HARFORD COUNTY DPW

UPPER FARNANDIS

SMALL WATERSHED ASSESSMENT REPORT

APRIL 02, 2018




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HARFORD COUNTY DEPARTMENT OF PUBLIC WORKS

(DRAFT)

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TABLES

FIGURES

1 EXECUTIVE SUMMARY

A watershed study was conducted in the Upper Farnandis Branch watershed in Harford County and the Town of Bel Air, Maryland, in response to Harford County's National Pollutant Discharge Elimination System (NPDES) MS4 permit requirements. The Upper Farnandis watershed is a subshed of the larger 8-digit Bynum Run watershed. Flow from the Upper Farnandis watershed eventually ends up in the Chesapeake Bay. The goals of this study were to assess the current physical conditions of the Upper Farnandis watershed, including the current land use, soils, and impervious area; conduct a field survey of the streams, outfalls, and Best Management Practices (BMPs) within the watershed; and prioritize potential restoration projects to meet pollutant reduction requirements within the County. The watershed study resulted in the identification of 10 potential restoration projects.

The Upper Farnandis watershed is an urban watershed that covers portions of the Town of Bel Air and Harford County and encompasses approximately 486 acres. The Upper Farnandis watershed is contained within the Bush River sub-basin draining to the Chesapeake Bay and is located on the western side of the Bynum Run watershed. The Upper Farnandis watershed has been divided into six subwatersheds to facilitate assessment and classification.

Land use, soils, and impervious area are three existing conditions that were assessed at the onset of this project. The majority of the soil within the watershed (nearly 85%) falls into hydrologic soil group B which has a moderate infiltration rate and therefore, relatively low runoff potential. Although there are no soils within the watershed that fall into soil group C, many urban disturbed B soils act more like C soils due to compaction/development. Type C soils have lower infiltration rates and a higher runoff potential.

The predominant land use types present within the Upper Farnandis watershed are low-, medium-, and high-density residential. These three land use classifications equate to nearly 91% of the total watershed area. The remaining 9% is divided between commercial, forest, open urban land, very low density residential, and institutional, each covering less than 3% of the total watershed. Due to the high percentage of residential land use within the watershed, the impervious area was a significant portion of the watershed. The total impervious area calculated is 102 acres or 21% of the watershed. Streams within watersheds with 10% or more impervious area are considered impacted and have a higher potential for negative impacts to the stream due to impervious area. The subwatershed with the highest percentage of impervious cover is E Macphail, with 26% impervious area.

A NPDES MS4 permit has been issued to Harford County that mandates restoration of pollutant laden streams from stormwater sources. The permit requires Harford County to treat 20% of their impervious area by the end of the permitting period (December 29, 2019). Impervious area is treated through stream restoration, outfall stabilization, and Best Management Practice (BMP) Stormwater Management Facilities.

This watershed study assessed 3.4 miles of stream, 41 outfalls, 10 existing BMPs, and 14 potential BMPs. Of the assessed features, five stream and outfall restoration projects, three retrofit BMP projects, and two proposed BMP projects are being recommended within the Upper Farnandis watershed. The projects have been prioritized based on several prioritization parameters, including, impervious area treated (acres), cost per impervious area treated, and number of threats to infrastructure. Based on these metrics, as well as other parameters specific to each project, five projects were selected as priority projects for the Upper Farnandis watershed. Table 1-1 provides the project list, with a description and the ranking of each project. If implemented, these projects would provide 57.6 acres of impervious area treatment, 421.4 lbs of nitrogen reductions, 364.6 lbs of phosphorus reductions, and 240,589.5 lbs of sediment reductions.

Table 1-1: Final list of Recommended Restoration Projects in the Upper Farnandis Watershed

RANKING	PROJECT NAME	PROJECT DESCRIPTION
1	Victory Stream and Outfall Restoration	2,200 feet of stream restoration and 2 outfall stabilization
2	Ring Factory Stream Restoration	2,180 feet of stream restoration
2	Fairmont Stream and Outfall Restoration	914 feet of stream restoration, including 20 feet impervious removal and 2 outfall stabilization*
3	RET_BMP_03	Wet Pond Retrofit
4	PR_BMP_01	Three Rain Gardens

*Fairmont Stream and Outfall Restoration project can be completed in conjunction with Ring Factory Stream Restoration for better water quality benefits and cost effectiveness.

2 WATERSHED CHARACTERISTICS

The Upper Farnandis watershed is an urban watershed that covers portions of the Town of Bel Air and Harford County and encompasses approximately 486 acres. The Upper Farnandis watershed is contained within the Bush River sub-basin draining to the Chesapeake Bay and is located on the western side of the Bynum Run watershed. The information presented in this section summarizes basic watershed elements including water quality, natural resources, and restoration.

2.1 WATERSHED DELINEATION

A watershed-based approach was used to evaluate water quality conditions and improvement potential. The first step in this process is determination of the watershed drainage area. Drainage areas vary greatly in size depending on the scale of the stream system of interest. Drainage areas for large river, estuary, and lake systems are typically on the order of several thousand square miles and are often referred to as basins. The Chesapeake Bay basin covers over 64,000 square miles, which includes over 100,000 tributaries and spans across portions of six different states (CBP, 2017).

Basins consist of smaller sub-basins, which refer to drainage areas on the order of several hundred square miles and may consist of one or more major stream networks. Maryland has 13 sub-basins including the Upper Western Shore sub-basin, which encompasses the study area for this report. Sub-basins are further subdivided into watersheds and then subwatersheds, which are the most commonly used and practical hydrologic units for management and restoration purposes. There are 138 state-defined watersheds (called 8-digit watersheds) in Maryland, ranging in size from 20 to 100 square miles, and these are comprised of over 1,100 subwatersheds (called 12-digit watersheds) identified by the Maryland Department of Natural Resources (DNR). A subwatershed refers to the drainage area of a specific stream and typically covers 10 square miles or less (DNR, 2005).

The Upper Farnandis watershed is contained within the 8-digit Bynum Run watershed (02-13-07-04) which is in Harford County, Figure 1. The Upper Farnandis watershed 12-digit watershed number is 02-13-07-04-1131. The Upper Farnandis watershed was subdivided into smaller drainage areas or subwatersheds, which are listed in Table 2-1 with respective drainage areas in acreage and square miles. In addition to characterizing the entire watershed, analyses were conducted on a subwatershed scale to provide detailed information for smaller areas. Success of restoration efforts can be more easily monitored on this smaller scale. Figure 2-2 shows the 6 subwatersheds in the Upper Farnandis watershed.

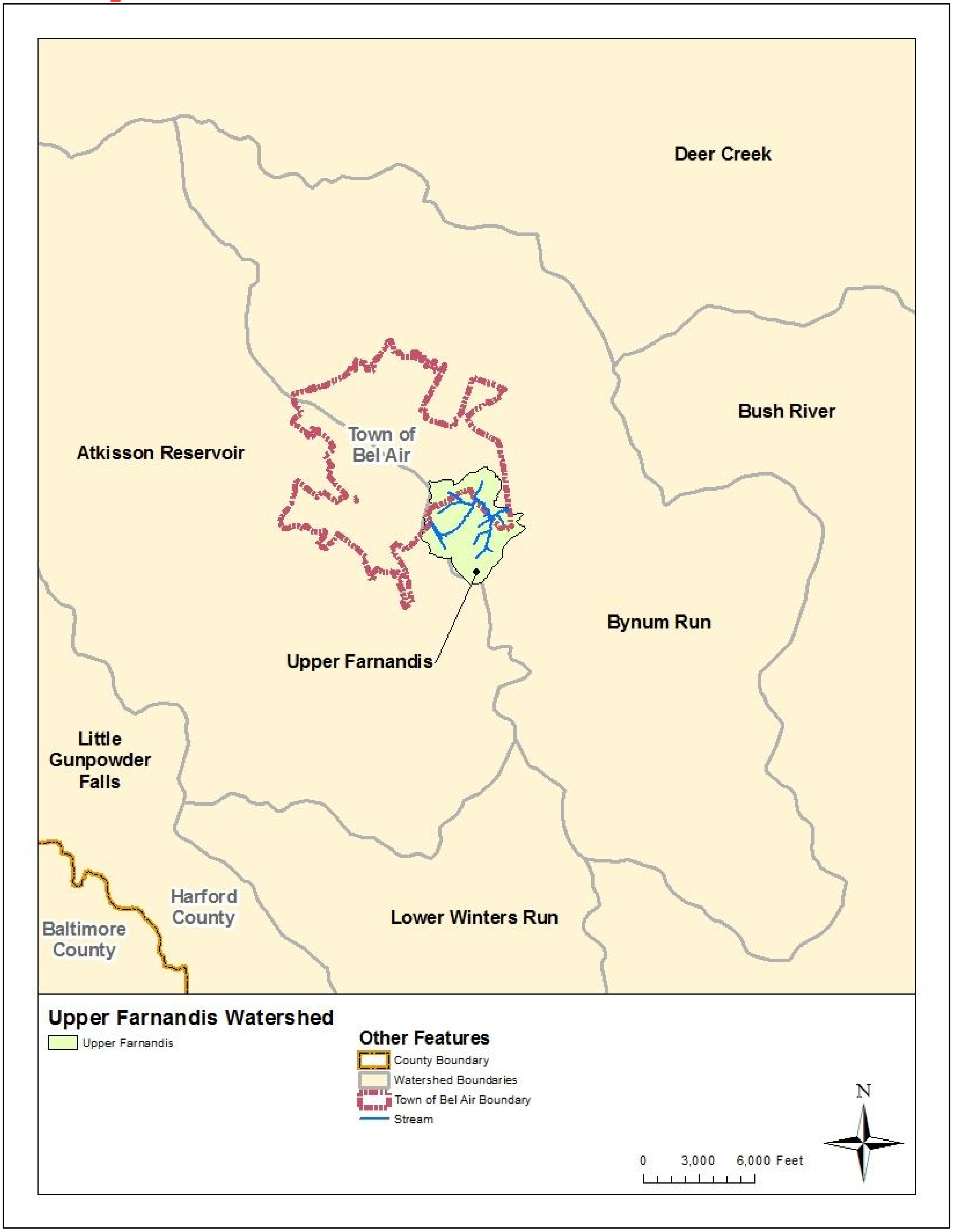

Figure 2-1: Location of Upper Farnandis Watershed

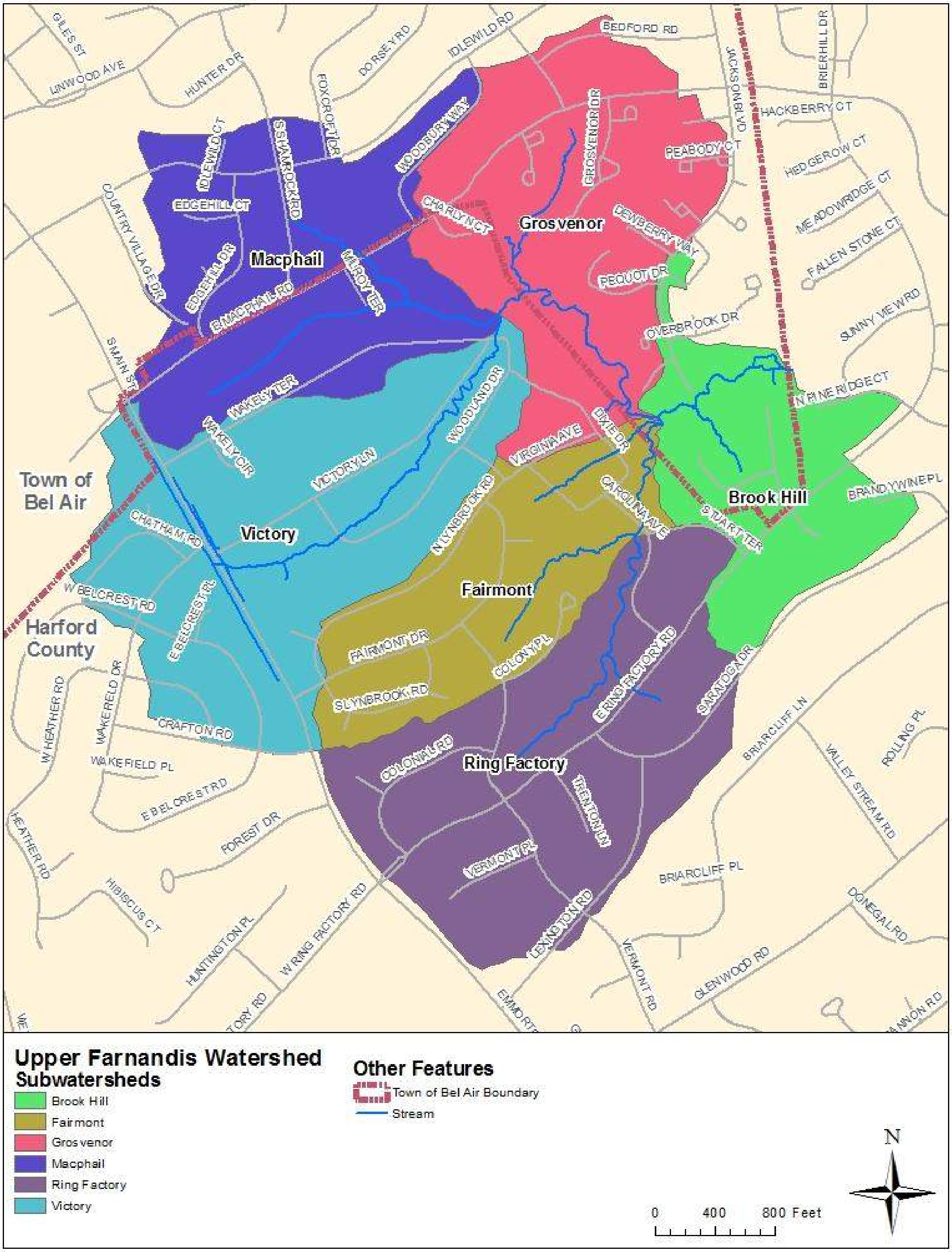

Figure 2-2: Upper Farnandis Subwatersheds

Table 2-1: Upper Farnandis Subwatershed Areas

SUBWATERSHED	AREA (ACRES)	AREA (SQ MILES)
Brook Hill	53	0.08
Fairmont	58	0.09
Grosvenor	86	0.13
Macphail	84	0.13
Ring Factory	106	0.17
Victory	100	0.16
Total	*486*	*0.76*

2.2 HYDROLOGIC SOIL GROUPS

Soil characteristics are an important consideration when evaluating water quantity and quality in streams and rivers. Soil type and moisture content impact how land may be used and its potential for vegetation and habitat. Soil conditions are also evaluated for projects aimed at improving water quality and habitat. Soils data including hydrologic soil groups (HSG) and soil erodibility for the Upper Farnandis watershed was obtained from spatial data provided by the NRCS SSURGO database (USDA, 2017).

The NRCS classifies soils into four HSGs based on their runoff potential and infiltration rates. Soils with high runoff potential have low infiltration capacity and tend to cause overland flow instead of allowing stormwater to infiltrate. Infiltration rates are highly variable among soil types and are influenced by disturbances to the soil profile such as land development activities. For example, urbanization on land composed of high infiltration soils (such as sands and gravels) will greatly increase runoff from the pre-development runoff rate. Whereas development on land composed of low infiltration soils (such as silts and clays) will have less of an impact on runoff.

The four HSGs range from A to D, lowest runoff potential to highest, respectively. Brief descriptions of each hydrologic soil group are provided below. Further explanation can be found in chapter 7 of the USDA/NRCS publication, *National Engineering Handbook- Hydrology Chapters* (USDA & NRCS, 2009).

- Group A soils include sand, loamy sand, or sandy loam types. These soils have low runoff potential when thoroughly wet and a high infiltration rate. This type of soil generally consists of sands and gravels, typically have less than 10 percent clay, and have gravel or sand textures. These soils have a high rate of water transmission.
- Group B soils include well aggregated loam, silt loam, or sandy clay loam. These soils have a moderately low runoff potential when thoroughly wet. These soils generally contain between 10 to 20 percent clay and 50 to 90 percent sand with a loamy sand or sandy loam texture. Water transmission through these soils is moderate.
- Group B/D soils are wet Group B soils, including well aggregated loam, silt loam, or sandy clay loam. These wet soils are placed in a dual category due to the presence of a water table within 24 inches of the surface. The first letter refers to the drained condition while the second letter describes the undrained condition. Only wet soils that can be adequately drained are placed into dual categories.
- Group C soils include silt loam, sandy clay loam, clay loam, and silty clay loam textures. These soils have a moderately high runoff potential when thoroughly wet. This soil typically contains

between 20 to 40 percent clay and less than 50 percent sand. Water transmission through these soils is low and somewhat restricted.

- Group C/D soils are wet Group C soils, including silt loam, sandy loam, clay loam, and silty clay loam. These wet soils are placed in a dual category due to the presence of a water table within 24 inches of the surface. The first letter refers to the drained condition while the second letter describes the undrained condition. Only wet soils that can be adequately drained are placed into dual categories.
- Group D soils include clayey textures. These soils have high runoff potential when thoroughly wet. These soils generally contain greater than 40 percent clay and less than 50 percent sand. These consist mainly of clays with high swell potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. Water transmission through this soil is very restricting with very low infiltration rates.

As shown in Table 2-2 and Figure 2-3, the Upper Farnandis subwatersheds possess similar HSG characteristics. Nearly 85% of the Upper Farnandis watershed falls into hydrologic soil group B which has a moderate infiltration rate and therefore, relatively low runoff potential. Most of the remaining soil types fall under the dual hydrologic soil groups B/D and C/D, based on their saturated hydraulic conductivity and the water table depth when drained as discussed above. 13% of the watershed falls into soil group C/D, while roughly 2% of the watershed falls into soil group B/D, mostly in the Grosvenor and Brook Hill areas. A small portion of the Brook Hill area falls into the D soil group (low infiltration, high runoff potential), representing less than 1% of the total watershed area.

As seen in Figure 2-3, areas classified as soil group B cover the vast extent of the watershed. The other soil groups found in the watershed are almost exclusively located adjacent to major streams where higher water table depths would be expected. Although there are no soils within the watershed that fall into soil group A or soil group C, many urban disturbed B soils can act more like C soils due to compaction/development.

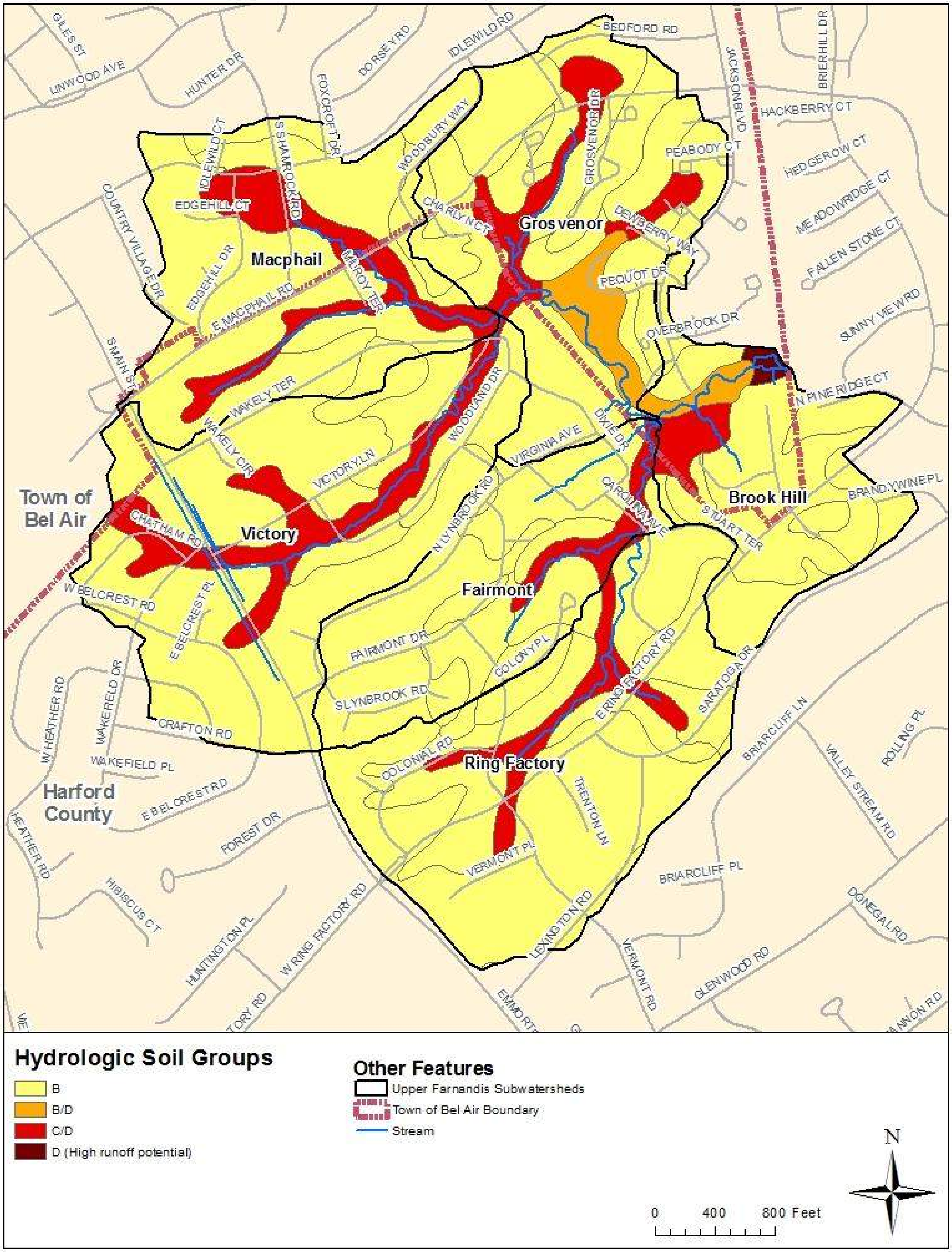

Figure 2-3: Upper Farnandis Hydrologic Soil Groups

Table 2-2: Upper Farnandis Hydrologic Soil Groups

	HYDROLOGIC SOIL GROUP (%)			
Subwatershed	B	B/D	C/D	D
Brook Hill	84.3%	5.4%	7.9%	2.4%
Fairmont	90.5%	0.0%	9.5	0.0%
Grosvenor	78.2%	8.5	13.3	0.0%
Macphail	81.9%	0.0%	18.1	0.0%
Ring Factory	90.9%	0.0	9.1	0.0
Victory	83.2%	0.0%	16.8%	0.0%
Total % of Watershed Area	84.7%	2.1%	13.0%	0.3%

2.3 LAND USE AND LAND COVER

Land use represents the types of human activities taking place within a watershed and has pronounced impacts on water quality and habitat. The extent of these impacts, including types and amounts of pollutants generated, will vary depending on the land uses that are present in the watershed. For example, a forested watershed can intercept pollutants such as sediment and nutrients and to reduce the flow rate of runoff into streams. Developed areas have impervious surfaces that block the natural infiltration of precipitation into the ground. These impervious surfaces include roads, parking lots, and roofs. Unlike most natural surfaces, impervious surfaces tend to concentrate stormwater runoff, accelerate flow rates, and direct stormwater to the nearest stream. This behavior can cause bank erosion and destruction of in-stream and riparian habitat of the receiving water body. Impervious areas also prevent infiltration which would otherwise filter pollutants and recharge groundwater aquifers that help to maintain baseflow in a stream channel. For these reasons, undeveloped watersheds and those with smaller amounts of impervious surfaces tend to have higher water quality in local streams than developed watersheds with greater impervious coverage.

Maryland Department of Planning (MDP) develops statewide land use/land cover (LU/LC) spatial data to provide a general overview of predominant land cover and usage and to monitor development activities throughout the state. The LU/LC delineations are based on high altitude aerial photography and satellite imagery. In this report, land use analyses were performed using 2010 MDP land use spatial data. This data was originally based on the 2007 National Agriculture Imagery Program (NAIP) aerial imagery and parcel information from Maryland Property View 2008. Table 2-3 summarizes land use categories in the Upper Farnandis watershed and their percent composition in each subwatershed. Figure 2-4 illustrates the LU/LC distribution in the watershed.

The predominant land use types present within the Upper Farnandis watershed are low-, medium-, and high-density residential. These three land use classifications equate to nearly 91% of the total watershed area. The remaining 9% is divided between commercial, forest, open urban land, very low density residential, and institutional, each covering less than 3% of the total watershed. Although a small percentage, these areas cover approximately 45 acres of the watershed.

The distribution of the predominant land use type is consistent between the subwatersheds within Upper Farnandis watershed as either low-, medium-, or high-density residential. Residential areas present an opportunity for community involvement in restoration efforts, neighborhood pollutant source control, and environmental stewardship. Grosvenor and Brook Hill contain the highest percentages of forest coverage at 9.1% and 13.2%, respectively.

Table 2-3: Upper Farnandis Land Use/Land Cover Classification (%)

SUBWATERSHED	MEDIUM DENSITY RESIDENTIAL	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	COMMERCIAL	FOREST	OPEN URBAN LAND	VERY LOW DENSITY RESIDENTIAL	INSTITUTIONAL
Brook Hill	46.5%	40.3%	0.0%	0.0%	13.2%	0.0%	0.0%	0.0%
Fairmont	62.6%	37.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Grosvenor	37.3%	27.1%	26.1%	0.4%	9.1%	0.0%	0.0%	0.0%
Macphail	58.8%	22.4%	7.2%	11.0%	0.0%	0.0%	0.0%	0.7%
Ring Factory	63.8%	29.4%	0.0%	0.0%	0.0%	6.8%	0.0%	0.0%
Victory	49.4%	37.5%	0.0%	4.6%	0.0%	0.0%	6.3%	2.2%
Total % of Watershed Area	53.1%	31.7%	5.8%	3.0%	3.0%	1.4%	1.4%	0.6%

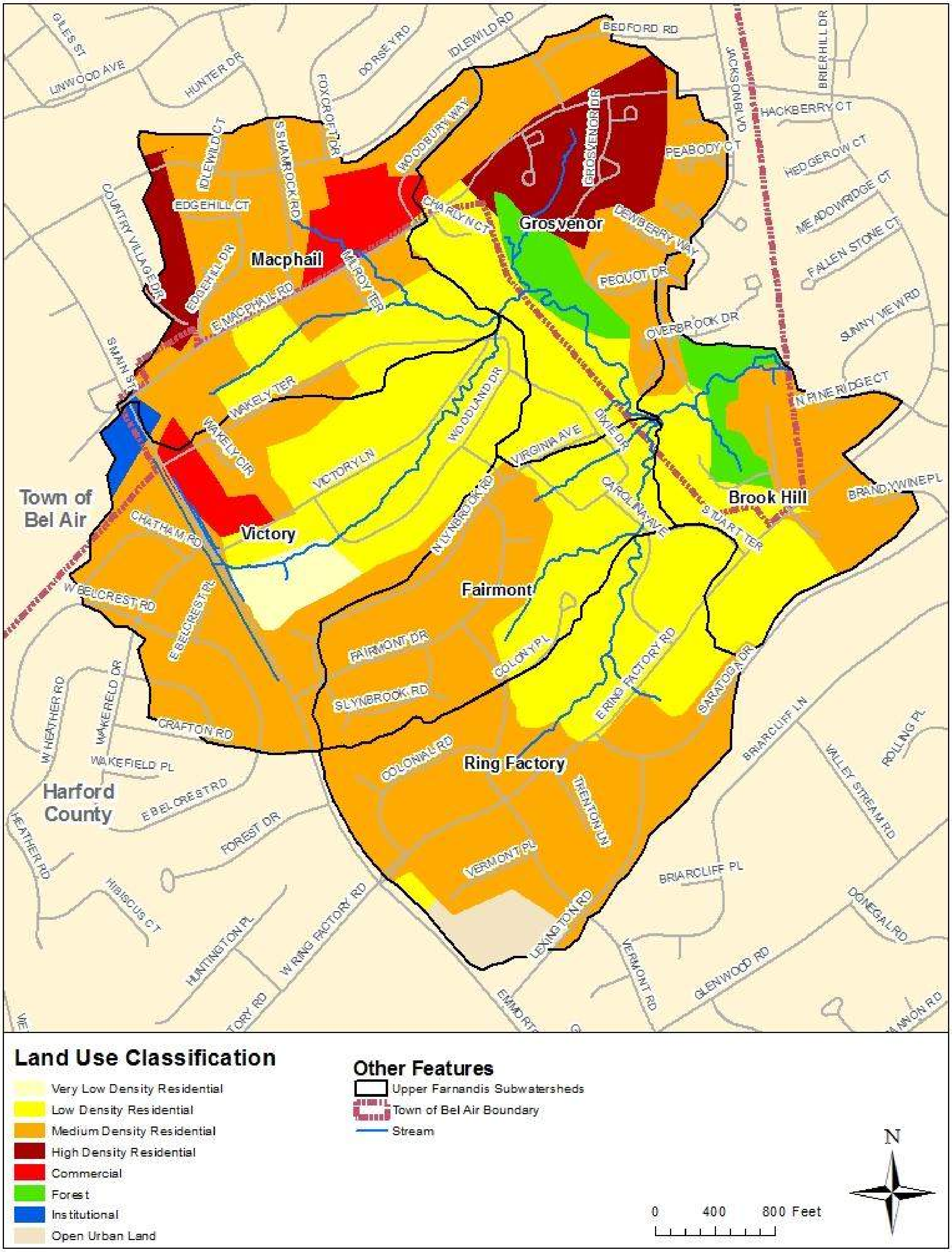

Figure 2-4: Upper Farnandis Land Use/Land Cover

2.4 IMPERVIOUS SURFACES

Impervious cover is a primary factor when determining pollutant characteristics and quantities in stormwater runoff. Research has been conducted to link the degree of urbanization (typically measured by amount of impervious cover) with various watershed-based indicators of water quality such as diversity and abundance of aquatic and terrestrial life. The Center for Watershed Protection (CWP) compiled stream research conducted in various parts of the country and developed a simple model that relates potential stream quality to percentage of impervious cover in a watershed. Studies used to develop the impervious cover model measured stream quality based on a variety of indicators such as number of aquatic insect species, stream temperature, channel stability, aquatic habitat, wetland plant diversity, and fish communities present.

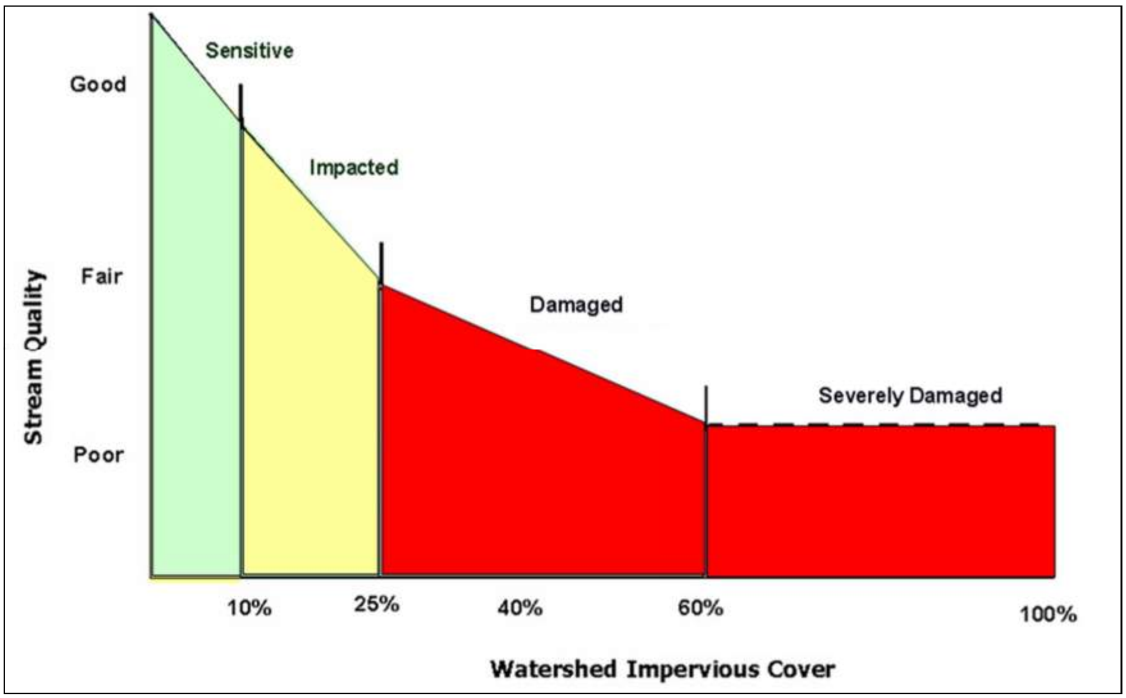

Figure 2-5: Impervious Cover Model (adapted from (CWP, 2003))

Based on the compiled research, CWP determined four classifications that predict stream quality based on watershed imperviousness: sensitive; impacted; damaged; or severely damaged. Watersheds with less than 10 percent impervious cover are referred to as sensitive and typically have high quality streams with stable channels, good habitat conditions, and good to high water quality. These watersheds are considered sensitive because they are susceptible to environmental degradation with increased urbanization and impervious cover. The model predicts that with between 10 and 25 percent impervious cover, watersheds become impacted and show clear signs of degradation such as erosion, channel widening, and a decline in stream habitat. There is potential to restore streams to a somewhat natural functioning system within this category. When a watershed has more than 25 percent impervious cover, streams are classified as damaged and characterized by fair to poor water quality, unstable channels, severe erosion, and inability to support aquatic life and provide habitat; many streams in this category are typically piped or channelized, or in some areas, may be piped beneath the impervious surfaces resulting in a lack of continuity between natural riparian areas along the stream corridor.

Figure 2-5 shows that when impervious cover exceeds 60 percent, a watershed is classified as severely damaged which means that most of the natural stream system has diminished. Management of damaged and severely damaged streams may focus on decreasing pollutant loads to downstream receiving waters (e.g., installing Best Management Practices (BMPs)) but the ability to restore natural functions, such as habitat, is unlikely. Restoration efforts may also focus on making the remaining stream systems stable, aesthetically pleasing, and an amenity to the community. It should be noted that the impervious cover model is a simplified approach for classifying the potential stream quality. Although it is based on research, there are inherent model assumptions and limitations that should be considered such as regional variations and scale effects. In addition, while impervious cover is a relevant and significant indicator for watershed health, it is only one of many different factors affecting stream health and contributing to the cumulative impacts of development on water quality. For example, agricultural land uses may also contribute sediment and nutrient loads to receiving waters. Furthermore, the ability of BMPs to offset adverse impacts from urbanized areas is not specifically accounted for in the model (CWP, 2003).

Impervious cover data for the Upper Farnandis watershed was obtained from 2014 impervious spatial data provided by Harford County. Impervious area quantities shown in Table 2-4 are the sum of road and building areas. Table 2-4 also shows the percentage of impervious cover within each subwatershed. It should be noted that parking lots and driveways are included in the roads column of Table 2-4, whereas sidewalks are not included. Figure 2-6 illustrates the location of impervious surfaces within the Upper Farnandis watershed. The total impervious area calculated is approximately 102 acres or 21% of the watershed. The subwatershed with the highest percentage of impervious cover is E Macphail, with 26% impervious. This causes the CWP rating for the Macphail subwatershed to be damaged.

Table 2-4: Upper Farnandis Impervious Area Estimates

SUBWATERSHED	TOTAL AREA (ACRES)	ROADS (ACRES)	BUILDINGS (ACRES)	IMPERVIOUS AREA (ACRES)	% IMPERVIOUS	CWP IMPERVIOUS RATING
Brook Hill	53	5	3	8	15	Impacted
Fairmont	58	8	5	13	22	Impacted
Grosvenor	86	10	7	17	20	Impacted
Macphail	84	14	8	22	26	Damaged
Ring Factory	106	12	7	19	18	Impacted
Victory	100	14	8	23	23	Impacted
Total	486	63	39	102	21	Impacted

Based on the CWP model (Figure 2-5), five of the subwatersheds within the Upper Farnandis watershed fall into the impacted impervious rating. The Macphail subwatershed falls into the damaged impervious rating. The overall CWP impervious rating for the entire Upper Farnandis watershed is impacted. "Impacted" subwatersheds mainly correspond to those with high amounts of residential development and "damaged" subwatersheds have more commercial development associated with more impervious cover density. In addition to impervious cover, other key watershed indicators must be examined to determine watershed health and restoration potential.

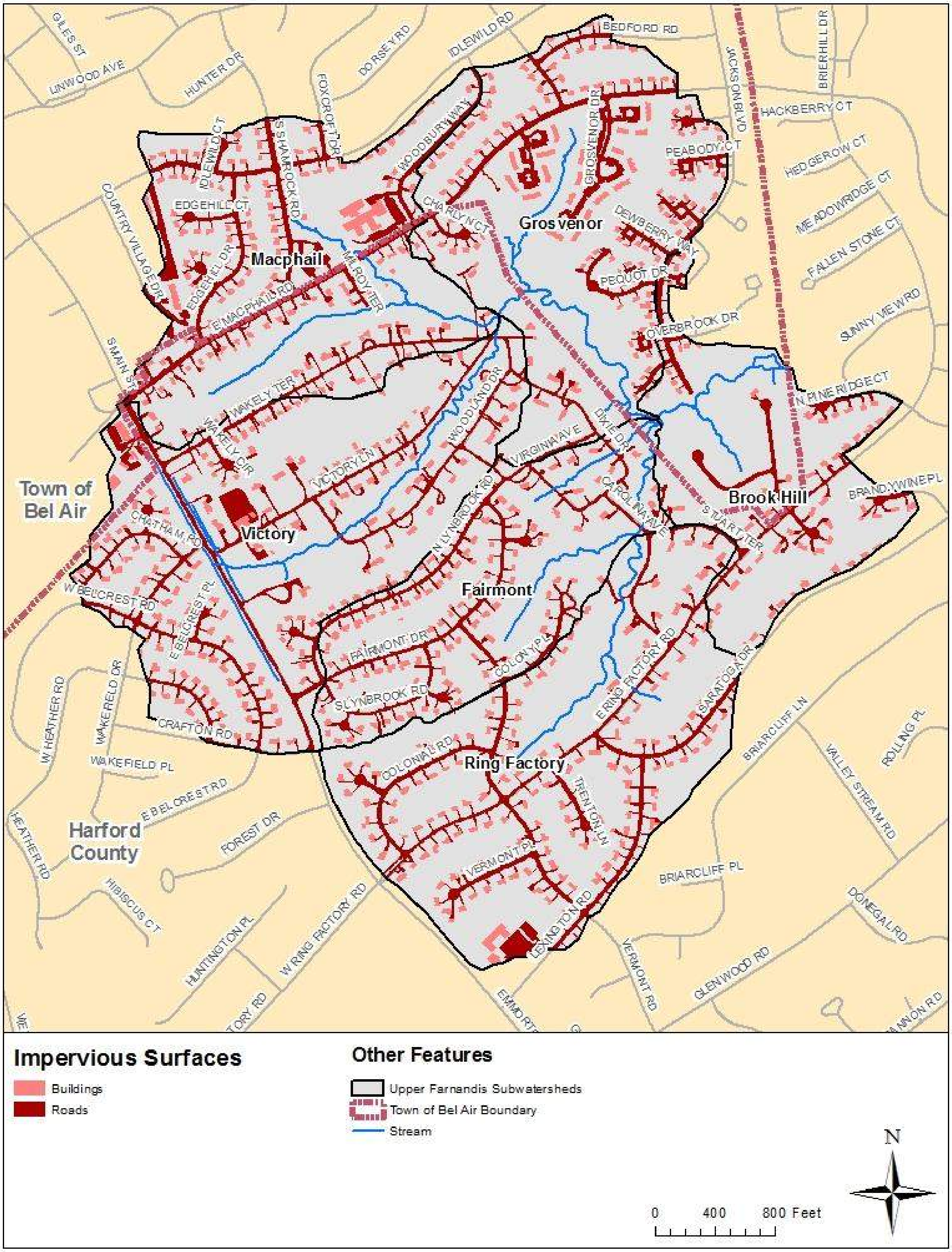

Figure 2-6: Upper Farnandis Impervious Surfaces

2.5 TMDL STATUS

The Clean Water Act (CWA) requires states, territories, and authorized tribes to: develop water quality standards for all jurisdictional surface waters; monitor these surface waters; and identify and list impaired waters. More specifically, Section 305(b) of the CWA requires annual water quality assessments to determine the status of jurisdictional waters. Section 303(d) requires states to identify and periodically update a list of impaired waters that fail to meet applicable state water quality standards. States must also establish priority rankings and develop Total Maximum Daily Loads (TMDLs) for waters on the 303(d) list, which generally target pollutants including sediment, metals, bacteria, nutrients, and pesticides. According to the United States Environmental Protection Agency (USEPA), a TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet state water quality standards.

Water quality standards are developed from a combination of the designated use for a given water body and the water quality criteria designed to protect that use. Table 2-5 provides the definition for each designated class.

Table 2-5: Maryland's Designated Uses for Surface Waters

CLASS	DEFINITION
Use I	Water Contact Recreation, and Protection of Nontidal Warm Water Aquatic Life
Use I-P	Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply
Use II	Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting
Use II-P	Tidal Fresh Water Estuary – includes applicable Use II and Public Water Supply
Use III	Nontidal Cold Water
Use III-P	Nontidal Cold Water and Public Water Supply
Use IV	Recreational Trout Waters
Use IV-P	Recreational Trout Waters and Public Water Supply

The surface waters (e.g. streams) within the Upper Farnandis watershed are designated as Use III – nontidal cold water (COMAR, 2014). Based on the water quality criteria associated with the above designated uses, the Upper Farnandis watershed is listed in Maryland's Integrated Report (IR) of Surface Water Quality for various pollutants of concern. Each listing is applicable to the Bynum Run watershed (basin 02130704) and sorted by attainment status or category upon which a water body is placed. Table 2-6 provides the definition for each attainment status or listing category within the report (MDE, 2014).

Table 2-6: Maryland Integrated Report Listing Categories (MDE, 2012a)

LISTING CATEGORY	DEFINITION
2	Waters meeting the standards for which they have been assessed
3	Waters that have insufficient data or information to determine whether any water quality standard is being attained
4a	Waters that are still impaired but have a TMDL developed that establishes pollutant loading limits designed to bring the waterbody back into compliance
4b	Waters that are impaired but for which a technological remedy should correct the impairment
4c	Waters that are impaired but not for a conventional pollutant. This includes pollution caused by habitat alteration or flow limitations
5	Water bodies that may require a TMDL

Maryland's IR is updated every two years. While Maryland's Final 2014 IR is the latest finalized report, Maryland's Draft 2016 IR is currently under review by the USEPA and is available for viewing now. Once the USEPA approves the IR, it will become the Final 2016 IR. The Bynum Run watershed (8-digit watershed) stream segments are listed in the Maryland's Final 2014 IR for the following water quality impairments: total suspended solids (TSS), channelization, and temperature (MDE, 2014). Impairment listings within categories 4a, 4b, 4c, or 5 reflect an inability to meet water quality standards. When a stream segment is listed as impaired, action can be taken by developing and/or adhering to a TMDL or by submitting a Water Quality Analysis (WQA) to remove a specific pollutant from the impairment listing. TMDLs can be developed for a single pollutant or group of pollutants of concern. WQAs are performed to determine if the pollutant of concern is the cause of the impairment. If it is determined that the pollutant of concern is not causing the impairment, a report documenting the findings is submitted to the USEPA for concurrence. Maryland's 2014 IR represents a fully combined 303(d) and 305(b) report approved by USEPA (MDE, 2014). Maryland's 2016 Draft IR is pending approval by USEPA (MDE, 2016).

Table 2-7 summarizes the status of the current listings for the Bynum Run watershed. Sampling for these impairments occurred within the Bynum Run watershed; however, sampling often occurred on tributaries in the northern portion of Bynum Run or at the outlet of Bynum Run. Since the Upper Farnandis watershed drains to the Bynum Run watershed, these impairments were applicable to the Upper Farnandis Watershed as well.

Table 2-7: Bynum Run Water Quality Impairment Listing and Status

		2014 FINAL INTEGRATED REPORT			2016 DRAFT INTEGRATED REPORT		
Impairment	Applicable Segment	Listing Category	Status	Approval Date	Listing Category	Status	Approval Date
Total Suspended Solids (TSS)	MD-02130704	4a	TMDL	2011	4a	TMDL	2011
Channelization	MD-02130704	4c	Impaired	N/A	4c	Impaired	N/A
Temperature	MD-021307041131-UTBynum_Run	5	Impaired	N/A	5	Impaired	N/A

As shown in Table 2-7, there are currently (2014 IR) three listings for the Bynum Run watershed. A WQA was approved in 2007 for nitrogen and phosphorus, indicating the concentrations of nitrogen and phosphorus fall below the water quality standard (MDE, 2007). The results of the WQA are reflected in the 2008 and subsequent IR's with the shift from category 5 to category 2 for mercury (MDE, 2008). Mercury in fish tissue was also placed in category 2 in the 2008 IR. A biological impairment was listed under category 5 in 2002 with an unknown source. A biological stressor identification (BSID) analysis was developed in 2011 to determine the cause of biological impairments. The BSID analysis determined the cause of degraded biological communities to be urban runoff through storm sewers (MDE, 2007). Because of the BSID study, the biological impairment was updated to a Total Suspended Solids (TSS) impairment in the 2012 IR (MDE, 2012). The Total Suspended Solids (TSS) listing was placed under category 4a, meaning a TMDL has been completed for this impairment. A listing for channelization was placed under category 4c, meaning that waters are impaired but not by a conventional pollutant. The watershed is an urbanized high density area. The biostressor analysis indicates that stream channelization due to urban development is a major stressor affecting the biological integrity in this watershed. This listing replaces the biological listing. The 2014 IR has one additional impairment listed under category 5 for temperature with an unknown source (MDE, 2014). In the listing, temperature was observed above criteria and no coldwater obligate taxa were found.

PCBs in fish tissue were listed in category 3, due to conflicting available monitoring data. PCBs in fish tissue were initially listed as an impairment in category 5 in the 2006 IR. High PCB concentrations were found in smallmouth bass between 1999-2003. New redbreast sunfish data meets the PCB fish tissue threshold; however, new eel samples exceed the threshold. Eels are not necessarily representative species since they are catadromous. As a result, additional monitoring data on other species is needed to determine if PCBs are an impairment within the watershed.

2.5.1 SEDIMENT TMDL

The TMDL for sediment applies to the entire 14,583-acre Bynum Run watershed which is entirely within Harford County and encompasses a portion of the Town of Bel Air. As such, the TMDL and reductions presented are for Bynum Run watershed as a whole. The sediment TMDL is 4,690.1 tons/yr. (14% reduction) (MDE, 2011). This TMDL includes nonpoint source loads from unregulated stormwater runoff within the Bynum Run watershed along with point source loads from industrial facilities that discharge process water, and National Pollutant Discharge Elimination System (NPDES) for regulated stormwater discharges. The Harford County urban load is responsible for reducing its sediment loading by 18% (MDE, 2011).

2.5.2 CHESAPEAKE BAY NUTRIENT AND SEDIMENT IMPAIRMENT

The Chesapeake Bay Program (CBP) has developed the Phase 5 Watershed Model, which, in conjunction with the Estuary Model, is used to determine the sources and reductions of nitrogen, phosphorus, and sediment needed to meet Chesapeake Bay tidal water quality standards. The Phase 5 model was used to develop a Chesapeake Bay-wide TMDL and to assign nutrient and sediment load reductions to individual states and ultimately local jurisdictions based on the segment loads. In Maryland, nutrient and sediment load reductions were assigned on a county basis for achievement by a 2025 timeframe. Table 2-8 lists the pollutant load reduction requirements for Harford County under the Chesapeake Bay TMDL.

Table 2-8: Harford County Stormwater Pollutant Load Reductions (County, 2012)

TMDL POLLUTANT	% POLLUTANT LOAD REDUCTION REQUIREMENTS FOR HARFORD COUNTY 2025
Nitrogen	37.9%
Phosphorus	24.0%

2.6 MS4 NPDES PERMIT

The Clean Water Act also requires jurisdictions to obtain a permit for any point source discharges to the waters of the U.S. Point source discharges are concentrated flows through pipes and ditches. The National Pollutant Discharge Elimination System (NPDES) was established to reduce and/or maintain pollutant loads through point sources to acceptable levels. For jurisdictions with urban land uses, NPDES municipal separate storm sewer systems (MS4) permits are required to treat a portion of polluted stormwater runoff before it enters the waters of the U.S.

Harford County currently has a NPDES MS4 permit (11-DP-3310, MD0068268). One requirement within the plan is the development of restoration plans for all watersheds within the County. The County's NPDES permit (effective December 2014) also requires the County to address 20% of the untreated impervious cover during each 5-year permit term (MDE, 2014). It is anticipated that future permits will have the same requirement. This report meets the systematic assessment and planning requirements of the NPDES permit and provides proposed projects to help Harford County meet goals for addressing impervious cover.

3 EXISTING MONITORING DATA SUMMARY

In the late 2000's, KCI Technologies, Inc. (KCI) conducted geomorphic, biological, and water quality monitoring within a 4,400-foot reach of the Farnandis Branch, below Woodland Drive and within the Grosvener and Victory subwatersheds. Data and additional details conducted during this study can be reviewed within the Farnandis Branch – Stream Restoration Project Pro-Construction Monitoring (KCI Technologies, 2010).

3.1 GEOMORPHIC MONITORING

The geomorphic monitoring program consisted of establishing benchmarks and cross-sections, surveying and analyzing the cross-sections and thalweg profiles, installing and monitoring bankpins, and evaluating substrate particle size distribution. The methods evaluated bed and bank stability, channel profile and bed features. Eight monumented channel cross-sections were established during baseline monitoring at various critical locations along the tributary, with annual measurements performed during subsequent monitoring years. Additionally, an inspection of the channel was made following a bankfull storm event and information was gathered and observed to compare with previously collected data and photographs.

Cross sectional surveys indicate degradation of the channel bed and/or bank erosion throughout the study area. Bank pin measurements throughout the study reach indicate substantial erosion in some areas. Figure 3-1 shows the location of the geomorphic monitoring sites.

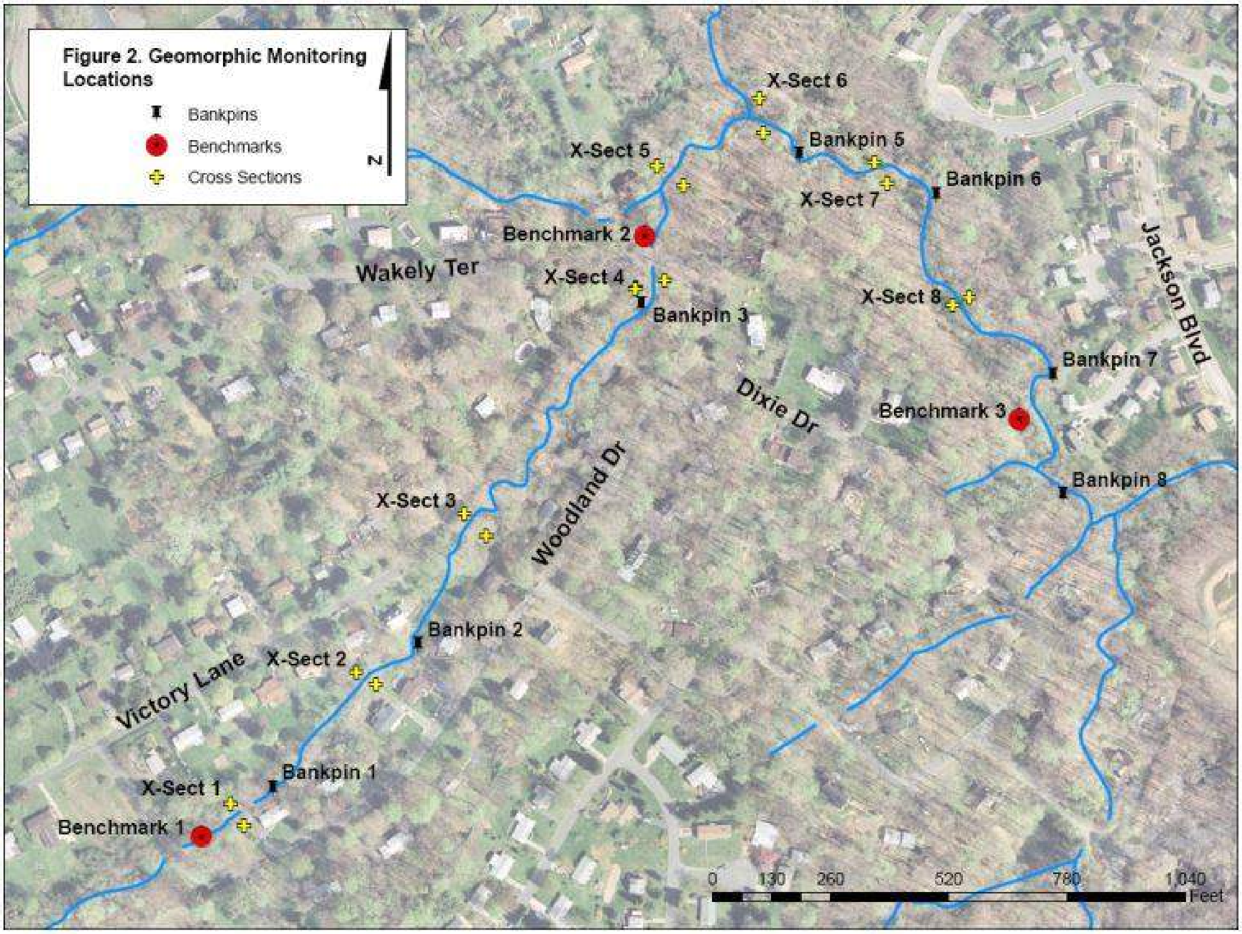

Figure 3-1: Geomorphic Monitoring Locations

3.2 BIOLOGICAL MONITORING

The biological monitoring program included the collection and analysis of the macroinvertebrate community, a physical habitat assessment, and measurements of in situ water chemistry. Biological assessments involved macroinvertebrate sampling at three sites – two within the Farnandis Branch and a third located off-site, within an adjacent watershed, serving as a control to which the other stations could be compared. Figure 3-2 shows the location of the water quality and biological sampling sites.

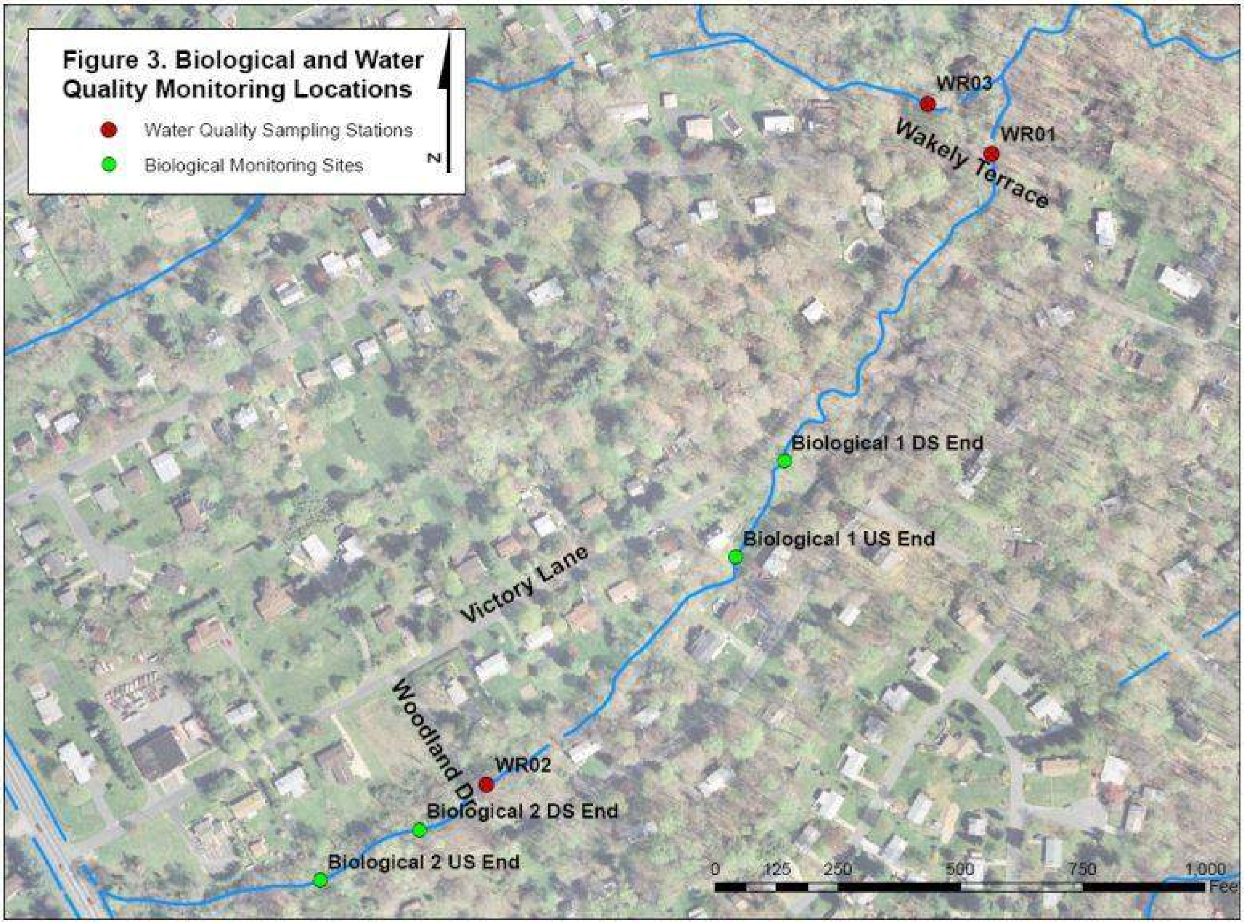

Figure 3-2: Biological and Water Quality Monitoring Locations

The biological monitoring for Farnandis Branch, conducted by KCI in 2007 through 2009, followed the Maryland Biological Stream Survey (MBSS) probabilistic monitoring methods to assess ecological health in local streams. Sampling results indicate impaired biological conditions (low Benthic Index of Biotic Integrity scores) throughout the study reach.

Overall, Benthic Index of Biotic Integrity (BIBI) scores remained relatively consistent with only minor changes observed at each of the two on-site stations. The biological rating for both on-site stations indicate impaired (ST-1) and highly impaired (ST-2) biological communities that will require restoration/mitigation measures for any chance of recovery. A summary of BIBI scores calculated by KCI can be found in Table 3-1 and Figure 3-3.

Table 3-1: BIBI Scores in the Farnandis Branch (KCI Technologies, 2010)

	2007			2008			2009		
	ST-1	ST-2	REF	ST-1	ST-2	REF	ST-1	ST-2	REF
Raw Metric Scores									
Total Number of taxa	31	15	25	19	12	17	20	9	19
Number of EPT taxa	5	1	11	2	1	7	2	1	10
Number of Ephemeroptera Taxa	0	0	7	0	0	4	0	0	4
Percent Intolerant Urban Taxa	15	55	54	6	3	73	27	3	66
Percent Chironomidae Taxa	71	93	26	59	28	4	38	29	4
Percent Clinger Taxa	31	3	26	32	65	44	34	66	16
BIBI Scores									
Total Number of taxa	5	3	5	3	1	3	3	1	3
Number of EPT taxa	3	1	5	1	1	3	1	1	3
Number of Ephemeroptera Taxa	1	1	5	1	1	5	1	1	5
Percent Intolerant Urban Taxa	3	5	5	1	1	5	3	1	5
Percent Chironomidae Taxa	1	1	3	3	3	5	3	3	5
Percent Clinger Taxa	3	1	1	3	3	3	3	3	1
Overall BIBI Score	***2.67***	***2.00***	***4.00***	***2.00***	***1.67***	***4.00***	***2.33***	***1.67***	***3.67***
Narrative Rating	***Poor***	***Poor***	***Good***	***Poor***	***Very Poor***	***Good***	***Poor***	***Very Poor***	***Fair***

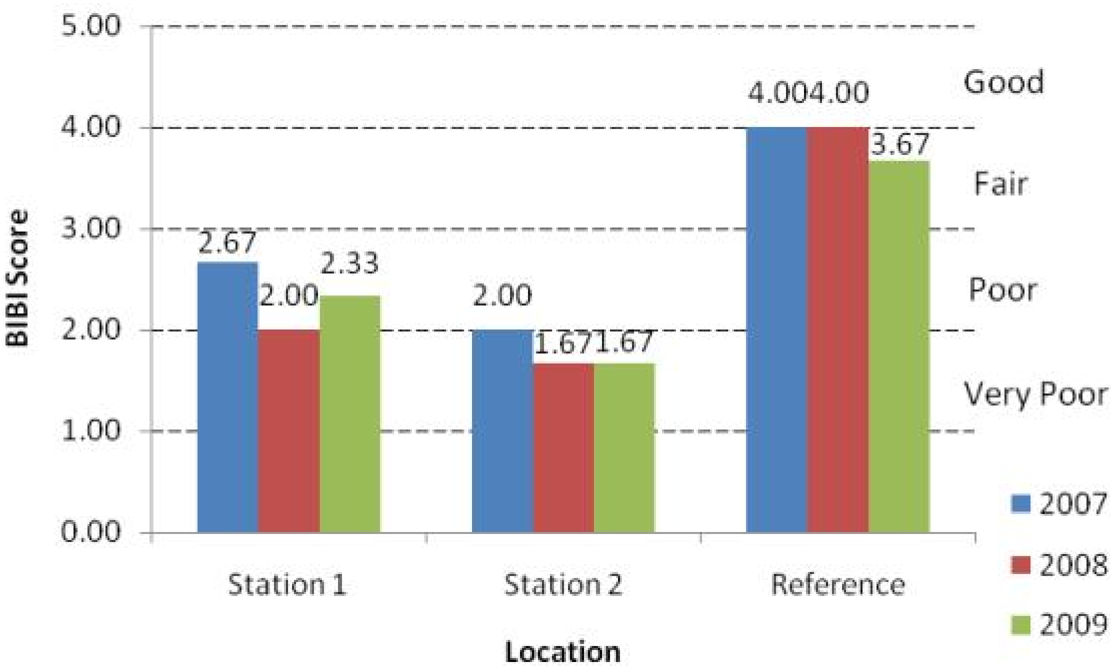

Figure 3-3: Comparison of BIBI Scores 2007-2008 (KCI Technologies, 2010)

Physical habitat assessments were conducted in conjunction with the benthic macroinvertebrate sampling and indicated relatively consistent physical habitat index (PHI) scores throughout the study reach. A summary of this data can be found in Table 3-2 and Figure 3-4.

Table 3-2: Summary of Physical Habitat Index Results (KCI Technologies, 2010)

Physical Habitat Parameter	2007			2008			2009		
	ST-1	ST-2	REF	ST-1	ST-2	REF	ST-1	ST-2	REF
Remoteness	43.8	68.8	81.3	43.8	62.5	75.0	31.3	62.5	75.0
Shading	33.4	70.3	72.4	33.4	64.8	72.4	37.0	64.8	72.4
Epibenthic Substrate	35.3	23.5	88.2	35.3	23.5	88.2	35.3	17.6	88.2
Instream Habitat	42.9	32.4	97.2	42.9	45.1	84.4	42.9	38.8	90.8
Woody Debris & Rootwads	0.0	41.7	25.0	8.3	75.0	25.0	16.7	83.3	25.0
Bank Stability	69.0	81.6	100.0	75.5	81.6	100.0	75.5	81.6	100.0
Riffle Quality	89.8	57.0	98.7	79.6	77.3	93.6	84.7	67.1	98.7
Embeddedness	55.6	38.9	94.4	55.6	38.9	94.4	83.3	38.9	88.9
PHI Score	**46.2**	**51.8**	**82.1**	**46.8**	**58.6**	**79.1**	**50.8**	**56.8**	**79.9**
Narrative Rating	**Severely Degraded**	**Degraded**	**Minimally Degraded**	**Severely Degraded**	**Degraded**	**Partially Degraded**	**Severely Degraded**	**Degraded**	**Partially Degraded**

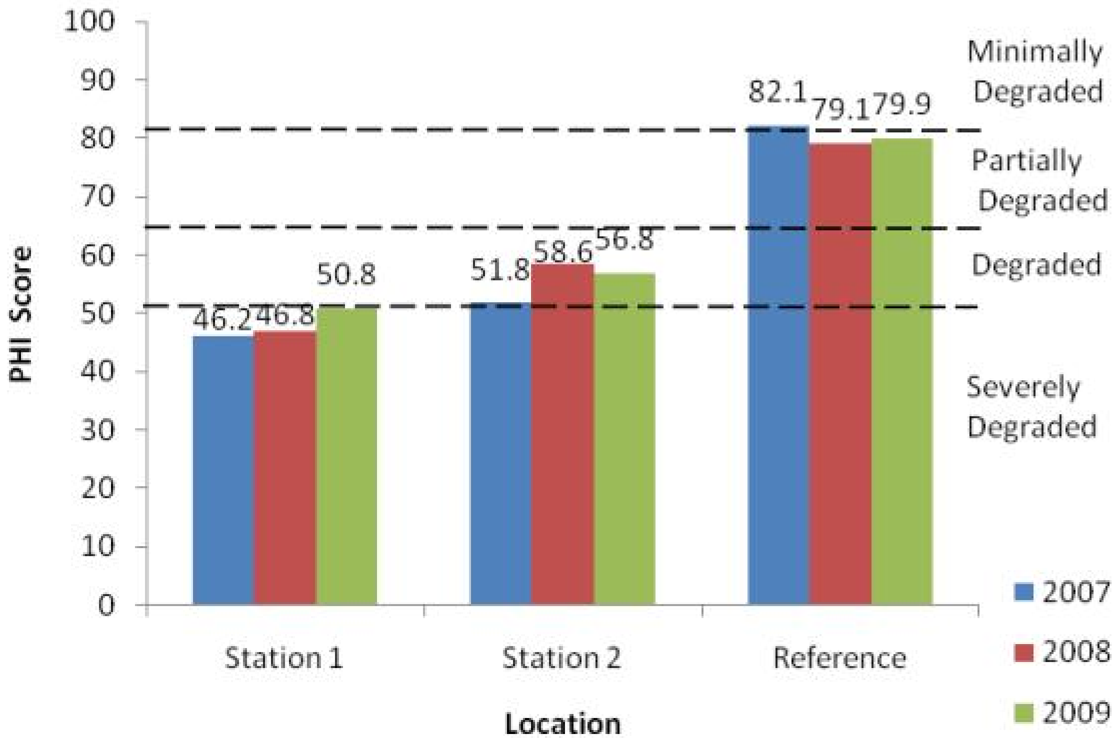

Figure 3-4: Comparison of PHI Data 2007-2009 (KCI Technologies, 2010)

3.3 WATER QUALITY MONITORING

The water quality monitoring program consisted of both dry weather (baseflow) sampling and wet weather (stormflow) sampling at three locations within the study area. Dry weather grab samples were collected to establish baseline data for comparison to wet weather conditions. Wet weather water quality samples were collected during storm events, one per season: Fall (September – November), Winter (December – February), Spring (March – May), and Summer (June – August). All samples were sent to a certified laboratory and analyzed for E. coli bacteria, total phosphorus, total nitrogen, chlorides, total suspended solids, lead, copper, zinc, and nickel.

Both physical habitat degradation and water quality conditions have contributed to impaired biota in the study reach. Water quality monitoring showed that concentrations of phosphorus and nitrogen were elevated in the second year of monitoring. While E. coli levels were an issue throughout the monitoring periods. A summary of in-situ water quality monitoring results can be found in Table 3-3.

Table 3-3: In-Situ Water Quality Monitoring Results (KCI Technologies, 2010)

Parameter	Units	Analytical Method	Method Detection Limit	10/31/2008			3/24/2009		
				WR01	WR02	WR03	WR01	WR02	WR03
Total Phosphorus	*mg/l*	*SM 4500P-E*	*0.01*	0.17	0.25	0.14	<0.01	0.01	0.03
Total Nitrogen	*mg/l*	*SM Calc*	*0.02*	0.35	0.68	1.6	2	2.1	2.8
Kjeldahl Nitrogen	*mg/l*	*SM 4500NH3-C*	*0.5*	<0.5	<0.5	<0.5	1	0.9	0.9
Nitrate-Nitrite	*mg/l*	*SM 4500N03-H*	*0.02*	0.35	0.68	1.6	1	1.2	1.9
Nickel	*µg/l*	*EPA 200.8*	*2*	<2	<2	<2	<2	<2	<2
Copper	*µg/l*	*EPA 200.8*	*2*	<2	<2	<2	<2	<2	<2
Zinc	*µg/l*	*EPA 200.8*	*10*	<10	12	11	11	18	<10
Lead	*µg/l*	*EPA 200.8*	*2*	<2	<2	<2	<2	<2	<2
Chloride	*mg/l*	*SM 45010-CL-E*	*1*	71	89	43	150	170	58
Suspended Solids	*mg/l*	*SM 2540 D*	*1*	<1	<1	<1	5	2	<1
E. coli	*mpn/ 100ml*	*SM 9221F*	*1*	930	230	9	2	<2	30

4 FIELD ASSESSMENT

4.1 OVERVIEW

Field assessments were conducted throughout the Upper Farnandis watershed to evaluate existing conditions within Upper Farnandis Branch and its tributaries. A total of 3.4 miles (17,796 linear feet) of stream, 41 outfalls, 10 existing BMPs, and 14 proposed BMPs were assessed during the field reconnaissance. During the field assessments, GPS enabled tablets were used to collect field information, location data of outfalls and stream characteristics as well as pictures that were taken at each location. Field maps were created for each existing and proposed BMP site at a scale to allow the entire drainage area to be shown on each map. For the stream and outfall assessments, a 1 inch = 150 feet grid was created. Field maps were printed at this scale to allow field notes and documentation of stream features and outfall locations during the assessment. These maps allowed for field notes and verification of drainage area and BMP locations. Protocols and field findings for each type of assessment can be found in the next several sections.

4.2 STORMWATER MANAGEMENT FACILITIES

During the field assessments, field teams assessed the conditions of existing BMPs and identified locations for proposed BMPs. The recommendations below represent opportunities where new or enhanced stormwater control measures can be developed that deliver greater management of stormwater runoff than is realized currently.

The Maryland Department of the Environment (MDE) developed stormwater management (SWM) regulations over 25 years ago to control the quantity of runoff. SWM practices have evolved since then, and will continue to progress as new technology and research are developed. SWM is a significant consideration for new development and redevelopment within Maryland. Per Title 4, Subtitle 2, of the Environment Article of Annotated Code of Maryland, management of stormwater runoff is required to reduce erosion, sedimentation, pollution, and flooding. Increased importance of water quality and water resource protection has led to the development of the Maryland Stormwater Design Manual in 2000 to provide Best Management Practice (BMP) design standards and environmental incentives, and has promoted a general shift toward low-impact SWM practices that mimic natural hydrologic processes and achieve pre-development conditions. The latter is evident by the Maryland Stormwater Management Act of 2007 which requires that Environmental Site Design (ESD) be implemented to the maximum extent practicable via nonstructural BMPs and/or other innovative design techniques.

There are many types of BMP options for managing stormwater runoff and providing stormwater quality treatment. SWM facilities can target specific objectives, depending on the BMP type, such as improving overall stormwater quality before it enters the stream, soil stabilization and erosion control, stormwater flow control or detention, and stream protection. In addition, different SWM facilities have different pollutant removal capabilities. For example, early pond designs for SWM have low pollutant removal efficiency compared to practices that filter stormwater or allow it to infiltrate into the ground or through plant roots. Considerations such as space requirements, maintenance needs, cost, and community acceptance are considered when selecting the appropriate stormwater treatment measures. Existing BMP retrofits and new BMP locations are detailed in Sections 4.2.1 and 4.2.2.

4.2.1 EXISTING STORMWATER MANAGEMENT FACILITIES

BMPs constructed prior to the 2010 MDE Stormwater Manual may not provide water quality treatment for runoff. These facilities may have the capacity to be retrofitted to help improve water quality. Stormwater retrofits improve water quality by capturing and treating runoff before it reaches receiving water bodies. Based on initial desktop evaluations, 7 existing BMPs were identified in the watershed. While field teams were performing the assessments, an additional 3 existing BMPs were identified and assessed. Two of these facilities are located at Christ Our King United Presbyterian Church while the third is an SHA wet pond. These existing BMPs collect runoff from approximately 8.5% of the watershed.

Table 4-1 summarizes the number of various types of public and private SWM facilities in the Upper Farnandis watershed. The SWM facilities are categorized into detention ponds, underground detention, infiltration practices, extended detentions, and ESD practices such as rain barrels/cisterns and rain gardens. Figure 4-1 shows the distribution of these facilities throughout the watershed. Data for SWM facilities and their drainage areas were obtained from Harford County and updated during field assessments.

Table 4-1: Stormwater Management Facilities in Upper Farnandis Watershed

BMP ID	SUBWATERSHED	TYPE	POTENTIAL RETROFIT	DRAINAGE AREA (ACRES)	OWNERSHIP
BMP-EX-01	Macphail	Underground Dry Well Infiltration	N	0.61	Commercial
BMP-EX-02	Brook Hill	Extended Detention	Y	4.70	HOA
BMP-EX-03	Grosvenor	Extended Detention	Y	21.24	HOA
BMP-EX-04	Brook Hill	Extended Detention	Y	6.15	HOA
BMP-EX-05	Ring Factory	Rain Garden	N	0.28	Institutional
BMP-EX-06	Ring Factory	Infiltration Trench	N	2.69	Institutional
BMP-EX-07	Victory	Infiltration Basin	Y	0.63	Town of Bel Air
BMP-EX-08	Ring Factory	Rain Garden	N	0.23*	Institutional
BMP-EX-09	Ring Factory	Rain Barrel	N	0.09*	Institutional
BMP-EX-10	Victory	Wet Pond	N	4.96*	SHA

*BMPs identified during the field assessment

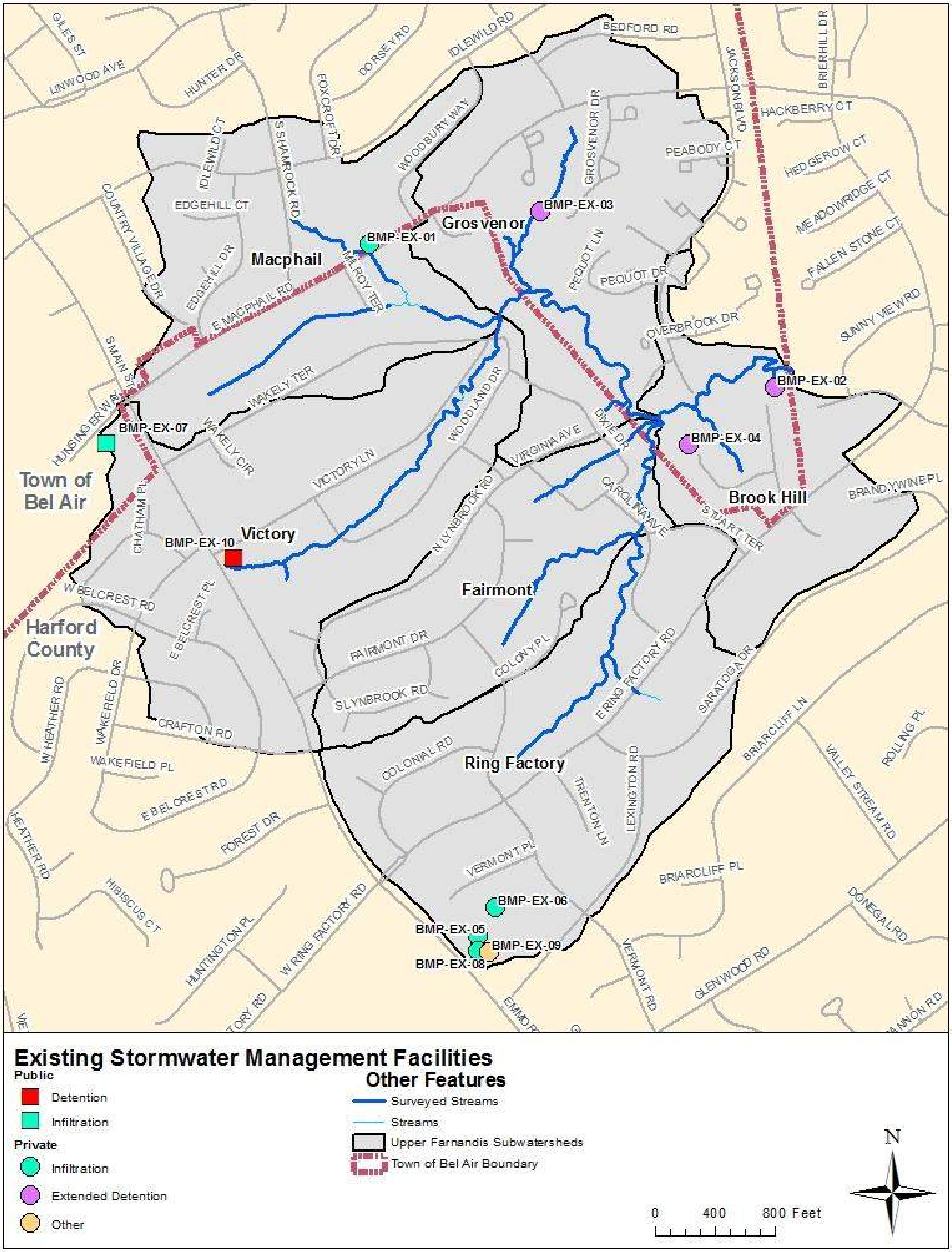

Figure 4-1: Summary of Existing Stormwater BMPs in the Upper Farnandis Watershed

EXISTING BMP ASSESSMENT PROTOCOL

Existing BMP assessments were conducted for all 10 BMPs in the Upper Farnandis watershed. The assessments were conducted based on protocols developed by WSP as a tool for field teams to quickly evaluate the current conditions of the facility and determine retrofit potential. The following sections present a description of the BMP protocol employed, an overview of the sites assessed, and general results for the Upper Farnandis watershed. Further detail on the sites listed for potential retrofit can be found in Section 6.2.1.

The BMP Assessment is used to quickly assess the physical conditions of existing BMPs and identify potential retrofit opportunities. The assessments were conducted in the fall of 2017 by two-person field crews from WSP. The teams walked each site in the Upper Farnandis watershed. Access had been granted for all sites. Due to the different types of existing BMPs, the following protocols were used to collect information at each site. Items in the protocol that were not applicable to a specific site were not filled out at that site.

- Verification of desktop/design plan drainage area
- Measurement of facility bottom width and length
- Descriptions of any maintenance needs
- Observations of accessibility for construction and maintenance access
- Identification of all inflow points into the facility and verification of the elevation change between the inflow inverts and the outflow structure invert for the facility.
- Evaluation of the condition of the inlets and outfall structure.
- Identification of standing water and/or wetland vegetation in the facility
- Identification of the facility's emergency spillway, if present
- Inspection of manholes near facility to verify storm drain network leading to facility

Field teams walked the selected sites while sketching a plan view of the facility and noting all inflow points and outfall points as well as the location of the emergency spillway and the facility bottom dimensions. A general sketch of the outfall structure was drawn to include the height of the structure from the facility bottom and the location and dimensions of the orifices. The outfall condition was also noted on the sketches. A third sketch of the embankment was drawn to include the embankment height from the facility bottom, the embankment top width, and the embankment condition.

For underground facilities and smaller ESD facilities, some sketches were not applicable. For these facilities, plan view sketches were drawn and notes were taken on the condition of the existing facility. Notes were collected to show if the facility currently appears to provide water quality treatment, based on design plans and site visits. Photographs were taken of the overall site and throughout the site assessment to document the conditions observed. Drainage areas were modified on the field maps. Each site was assigned a unique identification number.

GENERAL FINDINGS

SWM facilities are present in 5 (five) of the 6 (six) subwatersheds that make up the Upper Farnandis watershed. There are no documented SWM facilities in Fairmont. The most common SWM facility type are infiltration practices followed by extended detention facilities. SWM facilities in the Upper Farnandis watershed tend to have commercial/institutional and residential land uses. Eight of the 10 facilities are privately owned, while two facilities are publicly owned.

Stormwater retrofits for the purposes of this Small Watershed Assessment Report refer to optimization of existing BMPs to capture and provide greater treatment of runoff from impervious surfaces (i.e. parking lots, roadways), which are currently untreated or treated to a lesser extent. Of the 10 existing BMPs assessed, 3 of them are being recommended for BMP retrofits. These facilities are listed in Table 4-2. A detailed site description and recommended projects for these three facilities can be found in Section 6.2.1.

Table 4-2: Stormwater Retrofits in Upper Farnandis

BMP ID	SUBWATERSHED	EXISTING BMP TYPE	RETROFIT TYPE	DRAINAGE AREA (ACRES)	OWNERSHIP
BMP-EX-02	Brook Hill	Extended Detention	Wet Pond	4.70	HOA
BMP-EX-03	Grosvenor	Extended Detention	Submerged Gravel Wetland	21.24	HOA
BMP-EX-04	Brook Hill	Extended Detention	Wet Pond	6.15	HOA

The seven existing BMPs not recommended for retrofits are described in this section. A site description has been provided along with any maintenance recommendations, and the reason for not recommending a retrofit.

Existing BMP 1 is located at 410 East Macphail Road (Figure 4-2, left). The facility is within the Macphail subwatershed. One 12" corrugated metal pipe conveys flow from the adjacent parking lot to the existing underground dry well infiltration facility (Figure 4-2, right). The inlet in the parking lot is partially filled with sediment and the inlet box has severe sediment accumulation. The field team was unable to field-identify the storm drain network leading to underground facility due to severe sediment accumulation. The impervious area that drains to the existing BMP accounts for 48% of the drainage area. The facility discharges to the existing storm drain system underground.

Rain had been observed in the area one day prior to site visit. No flow was observed near or in to the underground facility. The underground dry well infiltration facility is not being recommended as a retrofit opportunity. It appears to be functioning as designed and is currently providing water quality benefits; however, maintenance is recommended in the form of removal of accumulated sediment.

Figure 4-2: Looking Southwest adjacent to E Macphail Road at ground above underground facility (left); Looking at clogged inflow point located in parking lot (right)

Existing BMP 5 is located at Christ Our King United Presbyterian Church (Figure 4-3, right). The facility is within the Ring Factory subwatershed. The impervious area that drains to the existing rain garden accounts for 11% of the drainage area. The existing rain garden is approximately 12' wide by 41' long. Inflow enters the facility via overland flow and piped flow to an existing riprap channel (Figure 4-3, left). The riprap channel entering the facility measures approximately 1' wide by 27' long. The facility outfalls to a grassy area and follows existing drainage patterns. Wetland plants may be present within the BMP.

No flow was observed to the facility. Rain had not been observed in the area 3 days prior to site visit. There was no standing water in the facility. The existing rain garden is not being recommended as a retrofit opportunity. It appears to be functioning as designed and providing water quality treatment.

Figure 4-3: Looking North along existing riprap channel leading to rain garden (left); Looking North at existing facility (right)

Existing BMP 6 is an infiltration trench located at Christ Our King United Presbyterian Church (Figure 4-4, left). The facility is within the Ring Factory subwatershed. A detention basin measures approximately 27' wide by 120' long and is surrounded by a chain link fence. The detention basin collects the flow and directs it to a yard inlet. An infiltration trench is underground and receives ground surface runoff from the yard inlet. The impervious area that drains to the existing facility accounts for 38% of the drainage area. Flow is conveyed to the facility via a 6" PVC pipe from roof downspout connection directly into the facility footprint. Additional inflow enters the facility via overland flow from daylighted 24" HDPE pipe located upstream of facility in the church yard. The detention basin is overgrown with vegetation and has approximately 3 inches of sediment buildup at the control structure.

No flow was observed to the facility. Rain had not been observed in the area within 3 days prior to the site visit, and the facility did not have standing water present. The existing infiltration trench is not being recommended as a retrofit opportunity. It appears to be functioning as designed and providing water quality treatment; however, maintenance is recommended in the form of sediment removal in the detention basin.


Figure 4-4: Looking North to facility footprint from inflow point (left); Looking North to outfall to existing storm drain network (right)

Existing BMP 8 is located at Christ Our King United Presbyterian Church (Figure 4-5, left). The facility is within the Ring Factory subwatershed. The impervious area that drains to the existing rain garden accounts for 13% of the drainage area. The existing rain garden is approximately 14' wide by 48' long. Inflow enters the facility as overland flow from a downspout disconnection on the Western side of the church roof (Figure 4-5, right). Overflow from the rain garden outfalls to follow the existing drainage pattern on the surrounding grass area. Wetland plants may be present with the BMP footprint.

No flow was observed to the facility. Rain had not been observed in the area 3 days prior to site visit. There was no standing water in the facility. The existing rain garden is not being recommended as a retrofit opportunity. It appears to be functioning as a water quality treatment facility.

Figure 4-5: Looking South to existing rain garden facility (left); Looking South to area of church roof that drains to existing BMP (right)

Existing BMP 9 is a rainwater harvesting cistern located a Christ Our King United Presbyterian Church (Figure 4-6, left). The facility is within the Ring Factory subwatershed. The rainwater harvesting cistern is approximately 4' high and has an 8-foot diameter. The impervious area that drains to the existing facility accounts for 100% of the drainage area. Flow is conveyed to the rainwater harvesting cistern via a downspout disconnection from the church roof directly to the facility. The rainwater harvesting cistern outfalls via a 6" PVC pipe to an existing pipe network that outfalls onto the grass area to the North of the cistern (Figure 4-6, right).

During the field visit, no flow was not observed to the facility. Rain had not been observed in the area within 3 days prior to site visit. The existing rain barrel is not being recommended as a retrofit opportunity.

Figure 4-6: Existing rain barrel captures runoff from roof (left); Overflow to existing pipe network that outfalls to grass area to North of rain barrel (right)

Existing BMP 10 is a wet pond located at the intersection of Victory Lane and South Main Street (Figure 4-7, left). The wet pond is approximately 124' long by 26' wide. The depth of the facility was unable to be field-identified due to standing water in the pond. A chain link fence and steep slopes surround the entire facility. The facility is adjacent to the stream channel. The impervious area that drains to existing BMP 10 accounts for 36% of the drainage area. Flow is conveyed to the pond via overland flow and from a 24" concrete pipe. Flow entering via the 24" concrete pipe is from the storm drain network along South Main Street, as confirmed with record drawings. A forebay exists at the pipe inflow point to allow for settlement prior to entering the wet pond. An overflow weir serves as the principle spillway for outfall from the facility (Figure 4-7, right). The weir is 15' long by 3' high. A 3" low flow orifice exists below the weir spillway. The weir discharges to a riprap channel approximately 30' from left bank of stream. The wet pond is in good condition, with cattails and vegetation present within the facility footprint.

Inflow was observed to the facility. Rain was observed in the area one day prior to the site visit. As expected, standing water was present in the wet pond footprint. The existing wet pond is not being recommended as a retrofit opportunity.

Figure 4-7: Looking West to South Main Street at location of inflow pipe (left); Looking South at overflow weir (right)

4.2.2 PROPOSED STORMWATER MANAGEMENT FACILITIES

In addition to evaluating existing BMPs for retrofit opportunities, the watershed was canvased for potential new BMP placement. A desktop evaluation was performed to identify ideal locations for proposed facilities which tend to be open, public spaces. Due to the large percentage of residential land use in the watershed, open space was limited to within the road right-of-way along neighborhood streets, HOA open space areas, and private commercial properties. Four proposed BMPs from a previous study, were re-evaluated during this assessment.

During the stream and outfall assessments, several of the proposed BMPs near an outfall were quickly evaluated and removed from consideration due to their proximity to the stream. Proposed BMPs were considered ineligible if the location was at an outfall and within 50 feet of the stream. These locations were evaluated during the outfall assessments for potential outfall stabilization projects. The following table provides the proposed BMP name, subwatershed, ownership, method of identification, and if it was removed from consideration during the outfall assessments. Figure 4-8 provides the locations of all the proposed BMP sites after the desktop evaluation. As noted in Table 4-3 and Figure 4-8, the four proposed BMP locations included from a previous study were removed from consideration during the outfall assessments. Also during the outfall assessments, an additional 5 desktop evaluation sites were removed from consideration. All 9 sites eliminated as proposed BMP locations were removed due to their proximity to the stream channel and a recommendation for outfall stabilization.

Table 4-3: Summary of Proposed BMPs from Desktop Evaluation

BMP ID	SUBWATERSHED	OWNERSHIP	IDENTIFIED	REMOVED FROM CONSIDERATION PRIOR TO ASSESSMENT
BMP-PR-01	Macphail	Commercial	Desktop Evaluation	No
BMP-PR-02	Macphail	Commercial	Desktop Evaluation	No
BMP-PR-03	Ring Factory	ROW	Desktop Evaluation	No
BMP-PR-04	Macphail	ROW	Desktop Evaluation	No
BMP-PR-05	Grosvenor	Private Homeowner	Desktop Evaluation	Yes
BMP-PR-06	Grosvenor	HOA	Desktop Evaluation	Yes
BMP-PR-07	Grosvenor	Town of Bel Air	Desktop Evaluation	No
BMP-PR-08	Brook Hill	HOA	Desktop Evaluation	Yes
BMP-PR-09	Macphail	Commercial	Desktop Evaluation	Yes
BMP-PR-10	Grosvenor	HOA	Desktop Evaluation	Yes
BMP-PR-11	Fairmont	Private Homeowner	Previous Study	Yes
BMP-PR-12	Fairmont	Private Homeowner	Previous Study	Yes
BMP-PR-13	Ring Factory	Private Homeowner	Previous Study	Yes
BMP-PR-14	Ring Factory	Private Homeowner	Previous Study	Yes

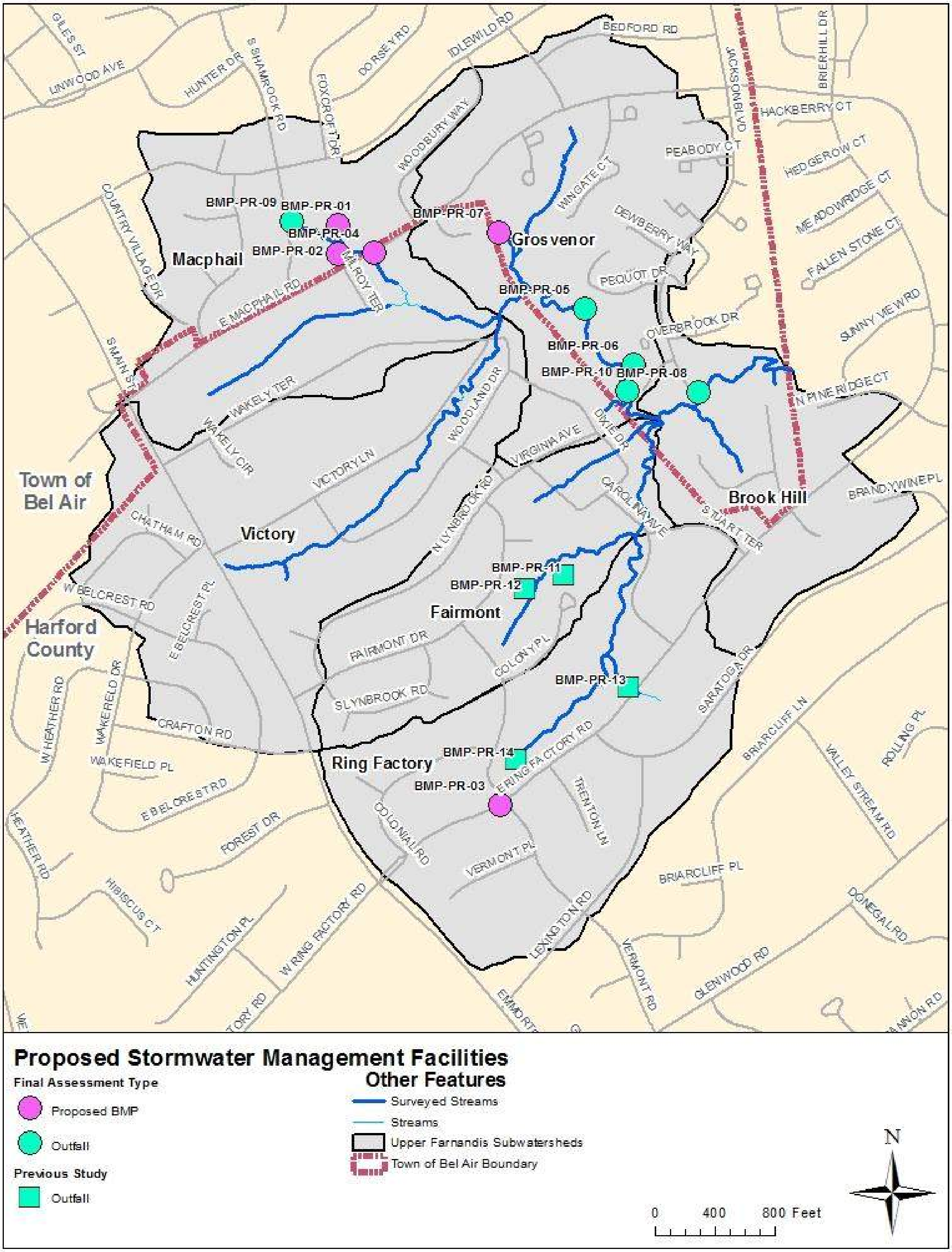

Figure 4-8: Proposed BMPs in the Upper Farnandis Watershed

PROPOSED BMP ASSESSMENT PROTOCOL

After the desktop evaluation and the outfall assessment were completed, 5 in-depth field assessments were performed for the remaining proposed BMP locations. The assessments were conducted based on protocols developed by WSP, which was developed as a tool for field teams to quickly evaluate the current site conditions and determine potential BMP placement. The following section presents a description of the BMP protocol employed, an overview of the sites assessed, and general results for the Upper Farnandis watershed. Further detail on the sites listed for potential new BMP projects can be found in Section 6.2.2.

The BMP assessment is used to quickly assess the physical conditions of the proposed site and any new BMP opportunities. The assessments were conducted in the fall of 2017 by two-person field crews from WSP. The teams walked each site in the Upper Farnandis watershed. Access was granted for all sites. Due to the different site constraints, the following protocols were used to collect information at each site. Items in the protocol that were not applicable to a specific site were not filled out at that site.

- Verification of desktop/design plan drainage area
- Measurement of available space for proposed facility footprint
- Observations of accessibility for construction and maintenance access
- Identification of how inflow would enter the proposed site and if alterations to the existing drainage patterns are needed to maximize impervious area runoff to the site.
- Verification of adequate elevation change is available for the facility to outfall to existing drainage patterns
- Identification of standing water and/or wetland vegetation near the proposed footprint
- Inspection of manholes near facility to verify storm drain network leading to facility
- Identification of potential hotspot at site
- Identification of trees and/or steep slopes present in the footprint
- Identification of private residences, businesses, or pedestrian areas that may be impacted by construction of BMP
- Identification of utility conflicts within the footprint and/or disturbance area

Field teams walked the selected sites while following the protocol list to determine if the site constraints allowed for the construction of a BMP or ESD facility. A general sketch of the footprint for the proposed facility was drawn to include the footprint bottom width and length and placement based on side slopes and site constraints in the area. How the flow would leave the facility and where it would connect with the existing drainage patterns was also noted. Photographs were taken of the overall site and throughout the site assessment to document the conditions observed. Drainage areas were modified on the field maps. Each site was assigned a unique identification number.

GENERAL FINDINGS

From these 5 field assessments, two locations are being recommended for potential BMPs, BMP-PR-01 and BMP-PR-02. Detailed information on the proposed BMPs can be found in Section 6.2.2. The three proposed BMPs that have been removed from consideration after the proposed BMP field assessment are described in this section.

BMP-PR-03 and *BMP-PR-04* are located within the ROW of Harford County roadways. BMP-PR-03 is located at the corner of East Ring Factory Road and Vermont Road while BMP-PR-04 is in front of 603

East Macphail Road. BMP-PR-03 is in a residential area with minimal space from the edge of the roadway to the property line., approximately 8 feet. The streets in this neighborhood are curbed, so there is currently no impervious area draining to the proposed site. With limited space constraints, BMP and ESD facilities are not optimal for this location; therefore, this site is not recommended for water quality treatment purposes. However, a non-MDE treatment, such as a Filterra over the curb inlet, would provide treatment with minimal impacts to the existing ROW. It was removed from the list of proposed projects due to the inability to construct an approved MDE facility.

Runoff from a roadway in a commercial area of the watershed drains to BMP-PR-04. A curb is located along the roadway, preventing runoff from impervious are from entering the proposed site. Similarly, to BMP-PR-03, the ROW width from the edge of the road to the private property line is less than 10 feet and not able to fit a BMP or ESD facility. With a curb inlet just downstream of the proposed facility, a non-MDE approved treatment method, such as a Filterra may be the best opportunity for water quality treatment in this location. It was removed from the list of proposed projects due to the inability to construct an approved MDE facility.

BMP-PR-07 is in public, open space within the Town of Bel Air. The proposed BMP is located at an outfall; however, the site was field assessed for a proposed BMP due to the open space, potential for an off-line facility, and distance from the confluence with the downstream tributary. From the site assessment, it was determined that this location would be better suited for an outfall stabilization project, due to minimal flat space to place the off-line facility, the difficulty to capture flow from the existing manhole, and the difficulty to tie-into the existing stream channel.

4.3 OUTFALL ASSESSMENTS

In urban areas, runoff from impervious areas, such as streets, parking lots, driveways, and buildings, is directed through a storm drain network to a nearby stream. Without stormwater control measures or outfall stabilization methods, high flows during storm events from these stormwater outfalls tend to cause erosion along the stream channel. Stabilizing the outfall channel and dissipating flows prior to entering the stream channel will alleviate stream degradation downstream.

Prior to field assessment, 36 outfalls were identified through Harford County and the Town of Bel GIS data. Harford County provided outfall locations while the the Town of Bel Air provided inlet and pipe networks. Using aerials and the GIS data, outfalls for the Town of Bel Air were identified in the office prior to performing the outfall assessments. The following sections provide details on the outfall assessment protocol, a summary of sites, and the general findings.

4.3.1 OUTFALL ASSESSMENT PROTOCOL

Outfall assessments were conducted for the 36 sites as well as 6 additional outfalls found by the field teams. The assessments were conducted based on protocols developed by WSP, which were developed as a tool for field teams to quickly evaluate the current conditions of the outfall and determine outfall stabilization opportunities. Potential outfall stabilization projects are proposed along with stream restoration projects and can be found in Section 6.3.

The outfall assessment is used to quickly assess the physical conditions of outfalls and identify potential restoration opportunities. The assessments were conducted in the fall of 2017 by two-person field crews from WSP. The teams walked each site in the Upper Farnandis watershed. Of the 41 sites, access was granted by the property owners for 38 outfalls. Three outfalls were unable to be accessed due to restricted access. The following protocols were used to collect information at each site. Items in the protocol that were not applicable to a specific site were not filled out at that site.

- Identification of type of flow at outfall
- Description of any maintenance needs
- Observation of accessibility for construction and maintenance access
- Identification of utilities within 10 feet of outfall protection
- Description of outfall structure (Pipe material, diameter, condition)
- Description of outfall protection (Material, length, width, condition)
- Identification of scour hole dimensions, if present
- Observation of active channel erosion occurrence within the outfall channel

Field teams walked the selected sites while sketching a plan view of the outfall, outfall protection, and outfall channel. Dimensions documented for any features added to the sketch. A profile sketch was also drawn in the field of the outfall, outfall protection, and outfall channel. The last sketch drawn was for a cross section at the outfall structure. Any pertinent information discovered at the site, including utilities, scour holes, damages, and steep slopes, were included in the sketches. An electronic form was filled out on a GIS enabled iPad to collect all the information in the protocol. Photographs were taken of the overall site and throughout the site assessment to document the conditions observed. Each site was assigned a unique identification number.

4.3.2 GENERAL FINDINGS

After the field assessments, an additional 6 outfalls were identified and assessed, bringing the total to 41 sites assessed. Of these 41 sites, the field teams found that seven sites were not outfalls. Instead these sites are either manholes, culverts, a concrete junction box, or yard inlets. Each site assessed and the structure type is identified in Table 4-4. The locations of each site are shown in Figure 4-9. Some of these outfalls are located within 10-15 feet of a stream bank, making it possible to perform outfall stabilization in conjunction with an adjacent stream restoration project. Potential outfall stabilization projects can be found in Section 6.3.

Table 4-4: Summary of Outfall Assessments

Outfall #	Field Verified Structure	Outfall #	Field Verified Structure
OF_01	Outfall	OF_22	Not Located
OF_02	Outfall	OF_23	Outfall
OF_03	Outfall	OF_24	Outfall
OF_04	BMP Outfall	OF_25	Outfall
OF_05	Outfall	OF_26	Outfall
OF_06	Outfall	OF_27	Outfall
OF_07	Outfall	OF_28	Outfall
OF_08	Outfall	OF_29	Outfall
OF_09	BMP Outfall	OF_30	Manhole
OF_10	BMP Outfall	OF_31	Outfall
OF_11	Culvert	OF_32	Junction Box
OF_12	Outfall	OF_33	Outfall
OF_13	Culvert	OF_34	Outfall
OF_14	Outfall	OF_35	Outfall
OF_15	Manhole	OF_36	Junction Box
OF_16	Yard Inlet	OF_37	Outfall
OF_17	Outfall	OF_38	BMP Outfall
OF_18	Outfall	OF_39	Outfall
OF_19	Inaccessible	OF_40	Outfall
OF_20	Outfall	OF_41	Outfall
OF_21	Outfall		

The 34 structures that were evaluated as outfalls fall under two categories, BMP outfalls and outfalls. BMP outfalls are those that convey flow from a BMP to a stream within the watershed. There were 4 BMP outfalls within the Upper Farnandis watershed. The remaining 26 outfalls convey stormwater flow from streets through the storm drain system directly to a stream within the watershed. Ten out of the 34 outfalls are being recommended for outfall stabilization projects in conjunction with a stream restoration project. Two additional outfalls are recommended for maintenance due to sediment accumulation in the outfall and outfall channel. Table 4-5 provides a list of outfalls that are recommended for outfall stabilization or outfall maintenance. Additional information on the type of project recommended can be found in Section 6.3.

Table 4-5: Outfalls Recommended for Outfall Stabilization or Maintenance

Outfall #	Field Verified Structure	Project Type
OF_04	BMP Outfall	Stabilization
OF_05	Outfall	Stabilization
OF_07	Outfall	Stabilization
OF_08	Outfall	Stabilization
OF_21	Outfall	Stabilization
OF_23	Outfall	Stabilization
OF_24	Outfall	Stabilization
OF_25	Outfall	Stabilization
OF_26	Outfall	Maintenance
OF_29	Outfall	Maintenance
OF_31	Outfall	Stabilization
OF_39	Outfall	Stabilization

Twenty-two outfalls were not recommended for outfall stabilization or maintenance. In most cases, the outfall structures and outfall channels were in good condition and do not require outfall stabilization. In a few cases, the outfall structure and/or channel were in fair condition. While minor bank stabilization may be an option for these outfalls, the sites are difficult to access with construction equipment and are not connected with a proposed stream restoration project. The sites were deemed in stable condition and not added to the list of outfall stabilization projects.

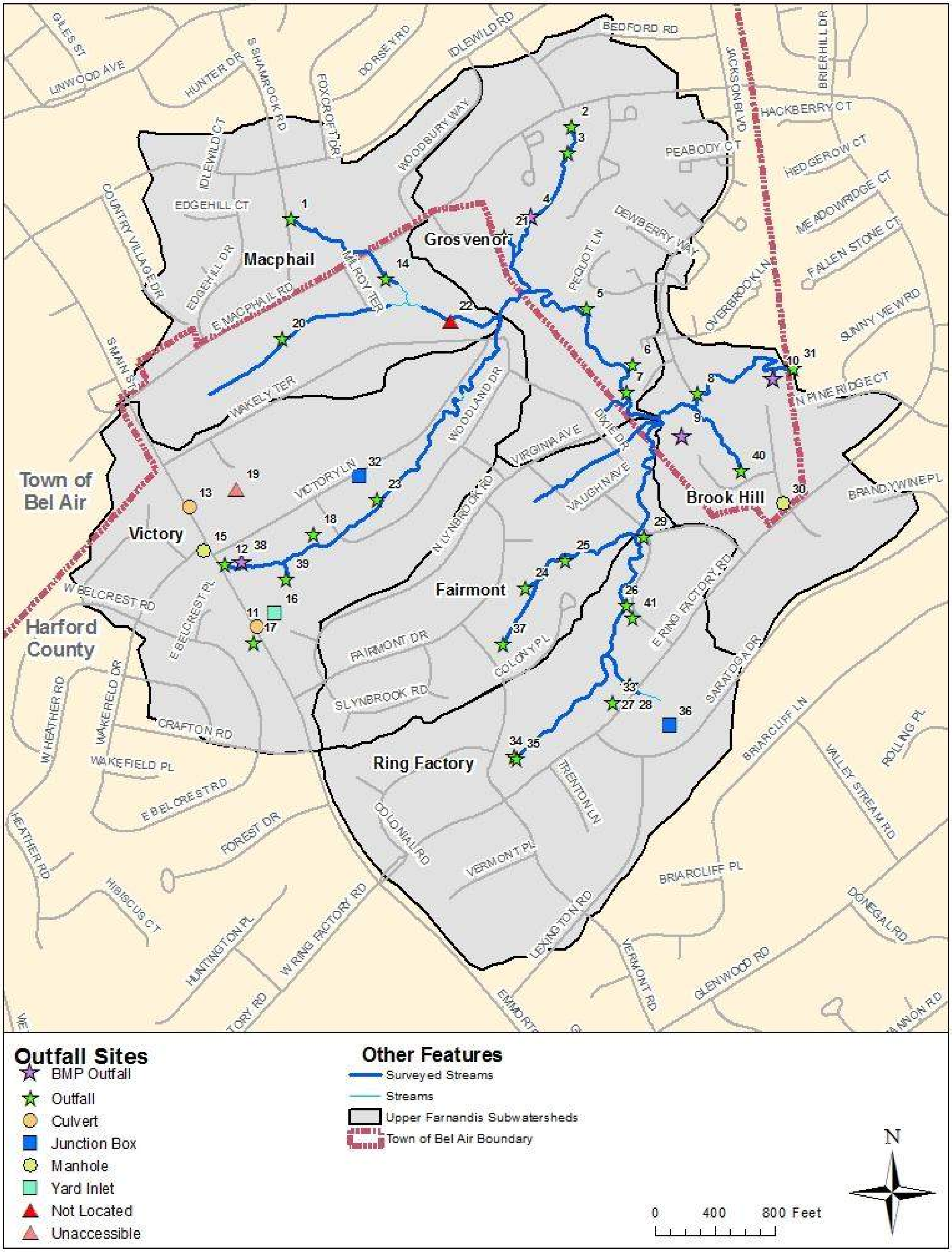

Figure 4-9: Outfall Assessments in the Upper Farnandis Watershed

4.4 STREAM CORRIDOR ASSESSMENTS

Stream Corridor Assessments (SCAs) were conducted for all streams in the Upper Farnandis watershed. The assessments were conducted based on Maryland DNR's SCA Survey Protocols, which were developed as a tool for environmental managers to quickly identify environmental problems within a watershed's stream network (Yetman, 2001). This methodology presents a rapid field survey, rather than a detailed scientific assessment, to better target monitoring, management, and conservation efforts on the watershed and subwatershed scale. The following sections present a description of the SCA protocol employed, an overview of the streams that were assessed, and general results for the Upper Farnandis watershed.

4.4.1 STREAM ASSESSMENT PROTOCOL

The SCA method is used to quickly assess the physical conditions and identify common environmental problems in a stream corridor. The assessments were conducted in the fall of 2017 by two-person field crews from WSP. The teams walked the stream segments in the Upper Farnandis watershed that were selected based on accessibility, owner permission, and stream feature. Following the SCA method, each field crew looked for the following environmental problems during the assessment.

- Channel Alteration Sites (CA)
- Erosion Sites (ES)
- Exposed Pipes (EP)
- Fish Migration Barriers (FB)
- Inadequate Stream Buffers (IB)
- Pipe Outfalls (PO)
- Trash Dumping (TD)

Field teams walked the selected stream corridors while noting the location of the problem sites on field maps and filling out the appropriate data at each site on a GPS enabled tablet. Electronic field forms were based on guidance provided in DNR's SCA manual. At least one photograph was taken at each site to document the conditions observed. Each site was assigned a unique identification number according to the map grid ID number, followed by a sequential site number, and two letters representing the type of problem as shown in the list above. The map grid is based on a 150-scale grid system used to generate paper field maps and assign unique IDs to field data items.

SCA problem sites were rated on a scale of one to five indicating the severity of the problem from minor to severe. Severity is a measure of how serious a problem site is compared to other problems within the same category. The most severe problems are those with a direct impact on stream resources. The severity ratings are intended to help prioritize potential restoration opportunities, ranging from a score of 5 which represents a minor problem, to a score of 1 denoting the worst or most severe observed.

4.4.2 SUMMARY OF SITES INVESTIGATED

Streams within the watershed were determined using county GIS hydrology lines data along streams and rivers. Landowner permission was required by mail for all private properties located along the proposed stream corridors. Stream corridors that were located on properties whose landowner denied permission for an assessment or whose reaches could not be accessed were not included in the SCAs. For stream corridors that were located on properties whose landowner did not respond to the written request for access, the County evaluated each property and determined if the field crews would be able to enter those properties. For example, HOA open spaces and other properties without buildings on them were granted access. Properties with residential homes were denied permission if the property owner did not respond to the written request. If a stream feature was found in the field, it was assessed. Based on these criteria, a total of 3.4 miles of stream were assessed, herein referred to as surveyed streams. Table 4-6 summarizes the total miles of surveyed streams in each subwatershed.

Table 4-6: Surveyed Streams in Upper Farnandis Watershed

SUBWATERSHED	SURVEYED STREAM MILES
Brook Hill	0.4
Fairmont	0.7
Grosvenor	0.7
Macphail	0.6
Ring Factory	0.5
Victory	0.6
Total	3.4

Figure 4-10 shows the stream network within the watershed, the streams surveyed are shown in dark blue. This figure also shows plots of land where landowner permission was denied and illustrates why certain stream segments could not be assessed.

As described previously, SCA problem sites were assigned unique identification numbers according to a map grid ID number. Each site was numbered sequentially during the assessment. The map grid used for the Upper Farnandis SCAs is shown in Figure 4-10. The field teams walked stream segments by map number. For example, the first SCA problem site located in Fairmont subwatershed within map number "D1" was an erosion site, and was numbered as 01-ES; the remaining inadequate buffer sites were numbered consecutively along the remaining stream segments within the map. Each problem type was numbered, starting at 01 within a mad grid (i.e. 02-ES, 03-ES, 01-IB, 02-IB, etc.). This same numbering convention was implemented using the map grid within all subwatersheds.

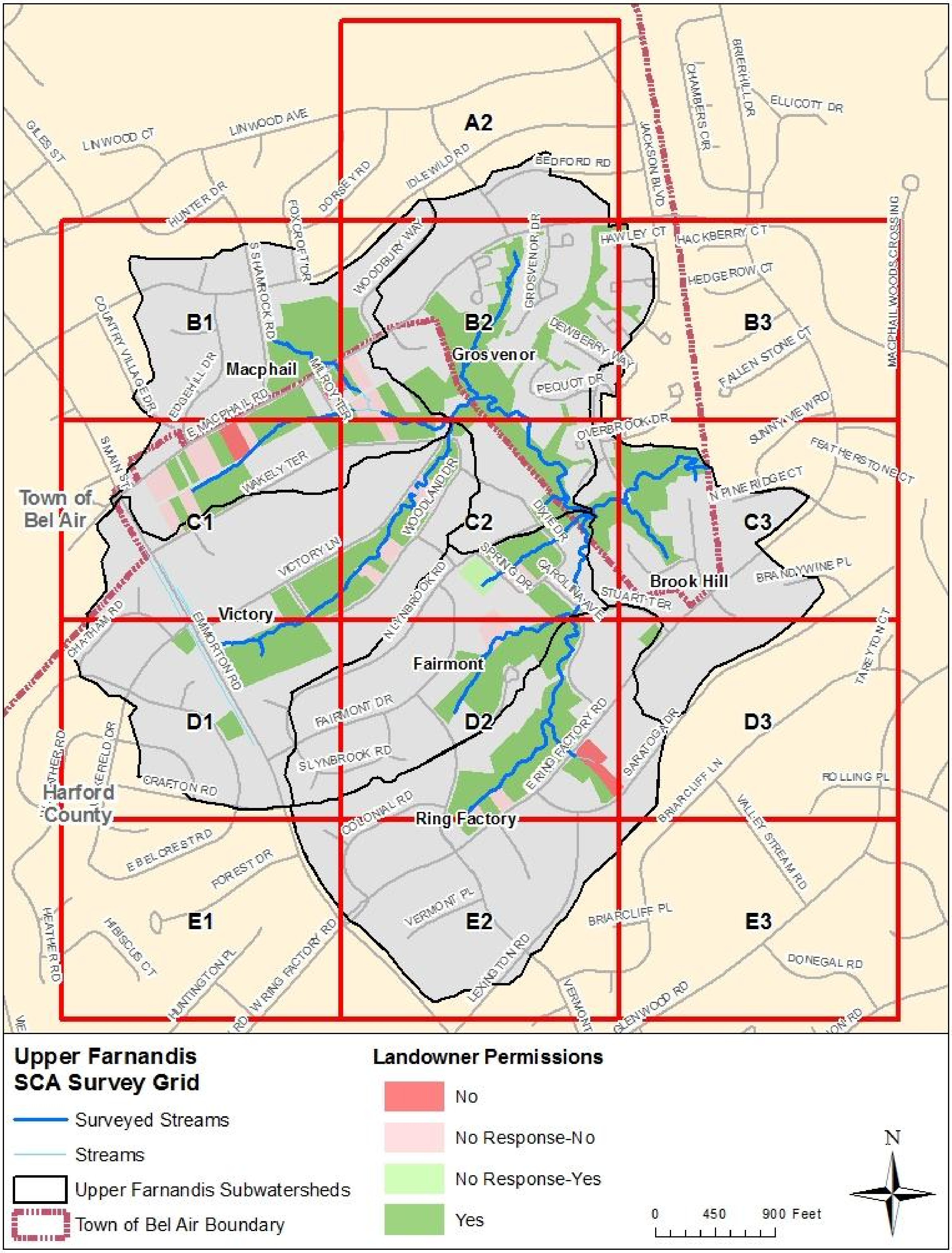

Figure 4-10: Upper Farnandis SCA Survey Grid and Map Numbers

4.4.3 GENERAL FINDINGS

Along the 3.4 miles of stream assessed within the Upper Farnandis watershed, 161 potential environmental problem sites were observed. The total number of problem sites observed within each subwatershed is summarized in Table 4-7.

Table 4-7: Upper Farnandis SCA Survey Results - Number of Potential Problems

Subwatershed	Inadequate Buffer	Erosion Sites	Trash Dumping	Fish Barriers	Pipe Outfalls	Exposed Pipes	Channel Alteration	Total
Brook Hill	0	14	0	0	0	2	1	17
Fairmont	5	12	0	0	5	2	4	28
Grosvenor	1	20	0	2	1	0	2	26
Macphail	9	9	0	0	7	0	3	28
Ring Factory	4	14	0	1	2	1	2	24
Victory	6	23	0	1	5	2	1	38
Total	*25*	*92*	*0*	*4*	*20*	*7*	*13*	*161*

Erosion sites were the most frequent problem observed (92) followed by inadequate buffers (25) and pipe outfalls (20). Trash dumping was not observed within the watershed. A summary of the lengths of channel alterations, erosion sites, and inadequate buffers are summarized in Table 4-8 for the Upper Farnandis watershed. A description of each potential problem category is provided in the proceeding sections.

Table 4-8: Upper Farnandis Subwatershed Survey Results – Length of Potential Problems

SUBWATERSHED	LENGTH OF CHANNEL ALTERATION (FT)	LENGTH OF EROSION (FT)	LENGTH OF INADEQUATE BUFFER (FT)
Brook Hill	68	2,934	0
Fairmont	355	2,195	1,430
Grosvenor	10	4,452	517
Macphail	134	1,203	2,610
Ring Factory	321	2,465	1,918
Victory	16	2,972	2,460
Total	*904*	*16,221*	*8,935*

INADEQUATE STREAM BUFFERS

Forested buffer areas along streams are important for improving water quality for flood mitigation as they provide stream bank stabilization through their root systems, reduce the rate of surface runoff, supply shade to streams, remove pollutants such as nutrients and sediments from runoff, and provide habitat for various types of terrestrial and aquatic life, including fish. For the SCA, a stream buffer was considered inadequate if it was less than 50 feet wide from the edge of either stream bank. Inadequate stream buffers were observed in five of the subwatersheds. The field teams identified 25 inadequate buffer sites with a total length of approximately 1.7 miles. This equates to approximately 50% of the total streams surveyed having inadequate buffer on one or both stream banks.

The severity of inadequate stream buffers was rated according to length and width. The most severe rating (very severe) of 1 would be given to inadequate buffer lengths with limited or no trees on either stream bank and no evidence that a tree buffer is beginning to form for a significant length of stream. The existing land use was also taken into consideration, such as pavement, lawn, or shrubs and trees. The highest inadequate buffer rating assigned in the assessed subwatersheds was a severe rating, which was given to six sites. Four of the sites were in Victory subwatershed while Ring Factory subwatershed contained two severe ratings. Two of the sites are shown in Figure 4-11. Most sites were rated between moderate (3) and minor (5). Stream buffer restoration potential depends on various factors such as accessibility, property ownership, and current land use. Many of the more severe inadequate buffer sites in the watershed were due to land clearing up to the stream banks in residential yards.

Figure 4-11: Examples of Severe (left) and Moderate (right) Inadequate Stream Buffer Locations in Upper Farnandis Watershed

Table 4-9 below summarizes the number of inadequate buffer sites associated with each severity rating. The total length of inadequate buffer in each subwatershed and the percentage of surveyed streams having inadequate buffer are also shown.

Table 4-9: Upper Farnandis SCA Survey Results - Inadequate Stream Buffers

	SEVERITY RATING						LENGTH		
	Severe			Minor					% of Surveyed
Subwatershed	1	2	3	4	5	Total	ft	mi	Streams
Brook Hill	0	0	0	0	0	0	0	0.0	0%
Fairmont	0	0	4	1	0	5	1,430	0.3	41%
Grosvenor	0	0	1	0	0	1	517	0.1	14%
Macphail	0	0	3	2	4	9	2,610	0.5	90%
Ring Factory	0	2	1	1	0	4	1,918	0.4	81%
Victory	0	4	0	1	1	6	2,460	0.5	80%
Total	*0*	*6*	*9*	*5*	*5*	*25*	*8,935*	*1.7*	50.2%

Most the inadequate buffer sites (57%) were in Macphail and Victory subwatersheds; approximately 50% of all streams assessed were identified as having some sort of inadequate buffer. Many of the inadequate buffers are due to residential lawns. Approximately 76% of the inadequate buffer sites ranked between minor to moderate in severity. Unshaded conditions can be detrimental to aquatic life as shade protects streams from excessive solar heating. A TMDL listing for temperature in the watershed indicates that unshaded reaches are currently experiencing solar heating. The locations of stream segments with inadequate buffers and their corresponding severity ratings are shown in Figure 4-12.

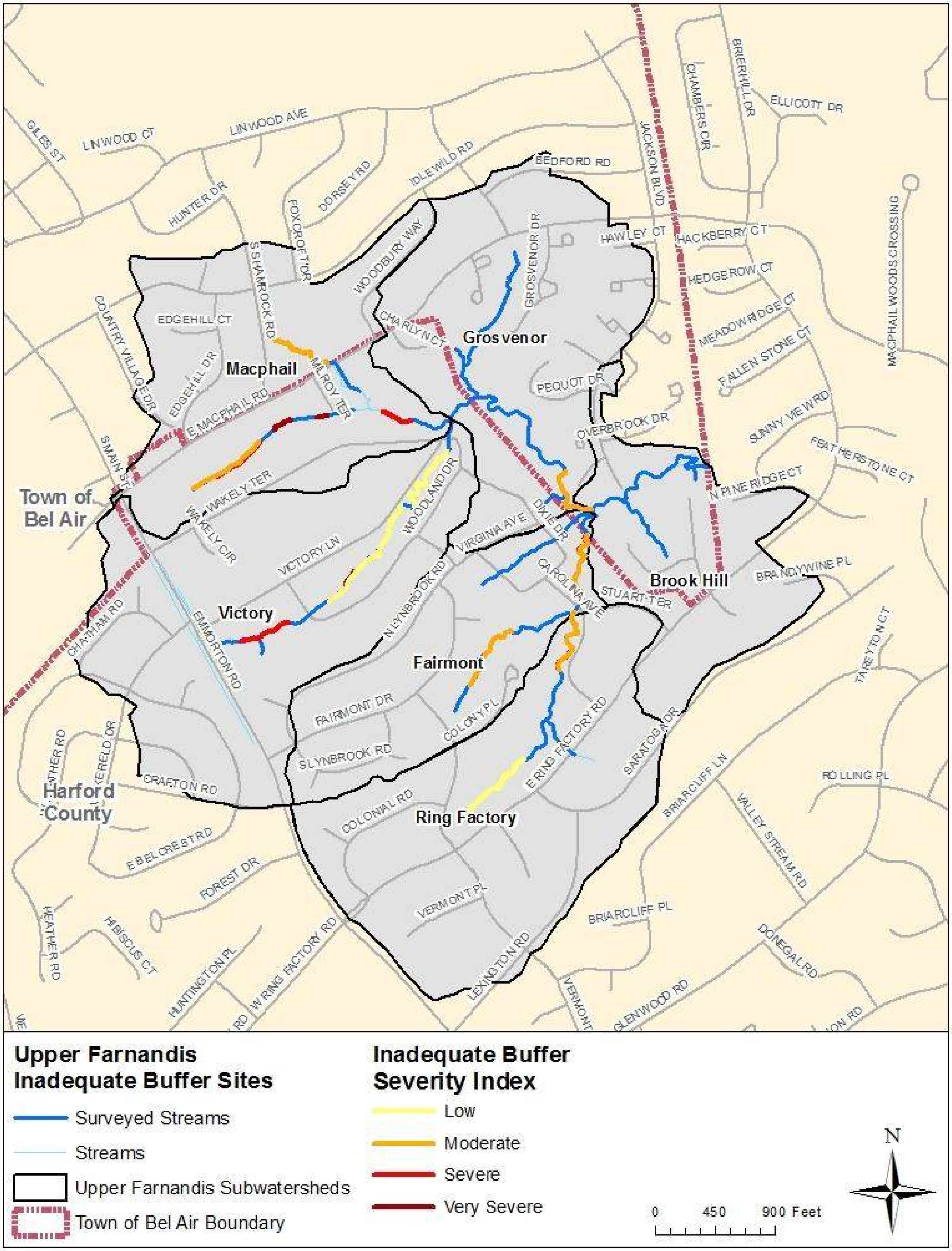

Figure 4-12: Inadequate Stream Buffer Locations in Upper Farnandis SCA

EROSION SITES

Stream bank erosion is a natural process necessary to maintain a healthy aquatic habitat. Conversely, too much erosion can have the opposite effect on a stream system by destabilizing banks, destroying in-stream habitat, and causing sediment pollution problems downstream. Significant erosion problems are the result of changes to stream hydrology or sediment supply which is often attributed to land use changes in a watershed (e.g., urbanization, increased impervious cover). This results in a much greater in-stream flow rate during storm events and leads to eroded streambeds and banks. Although streams in forested areas may have adequate 50-foot forest buffers, they can also experience erosion problems due to these high flows from upstream.

Because erosion is a natural process, it was not the purpose of the SCA survey to identify every erosion occurrence. Significant erosion sites were defined by vertical stream banks with exposed soil and overall instability. The type of erosion, possible cause, adjacent land use, and whether there was a threat to nearby infrastructure were noted for each erosion site. Table 4-10 summarizes the number of erosion sites identified in the Upper Farnandis subwatersheds and their severity rating.

Table 4-10: Upper Farnandis SCA Survey Results - Erosion Sites

	SEVERITY RATING						LENGTH*		
	Very Severe				Minor				% of Surveyed Streams
Subwatershed	1	2	3	4	5	Total	ft	mi	
Brook Hill	2	1	3	1	7	14	2,934	0.6	136.6%
Fairmont	1	1	0	7	3	12	2,195	0.4	63.4%
Grosvenor	0	2	6	11	1	20	4,452	0.8	116.9%
Macphail	0	1	5	1	2	9	1,203	0.2	41.3%
Ring Factory	0	3	4	7	0	14	2,465	0.5	103.5%
Victory	2	1	6	8	6	23	2,972	0.6	96.3%
Total	*5*	*9*	*24*	*35*	*19*	*92*	*16,221*	*3.1*	*91.2%*

*left and right banks are counted individually and stream length may overlap in some cases

A total of 92 erosion sites were documented. Erosion was the most documented problem identified from the SCA surveys. The length of stream channel identified with erosion totaled 3.1 miles (although left and right bank were summed individually and in some cases, may overlap). During the Upper Farnandis stream assessments, the channel condition of erosion sites was classified as one of four stages, based on a condensed version of the Channel Evolution Model (CEM): Stage I- Incision, Stage II- Widening, Stage III- Deposition; and Stage IV- Recovery and Reconstruction. This classification helps identify the direction of current trends in a stream channel and match restoration solutions to its current behavior. The channel condition for nearly all the erosion sites were Stage II Widening (87.1%). The remainder of the sites were Stage I – Incision. Stage I Incision describes a channel that is downcutting, which liberates sediment and creates unstable banks. Stage II Widening often results in widespread bank failures as high flows undercut banks because they can no longer access the floodplain; the most significant erosion hazard occurs during this phase. Stage II- Widening is usually found at a meander bend and/or associated with steep slopes. Some of this type of erosion could be described as a natural process. All five of the “very severe” erosion sites were classified as Stage II-Widening and four of the sites were in first order or headwater tributaries. Streams in the incision stage have the most potential for prolonged degradation and may contribute large amounts of sediment downstream through the channel evolution process.

The severity of the stream segments led to the development of five potential stream projects. These projects will be discussed in detail in Chapters 5 and 6; however, it is important to note the degree of erosion seen in the proposed project stream reaches during the field assessment. Table 4-11 provides the length of erosion by severity seen at each proposed stream project. The table also includes the sum of the moderate to very severe erosion for each proposed project, the stream bank total including the sum of both stream banks, and the percentage of moderate to very severely eroded stream banks throughout each project. The Fairmont Stream and Outfall Restoration project has the highest percentage of moderate to very severely eroded stream banks while Macphail Stream Restoration has no moderate to very severely eroded banks.

Table 4-11: Erosion Lengths by Severity for Each Potential Stream Restoration Project

	Low Severity	Minor	Moderate	Severe	Very Severe	Erosion (Moderate to Very Severe)	Stream Bank Total (includes both banks)	% Moderate to Very Severe
Fairmont Stream and Outfall Restoration	127.3			508.3	659.6	1,295.3	1,828.0	63.89%
Ring Factory Stream Restoration	716.6		714.3	994.3		2,425.2	4,358.0	39.21%
Victory Stream and Outfall Restoration	634.6	388.8	967.5	72.3	148.7	2,212.0	4,396.0	27.04%
Macphail Stream Restoration		841.8				841.8	1,122.0	0.00%
Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration	1,725.6	350.4	2,789.6	1,119.0	983.8	6,968.4	9,580.0	51.07%
Total	3,204.1	739.2	5,313.2	2,693.9	1,792.1	13,742.6	21,284.0	64.57%

Figure 4-13 shows an example of two very severe erosion site. The figure on the left is of site D2-ES-04, a very severe erosion site with six to nine-foot vertical bank heights over a 650-foot distance. The figure on the right is of site C2-ES-15, a very severe erosion site in Fairmont with nine-foot vertical bank heights over a 70-foot distance. The edge of pavement on Victory Road can be seen from the stream channel. Both erosion sites are widening. The location of all erosion sites can be seen in Figure 4-14.

Figure 4-13: Example of a Very Severe Erosion Site in Fairmont (Left) and a Very Severe Erosion Site in Victory (Right)

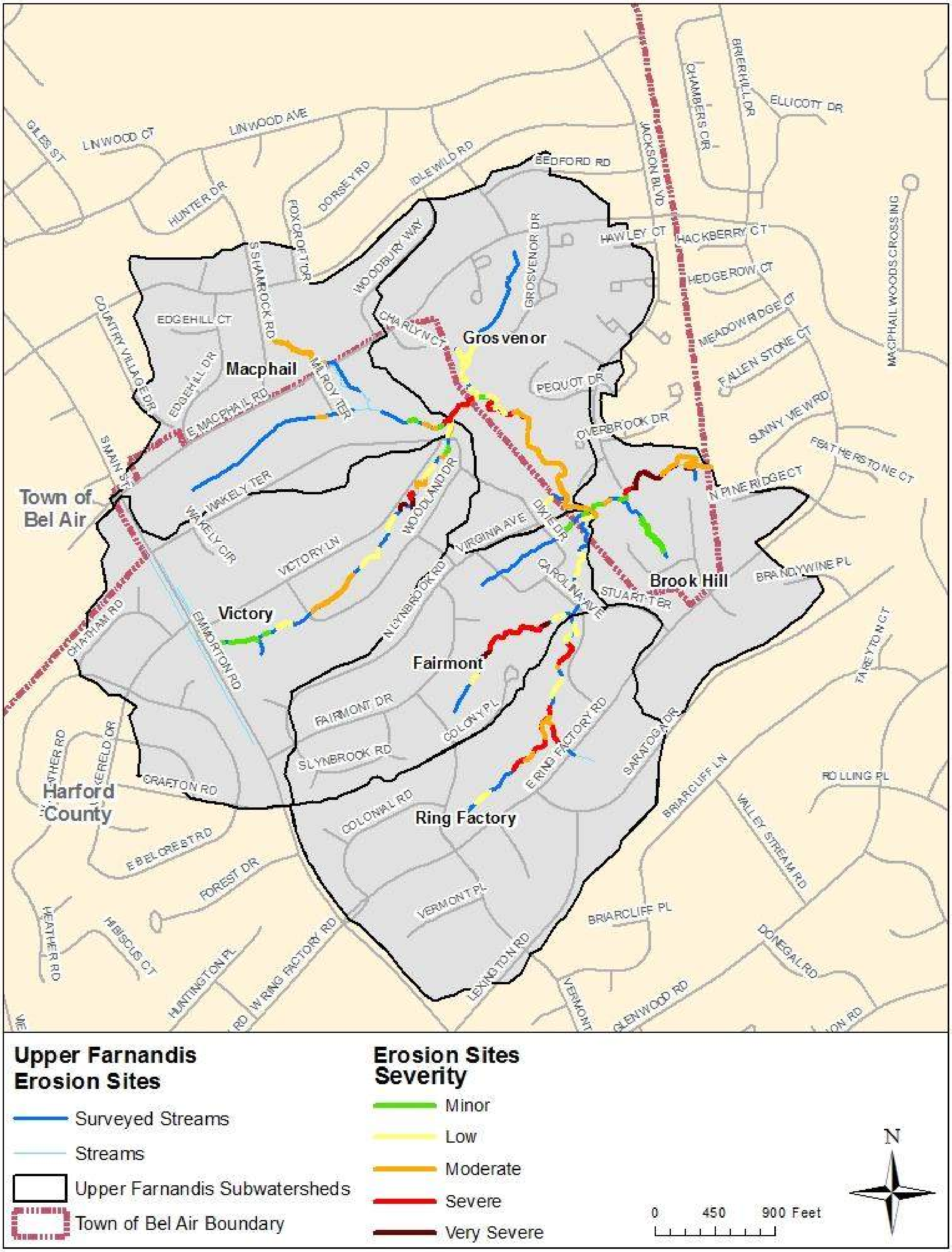

Figure 4-14: Location of Erosion Sites in the Upper Farnandis Watershed

FISH MIGRATION BARRIERS

Fish migration barriers refer to anything in the stream that significantly interferes with the upstream movement of fish. Unobstructed upstream movement is important for various species of fish that move up and downstream during different cycles of their life such as spawning. Fish barriers can reduce the fish population and diversity in stream sections. These barriers include manmade structures such as dams or roadway culverts and natural features such as waterfalls or debris jams. Three main problems regarding fish barriers were evaluated when identifying blockages:

1) vertical drop is too high (>6 inches) for fish to swim over;
2) water depth is too shallow such as when water is spread over a large area at channelized sections or road crossings; and
3) water is moving too fast such as when a steep culvert pipe is discharging high velocity flow.

The variety of barrier is also noted, including man-made dam, debris dam, road or pipe crossing, natural falls, beaver dam, pond, or other causes.

The severity of the barrier was rated based on location in the stream network and whether the blockage was total, partial, or temporary. A fish migration barrier was considered very severe when a structure completely blocked a large stream. A minor rating was assigned to temporary and/or natural fish barriers that blocks little in-stream habitat. Locations of fish migration barrier sites are shown on Figure 4-19. Table 4-12 summarizes the number of fish migration barrier sites identified in the Upper Farnandis watershed and their severity rating.

Table 4-12: Upper Farnandis SCA Survey Results - Fish Passage Barriers

	SEVERITY RATING					
	Very Severe				Minor	
Subwatershed	1	2	3	4	5	Total
Brook Hill	0	0	0	0	0	0
Fairmont	0	0	0	0	0	0
Grosvenor	0	0	1	1	0	2
Macphail	0	0	0	0	0	0
Ring Factory	0	0	1	0	0	1
Victory	0	0	0	0	1	1
Total	*0*	*0*	*2*	*1*	*1*	*4*

Figure 4-15 shows two moderate fish barriers where the drop between the culvert and the natural channel is too high for the fish to pass and/or too shallow. In all cases, the location of the fish barrier within the subwatershed has an impact on the severity rating.

Figure 4-15: Example of a Moderate Fish Barrier where a Gabion Basket Blocks a Tributary to the Main Stem (Left) and Moderate Bedrock Fish Barrier (Right)

PIPE OUTFALLS AND EXPOSED PIPES

Pipe outfalls include pipes or small manmade channels that discharge into the stream. They are considered a potential environmental problem because they can carry uncontrolled runoff and pollutants such as oil, heavy metals, and nutrients into a stream system. Pipe outfalls can also create significant erosion problems as high flows without proper velocity dissipation can lead to extensive erosion and scour in the receiving channel; separate erosion sites were also documented if necessary at pipe outfall locations. The severity rating for a pipe outfall was primarily based on the discharge including whether discharge was present, color, odor, amount, and downstream impacts (not including erosion, which was assessed separately). A total of 20 pipe outfalls were surveyed during the SCAs in Upper Farnandis (Table 4-13). The highest severity rating for pipe outfalls was minor, shown in Figure 4-16.

Table 4-13: Upper Farnandis SCA Survey Results - Pipe Outfalls

	SEVERITY RATING					
	Very Severe				Minor	
Subwatershed	1	2	3	4	5	Total
Brook Hill	0	0	0	0	0	0
Fairmont	0	0	0	0	5	5
Grosvenor	0	0	0	0	1	1
Macphail	0	0	0	0	7	7
Ring Factory	0	0	0	0	2	2
Victory	0	0	0	0	5	5
Total	*0*	*0*	*0*	*0*	*20*	*20*

Figure 4-16: Minor Pipe Outfalls

Exposed pipes were also assessed and include any pipes that are in the stream or along the stream's immediate banks that could be damaged by a high flow event. Exposed pipes include manhole stacks, pipes exposed along the stream banks or under the stream bed, and pipes built over a stream but that are low enough to be affected by frequent high storm flows. These pipes can be vulnerable to puncture by debris in the stream and pose a threat to water quality depending on the contents within the pipe.

Seven exposed pipes were observed during the Upper Farnandis SCAs (Table 4-14). The exposed pipes are located within four different subwatersheds. Two pipes were found protruding up from the bottom of the stream bed. One of these exposed pipes was within the Fairmont subwatershed (Figure 4-17, left). A sewer manhole was also found exposed along the right bank of the Victory subwatershed (Figure 4-17, right).

Table 4-14: Upper Farnandis SCA Survey Results - Exposed Pipes

	SEVERITY RATING					
	Very Severe				Minor	
Subwatershed	1	2	3	4	5	Total
Brook Hill	0	1	1	0	0	2
Fairmont	1	1	0	0	0	2
Grosvenor	0	0	0	0	0	0
Macphail	0	0	0	0	0	0
Ring Factory	0	0	0	1	0	1
Victory	1	1	0	0	0	2
Total	*2*	*3*	*1*	*1*	*0*	*7*

Figure 4-17: Exposed Pipes in the Fairmont (left) and Victory (right) subwatersheds

CHANNEL ALTERATIONS

Channel alterations refer to significantly altered channel or stream banks from their naturally occurring structure or condition. This includes channelized stream sections where a stream channel has been straightened, widened, deepened, or lined with concrete or rock. This can increase flow rates and decrease habitat and nutrient uptake in the waterway.

Channelized streams are typically intended to convey more water and to prevent flooding but often create adverse environmental impacts such as impairing habitat and increasing water temperature. Table 4-15 summarizes the number and length of channel alteration sites in each subwatershed and their associated severity rating. Locations of channel alteration sites are shown on Figure 4-19.

Table 4-15: Upper Farnandis SCA Survey Results - Channel Alterations

	SEVERITY RATING						LENGTH		
	Severe				Minor				
Subwatershed	1	2	3	4	5	Total	ft	mi	% of Surveyed Streams
Brook Hill	0	0	0	0	1	1	68	0.01	3.2%
Fairmont	0	0	0	0	4	4	355	0.07	10.3%
Grosvenor	0	0	0	0	2	2	10	0.00	0.3%
Macphail	0	1	0	1	1	3	134	0.03	4.6%
Ring Factory	0	1	0	1	0	2	321	0.06	13.5%
Victory	0	0	0	0	1	1	16	0.00	0.5%
Total	*0*	*2*	*0*	*2*	*9*	*13*	*904*	*0.2*	5.1%

A total of 13 channel alteration sites were documented during the survey for a total length of 904 feet or 5.1% of the entire stream lengths surveyed. Severe channel alterations were the highest ranking for the Upper Farnandis watershed. The remaining sites inventoried for channel alterations, ranked either low severity or minor. A series of channel alterations were professionally designed to protect several private properties using imbricated rock walls. One severe channel alteration involves a concrete channel where sediment has filled the entrance to the concrete channel and defined a new earthen channel to the right of the concrete channel (Figure 4-18, left). A common type of channel alteration observed throughout the Upper Farnandis watershed was grouted stone placed along the channel and banks for stabilization (Figure 4-18, right). Several channel alteration sections identified in the Upper Farnandis watershed consist of longer stream lengths and may represent an opportunity for water quality improvements. Many channel alterations are expensive and challenging to correct.

Figure 4-18: Examples of two severe Channel Alterations to convey flow under a roadway (Left) or by hardening the channel (Right)

TRASH DUMPING

Trash dumping sites are locations where large amounts of trash are inside the stream corridor; either as a site of deliberate dumping or as a place where trash tends to accumulate (often because of wind or storm drainage). Identifying trash dumping sites serves two main purposes: 1) to limit access to the areas of the stream corridor where dumping and accumulation is a problem and 2) to encourage volunteer stream clean-ups which promote community involvement and raises awareness among the community of the condition of their local streams. No trash dumping sites were observed throughout the Upper Farnandis watershed.

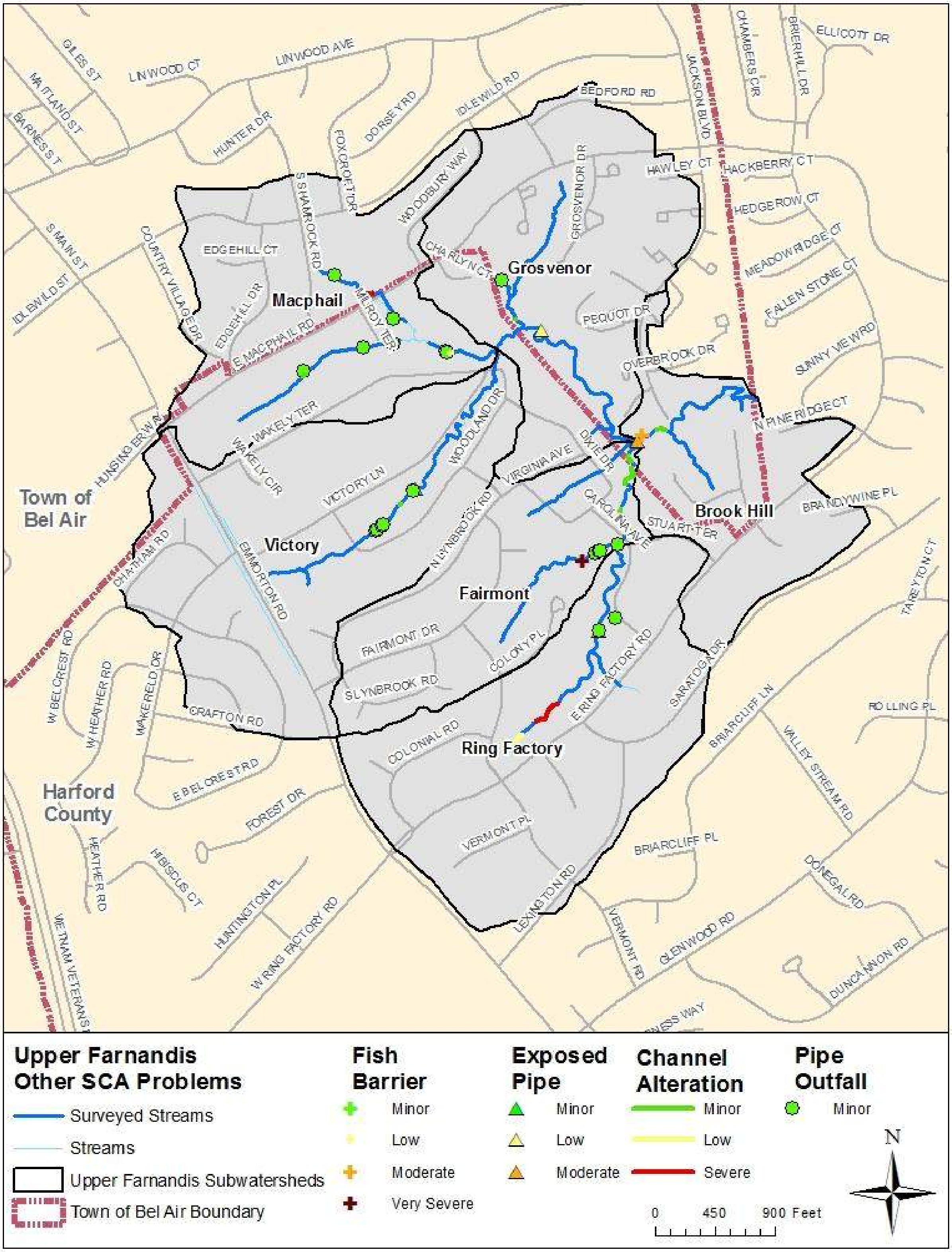

Figure 4-19: Location of Other SCA Problem Sites in the Upper Farnandis Watershed

4.5 SUBWATERSHED ASSESSMENTS

Following the general field findings, an assessment of each subwatershed was performed to assist in the development of proposed projects for the Upper Farnandis watershed. Each subwatershed assessment summarizes the location of the subwatershed, watershed characteristics, and field findings, including threats to infrastructure.

4.5.1 BROOK HILL SUBWATERSHED

Brook Hill subwatershed encompasses a portion of Upper Farnandis Branch to the outlet. The subwatershed includes the southern half of Jackson Boulevard, north to Dewberry Way. The subwatershed stretches to the south to Saratoga Drive and includes the East Brook Hill Court and Raspberry Hill Court neighborhoods. Part of East Ring Factory Road also drains to the main stem. Brook Hill subwatershed has the highest percentage of forested land use in the watershed at 13.2 percent. The remaining land use for the subwatershed consists of medium and low density residential. Brook Hill is 53 acres of mostly type B soils. The subwatershed is 15 percent impervious or 8 acres of impervious area.

There is one tributary, B-T1, that conveys runoff from portions of the East Brook Hill Court and Raspberry Hill Court neighborhoods as well as a portion of East Ring Factory Road. The tributary stream banks are between 6 inches and 3 feet high. There are several debris jams from tree branches and plywood that have led to channel braiding in the middle segment of the tributary. Overall, the tributary appears stable.

Two existing BMP facilities are present within the subwatershed. They are designed for water quantity and do not currently provide water quality treatment. These facilities receive runoff from the East Brook Hill Court and Raspberry Hill Court neighborhoods. Both outfalls are stable.

Outfall 8 conveys runoff from Jackson Boulevard to the main stem. The outfall structure is exposed and protruding over the stream. Currently, two large trees are providing bank stability just upstream of Outfall 8. With additional erosion and the loss of these trees, the end of Jackson Boulevard is in jeopardy. The stream banks downstream of outfall 8 are severely eroded. Bank heights range from 4 to 7 feet.

4.5.2 FAIRMONT SUBWATERSHED

The Fairmont subwatershed encompasses a drainage area of 58 acres. The upper portion of the drainage area includes South Lynbrook Road, Fairmont Drive, and North Lynbrook Road. The subwatershed extends east of Dixie Drive. Medium and low density residential land uses span the entire subwatershed with most the subwatershed in medium density residential land use, 62.6%. The buildings, roads, and driveways within this subwatershed account for 13 acres of impervious area or 22% of the subwatershed.

There are 3 tributaries and a portion of the main stem within this subwatershed. Tributary F-T2 is an intermittent channel fed by roadway runoff from outfall 37. Runoff from this tributary flows into tributary F-T1, which is a perennial stream, experiencing very severe erosion. Outfall 24, located in the backyard of 130 Fairmont Drive, conveys a large volume of runoff, likely causing the downstream erosion. The stream length for this reach is approximately 850 feet long with 760 feet of eroded banks. Bank heights range from 2 to 8 feet along tributary F-T1. A second outfall directs runoff from a cul-de-sac to the stream. Steep slopes are present above the right bank while the properties to the north of the left bank have more gradual slopes. A private pond, fed by tributary F-T1, is located just above the confluence with the main stem. The lower portion of the stream reach has more gradual slopes with a forested floodplain and a natural spring south of the right bank.

Tributary F-T3 is a spring fed tributary that begins west of Spring Drive as an undefined channel. Once the flow crosses under Spring Drive, a stable channel forms, conveying flow under Dixie Road. A property owner on Dixie road mentioned that a larger culvert had been installed under Dixie Road during the previous homeownership. Since then, the property has not experienced flooding issues. There is some erosion downstream of Dixie Road. The banks are 2 feet high and the erosion is considered minor. Some additional erosion occurs at the confluence with the main stem. The stream flows underground for approximately 20 feet. When the stream resurfaces, the channel bed is approximately 4 feet lower. This erosion may be due to a headcut from the lower channel bed of the main stem.

Both F-T2 and F-T3 flow into the main stem at different locations within the subwatershed. The portion of the main stem within the Fairmont subwatershed has multiple channel alteration segments. Property owners have previously worked with the County to have imbricated rock walls installed on portions of the right and left banks between Carolina Avenue and the Brook Hill Manor Community HOA. Minor erosion was observed on stream banks between the imbricated rock wall segments.

There are currently no stormwater controls within this subwatershed.

4.5.3 GROSVENOR SUBWATERSHED

The Grosvenor subwatershed encompasses a drainage area of 86 acres, reaching Bedford Road to the north, and Jackson Boulevard to the east. The subwatershed outfalls to the main stem south of Spindle Hill Court. Grosvenor has the second highest percentage of forest in the watershed at 9.1%. Over 90% of the subwatershed is made up of low, medium, and high density residential land use. At 26.1 percent, this subwatershed has the highest percentage of high residential land use in the watershed. There are 17 acres of impervious area within this subwatershed. The impervious area accounts for 20% of the area within the subwatershed.

There are 4 tributaries in the Grosvenor subwatershed. G-T2 originates at the headwaters of the subwatershed and receives stormwater flow from Outfall 2. Impervious runoff from East Macphail Road enters the stream channel. Outfall 3 provides additional stormwater flow from the Cheswold Court townhomes on the right bank of G-T2. Tributary G-T2 flows through existing BMP 3. The BMP provides water quantity control measures and is stable. Outfall 4 is the outlet for existing BMP 3 and is also stable. Tributary G-T2 continues south until it outfalls to tributary G-T1.

Outfall 21 conveys stormwater from Charlyn Court to tributary G-T3. Tributary G-T3 is approximately 160 feet long and flows into G-T2. Tributary G-T1 receives flow from tributaries in the Macphail and Victory subwatersheds. Tributary G-T1 is a mostly forested stream reach with a large portion of the stream reach within the Bradford Village Association HOA property. Moderate erosion is evident along most of the 2000 feet reach. The bank heights along this stream reach are between 3 and 6 feet high. Outfalls 5, 6, and 7 are located along the right bank of G-T1. Outfall stabilization may be an option at outfall 5 and outfall 7 in conjunction with a stream restoration project. Tributary G-T4 is a 284 feet stream reach that outfalls near the lower segment of G-T1. There is some minor erosion along G-T4; however, the tributary disperses across the floodplain before entering G-T1. Tributary G-T1 outfalls to the Upper Farnandis Branch south of Spindle Hill Court. The outlet is mostly blocked by a gabion basket.

4.5.4 MACPHAIL SUBWATERSHED

The Macphail subwatershed encompasses a drainage area of 84 acres. The drainage includes Idlewild Road to the north, Wakely Terrace to the south and South Main Street to the west. The subwatershed outfalls to tributary G-T1 near the intersection of Wakely Terrace and Victory Lane. Eleven percent of the subwatershed is in commercial land use, which is the highest percentage of all the subwatersheds. The subwatershed also has 0.7 percent institutional, which is the second highest percentage in the watershed. The remainder of the land use within the subwatershed is low, medium, and high density residential. Twenty-two acres of impervious area cover the Macphail subwatershed. This accounts for 26% of the total area of subwatershed, which is the highest percentage of all the subwatersheds in the Upper Farnandis watershed.

There are two tributaries in the Macphail subwatershed. A small portion of the two tributaries were unable to be assessed due to restricted access by the property owners. Tributary M-T1 begins at Outfall 1, just east of South Shamrock Road. Moderate erosion occurs along M-T1 between South Shamrock Road and East Macphail Road. Upstream of East Macphail Road, sediment has accumulated prior to a concrete channel. The stream is now bypassing a portion of the concrete channel before flowing through a culvert under East Macphail Road. South of East Macphail Road, flow discharges from Outfall 14.

Tributary M-T2 captures runoff from residential properties and conveys the flow to M-T1. There two pipe segments that convey flow underground along M-T2 before resurfacing. Outfall 20 conveys stormwater runoff from East Macphail Road to the left bank of M-T2. The confluence of M-T2 with M-T1 is in the backyard of 291 Wakely Terrace. Downstream of the confluence, there is a gabion basket channel alteration and some isolated moderate erosion along the banks.

The outlet for Macphail occurs at the confluence of M-T1 with G-T1 at 305 Wakely Terrace. There are currently no stormwater management controls within this subwatershed.

4.5.5 RING FACTORY SUBWATERSHED

The Ring Factory subwatershed encompasses a drainage area of 106 acres. This is the largest of the six subwatersheds and only includes residential neighborhoods. The drainage area extends nearly to South Main Street to the west, Lexington Road to the south, and Colony Place to the north. The subwatershed outfalls to the main stem in the Fairmont subwatershed west of Carolina Avenue. The Ring Factory subwatershed is the only subwatershed with designated open urban land use. This land use encompasses the Christ Our King Presbyterian property in the southwestern portion of the subwatershed. The remainder of the land use in the subwatershed is low and medium density residential, 93.2 percent. The impervious area within this subwatershed covers 19 acres and accounts for 18% of the subwatershed area.

Ring Factory subwatershed consists of one tributary, R-T1, and the headwaters of the main stem. Nine outfalls are located within this subwatershed and there are currently no stormwater controls in the subwatershed. Tributary R-T1 is believed to originate from outfall 36; however, the outfall for the curb inlets on Saratoga Road was not located due to restricted property access. A concrete junction box was located at the GIS location for outfall 36 and a gully was observed behind the property leading towards East Ring Factory Road. An endwall northeast of East Ring Factory Road conveys flow from the tributary under the road and from East Ring Factory Road through two outfalls. Outfalls 27 and 28 are on the wing walls of the outfall structure. The tributary is steep from the outfall to the main stem. Erosion has occurred downstream of the outfall protection. At the erosion sites, the banks range in height from 3 to 10 feet.

The main stem is fed by outfalls 34 and 35. Flow was observed at the outfalls and the stream is believed to be perennial. The outfalls are part of one outfall structure. A concrete/rock mixture has been used downstream of the outfall to stabilize the stream at the headwaters. Minimal erosion was observed at the channel alteration sites; however, at the end of the second channel alteration, moderate erosion was observed on both banks for 650 feet. Bank heights ranged from 4 to 8 feet along this segment of stream.

Outfall 41 conveys intermittent flow from Carolina Avenue and Ring Factory Road. The dry channel is stable. Outfall 26 conveys flow from Carolina Avenue and Ring Factory Road to the main stem, just upstream of the culvert crossing under the driveway of 4 Carolina Avenue. Moderate erosion and a sinuous stream were noted downstream of the culvert. One bend in the stream may soon become a threat to the edge of Carolina Avenue. The stream bank is currently 5 feet from Carolina Avenue. Outfall 29 conveys flow from Carolina Avenue to the main stem. Flow from the outfall enters the main stem at the subwatershed outlet, just upstream of the double culvert crossing under Carolina Avenue.

4.5.6 VICTORY SUBWATERSHED

The Victory subwatershed encompasses a drainage area of 100 acres. The subwatershed extends west of South Main Street to Crafton Road and includes the entire length of Victory Lane. The subwatershed outlet is north of the Wakely Terrace and Victory Lane intersection. Victory subwatershed has the highest percentage of institutional and the second highest percentage of commercial land use in the watershed, 2.2% and 4.6%, respectively. The remainder of the subwatershed is very low, low, and medium density residential. This subwatershed is the only one to have very low density residential land use. The impervious area within this subwatershed accounts for 23% of the drainage area and covers 23 acres.

There are two tributaries in the subwatershed, V-T1 and V-T2. V-T2 conveys flow from a commercial parking lot, Heather Road, Belcrest Road, and Sherwood Road. There is a large scour hole at the outfall. The tributary has bank heights between 6 inches and 3 feet. High flows have created multiple side channels that outfall to tributary V-T1 in multiple locations.

The headwaters of tributary V-T1 originate at South Main Street with an SHA-maintained endwall. The flow is intermittent at this location. An SHA-owned BMP facility located south of Victory Lane outfalls (Outfall 38) to V-T1. Downstream of outfall 38, flow is perennial. In the backyard of 110 Victory Lane, prior to outfall 18, the channel is experiencing incision. According to the homeowner, the majority of the change in the stream channel occurred after one storm a couple of years ago. The channel banks increase from 2 feet upstream of the incision to 4 feet high. The stream banks return to 1 to 2 feet high about 115 feet downstream of the beginning of the incising location.

Flow is conveyed under Woodland Drive where moderate erosion has occurred. Stream banks range in height from 3 to 10 feet in the stream segment between the Woodland Drive culvert and the Wakely Terrace culvert. There are several threats to infrastructure in this subwatershed, including an exposed manhole. One sharp bend in the stream has exposed the edge of pavement at Victory Lane while another bend in the stream is undercut and within 10 feet of the edge of a home. A portion of the stream was not accessible due to restricted access.

Outfall sites 32, 16, and 15 were manholes and junction boxes, not outfalls, while outfalls 13 and 11 were culverts. The SHA-owned BMP is the only stormwater control in the subwatershed and treats runoff for a portion of South Main Street.

5 RESTORATION STRATEGIES

5.1 INTRODUCTION

This chapter presents an overview of the key restoration strategies and associated pollutant load reductions proposed for restoring and preserving the Upper Farnandis watershed. Local governments can implement large capital projects such as stream restoration, large-scale stormwater retrofits, changes in municipal operations, and large-scale public awareness.

The watershed pollutant loading analysis performed to estimate current nutrient loads generated by the various non-point sources within the Upper Farnandis watershed is discussed in Section 5.3.1 and Section 5.3.2 discusses the pollutant removal calculations for proposed practices to ensure that regulatory requirements are met in Upper Farnandis.

5.2 MUNICIPAL STRATEGIES

Harford County works to restore local streams and improve water quality through capital improvement projects. This plays an important role in the implementation of restoration opportunities. Key municipal strategies proposed for restoring the Upper Farnandis watershed are discussed in the following sections.

5.2.1 STORMWATER MANAGEMENT

Increased importance of water quality and water resource protection has led to the development of the Maryland Stormwater Design Manual which provided BMP design standards and environmental incentives (MDE, 2000). Since that time there has been a general shift towards adopting low-impact practices that mimic natural hydrologic processes and achieve pre-development conditions. The Maryland Stormwater Act of 2007 takes those principles one step further and requires that environmental site design (ESD) be implemented to the maximum extent practicable via nonstructural BMPs and/or other better site design techniques. The intent of ESD BMPs is to distribute flow throughout a development site and reduce stormwater runoff leaving the site. This will also reduce pollutant loads and prevent stream channel erosion.

EXISTING STORMWATER MANAGEMENT

A total of 10 existing stormwater management facilities are located within the Upper Farnandis watershed including underground detention, infiltration practices, filtration practices, and extended detention. Existing stormwater management (SWM) facilities treat a total drainage area of approximately 41.6 acres of land or approximately 8.5% of the watershed.

STORMWATER RETROFITS

Stormwater retrofits involve modifying existing BMPs that may not currently help improve water quality. Stormwater retrofits improve water quality by capturing and treating runoff before it reaches receiving water bodies. Based on initial field and desktop evaluations, three existing BMP sites with sufficient space for stormwater retrofits to treat runoff from impervious parking lots or roadways were identified. These sites are in multiple HOA areas as well as the Town of Bel Air.

NEW STORMWATER BEST MANAGEMENT PRACTICE FACILITIES

New stormwater BMPs are implemented in existing developed areas where SWM practices do not currently exist to help improve water quality. Based on initial field and desktop evaluations, two sites with sufficient open space for placement of new stormwater BMPs to treat runoff from impervious parking lots or roofs were identified. These two sites are located on institutional properties.

STREAM RESTORATION

Stream restoration practices are used to enhance the aquatic function, appearance, and stability of stream corridors. Stream restoration practices range from routine, simple stream repairs such as vegetative bank stabilization and localized grade control to comprehensive repairs such as full channel redesign and realignment. Stream corridor assessments (SCAs) performed in the Upper Farnandis watershed identified restoration opportunities for stream repair and outfall stabilization. Stream segments identified during the SCAs with significant erosion and channel alteration are used to estimate pollutant load reductions which would result from stream repair efforts. Stabilizing the stream channel improves water quality by preventing soil and the pollutants contained in them, from eroding into the stream and receiving waters. Lengths of eroded and altered channel segments were recorded during the SCAs.

5.3 POLLUTANT LOADING & REMOVAL ANALYSIS

This section presents results of the watershed pollutant loading analysis performed to estimate current nutrient and sediment loads generated by the various non-point within the Upper Farnandis watershed. Also discussed are the pollutant removal calculations for proposed BMPs and stream restoration projects to provide options for meeting the TMDL requirements in the Upper Farnandis watershed.

5.3.1 LAND USE POLLUTANT LOADING

A land use analyses was performed by Harford County for the Bynum Run 8-digit watershed, located entirely within Harford County. As part of this analysis, Harford County derived watershed-specific pollutant loading rates for nitrogen, phosphorus, and sediment based on the Bayfast Watershed Model. The Bayfast Watershed Model was run in January 2018 to develop the pollutant load for each pollutant across different land uses. The load for each pollutant was divided by the urban and non-urban land uses (acres) for that pollutant to develop the Bynum Run pollutant loading rates in Table 5-1.

Table 5-1: Bynum Run Annual Pollutant Loading Rates for Land Use Classifications (lbs./acre/yr.)

WRE Land Cover	Nitrogen Per Acre	Phosphorus Per Acre	Sediment Per Acre
Impervious Urban	17.69	1.61	748
Pervious Urban	13.40	0.32	111
Cropland	30.31	1.13	823
Forest	3.76	0.07	56
Water*	-	-	-

*Nutrient loadings from water were not included in the analysis

As presented in Chapter 2, land use information for the Upper Farnandis watershed was obtained from Maryland's Department of Planning (MDP's) 2010 land use/land cover (LU/LC) GIS spatial data. For purposes of the watershed pollutant loading analysis, a consolidated version of MDP's LU/LC classifications is used because loading rates do not differ significantly between certain land use classes (e.g., various forest types). The MDP LU/LC categories present in the Bynum Run watershed and the corresponding Water Resources Element (WRE) land use classes used for the pollutant loading analysis are summarized in Table 5-2.

Table 5-2: Reclassification of MDP LU/LC to Water Resources Element (WRE) Land Use for Bynum Run Watershed

MDP LU/LC Classification	WRE Land Cover
11 Low Density Residential	Urban*
12 Medium Density Residential	Urban*
13 High Density Residential	Urban*
14 Commercial	Urban*
16 Institutional	Urban*
18 Open Urban Land	Urban*
21 Cropland	Cropland
41 Deciduous Forest	Forest and Wetlands
50 Water	Water

*These categories were split into pervious urban and impervious urban areas using Harford County roads and buildings spatial data.

Pollutant loading rates are impacted by impervious cover; therefore, Upper Farnandis urban land uses from MDP land use/land cover dataset are split into urban pervious and urban impervious to account for the effect on pollutant loading rates. Total acreages of each WRE land use category were calculated for the Upper Farnandis watershed. These were multiplied by the corresponding loading rates presented in Table 5-1, yielding annual pollutant loads for total nitrogen, total phosphorus, and total sediment from the watershed. The total annual land use pollutant loadings calculated for the Upper Farnandis watershed are summarized in Table 5-3.

Table 5-3: Upper Farnandis Land-Use Nitrogen, Phosphorus, and Total Suspended Solids Loads

		NITROGEN		PHOSPHORUS		SEDIMENT	
WRE Land Use	Area (acres)	Loading Rate (lbs/ac)	Load (lbs)	Loading Rate (lbs/ac)	Load (lbs)	Loading Rate (lbs/ac)	Load (lbs)
Impervious Urban	102	17.69	1,799	1.61	164	748	76,064
Pervious Urban	369	13.40	4,949	0.32	116	111	41,004
Cropland	0	30.31	0	1.13	0	823	0
Forest and Wetlands	15	3.76	56	0.07	1	56	837
Water*	0	-	-	-	-	-	-
Total	*486*		*6,805*		*281*		*117,905*

* Nutrient loadings from water were not included in the analysis

Note that the pollutant loading rates developed for the water land use category represent atmospheric deposition of nitrogen and phosphorus to water. Total annual nitrogen and phosphorus loads estimated for the Upper Farnandis watershed are 6,805 lbs. TN/year and 281 lbs. TP/year, respectively. Total annual sediment loading from land use sources into the Upper Farnandis watershed is 117,905 lbs/sediment/year.

5.3.2 POLLUTANT REMOVAL ANALYSIS

As discussed in Chapter 2, as part of the local Bynum Run Sediment TMDL, a reduction in total urban sediment loads from stormwater discharges is necessary to meet water quality standards. Section 2.5.1 provides more information on the Bynum Run Sediment TMDL and the sediment reduction goal of 18%. Since the Upper Farnandis watershed is within the Bynum Run watershed, the sediment reduction goal is also 18%. In addition to the local sediment TMDL, the Upper Farnandis watershed falls within the Chesapeake Bay watershed. Section 2.5.2 provides more detail on the pollutant reduction goals for Bynum Run. The pollutant reductions for nitrogen and phosphorus within the Upper Farnandis Watershed, based on the Chesapeake Bay TMDL are 37.9% and 24%, respectively.

Due to the high percentage of residential land use in the Upper Farnandis watershed, most of the pollutant loads within the watershed are from impervious and pervious urban land uses. Since Harford County is responsible for reducing the urban loads within the County, pollutant reductions are applied only to the urban loads within the watershed. The total urban loads within the watershed and the urban load reductions needed within the Upper Farnandis watershed to achieve this are summarized in Table 5-4. Full implementation is required for the Bynum Run TMDL by 2025.

Table 5-4: Upper Farnandis Urban Load Reductions Based on Bynum Run TMDL and Chesapeake Bay Reduction Goals

Source	Area (acres)	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)	Total Sediment (lbs/yr)
Total Urban Load	471	6,749	280	117,068
2025 Reduction Goal:		*2,558*	*67*	*21,072*

The following subsections present a quantitative analysis of pollutant removal capabilities of proposed restoration practices to ensure that the required reductions in nutrient and sediment loads from urban runoff in the Upper Farnandis watershed are achieved. Note that many of the removal efficiencies used to estimate pollutant reductions are based on the peer-reviewed and CBP-approved nonpoint source BMP tables developed for the Phase 5.0 CBP Watershed Model. Additional pollutant reductions from the 2011 MDE *Draft Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated,* the 2014 MDE *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated*, and the 2013 *Recommendations of the Expert Panel to Define Removal Rates for Urban Nutrient Management* were used if values were not available in the BMP tables. Also, note that the calculations and estimates presented in the following subsections represent maximum potential pollutant removal capabilities. Not all of these projects in the Upper Farnandis will be implemented. A summary of overall pollutant load reduction estimates is presented at the end of this section to provide the different project opportunities to meet the Upper Farnandis TMDL regulations.

EXISTING URBAN RESTORATION PRACTICES

STORMWATER MANAGEMENT (SWM)

Stormwater Management (SWM)

As described in Chapter 4, there are 10 existing SWM facilities in the Upper Farnandis watershed including underground detention, infiltration and filtration practices, extended detention, and other types of SWM facilities (i.e. environmentally sensitive design). The pollutant load reductions for these existing SWM facilities are included in the Bayfast model pollutant load scenario. Therefore, the pollutant load reductions from the existing facilities were not included in the pollutant load reductions analysis.

PROPOSED URBAN RESTORATION PROJECTS

STORMWATER RETROFITS AND NEW BMP FACILITIES

Proposed stormwater retrofits for the purposes of this study refer to implementing BMPs to capture and treat runoff from impervious surfaces (i.e. parking lots, roadways), which are currently untreated. This includes sites identified for retrofit potential during the existing BMP site assessments and new BMPs locations. Pollutant reductions for stormwater retrofits and new BMPs are calculated based on the approximate pollutant load received from the impervious drainage area (DA) and removal efficiency of infiltration type BMPs.

The equation used to estimate TN load reductions for stormwater retrofits and new BMPs is expressed as:

[17.69 *(lbs/ac/yr)* x Impervious *DA (acres)*] x *efficiency (%)*

The equation used to estimate TP load reductions for stormwater retrofits is expressed as:

[1.61 *(lbs/ac/yr)* x Impervious *DA (acres)*] x *efficiency (%)*

The equation used to estimate TSS load reductions for stormwater retrofits is expressed as:

[747.7 *(lbs/ac/yr)* x Impervious *DA (acres)*] x *efficiency (%)*

The pollutant load received from the impervious portion of the drainage area contributing to the SWM facility is denoted by the first expression in brackets in the equations above. The pollutant loading rates shown, 17.69 lbs TN/ac/yr, 1.61 lbs TP/ac/yr, and 747.7 lbs TSS/ac/yr, are the impervious urban rates used in the pollutant loading analysis (Table 5-1) since this represents the source of runoff being treated. Pollutant removal efficiencies are provided by MDE for BMP practices (MDE, 2011). A summary of stormwater retrofit load reduction calculations and results for the Upper Farnandis watershed are shown in Table 5-5.

Table 5-5: Stormwater Retrofit and New BMP Load Reductions

SWM Facility Type	Facility Type	Impervious DA (acres)	TN Load from DA (lbs/yr)	TN Removal Efficiency (%)	TN Load Reduction (lbs/yr)	TP Load from DA (lbs/yr)	TP Removal Efficiency (%)	TP Load Reduction (lbs/yr)	TSS Load from DA (lbs/yr)	TSS Removal Efficiency (%)	TSS Load Reduction (lbs/yr)
RET_BMP_02	Wet Pond	1.70	17.69	20%	6.0	1.61	45%	1.2	748	60%	763
RET_BMP_03	Wet Pond	6.40	17.69	20%	22.6	1.61	45%	4.6	748	60%	2,871
RET_BMP_04	Wet Pond	1.70	17.69	20%	6.0	1.61	45%	1.2	748	60%	763
PR_BMP_01	Rain Garden	0.22	17.69	50%	1.9	1.61	60%	0.2	748	90%	148
PR_BMP_02	Bioretention	0.84	17.69	40%	5.9	1.61	60%	0.8	748	80%	502
Totals:		*10.9*			*43*			*8.1*			*5,047*

STREAM CORRIDOR RESTORATION

Stream corridor restoration practices are used to enhance the appearance, stability, and aquatic function of stream corridors. These practices include stream stabilization (i.e. grading and vegetative stabilization) and stream restoration (i.e. redesign and realignment). Several potential stream restoration sites were identified during the stream corridor assessments (SCAs) to improve water quality and address potential environmental problem sites, such as significant erosion and channel alterations. The SCAs are explained in Chapter 4. Stream corridor assessments were conducted along all 3.4 miles of stream segments within the Upper Farnandis watershed. Pollutant reduction for stream corridor restoration are calculated based on EPA approved interim load reduction factors reported in the 2014 MDE report, *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE, 2014a) and are multiplied by the linear feet of identified significant erosion and channel alteration sites.

The equation used to estimate TN load reductions for stream restoration is expressed as:

0.075 *(lbs/ft)* x *Restoration Length (ft)*

The equation used to estimate TP load reductions for stream restoration is expressed as:

0.068 *(lbs/ft)* x *Restoration Length (ft)*

The equation used to estimate TSS load reductions for stream restoration is expressed as:

44.900 *(lbs/ft)* x *Restoration Length (ft)*

Stream restoration projects along with a summary of stream corridor restoration reduction results are shown in Table 5-6.

Table 5-6: Stream Restoration Load Reductions for Stream Reaches in the Upper Farnandis Watershed

Stream Restoration Site	Length of Restoration (ft)	Reduction in Loading Rate (lbs/ft/yr)	TN Load Reduction (lbs/yr)	Reduction in Loading Rate (lbs/ft/yr)	TP Load Reduction (lbs/yr)	Reduction in Loading Rate (lbs/ft/yr) *	TSS Load Reduction (lbs/yr)
Fairmont	914	0.075	68.6	0.068	62.2	44.9	41,039
Ring Factory	2,180	0.075	163.4	0.068	148.2	44.9	97,837
Victory	2,200	0.075	164.9	0.068	149.5	44.9	98,695
Macphail	560	0.075	42.1	0.068	38.1	44.9	25,189
Macphail, Grosvenor, Brook Hill	4,700	0.075	359.3	0.068	325.7	44.9	215,071
Totals:	*10,642.1*		*798.2*		*723.7*		*477,830*

*Non-coastal plain pollutant removal rate

5.3.3 IMPERVIOUS AREA CREDIT

Jurisdictions across the country have been mandated to improve the water quality of runoff and control stormwater pollution through the National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer system (MS4) permit. Through this permit, Harford County is required to treat 20% of the impervious runoff from roadways, parking lots, driveways, buildings, etc. Runoff from impervious area is treated through BMPs, stream restoration and outfall stabilization. The County's current NPDES permit expires on December 29, 2019.

Section 2.4 summarizes the impervious area in the Upper Farnandis watershed. A total of 102 acres of land is impervious in this watershed. To meet the MS4 permit requirements and treat 20% of the impervious area, 20.4 acres of impervious area needs to be treated through restoration efforts.

Table 5-7: Summary of Potential Impervious Area Credit from Proposed Restoration Projects

Project	Impervious Area Treated (Ac)	% Impervious Treated in Watershed
RET_BMP_02 (Wet Pond)	1.0	1.0%
RET_BMP_03 (Wet Pond)	3.3	3.2%
RET_BMP_04 (Wet Pond)	1.7	1.7%
PR_BMP_01 (Rain Gardens)	0.3	0.3%
PR_BMP_02 (Bioretention)	0.8	0.8%
Fairmont Stream and Outfall Restoration	9.8	9.6%
Ring Factory Stream Restoration	21.8	21.4%
Victory Stream and Outfall Restoration	22.4	22.0%
Macphail Stream Restoration	5.6	5.5%
Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration	47.8	46.9%

Three proposed restoration projects provide impervious area credit for greater than 20% of the watershed or 20.4 acres of impervious area. These three projects Victory Stream and Outfall Restoration, Ring Factory Stream and Outfall Restoration, and Macphail, Grosvenor, Brook Hill Stream and Outfall Restoration. Any one of these three projects constructed on its own would provide the impervious area credit needed to meet the MS4 permit requirements for this watershed.

5.3.4 OVERALL POLLUTANT LOAD REDUCTIONS

The sum of maximum potential pollutant load reductions calculated for individual BMPs represents the overall pollutant removal capacity for a maximum implementation scenario (i.e., 100% of the projects implemented).

Table 5-8 presents a summary of estimated pollutant load reductions and impervious areas treated for each proposed project, including BMP and stream projects. The table includes how reductions were credited, pollutant removal efficiencies, maximum potential load reductions, units available for restoration, projected load reductions, and impervious area treated. While this is a list of all 10 potential projects proposed within the watershed, not all projects will be implemented within the watershed due to costs and property ownership constraints. Currently, Table 5-8 shows the reductions and credits for each project and the total reductions if all projects are implemented. The total reductions exceed the 2025 Bynum Run TMDL reduction goals for nitrogen, phosphorus and sediment. Based on the observed reductions and credits, if one project is selected to move to design and construction, three options are available that would meet the pollutant reduction goals and impervious acre credit goals. These three projects are Victory Stream and Outfall Restoration, Ring Factory Stream Restoration, and Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration.

Table 5-8: Summary of Pollutant Load Reduction Estimates for Proposed Projects

Project	How Credited	TN Efficiency	TP Efficiency	TSS Efficiency	Total Units Available		Max Potential TN Load Reduction (lbs/yr)	Max Potential TP Load Reduction (lbs/yr)	Max Potential TSS Load Reduction (lbs/yr)
RET_BMP_02 (Wet Pond)	Efficiency	20%	45%	60%	1.7	acres	6	1.2	763
RET_BMP_03 (Wet Pond)	Efficiency	20%	45%	60%	6.4	acres	23	4.6	2,871
RET_BMP_04 (Wet Pond)	Efficiency	20%	45%	60%	1.7	acres	6	1.2	763
PROP_BMP_01 (Rain Gardens)	Efficiency	50%	60%	90%	0.2	acres	2	0.2	148
PROP_BMP_02 (Bioretention)	Efficiency	40%	60%	80%	0.8	acres	6	0.8	502
Fairmont Stream and Outfall Restoration (Stream)	Lbs per Ln Ft	0.075	0.068	44.9	914	ft	69	62	41,039
Ring Factory Stream Restoration	Lbs per Ln Ft	0.075	0.068	44.9	2,179	ft	163	148	97,837
Victory Stream and Outfall Restoration (Stream)	Lbs per Ln Ft	0.075	0.068	44.9	2,198	ft	165	149	98,695
Macphail Stream and Outfall Restoration (Stream)	Lbs per Ln Ft	0.075	0.068	44.9	561	ft	42	38	25,189
Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration (Stream)	Lbs per Ln Ft	0.075	0.068	44.9	4,790	ft	359	326	215,071
Total Upper Farnandis Load Reduction (lbs/yr):							*841*	*732*	*482,877*
Total Upper Farnandis Existing Urban Load (lbs/yr)							6,749	280	117,066
Upper Farnandis Urban Load Reduction (%)							*12%*	*261%*	*412%*
Total Bynum Run Existing Urban Load (lbs/yr)							117,139	5,394	2,302,403
Bynum Run Urban Load Reduction (%)							1%	14%	21%

6 PROPOSED RESTORATION PROJECTS

Field findings identified areas within the Upper Farnandis watershed where potential restoration projects have the opportunity to protect infrastructure, improve water quality, and/or reduce flooding. These projects fall into three categories: BMP retrofits, new BMP facilities, and stream and outfall restoration. Descriptions of each category are provided in the following sections. A total of 3 BMP retrofits, 2 new BMPs, 5 stream restorations, and 10 outfall stabilization projects have been recommended. The outfall stabilization projects are combined with the stream restoration projects since all of the outfall stabilization projects are either at the headwaters or on stream banks. Due to the number of projects, a matrix has been developed to provide recommendations based on priority. Section 6.1 provides details on how the projects were ranked.

Each project description begins with an "at a glance" summary of the recommended restoration, the location of the project, the number of properties impacted, the pollutant load reductions and impervious area treated. The project description also includes a site description, recommended actions, threats to infrastructure, impacted property addresses, a cost estimate, and a map showing the extents of the project. Projects descriptions are provided for BMP projects and stream and outfall projects in Sections 6.2 and Sections 6.3, respectively.

6.1 PROJECT PRIORITIZATION

6.1.1 INTRODUCTION

The ten proposed projects are different types and sizes, with varying costs to design and construct. Each project provides different quantities and types of treatment to meet regulations and improve the quality of the streams. Some of these projects have been proposed to resolve immediate threats to infrastructure while other projects primary goals are water quality improvements. Access to project sites will be a key component of each project. The majority of stream projects will require concurrence of multiple property owners while the BMPs typically only impact one property. A project prioritization was created to ensure that the projects are ranked accurately, based on many of the parameters above. The projects recommended as a result of this project can be found in Section 6.4. The following subsections describe the methodology for the Upper Farnandis watershed prioritization.

6.1.2 PRIORITIZATION CRITERIA

This section describes the criteria and methodology used to rank the ten projects. The project ranking provides a tool for targeting restoration opportunities by need and environmental benefits. A ranking methodology was developed to prioritize projects within this study in terms of restoration need and potential. BMP projects and stream and outfall restoration projects were evaluated based on the same three metrics. Each criterion was scored from 1 to 3. The sum of the criteria for each project was used to prioritize projects within this study in terms of restoration need and potential.

The potential projects are represented by an overall prioritization score on a scale of 9, where 1 denotes the least significant impacts to water quality and 9 corresponds to the greatest water quality improvement potential. The total prioritization score for each project is comprised of the following ranking criteria:

Prioritization Metrics:

- Impervious Area Treated (Acres)
- Cost/Impervious Area Treated
- Threat to Infrastructure

Each criterion has a maximum possible score of 3. In general, projects were divided into thirds based on supporting criterion data to yield an even distribution of the number of watersheds per possible score (i.e., 1, 2, 3). The 10 projects are identified by name in Table 6-1.

Table 6-1: Proposed Project Descriptions

PROJECT NAME	PROJECT DESCRIPTION
RET_BMP_02	Wet Pond Retrofit
RET_BMP_03	Wet Pond Retrofit
RET_BMP_04	Wet Pond Retrofit
PR_BMP_01	Three Rain Gardens
PR_BMP_02	Bioretention
Fairmont Stream and Outfall Restoration	914 feet of stream restoration, including 20 feet impervious removal and 2 outfall stabilization
Ring Factory Stream Restoration	2,179 feet of stream restoration
Victory Stream and Outfall Restoration	2,198 feet of stream restoration and 2 outfall stabilization
Macphail Stream Restoration	561 feet of stream restoration
Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration	4,714 feet of stream restoration and six outfall stabilization

Criteria used to calculate overall prioritization scores were selected considering current regulations and information compiled during watershed characterization and field efforts. Criteria and scoring designations are described in the sections below. Project restoration prioritization scoring and ranking results are summarized at the end of this section.

6.1.3 IMPERVIOUS AREA TREATED

Impervious areas, such as roads, parking lots, driveways, and building rooftops lead to increased runoff in a watershed. In the Upper Farnandis watershed, where there is a high percentage of residential properties throughout the watershed, increased runoff can lead to stream flooding and eroded banks. When residential houses are close to the stream, flooding and erosion can negatively impact the nearby properties. Treating impervious area through the creation of BMPs or stream and outfall restoration projects reduces the flow through the streams in the watershed. These practices reduce the impacts to adjacent properties and downstream stream reaches.

As mentioned in Section 2.6, Harford County has a goal of treating 20% of impervious area within the County; therefore, the amount of impervious area treated by each project is important in the project selection process. The Upper Farnandis watershed has 102 acres of impervious area. Treating 20% of the impervious area would result in 20.4 acres treated. Projects that generate a larger impervious area credit are ranked higher in the prioritization matrix. The drainage area was defined for each potential project and the impervious area within each drainage area was calculated. Projects were ranked according to the percent impervious area treated in the watershed, where 3 points were assigned for projects that treated 20% or more of the impervious area within the watershed (20.4 acres) and 1 point was assigned for projects with the lowest percentage of impervious area treated within the watershed.

- ≥ 20% = 3 pts
- 1.1% - 19.9% = 2 pts
- ≤ 1% = 1 pt

Table 6-2 summaries the impervious area treated and the percent of impervious area treated within the watershed for each proposed project along with the corresponding % impervious area prioritization scores by project.

Table 6-2: Impervious Area Treated

Project	Impervious Area Treated (Ac)	% Impervious Treated in Watershed	% Impervious Score
RET_BMP_02 (Wet Pond)	1.0	1.0%	1
RET_BMP_03 (Wet Pond)	3.3	3.2%	2
RET_BMP_04 (Wet Pond)	1.7	1.7%	2
PR_BMP_01 (Rain Gardens)	0.3	0.3%	1
PR_BMP_02 (Bioretention)	0.8	0.8%	1
Fairmont Stream and Outfall Restoration	9.8	9.6%	2
Ring Factory Stream Restoration	21.8	21.4%	3
Victory Stream and Outfall Restoration	22.4	22.0%	3
Macphail Stream Restoration	5.6	5.5%	2
Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration	47.8	46.9%	3

6.1.4 COST/IMPERVIOUS AREA TREATED

Cost is a major consideration when selecting a project for water quality improvement. Cost estimates have been created for each proposed BMP project based on a 2011 cost estimate spreadsheet for Maryland Counties. The cost estimate for each project includes both construction and design costs. Due to the variability in land costs, it is important to note that right of way/easement costs have not been included in the cost estimates. The present 2017 values have been calculated for each project and adjusted based on similar projects that have been designed and constructed in Maryland. The cost for each BMP is dependent on the amount of impervious area treated. The project cost for each proposed BMP retrofit and new BMP are shown in Table 6-3.

Table 6-3: Total Project Cost (Design and Construction) Estimates for Proposed BMP Projects (excluding ROW acquisition)

BMP Project	BMP Type	Project Cost
RET_BMP_02	Wet Pond	$193,750.00
RET_BMP_03	Wet Pond	$250,000.00
RET_BMP_04	Wet Pond	$206,250.00
PR_BMP_01	Rain Gardens	$ 45,000.00
PR_BMP_02	Bioretention	$177,270.56

Cost estimates for each stream restoration project is based on three project sizes, small, medium, and large projects. Small projects are those that are less than 1,000 linear feet of restoration while medium projects have between 1,000 and 3,000 linear feet of stream restoration, and large projects have greater than 3,000 linear feet of stream restoration. Each project type has been assigned a cost per linear foot, with the small projects costing the most per linear feet and the large projects costing the least per linear foot. These values were estimated based on estimates from other Maryland Counties as well as state agencies. The cost estimates for the types of stream projects are shown in Table 6-4.

Table 6-4: Stream Design and Construction Cost Estimates for Small, Medium, and Large Stream Projects (excluding ROW acquisition)

Project Type	Cost/L.F.
Small	$750
Medium	$650
Large	$550

Several of the stream projects include outfall stabilization efforts. A cost is assigned to each outfall and added to the overall stream and outfall restoration project cost estimate. Each outfall has been assigned a cost related to the magnitude of the project. Small projects are those that require a design component and grading and riprap stabilization. Medium projects also involve a design component in addition to a new outfall structure, plunge pool, and less than 40 feet of additional pipe. Large projects include all items listed in the medium projects; however, the amount of additional pipe needed to convey flow to the stream is greater than 40 feet. Table 6-5 provides the breakdown of cost for the small, medium, and large outfall and stream projects.

Table 6-5: Cost Estimates for Outfall Projects (excluding ROW acquisition)

Outfall Project Type	Project Cost
Small	$50,000
Medium	$100,000
Large	$150,000

Impervious removal and outfall maintenance are two additional categories that are associated with the stream restoration projects. Outfall maintenance to remove accumulated sediment is estimated at $5,000 for each outfall. Impervious removal of concrete lined stream channels is grouped into two project types, small and medium. The small impervious removal project is $5,000 and includes the removal of less than 1,000 square feet of concrete. The medium impervious removal project is $20,000 and includes the removal of more than 1,000 square feet of concrete. These costs are added to the overall cost of the stream projects.

Harford County is required to treat 20% of the impervious area within the County as well as reduce the pollutant loads of nitrogen, phosphorus, and sediment within the watershed. When considering potential projects, the cost per impervious acre treated provides a normalized comparison between projects. Projects can then be selected that provide a greater amount of water quality treatment for a similar or lower cost to other projects. Depending on available budgets, multiple projects may be selected that have a lower cost per water quality metric treated. For each proposed BMP and stream and outfall project in Chapter 6, the cost to complete the design and the construction of the project was estimated. This cost was then divided by the impervious area treated for each project to get a cost per impervious area treated. Projects with lower cost per impervious area treated were assigned 3 points where the projects with the highest cost per impervious area treated were assigned 1 point.

- ≤ $70,000/ac treated = 3 pts
- $70,001 - $99,999/acre treated = 2 pts
- ≥ $100,000/acre treated = 1 pt

Table 6-6 summaries the cost per impervious area treated for each proposed project and the corresponding cost per impervious area prioritization scores by project.

Table 6-6: Project Cost per Impervious Area Treated (excluding ROW acquisition)

Project	Cost/Impervious Acre Treated	Cost/Impervious Acre Treated Score
RET_BMP_02 (Wet Pond)	$ 193,750.00	1
RET_BMP_03 (Wet Pond)	$ 75,757.58	2
RET_BMP_04 (Wet Pond)	$ 121,323.53	1
PR_BMP_01 (Rain Gardens)	$ 145,161.29	1
PR_BMP_02 (Bioretention)	$ 211,036.38	1
Fairmont Stream and Outfall Restoration	$ 83,724.50	2
Ring Factory Stream Restoration	$ 66,376.15	3
Victory Stream and Outfall Restoration	$ 65,065.50	3
Macphail Stream Restoration	$ 75,000.00	2
Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration	$ 59,978.77	3

6.1.5 THREAT TO INFRASTRUCTURE

Infrastructure is prevalent throughout the Upper Farnandis watershed. Utilities run parallel to the stream in some areas and cross the stream in other parts of the watershed. Multiple pedestrian bridges crossing the stream were observed throughout the watershed. Roadways, houses, and driveways are near the stream banks in several of the subwatersheds within the Upper Farnandis watershed. Infrastructure is often observed near streams in urban watersheds. Threats to infrastructure occur when the stream shifts and/or erodes due to both natural and manmade processes. Threats to roadways, buildings, and utilities have the potential to be life threatening and therefore, are an important indicator of which projects receive a higher priority. Potential projects where infrastructure could be directly impacted in the next large storm were assigned 3 points where as potential projects with no infrastructure problems were assigned 0 points.

- High probability of infrastructure problems = 3 pts
- Medium probability of infrastructure problems = 2 pts
- Low probability of infrastructure problems = 1 pt

- No infrastructure problems = 0 pts

Table 6-7 summaries the threats to infrastructure for each proposed project along with the corresponding prioritization scores by project and comments describing each threat to infrastructure for each project.

Table 6-7: Number of Threats to Infrastructure by Project

Project	Threat to Infrastructure	Property Impact Score	Comments
RET_BMP_02 (Wet Pond)	No	0	
RET_BMP_03 (Wet Pond)	No	0	
RET_BMP_04 (Wet Pond)	No	0	
PR_BMP_01 (Rain Gardens)	No	0	
PR_BMP_02 (Bioretention)	No	0	
Fairmont Stream and Outfall Restoration	Yes	2	Utility pole leaning at top of 7' bank; Exposed pipe in stream; impact to private pond
Ring Factory Stream Restoration	Yes	2.5	9' vertical bank within 5' of Carolina Ave
Victory Stream and Outfall Restoration	Yes	3	6' undercut bank within 10' of home; Sewer manhole exposed; Pedestrian bridges in good condition; Exposed pipe
Macphail Stream Restoration	Yes	1	Concrete channel experiencing erosion 40' from East Macphail Rd
Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration	Yes	3	When two large trees holding back bank at end of Jackson Blvd fall, problems to Jackson Blvd will occur; 2 exposed pipes; Sewer manhole exposed in stream; Stream bank will soon undercut end of gabion pad for OF 10

6.1.6 PROJECT PRIORITIZATION SUMMARY

The 10 proposed projects within the Upper Farnandis watershed are ranked according to their total prioritization score (i.e. the sum of prioritization criterion scores) based on their need and restoration potential. Project ranking results are summarized in Table 6-8. The ranking result table includes criterion scores, total scores, and ranking by project.

Projects were placed into one of three priority categories based on ranking results: high, medium, or low. Projects given a high priority are those with immediate threats to infrastructure and with greater pollution and restoration potential, while those with low priority are those without immediate threats to infrastructure and with lower pollution and restoration potential. These results are summarized for BMP projects and stream and outfall restoration projects in Table 6-9.

Project prioritization scores range from 2 to 9 points. The following point system was used to assign prioritization categories for the projects based on the distribution and range of prioritization scores:

- 7 – 9 = High
- 4 – 6 = Medium

- 1 – 3 = Low

Table 6-8: Proposed Project Ranking Results

Projects	Impervious Area Treated (Ac)	Cost/Impervious Treated	Threat to Infrastructure	TOTAL SCORE
RET_BMP_02 (Wet Pond)	1	1	0	*2*
RET_BMP_03 (Wet Pond)	2	2	0	*4*
RET_BMP_04 (Wet Pond)	2	1	0	*3*
PR_BMP_01 (Rain Gardens)	1	1	0	*2*
PR_BMP_02 (Bioretention)	1	1	0	*2*
Fairmont Stream and Outfall Restoration	2	2	2	*6*
Ring Factory Stream Restoration	3	3	2.5	*8.5*
Victory Stream and Outfall Restoration	3	3	3	*9*
Macphail Stream Restoration	2	2	1	*5*
Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration	3	3	3	*9*

Table 6-9: Proposed Project Prioritization

Rank	Project	Total Score	Prioritization Category
1	Victory Stream and Outfall Restoration	*9*	High
1	Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration	*9*	High
3	Ring Factory Stream Restoration	*8.5*	High
4	Fairmont Stream and Outfall Restoration	*6*	Medium
5	Macphail Stream Restoration	*5*	Medium
6	RET_BMP_04 (Wet Pond)	*4*	Medium
7	RET_BMP_03 (Wet Pond)	*3*	Medium
8	RET_BMP_02 (Wet Pond)	*2*	Low
8	PR_BMP_01 (Rain Gardens)	*2*	Low
8	PR_BMP_02 (Bioretention)	*2*	Low

6.2 BMP PROJECTS

BMP projects listed below have been separated into two sections, existing BMP retrofits and new BMP projects. Due to a high percentage of residential land use within the watershed and limited right of way space adjacent to streets, space is limited within this watershed for the construction of BMPs. Five BMP projects have been recommended based on the field findings. Of these five BMP projects, two are located on institutional property, two are located on HOA property, and one is located on Town of Bel Air property. The types of retrofit and new BMPs being recommended include, bioretention, rain gardens, and wet ponds. Existing BMPs that are recommended for retrofit are listed in section 6.2.1 while new BMP projects are described in section 6.2.2. Section 6.4 describes the project recommendations.

6.2.1 EXISTING BMP RETROFITS

As a result of the field assessment of the 10 existing BMPs within the Upper Farnandis watershed, three were found to have potential retrofit opportunities. The three facilities currently provide for water storage needs and minimal water quality benefits. Retrofitting Existing BMPs 2, 3, and 4 would provide impervious area credit for these facilities as well as additional water quality benefits. Each of the three retrofit projects is described in detail in this section. Chapter 4 provides additional information on the field findings throughout each of these projects.

RETROFIT OF EXISTING BMP 2: EXTENDED DETENTION RETROFIT

Project Description: Retrofit existing extended detention facility (Existing BMP 2) with wet pond

Location: Brook Hill Court

Property Ownership: Brook Hill Manor Community Association, Inc.

Length of Project: N/A

Potential Impervious Acres Treated: 1.0 Acres

Potential Load Reductions TP: 13.5 lbs/year

Potential Load Reductions TN: 1.3 lbs/year

Potential Load Reductions TSS: 701 lbs/year

Estimated Design/Construction Costs: $193,750

Adjacent Projects: Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration

Site Description

Existing BMP 2 is located at the Northern end of Brook Hill Court within the Brook Hill subwatershed (Figure 6-1, left). One 18” and one 15” pipe convey flow from the surrounding neighborhood, including most Brook Hill Court, to the existing extended detention facility. The impervious area that drains to the existing BMP accounts for 36% of the drainage area. The two pipes outfall into a pilot channel within the BMP footprint. Flow from the extended detention basin outfalls via a metal riser structure with a 30” corrugated metal pipe to gabion outfall protection before entering the perennial tributary (Figure 1, right). This metal riser serves as the emergency spillway for the facility. The facility is in good condition, with no erosion or sediment build up present.

No flow was observed to the facility. Rain had been observed in the area one day prior to the site visit. There was no standing water in the facility. The extended detention facility is being recommended as a retrofit opportunity.

- Drainage Area: 4.70 Acres
- Impervious Area: 1.70 Acres

Figure 6-1: Looking West to existing extended detention facility (left); Looking South at gabion outfall protection and towards existing BMP (right)

Recommended Restoration Actions

- A wet pond retrofit is recommended to target improved water quality for flow exiting the facility into the perennial stream. Permanent pools excavated down from the existing dry pond bottom are to be created to improve water quality.
- A forebay can be placed at the outfall of each pipe to slow flow entering the facility and reduce sediment loadings.
- Proposed retrofit plans are shown in Figure 6-2.

Threats to Infrastructure

- There is no critical infrastructure in the project limits.
- There are surrounding homes in the community.

Property Ownership

- Ownership: Homeowner Association, Brook Hill Manor Community Associated, Inc.

Access

- Moderate Access: Steep slopes and fence surrounding entire existing extended detention basin. Existing facility located on communal HOA land.

Summary of Restoration Improvements

A summary of improvements for retrofitting existing BMP 2 are shown in Table 6-10. The table includes the drainage area of each improvement, the impervious area within the drainage area, the impervious area treated, and the pollutant load reductions. The quantity of impervious area treated is dependent on the rainfall depth of water treated. The proposed wet pond treats 0.6" of rainfall which corresponds to 0.6 impervious acre credit per acre of watershed impervious area. This proposed wet pond would provide 1.0 impervious acres of treatment.

While the existing BMP does manage stormwater, the proposed wet pond retrofit will also target water quality. Wet ponds provide a pollutant load reduction of 20% for nitrogen, 45% for phosphorus, and 60% for sediment (MDE, 2011).

Items of Note

Due to the highly residential nature of the proposed retrofit, there may be concerns from the community about the conversion from dry to wet pond. Community outreach/buy in should be obtained early on in the project to ensure success.

Retrofits assume that by using the Embankment Retrofit Design guidance (MDE, 2015), the existing Maryland pond 378 dam classification of the facility will not be impacted.

Project Costs

Total project costs are $193,750 for retrofitting existing BMP 2. Project costs are broken down by cost/ac for impervious area credit when impervious area treated is greater than one acre (Table 6-11). BMP project costs have been estimated based on the type of the project and the cost per impervious area treated (King & Hagan, 2011). The Maryland Stormwater BMP Cost Worksheet was used to determine design and construction costs for this project. ROW costs are not included in this estimate. The worksheet is setup for 2011 dollar values; therefore, the design and construction costs from 2011 were brought to present day, 2017, values to provide an accurate estimate of project costs.

Table 6-10: Summary of Improvements for Existing BMP 2

PROJECT TYPE	PROJECT NAME	DRAINAGE AREA (ACRES)	IMPERVIOUS AREA (ACRES)	RESTORATION LENGTH (FEET)	IMPERVIOUS AREA CREDIT (ACRES)	TN REDUCTIONS (LBS/YEAR)	TP REDUCTIONS (LBS/YEAR)	TSS REDUCTIONS (LBS/YEAR)
BMP	RET_BMP_2	4.70	1.70	-	1.0	13.5	1.3	701
Outfall								
Stream								
Total Credit/ Reductions					1.0	13.5	1.3	701

Table 6-11: Summary of Project Costs for Retrofitting Existing BMP 2

PROJECT TYPE	PROJECT NAME	PROJECT COST	COST/IMPERVIOUS ACRE TREATED
BMP	RET_BMP_2	$193,750	$193,750
Outfall			
Stream			
Total Costs		$193,750	$193,750

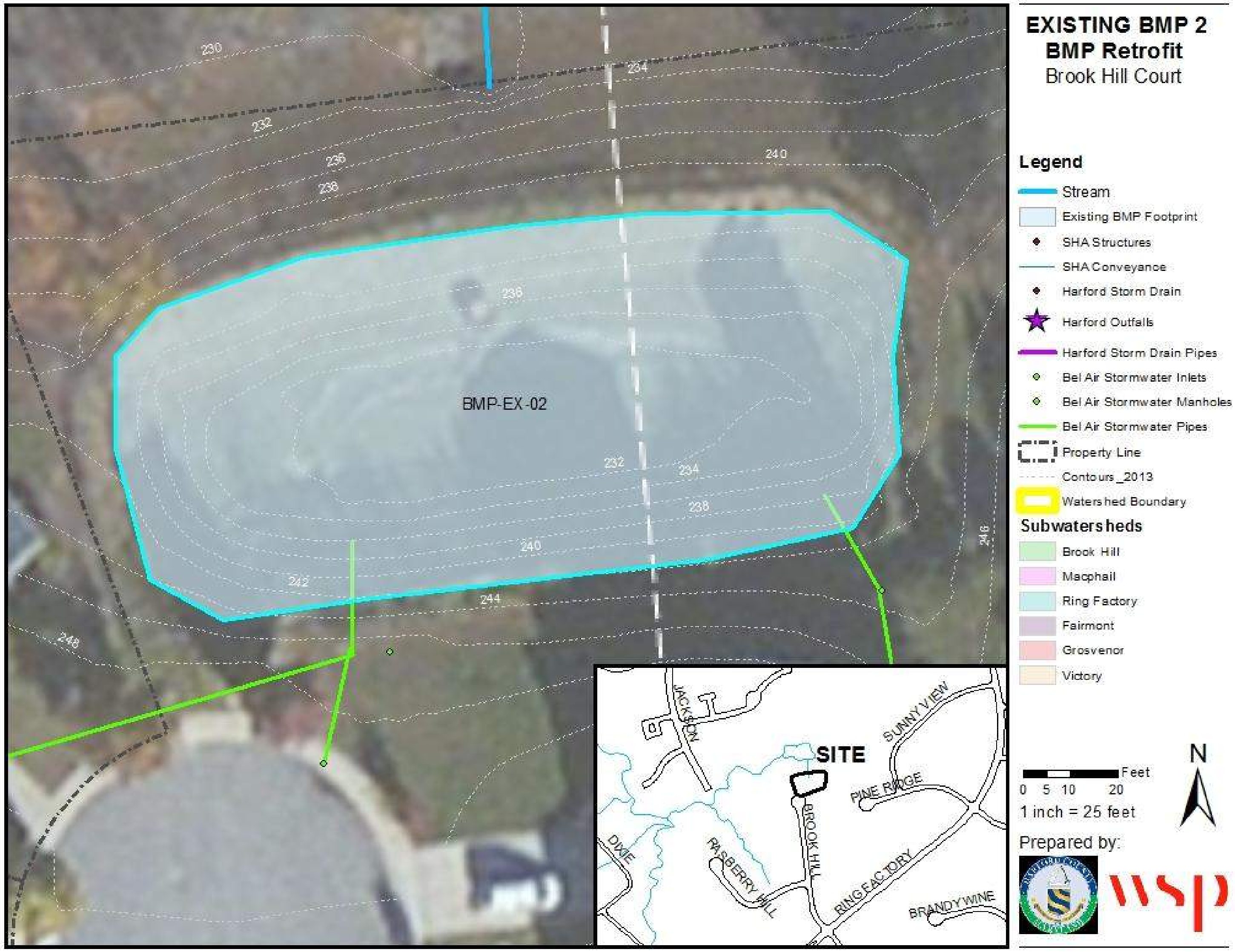

Figure 6-2: Site Location and Proposed Retrofit for Existing BMP 2

RETROFIT OF EXISTING BMP 3: EXTENDED DETENTION RETROFIT

Project Description: Retrofit existing extended detention facility (Existing Pond 3) with wet pond

Location: Communal area of White Oak Community, Southern point of Grosvenor Drive

Property Ownership: Bradford Village Association, Inc.

Length of Project: N/A

Potential Impervious Acres Treated: 3.3 Acres

Potential Load Reductions TP: 60.7 lbs/year

Potential Load Reductions TN: 5.7 lbs/year

Potential Load Reductions TSS: 3,161 lbs/year

Estimated Design/Construction Costs: $250,000

Adjacent Projects: Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration

Site Description

Existing BMP 3 is in the communal area of White Oak Community at the Southern point of Grosvenor Drive (Figure 6-3, left). The facility is within the Grosvenor subwatershed. There are two inflow points to the existing BMP. One 24" concrete pipe conveys flow from the surrounding Eastern neighborhood, including runoff from Grosvenor Drive, to the existing extended detention facility. This inflow point has drop structures along the Eastern slope. Inflow also enters the facility via a heavily eroded channel that is approximately 100' long by 2' wide (Figure 6-3, right). This channel is not perennial due to the lack of evidence of flow in the channel at the time of the field visit. Flow enters this channel via an upstream riprap channel and an 18" concrete pipe, conveying flow from the Western neighborhood and the area North of Macphail Road. The impervious area that drains to the existing BMP accounts for 30% of the drainage area. The two inflow points enter a riprap extended detention area, measuring 39' long by 17' wide. Outflow from this facility enters an 18" corrugated metal pipe and outfalls to the headwaters of the connected tributary via a 24" corrugated metal pipe. The facility also has a 4' by 4' concrete riser structure for overflow approximately 15-20' above the 18" CMP outfall pipe. The extended detention facility has an emergency spillway with gabions to the East of the facility. No sediment around riser structure.

No flow was observed to the facility. Rain had been observed in the area within 3 days prior to site visit. The facility had 4" of standing water present, so water is not infiltrating. The extended detention facility is being recommended as a wet pond retrofit opportunity.

- Drainage Area: 21.2 Acres
- Impervious Area: 6.4 Acres

Figure 6-3: Looking Southwest to outfall structure (left); Looking Northeast to inflow to existing facility (right)

Recommended Restoration Actions

- To improve water quality, a wet pond retrofit is recommended within the current extended detention basin footprint. The drop manhole structure and inflow point coming from Grosvenor Drive would need to be redirected north, across from the inflow point at Cheswold Court. The wet pond would be excavated down from the existing detention basin bottom.
- Stabilize heavily eroded channel (100' long by 2' wide) that serves as inflow point to facility.
- Clean riser structure because currently clogged with large debris/wood.
- Proposed project plans are shown in Figure 6-4.

Threats to Infrastructure

- There is no critical infrastructure in the project limits.
- There are surrounding homes in the community.

Property Ownership

- Ownership: Homeowner Association, Bradford Village Association, Inc.

Access

- Moderate Access: Steep slopes and wooden fence surrounding entire existing extended detention facility. Existing facility located on communal HOA land.

Summary of Restoration Improvements

A summary of improvements for retrofitting existing BMP 3 are shown in Table 6-12. The table includes the drainage area of each improvement, the impervious area within the drainage area, the impervious area treated, and the pollutant load reductions. The quantity of impervious area treated is dependent on the rainfall depth of water treated. The proposed wet pond treats 0.5" of rainfall which corresponds to 0.5 impervious acre credit per acre of watershed impervious area. This proposed wet pond would provide 3.3 impervious acres of treatment.

While the existing BMP does manage stormwater, the proposed wet pond retrofit will also target water quality. Wet ponds provide a pollutant load reduction of 20% for nitrogen, 45% for phosphorus, and 60% for sediment (MDE, 2011).

Items of Note

Since a stream channel flows directly into the pond, this facility is an inline pond. Due to current permitting environmental regulations, permitting for this retrofit will be a challenge.

Due to the highly residential nature of the proposed retrofit, there may be concerns from the community about the conversion from dry to wet pond. Community outreach/buy in should be obtained early on in the project to ensure success.

Retrofits assume that by using the Embankment Retrofit Design guidance (MDE, 2015), the existing Maryland pond 378 dam classification of the facility will not be impacted.

Project Costs

Total project costs (excluding ROW acquisition) are $250,000 for retrofitting existing BMP 3. Project costs are broken down by cost/ac for impervious area credit when impervious area treated is greater than one acre (Table 6-13). BMP project costs have been estimated based on the type of the project and the cost per impervious area treated (King & Hagan, 2011). The Maryland Stormwater BMP Cost Worksheet was used to determine design and construction costs for this project. ROW costs are not included in this estimate. The worksheet is setup for 2011 dollar values; therefore, the design and construction costs from 2011 were brought to present day, 2017, values to provide an accurate estimate of project costs.

Table 6-12: Summary of Improvements for Existing BMP 3

PROJECT TYPE	PROJECT NAME	DRAINAGE AREA (ACRES)	IMPERVIOUS AREA (ACRES)	RESTORATION LENGTH (FEET)	IMPERVIOUS AREA CREDIT (ACRES)	TN REDUCTIONS (LBS/YEAR)	TP REDUCTIONS (LBS/YEAR)	TSS REDUCTIONS (LBS/YEAR)
BMP	RET_BMP_3	21.2	6.4	-	3.3	60.7	5.7	3,161
Outfall								
Stream								
Total Credit/ Reductions					3.3	60.7	5.7	3,161

Table 6-13: Summary of Project Costs for Retrofitting Existing BMP 3

PROJECT TYPE	PROJECT NAME	PROJECT COST	COST/IMPERVIOUS ACRE TREATED
BMP	RET_BMP_3	$250,000	$75,757.58
Outfall			
Stream			
Total Costs		$250,000	$75,757.58

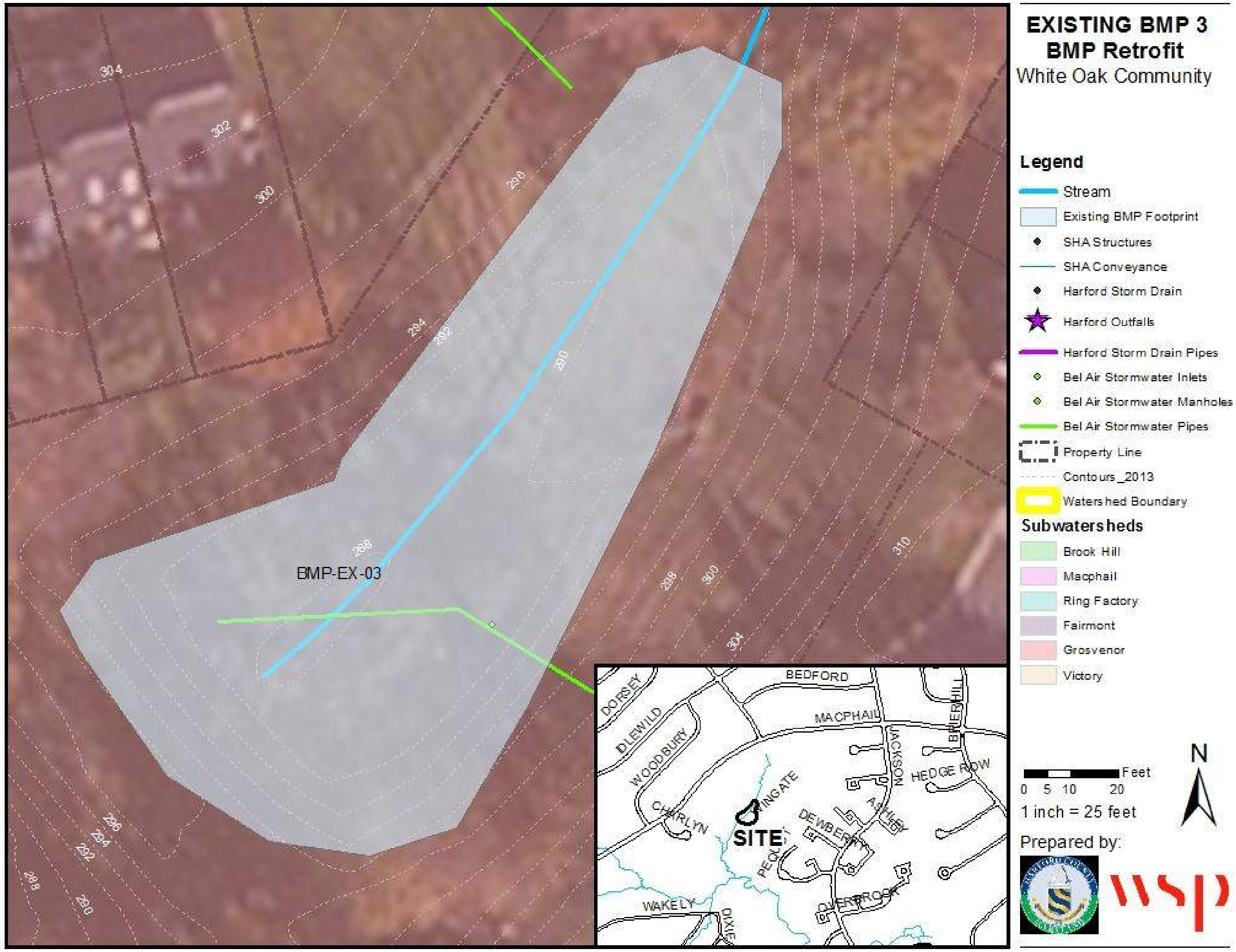

Figure 6-4: Site Location and Proposed Retrofit for Existing BMP 3.

RETROFIT OF EXISTING BMP 4: EXTENDED DETENTION RETROFIT

Project Description: Retrofit existing extended detention basin (Existing BMP 4) with wet pond

Location: Northern end of Raspberry Hill Court

Property Ownership: Brook Hill Manor Community Association, Inc.

Length of Project: N/A

Potential Impervious Acres Treated: 1.7 Acres

Potential Load Reductions TP: 17.8 lbs/year

Potential Load Reductions TN: 1.7 lbs/year

Potential Load Reductions TSS: 925 lbs/year

Estimated Design/Construction Costs: $177,271

Adjacent Projects: Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration

Site Description

Existing BMP 4 is located at the Northern end of Raspberry Hill Court within the Brook Hill subwatershed (Figure 6-5, left). One 18” and two 12” pipes convey flow from the surrounding neighborhood, including most of Raspberry Hill Court, to the existing extended detention facility. The impervious area that drains to the existing BMP accounts for 28% of the drainage area. The three pipes outfall into pilot channels within the BMP footprint. Flow from the extended detention facility outfalls via a metal riser structure with a 30” corrugated metal pipe to gabion outfall protection (Figure 6-5, right). There is no defined channel from the gabion outfall protection to the Upper Farnandis Branch main stem. There is a 12” dewatering device below ground at the riser. The metal riser serves as the emergency spillway for the facility. The facility is in good condition, with no erosion or sediment build up present. No flow was observed to the facility and there was no standing water in the facility. Rain had been observed in the area one day prior to the site visit.

A member of the Brook Hill Manor Community Association indicated that the facility was maintained last year, during which the embankment was graded and the riser was cleaned out. This was confirmed with the person who performed the maintenance.

- Drainage Area: 6.2 Acres
- Impervious Area: 1.7 Acres

Figure 6-5: Looking west towards existing extended detention facility (left); Looking South to outfall pipe onto gabion outfall protection (right)

Recommended Restoration Actions

- A wet pond retrofit is recommended within the current extended detention basin footprint. The wet pond is recommended to target improved water quality for flow exiting the facility into the perennial stream. A forebay will be placed at the outfall of each pipe to dissipate the flow entering the facility and reduce sediment loadings. A permanent pool will be excavated from the existing detention basin bottom to provide water quality treatment.
- Proposed project plans are shown in Figure 6-6.

Threats to Infrastructure

- There is no critical infrastructure in the project limits.
- There are surrounding homes in the community.

Property Ownership

- Ownership: Homeowner Association, Brook Hill Manor Community Association, Inc.

Access

- Moderate Access: Steep slopes and fence surrounding entire existing extended detention facility. The existing facility is located on communal HOA land.

Summary of Restoration Improvements

A summary of improvements for retrofitting existing BMP 4 are shown in Table 6-14. The table includes the drainage area of each improvement, the impervious area within the drainage area, the impervious area treated, and the pollutant load reductions. The quantity of impervious area treated is dependent on the rainfall depth of water treated. The proposed wet pond treats 1" of rainfall which corresponds to 1.0 impervious acre credit per acre of watershed impervious area. This proposed wet pond would provide 1.7 impervious acres of treatment.

While the existing BMP does manage stormwater, the proposed wet pond retrofit will also target water quality. Wet ponds provide a pollutant load reduction of 20% for nitrogen, 45% for phosphorus, and 60% for sediment (MDE, 2011).

Items of Note

Due to the highly residential nature of the proposed retrofit, there may be concerns from the community about the conversion from dry to wet pond. Community outreach/buy in should be obtained early on in the project to ensure success.

Retrofits assume that by using the Embankment Retrofit Design guidance (MDE, 2015), the existing Maryland pond 378 dam classification of the facility will not be impacted.

Project Costs

Total project costs are $177,271 for retrofitting existing BMP 4. Project costs are broken down by cost/ac for impervious area credit when impervious area treated is greater than one acre (Table 6-15). BMP project costs have been estimated based on the type of the project and the cost per impervious area treated (King & Hagan, 2011). The Maryland Stormwater BMP Cost Worksheet was used to determine design and construction costs for this project. ROW costs are not included in this estimate. The worksheet is setup for 2011 dollar values; therefore, the design and construction costs from 2011 were brought to present day, 2017, values to provide an accurate estimate of project costs.

Table 6-14: Summary of Improvements for Existing BMP 4

PROJECT TYPE	PROJECT NAME	DRAINAGE AREA (ACRES)	IMPERVIOUS AREA (ACRES)	RESTORATION LENGTH (FEET)	IMPERVIOUS AREA CREDIT (ACRES)	TN REDUCTIONS (LBS/YEAR)	TP REDUCTIONS (LBS/YEAR)	TSS REDUCTIONS (LBS/YEAR)
BMP	RET_BMP_4	6.2	1.7	-	1.7	17.8	1.7	925
Outfall								
Stream								
Total Credit/ Reductions					1.7	17.8	1.7	925

Table 6-15: Summary of Project Costs for Retrofitting Existing BMP 4

PROJECT TYPE	PROJECT NAME	PROJECT COST	COST/IMPERVIOUS ACRE TREATED
BMP	RET_BMP_4	$177,271	$104,277
Outfall			
Stream			
Total Costs		$177,271	$104,277

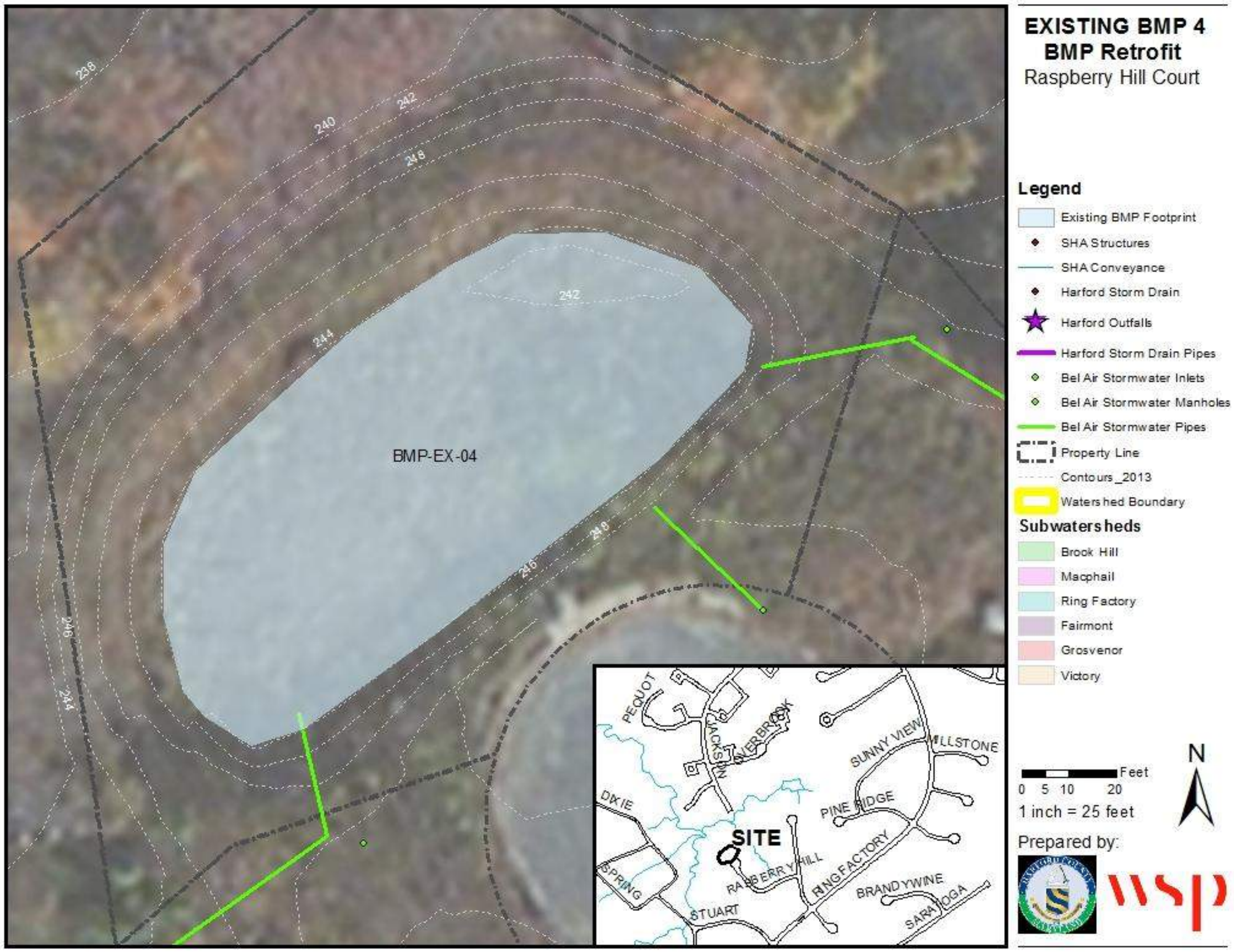

Figure 6-6: Site Location and Proposed Retrofit for Existing BMP 4.

6.2.2 PROPOSED BMP PROJECTS

A desktop evaluation of the watershed and an evaluation of previous studies within the watershed identified 14 potential new BMP projects within the watershed. Many of these potential projects are located at stormwater outfalls. During the outfall field assessment, many of the potential sites were removed from consideration due to available space and the proximity to the stream. As a result of the initial screening of sites during the outfall assessment, a total of 5 of the 14 sites were identified for an in-depth field assessment. The field assessment identified 2 sites with adequate space, accessibility, and limited constructability constraints. The two proposed BMP projects are described in detail in this section. Chapter 4 provides additional information on the field findings throughout each of these projects.

PROPOSED BMP 1: RAIN GARDENS

Project Description: Three rain gardens

Location: Bel Air Health and Rehabilitation Center

Property Ownership: SMV Bel Air, LLC

Length of Project: N/A

Potential Impervious Acres Treated: 0.31 Acres (Total)

Potential Load Reductions TP: 1.6 lbs/year

Potential Load Reductions TN: 0.08 lbs/year

Potential Load Reductions TSS: 49.2 lbs/year

Estimated Design/Construction Costs: $45,000

Adjacent Projects: Macphail Stream and Outfall Restoration

Site Description

The Bel Air Health and Rehabilitation Center is located at the intersection of E Macphail Rd. and Woodbury Way within the Macphail subwatershed. Under current conditions, the rooftop drains into an existing grass swale (Figure 1) located behind the Bel Air Health and Rehabilitation Center prior to discharging into an existing stream and storm drain system. Approximately, 2.33 acres comprising of 0.22 acres of impervious area drain to the confluence of the existing grass swale and stream (Figure 2). The confluence point of the existing grass swale and stream are unstable and eroded.

Figure 6-7: Looking West to existing grass swale (left); Looking South to existing grass swale (right)

Figure 6-8: Looking South to existing grass swale prior to discharge into stream (left)

<u>Recommended Restoration Actions</u>

- Three rain gardens are proposed adjacent to the Bel Air Health and Rehabilitation Center to treat rooftop runoff.
- Rain garden #1 (Figure 6-9, left) is proposed to be located adjacent to the back building at the downstream point of the disconnected downspouts.
- Rain garden #2 and #3 are proposed to be located adjacent to the building within the existing white fence area. Rain garden #2 and #3 (Figure 6-9, right) should be located at the downstream point of the disconnected downspouts for the applicable rooftop drainage.
- The proposed rain gardens have the potential to treat 0.22 total impervious acres.
- Proposed BMP plans are shown in Figure 6-10.

Figure 6-9: Looking South at proposed rain garden #1 location (left); Looking South to existing grass swale prior to discharge into stream (right)

Threats to Infrastructure

- There is no critical infrastructure in the project limits.
- There are surrounding homes in the community.

Property Ownership

- Ownership: Private Business, SMV Bel Air, LLC

Access

- Moderate Access: Steep slopes near proposed Rain Garden #1. Existing fence surrounding proposed rain gardens #2 and #3. Existing facility located on private land.

Summary of Restoration Improvements

A summary of improvements for the three proposed rain gardens are shown in Table 6-16. The table includes the drainage area of each improvement, the impervious area within the drainage area, the impervious area treated, and the pollutant load reductions. The quantity of impervious area treated is dependent on the rainfall depth of water treated. The proposed rain gardens each treat 2.6" of rainfall which corresponds to 1.4 impervious acre credit per acre of watershed impervious area. This proposed rain gardens would provide a total of 0.31 impervious acres of treatment. Rain gardens provide a pollutant load reduction of 50% for nitrogen, 60% for phosphorus, and 90% for sediment (MDE, 2011).

Items of Note

The responsibility of maintenance and inspection of the rain gardens will need to be established with the property owner. County should consider taking of maintenance responsibilities in order to ensure credit into perpetuity.

Project Costs

The total project cost (excluding ROW/easements) is $45,000 for the proposed rain gardens. Project costs are broken down by cost/ac for impervious area credit when the impervious area is greater than one acre (Table 6-17). BMP project costs have been estimated based on the type of the project and the cost per impervious area treated (King & Hagan, 2011). The Maryland Stormwater BMP Cost Worksheet was used to determine design and construction costs for this project. ROW costs are not included in this estimate. The worksheet is setup for 2011 dollar values; therefore, the design and construction costs from 2011 were brought to present day, 2017, values to provide an accurate estimate of project costs.

Table 6-16: Summary of Improvements for Proposed BMP 1

PROJECT TYPE	PROJECT NAME	DRAINAGE AREA (ACRES)	IMPERVIOUS AREA (ACRES)	RESTORATION LENGTH (FEET)	IMPERVIOUS AREA CREDIT (ACRES)	TN REDUCTIONS (LBS/YEAR)	TP REDUCTIONS (LBS/YEAR)	TSS REDUCTIONS (LBS/YEAR)
BMP	BMP-PR-01 (Rain Garden #1)	0.11	0.11	-	0.15	0.8	0.05	24.6
BMP	BMP-PR-01 (Rain Garden #2)	0.07	0.07	-	0.10	0.5	0.02	15.7
BMP	BMP-PR-01 (Rain Garden #3)	0.04	0.04	-	0.06	0.3	0.01	8.9
Outfall								
Stream								
Total Credit/ Reductions					0.31	1.6	0.08	49.2

Table 6-17: Summary of Project Costs for Proposed BMP 1

PROJECT TYPE	PROJECT NAME	PROJECT COST	COST/IMPERVIOUS ACRE TREATED
BMP	BMP-PR-01 (Rain Garden #1)	$21,775.30	
	BMP-PR-01 (Rain Garden #2)	$14,515.11	
	BMP-PR-01 (Rain Garden #3)	$8,709.59	
Outfall			
Stream			
Total Costs		$45,000.00	$145,161.29

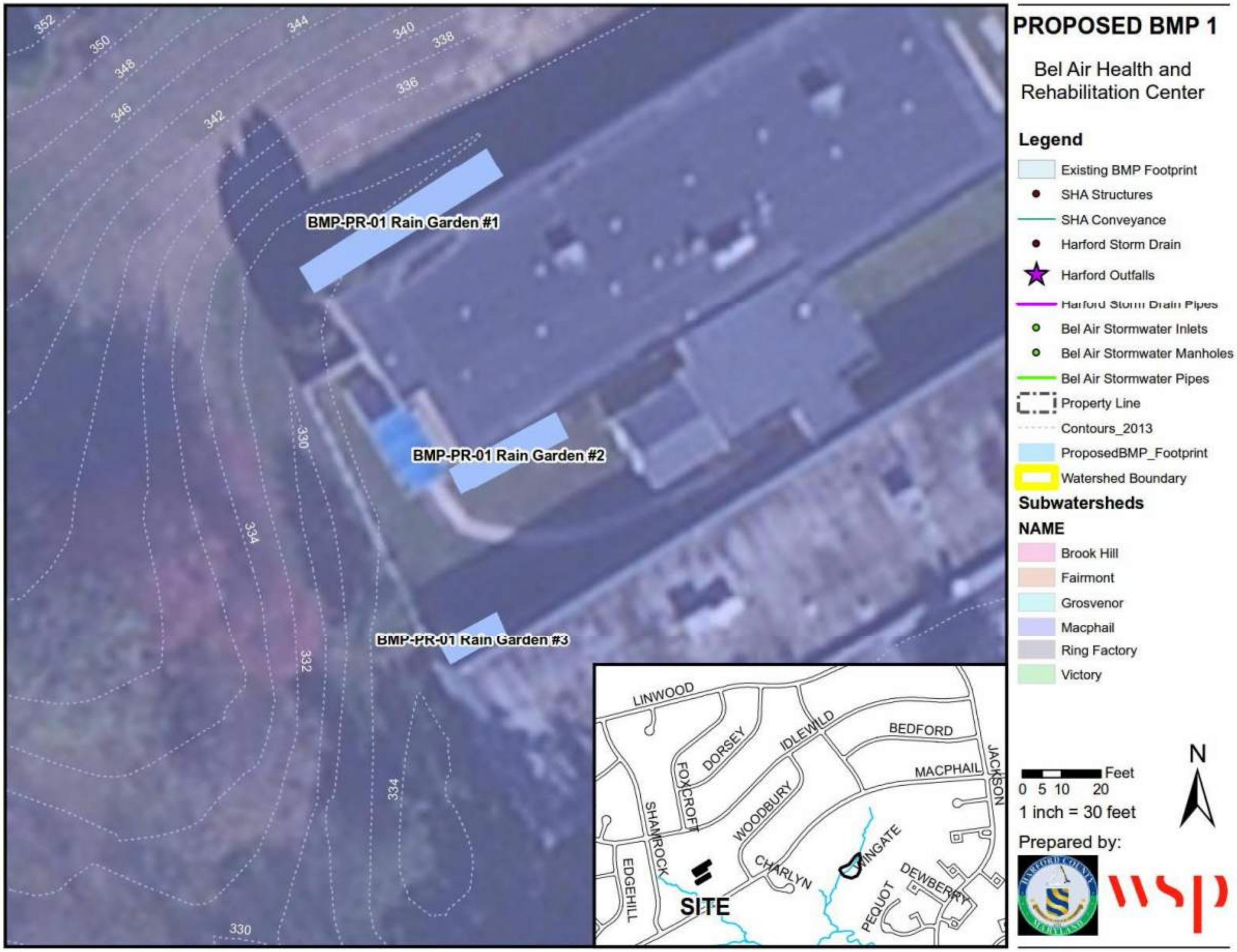

Figure 6-10: Proposed BMP 1 Site Location

PROPOSED BMP 2: BIORETENTION

Project Description: Bioretention

Location: Mariner Health

Property Ownership: Shamrock Creek Enterprises, LLC

Length of Project: N/A

Potential Impervious Acres Treated: 0.84 Acres

Potential Load Reductions TP: 35.5 lbs/year

Potential Load Reductions TN: 2.2 lbs/year

Potential Load Reductions TSS: 1,233 lbs/year

Estimated Design/Construction Costs: $177,270.56

Adjacent Projects: Macphail Stream and Outfall Restoration

Site Description

Mariner Health is located at the intersection of East Macphail Rd. and South Shamrock Rd. within the Macphail subwatershed. Under current conditions, South Shamrock Rd. from the high point to the driveway entrance to Mariner Health drains through curb and gutter (Figure 5) prior to discharging to an existing stream and storm drain system. The existing stream is located behind the Mariner Health property. The downspouts are disconnected allowing the rooftop of Mariner Health building to drain to the existing stream. Additionally, the parking lot of Mariner Health drains to an existing apron prior to discharging to the existing stream (Figure 6). Approximately, 1.97 acres comprising of 0.84 acres of impervious area drain to the existing stream.

Figure 6-11: Looking West along driveway entrance to Mariner Health (left); Looking East to existing deteriorated curb within parking lot at Mariner Health (right)

Figure 6-12: Looking West toward Mariner Health building (left); Looking East at parking lot behind Mariner Health toward proposed BMP (right)

Figure 6-13: Looking West at proposed bioretention location (left); Looking North at proposed bioretention location (right)

Recommended Restoration Actions

- A bioretention facility is proposed in the flat area adjacent to E. Macphail Rd. and the Mariner Health parking lot to treat impervious area runoff (Figure 6-13). The soils in the area are type C, indicating low infiltration rates. An underdrain is recommended to convey treated runoff that does not infiltrate into the ground to the nearby stream.
- The proposed bioretention has the potential to treat 0.84 total impervious acres.
- Proposed BMP plans are shown in Figure 6-14.

Threats to Infrastructure

- There is no critical infrastructure in the project limits.
- There are surrounding homes in the community.
- There are no utility conflicts.

Property Ownership

- Ownership: Private Business, Shamrock Creek Enterprises, LLC

Access

- Minor Access: Existing facility located on private land. Mature trees near vicinity of proposed BMP footprint.

Summary of Restoration Improvements

A summary of improvements for the proposed bioretention facility are shown in Table 6-18. The table includes the drainage area of each improvement, the impervious area within the drainage area, the impervious area treated, and the pollutant load reductions. The quantity of impervious area treated is dependent on the rainfall depth of water treated. The proposed bioretention facility treats 1.0" of rainfall which corresponds to 1 impervious acre credit per acre of watershed impervious area. This proposed bioretention facility would provide a total of 0.84 impervious acres of treatment. Bioretention facilities provide a pollutant load reduction of 40% for nitrogen, 60% for phosphorus, and 80% for sediment (MDE, 2011).

Items of Note

The responsibility of maintenance and routine inspection of the bioretention facility will need to be established with the property owner. County should consider taking of maintenance responsibilities in order to ensure credit into perpetuity.

Project Costs

The total project cost (excluding ROW/easements) is $177,270.56 for the proposed bioretention facility. Project costs are only broken down by cost/ac for impervious area credit when the area treated is greater than one acre (Table 6-19). BMP project costs have been estimated based on the type of the project and the cost per impervious area treated (King & Hagan, 2011). The Maryland Stormwater BMP Cost Worksheet was used to determine design and construction costs for this project. ROW costs are not included in this estimate. The worksheet is setup for 2011 dollar values; therefore, the design and construction costs from 2011 were brought to present day, 2017, values to provide an accurate estimate of project costs.

Table 6-18: Summary of Improvements for Proposed BMP 2

PROJECT TYPE	PROJECT NAME	DRAINAGE AREA (ACRES)	IMPERVIOUS AREA (ACRES)	RESTORATION LENGTH (FEET)	IMPERVIOUS AREA CREDIT (ACRES)	TN REDUCTIONS (LBS/YEAR)	TP REDUCTIONS (LBS/YEAR)	TSS REDUCTIONS (LBS/YEAR)
BMP	BMP-PR-2	1.97	0.84	-	0.84	35.5	2.2	1,233
Outfall								
Stream								
Total Credit/ Reductions					0.84	35.5	2.2	1,233

Table 6-19: Summary of Project Costs for Proposed BMP 2

PROJECT TYPE	PROJECT NAME	PROJECT COST	COST/IMPERVIOUS ACRE TREATED
BMP	BMP-PR-2 Bioretention	$177,270.56	$211,036.38
Outfall			
Stream			
Total Costs		$177,270.56	$211,036.38

Figure 6-14: Proposed BMP 2 Site Location

6.3 STREAM AND OUTFALL RESTORATION PROJECTS

Combination stream restoration and outfall stabilization projects are presented in the following subsections. Five projects have been recommended for the Upper Farnandis watershed. These projects include stream restoration from 561 linear feet to 4,790 linear feet. Two projects are stream restoration projects while the other three projects are a combination of stream restoration and outfall stabilization projects. Outfalls have been identified at the headwater of the stream or on the left or right bank of the stream that are in need of repair, replacement, or stabilization. Section 6.1 describes the prioritization of stream and outfall restoration projects for the Upper Farnandis watershed in further detail and Section 6.4 provides project recommendations.

FAIRMONT STREAM AND OUTFALL RESTORATION

Project Description: Restore 914 feet of stream; tie outfall 24 into drop manhole structure and outfall to plunge pool; tie outfall 25 into stream bed

Location: Backyard of 130 Fairmont Dr, side yard of 128 Fairmont Dr, backyard of 4 Carolina Ave

Property Ownership: Eleven Private Properties (2 properties for Outfall 24; 2 properties for Outfall 25, and 8 properties for stream restoration)

Length of Project: 914 feet of stream restoration and 73 feet of outfall stabilization

Potential Impervious Acres Treated: 9.8 Acres

Potential Load Reductions TP: 68.6 lbs/yr

Potential Load Reductions TN: 62.2 lbs/yr

Potential Load Reductions TSS: 41,039 lbs/yr

Estimated Design/Construction Costs: $820,500

Adjacent Projects: Ring Factory Stream Restoration

Site Description

Outfall 24 is at the headwaters of tributary F-T1 and is in the backyard of a private property owner (

Figure 6-17). Two 33" pipes convey flow from the surrounding neighborhood, including the majority of Fairmont Drive and North Lynbrook Road and all of South Lynbrook Road, towards the tributary in the Fairmont subwatershed. The impervious area that drains to Outfall 24 accounts for 27% of the drainage area. The two pipes outfall at one endwall made of slate and cascade a couple of feet to the channel (Figure 6-15, left). High flow storm events have contributed to channel incision and widening. Approximately 20 feet downstream of the endwall, the channel bed drops 5-6 feet over a 10 feet linear section, before hitting bedrock (Figure 6-15, right). Over the next 45 feet, the channel continues to slope downward toward the existing stream channel. The channel widens from 8 feet at the outfall to 12 feet at the stream channel.

Looking downstream, flow was observed from the right outfall pipe, while no flow was observed from the left outfall pipe. Rain had not been observed in the area for 3 days prior to the site visit. It is believed that flow from this outfall is perennial; therefore, the stream channel begins downstream of the outfall.

Runoff from the outfall flows into F-T1 tributary. The tributary is approximately 1,000 feet to the confluence of the Upper Farnandis Branch main stem. Approximately 914 feet of F-T1 has eroded banks. The first 700 feet of the tributary, downstream of outfall 24, has 6 to 8 feet of vertical banks on the right bank (Figure 6-16, left) while the left bank has 5 to 6 foot vertical banks.

Outfall 25 is a 12” concrete pipe that conveys stormwater flow from Colony Place to the right bank of tributary F-T1. Flow is conveyed through a rock/concrete grouted channel. Both the outfall structure and the concrete channel are in good condition; however, as the channel reaches the right bank of tributary F-T1, part of the concrete channel has broken off into the stream. This is due to the receding right bank of F-T1. No flow was observed at Outfall 25. It is believed that the channel at this outfall is ephemeral.

An exposed metal pipe protrudes from the channel bottom and the right bank (Figure 6-16, right). The purpose of the pipe is unknown; however, it does have a cleanout access. While the pipe is currently not leaking, with the length of exposed pipe and the large amount of debris trapped behind the pipe, it is only a matter of time before the exposed pipe is impacted.

The last 200 feet of the tributary prior to reaching the confluence with the main stem has approximately 2 to 3 foot banks with a large floodplain on the right and a private pond beyond the left bank. The private pond has been fed by flow from the tributary in the past; however, the homeowner has voiced concern about the lack of flow currently entering the pond. The inflow pipe is a 4-inch plastic drainage pipe that is approximately half a foot above the stream bottom.

Figure 6-15: Looking upstream towards Outfall 24 (left); Looking downstream of Outfall 24 (right)


Figure 6-16: Looking upstream at 9 feet eroded right bank (left); Looking towards right bank at exposed pipe (right)

Recommended Restoration Actions

- Stream Restoration
    - *F-T1*: 914 feet from Outfall 24 plunge pool to 90 feet upstream of confluence with mainstem
- Outfall Stabilization
    - *Outfall 24*: Due to the steep nature of the channel at Outfall 24 and an approximately 13% grade, a drop manhole structure is recommended at the outfall. The two pipe outfalls will tie into the drop manhole approximately 15 feet downstream of the current endwall. An outfall pipe with an invert 8 feet below the inlet invert will allow the flow to discharge in line with the stream channel. The endwall of the newly constructed outfall will be approximately 40 feet downstream of the current endwall. A plunge pool will be placed at the proposed outfall location to dissipate the discharge during high flow events before entering the steam channel. It is recommended that this outfall stabilization project be conducted along with the stream project.
    - *Outfall 25*: 23 feet of stabilization
- Impervious Removal
    - *Outfall 25 channel*: Remove the concrete channel from Outfall 25 to the right bank of F-T1. Grade the outfall channel to tie in with the stream channel and install rip-rap protection from the outfall to the right bank of F-T1.
- Proposed project limits are shown in Figure 6-17.

Threats to Infrastructure

- There is a utility pole along the edge of the right bank approximately 90 feet downstream from Outfall 24. The right bank at this location is 8 feet high.
- A metal pipe protrudes from the stream bed and the stream bank. The pipe usage is unknown. The pipe has a cleanout cover. Debris carried downstream during a storm event may damage the exposed pipe.

- Stream restoration will likely impact the private property, aesthetic pond that has received inflow from the stream in the past. The property owner is interested in regaining flow from the stream. The County may decide to work with the property owner to return flow to the pond.

Property Ownership

There are numerous private property owners along this reach. Buy in from property owners at the beginning of the project will help maximize design dollars and project efforts. Having one or two critical property owners drop out of the project late in the design will likely necessitate a redesign of the stream channel and project delays. It is recommended that the County try to obtain buy in after conceptual design level.

- Ownership: Private homeowner, 128 Fairmont Drive
  Private homeowner, 130 Fairmont Drive
  Private homeowner, 132 Fairmont Drive
  Private homeowner, 138 Fairmont Drive
  Private homeowner, 4 Carolina Avenue
  Private homeowner, 6 Spring Drive
  Private homeowner, 8 Spring Drive
  Private homeowner, 2 Vaughn Avenue
  Private homeowner, 111 Colony Place
  Private homeowner, 113 Colony Place
  Private homeowner, 115 Colony Place

Access

- Moderate Access at 130 Fairmont Drive for stream and outfall restoration.
- Moderate Access at level area at 4 Carolina Avenue for stream restoration.

Summary of Restoration Improvements

A summary of improvements for this project are provided in Table 6-20. Two outfall stabilization projects, totaling 73 linear feet are recommended alongside 914 linear feet of stream restoration. One of the outfall stabilization components of this project includes the removal of 20 feet of concrete lined channel. The construction of 914 linear feet of stream restoration and 73 feet of outfall stabilization in this project will treat 9.8 impervious acres within the watershed. This treatment amount accounts for approximately 10% of the impervious area within the watershed.

Project Costs

The total project cost (excluding ROW/easements) is $820,500 for the Fairmont Stream and Outfall Restoration project. This cost estimate includes one small and one large outfall stabilization project as well as a small stream restoration project. Cost estimates for each project type are described in Section 6.1.4. The cost estimate for each component of the project as well as the total project cost are provided in Table 6-21.

Table 6-20: Summary of Improvements for Fairmont Stream and Outfall Restoration

PROJECT TYPE	PROJECT NAME	DRAINAGE AREA (ACRES)	IMPERVIOUS AREA (ACRES)	RESTORATION LENGTH (FEET)	IMPERVIOUS AREA CREDIT (ACRES) †	TN REDUCTIONS (LBS/YEAR) *	TP REDUCTIONS (LBS/YEAR) **	TSS REDUCTIONS (LBS/YEAR) ***
BMP								
Impervious Removal	OF_25	-	0.0005		0.0005			
Outfall Maintenance								
Outfall	OF_24	29.0	7.9	50	0.5	-	-	-
	OF_25	1.64	0.66	23	0.2	-	-	-
Stream	F-T1	42.3	9.90	914	9.1	68.6	62.2	41,039
Total Credit/ Reductions				987	9.8	68.6	62.2	41,039

†Impervious Area Credit equals restoration length times 0.01
*TN reductions equal restoration length times 0.075 lbs/ft/yr
**TP reductions equal restoration length times 0.068 lbs/ft/yr
***TSS reductions equal restoration length times 44.9 lbs/ft/yr

Table 6-21: Summary of Project Costs for Fairmont Stream and Outfall Restoration

PROJECT TYPE	PROJECT NAME	PROJECT SIZE	UNIT COST	UNIT	PROJECT COST	COST/IMPERVIOUS ACRE TREATED*
BMP						
Impervious Removal	OF_25	Small	$5,000	Project	$5,000	
Outfall Maintenance						
Outfall	OF_24	Large	$100,000	Project	$100,000	
	OF_25	Small	$30,000	Project	$30,000	
Stream	F-T1	Small	$750	L.F.	$685,500	$75,329.70
Total Costs					$820,500	$83,724.50

*Project cost divided by stream restoration impervious area treated

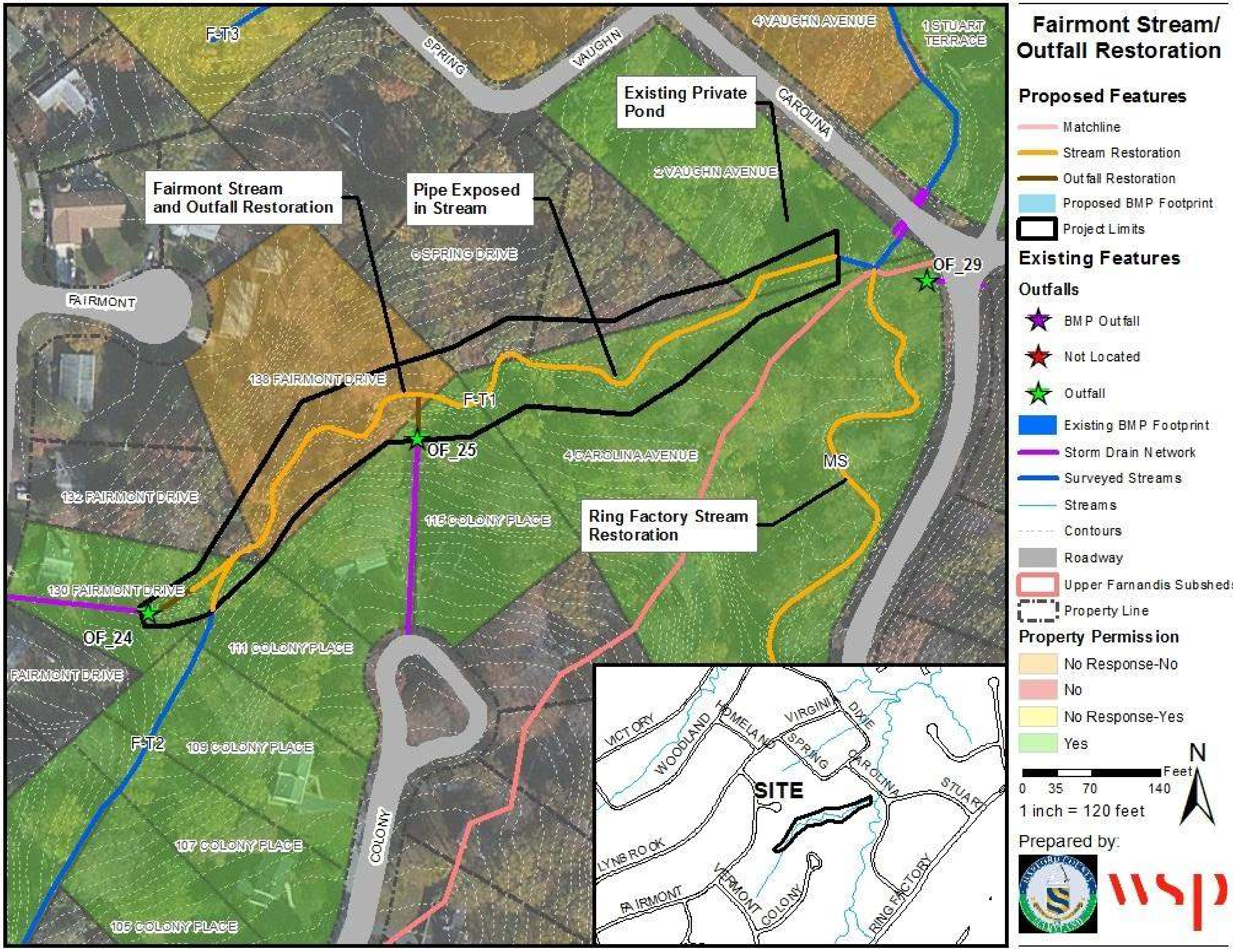

Figure 6-17: Site Location and Proposed Project Plan for Fairmont Stream and Outfall Restoration

RING FACTORY STREAM RESTORATION

Project Description: Restore 1,981 feet of the main stem and 198 feet of tributary R-T1

Location: 114 East Ring Factory Rd; 4 Carolina Ave

Property Ownership: Twelve Private Properties

Length of Project: 2,180 feet of stream restoration

Potential Impervious Acres Treated: 21.8 Acres

Potential Load Reductions TP: 163.4 lbs/yr

Potential Load Reductions TN: 148.2 lbs/yr

Potential Load Reductions TSS: 97,837 lbs/yr

Estimated Design/Construction Costs: $1,447,000

Adjacent Projects: Fairmont Stream and Outfall Restoration

Site Description

The headwaters of the main stem originate at outfalls 34 and 35. Outfall 34 provides stormwater runoff from Colonial Road while Outfall 35 conveys flow from East Ring Factory Road. The main stem flows for 1,028 feet before receiving flow from tributary R-T1. Along this 1,028-foot section of stream, 594 feet of inadequate buffer has been identified and two stream segments are currently channelized with a rock/concrete grout, lining the channel bottom and banks. The channelized stream segments total 320 feet. The downstream channelized segment ends within the property boundaries of 114 East Ring Factory Road. This property contains a playground and is largely a grassy, open space. A wooden pedestrian bridge is located over the concrete lined stream channel near the playground. The location of the bridge is shown on the project map in Figure 6-20. Steep, high banks are evident after the channelization ends, as is seen in Figure 6-18. Minimal erosion was observed at the channel alteration sites; however, at the end of the second channel alteration, moderate erosion was observed on both banks for 650 feet. The stream has experienced channel incision and widening with bank heights ranging from 4 to 8 feet along this segment of eroded stream. A second pedestrian bridge is in the backyard of 208 East Ring Factory Road.

An endwall northeast of East Ring Factory Road conveys flow from tributary R-T1 and from East Ring Factory Road through two outfalls. Outfalls 27 and 28 are on the wing walls of the outfall structure. The channel of tributary R-T1 is steep from the outfall to the main stem. The outfall structure and outfall protection are in good condition; however, erosion has occurred downstream of the outfall protection. The banks range in height from 3 to 10 feet along the eroded downstream section of tributary R-T1.

The main stem from the confluence of R-T1 to Outfall 26 is 390 feet long. Bedrock is exposed along this stream segment and the stream channel drops over 8 feet within the property boundary of 6 Carolina Ave. According to one homeowner, this stream segment has widened significantly since the storm drain network at Ring Factory Road (outfalls 27 and 28) was installed/upgraded. This stream segment consists of mostly forested, residential backyards.

The stream segment that flows through 4 Carolina Avenue flows through a culvert on both the upstream and downstream ends of the property. This stream segment is 570 feet long. Moderate erosion and a sinuous stream were noted along this stream segment. One bend in the stream may soon become a threat to the edge of Carolina Avenue. The stream bank is currently 5 feet from Carolina Avenue. Figure 6-19 shows the steep bank near Carolina Avenue. Outfall 29 conveys flow from Carolina

Avenue to the main stem. Flow from the outfall enters the main stem at the subwatershed outlet, just upstream of the double culvert crossing under Carolina Avenue.

All eight outfalls contributing flow to the main stem and R-T1 within Ring Factory watershed are in good condition and do not require stabilization. Flow was not observed at outfalls 29 and 33.

Figure 6-18: Looking downstream at erosion at end of channel alteration at 114 East Ring Factory Rd (left); Erosion downstream of channel alteration (right)

Figure 6-19: Looking upstream at 4 Carolina Ave, Steep banks creeping towards Carolina Ave (left); Bank heights are lower further downstream on property 4 Carolina Ave (right)

<u>Recommended Restoration Actions</u>

- Stream Restoration
    - *Main stem*: 1,981 feet from Outfalls 34 and 35 to the culvert at Carolina Ave, including removal of 320 feet of concrete channel protection on both banks.
    - *R-T1*: 198 feet from end of Outfall 27 and 28 outfall protection to confluence with main stem.

- Outfall Maintenance
    - *Outfalls 26:* Replacement of 3 linear feet of riprap outfall protection on the right bank of the stream during the stream restoration project. Movement of riprap due to high flows in the stream channel.
    - *Outfall 29:* Outfall is 50% buried with sediment. Pipe cleanout recommended.
- Proposed project limits are shown in Figure 6-20 and Figure 6-21.

Threats to Infrastructure

- One bend in the stream on private property (4 Carolina Ave) is within 5 feet of the edge of pavement on Carolina Ave. The right bank at this location is 6 feet high.
- Two pedestrian bridges (114 East Ring Factory Road and 208 East Ring Factory Road) are currently in good condition.

Property Ownership

There are numerous private property owners along this reach. Buy in from property owners at the beginning of the project will help maximize design dollars and project efforts. Having one or two critical property owners drop out of the project late in the design will likely necessitate a redesign of the stream channel and project delays. It is recommended that the County try to obtain buy in after conceptual design level.

- Ownership: Private homeowner, 104 East Ring Factory Road
  Private homeowner, 106 East Ring Factory Road
  Private homeowner, 108 East Ring Factory Road
  Private homeowner, 114 East Ring Factory Road
  Private homeowner, 1211 Vermont Road
  Private homeowner, 1213 Vermont Road
  Private homeowner, 1215 Vermont Road
  Private homeowner, 1217 Vermont Road
  Private homeowner, 208 East Ring Factory Road
  Private homeowner, 210 East Ring Factory Road
  Private homeowner, 4 Carolina Avenue
  Private homeowner, 6 Carolina Avenue

Access

- Good Access at 114 East Ring Factory Road for stream restoration
- Good Access at 4 Carolina Avenue for stream restoration

Summary of Restoration Improvements

A summary of improvements for this project are provided in Table 6-22. 2,180 linear feet of stream restoration is being recommended at this location. This stream project includes the removal of 320 linear feet of concrete lined channel. The construction of 2,180 linear feet of stream restoration in this project will treat 21.8 impervious acres within the watershed. This treatment amount accounts for approximately 21% of the impervious area within the watershed.

Project Costs

The total project cost (excluding ROW/easements) is $1,447,000 for the Ring Factory Stream Restoration project. This cost estimate includes zero outfall stabilization projects and one medium stream restoration project with impervious removal. The cost estimate for the project type is described in Section 6.1.4. The cost estimate for this project is provided in Table 6-23.

Table 6-22: Summary of Improvements for Ring Factory Stream Restoration

PROJECT TYPE	PROJECT NAME	DRAINAGE AREA (ACRES)	IMPERVIOUS AREA (ACRES)	RESTORATION LENGTH (FEET)	IMPERVIOUS AREA CREDIT (ACRES) †	TN REDUCTIONS (LBS/YEAR) *	TP REDUCTIONS (LBS/YEAR) **	TSS REDUCTIONS (LBS/YEAR) ***
BMP								
Impervious Removal	MS		0.044	320	0.044	-	-	-
Outfall Maintenance	OF_26	-	-	-	-	-	-	-
	OF_29	-	-	-	-	-	-	-
Outfall								
Stream	MS and R-T1	106	19.0	2,180	21.8	163.4	148.2	97,837
Total Credit/ Reductions				2,180	21.8	163.4	148.2	97,837

†Impervious Area Credit equals restoration length times 0.01
*TN reductions equal restoration length times 0.075 lbs/ft/yr
**TP reductions equal restoration length times 0.068 lbs/ft/yr
***TSS reductions equal restoration length times 44.9 lbs/ft/yr

Table 6-23: Summary of Project Costs for Ring Factory Stream Restoration

PROJECT TYPE	PROJECT NAME	PROJECT SIZE	UNIT COST	UNIT	PROJECT COST	COST/IMPERVIOUS ACRE TREATED*
BMP						
Impervious Removal	MS	Medium	$20,000	Project	$20,000	
Outfall Maintenance	OF_26	Small	$5,000	Project	$5,000	
	OF_29	Small	$5,000	Project	$5,000	
Outfall						
Stream	MS and R-T1	Medium	$650	L.F.	$1,417,000	$65,000.00
Total Costs					$1,447,000	$66,376.15

*Project cost divided by stream restoration impervious area treated

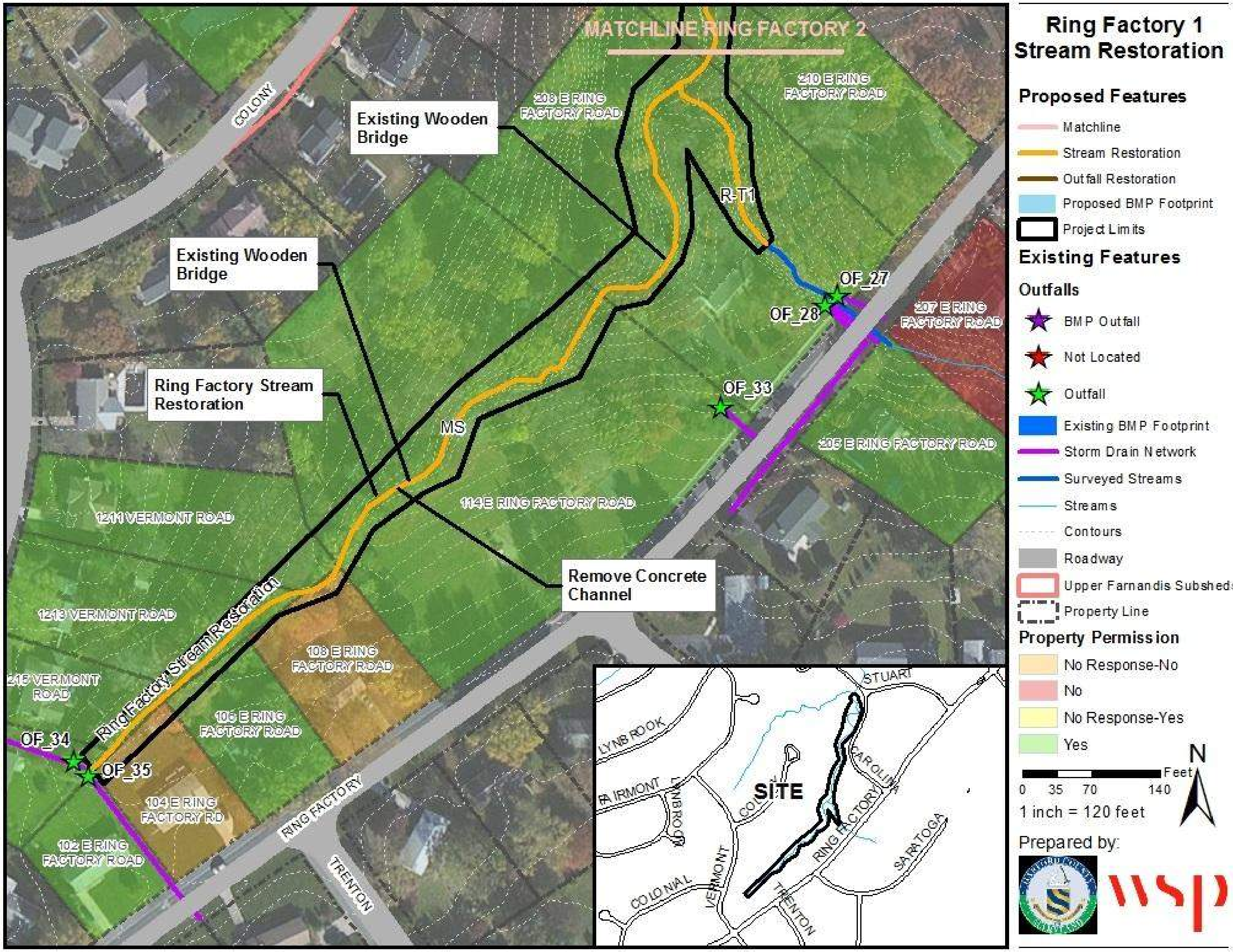

Figure 6-20: Site Location and Proposed Project Plan for Ring Factory Upstream Stream Restoration Segment (Sheet 1 of 2)

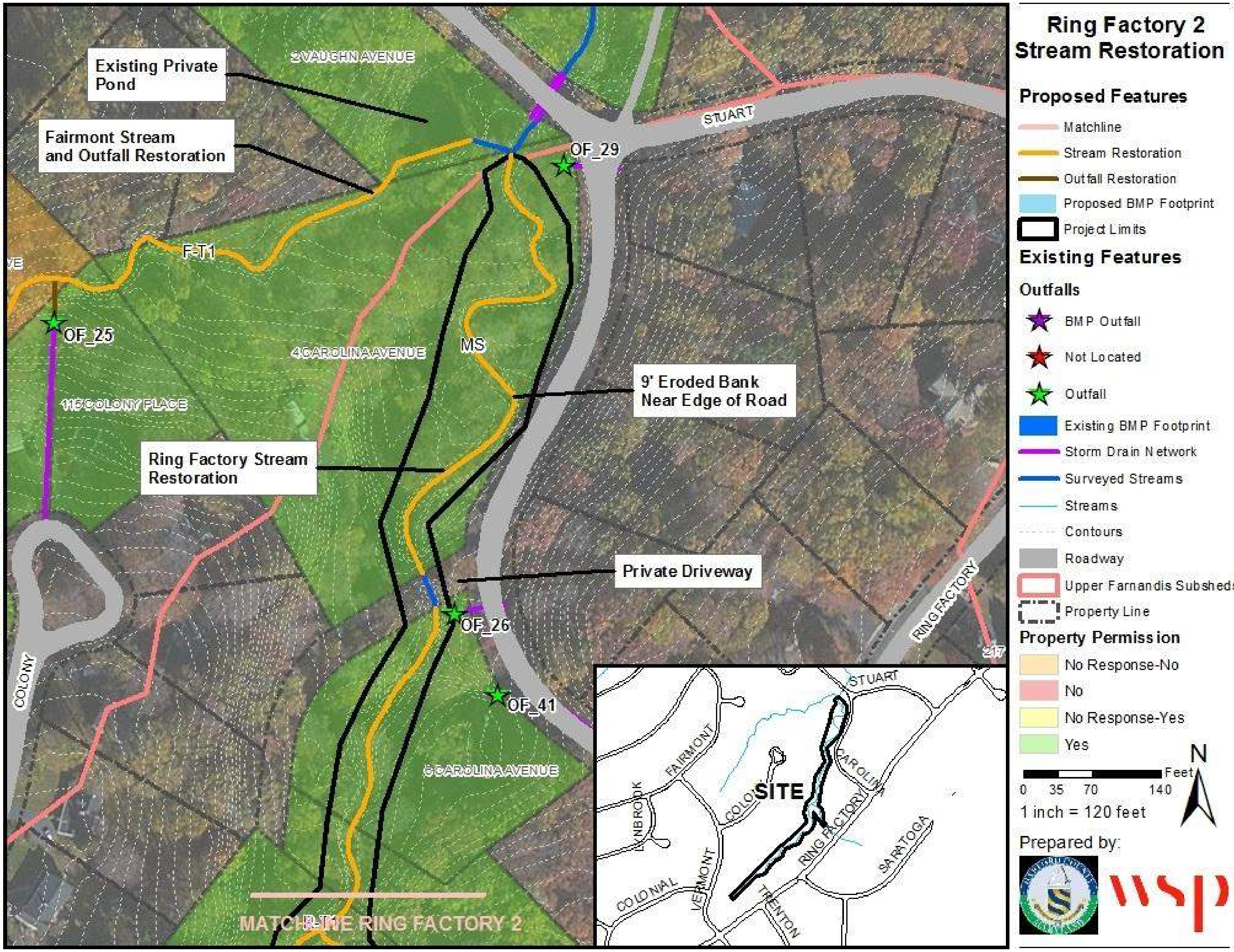

Figure 6-21: Site Location and Proposed Project Plan for Ring Factory Downstream Stream Restoration Segment (Sheet 2 of 2)

VICTORY STREAM AND OUTFALL RESTORATION

Project Description: Restore two stream segments along V-T1, 1,968 feet and 230 feet segments, and stabilize 30 feet of channel at Outfall 39 and 7 feet of channel at Outfall 23

Location: 1115 South Main St; 209 Woodland Dr

Property Ownership: 1 SHA property and 17 Private Properties

Length of Project: 2,200 feet of stream restoration and 37 feet of outfall stabilization

Potential Impervious Acres Treated: 22.9 Acres

Potential Load Reductions TP: 164.9 lbs/yr

Potential Load Reductions TN: 149.5 lbs/yr

Potential Load Reductions TSS: 98,690 lbs/yr

Estimated Design/Construction Costs: $1,490,000

Adjacent Projects: Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration

Site Description

There are two tributaries in the subwatershed, V-T1 and V-T2. V-T2 conveys flow from a commercial parking lot, Heather Road, Belcrest Road, and Sherwood Road. A large scour hole is present at the outfall (Figure 6-22, right). The tributary has bank heights between 6 inches and 3 feet. High flows have created multiple side channels that outfall to the right bank of tributary V-T1 in multiple locations.

The headwaters of tributary V-T1 originate at South Main Street with an SHA-maintained endwall (Outfall 12). The flow is intermittent at this location. An SHA-owned BMP facility located south of Victory Lane outfalls (Outfall 38) to V-T1. Both Outfall 12 and Outfall 38 are in good condition. Downstream of outfall 38, flow is perennial. Little to no active erosion was observed between the confluence of Outfall 39 and V-T1 and Outfall 18.

In the backyard of 110 Victory Lane, prior to outfall 18, the channel is experiencing incision. According to the homeowner, the majority of the change in the stream channel occurred after one storm a couple of years ago. The channel banks increased from 2 feet upstream of the incision to 4 feet high. The stream banks return to 1 to 2 feet high about 115 feet downstream of the beginning of the incising location. This is an isolated occurrence in the stream reach and is not currently recommended for restoration. The location is indicated on the project map in Figure 6-24.

Downstream of Outfall 18, flow is conveyed under Woodland Drive, where moderate erosion has occurred. Stream banks range in height from 3 to 10 feet in the stream segment between the Woodland Drive culvert and the Wakely Terrace culvert. Outfall 23 enters tributary V-T1 at the left bank and conveys flow from Victory Lane. The invert of the outfall is 2.5 feet above the stream bottom (Figure 6-23, left). There are several threats to infrastructure in this stream segment, including an exposed manhole. One sharp bend in the stream has exposed the edge of pavement at Victory Lane (Figure 6-23, right) while another bend in the stream is undercut and within 10 feet of the edge of a home. A portion of the stream was not accessible due to restricted access.


Figure 6-22: Erosion downstream of Outfall 38 (left); Scour hole and erosion on left and right banks of Outfall 39 (right)


Figure 6-23: Looking towards the left bank at Outfall 23, (left); Erosion on left bank reaches the edge of Victory Lane at the top of the bank, 9 feet bank (right)

Recommended Restoration Actions

- Stream Restoration
    - *V-T1*: 230 feet between Outfall 38 and confluence with V-T2.
    - *V-T1*: 1892 feet between Woodland Drive and Wakely Terrace.
- Outfall Stabilization
    - *Outfall 39*: 30 feet of stabilization
    - *Outfall 23*: 7 feet of stabilization
- Proposed project limits are shown in Figure 6-24, Figure 6-25, and Figure 6-26.

Threats to Infrastructure

- One bend in the stream on private property (201 Woodland Drive) has left banks of 9 feet and is at the edge of pavement on Victory Lane. There is currently no undercutting of the roadway on Victory Lane; however, any further erosion may impact the structural integrity of the road.
- A 4-inch metal pipe was found in the stream channel at 240 Victory Lane. This pipe protrudes vertically from the stream channel, approximately 3 feet, and has a cleanout cover at the top. The purpose of this pipe is currently unknown. It should be investigated further to determine if it may cause a threat. At the very least, it may cause a debris jam due to its location in the stream.
- A sanitary sewer manhole is exposed on the right bank at the property boundaries of 242 Victory Lane and 115 Woodland Drive. The manhole is currently stable. Riprap has been placed upstream and downstream of the manhole; however, approximately 80% of the manhole is exposed to the stream. The manhole cover is approximately 5 feet above the stream bottom.

Property Ownership

There are numerous private property owners along this reach. Buy in from property owners at the beginning of the project will help maximize design dollars and project efforts. Having one or two critical property owners drop out of the project late in the design will likely necessitate a redesign of the stream channel and project delays. It is recommended that the County try to obtain buy in after conceptual design level.

In addition, one of the outfalls is on MDOT SHA property. There is a potential partnering opportunity for this location.

- Ownership: MDOT State Highway Administration, Route 924
  Private homeowner, 104 Victory Lane
  Private homeowner, 1115 South Main Street
  Private homeowner, 230 Victory Lane
  Private homeowner, 232 Victory Lane
  Private homeowner, 240 Victory Lane
  Private homeowner, 242 Victory Lane
  Private homeowner, 101 Woodland Drive
  Private homeowner, 105 Woodland Drive
  Private homeowner, 109 Woodland Drive
  Private homeowner, 109-B Woodland Drive
  Private homeowner, 109-C Woodland Drive
  Private homeowner, 111 Woodland Drive
  Private homeowner, 115 Woodland Drive
  Private homeowner, 201 Woodland Drive
  Private homeowner, 203 Woodland Drive
  Private homeowner, 207 Woodland Drive
  Private homeowner, 209 Woodland Drive

Access

- Fair Access at 1115 South Main Street for Outfall 39 stabilization and two upper stream restoration segments

- Good Access at 209 Woodland Drive for stream restoration

- Good Access at 101 Woodland Drive for stream restoration

Summary of Restoration Improvements

A summary of improvements for this project are provided in Table 6-24. Two outfall stabilization projects, totaling 37 linear feet are recommended alongside 2,200 linear feet of stream restoration. The construction of 2,200 linear feet of stream restoration and 37 feet of outfall stabilization in this project will treat 22.9 impervious acres within the watershed. This treatment amount accounts for approximately 22% of the impervious area within the watershed.

Project Costs

Total project costs (excluding ROW/easements) are $1,490,000 for the Victory Stream and Outfall Restoration project. This cost estimate includes two small outfall stabilization projects as well as a medium stream restoration project. Cost estimates for each project type are described in Section 6.1.4. The cost estimate for each component of the project as well as the total project cost are provided in Table 6-25.

Table 6-24: Summary of Improvements for Victory Stream and Outfall Restoration

PROJECT TYPE	PROJECT NUMBER	DRAINAGE AREA (ACRES)	IMPERVIOUS AREA (ACRES)	RESTORATION LENGTH (FEET)	IMPERVIOUS AREA CREDIT (ACRES) †	TN REDUCTIONS (LBS/YEAR) *	TP REDUCTIONS (LBS/YEAR) **	TSS REDUCTIONS (LBS/YEAR) ***
BMP								
Impervious Removal								
Outfall Maintenance								
Outfall	OF 23	4.8	0.6	7	0.1	-	-	-
	OF 39	21.2	5.1	30	0.3	-	-	-
Stream	V-T1	105.6	22.5	2,200	22.5	164.9	149.5	98,690
Total Credit/ Reductions				2,237	22.9	164.9	149.5	98,690

†Impervious Area Credit equals restoration length times 0.01
*TN reductions equal restoration length times 0.075 lbs/ft/yr
**TP reductions equal restoration length times 0.068 lbs/ft/yr
***TSS reductions equal restoration length times 44.9 lbs/ft/yr

Table 6-25: Summary of Project Costs for Victory Stream and Outfall Restoration

PROJECT TYPE	PROJECT NAME	PROJECT SIZE	UNIT COST	UNIT	PROJECT COST	COST/IMPERVIOUS ACRE TREATED*
BMP						
Impervious Removal						
Outfall Maintenance						
Outfall	OF 23	Small	$30,000	Project	$30,000	
	OF 39	Small	$30,000	Project	$30,000	
Stream	V-T1	Medium	$650	L.F.	$1,430,000	$63,555.55
Total Costs					$1,490,000	$65,065.50

*Project cost divided by stream restoration impervious area treated

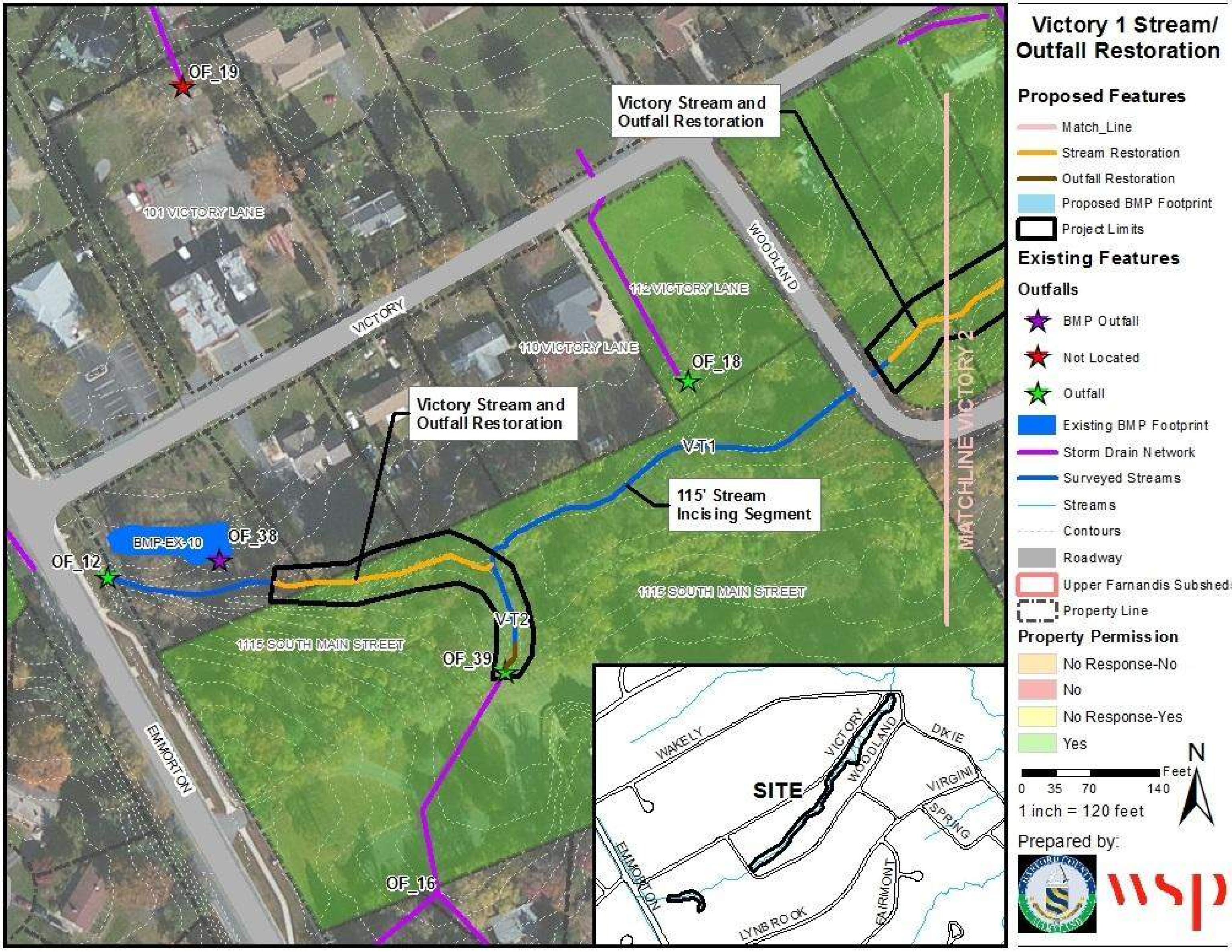

Figure 6-24: Site Location and Proposed Project Plan for Victory Stream and Outfall Restoration (Sheet 1 of 3)

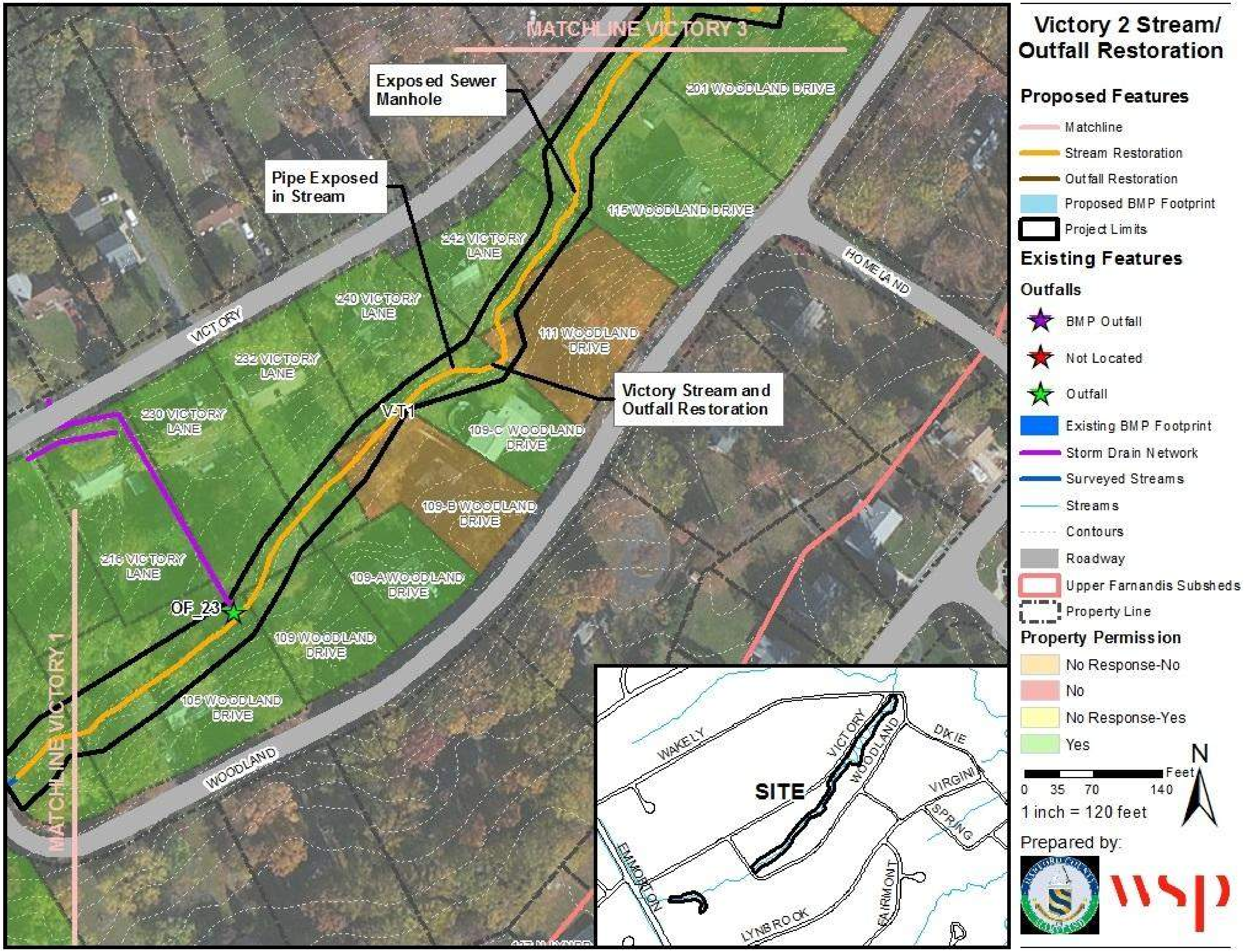

Figure 6-25: Site Location and Proposed Project Plan for Victory Stream and Outfall Restoration (Sheet 2 of 3)

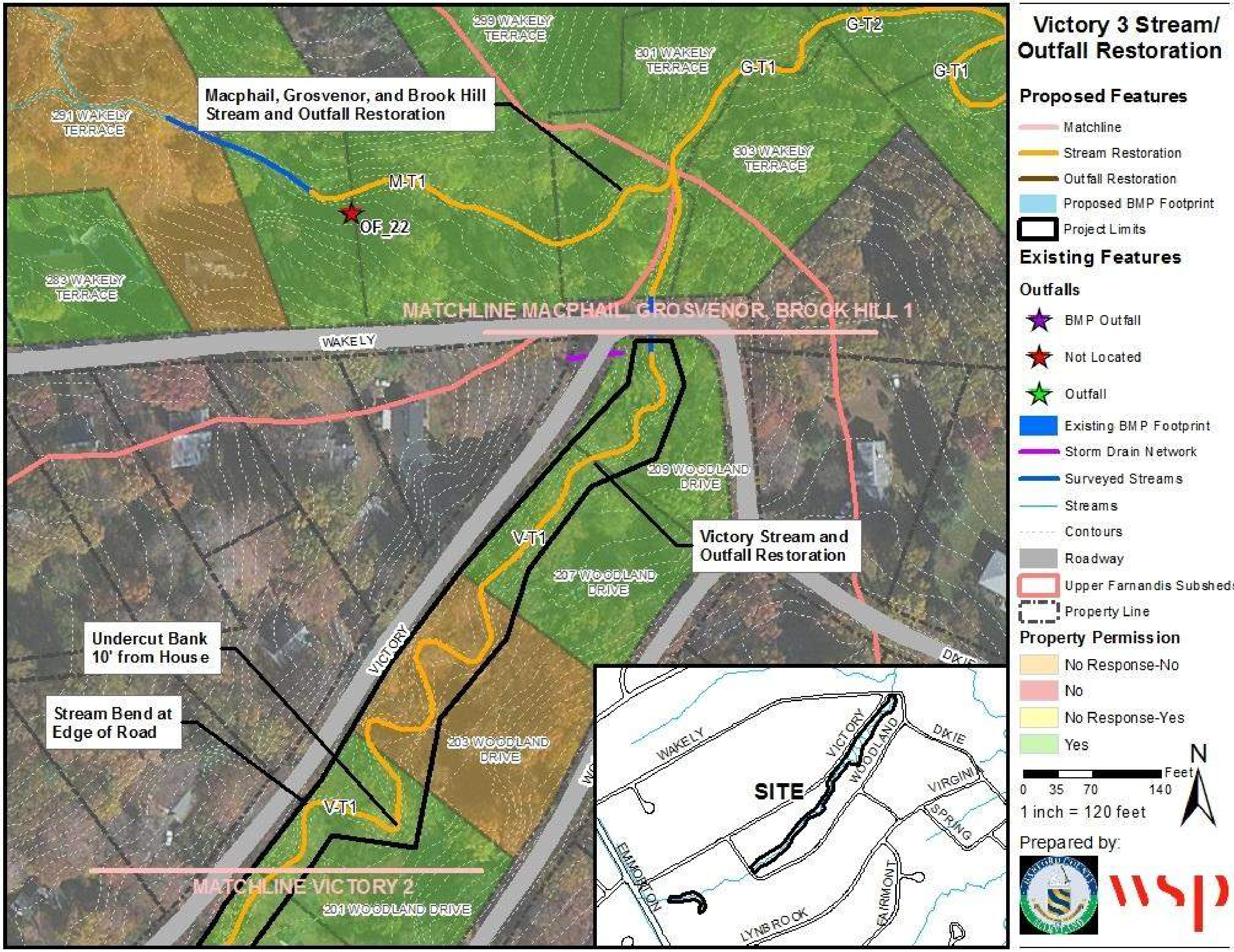

Figure 6-26: Site Location and Proposed Plan for Victory Stream and Outfall Restoration (Sheet 3 of 3)

MACPHAIL STREAM RESTORATION

Project Description: Restore 560 feet of the tributary M-T2

Location: 707 South Shamrock Rd; 715 South Shamrock Rd

Property Ownership: Three institutional properties

Length of Project: 560 feet of stream restoration

Potential Impervious Acres Treated: 5.6 Acres

Potential Load Reductions TP: 42.1 lbs/yr

Potential Load Reductions TN: 38.1 lbs/yr

Potential Load Reductions TSS: 25,189 lbs/yr

Estimated Design/Construction Costs: $420,000

Adjacent Projects: BMP-PR-01 and BMP-PR-02

Site Description

Outfall 01 is at the headwaters of tributary M-T2. The outfall structure is in good condition (Figure 6-27, left) while the channel just downstream of the structure is eroded from high flow storm events (Figure 6-27, right). Since flow was not observed at the outfall during the site visit, this channel is believed to be ephemeral. The outfall structure emerges east of Shamrock Road and flows into the stream channel next to a human services office. The stream channel flows through two additional properties before reaching a road crossing culvert at East Macphail Road. The channel is 560 feet long and experiences moderate erosion throughout (Figure 6-28, left). The banks along this channel average 4 feet in height. There is less than 50 feet of buffer along the majority of both sides of the stream.

Just upstream of East Macphail Road, sediment has accumulated prior to a concrete channel. The stream is now bypassing a portion of the concrete channel before flowing through a culvert under East Macphail Road (Figure 6-28, right). The downstream portion of the channel is easily accessible from East Macphail Road.

Figure 6-27: Looking upstream at Outfall 01, erosion on left bank and scour hole at end of outfall structure (left); Looking downstream from Outfall 01, erosion on right bank (right)

Figure 6-28: Looking downstream at start of erosion on left bank (left); Looking downstream at concrete channel, flow diverted to the right of the concrete channel prior to East Macphail Road (right)

Recommended Restoration Actions

- Stream Restoration
    - M-T2: 560 feet from Outfall 01 to East Macphail Road culvert, including removal of concrete channel protection at East Macphail Road.
    - Proposed project limits are shown in Figure 6-29.

Threats to Infrastructure

- Development of earthen channel to the right of concrete channel upstream of East Macphail Road may cause problems to culvert and East Macphail Road in the future. Removal of concrete channel protection during stream restoration recommended. Concrete channel ties into culvert at East Macphail Road.

Property Ownership

- Ownership: Private Institutional, 707 South Shamrock Road
  Private Institutional, 715 South Shamrock Road
  Private Institutional, 410 East Macphail Road

Access

- Good Access at 410 East Macphail Road and 715 South Shamrock Road for stream restoration

Summary of Restoration Improvements

A summary of improvements for this project are provided in Table 6-26. 561 linear feet of stream restoration is being recommended at this location. The construction of 560 linear feet of stream restoration in this project will treat 5.6 impervious acres within the watershed. This treatment amount accounts for approximately 5.5% of the impervious area within the watershed.

Project Costs

Total project costs (excluding ROW/easements) are $420,000 for the Macphail Stream Restoration project. This cost estimate includes zero outfall stabilization projects and one small stream restoration project. The cost estimate for the project type is described in Section 6.1.4. The cost estimate for the project is provided in Table 6-27.

Table 6-26: Summary of Improvements for Macphail Stream Restoration

PROJECT TYPE	PROJECT NUMBER	DRAINAGE AREA (ACRES)	IMPERVIOUS AREA (ACRES)	RESTORATION LENGTH (FEET)	IMPERVIOUS AREA CREDIT (ACRES) †	TN REDUCTIONS (LBS/YEAR) *	TP REDUCTIONS (LBS/YEAR) **	TSS REDUCTIONS (LBS/YEAR) ***
BMP								
Impervious Removal								
Outfall Maintenance								
Outfall								
Stream	M-T2	33.0	10.1	560	5.6	42.1	38.1	25,189
Total Credit/ Reductions				560	5.6	42.1	38.1	25,189

†Impervious Area Credit equals restoration length times 0.01
*TN reductions equal restoration length times 0.075 lbs/ft/yr
**TP reductions equal restoration length times 0.068 lbs/ft/yr
***TSS reductions equal restoration length times 44.9 lbs/ft/yr

Table 6-27: Summary of Project Costs for Macphail Stream Restoration

PROJECT TYPE	PROJECT NAME	PROJECT SIZE	UNIT COST	UNIT	PROJECT COST	COST/IMPERVIOUS ACRE TREATED*
BMP						
Impervious Removal						
Outfall Maintenance						
Outfall						
Stream	M-T2	Small	$750	L.F.	$420,000	$75,000
Total Costs					$420,000	$75,000

*Project cost divided by stream restoration impervious area treated

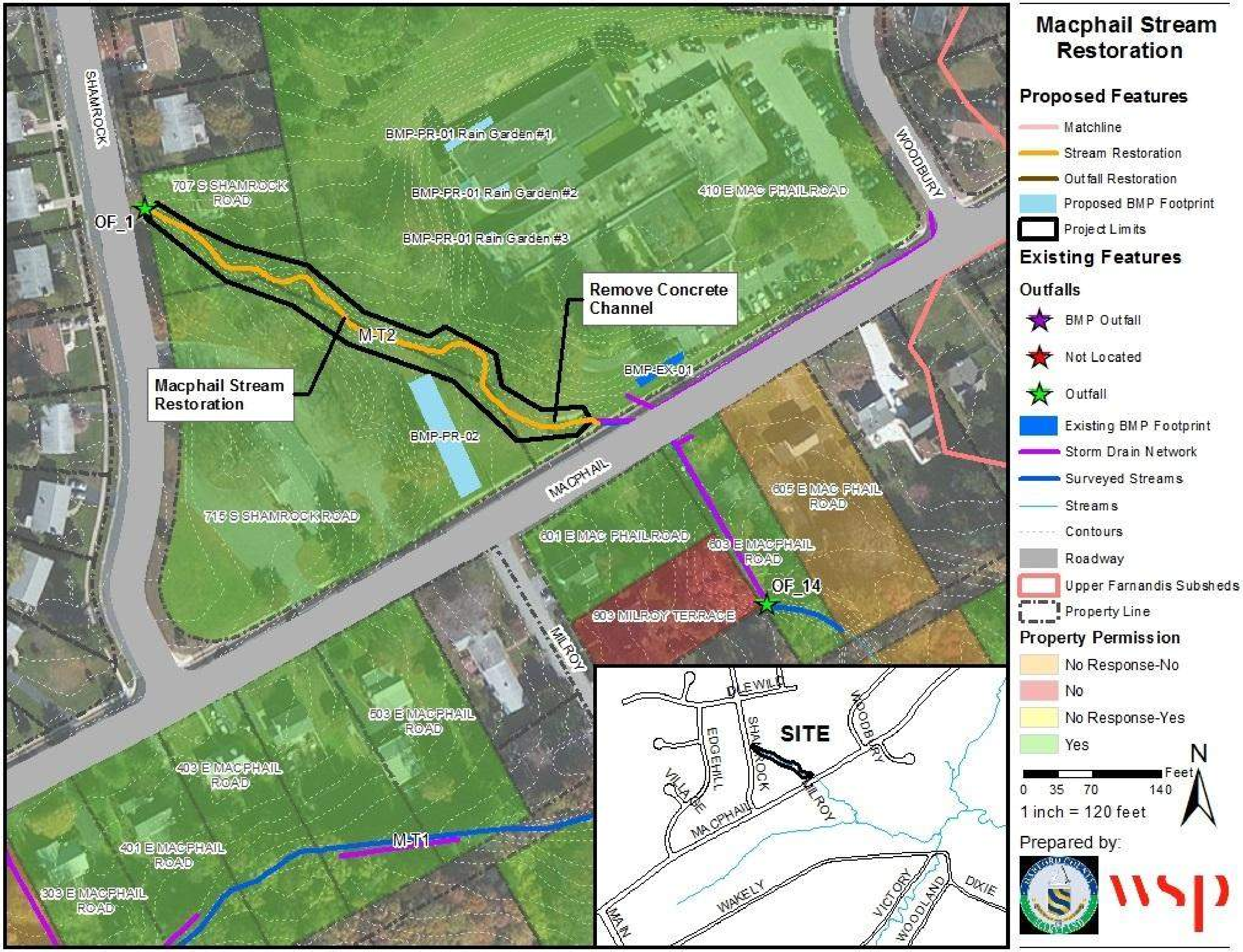

Figure 6-29: Site Location and Proposed Project Plan for Macphail Stream Restoration

MACPHAIL, GROSVENOR AND BROOK HILL STREAM AND OUTFALL RESTORATION

Project Description: Restore 423 feet of M-T1, 168 feet of V-T1, 160 feet of G-T3, 578 feet of G-T2, 1,997 feet of G-T1, and 1,388 feet of the main stem; Stabilize 13 feet of channel at Outfall 05 and 16 feet at Outfall 07

Location: 1007 Jackson Boulevard; 11 Pequot Drive, Homestead Park (East Macphail Rd)

Property Ownership: Twelve Private Properties

Length of Project: 4,700 feet of stream restoration

Potential Impervious Acres Treated: 47.1 Acres

Potential Load Reductions TP: 353.6 lbs/yr

Potential Load Reductions TN: 320.6 lbs/yr

Potential Load Reductions TSS: 211,659 lbs/yr

Estimated Design/Construction Costs: $2,825,000

Adjacent Projects: Victory Stream and Outfall Restoration

Site Description

Outfall 22 was not located at the GIS location. A stormwater drop structure was located along Wakely Terrace at the property boundaries of 283 and 291 Wakely Terrace. 291 Wakely Terrace was not accessible, but Outfall 22 may be located on this property. Further investigation would need to be performed to verify this assumption. The site begins at 295 Wakely Terrace and receives flow from the headwaters of tributary M-T1 and M-T2. The site includes 423 feet of M-T1 where it then flows into G-T1. At the upstream end of M-T1, gabion baskets have been placed in a bend on the right bank to prevent erosion from impacting the rear of the house on this property. Just downstream of the gabion baskets, minor to moderate erosion occurs at two bends in the stream. The stream banks are 3 feet high. At this point, the stream flows under a driveway, resurfaces, and flows under another driveway. Prior to the first driveway, sediment deposition upstream of the culvert requires flow to get to the culvert at a 90-degree angle. During high flow storm events, flow may undercut the driveway and cause a threat to the infrastructure. The culvert under both driveways are 48 inches in diameter.

The second driveway is at 301 Wakely Terrace. The homeowner has said that during high flow events the stream comes up to the front porch. This area is just downstream of the 48-inch culvert crossing under his driveway. At 135 feet, downstream of the second 48-inch culvert, tributary M-T1 flows into G-T1 and changes from the Macphail subwatershed to the Grosvenor subwatershed.

Most of tributary G-T1 is in a forested area of one HOA community. The stream through this section is 1997 feet in length and contains eroded banks ranging from 3 to 5 feet in height. G-T1 receives flow from tributary G-T2, G-T4, and three outfalls. Tributary G-T2 is part of this project site. It receives flow from G-T3 and from an extended dry detention basin, BMP-EX-03. The outfall from BMP-EX-03 was assessed as outfall 04. Outfall 04 is in good condition; however, some of the riprap outfall protection has moved downstream and is no longer protecting the outfall (Figure 6-31, left). Outfall 21 is at the headwater of G-T3 and provides flow from Charlyn Court (Figure 6-30, left). Both G-T3 and G-T2 are experiencing active erosion with 3 to 5 feet of exposed banks (Figure 6-30).

Outfall 05 is a 36-inch pipe with the invert 4” above the water surface of a scour hole (Figure 6-32, left). The scour hole is 8 feet by 9 feet and the end of the pipe is 13 feet from the left stream bank of G-T1. Outfall 06 is a 12-inch pipe. No flow was seen during the field investigation. The outfall protection is stable; however, the bank is steep from the end of outfall protection to the stream bed. Outfall 07 is at the end of Spindle Hill and is being crushed by a tree. This outfall has no outfall protection. Both Outfall 06 and Outfall 07 are also on the left bank of G-T1.

Tributary G-T4 flows into G-T1 approximately 290 feet above the confluence with the main stem. G-T4 is spring fed and shows evidence of some minor erosion. G-T4 is not included in this project site.

Brook Hill subwatershed begins at the confluence of G-T1 and the main stem. A gabion basket is located at the confluence of G-T1 and the main stem (Figure 6-31, right). As a result, sediment has filled in the channel of G-T1 just upstream of the gabion basket. Flow enters the main stem through a narrow channel next to the gabion basket. On the opposite side of the gabion basket, in the main stem, 16 feet of a 10” pipe has become exposed along the bottom of the stream.

The main stem is 1388 feet in length through this portion of the project site. Approximately 170 feet downstream of the confluence with G-T1, the left bank of the main stem has been hardened. At the end of Jackson Boulevard, Outfall 08 has become unstable. The pipe outfall is protruding one foot above the stream and 5 feet of the pipe is exposed (Figure 6-33, left). The left stream bank at the end of Jackson Boulevard is being held in place by two large trees. The roots are currently exposed. If these trees fall, the 7-foot left bank at Jackson Boulevard will have no protection from further erosion. From Outfall 08 to the outlet of the watershed, the main stem experiences moderate to very severe erosion with 3 to 6 foot banks. The left bank also has a very limited tree buffer (Figure 6-33, right). A sewer manhole near the outlet of the watershed is just beginning to become exposed at the top of a 7-foot bank. The outfall protection for Outfall 10 is in good condition; however, at the end of the gabion pad, the bank drops four feet to the stream bed. Further erosion along the right bank of the main stem will lead to undercutting of the gabion pad for Outfall 10. Significant erosion has occurred around outfall 31. Approximately seven feet of this 18-inch corrugated plastic pipe is exposed. The end of the pipe is laying in the stream and the slope above the right bank has caved in.

Figure 6-30: Looking downstream from Outfall 21, erosion on both banks (left); Erosion along Tributary G-T2 (right)

Figure 6-31: Looking upstream at displaced rip rap around Outfall 04 (left); Exposed pipe, gabion basket blocking flow from G-TI, confluence of G-T1 and main stem (right)

Figure 6-32: Looking towards the left bank at Outfall 05, scour hole (left); Inadequate buffer and erosion on left bank of G-T1, downstream of Outfall 06 (right)

Figure 6-33: Looking downstream towards the left bank at Outfall 08 (left); Looking upstream, inadequate buffer and erosion on right bank of main stem, at watershed outlet (right)

<u>Recommended Restoration Actions</u>

- Stream Restoration
    - M-T1: 423 feet from 295 Wakely Terrace to confluence with V-T1
    - V-T1: 168 feet from culvert at Wakely Terrace to confluence with M-T1
    - G-T3: 160 feet from Outfall 21 to confluence with G-T2
    - G-T2: 578 feet from Outfall 04 to confluence with G-T1
    - G-T1: 1,997 feet from confluence of M-T1 and V-T1 to confluence with main stem
    - Main stem: 1,388 feet from confluence of G-T1 and main stem to watershed outlet
- Outfall Stabilization
    - Outfall 04: 33 feet of stabilization
    - Outfall 05: Replace outfall pipe and 13 feet of stabilization
    - Outfall 07: Replace outfall structure and 7 feet of stabilization
    - Outfall 08: Replace outfall structure and shift stream channel
    - Outfall 21: 20 feet of stabilization
    - Outfall 31: Grade and shift stream channel
- Proposed project plans are shown in Figure 6-34, Figure 6-35, and Figure 6-36.

<u>Threats to Infrastructure</u>

- 16 feet of exposed pipe along left bank of main stem at confluence with tributary G-T1
- 5 feet of Outfall 08 is exposed from the left bank.
- If two trees fall upstream of Outfall 08, Jackson Boulevard will be susceptible to failure from erosion of the left bank.
- A sewer manhole near the watershed outlet is beginning to be exposed on the right bank.
- The end of the gabion pad for Outfall 10 may soon experience undercutting on the right bank of the main stem.

Property Ownership

There are numerous private property owners along this reach. Buy in from property owners at the beginning of the project will help maximize design dollars and project efforts. Having one or two critical property owners drop out of the project late in the design will likely necessitate a redesign of the stream channel and project delays. It is recommended that the County try to obtain buy in after conceptual design level.

- Ownership: Private homeowner, 295 Wakely Terrace
  Private homeowner, 299 Wakely Terrace
  Private homeowner, 301 Wakely Terrace
  Private homeowner, 303 Wakely Terrace
  Public Property: Town of Bel Air
  Private Property, HOA: Bradford Village Association Inc
  Private homeowner, 11 Pequot Drive
  Private homeowner, 5 Pequot Garth
  Private homeowner, 8 Spindle Hill Court
  Private Property, HOA: Brook Hill Manor Community Association Inc
  Private homeowner, 1007 Jackson Boulevard

Access

- Good Access at 1007 Jackson Boulevard for stream restoration and Outfall 08, Outfall 10 and Outfall 31 stabilization.
- Good Access at 11 Pequot Drive for stream restoration and Outfall 05 and Outfall 07 stabilization.
- Good Access at 299 Wakely Terrace for stream restoration along tributary M-T1.
- Good Access at Homestead Park (East Macphail Rd) for stream restoration along tributary G-T3 and G-T2 and Outfall 04 and Outfall 21 stabilization

Summary of Restoration Improvements

A summary of improvements for this project are provided in Table 6-28. Six outfall stabilization projects, totaling 76 linear feet are recommended alongside 4,700 linear feet of stream restoration. The construction of 4,700 linear feet of stream restoration and 76 feet of outfall stabilization in this project will treat 47.8 impervious acres within the watershed. This treatment amount accounts for approximately 47% of the impervious area within the watershed.

Project Costs

Total project costs (excluding ROW/easements) are $2,825,000 for the Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration project. This cost estimate includes three small and three medium outfall stabilization projects as well as a large stream restoration project. Cost estimates for each project type are described in Section 6.1.4. The cost estimate for each component of the project as well as the total project cost are provided in Table 6-29.

Table 6-28: Summary of Improvements for Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration

PROJECT TYPE	PROJECT NAME	DRAINAGE AREA (ACRES)	IMPERVIOUS AREA (ACRES)	RESTORATION LENGTH (FEET)	IMPERVIOUS AREA CREDIT (ACRES) †	TN REDUCTIONS (LBS/YEAR) *	TP REDUCTIONS (LBS/YEAR) **	TSS REDUCTIONS (LBS/YEAR) ***
BMP								
Impervious Removal								
Outfall Maintenance								
Outfall	OF 04	20.9	6.3	33	0.3	-	-	-
	OF 05	19.8	5.2	13	0.1	-	-	-
	OF 07	0.5	0.2	10	0.1	-	-	-
	OF 08	2.8	1.4	0	-	-	-	-
	OF 21	0.5	0.3	20	0.2	-	-	-
	OF 31	3.1	0.8	0	-	-	-	-
Stream	G-T3, G-T2, G-T1, M-T1, V-T1, and main stem	486	102	4,700	47.1	353.6	320.6	211,659
Total Credit/ Reductions				4,790	47.8	353.6	320.6	211,659

†Impervious Area Credit equals restoration length times 0.01
*TN reductions equal restoration length times 0.075 lbs/ft/yr
**TP reductions equal restoration length times 0.068 lbs/ft/yr
***TSS reductions equal restoration length times 44.9 lbs/ft/yr

Table 6-29: Summary of Project Costs for Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration

PROJECT TYPE	PROJECT NAME	PROJECT SIZE	UNIT COST	UNITS	PROJECT COST	COST/IMPERVIOUS ACRE TREATED*
BMP						
Impervious Removal						
Outfall Maintenance						
Outfall	OF 04	Small	$30,000	Project	$30,000	
	OF 05	Medium	$50,000	Project	$50,000	
	OF 07	Medium	$50,000	Project	$50,000	
	OF 08	Medium	$50,000	Project	$50,000	
	OF 21	Small	$30,000	Project	$30,000	
	OF 31	Small	$30,000	Project	$30,000	
Stream	G-T3, G-T2, G-T1, M-T1, and main stem	Large	$550	L.F.	$2,585,000	$54,883.23
Total Costs					$2,825,000	$59,978.77

*Project cost divided by stream restoration impervious area treated

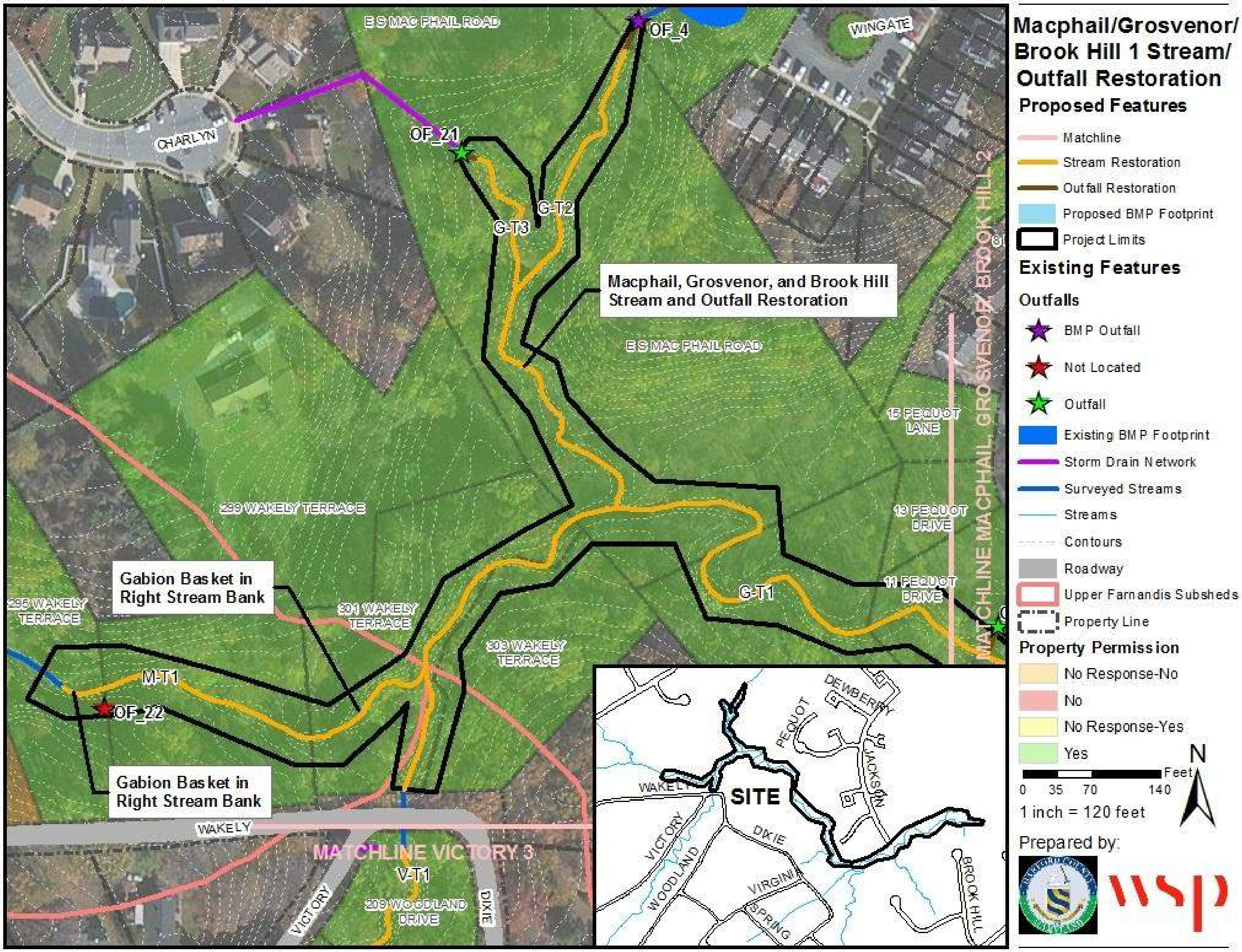

Figure 6-34: Site Location and Proposed Project Plan for Grosvenor and Brook Hill Stream and Outfall Restoration (Sheet 1 of 3)

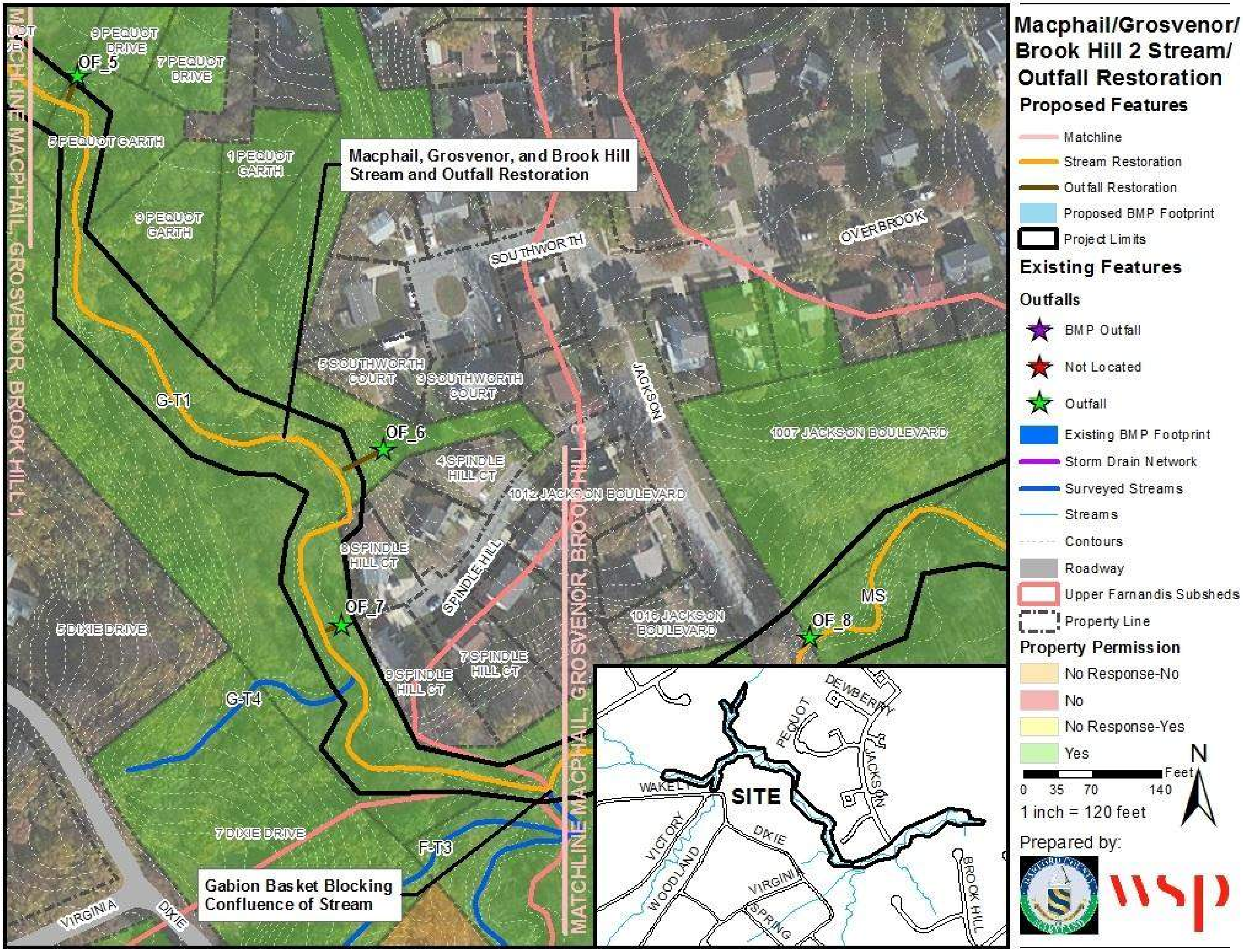

Figure 6-35: Site Location and Proposed Project Plan for Grosvenor and Brook Hill Stream and Outfall Restoration (Sheet 2 of 3)

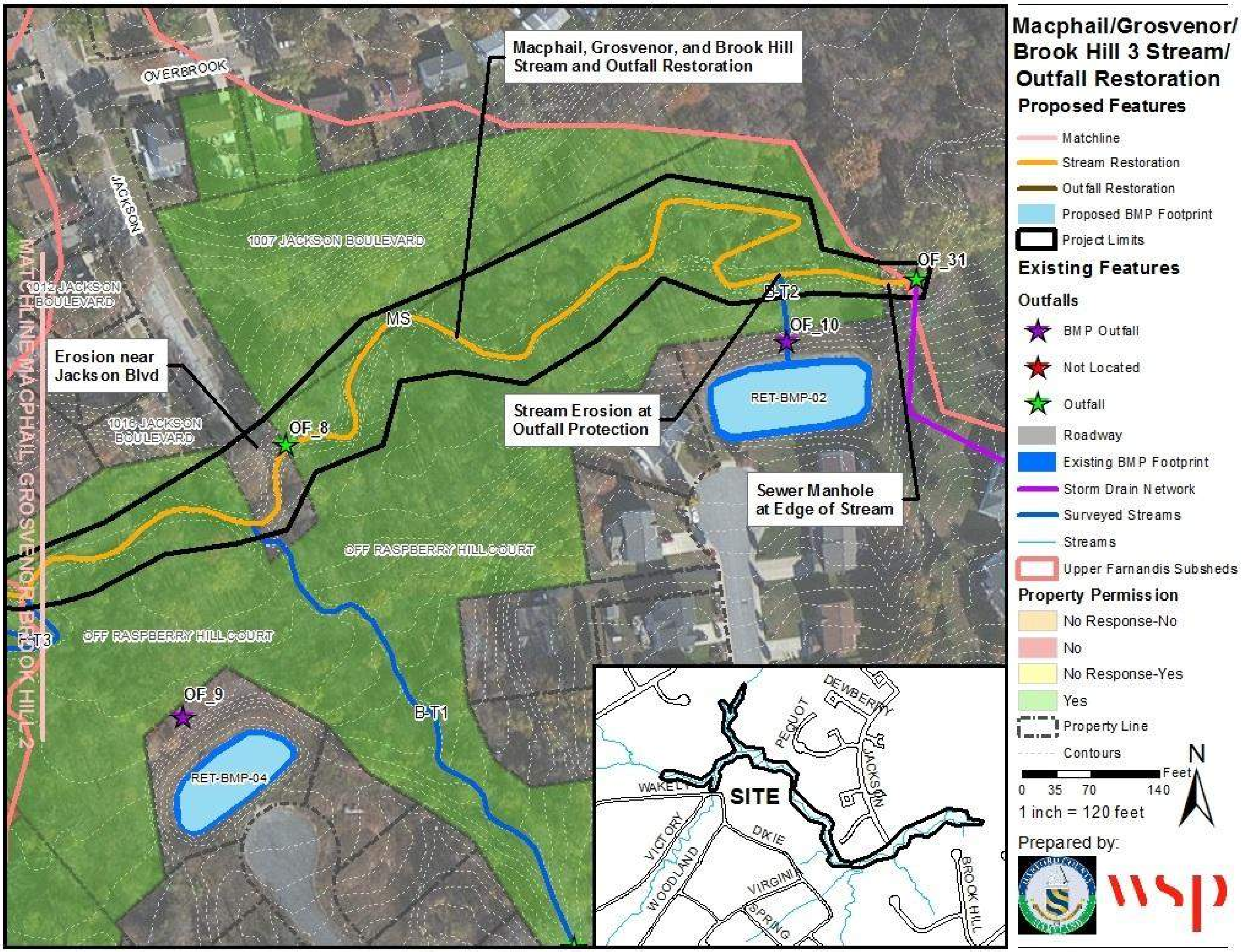

Figure 6-36: Site Location and Proposed Project Plan for Grosvenor and Brook Hill Stream and Outfall Restoration (Sheet 3 of 3)

6.4 PROJECT RECOMMENDATIONS

Ten projects have been initially recommended as a result of the Upper Farnandis watershed assessment, including three BMP retrofit projects, two new BMP projects, and five stream and outfall restoration projects. The ten projects have been narrowed down to the top five projects recommended for implementation. A prioritization ranking has been developed and described in detail in Section 6.1. Each of the projects have been described in Section 6.2 and 6.3 including accessibility, threats to infrastructure, properties impacted, restoration recommendations, and maps of the project area.

6.4.1 STREAM PROJECTS

The project prioritization in Section 6.1 identified three stream projects ranked in the high priority category. These projects are:

- Victory Stream and Outfall Restoration
- Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration
- Ring Factory Stream Restoration

While these three projects received the highest rankings during the prioritization, there are other important factors to note. The largest stream project, the Macphail, Grosvenor, and Brook Hill Stream and Outfall Restoration project, weighted high on all accounts. It is recommended that the County start with the upland most stream channels first and then proceed with the Macphail, Grosvernor and Brook Hill Stream and Outfall Restorations. The upstream reaches also have more threats to roadway and houses due to the proximity of these types of infrastructure to the stream. Therefore, it is recommended that the Victory Stream and Outfall Restoration project and the Ring Factory Stream Restoration project be prioritized for implementation within the Upper Farnandis watershed.

To improve project cost effectiveness, it is recommended to combine the Fairmont Stream and Outfall Restoration project with the Ring Factory Stream Restoration project. The Fairmont stream reach flows into the Ring Factory Stream Restoration reach, so construction access and disruption of that area of the watershed could be contained by constructing the projects at the same time. The stream reach in the Fairmont Stream and Outfall Restoration project also has the greatest percentage of moderate to very severely eroded banks of all the stream projects. The final recommended stream projects are:

1. Victory Stream and Outfall Restoration
2. Ring Factory Stream Restoration along with Fairmont Stream and Outfall Restoration

6.4.2 BMP PROJECTS

While the BMP projects received medium and low rankings in the priority categories due to the smaller nature of the projects and fewer impervious area reductions, a well balanced watershed plan includes the combination of both stormwater and stream restoration projects. Of the three BMP retrofit projects examined, the existing BMP near East Macphail Road (RET_BMP_03) has the lowest cost per impervious area to design and construct. This BMP retrofit project also has the highest percentage of impervious area treated within the watershed for all the BMP projects.

Both proposed BMP projects are located near an assisted living facility. Due to the potential to educate the public and the potential interest and involvement from the senior citizens at the facility and the low cost to design and build the BMPs, the three rain gardens (PR_BMP_01) are recommended for implementation.

6.4.3 FINAL RECOMMENDATIONS

The final recommendations of the watershed study include a mix of stream and outfall projects, a BMP retrofit project, and a new BMP project. The recommended projects are shown in Table 6-30.

Table 6-30: Summary of Project Recommendations for the Upper Farnandis Watershed

RANKING	PROJECT NAME	PROJECT DESCRIPTION
1	Victory Stream and Outfall Restoration	2,200 feet of stream restoration and 2 outfall stabilization
2	Ring Factory Stream Restoration	2,180 feet of stream restoration
2	Fairmont Stream and Outfall Restoration	914 feet of stream restoration, including 20 feet impervious removal and 2 outfall stabilization
3	RET_BMP_03	Wet Pond Retrofit
4	PR_BMP_01	Three Rain Gardens

7 PUBLIC OUTREACH PROCESS

Harford County provides continual public outreach to keep the public informed of watershed assessments and restoration plans to reduce stormwater pollutants. For the Upper Farnandis Branch watershed assessment, Harford County has created a website with information on the Upper Farnandis Branch watershed to inform the public. The County will make this watershed assessment report available for public review and will provide a visual online aid to educate and inform the public of the results of the watershed assessment and potential restoration plans.

7.1 WATERSHED ASSESSMENT

This report, The Upper Farnandis Small Watershed Assessment Report, will be made available in its entirety to the public electronically. The public will have a 30-day window to read through the existing physical conditions in the watershed, understand the general findings of the assessment, and learn about the potential restoration projects that the County is considering for the Upper Farnandis watershed. The public will be able to comment on the findings in the report during the 30-day review period. The public comments will be incorporated into this report and into the restoration plans.

7.2 STORY MAP

A story map uses the ArcGIS Online application to share information in an easy to follow and systematic way. Story maps are useful for showcasing spatial data through a map interface. For the Upper Farnandis Branch watershed assessment, a series of maps have been provided to show existing physical conditions within the watershed as well as potential restoration projects. The existing conditions include land use and soils maps while the proposed restoration map shows proposed BMP retrofits and new BMPs and stream and outfall restoration projects. The Upper Farnandis Branch Stream Study Story Map can be viewed through the following link: https://arcg.is/XCmDP.

Figure 7-1 shows a snapshot of the Watershed Land Use tab in the Story Map. The panel on the left provides information to the public on why land use types are important when assessing a watershed. The map shows the different types of land use within the Upper Farnandis watershed.

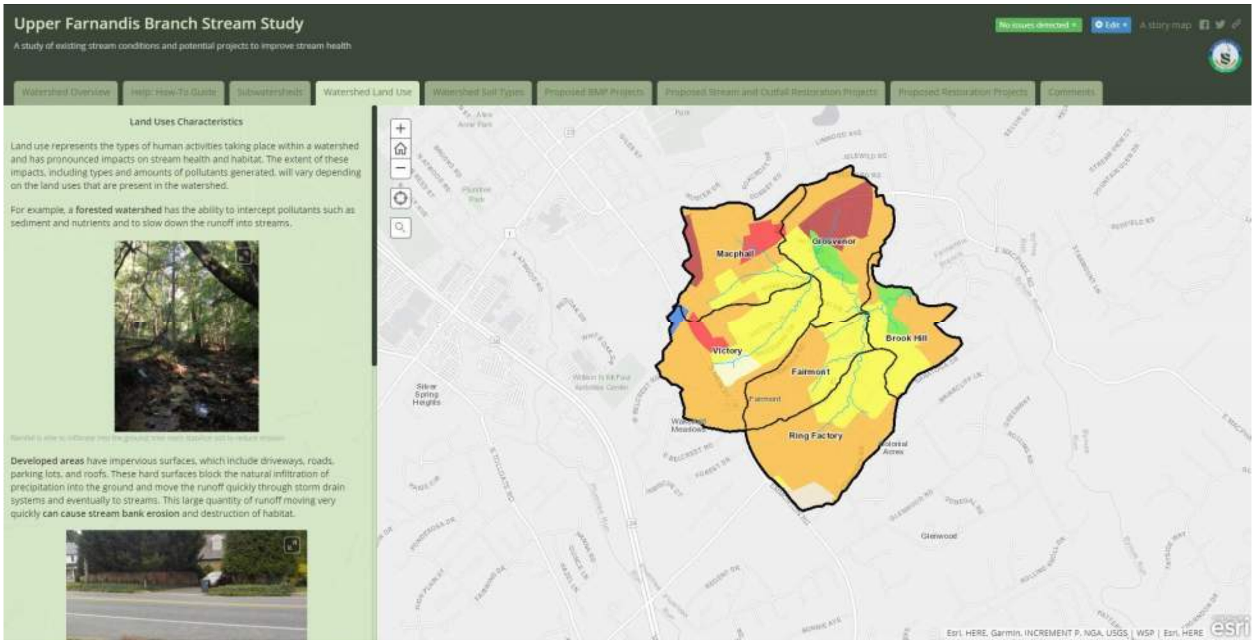

Figure 7-1: Snapshot of Land Use in the Upper Farnandis Branch Stream Study Story Map

The public has the capability to view the story map at their own convenience and at their own pace. The maps are interactive and include text to guide the user through the application. The user can zoom in and out and see different features on the map. They can type in their address to see what the existing conditions are at their property as well as find out if there are any proposed projects nearby. Figure 7-2 shows a zoomed in view of the Proposed Restoration Projects tab. The public can see the proposed stream project (in orange and green) as well as click on popup images throughout the watershed to gain additional information. These popups provide pictures of the watershed at that location.

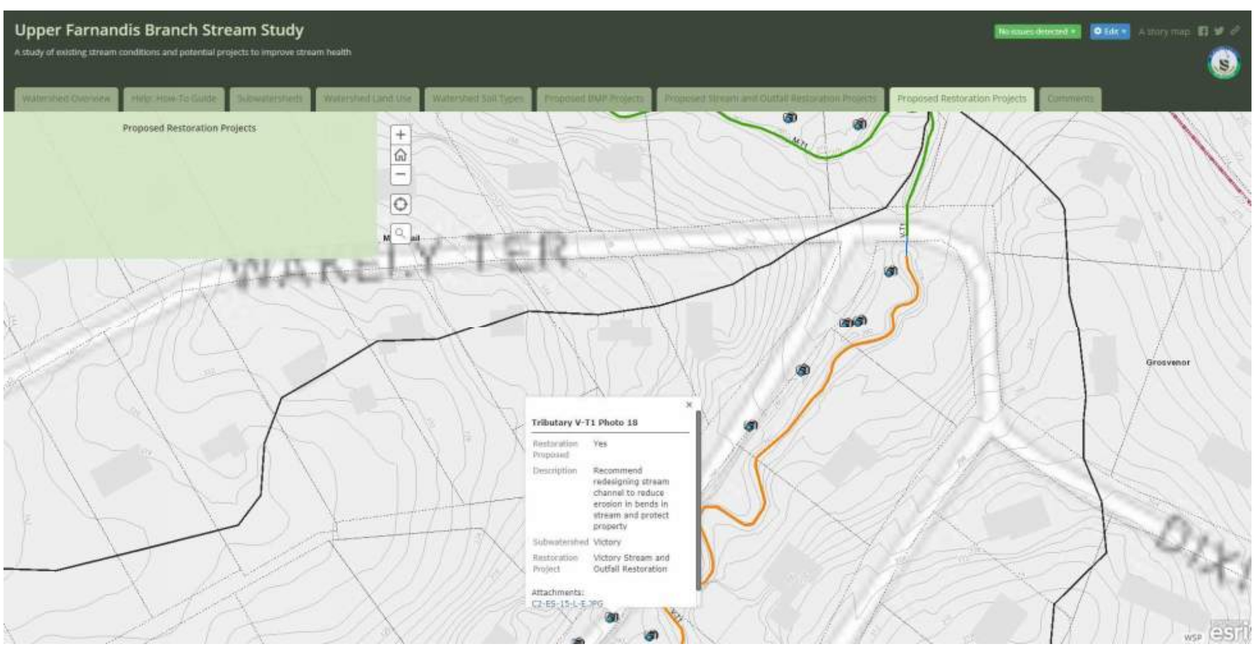

Figure 7-2: Snapshot of Proposed Projects for the Upper Farnandis Branch Watershed Study Story Map

The story map provides a link to an online comments form at the Harford County website that allows the public to post questions, concerns, and comments. The comments provided by the public through the story map and the 30-day public review period of this report are considered when selecting which potential restoration projects to progress. Figure 7-3 shows the Comment tab in the Story Map for the Upper Farnandis watershed, with the link to access the Harford County website and comment form.

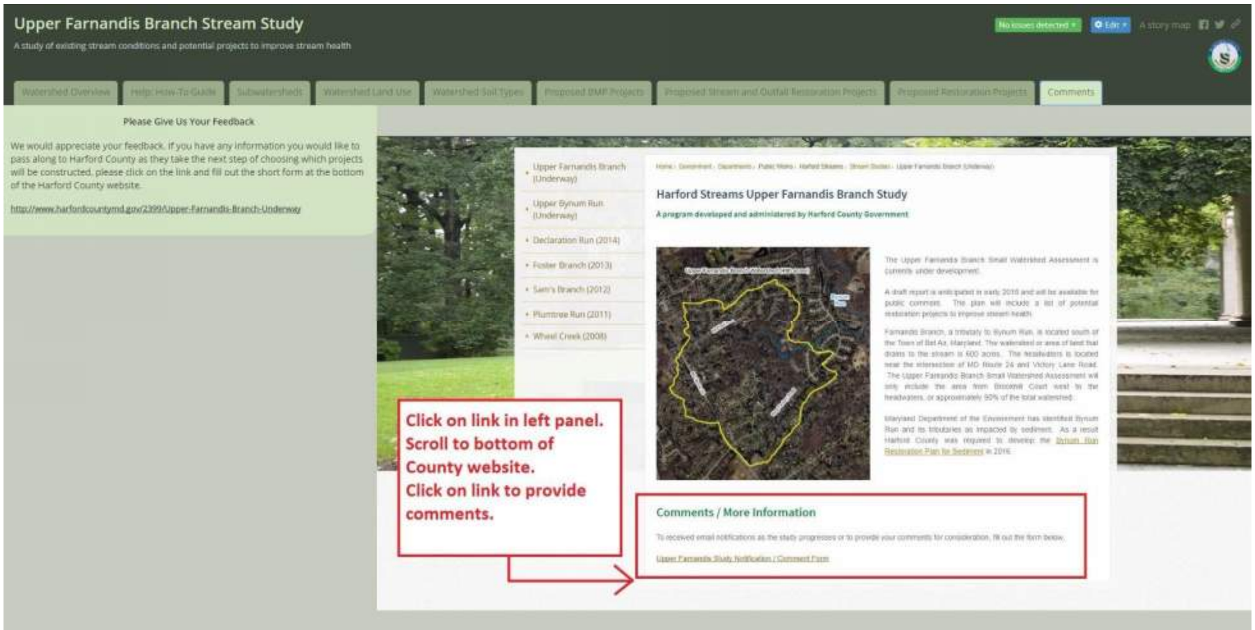

Figure 7-3: Snapshot of Comments Tab for the Upper Farnandis Branch Watershed Study Story Map

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APPENDIX

A SUBWATERSHED PHOTOGRAPHS

APPENDIX

APPENDIX

A-1 *MACPHAIL SUBWATERSHED*

APPENDIX

Figure 1: Outfall 1 at headwaters of tributary 2 in Macphail subwatershed

Figure 2: Erosion along tributary 2 in Macphail subwatershed

APPENDIX

Figure 3: Inadequate buffer in tributary 2 of Macphail subwatershed.

Figure 4: Debris jam in tributary 2 of Macphail subwatershed

APPENDIX

Figure 5: Concrete channel alteration placed upstream of culvert under East Macphail Road in tributary 2 of subwatershed.

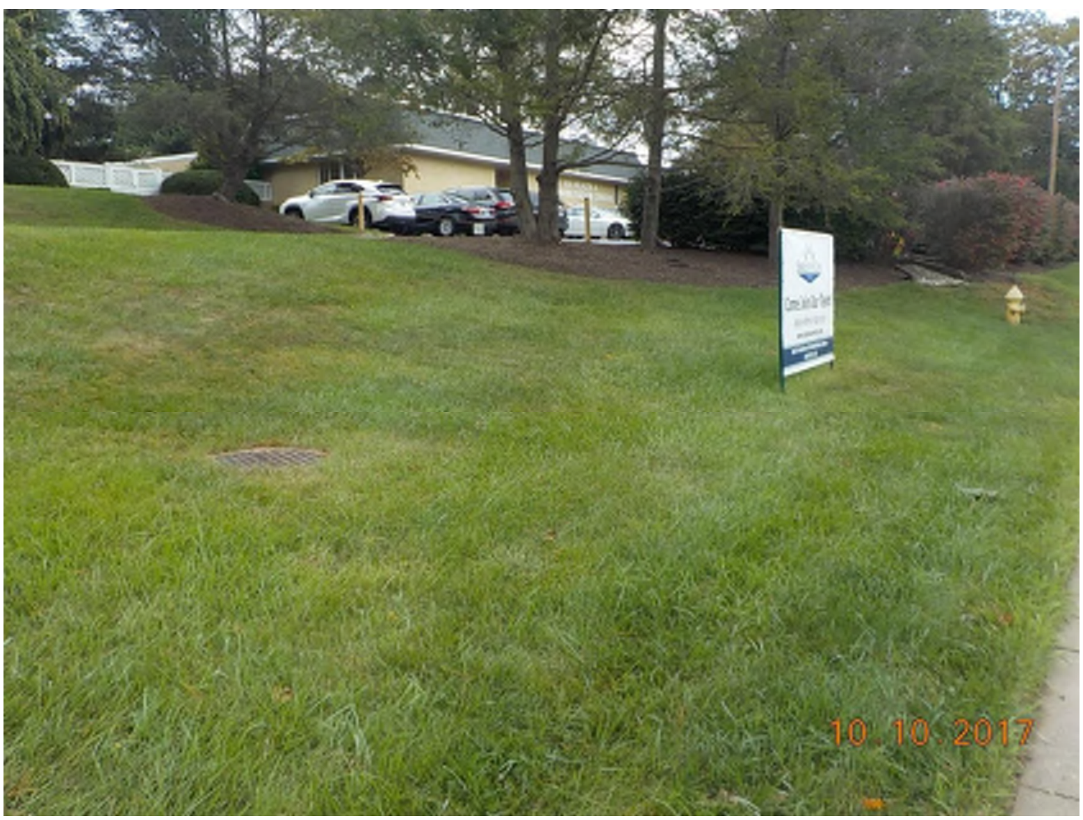

Figure 6: Existing BMP 1 is an underground dry well located adjacent to East Macphail Road. Flow is conveyed from the pictured parking lot to the existing underground facility.

APPENDIX

Figure 7: Outfall 14 in private property backyard conveys flow from tributary 2 North of East Macphail Road.

Figure 8: Inadequate stream buffer adjacent to each side of tributary 1, in residential backyards.

APPENDIX

Figure 9: Outfall 20 enters left bank of tributary 1. Outfall is 18" concrete pipe approximately 7 feet from stream.

Figure 10: Concrete culvert conveys flow underground from location of outfall 20 to downstream in tributary 1. Downstream outfall pictured.

APPENDIX

Figure 11: Chickens adjacent to tributary 1 of subwatershed.

Figure 12: Concrete culvert conveys flow underground in tributary 1 of subwatershed. Upstream entrance pictured.

APPENDIX

Figure 13: Gabion and wood channel alteration present in tributary 1 of subwatershed

Figure 14: Culverts used to convey flow under driveways in tributary 1. Erosion occurring on banks adjacent to culverts.

APPENDIX

Figure 15: Erosion and undercutting present in tributary 1 prior to confluence of Macphail subwatershed with Victory and Grosvenor subwatersheds.

Figure 16: Confluence of Macphail subwatershed (right) with Victory subwatershed (left) at entrance to Grosvenor subwatershed.

APPENDIX

A-2 *VICTORY SUBWATERSHED*

APPENDIX

Figure 1: Existing BMP 10 is a wet pond located adjacent to South Main Street and outfall 12. Flow is conveyed from South Main Street to the existing SHA facility. Flow exits facility at outfall 38 (Figure 3).

Figure 2: Outfall 12 is a 30" metal pipe at headwaters of Victory subwatershed tributary 1. The outfall collects runoff from the roadway and neighborhood.

APPENDIX

Figure 3: Outfall 38 conveys overflow from existing BMP 10 (Figure 1) to left bank of tributary 1. Weir outfall and 3-inch orifice approximately 30 feet from tributary 1.

Figure 4: Inadequate buffer in tributary 1 of subwatershed prior to outfall 18.

Figure 5: Bank erosion along tributary 1 in subwatershed prior to outfall 23.

Figure 6: Outfall 18 is elliptical concrete pipe entering left bank of tributary 1. Outfall is approximately 129 feet from the stream.

APPENDIX

Figure 7: Outfall 23 is an 18” corrugated metal pipe on the left bank of tributary 1. Outfall is approximately 7 feet from stream.

Figure 8: Corrugated metal pipe conveys flow in channel in tributary 1.

APPENDIX

Figure 9: Wooden bridge crossing over tributary 1.

Figure 10: Bank erosion and inadequate buffer downstream of outfall 23 in tributary 1.

APPENDIX

Figure 11: High banks resulting from erosion in tributary 1 channel.

Figure 11: Severely undercut bank in tributary 1.

APPENDIX

Figure 12: Culvert conveys tributary 1 flow under Wakely Terrace just upstream of confluence with Macphail subwatershed.

Figure 13: Confluence of Macphail subwatershed (right) with Victory subwatershed (left) at entrance to Grosvenor subwatershed.

APPENDIX

Figure 14: Outfall 17 conveys drainage via grass ditch to follow existing drainage network to outfall 39 (Figure 15).

Figure 15: Outfall 39 conveys flow to tributary 2 from upstream drainage network via 30-inch concrete pipe. Outfall channel splits and has multiple connections to right bank of tributary 1. Outfall is approximately 117 feet from tributary 1.

APPENDIX

Figure 16: Existing BMP 7 is an infiltration basin located between 900A South Main Street and Homestead-Wakefield Elementary School. Flow enters facility via curb opening from parking lot. Facility is filled with approximately one foot of sediment deposition.

APPENDIX

A-3 *GROSVENOR SUBWATERSHED*

APPENDIX

Figure 1: Confluence of Macphail subwatershed (right) with Victory subwatershed (left) at beginning of Grosvenor subwatershed.

Figure 2: Tributary 1 bank erosion upstream of confluence with tributary 2. Channel is wide in this portion of stream.

Figure 3: Outfall 2 is a 30-inch concrete pipe conveying flow at the head of tributary 2. Outfall is approximately 495 feet to channel and has 430 feet of riprap outfall protection.

Figure 4: Outfall 3 is an 18-inch concrete pipe conveying flow to the right bank of the outfall protection riprap channel of outfall 2 (Figure 3). Photo is looking downstream on outfall 2 riprap channel.

APPENDIX

Figure 5: Existing BMP 3 is an extended detention basin. A wet pond retrofit to the facility is proposed. Flow from outfall 2 (Figure 3) and outfall 3 (Figure 4) enters facility.

Figure 6: Outfall 4 is a 24-inch metal pipe conveying flow from existing BMP 3 (Figure 5) to the headwaters of tributary 2 in the subwatershed. A 49-foot riprap channel exists as outfall protection.

Figure 7: Concrete weir channel alteration downstream of outfall 4 in tributary 2.

Figure 8: Outfall 21 is a 24-inch metal pipe at the head of tributary 3. Outfall is 179 feet from right bank of tributary 2. Erosion present in outfall channel.

APPENDIX

Figure 9: Confluence of tributary 3 (left) with tributary 2 (right).

Figure 10: Debris jam in tributary 2.

Figure 11: Bank erosion along tributary 2

Figure 12: Concrete weir channel alteration upstream of confluence of tributary 2 with tributary 1.

Figure 13: Confluence of tributary 2 with tributary 1. Picture of tributary 2 looking towards tributary 1.

Figure 14: Tributary 1 bank erosion after confluence with tributary 2.

APPENDIX

Figure 15: Fish barrier in tributary 1.

Figure 16: Undercut bank in tributary 1 upstream of outfall 5 (Figure 17).

Figure 17: Outfall 5 is a 36-inch metal pipe conveying flow to left bank of tributary 1. Outfall is approximately 13 feet from tributary 1.

Figure 18: Erosion upstream of outfall 6 in tributary 1.

Figure 19: Outfall 6 is a 15-inch metal pipe conveying flow to left bank of tributary 1. Outfall is approximately 15 feet from tributary 1 and has 15 feet of riprap outfall protection.

Figure 20: Tributary 1 inadequate buffer extending from outfall 6 to confluence with Brook Hill and Fairmont subwatersheds.

Figure 21: Outfall 7 is an 18-inch metal pipe conveying flow to left bank of tributary 1. Outfall is 7 feet from left bank of stream.

Figure 22: Inflow from roadway to start of tributary 4. Bank erosion present at location of inflow.

APPENDIX

Figure 23: Bank erosion along tributary 4.

Figure 24: Existing fish barrier at confluence of tributary 1 with mainstem. Barrier is too high for fish passage.

APPENDIX

A-4 FAIRMONT SUBWATERSHED

APPENDIX

Figure 1: Outfall 37 is an 18-inch concrete pipe at the headwaters of tributary 2. Outfall is approximately 114 feet from the stream and has a 90-foot riprap outfall protection channel.

Figure 2: Bank erosion in tributary 2.

APPENDIX

Figure 3: Wooden footbridge across tributary 2. Private backyard goes to edge of stream and to footbridge.

Figure 4: Lawn comes to edge of stream. Inadequate buffer in tributary 2.

Figure 5: Channel drop of approximately 1.75 feet in tributary 2.

Figure 6: Outfall 24 is two pipes at the headwaters of tributary 1. Outfall is approximately 74 to stream with 19-foot riprap outfall channel protection.

Figure 7: Outfall 25 is a 12-inch concrete pipe conveying flow to the right bank of tributary 1. Outfall is approximately 23 feet from stream. Entire distance to stream is concrete channel outfall protection.

Figure 8: Exposed pipe extended from right bank to stream bottom in tributary 1. Pipe is approximately 9 feet long. The purpose of the pipe is unknown.

Figure 9: Natural spring to right of tributary 1. Confluence of natural spring with tributary 1 on right bank.

Figure 10: Existing pond adjacent to tributary 1 on private property. Overflow from pond enters stream.

APPENDIX

Figure 11: Confluence of tributary 1 (right) and mainstem (left).

Figure 12: Culvert under Carolina Avenue in mainstem. Culvert on left in photo is a 78-inch cast iron pipe that conveys most the flow. Culvert on right in photo is a 48-inch reinforced concrete pipe. Flow exits culverts to concrete outfall protection and flows a 4-foot drop over pictured rock sill.

Figure 13: Looking upstream at channel alteration of mainstem just downstream of Carolina Avenue culvert (Figure 12). Right bank armored with stone boulders for approximately 86 feet in mainstem.

Figure 14: Inadequate buffer along mainstem. Lawn comes directly to right bank of stream. Inadequate buffer along right bank for majority of mainstem reach between culvert under Carolina Avenue to confluence with tributary 3.

Figure 15: Channel alteration in mainstem. Left bank armored with stone boulders for approximately 33 feet.

Figure 16: Bank erosion in mainstem.

Figure 17: Channel alteration in mainstem. Left bank armored with approximately 180 feet of stone boulders.

Figure 18: Channel alteration in mainstem prior to confluence with tributary 3. Left bank armored with approximately 58 feet of riprap.

Figure 19: Inflow at headwaters of tributary 3.

Figure 20: 36-inch culvert conveys flow under Spring Drive in tributary 3.

Figure 21: Culvert conveys flow under Dixie Drive in tributary 3. Culvert is a 36-inch reinforced concrete pipe with 13 feet of outfall protection.

Figure 22: Bank erosion in tributary 3

Figure 23: Subsurface flow begins in tributary 3 prior to confluence with mainstem.

Figure 24: Debris jam at confluence of tributary 3 (right) with mainstem (left).

APPENDIX

A-5 RING FACTORY SUBWATERSHED

APPENDIX

Figure 1: Outfall 34 (pictured on right) and outfall 35 (left) convey inflow to headwaters of mainstem. Outfall 34 is a 24-inch concrete pipe. Outfall 35 is a 30-inch concrete pipe. Standing water present at outfalls. Brick and concrete structure surrounding outfalls.

Figure 2: Concrete and riprap channel alteration immediately downstream of outfall 34 and outfall 35 in mainstem.

Figure 3: Lawn to edge of stream banks. Inadequate buffer present in mainstem.

Figure 4: Concrete armored banks in mainstem for approximately 233 feet.

Figure 5: Bank erosion in mainstem.

Figure 6: Footbridge at downstream end of concrete channel alteration (Figure 4).

Figure 7: Outfall 33 is an 18-inch concrete pipe that conveys flow to the right bank of the mainstem. Outfall is approximately 150 feet from stream.

Figure 8: Natural spring starting location and channel leading to right bank of mainstem.

Figure 9: Wooden pedestrian bridge on mainstem prior to confluence with tributary 1.

Figure 10: Outfall 28 is an 18-inch concrete pipe at the headwaters of tributary 1. Outfall is approximately 62 feet from the stream. Tributary 1 enters mainstem on right bank.

Figure 11: Bank erosion in tributary 1.

Figure 12: Fish barrier in mainstem upstream of outfall 41. Natural falls barrier with too high jump for fish passage.

Figure 13: Outfall 41 is a 15-inch metal pipe conveying flow to the right bank of the mainstem. Outfall is approximately 89 feet form stream and has approximately 4 feet of riprap outfall protection.

Figure 14: Dry basin outfall to left bank of mainstem.

Figure 15: Outfall 26 is an elliptical pipe (24" high by 45" wide) conveying flow to the right bank of the mainstem just upstream of the culvert under Tennessee Drive. Outfall is 20 feet from stream and has 7 feet of riprap outfall protection.

Figure 16: Looking upstream to culvert under Tennessee Drive. Culvert is 78-inch cast iron pipe that is 32 feet long. There is a 2-foot drop to water surface. 10-foot-wide by 12-foot-long scour hole on downstream side.

Figure 17: Inadequate buffer along mainstem. Lawn comes to edge of bank.

Figure 18: Bank erosion on mainstem.

Figure 19: Old oxbow channel on left bank of mainstem.

Figure 20: Natural spring enters mainstem on left bank.

Figure 21: Outfall 29 is a 24-inch concrete pipe that conveys flow to right bank of mainstem upstream of Carolina Avenue culvert. Outfall is 24 feet from stream and does not have outfall protection. Pipe is half full of sediment.

Figure 22: Existing BMP 5 is a rain garden at Christ Our King United Presbyterian Church on Lexington Road. Flow is conveyed to facility via riprap channel. Overflow to follow existing drainage network. Retrofit not recommended.

Figure 23: Existing BMP 6 is an infiltration trench located at Christ Our King United Presbyterian Church on Lexington Road. Flow is conveyed to the facility via downspout disconnection. Outfall to existing drainage network. Retrofit not recommended.

Figure 24: Existing BMP 8 is a rain garden at Christ Our King United Presbyterian Church on Lexington Road. Flow is conveyed to the facility via overland flow from downspout disconnection. This facility is not recommended for a retrofit.

Figure 25: Existing BMP 9 is a rain barrel at Christ Our King United Presbyterian Church on Lexington Road. Flow is conveyed to the facility via downspout disconnection. Flow exits facility via PVC pipe. This facility is not recommended for a retrofit.

A-6 BROOK HILL SUBWATERSHED

APPENDIX

Figure 1: Bank erosion in mainstem.

Figure 2: Channel alteration in mainstem. Riprap along left bank.

Figure 3: Outfall 40 is a 36-inch plastic pipe at headwaters of tributary 1. Outfall is 44 feet from stream and has riprap outfall protection.

Figure 4: Bank erosion along both banks in tributary 1.

Figure 5: Debris jam in channel of tributary 1. 1.5-foot drop in channel.

Figure 6: Confluence of dry ditch/depression and stream in tributary 1.

Figure 7: Sediment deposition and shallow channel causes braiding in tributary 1. Channel shifted to left of original channel.

Figure 8: Tributary 1 confluence with mainstem. Tributary 1 enters mainstem on right bank. Minimal flows entering mainstem from tributary 1.

Figure 9: Outfall 8 is a 24-inch metal pipe conveying flow to the left bank of the mainstem. Invert of outfall is one foot above water surface.

Figure 10: Bank erosion in mainstem downstream of outfall 8.

APPENDIX

Figure 11: 12-inch reinforced concrete drainage ditch culvert that parallels mainstem.

Figure 12: Beginning of abandoned channel in mainstem. Stream has shifted.

Figure 13: Abandoned channel in mainstem.

Figure 14: Abandoned channel meets existing channel in mainstem.

Figure 15: End of abandoned channel in mainstem.

Figure 16: Outfall 10 is a 24-inch metal pipe conveying flow to the right bank of the mainstem. Outfall is in tributary 2 and is 50 feet to the stream.

Figure 17: Outfall 31 is an 18-inch plastic pipe conveying flow to the right bank of the mainstem. Outfalls directly into stream. Outfall structure has severe damage.

Figure 18: Existing BMP 2 is an extended detention basin in Brook Hill Court. Inflow from the surrounding neighborhood via two pipes. Outfall via metal riser to gabion outfall protection. Proposed wet pond retrofit.

APPENDIX

Figure 19: Existing BMP 4 is an extended detention basin at the Northern end of Raspberry Hill Court. Inflow from the surrounding neighborhood via three pipes. Outfall via metal riser to gabion outfall protection. Proposed wet pond retrofit.