N	NOTYPE	0	4	0	0	0.01	
Bluntnose Minnow	*Pimephales notatus*	2	OTHRCYPR	T	OM		NOTYPE	2	2	0	0	0.00	
Longnose Dace	*Rhinichthys cataractae*	61	OTHRCYPR	NOTYPE	OM	N	NOTYPE	0	61	0	0	0.14	
	Total Count	*578*						*54.15%*	*67.47%*	*54.15%*	*0.62*	1.29	*4.73*
	Total Biomass (g)	*2119*											

Project Name: Plumtree Run Monitoring Plan and Biological Monitoring
Project Number: 161602035.02
Prepared by: JSM Checked by: SKB
Prepared date: 7/11/2019 Checked date: 8/23/2019

FIBI_Plumtree_2019.xlsx

Site Name: Plum 2

Final ID	Scientific Name	Number of Organisms	Type	Tolerance	Trophic Status	Lithophilic Spawner	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	Lithophilic Spawner	Adjusted No. Benthic Species	Abundance per Square Meter	Biomass per Square Meter
Blacknose Dace	*Rhinichthys atratulus*	411	OTHRCYPR	T	OM	N	NOTYPE	411	411	0	0	0.97	
Creek Chub	*Semotilus atromaculatus*	159	OTHRCYPR	T	GE	Y	NOTYPE	159	159	159	0	0.38	
Rosyside Dace	*Clinostomus funduloides*	38	OTHRCYPR	NOTYPE	IV	Y	NOTYPE	0	38	38	0	0.09	
Bluntnose Minnow	*Pimephales notatus*	295	OTHRCYPR	T	OM		NOTYPE	295	295	0	0	0.70	
Common shiner	*Luxilus cornutus*	30	SHINER	I	OM	Y	NOTYPE	0	30	30	0	0.07	
White Sucker	*Catostomus commersonii*	112	SUCKER	T	OM	Y	NOTYPE	112	112	112	0	0.27	
Blue Ridge Sculpin	*Cottus caeruleomentum*	151	SCULPIN	I	IS	Y	B	0	0	151	1	0.36	
Redbreast Sunfish	*Lepomis auritus*	60	SUNFISH	NOTYPE	GE	N	NOTYPE	0	60	0	0	0.14	
Fathead Minnow	*Pimephales promelas*	20	OTHRCYPR	NOTYPE	OM	N	NOTYPE	0	20	0	0	0.05	
Longnose Dace	*Rhinichthys cataractae*	76	OTHRCYPR	NOTYPE	OM	N	NOTYPE	0	76	0	0	0.18	
Brown Bullhead	*Ameiurus nebulosus*	2	NOTYPE	T	OM	N	NOTYPE	2	2	0	0	0.00	
	Total Count	*1354*						*72.30%*	*88.85%*	*36.19%*	*0.65*	3.21	*17.96*
	Total Biomass (g)	*7577*											

Project Name: Plumtree Run Monitoring Plan and Biological Monitoring
Project Number: 161602035.02
Prepared by: JSM Checked by: SKB
Prepared date: 8/19/2019 Checked date: 8/23/2019

FIBI_Plumtree_2019.xlsx

Site Name: Plum 3

Final ID	Scientific Name	Number of Organisms	Type	Tolerance	Trophic Status	Lithophilic Spawner	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	Lithophilic Spawner	Adjusted No. Benthic Species	Abundance per Square Meter	Biomass per Square Meter
Creek Chub	*Semotilus atromaculatus*	251	OTHRCYPR	T	GE	Y	NOTYPE	251	251	251	0	0.85	
Blacknose Dace	*Rhinichthys atratulus*	381	OTHRCYPR	T	OM	N	NOTYPE	381	381	0	0	1.29	
Bluntnose Minnow	*Pimephales notatus*	60	OTHRCYPR	T	OM		NOTYPE	60	60	0	0	0.20	
Longnose Dace	*Rhinichthys cataractae*	79	OTHRCYPR	NOTYPE	OM	N	NOTYPE	0	79	0	0	0.27	
Blue Ridge Sculpin	*Cottus caeruleomentum*	76	SCULPIN	I	IS	Y	B	0	0	76	1	0.26	
Rosyside Dace	*Clinostomus funduloides*	13	OTHRCYPR	NOTYPE	IV	Y	NOTYPE	0	13	13	0	0.04	
White Sucker	*Catostomus commersonii*	2	SUCKER	T	OM	Y	NOTYPE	2	2	2	0	0.01	
	Total Count	*862*						*80.51%*	*91.18%*	*39.68%*	*0.84*	2.91	*4.81*
	Total Biomass (g)	*1426*											

Project Name: Plumtree Run Monitoring Plan and Biological Monitoring
Project Number: 161602035.02
Prepared by: JSM Checked by: SKB
Prepared date: 6/27/2019 Checked date: 8/23/2019

FIBI_Plumtree_2019.xlsx

Site Name: Plum 4

Final ID	Scientific Name	Number of Organisms	Type	Tolerance	Trophic Status	Lithophilic Spawner	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	Lithophilic Spawner	Adjusted No. Benthic Species	Abundance per Square Meter	Biomass per Square Meter
Creek Chub	*Semotilus atromaculatus*	236	OTHRCYPR	T	GE	Y	NOTYPE	236	236	236	0	1.59	
Blacknose Dace	*Rhinichthys atratulus*	124	OTHRCYPR	T	OM	N	NOTYPE	124	124	0	0	0.84	
	Total Count	*360*						*100.00%*	*100.00%*	*65.56%*	*0.00*	2.43	*7.83*
	Total Biomass (g)	*1160*											

Project Name: Plumtree Run Monitoring Plan and Biological Monitoring
Project Number: 161602035.02
Prepared by: JSM Checked by: SKB
Prepared date: 6/27/2019 Checked date: 8/23/2019

FIBI_Plumtree_2019.xlsx

Site Name: Plum 5

Final ID	Scientific Name	Number of Organisms	Type	Tolerance	Trophic Status	Lithophilic Spawner	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	Lithophilic Spawner	Adjusted No. Benthic Species	Abundance per Square Meter	Biomass per Square Meter
Creek Chub	*Semotilus atromaculatus*	79	OTHRCYPR	T	GE	Y	NOTYPE	79	79	79	0	0.59	
Blacknose Dace	*Rhinichthys atratulus*	93	OTHRCYPR	T	OM	N	NOTYPE	93	93	0	0	0.70	
Longnose Dace	*Rhinichthys cataractae*	12	OTHRCYPR	NOTYPE	OM	N	NOTYPE	0	12	0	0	0.09	
Rosyside Dace	*Clinostomus funduloides*	5	OTHRCYPR	NOTYPE	IV	Y	NOTYPE	0	5	5	0	0.04	
Blue Ridge Sculpin	*Cottus caeruleomentum*	14	SCULPIN	I	IS	Y	B	0	0	14	1	0.11	
	Total Count	*203*						*84.73%*	*93.10%*	*48.28%*	*3.70*	1.52	*3.49*
	Total Biomass (g)	*464*											

Appendix D: Supplemental Flora/Fauana Data

Plum-1

Invasive Plants	Relative Abundance
multiflora rose	Present
Japanese stiltgrass	Present
autumn olive	Present
Japanese barberry	Present
oriental bittersweet	Present
Japanese honeysuckle	Present
garlic mustard	Present
English ivy	Present

Stream Salamanders
Northern two-lined salamander

Other Herpetofauna
Northern green frog
American bullfrog

Crayfish
Faxonius virilis

Plum-2

Invasive Plants	Relative Abundance
common ragweed	Present
oriental bittersweet	Present
wineberry	Present
multiflora rose	Present
mile-a-minute	Present
mimosa tree	Present
Japanese stiltgrass	Present
English ivy	Present

Stream Salamanders
Northern two-lined salamander

Other Herpetofauna
Northern watersnake
Northern green frog

Crayfish
Faxonius virilis

Plum-3

Invasive Plants	Relative Abundance
multiflora rose	Extensive
mile-a-minute	Present
oriental bittersweet	Extensive
Japanese honeysuckle	Present
Japanese stiltgrass	Extensive
wineberry	Present

Stream Salamanders
None observed

Other Herpetofauna
Northern green frog

Crayfish
Faxonius virilis

Plum-4

Invasive Plants	Relative Abundance
Multiflora rose	Present
Japanese stiltgrass	Present
wineberry	Present

Stream Salamanders
Northern two-lined salamander
Northern dusky salamander

Other Herpetofauna
Northern green frog

Crayfish
Faxonius virilis

Plum-5

Invasive Plants	Relative Abundance
multiflora rose	Present
Japanese stiltgrass	Present
common ragweed	Present
mile-a-minute	Present
oriental bittersweet	Present
wineberry	Present
Japanese honeysuckle	Present
garlic mustard	Present

Stream Salamanders
Northern two-lined salamander
Northern dusky salamander

Other Herpetofauna
Northern green frog

Crayfish
Faxonius virilis