AN ASSESSMENT OF STREAM RESTORATION AND STORMWATER MANAGEMENT RETROFIT OPPORTUNITIES IN LOWER BUSH CREEK WATERSHED, FREDERICK COUNTY, MARYLAND

Prepared for

Frederick County
Division of Public Works
118 North Market Street
Frederick, Maryland 21701-5422

Prepared by

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9200 Rumsey Road
Columbia, Maryland 21045

August 2003

Versar INC.

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1.0 INTRODUCTION

The Lower Bush Creek Watershed in Frederick County, Maryland, is a relatively rural area southeast of the City of Frederick that is experiencing rapid growth and development. Given the potential for urban watershed stresses to impact the environmental quality of the watershed's streams (Table 1-1), Frederick County sponsored a study to identify projects that could improve and protect water quality and stream conditions. This report documents the findings of this study conducted by Versar, Inc., under contract to the Frederick County Division of Public Works (Task Order No. 02-CSC-04-49237).

Table 1-1. Major pollutants (stressors) in urban or suburban areas and their effect on streams (Fairfax County 2001)

Stressor	Source	Environmental Effect
Nutrients (Nitrogen and Phosphorous)	Improper use (over application) of lawn fertilizers.	Stimulate algae blooms. May reduce sunlight reaching stream bottom, limiting plant growth. Rapid accumulation of dead algae decomposes aerobically, robbing other stream animals of oxygen.
Toxics	Various. Underground storage tank leakage, surface spills, illegal discharges, chlorine from swimming pool drainage, etc.	Can have an immediate (acute) affect on stream biota if levels are high enough. May be chronic, eliminating the more sensitive species and disrupting ecosystem balance over time.
Sediment	Poorly managed construction areas, winter road sand, instream erosion, bare soils.	Clogs gills of fish and insects, embeds substrate, reducing available habitat and potential fish spawning areas.
Organic Loading	Sewage leaks, domestic and livestock wastes, yard wastes dumped into streams.	Human health hazard (pathogens), similar oxygen depletion situation as Nutrients. Causes benthic community shift to favor filter feeders as well as organisms with low oxygen requirements.
Exotic Species	Human transportation and release (intentional and unintentional).	Invade ecosystem and out compete native species for available resources (food and habitat). Some introduced intentionally to control other pests.
Thermal Loading	Water impoundments (lakes or ponds). Industrial discharges and power plants. Removal of riparian tree cover. Runoff from hot paved surfaces.	Biological community structure altered, shift to species tolerant of higher temperatures, sensitive species lost. Dissolved oxygen depletion.
Channel Alteration	In very urban areas, concrete, metal and rip-rap stabilization of stream banks. Stream channel-ization, flood erosion control.	Major habitat reduction/elimination, changes flow regime dramatically. Dramatic alteration of biological communities can cause Thermal Loading and Sediment problems. Transfer erosion potential downstream.
Altered Hydrology	Conversion of forested/natural areas to impervious surfaces. Increases amount and rate of surface runoff and erosion.	Overall channel instability, habitat degradation or loss.
Riparian Loss	Development. Clearing or mowing of vegetation all the way up to stream banks.	Increase water temperature, greater pollutant input, less groundwater recharge, greater erosion potential from streambanks. Alters community composition.

Building upon previous efforts to assess watershed conditions and stressors affecting Lower Bush Creek (Roth et al. 2001), the objective of the study was to identify stream restoration and stormwater management controls that could cost-effectively improve watershed conditions. Utilizing the methods outlined below, Versar worked in collaboration with County personnel to develop a prioritized list of candidate stream restoration and stormwater management sites. For sites on this list, we present conceptual plans for the best opportunities based on the unique features of each site.

It is important to note that if left unchecked, many of the stormwater runoff and associated nonpoint source pollution problems noted in this study may lead to long-term impacts to the quality of Frederick County's water resources, as well as exacerbate regional water quality problems by contributing to cumulative impacts downstream in the Monocacy and Potomac Rivers, and ultimately in the Chesapeake Bay. Potential impacts to water resources include:

- Destabilization of drainage pathways and stream channels
- Damage to infrastructure and private property from erosion
- Reduction of drinking water quality and increased treatment costs for local water supplies, and if left untreated, potential public health and safety concerns
- Reduction of the quality and diversity of physical habitat available to aquatic organisms
- Reduction in species diversity and abundance within stream communities
- Reduction in economic, social, and aesthetic benefits to local communities (e.g., tourism, recreational fisheries, sense of well-being, community identity, etc.)

2.0 METHODS

In order to identify the best opportunities for stream restoration and stormwater controls within the study area, Versar adapted a restoration targeting approach, successfully employed by Versar in other watershed investigations (Southerland et al. 1999; Southerland et al. 2000; Roth et al. 2002). This approach uses both existing data and new investigations, to carry out the following steps:

1. Determine general problem types and trends in stream condition
2. Develop criteria within existing information to distinguish problem types
3. Identify areas or sites experiencing degradation and the most likely causes of those problems
4. Develop and apply criteria to rank candidate restoration sites
5. Recommend site-specific restoration measures

As the first step toward characterizing general problem types and planning our subsequent field investigations, we reviewed existing background information on the most significant problems affecting streams in the study area. Available information included (1) the 2001 watershed assessment of Lower Bush Creek (Roth et al. 2001), (2) long-term stream assessment and stormwater monitoring conducted by Versar in the watershed, and (3) other relevant maps, aerial photographs, and geographic information systems (GIS) data provided by the County.

Next, the project team employed a targeting approach to identify the most important stream restoration and stormwater management (SWM) control opportunities within the study area. The approach used GIS data and information from previous studies to focus field efforts within or downstream from developed areas. Once these areas had been identified, field teams conducted stream reconnaissance walks to visually identify degraded conditions indicative of upstream SWM problems and identify stream restoration opportunities. A customized field data sheet for the stream reconnaissance walks was developed to record and rate individual ecological, physical condition, and restoration constraint characteristics (Appendix A). Information gathered during the stream walks was then used to focus follow-up visits to SWM facilities and other developed upland areas that might negatively influence stream stability and or water quality.

To evaluate stream conditions and collect data to support the identification of candidate restoration sites, Versar staff conducted detailed visual stream inspections between December 2002 and January 2003. The stream reconnaissance was targeted towards approximately half of the streams in the study area, as outlined above. Stream reconnaissance was performed by two-person crews versed in stream ecology and watershed restoration techniques. In addition to the observational data, global positioning system (GPS) coordinates and photographs were recorded at each site. Annotated field maps and completed field data sheets for all evaluated sites may be

found in Appendices B and C, respectively. Locations of candidate sites were also superimposed onto aerial photographs to provide additional contextual information for each site (Appendix D).

Stream names from U.S. Geological Survey 7.5–minute topographic maps and the 2002 ADC Street Map for Frederick County were used to assign a two-letter abbreviation to the named tributaries (i.e., Peter Pan Run = PP, Davis Branch = DB, Wood Run = WR, School Run = SR, Bush Creek = BC). Unnamed tributaries were assigned a two or three letter abbreviation and then numbered, clockwise, starting from the north side of Bush Creek (i.e., Monocacy Tributaries = MTX, Peter Pan Run Tributaries = PPTX, Bush Creek Tributaries = TX). Candidate restoration sites were then sequentially numbered along each tributary as they were encountered in the field (e.g., T1-3).

Next, upland site visits were conducted to evaluate factors such as existing stormwater management structures and other Best Management Practices (BMPs), site drainage pathways, land uses for potential water pollution sources, hydraulic/hydrologic problems, stressed vegetation, nuisance species (e.g., invasive plant species, potential mosquito breeding habitat), and excessive sedimentation to identify specific improvement opportunities. Potential retrofits might include not only modification of existing SWM controls to increase efficacy, but construction of new quantity and quality BMPs for parking lots, stormdrains, rooftops, and other impervious surfaces to increase infiltration and reduce runoff that needs to be controlled.

Follow-up field visits to SWM facilities and other developed upland areas that might negatively influence stream stability and/or water quality were conducted in January 2003. These sites were examined by Versar's stormwater engineers and watershed restoration staff. Additional data, including as-built plans, the County's facility database, and inspection records, aided formulation of site-specific recommendations for a number of locations.

To gain further understanding of the general problem types and trends in stream condition, we solicited input from County staff and the public. County input was obtained throughout the project, and in particular, County staff accompanied Versar during several field inspections of upland SWM opportunities in which they contributed specific knowledge of the sites' construction, operation, and maintenance history, as well as constraints that might influence potential improvements.

A public meeting was held on February 13, 2003 at Urbana High School to provide an overview of the County's study, identify public concerns (e.g., frequent flooding, poor aesthetics, pollution, etc.), and solicit public input for identification of restoration and SWM opportunities. Meeting announcement and presentation materials have been included in Appendix E. The meeting was attended by County staff from several offices, as well as a reporter from the Frederick News Post and several private citizens. Meeting attendants were receptive to the general types of restoration and retrofit approaches presented at the meeting. In addition, meeting attendants made a number of suggestions, as summarized in Table 2-1.

Table 2-1. Summary of comments received at the February 13, 2003 public meeting	
Comment	**Response**
Bush Creek at Ijamsville Road, upstream from pony club – apply money to implement BMPs on agricultural land and explore the existence or revision of soil and water conservation plans on these farms.	Same location as Site BC-1; comments incorporated into recommendations.
Wood Run and School Run – Farmer stated that streams have become severely eroded since building of I-70. Farmer is interested in stream restoration opportunities on and near his property to address problems.	Same location as Sites WR1, WR-2, WR-3, and SR-1; comments incorporated into recommendations.
Potential avenues to increase participation in meetings and projects – contact home owners associations to announce meetings/projects, and to solicit feedback on individual projects on their property	Project team will contact these groups for similar efforts in the future.
Potential avenues to increase participation in meetings and projects – provide announcement and educational materials to schools to pass to students/public through their media centers (e.g., posters, brochures, reports)	Project team will contact schools for applicable efforts in the future.
Potential avenues to increase participation in meetings – provide announcements to churches and other local groups to announce in their newsletters	Project team will contact these groups for similar efforts in the future.
Opportunity for coordination of outreach/volunteers - Dale Peters is a high school teacher who does stream sampling in Urbana area	Project team will explore opportunity for collaboration in future volunteer monitoring and other outreach events

Once the visual field inspection of streams and follow-up visits to upland areas in the study area was complete, field data were compiled for analysis of impact severity and other factors. To begin, numerical ratings from the field data sheets, generally 0 = None, 1 = Minor, 2 = Moderate, and 3 = Severe, were tabulated in Microsoft Excel; entries were double-checked against the original field data sheets as a quality control check. To facilitate equal comparison, average scores were also calculated for the five subcategories within Severity of Stream Impacts. Along with these measures of stream impact severity, four other categories were evaluated: extent of the problem, factors representing constraints or likelihood of public acceptability, threats to property and infrastructure, and relative cost. The likelihood of meeting restoration goals, given site conditions, severity and type of problem, and the state of the science for addressing the type of problem was also considered in the analysis to aid in prioritization. Category scores were derived for each site by dividing the average rating by three to normalize the value; the product was then multiplied by a weighting factor (i.e., Severity of Stream Impacts (30%), Extent of Problem (20%), Constraints/Acceptability (10%), Property/Infrastructure (20%), Economic Feasibility (20%)). The sum of the first five Category Scores was then

multiplied by the Probability of Restoration Success (0 to 1.0) to derive a total score for each site (maximum possible score = 100), following the formulas below.

$$\text{Category Score} = (\text{Average Rating}/3) * \text{Weighting Factor}$$

$$\text{Total Score} = \left(\text{Severity of Stream Impacts} + \text{Extent of Problem} + \text{Constraints/ Acceptability} + \text{Property/ Infrastructure} + \text{Economic Feasibility} \right) * \text{Probability of Success}$$

3.0 GENERAL PROBLEM TYPES ENCOUNTERED

While water resources streams in the Lower Bush Creek Watershed reflect stresses brought about by the region's long agricultural history, overall conditions appeared to be moderately impacted by current stressors that include not only agricultural practices, but rapid urban land use changes (e.g., construction of homes, retail shopping centers, and roads). The primary stressor appears to be changes in watershed hydrology which can drive more secondary problems, as described below. Symptoms of problems evident in area streams included bank erosion, channel incision, overwidened channels, excessive gravel bar formation, headcutting, and embedded stream substrates, and were generally localized. In a number of locations, problems were more widespread and extended along long sections of stream or even entire stream lengths. While some of these symptoms were indicative of hydrologic and geomorphic adjustments to historical conditions, such as abandoned floodplain terraces observed in several locations, others were more recent in origin (e.g., within the last 20-30 years).

Many of the more recent impacts to the watershed's hydrology appear to be related to stormwater runoff, which can result in rapidly fluctuating flow conditions, higher peak flows, and lower base flows, especially in urbanized areas with little to no stormwater controls. The most severe problems were noted in streams below several major roads and highways in the New Market area (i.e., Interstate 70, State Route 144, and State Route 75). Major issues observed in the study area included the following:

Hydrologic modifications: Streams form under certain hydrologic conditions, and when variables that define these conditions (e.g., infiltration, evapotranspiration, runoff, drainage area, flow volume, and flow velocity) change, streamflow and channel morphology adjust in response. Modification of natural flow regimes was the most apparent stressor to the watershed. While many modifications are related to historical agricultural practices (e.g., conversion of forest to cropland), a large portion are associated with historic and current stormwater management practices. Development practices have resulted in additional changes in land cover and the introduction of extensive impervious surfaces (i.e., roads, parking areas, and rooftops). Furthermore, grading and drainage alterations in older developments and along roads have changed catchment size for some areas. Because of the predominance of rural land within the study area, few stormwater management facilities exist within the study area. While much of the recently developed area is served by stormwater management, some older developed areas, including highways, lack controls to adequately detain and diffuse the erosive volume and velocity of stormwater runoff.

Erosion and channel destabilization: When agricultural and development practices alter vegetative cover and natural flow regimes, erosion, sedimentation, and stream channel instabilities are often the result. A number of large developments in the area have resulted in clearing vegetation from large expanses, and even with the required erosion and sedimentation controls in place, large quantities of sediment are transported into the receiving stream channels. Coupled with increased runoff as a result of the cleared vegetation, an increased sediment supply

can destabilize the stream's sediment transport regime and result in channel adjustments to accommodate the increased sediment load.

Channel instabilities are also induced in many parts of the study area, especially along the major roads and highways, when stormwater is discharged directly to natural surface drainages in areas where steep slopes increase the velocity and erosive power of the concentrated flows. These hydrologic modifications often upset the dynamic equilibrium among velocity, flow resistance, stream discharge, sediment size, and sediment load that influences channel morphology (i.e., channel pattern, cross-sectional profile, and slope) in natural stream channels (Nunnally 1978; Rosgen 1993). The increased erosive power of stormwater within the study area has caused stream channels to respond to the disrupted equilibrium by incision, headcutting, gravel bar formation, sedimentation, and other channel adjustments. Once the equilibrium has been upset, it can often take several decades to reestablish a balance–one that could look and behave very differently than before. It is also possible that a morphologically stable channel may not develop, even after a considerable time (Keller 1975, 1978).

Nonpoint source pollution: In many areas, nonpoint source pollutants (e.g., sediment, pesticides and herbicides, fertilizers, pet wastes, heavy metals) washed from roads, rooftops, and lawns are rapidly conveyed through roadside ditches and manmade drainage networks into area streams. This effectively bypasses the network of riparian buffers found along many sections of the watershed's streams and eliminates much of their natural filtering and stormwater retention capacity. Therefore, surface water quality may be degraded.

Existing stormwater management controls were also examined during this study and in most cases appeared to be well maintained and functioning as intended. As discussed in Section 4, opportunities to improve existing facilities were very limited as most facilities provide some level of water quality treatment. In addition, opportunities to reduce mosquito breeding habitat and concerns over West Nile Virus were not substantial as most facilities are dry detention ponds and do not retain standing water for extended periods.

4.0 SITE-SPECIFIC OPPORTUNITIES

Twenty-four candidate restoration sites were identified in the field surveys. A map of all site locations, including those identified as localized point problems or longer problem reaches, was constructed using field GPS coordinates (Figure 4-1). Based upon the analysis described above, numerical ratings were used to rank each site according to its opportunity to improve watershed conditions (Table 4-1). As shown in Table 4-1, six sites presented opportunities for both stream restoration and SWM controls; 17 sites were candidates for stream restoration; and one site presented an opportunity for SWM maintenance. Although these rankings are based on a number of important factors, we anticipate that the County will ultimately choose a suite of final sites based on integrating these results with other information, including data not currently available. In addition, some of these projects may be implemented by other organizations.

A review of the County's stormwater management facility database indicates that, within the watershed, as-built plans for seven facilities are on file with the County (Figure 4-1, Table 4-2). Six of the seven facilities currently treat quality as well as quantity; Structure No. 465 does not. All seven of these facilities pre-date the County's current design standards. A number of ponds within the Villages of Urbana are in various stages of completion and are not yet included in the County's database of active SWM facilities. County staff indicated that these recently designed facilities would not likely present significant opportunities for improvement.

The targeting approach employed in this assessment identified stream problems downstream from only one of the watershed's seven SWM facilities. As discussed in the following Site-Specific Opportunities section (Section 4), the infiltration pond at the New Market Post Office (Structure No. 466) presents an opportunity to retrofit the existing facility to a rain garden, which would upgrade the facility to a more current treatment technology, provide additional water quality improvements through biological processes, and improve aesthetics at this highly visible location. However, the Post Office SWM facility does not provide an opportunity to control runoff from additional area beyond its 1-acre drainage area because it is situated near the top of a hill.

The project team subsequently reviewed data on the remaining six SWM facilities to see if they presented opportunities for improvements such as changing outlet structures, adding quality management in addition to quantity, or elimination of standing water to help prevent mosquitoes and the spread of West Nile virus. Factors such as approval dates, drainage area, and treatment type (quality, quantity, or both) were considered in this review. Five of the remaining facilities are relatively small, with three treating areas less than 10 acres and two treating between 23 and 35 acres, and thus did not represent cost-effective retrofit opportunities to gain significant benefits for the watershed. The last facility, Structure No. 45 - The Meadows at Woodspring, SWM Pond No. 1, treats a larger area (135 acres) and was considered further for stormwater retrofit opportunities. Based upon a review of site plans provided by the County for this facility, any design deficiencies appear to have been corrected during the review period, and, therefore, additional improvements are not recommended at this location.

Because few retrofit opportunities were apparent at existing SWM structures, the majority of our recommendations are directed towards stream restoration (to improve upon degraded stream conditions) and provision of new stormwater controls (where they are currently lacking). Recommendations were developed for 24 candidate sites. In some cases, we note where implementing restoration and retrofits at two or more sites in close proximity would have a beneficial synergistic effect. In particular, the six combined stream restoration and SWM control candidate sites present the best opportunities to address urban stormwater impacts. These opportunities involve a combined approach that targets the site's symptoms of stormwater problems as well as the underlying causes.

It should also be noted that many of the opportunities to provide new SWM controls and improve stream stability identified in this study are located on property not owned by the County. Additionally, SWM facilities in Frederick County are generally owned and maintained by private entities, and any actions by the County (beyond routine inspection) at these facilities would require additional landowner cooperation. As such, the County will need to approach individual private property owners to assess the likelihood (and relative potential cost) of gaining landowner permission and support for the project via easements, out right purchase, or other approaches.

The following pages present a description of each of the 24 candidate sites, including a description of site conditions and a brief conceptual restoration approach. Sites have been separated into three broad groups (stream restoration with SWM, stream restoration, and SWM maintenance), and then described in priority order following the ranking scores in Table 4-1. We have also included rough cost estimates (i.e., a ±30% range) that may be used for planning purposes. Cost information was gathered from a number of sources that typically included engineering, design, and construction costs. Note that costs may vary depending on location, accessibility, whether or not land or easement purchase is required, and other site-specific factors. The estimates below are intended for general planning purposes only.

In general, cost estimates for stormwater retrofits were based on those provided by the Rouge Program Office (RPO; 2001) for wet retention ponds. In their report, the RPO states that pond volume is the single most important determinate of cost and that a typical estimate of volume is 7,000 cubic feet (0.05 million gallons [MG]) per impervious acre for a 1-hour, 100-year event. Costing guidance in the RPO report includes $160,000/MG for construction (excluding land acquisition) and 30 percent of construction costs for project design and permits. Additional cost information for infiltration basins was based on data from the Stormwater Manager's Resource Center, indicating that total construction costs for this technique is approximately $2 per cubic foot of storage (SMRC 2003).

Cost estimates for urban stream restoration projects were based on Haupt et al. (2002), who provided a provided an average total cost estimate of $218 per linear foot. This estimate included costs for site identification and acquisition, design, construction and construction management, post-construction monitoring and maintenance, and long-term management. Additional cost information for other stream restoration elements, namely conservation easements to protect restored riparian buffer (i.e., $2,500 per acre) and streambank stabilization

measures using bioengineering approaches (i.e., $50 linear foot) was obtained from the Center for Watershed Protection (CWP 1998). Forest buffer materials, planting, and maintenance costs in Maryland (i.e., $2,6000 an acre) were obtained from Lynch and Tjaden (2000). Estimated costs for replacing road culverts is based on approximately $500 per linear foot of road (Brian Mulvenna, US Army Corps of Engineers, personal communication, May 2003).

Cost estimates for other BMPs in agricultural areas were obtained from a variety of sources. Lynch and Tjaden (2000) describe costs of keeping animals away from streams in Maryland, that include $2.60 per foot for high tensile, 3-strand electric fence, $7,000 per unit for alternate watering sources, and $6,000 for dedicated stream crossings using stone. The Frederick County Soil Conservation District (SCD) routinely develops site-specific conservation plans for local farmers at no cost (Chad Wentz, Frederick County SCD, personal communication, August 2003).

In many cases, costs for agricultural BMPs, including riparian buffers, livestock exclusions from streams, alternate watering sources, stream crossings, conservation plans, etc., may be substantially off-set through programs offered by the US Department of Agriculture's Natural Resources Conservation Service (NRCS), the Maryland Department of Agriculture, and the Frederick County SCD.

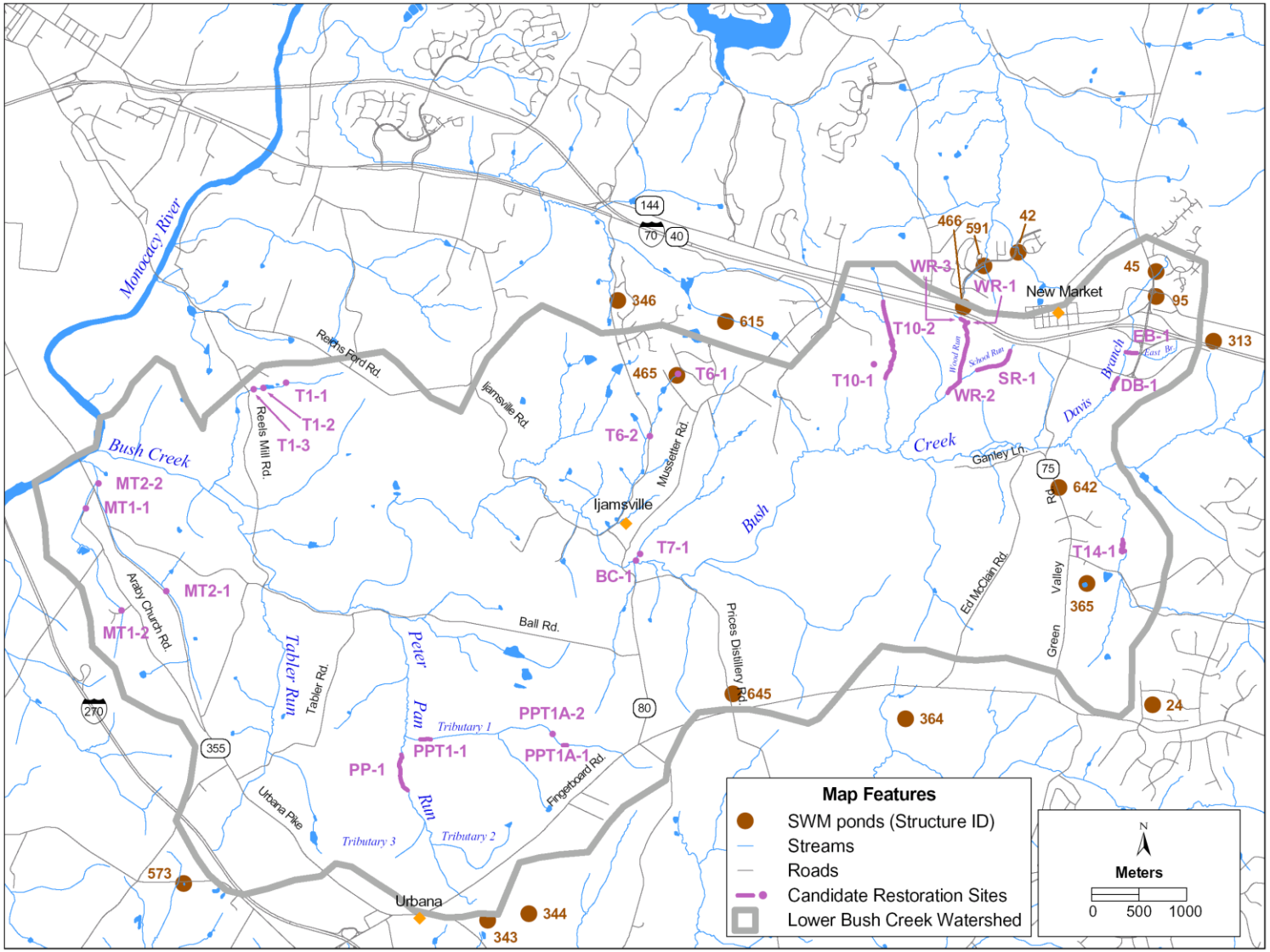

Figure 4-1. Candidate stream restoration and SWM retrofit sites identified during reconnaissance surveys in Lower Bush Creek Watershed, Frederick County, MD. Existing SWM facilities are also shown.

See Excel File for Table 4-1 on 11 x 17 paper

Table 4-1. Summary and ranking of stream restoration and SWM retrofit opportunities in Lower Brush Creek, Frederick County, MD

Table 4-2. As-built approved stormwater management facilities within Lower Bush Creek Watershed, Frederick County, MD

Structure Number	Name	As-Built Approval	Drainage Area (acres)	Storage Area (acre ft.)	Management Type	Practice Type	Structure Type	Outlet Info
45	The Meadows at Woodspring - SWM Pond. No. 1	02/06/1996	135.25	9.53	Quantity & Quality	Extended Detention Structure (Dry)	Concrete Weir Wall	2' Sq Orifice; 28' Weir
95	New Market Shopping Center - Extended Detention Pond	09/10/1996	6.2	1	Quantity & Quality	Extended Detention Structure (Dry)	Metal Pipe Riser with Metal Pipe Barrel	2.5"OR; 1' W; 36"R; 24"B
365	Weller Estates - Modified Farm Pond	09/09/1992	34.1	1.39	Quantity & Quality	Extended Detention Structure (Wet)	Metal Pipe Riser with Metal Pipe Barrel	4" ED OR; 36"Riser; 24" Barrel
465	The Greens - SWM Dry Pond	No Data	23	0.77	Quantity	Detention Structure (Dry Pond)	Metal Pipe Riser with Metal Pipe Barrel	12"OR; 36"R; 24"B
466	New Market Post Office	01/11/1994	1	0.2	Quantity & Quality	Infiltration Basin	No Data	4'x12'x80' Trench within Basin
642	Bush Creek Church of the Brethren	05/17/2002	1.95	0.14	Quantity & Quality	Extended Detention Structure (Dry)	Concrete Weir Wall	2" OR, 1.81' x 4.25' Weir
645	Saint Ignatius Church	08/13/2002	10.8	1.55	Quantity & Quality	Extended Detention Structure (Wet)	Concrete Box Riser with Plastic Pipe	3" OR, 9" W, 18" B

4.1 CANDIDATE SITES: STREAM RESTORATION WITH STORMWATER RETROFITS

Site No.: WR-1

Site Score: 45.08 – One of the six most significantly impacted streams observed in the study, the score reflects high Severity of Stream Impacts and damage to Property/Infrastructure.

Location: Eastern branch of Wood Run

Site Description: This reach receives drainage from a resident's driveway, I-70 (i.e., 6 lanes, median, and concrete swales draining shoulder areas) and MD-144. Concrete apron below culvert beneath Baldwin Rd and I-70 drops off into an approximately 10-foot deep scour hole. Stream below scour hole is eroded and steeply incised down to the confluence with the western branch of Wood Run, approximately 50 feet. Opportunities may exist for the County to work with SHA to improve site conditions.

Photographs:

Restoration Approach: Contact SHA regarding potential collaboration on stormwater management improvements and stream restoration because stormwater runoff from these roads is causing major channel instabilities at this location. The volume, frequency, and flashiness of runoff should be reduced to prevent further problems with the receiving channel. (1) Structures to control runoff through infiltration, detention, and/or bioretention measures should be constructed within roadside drainage systems (median and edges) or immediately upstream of the road culvert. (2) In addition, restoration efforts in the destabilized channel should include recreation of the stream channel using nearby reference reaches as a template for designing stable channel dimensions, patterns, and profiles,[1] stabilizing the banks with native vegetation, and installing grade control structures to prevent further incision of the channel. Below the culvert, vertical drops in the stream channel formed by headcutting processes should be stabilized by creating a step pool type channel morphology (using large rock to line the bottom of the step pools to diffuse energy).

[1] Channel dimensions include such measures as bankfull width/depth ratio, bankfull cross-sectional area, and slope; channel patterns include straight, meandering, or braided forms; and stream profiles include both cross-sectional and longitudinal.

Site No.: WR-1 (continued)

If retrofits above I-70, or between I-70 and Baldwin Road, are deemed not possible because required landowner/SHA approvals and/or expense, downstream solutions to the flow problem are also possible. Downstream of the culvert exit, there is more room for construction, there is a willing landowner, and the area is undeveloped.

Restoration should be considered in conjunction with adjacent sites WR-3 and WR-2.

Planning Level Cost Estimate: (1) $44,000 - $82,000, (2) $7,500 - $15,000

Key Issues for Implementation:

1. Contact property owner(s) to discuss the project and encourage support/permission
2. Review catchment calculations for culverts beneath I-70 and MD-144
3. Contact SHA regarding potential collaboration on stormwater management and stream restoration improvements
4. Refine approach in conjunction with plans for adjacent sites WR-3 and WR-2

Site No.: WR-3

Site Score: 41.60 – One of the six most significantly impacted streams observed in the study, the score reflects moderate Severity of Stream Impacts and Extent, and high threats to Property/Infrastructure.

Location: Western branch of Wood Run

Site Description: This reach receives drainage from a resident's driveway, I-70 (i.e., 6 lanes, median, and concrete swales draining shoulder areas), MD-144, and the New Market Post Office. Streambank erosion, gully formation, and several vertical knickpoints were noted below the road culvert, extends approximately 200 feet down to confluence with eastern branch of Wood Run. Opportunities may exist for the County to work with SHA to improve site conditions.

Photographs:

Restoration Approach: Contact SHA regarding potential collaboration on stormwater management improvements and stream restoration because stormwater runoff from these roads is causing major channel instabilities at this location. The volume, frequency, and flashiness of runoff should be reduced to prevent further problems with the receiving channel. (1) Structures to control runoff through infiltration, detention, and/or bioretention measures should be constructed within roadside drainage systems (median and edges) or immediately upstream of the road culvert. (2) In addition, restoration efforts in the destabilized channel should include recreation of the stream channel using nearby reference reaches as a template for designing stable channel dimensions, patterns, and profiles, stabilizing the banks with native vegetation, and installing grade control structures to prevent further incision of the channel. Vertical drops in the stream channel, near the confluence with WR-1and formed by headcutting processes, should be stabilized by creating a step pool type channel morphology (using large rock to line the bottom of the step pools to diffuse energy).

(3) The SWM facility at the New Market Post Office (Structure No. 466) may provide an opportunity to retrofit the current infiltration pond to a rain garden (a more current treatment technology), improve the quality of water discharged from the facility via biological processes, and improve aesthetics at this prominent location.

If retrofits above I-70, or between I-70 and Baldwin Road, are deemed not possible because required landowner/SHA approvals and/or expense, downstream solutions to the flow problem are also possible. Downstream of the culvert exit, there is more room for construction, there is a willing landowner, and the area is undeveloped.

Restoration should be considered in conjunction with adjacent sites WR-1 and WR-2.

Site No.: WR-3 (continued)

Planning Level Cost Estimate: (1) $47,000 - $89,000, (2) $30,000 - $57,000, (3) $10,000 - $20,000

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Review catchment calculations for culverts beneath I-70 and MD-144
3. Contact SHA and the Post Office regarding potential collaboration on stormwater management and stream restoration improvements
4. Refine approach in conjunction with plans for adjacent sites WR-1 and WR-2

Site No.: EB-1
Site Score: 35.12 – Score reflects moderate values for each category.

Location: East Branch west of MD-75

Site Description: This reach receives drainage from I-70 interchange at MD-75, agricultural lands, and commercially zoned land. Concrete swales from along MD-75 and culvert beneath MD-75 are eroded and undermined. Approximately 500 linear feet of stream below these structures has widened and eroded banks, undercut trees, and unstable substrate. Wetland delineation flags and other markings indicate that the site may be developed soon, providing a potential opportunity for the County to work with the developer to improve site conditions. Opportunities for collaboration may also exist with SHA.

Photographs:

Restoration Approach: Contact SHA regarding potential collaboration on stormwater management improvements and stream restoration because stormwater runoff from these roads is causing major channel instabilities at this location. The volume, frequency, and flashiness of runoff should be reduced to prevent further problems with the receiving channel. (1) Structures to encourage infiltration and detain runoff through wet pond, bioretention or other measures should be constructed in the roadside ditches, and, if necessary, within the cloverleaf, to control runoff. (2) In addition, restoration efforts in the destabilized channel should include recreation of the stream channel using nearby reference reaches as a template for designing stable channel dimensions, patterns, and profiles, stabilizing the banks with vegetation, and installing grade control structures to prevent further incision of the channel. (3) The concrete swales conveying drainage from MD-75 should be redesigned and replaced with structures capable of conveying water and dissipating sufficient energy as to avoid impacts to the stream below the swale's discharge point. Because land use in the immediate area is likely to change in the near future, it is important to work in conjunction with future development plans before appropriate solutions can be specified.

Planning Level Cost Estimate: (1) $11,000 - $20,000, (2) $76,000 - $142,000, (3) $25,000 - $45,000

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Review catchment calculations for culverts beneath I-70 interchange and MD75
3. Contact SHA regarding potential collaboration on stormwater management and stream restoration improvements
4. Review preliminary site plans, if any, for adjacent and upstream development
5. Factor developer plans and participation into next steps

Site No.: T1-2

Site Score: 33.30 – Score reflects moderate values for most categories, which are somewhat off-set by a low value (i.e., localized) for Extent of Problem.

Location: Unnamed tributary along Doubletree Court

Site Description: This reach drains woods, rural residential areas, and a small farm. An area adjacent to the stream has been cleared for the Doubletree Estates development at this location (developer office trailer on-site). An old pond and sediment basin were present at the site, with erosion observed below both structures. The culvert from the old pond has created a scour hole in the stream channel and has a 12" drop. Approximately 200 linear feet of stream below the pond outfalls is eroded and needs stabilization. Development of this site may provide the County with an opportunity to work with the property owner to improve site conditions.

Photographs:

Restoration Approach: (1) Native species of shade tolerant grasses and shrubs should be planted along the stream to help stabilize stream banks, filter runoff, and increase the density and diversity of vegetation within the existing forested riparian buffer. (2) If not already protected, the buffer should be protected through easements or other long-term conservation measures. In addition, future development designs and construction activities should prevent concentrated flows from entering or passing through the buffer.

Any other action here would depend on what the developer plans to do at the site. That may either mitigate the problem, or worsen it. (3) The minimum action recommended is restoring stable channel dimensions and profile by filling the scour pool and regrading the culvert outlet to match the final channel slope and elevation (approximately 50 linear feet). (4) The channel below requires minor bank stabilization along about 200 feet of stream. If the development above is going to put more water into the stream at or below the pond location, then this strategy will be have to be reassessed to account for hydrologic influences on long-term stream channel stability and morphology. (5) It may be desirable to redesign the pond to provide additional flow and water quality benefits.

Planning Level Cost Estimate: (1) $2,600 per acre riparian reforestation, (2) $2,500 per acre conserved for acquisition of conservation easements, (3) $7,600 - $15,000, (4) $7,000 - $13,000, (5) $15,000 - $40,000

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Review preliminary site plans for Doubletree Estates
3. Factor developer plans and participation into next steps

Site No.: SR-1

Site Score: 29.26 – One of the six most significantly impacted streams observed in the study, the high Severity of Stream Impacts, widespread Extent of Problem, high Acceptability, and damage to Property/Infrastructure are largely off-set by scores reflecting high relative costs and complexity of restoration success.

Location: School Run

Site Description: This reach receives drainage from the parking lot at Hahn Trucking, portions of western New Market, and I-70 (i.e., 6 lanes, median, and concrete swales draining shoulder areas). Located in the Intercoastal Industrial Center, public notice signs at the site indicate that 24-acres will be developed as a family entertainment center. Runoff from two road culverts has eroded a 6-inch by 6-inch gully in the meadow below Baldwin Road, which rapidly increases in size (via headcutting and lateral erosion) to become approximately 10-feet by 10-feet within about 300 feet. This gully has near vertical banks that are rapidly eroding. Banks along lower sections of this stream widen out into a broader valley, forming abandoned terraces. Side tributaries to this stream are also headcutting to match the grade of School Run as it continues to downcut. This reach is experiencing on-going planform, slope, and cross-sectional channel adjustments in response to the upstream hydrologic disturbances. Development of this site may provide the County with an opportunity to work with the property owner, and perhaps Hahn Trucking, to improve site conditions. Opportunities for collaboration may also exist with SHA.

Photographs:

Site No.: SR-1 (continued)

Restoration Approach: To determine whether additional controls are possible for existing impervious areas, SHA, Hahn Trucking, and the developer of the family entertainment center should be advised that stormwater runoff from the roads and parking areas is causing major channel instabilities at this location. The volume, frequency, and flashiness of runoff should be reduced to prevent further problems with the receiving channel. Structures to encourage infiltration and detain runoff should be constructed along or near the roads and parking areas to control runoff. While opportunities may exist to control runoff from the Hahn Trucking parking areas prior to passing beneath I-70, and runoff from I-70 before it passes beneath Baldwin Road, (1) construction of a small wet detention pond below Baldwin Road may be the best opportunity to reduce stormwater peak flows because of economies of scale and available space. (2) If space allows, an alternative would be to construct an infiltration gallery to allow for accelerated dissipation of runoff as it moves through the field. Before a solution can be finalized, future development plans for the site (i.e., entertainment complex) should be considered further.

(3) Planform, slope, and cross-sectional channel adjustments below Baldwin Road require significant stabilization efforts. Efforts in the destabilized channel should include recreation of the stream channel along approximately 2,500 feet of channel using nearby reference reaches as a template for designing stable channel dimensions, patterns, and profiles, stabilizing the banks with vegetation, and installing grade control structures to prevent further incision of the channel. Several vertical drops noted in the stream channel could be stabilized by creating a step pool type channel morphology (using large rock to line the bottom of the step pools to diffuse energy). (4) Native species of woody vegetation should be planted in the meadow below Baldwin Road and along the entire stream reach to stabilize the streambanks, create new buffer, increase existing buffer width and density, and increase plant community diversity. (5) The forested riparian buffer located along this stream should be protected through easements or other long-term conservation measures. Development designs and construction activities should prevent concentrated flows from entering the buffer. The pre-development storm hydrograph should also be maintained throughout all phases of construction and completion of the ensuing entertainment center.

Restoration should be considered in conjunction with adjacent site WR-2.

Planning Level Cost Estimate: (1) $42,000 - $78,000, (2) $105,000 - $195,000, (3) $380,000 - $710,000, (4) $2,600 per acre riparian reforestation, (5) $2,500 per acre conserved for acquisition of conservation easements

Key Issues for Implementation:

1. Contact property owner(s) to discuss the project and encourage support/permission
2. Review catchment calculations for culverts beneath I-70 and MD-144
3. Contact SHA regarding potential collaboration on stormwater management and stream restoration improvements
4. Review preliminary site plans for the Intercoastal Industrial Center
5. Factor developer plans and participation into next steps
6. Refine approach in conjunction with plans for downstream portions of site WR-2

Site No.: T10-2

Site Score: 25.04 – One of the six most significantly impacted streams observed in the study, the high Severity of Stream Impacts and widespread Extent of Problem are largely off-set by high relative costs and complexity of restoration success.

Location: Unnamed tributary to Bush Creek east of Brenda Road

Site Description: This reach receives drainage from I-70 (i.e., 6 lanes, median, and concrete swales draining shoulder areas), along MD-144, and residential area north of MD-144. Drainage flows beneath MD-144 through galvanized apron (displaced) and corroded metal pipe, with a transition to a vertical, rectangular concrete/stone culvert (approx. 18" wide and 36" tall), outletting into an eroded stream with undercut banks and trees. Stream flows through woods for about 250 feet, receiving drainage from concrete swales from I-70 and adjacent hillsides before flowing though a 64" culvert beneath I-70. The stream below I-70 has significant bank erosion, unstable substrates, and is undergoing planform and cross-sectional adjustments along approximately 4,000 linear feet in response to increased runoff. Opportunities may exist for the County to work with SHA to improve site conditions.

Photographs:

Site No.: T10-2 (continued)

Restoration Approach: This area appears to be under a severe volume strain, with runoff coming from both I-70 and the residential area north of MD-144. SHA should be contacted regarding potential collaboration on stormwater management and stream restoration improvements because stormwater runoff from the roads is causing major channel instabilities at this location. The volume, frequency, and flashiness of runoff should be reduced to prevent further problems with the receiving channel. (1) Structures to encourage infiltration and detain runoff should be constructed along both the north and south sides of I-70 to control runoff (e.g., creation of small detention pools where the concrete swales feed highway runoff into the mainstem channel).

The residential area north of MD-144 drains through a culvert that is undersized and damaged. (2) This culvert beneath MD-144 should be repaired and/or resized. Because the slope is fairly steep from MD-144 down to the culvert beneath I-70, flows should be slowed to reduce erosive energy and detained to reduce stormwater peak discharges. (3) The stream channel between MD-144 and I-70 should be reconfigured with step pools to stabilize banks and dissipate energy.

Planform, slope, and cross-sectional channel adjustments below I-70 require significant stabilization efforts. (4) Efforts in the destabilized channel should include recreation of the stream channel along approximately 4,000 feet of channel using nearby reference reaches as a template for designing stable channel dimensions, patterns, and profiles, stabilizing the banks with vegetation, and installing grade control structures to prevent further incision of the channel.

Planning Level Cost Estimate: (1) $ 109,000 - $203,000, (2) $14,000 - $26,000, (3) $39,000 - $72,000, (4) $630,000 - $1,200,000

Key Issues for Implementation:

1. Contact property owner(s) to discuss the project and encourage support/permission
2. Review catchment calculations for culverts beneath I-70 and MD-144
3. Contact SHA regarding potential collaboration on stormwater management and stream restoration improvements

4.2 CANDIDATE SITES: STREAM RESTORATION

Site No.: T10-1

Site Score: 55.00 – Score reflects moderate Severity of Stream Impacts and extent, low relative potential costs, and relative ease with which the site could be fixed.

Location: Small, unnamed stream flowing from farm at end of Brenda Avenue into Tributary T10

Site Description: Small stream flows from spring through barnyard and pasture. Extensive bank trampling has destabilized stream banks, caused bank erosion, and downstream sediment deposition along approximately 175 linear feet of channel. Livestock wastes also threaten water quality.

Photographs:

Restoration Approach: Agricultural BMPs – work with landowners along this reach to (1) plant riparian buffer using native vegetation; (2) provide long-term protections for riparian buffers through easements; (3) construct livestock exclusions from stream, (4) dedicated stream crossings, and (5) alternate watering sources; and (6) utilize conservation plans.

Planning Level Cost Estimate: (1) $2,600 per acre riparian reforestation, (2) $2,500 per acre conserved for acquisition of conservation easements, (3) $600 - $1,200, (4) $4,200 - $7,800, (5) $4,900 - $9,100, (6) nominal

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Contact NRCS and the SCD to notify them of problem and discuss opportunities for improvement

Site No.: T6-2

Site Score: 50.65 – Score reflects minor stream impacts that are widespread, but relatively inexpensive and easy to fix.

Location: Unnamed tributary to Bush Creek, paralleling west side of Ijamsville Road

Site Description: Stream flows through approximately 1,300 linear feet of livestock pasture without riparian buffer. Minor streambank erosion was noted at this site.

Photographs:

Restoration Approach: Agricultural BMPs – work with landowners along this reach to (1) plant riparian buffer using native vegetation; (2) provide long-term protections for riparian buffers through easements; (3) construct livestock exclusions from stream, (4) dedicated stream crossings, and (5) alternate watering sources; and (6) utilize conservation plans.

Planning Level Cost Estimate: (1) $2,600 per acre riparian reforestation, (2) $2,500 per acre conserved for acquisition of conservation easements, (3) $4,700 - $8,800, (4) $4,200 - $7,800, (5) $4,900 - $9,100, (6) nominal

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Contact NRCS and SCD to notify them of problem and discuss opportunities for improvement

Site No.: T1-3

Site Score: 46.97 – Score reflects localized impacts to Property/Infrastructure that should be relatively inexpensive and easy to fix.

Location: Unnamed tributary to Bush Creek above Doubletree Court

Site Description: This site is adjacent to a small farm and is located downstream from the new development at Doubletree Estates. A gas pipeline crosses the stream and runoff down the pipeline rights-of-way (ROW) has eroded a gully into the stream. The pipeline has also caused localized scour and deposition.

Photographs:

Restoration Approach: (1) To allow for adequate transport of both water and sediment through approximately 35 linear feet of stream channel at the pipeline crossing, perforated geogrid filled with riprap should be placed flush with the bed of the stream channel, with the finished crossing matching the dimensions of stable reaches located immediately above and below the crossing (i.e., same bankfull width/depth ratio, bankfull cross-sectional area, and slope). (2) To further protect the eroding streambanks, the eroded gully running down the pipeline ROW (approximately 100 feet) should be filled and stabilized (e.g., using vegetated geogrid or other suitable erosion control fabric) to provide a more stable slope.

Planning Level Cost Estimate: (1) $5,300 - $9,900, (2) $3,500 - $6,500

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Identify mechanisms to work with, or encourage, property owner to improve site conditions.

Site No.: MT1-1

Site Score: 46.95 – Score reflects high Severity of Stream Impacts that are localized and should be relatively inexpensive and easy to fix.

Location: Unnamed tributary to Monocacy River, paralleling the northwest side of Araby Church Road

Site Description: This small stream passing through active pasture showed evidence of channelization. A riparian buffer was absent and stream banks showed extensive signs of bank trampling along approximately 3,500 linear feet of stream channel. Livestock wastes also threaten water quality. The National Park Service – Monocacy National Battlefield (NPS) appears to be the property owner. Opportunities may exist for the County to work with the NPS to improve site conditions.

An adjacent property owner reported that the stream "runs blue" after large storms. Apparently, wastewater is being discharged to the stream in spite of recent repairs to nearby residential septic systems.

Photographs:

Restoration Approach: (1) Further investigate water quality following storm events to confirm whether wastewater or other discharges are entering the stream in this area.

Agricultural BMPs – work with landowners along this reach to (2) plant riparian buffer using native vegetation; (3) provide long-term protections for riparian buffers through easements; (4) construct livestock exclusions from stream, (5) dedicated stream crossings, and (6) alternate watering sources; and (7) utilize conservation plans.

Planning Level Cost Estimate: (1) nominal, (2) $2,600 per acre riparian reforestation, (3) $2,500 per acre conserved for acquisition of conservation easements, (4) $6,300 - $11,800, (5) $4,200 - $7,800, (6) $4,900 - $9,100, (7) nominal

Key Issues for Implementation:

1. DPW inspection of area for possible illicit discharges
2. Contact property owner(s) to discuss agricultural BMP projects and encourage support/permission
3. Contact NPS, NRCS and SCD to notify them of problem and discuss opportunities for improvement

Site No.: MT1-2
Site Score: 46.61 – Score reflects localized stream impacts that threaten Property/Infrastructure.

Location: Unnamed tributary to Monocacy River at Wallace Circle.

Site Description: Culvert beneath Wallace Circle, receiving drainage from woods and residential area, has a 12-inch drop that has created a large scour pool immediately below the road and blocks fish passage to upstream habitat. Water flows about half way through the 36-inch squashed corrugated metal culvert pipe before dropping through a crack or seam in the pipe, and then flows beneath the pipe to drop into the scour pool. The channel below the scour pool, lined with large cobble and bedrock outcrops, is largely stable.

Photographs:

Restoration Approach: (1) To allow for adequate transport of both water and sediment through the stream channel at this location, the culvert pipe should be replaced with a pipe sized to convey bankfull flows and set to match the current channel slope and elevation. Secondary pipes, set adjacent to the primary pipe with the invert at a bankfull elevation, would provide additional capacity to convey water in the floodplain. (2) Following replacement of the culvert, the scour pool should be filled to reestablish stable channel dimensions and profile through this section. (3) The banks should be stabilized with native vegetation, and geogrid if necessary.

Planning Level Cost Estimate: (1) $10,500 - $19,500, (2) $3,000 - $5,700, (3) $2,800 - $5,200

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Contact County Department of Highways and Transportation to notify them of problem and discuss opportunities for improvement

Site No.: MT2-2

Site Score: 44.63 – Score reflects localized stream impacts that should be relatively inexpensive and easy to fix.

Location: Unnamed tributary to Monocacy River at entrance to Monocacy National Battlefield Visitors Center on Urbana Pike

Site Description: Approximately 350 linear feet of stream above the entrance to the Visitors Center showed evidence of channelization and was surrounded by maintained lawn extending down into the channel. The 3-4-foot high banks were slumping in locations. Opportunities may exist for the County to work with the NPS to improve site conditions.

Photographs:

Restoration Approach: Agricultural BMPs – work with the National Park Service to plant riparian buffer using native vegetation. Creating a buffer with an herbaceous and shrub community may provide additional bank stability and meet the Battlefield's need to maintain historical conditions (i.e., where tree plantings would not be allowed).

Planning Level Cost Estimate: $2,600 per acre riparian reforestation

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Contact NPS, NRCS and SCD to notify them of problem and discuss opportunities for improvement

Site No.: PPT1A-2

Site Score: 43.51 – Score reflects localized stream impacts that should be relatively inexpensive and easy to fix.

Location: Northern branch of unnamed tributary to Peter Pan Run, above proposed location for SWM Pond "I"

Site Description: The banks along this small stream were approximately 10 to 15-feet high, and had localized undercuts and bank erosion along approximately 100 linear feet of channel. The riparian buffer along the north side of the stream was poor, with crops planted within three feet of the stream. Future development of this site may provide the County with an opportunity to work with the property owner to improve site conditions.

Photographs:

Restoration Approach: (1) The width, density, and species diversity of the existing riparian buffer should be enhanced through the addition of a variety of native woody and herbaceous plants along this section of stream. (2) If not already protected, the buffer should be protected through easements or other long-term conservation measures. Buffer enhancement or other actions at this location should be coordinated with future development plans for the north side of the stream, especially regarding planned SWM facilities at or near this location.

(3) Channel stability and bank erosion along this stream will be monitored in the County's geomorphic assessment of this stream.

Planning Level Cost Estimate: (1) $2,600 per acre riparian reforestation, (2) $2,500 per acre conserved for acquisition of conservation easements, (3) on-going study, therefore no additional cost

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Work with developer to address these issues during future site development and construction activities

Site No.: BC-1

Site Score: 40.74 – One of the six most significantly impacted stream locations observed in the study, the high Severity of Stream Impacts and damage to Property/Infrastructure is largely offset by high relative costs and complexity of restoration success.

Location: Mainstem of Bush Creek above Ijamsville Road, in livestock pasture

Site Description: Rapid lateral channel erosion has formed an oxbow meander in a livestock pasture immediately upstream from Ijamsville Road. Continued bank erosion over the last three years has breached the neck of the oxbow, cutting off the meander bend. Effectively shortening the channel length, this meander cutoff has increased local channel slope, velocity, sediment transport, and a number of other critical variables along approximately 1,750 linear feet of channel. These channel adjustments may potentially threaten the bridge at Ijamsville Road and lead to other channel adjustments above and below this location. Historical disturbances, such as direct livestock access to the stream and/or altered watershed hydrology may be responsible for this destabilization.

Photographs:

Restoration Approach: (1) The stream channel along this reach should be stabilized using natural stream channel design principles to recreate stable channel dimensions, patterns, and profiles. Grade control structures should also be installed to prevent future channel adjustments along the mainstem from affecting the restored section. A nearby reference reach should be used as a template for a stable restoration design. (2) Native vegetation should be used to create a riparian buffer and with other bioengineering approaches to stabilize streambanks. Long-term conservation measures, including (3) livestock exclusions from the stream, (4) dedicated stream crossings, (5) alternate watering sources, (6) conservation plans, and (7) conservation easements, should be used to protect the restoration project and riparian buffer.

Planning Level Cost Estimate: (1) $267,000 - $496,000, (2) $2,600 per acre riparian reforestation, (3) $6,300 - $12,000, (4) $4,200 - $7,800, (5) $4,900 - $9,100, (6) nominal, (7) $2,500 per acre conserved for acquisition of conservation easements

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Contact County Department of Highways and Transportation, NRCS, and SCD to notify them of problem and discuss opportunities for improvement

Site No.: T1-1

Site Score: 40.28 – Score reflects localized stream impacts that should be relatively inexpensive and easy to fix.

Location: Unnamed tributary to Bush Creek above Doubletree Court

Site Description: Trees and construction debris were noted in the stream above the Doubletree Estates development at a permitted logging site.

Photographs:

Restoration Approach: Clean up trash in this area, leaving some woody debris as habitat for stream organisms.

Planning Level Cost Estimate: Nominal cost

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Notify appropriate County and other resource agencies to work with landowner to clean up trash

Site No.: PP-1

Site Score: 38.57 – Score reflects high Severity of Stream Impacts and moderate extent, high threats to Property/Infrastructure, and relatively high restoration costs.

Location: Mainstem Peter Pan Run below Sugarloaf Parkway

Site Description: Moderate bank erosion and channel adjustments were observed along this approximately 1,750-foot reach, including a meander cut off, slumping banks, undercut banks, and excessive sediment deposition in the channel. Many of these problems appear to predate the ongoing construction in the upstream Villages of Urbana; however, development activities may exacerbate channel adjustments in the already impacted channel. Continuing development of this site may provide the County with an opportunity to work with developers to improve site conditions and to evaluate whether improvements to upstream stormwater management are warranted.

Photographs:

Restoration Approach: (1) The County should continue to evaluate channel stability in this stream through its regular stormwater monitoring program, which evaluates long-term conditions in Peter Pan Run, to determine whether additional measures are warranted here. (2) Future development in this area may necessitate restoration of the stream's cross-sectional and plan-view profiles to provide adequate stability of the stream channel.

Planning Level Cost Estimate: (1) on-going studies, therefore no additional cost, (2) $267,000 - $496,000

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Work with developer to address these issues during future site development and construction activities

Site No.: T14-1

Site Score: 37.73 – Widespread problems at this site are largely off-set by moderate Severity of Stream Impacts and minor impacts to Property/Infrastructure.

Location: Unnamed tributary below Weller Road

Site Description: This reach flows through a horse pasture and receives drainage from a large agricultural area containing a few single-family homes. Banks 3-6-feet high, along approximately 1,000 linear feet, are undercut, slumping into the stream, and eroding laterally. There is no riparian buffer along this reach and livestock have unrestricted access to the stream channel. Planform channel adjustments will likely result in a meander cut off within approximately five years.

Photographs:

Restoration Approach: Agricultural BMPs – (1) To allow for adequate transport of both water and sediment through the stream channel at this location, reestablish stable channel dimensions, patterns, and profiles throughout the reach using bioengineering approaches (e.g., live stakes[2]). Work with landowners along this reach and upstream to (2) plant riparian buffer using native vegetation; (3) provide long-term protections for riparian buffers through easements; (4) construct livestock exclusions from stream, (5) dedicated stream crossings, and (6) alternate watering sources; and (7) utilize conservation plans.

Planning Level Cost Estimate: (1) $35,000 - $65,000, (2) $2,600 per acre riparian reforestation, (3) $2,500 per acre conserved for acquisition of conservation easements, (4) $3,600 - $6,800, (5) $4,200 - $7,800, (6) $4,900 - $9,100, (7) nominal

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Contact NRCS and SCD to notify them of problem and discuss opportunities for improvement

[2] Live stakes are cuttings from certain tree species (e.g., willow, black alder) that grow when driven into soil near the saturated zone. They provide riparian vegetation and roots growing from the stakes help stabilize banks.

Site No.: DB-1
Site Score: 37.06 – Score reflects localized and minor impacts observed at this site.

Location: Davis Branch below Baldwin Road/MD-75

Site Description: This reach receives drainage from MD-75, I-70 interchange area, New Market Shopping Center, and the Meadows at Woodspring development. Streambanks are moderately eroded along this reach (approximately 750 linear feet), receiving runoff directly from concrete swales along MD-75. Portions of this channel may have been straightened and widened. Nearby upstream development may provide the County with an opportunity to work with property owners to improve site conditions.

Photographs:

Restoration Approach: (1) To prevent further degradation of the stream at this location, the existing forested riparian buffer should be supplemented by planting native species of shade tolerant grasses and shrubs along selected portions of the stream. (2) If not already protected, the buffer should be protected through easements or other long-term conservation measures. In addition, future development designs and construction activities should prevent concentrated flows from entering or passing through the buffer. (3) Bioengineering approaches should be used to stabilize localized bank erosion. Future upstream development should also be examined, with a goal of maintaining or restoring a pre-development storm hydrograph. (4) Future development in this area may also necessitate restoration of the stream's cross-sectional and plan-view profiles to provide adequate stability of the stream channel.

Planning Level Cost Estimate: (1) $2,600 per acre riparian reforestation, (2) $2,500 per acre conserved for acquisition of conservation easements, (3) $26,000 - $49,000, (4) $114,000 - $213,000

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Review catchment calculations for culverts beneath MD75
3. Review preliminary site plans, if any, for adjacent and upstream development
4. Factor developer plans and participation into next steps

Site No.: MT2-1

Site Score: 34.95 – Score reflects localized, but moderate Severity of Stream Impacts, and high threats to Property/Infrastructure.

Location: Unnamed tributary to Monocacy River, along Urbana Pike

Site Description: At an undeveloped lot along the northeast side of Urbana Pike, construction debris (i.e., concrete, asphalt, wood) had been dumped over a silt fence into the stream channel. In addition, an accumulation of sediment and construction debris approximately 30-feet long and 10-feet wide partially blocks the culvert beneath the gated access road to this lot. The channel below the culvert is incised approximately 8 feet, while above the culvert, it does not appear to be incised. Approximately 700 linear feet of stream channel are affected at this location.

Photographs:

Restoration Approach: (1) Clean up trash in this area, leaving some natural woody debris as habitat for stream organisms. (2) To allow for adequate transport of both water and sediment through the stream channel at this location, the culvert pipe should be replaced with a pipe sized to convey bankfull flows and set to match a stable channel slope and elevation. Secondary pipes, set at a bankfull elevation adjacent to the primary pipe would provide additional capacity to convey water in the floodplain. (3) Following replacement of the culvert, stable channel dimensions, patterns, and profiles should be reestablished through this section. If differences in bed elevation and slope remain after the culvert is replaced, it may be necessary to stabilize the channel by creating a step pool type channel morphology (using large rock to line the bottom of the step pools to diffuse energy). Grade control structures should also be considered to prevent channel incision from working headward. The banks should be stabilized with native vegetation, and, if necessary, geotextile material.

Planning Level Cost Estimate: (1) nominal, (2) $5,200 - $9,800, (2) $107,000 - $199,000

Key Issues for Implementation:

1. Contact property owner(s) to discuss the project and encourage support/permission
2. Notify appropriate County and other resource agencies to work with landowner to clean up trash
3. Contact County Department of Highways and Transportation or SHA to notify them of culvert problems at this location and discuss opportunities for improvement

Site No.: PPT1A-1
Site Score: 33.18 – Score reflects minor impacts observed over a relatively short stream reach.

Location: Northern branch of unnamed tributary to Peter Pan Run, below SWM Pond "PC" in Urbana Highlands

Site Description: Erosion of the approximately 6-8 foot high, near-vertical banks appears to predate the ongoing construction in Urbana Highlands. At some point, the stream had been routed into a pond constructed next to the original stream channel, however, the pond has been breached and the current stream channel passes through the bottom of the pond. Future development activities near this site may provide the County with an opportunity to work with developers to improve site conditions.

Photographs:

Restoration Approach: (1) The width, density, and species diversity of the existing riparian buffer should be enhanced through the addition of a variety of native woody and herbaceous plants along this section of stream (approximately 750 linear feet). (2) If not already protected, the buffer should be protected through easements or other long-term conservation measures. (3) The inner slopes of the berm at the breached location should be stabilized with geogrid and vegetation to prevent further erosion and subsequent sediment deposition into the stream. (4) The pond may present a future opportunity for an additional stormwater management structure at this location. However, any potential projects here should be coordinated with future development plans for the north side of the stream, especially regarding planned SWM facilities at or near this location.

(5) Channel stability and bank erosion along this stream will be monitored in the County's long-term geomorphic assessment of this stream.

Planning Level Cost Estimate: (1) $2,600 per acre riparian reforestation, (2) $2,500 per acre conserved for acquisition of conservation easements, (3) $1,000 - $2,000, (4) $15,000 - $40,000, (5) on-going study, therefore no additional cost

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Work with developers to address these issues during future site development and construction activities

Site No.: PPT1-1
Site Score: 30.92 – Score reflects minor impacts observed over a relatively short stream reach.

Location: Mainstem of unnamed tributary to Peter Pan Run

Site Description: With near-vertical banks 2-4-feet high, and a width of approximately 15 feet, this channel had actively eroding banks and appeared to be overwidened. Bank material was heard falling from the banks into the stream, banks were moderately undercut, and moderate bar formation was observed along approximately 500 linear feet of stream. On-going development of this site may provide the County with an opportunity to work with developers to improve site conditions.

Photographs:

Restoration Approach: (1) To prevent further degradation of the stream at this location, the existing forested riparian buffer should be supplemented by planting native species of shade tolerant grasses and shrubs along selected portions of the stream. (2) If not already protected, the buffer should be protected through easements or other long-term conservation measures. In addition, future development designs and construction activities should prevent concentrated flows from entering or passing through the buffer. Future upstream development should also be examined, with a goal of maintaining or restoring a pre-development storm hydrograph. (3) Future development in this area may also necessitate restoration of the stream's cross-sectional and plan-view profiles to provide adequate stability of the stream channel.

(4) Channel stability and bank erosion along this stream will be monitored in the County's long-term geomorphic assessment of this stream.

Planning Level Cost Estimate: (1) $2,600 per acre riparian reforestation, (2) $2,500 per acre conserved for acquisition of conservation easements, (3) $76,000 - $142,000, (4) on-going study, therefore no additional cost

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Work with developer to address these issues during future site development and construction activities

Site No.: T7-1

Site Score: 28.02 – Score reflects minor impacts due to blocked fish passage and minor threats to Property/Infrastructure.

Location: Unnamed tributary to Bush Creek at culvert beneath railroad tracks east of Mussetter Road

Site Description: The culvert beneath the railroad tracks has created a scour pool and a 6-inch vertical drop at its downstream end. The scour pool is approximately 20 feet wide, 25 feet long, and three feet deep. The hanging culvert creates a blockage for fish and other aquatic organisms, and effectively denies access to the entire tributary and its habitat.

Photographs:

Restoration Approach: (1) To allow for adequate transport of both water and sediment through the stream channel at this location, the culvert pipe should be replaced with a pipe sized to convey bankfull flows and set to match the current channel slope and elevation. Secondary pipes, set at a bankfull elevation adjacent to the primary pipe would provide additional capacity to convey water in the floodplain. (2) Following replacement of the culvert, the scour pool should be filled to reestablish stable channel dimensions and profile through this section. (3) The banks should be stabilized with native vegetation, and geogrid if necessary.

Planning Level Cost Estimate: (1) $10,500 - $19,500, (2) $3,800 - $7,100, (3) $1,400 - $2,600

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Contact railroad to notify them of problem and discuss opportunities for improvement

Site No.: WR-2

Site Score: 26.46 – One of the six most significantly impacted stream reaches observed in the study, the high Severity of Stream Impacts, widespread Extent of Problem, high Acceptability, and damage to Property/Infrastructure are largely off-set by high relative costs and complexity of restoration success.

Location: Wood Run from confluence of two branches down below confluence with School Run

Site Description: The mainstem of Wood Run in this reach is experiencing on-going planform, slope, and cross-sectional channel adjustments in response to upstream disturbance (i.e., uncontrolled stormwater runoff from I-70 and MD-144). The upper portions of this stream (approximately 1,500 feet) have formed a gully with steep, near-vertical banks. The gully, which starts at sites WR-1 and WR-3, gets progressively deeper and wider, reaching about 20 feet wide and 10 feet deep before the valley widens out. Once the valley widens out, the stream has downcut through its floodplain, becoming incised and forming terraces. Severe bank erosion, undercut trees, and slumping banks were noted throughout the segment, as were accelerated lateral channel migration and head-cutting processes. Two large knickpoints, with approximately 10-foot drops, were noted immediately above the confluence of Wood Run and School Run. Several side tributaries were also headcutting to adjust their grade with Wood Run.

Photographs:

Site No.: WR-2 (continued)

Restoration Approach: Restoration of the upper branches of this tributary and associated SWM measures (i.e., WR-1 and WR-3) are integral to the successful restoration of this portion of the tributary because excess sediment and runoff from above this site are driving these channel adjustments. To prevent further degradation of this stream, opportunities to control stormwater flows stemming from WR-1 and WR-3 should be examined and implemented, with a goal of maintaining or restoring a pre-development storm hydrograph. To repair the existing stream degradation problems, restoration efforts in the destabilized channel should include recreation of the entire stream channel (approximately 4,000 feet) using nearby reference reaches as a template for designing stable channel dimensions, patterns, and profiles, and stabilizing the banks with native vegetation. Vertical drops in the stream channel formed by headcutting processes can be stabilized by creating a step pool type channel morphology (using large rock to line the bottom of the step pools to diffuse energy); grade control structures should also be installed to prevent further incision of the channel.

Planning Level Cost Estimate: $611,000 - $1,134,000

Key Issues for Implementation:
1. Contact property owner(s) to discuss the project and encourage support/permission
2. Refine approach in conjunction with plans for upstream sites WR-1, WR-3, and SR-1, which should be restored prior to WR-2

4.3 CANDIDATE SITES: SWM MAINTENANCE

Site No.: T6-1

Site Score: 47.91 – Score reflects significant impacts to Property/Infrastructure that could be fixed at minimal cost.

Location: SWM Structure No. 465 at Muirfield Drive

Site Description: Grassy swale entering the dry pond has eroded headward approximately 100 feet. This erosion also poses a minor safety hazard for children playing in the adjacent open space area.

Photographs:

Restoration Approach: Fill and regrade the inlet to provide a stable slope, and then use geotextile materials and vegetation to protect the swale and inlet from further erosion.

Planning Level Cost Estimate: $3,500 - $6,500

Key Issues for Implementation:
1. DPW inspection of SWM facility
2. Contact owner to notify them of problem and encourage them to improve site conditions

5.0 SUMMARY AND RECOMMENDATIONS

As described earlier, many problems affecting streams and associated water quality in Lower Bush Creek watershed can be linked to historical (and current) agricultural practices; however, more recent stormwater management practices have also had a dramatic effect. Taken individually, many of the recent watershed problems might have little detrimental effect;. However, the cumulative effect throughout the watershed has resulted in moderate impacts, that if left unattended, will continue to get worse, leading to further impacts to watershed hydrology, stream stability, water quality, infrastructure, and private property. General problem types evident in the area's streams include alteration of natural flow regimes, erosion and channel destabilization, sediment deposition, nonpoint source pollution, and physical habitat degradation. In many cases, problems are most severe where the unrestricted discharge of large volumes of stormwater collected over large areas, particularly road surfaces, has destabilized the receiving stream channel.

This study identified a number of site-specific opportunities available to the County to protect and improve Lower Bush Creek's valuable water resources (Table 5-1). While the 24 candidate sites have been ranked within three categories based on a range of relevant factors, we consider this a preliminary prioritization. We expect that the County will further refine these priorities and select from among these candidates based on additional factors, including landowner permission, or the likelihood that the County can acquire an easement or outright purchase the land, and in consideration with other County initiatives, projects, and needs. As such, it is recommended that the County select a subset of high priority sites to pursue further through subsequent feasibility assessment(s) that would collect additional site-specific information, evaluate landowner cooperation, identify additional project constraints, further refine project approach and design, and determine if additional action is warranted for each high priority candidate site.

While a number of candidate sites identified in this assessment represent opportunities for urban SWM improvement, many of the opportunities for improvement are not clearly linked to urban development (Table 5-1). However, they do represent attractive opportunities to apply agricultural BMPs and riparian buffer restoration/protection projects that can often be done at little to no cost to the County through state or federal (e.g., NRCS) partnerships and programs. Costs for more extensive stream restoration (e.g., channel restructuring), which can be estimated using the guidelines described in Section 4, can often be off-set though cost-share programs (e.g., US Army Corps of Engineers, NRCS), and grants.

Development of new properties and redevelopment of existing areas adjacent to and upstream from these high priority sites provides the County with an opportunity to work with, and encourage, developers to improve stream conditions and provide new or improved SWM protections. The County's role in this relationship can also be used to encourage innovative development plans that might not otherwise be considered. For example, the County should encourage developers to utilize Low Impact Development/Innovative Site Designs.

Table 5-1. Summary of Candidate Sites, Recommended Actions, and Cost Estimates

Site No.	Total Score (max. 100)	Recommended Action	Planning Level Cost Estimate (± 30 percent)
Stream Restoration and Stormwater Retrofit			
WR-1	45.08	(1) new SWM facility to control road runoff, and (2) restore 50 feet of stream below culvert	(1) $44,000 - $82,000, (2) $7,500 - $15,000
WR-3	41.60	(1) new SWM facility to control road runoff, (2) restore 200 feet of stream below culvert, and (3) retrofit infiltration pond to rain garden at Post Office	(1) $47,000 - $89,000, (2) $30,000 - $57,000, (3) $10,000 - $20,000
EB-1	35.12	(1) control runoff from MD75, (2) restore 500 feet of stream, and (3) fix concrete swale	(1) $11,000 - $20,000, (2) $76,000 - $142,000, (3) $25,000 - $45,000
T1-2	33.30	(1) enhance riparian buffer, (2) conservation easements, (3) repair pond outfall, (4) stabilize 200 feet of stream bank, and (5) retrofit pond for additional SWM controls	(1) $2,600 per acre, (2) $2,500 per acre, (3) $7,600 - $15,000, (4) $7,000 - $13,000, (5) $15,000 - $40,000
SR-1	29.26	(1) new wet pond to control road runoff, (2) new infiltration gallery to control road runoff, (3) restore 2,500 feet of stream, (4) create riparian buffer, and (5) conservation easements	(1) $42,000 - $78,000, (2) $105,000 - $195,000, (3) $380,000 - $710,000, (4) $2,600 per acre, (5) $2,500 per acre
T10-2	25.04	(1) new wet pond(s) to control highway runoff, (2) replace road culvert, (3) restore 250 feet of stream between MD-144 and I-70, and (4) restore 4,000 feet of stream below I-70	(1) $ 109,000 - $203,000, (2) $14,000 - $26,000, (3) $39,000 - $72,000, (4) $630,000 - $1,200,000
Stream Restoration			
T10-1	55.00	Agricultural BMPs - along 175 feet of stream, (1) riparian buffer enhancement, (2) conservation easements, (3) livestock exclusions, (4) dedicated stream crossings, (5) alternate watering sources, and (6) conservation plans	(1) $2,600 per acre, (2) $2,500 per acre, (3) $600 - $1,200, (4) $4,200 - $7,800, (5) $4,900 - $9,100, (6) nominal
T6-2	50.65	Agricultural BMPs - along 1,300 feet of stream, (1) riparian buffer enhancement, (2) conservation easements, (3) livestock exclusions, (4) dedicated stream crossings, (5) alternate watering sources, and (6) conservation plans	(1) $2,600 per acre, (2) $2,500 per acre, (3) $4,700 - $8,800, (4) $4,200 - $7,800, (5) $4,900 - $9,100, (6) nominal
T1-3	46.97	(1) Reestablish stable channel dimensions and profile at pipeline stream crossing and harden with riprap, stabilize stream banks, and (2) repair gully in gas pipeline ROW	(1) $5,300 - $9,900, (2) $3,500 - $6,500
MT1-1	46.95	(1) Investigate possible illicit discharges; Agricultural BMPs - along 3,500 feet of stream, (2) riparian buffer enhancement, (3) conservation easements, (4) livestock exclusions, (5) dedicated stream crossings, (6) alternate watering sources, and (7) conservation plans	(1) nominal, (2) $2,600 per acre, (3) $2,500 per acre, (4) $6,300 - $11,800, (5) $4,200 - $7,800, (6) $4,900 - $9,100, (7) nominal
MT1-2	46.61	(1) Replace road culvert to allow adequate water and sediment transport, and fix fish passage; (2) fill scour pool, and (3) stabilize banks	(1) $10,500 - $19,500, (2) $3,000 - $5,700, (3) $2,800 - $5,200
MT2-2	44.63	Agricultural BMPs - riparian buffer enhancement along 350 feet of stream	$2,600 per acre riparian reforestation

Table 5-1. (Continued)

Site No.	Total Score (max. 100)	Recommended Action	Planning Level Cost Estimate (± 30 percent)
PPT1A-2	43.51	(1) Riparian buffer enhancement along 100 feet of channel, (2) conservation easements to protect buffer, (3) monitor stability via existing geomorphic assessment of this stream. Future upstream development plans should also be considered	(1) $2,600 per acre, (2) $2,500 per acre, (3) on-going study, therefore no additional cost
BC-1	40.74	(1) Realign 1,750 feet of stream channel to provide grade controls and bank stabilization, (2) plant riparian buffer, (3) livestock exclusions, (4) dedicated stream crossings, (5) alternate watering sources, (6) conservation plans, and (7) conservation easements	(1) $267,000 - $496,000, (2) $2,600 per acre, (3) $6,300 - $12,000, (4) $4,200 - $7,800, (5) $4,900 - $9,100, (6) nominal, (7) $2,500 per acre
T1-1	40.28	Remove trash and trees in stream from permitted logging operation	Nominal cost
PP-1	38.57	(1) Continue to monitor channel stability through long-term monitoring at Peter Pan Run stations, and (2) future development may necessitate restoration of 1,750 feet of stream	(1) on-going studies, therefore no additional cost, (2) $267,000 - $496,000
T14-1	37.73	Agricultural BMPs – (1) bioengineering to stabilize localized bank erosion along 1,000 feet of channel, (2) riparian buffer enhancement, (3) conservation easements, (4) livestock exclusions, (5) dedicated stream crossings, (6) alternate watering sources, and (7) conservation plans	(1) $35,000 - $65,000, (2) $2,600 per acre, (3) $2,500 per acre, (4) $3,600 - $6,800, (5) $4,200 - $7,800, (6) $4,900 - $9,100, (7) nominal
DB-1	37.06	(1) Riparian buffer enhancement along 750 feet of channel, (2) conservation easements, (3) bioengineering to stabilize localized bank erosion, and possibly in future, (4) stream restoration. Future upstream development plans should also be considered	(1) $2,600 per acre, (2) $2,500 per acre, (3) $26,000 - $49,000, (4) $114,000 - $213,000
MT2-1	34.95	(1) Remove trash, (2) replace culvert pipe, and (3) stabilize bed elevations, slope, banks, and vegetation to prevent further channel incision along 700 feet of stream	(1) nominal, (2) $5,200 - $9,800, (2) $107,000 - $199,000
PPT1A-1	33.18	(1) Riparian buffer enhancement along 750 feet of channel, (2) conservation easements, (3) stabilize berm breach with vegetated geogrid, (4) future SWM retrofit opportunity for old farm pond with future development plans, and (5) monitor under current geomorphic stream assessment program	(1) $2,600 per acre, (2) $2,500 per acre, (3) $1,000 - $2,000, (4) $15,000 - $40,000, (5) on-going study, therefore no additional cost
PPT1-1	30.92	(1) Riparian buffer enhancement along 500 feet of channel, (2) conservation easements, (3) future development may necessitate stream restoration, and (4) monitor stability via current geomorphic stream assessment program. Future upstream development plans should also be considered	(1) $2,600 per acre, (2) $2,500 per acre, (3) $76,000 - $142,000, (4) on-going study, therefore no additional cost
T7-1	28.02	(1) Replace railroad culvert to allow adequate water and sediment transport, and fix fish passage; (2) fill scour pool, and (3) stabilize banks and vegetation	(1) $10,500 - $19,500, (2) $3,800 - $7,100, (3) $1,400 - $2,600
WR-2	26.46	Following improvements to WR-1, WR-3, and SR-1, reprofile 4,000 feet of stream, fix headcuts, add grade controls, and use bioengineering approaches to stabilize banks	$611,000 - $1,134,000
SWM Facility Maintenance			
T6-1	47.91	Maintain SWM facility by regrading inlet and protecting with geotextile materials and vegetation	$3,500 - $6,500

Low impact development (LID) approaches, such as those developed by Prince George's County, Maryland (1999), offer innovative solutions that can prevent or reduce stormwater-related and other adverse environmental impacts resulting from development. The principal goal of low impact development is to protect stream integrity by maintaining the watershed's hydrologic regime. The challenge is to make a developed area function hydrologically like a natural system both at the lot level and development-wide scales. The idea is to maintain watershed integrity by maintaining (or restoring) natural, pre-development hydrology on each development site, so that the overall landscape functions more effectively to mimic natural flows. Practices are targeted to reducing stormwater runoff at the source, not merely in managing flows as they leave a site, thus having a significant positive effect on stream stability, habitat structure, base flows, and water quality.

Examples of LID practices include:

- *Conserve naturally vegetated areas*. Not only is it critical to maintain an adequate riparian buffer (e.g., with a dense and diverse mix of native herbaceous and woody vegetation, wider is better), but also to preserve as much overall watershed forest/ vegetation cover as possible, to provide for rainfall interception, water uptake by plants, and reduce runoff.

- *Minimize development impacts*. Configure development layouts to reduce impervious surfaces, cluster buildings and reduce building footprints, reduce road and driveway widths, utilize porous pavement for overflow parking, preserve sensitive soils and those with higher infiltration rates, and seek alternatives to the direct transport of stormwater through storm pipes, curbs, and gutters. During construction, minimize disturbance and grading, both in time and area, to limit bare soil exposure and minimize impacts to existing vegetation.

- *Maintain site runoff rate*. Where practical, use open drainage (e.g., grassy swales instead of enclosed pipes), maintain natural flow paths, disperse rather than concentrate drainage, lengthen flow paths, and maximize sheet flow. Directing flow to properly designed vegetated or bioretention areas will allow increased infiltration.

- *Use integrated management practices (IMPs), where applicable*. In some cases, small-scale SWM controls distributed throughout site can prove more effective than larger ponds. Controls should be designed to maintain flow patterns, filter pollutants, and re-create or maintain natural hydrology. Employ practices such as disconnectivity (e.g., diverting roof or parking lot drains to rain barrels or vegetated areas), bioretention, open swales, permeable/porous pavement, sand filters, and inlet retrofits.

- *Implement pollution prevention, proper maintenance, and public education programs*. Particularly with an influx of many new residents, individual actions that reduce runoff (e.g., rain gardens, rain barrels) and improve water quality (e.g., proper use of fertilizers and pesticides) can together have a substantial impact. Public

education programs can help instruct property owners on appropriate maintenance practices that will promote the long-term function of each IMP. In addition, the County should ensure that it has adequate enforcement measures (e.g., easements, maintenance agreements) in place to address IMP maintenance problems as they arise.

Innovative site designs can also employ one or more strategies, such as (1) open space or cluster housing, (2) green parking lots, (3) narrower streets near headwater streams, and (4) directing rooftop runoff onto pervious surfaces. Open space or cluster development can reduce the amount of impervious surface by 10 to 50 percent, and often reduces development costs (CWP 1998). Green parking lots and "headwater" streets may involve revising current codes on the number and size of impervious surfaces needed to meet transportation needs, as well as modifying designs to route runoff to pervious surfaces. Permeable materials, such as geosynthetics, may also be used for infrequently used parking and driving surfaces. Routing rooftop runoff to grassy areas or stormwater control features can reduce annual runoff volumes in medium- to low-density residential land uses by 50 percent (Pitt 1987).

We recommend that Frederick County use this list of candidate sites as a guide for selecting and implementing stream and stormwater management improvements. Because the County's priorities may change and other opportunities arise over time, the County should be free to respond accordingly in order to encourage, collaborate, or require improvements at any of the candidate sites, and not just those currently identified as high priority sites.

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Appendix A

Stream Reconnaissance Datasheet

Frederick County: Lower Bush Creek
Stream Reconnaissance

Site ID: _____ Team: _____
Reach Length (m): _____ Date: _____
Description of Problem: _____ Type of Problem: _____
_____ Instream = IS
_____ Bank Stability = BS
Latitude: N _____ Riparian = RP
Longitude: W _____ Other = O Other Type: _____

	None	Minor	Moderate	Severe	Type
Hydrologic Modifications					
Impairment from blockages	0	1	2	3	
Impairment from stormwater runoff	0	1	2	3	
Impairment from channel alterations	0	1	2	3	
Channel Condition	None	Minor	Moderate	Severe	Type
Excessive sediment deposition	0	1	2	3	
Excessive bar formation	0	1	2	3	
Unstable substrate	0	1	2	3	
Bank erosion/undercuts/slumping	0	1	2	3	LB - RB - BB
High Width/Depth ratio	0	1	2	3	
Channel incision	0	1	2	3	
Channel headcutting	0	1	2	3	
Debris jams/blockages	0	1	2	3	
Accelerated lateral channel migration	0	1	2	3	
Channel type (planform)		*straight*	*meandering*	*braided*	
Channel slope		*low*	*moderate*	*high*	
Side slopes		*low*	*moderate*	*high*	
Instream habitat	None	Minor	Moderate	Severe	Type
Heavily silted substrate	0	1	2	3	
Poor instream fish cover	0	1	2	3	
Poor epifaunal substrate	0	1	2	3	
Lack of woody debris	0	1	2	3	
Poor vegetative bank protection	0	1	2	3	
Poor stream shading	0	1	2	3	
Riparian habitat	None	Minor	Moderate	Severe	Type
Narrow buffer width	0	1	2	3	
Breaks in buffer (crops/lawn/pipes/ditches)	0	1	2	3	
Poor buffer density/diversity	0	1	2	3	
Existing wetlands adjacent to area	0	minor (1)	moderate (2)	extensive (3)	
Water quality	None	Minor	Moderate	Severe	Type
Excessive algae	0	1	2	3	
Organic scum	0	1	2	3	
High turbidity	0	1	2	3	
Obvious spills, discharges, plumes, odors	0	1	2	3	
Trash problems	0	1	2	3	

REACH ID: _____ **DATE:** _____

Restoration goals	None	Minor	Moderate	Severe	Type
Threat(s) to public safety	0	1	2	3	
Infrastructure threatened	0	1	2	3	
Infrastructure damaged	0	1	2	3	
Adjacent properties severely impacted	0	1	2	3	

Constraints/acceptability			
Land ownership	improved (1)	vacant (2)	public (3)
Utility relocation required	yes (1)		no (3)
Sufficient adjacent land for restoration	no (1)		yes (3)
Suitable access for construction/maintenance	no (1)		yes (3)
Proximity to houses and roads	near (1)	intermediate (2)	far (3)
Opportunity for environmental education	minor (1)	moderate (2)	major (3)

Restoration opportunity	None	Poor	Fair	Good
Bank stabilization	0	1	2	3
Adjust width/depth ratio	0	1	2	3
Grade protection	0	1	2	3
Channel realignment	0	1	2	3
Fish passage	0	1	2	3
Instream habitat	0	1	2	3
Riparian buffer	0	1	2	3
Wetland protection/creation	0	1	2	3
SWM facility - new	0	1	2	3
SWM facility - retrofit	0	1	2	3

Restoration comments: _____

Site sketch:

Description of photos: _____

Key:
gravel – ○
tree – ⊗
riprap – x

Datasheet Codes

Impairment From Blockage
D=Dam
RC = Road Crossing
PC = Pipe Crossing
BD = Beaver Dam
NF = Natural Falls/Rapids
KP = Knickpoint
O = Other

Impairment From Channel Alterations
D = Dredged
H = Hardened
S = Straightened
F = Flashy Flows

Widespread Bank Instability/Erosion
LB = Left Bank
RB = Right Bank
BB = Both Banks

Riparian Land Cover
FR = Forest
OF = Old Field
EM = Emergent Vegetation
LN = Mowed Lawn
TG = Tall Grass
LO = Logged Area
SL = Bare Soil
RR = Railroad
PV = Paved Road
PK = Parking Lot/Industrial/Commercial
GR = Gravel Road
DI = Dirt Road
PA = Pasture
OR = Orchard
CP = Cropland
HO = Housing

Utility Type
SW = Sewer/Water
ETP = Electric/TV/Phone

Bank Stabilization
BE = Bioengineering
TE = Traditional Engineering

Appendix B

Annotated Field Maps

Appendix C

Completed Field Data Sheets

Appendix D

Aerial Photographs of Candidate Site Locations

(Digital Orthophotography obtained by Frederick County, March 2000)

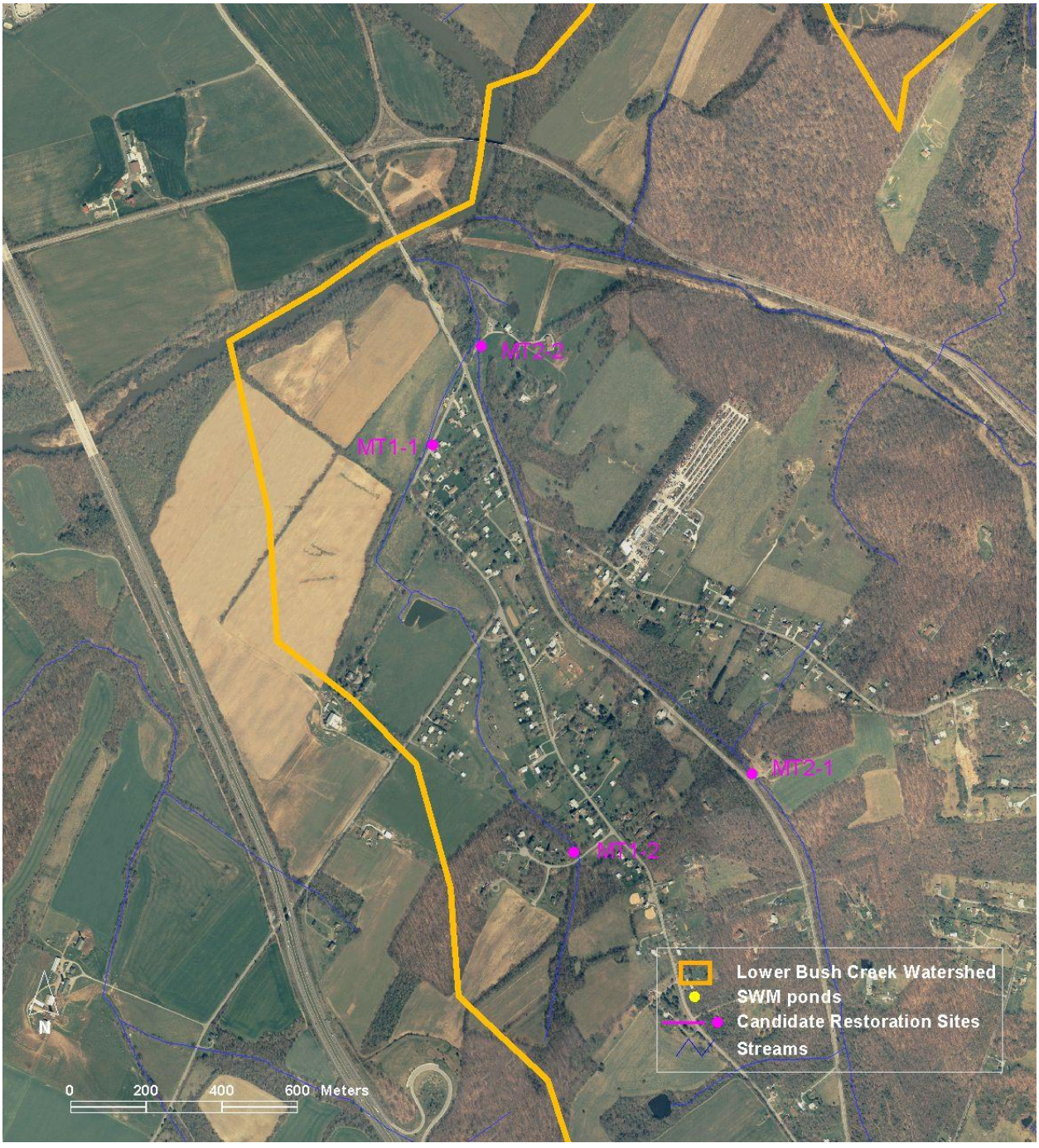

Figure D-1. Candidate sites in the western portion of Lower Bush Creek Watershed

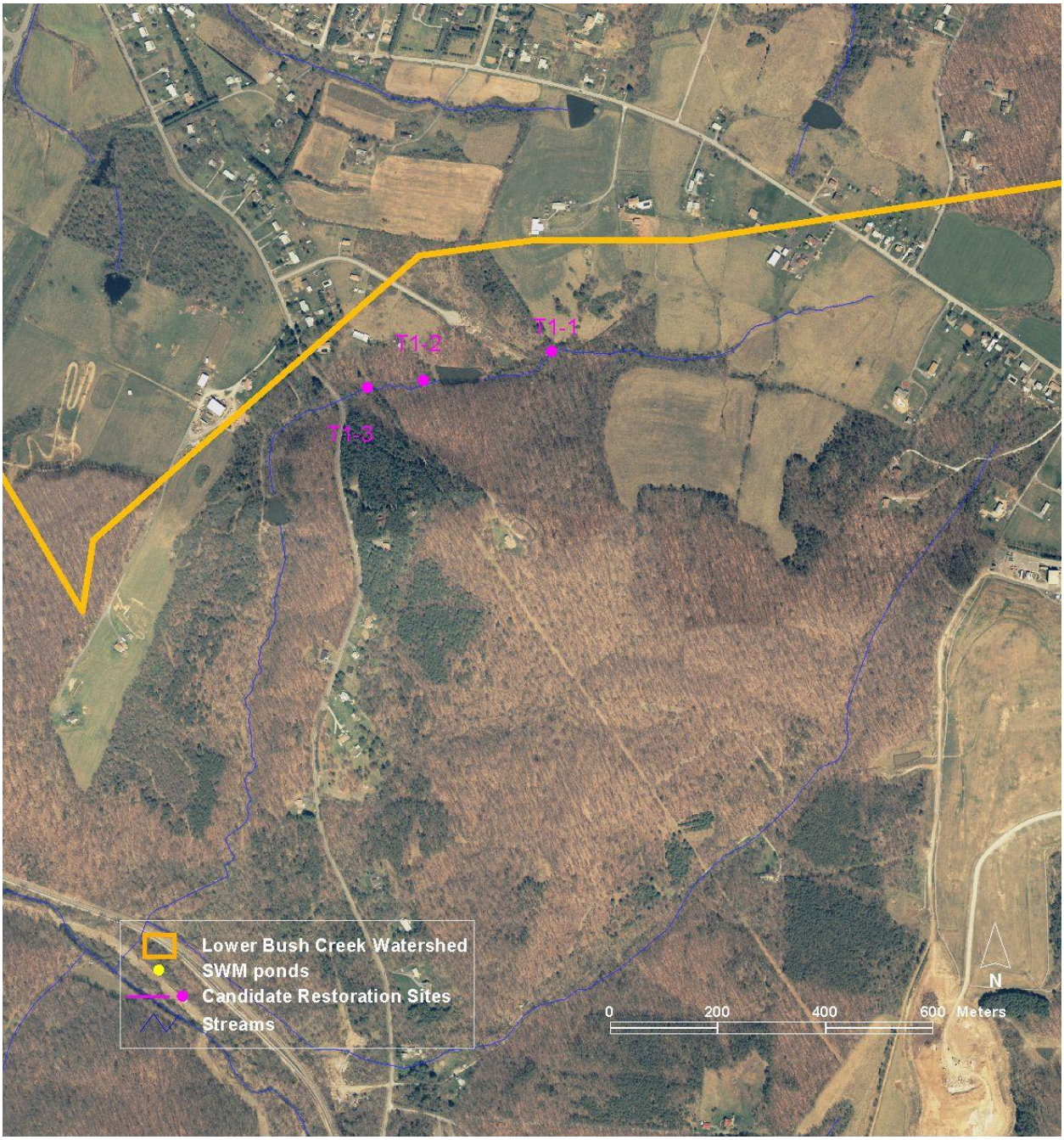

Figure D-2. Candidate sites in the northwestern portion of Lower Bush Creek Watershed

Figure D-3. Candidate sites in the north-central portion of Lower Bush Creek Watershed

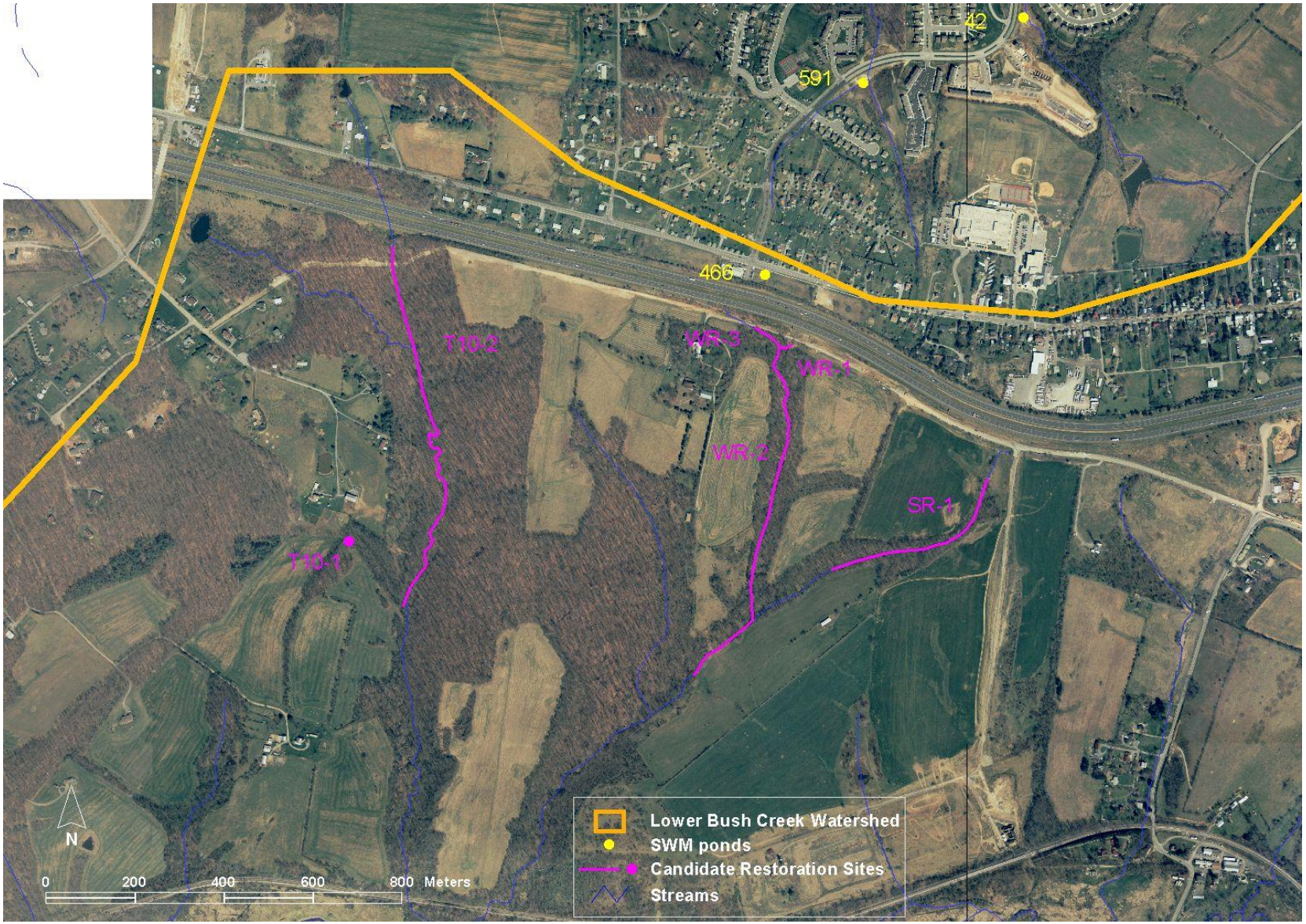

Figure D-4. Candidate sites in the northeastern portion of Lower Bush Creek Watershed

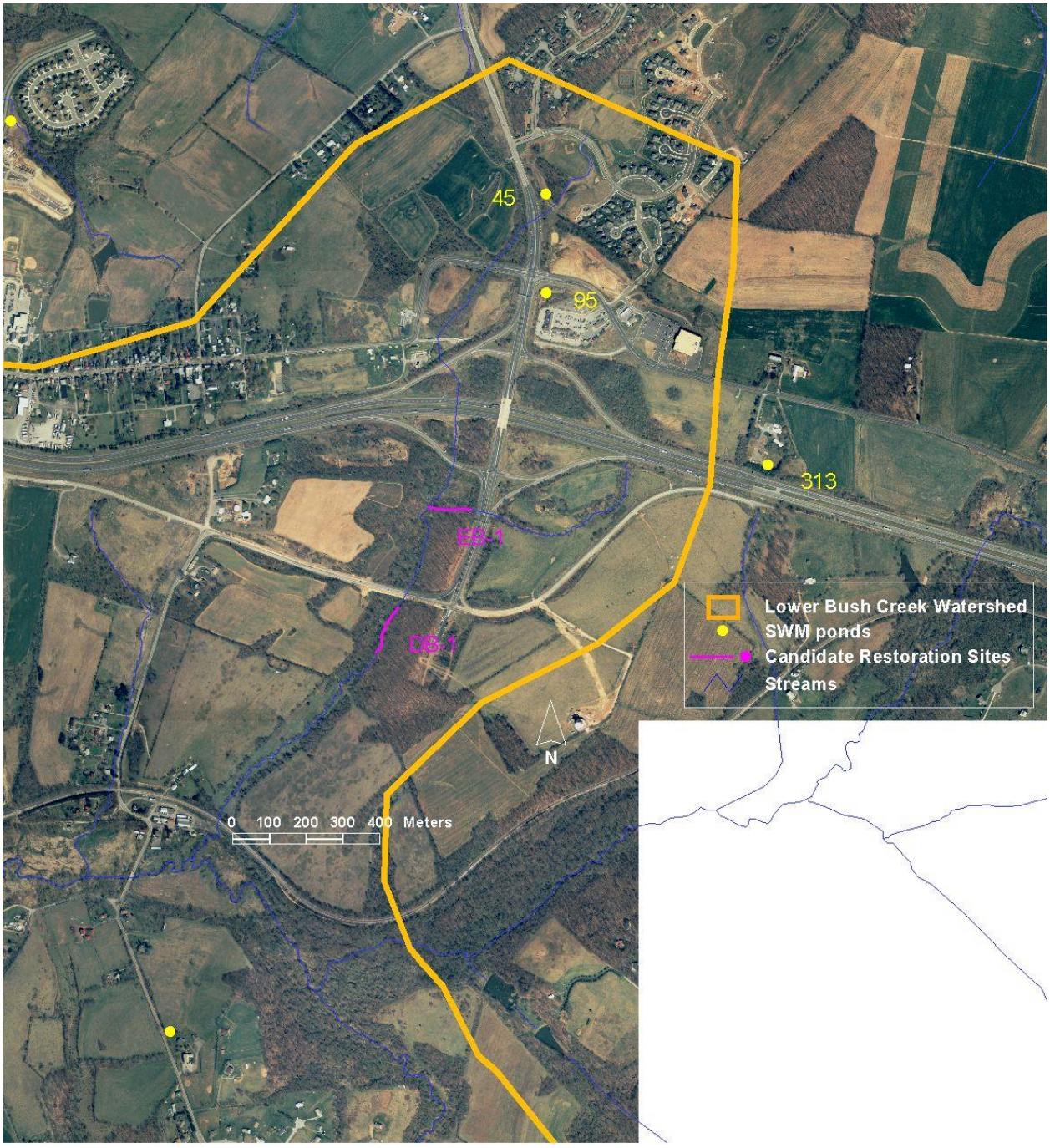

Figure D-5. Candidate sites in the extreme northeastern portion of Lower Bush Creek Watershed

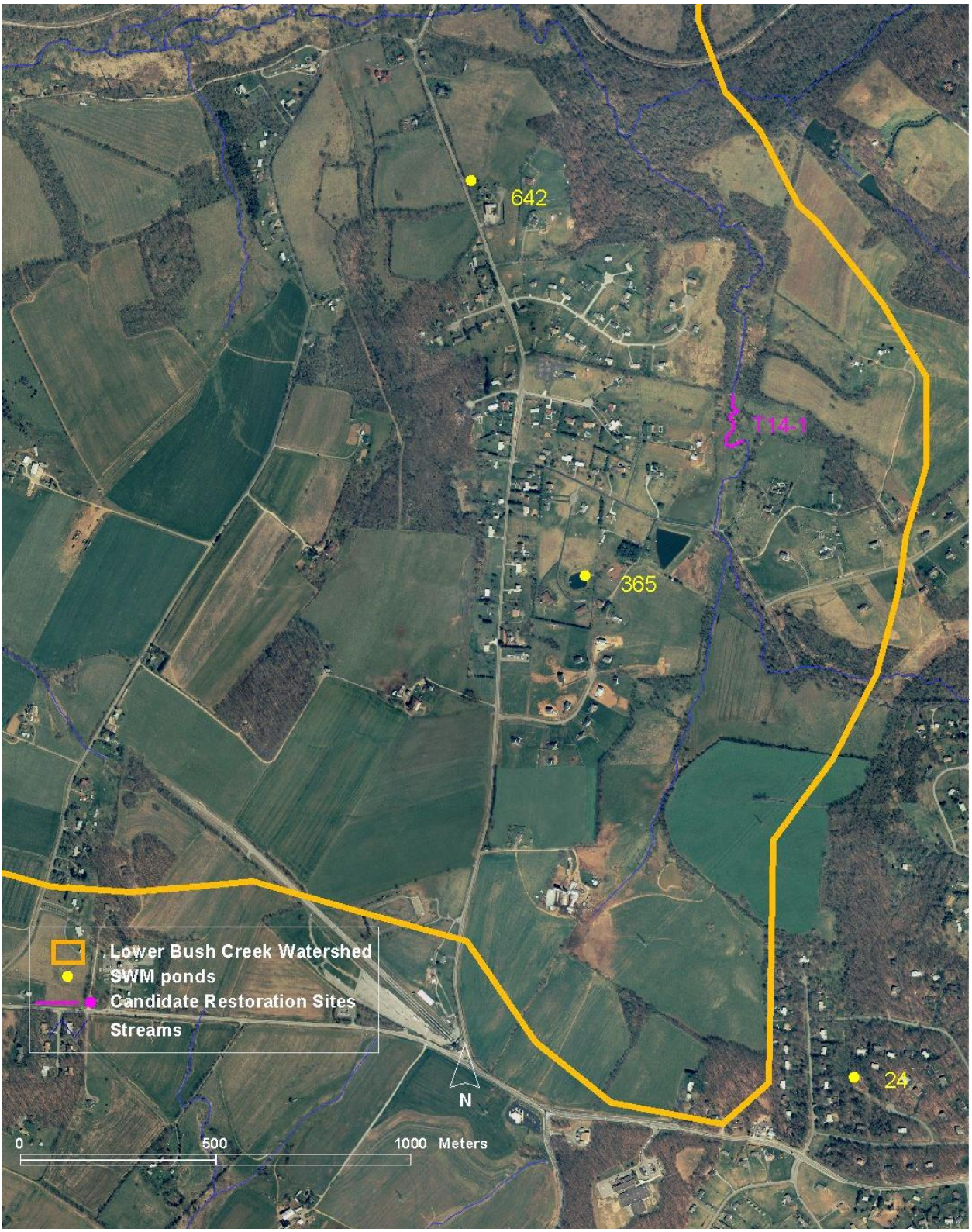

Figure D-6. Candidate sites in the southeastern portion of Lower Bush Creek Watershed

Figure D-7. Candidate sites in the south-central portion of Lower Bush Creek Watershed

Appendix E

Public Meeting Announcement and Presentation Materials

DIVISION OF PUBLIC WORKS
FREDERICK COUNTY, MARYLAND
Department of Program Development and Management
Office of Development Review
118 North Market Street Frederick, Maryland 21701
(301) 696-2952 FAX (301) 694-1808 TDD (301) 694-1672

Serving with Pride County Wide

RELEASE DATE: *For Immediate Release*
DATE ISSUED: *January 13, 2003*

CONTACT: Shannon Moore, Frederick County NPDES Program
(301) 694-1413

PUBLIC MEETING TO IDENTIFY STORMWATER PROBLEMS: Lower Bush Creek Watershed Restoration Team Seeks Input

February 13, 2003 – 6:30 to 8:30 PM – Urbana High School Media Center

Urbana…… Frederick County's Division of Public Works is planning future projects to protect Lower Bush Creek and its tributaries from a variety of stormwater and pollution runoff problems and invites your participation in the study. Planned projects may include fixing damaged streams, improving existing stormwater management facilities, providing new stormwater management controls, and planting trees and shrubs as streamside buffers. To help with the study, the project team is hosting a public workshop so that watershed residents, organizations, and agencies can help identify problems, recommend restoration sites, and discuss potential concerns. The workshop will begin with a brief introduction to the on-going watershed assessment and restoration activities in Lower Bush Creek, and then workshop attendees will break out into smaller groups to discuss and identify opportunities in the following areas:

- improving water quality
- reducing sediment and erosion impacts to streams
- improving existing stormwater management controls
- improving habitat for fish and other wildlife
- restoring degraded streams
- identifying locations for new stormwater management controls

The workshop will be held on Thursday, February 13th from 6:30 to 8:30 PM at the Urbana High School Media Center at 3471 Campus Drive in Ijamsville and is being hosted by County program staff and their consultants, Versar, Inc. All concerned citizens, organizations, agency representatives, and elected officials are invited to attend and offer their suggestions and comments.

This site selection process is part of an extensive, ongoing effort. Site selection was preceded by a baseline watershed assessment report, completed in March 2001, which characterized Lower Bush Creek watershed conditions as being moderately impacted by stormwater runoff from agricultural and urban development, and recommended that a more detailed study be conducted to identify specific opportunities for water quality improvement. Once potential watershed restoration sites have been identified and evaluated, a number of high-priority restoration opportunities will be selected. These high-priority restoration opportunities will be used to target County restoration efforts using Capital Improvement Program and other funding sources.

Additional information on Frederick County's efforts to protect water resources may be found on their new Clean Water web site located at: http://www.co.frederick.md.us/NPDES/. Future meeting announcements and periodic project updates will also be posted at this web site.

Public Workshop to Identify Watershed Restoration Opportunities in Lower Bush Creek

February 13, 2003 – Urbana High School Media Center

1. Introduction
   - Project Team introductions
   - Objectives for the meeting
   - Overview of County NPDES stormwater program permit and activities

2. Presentation
   - Overview of Lower Bush Creek Watershed Assessment Report findings
   - Objectives for Watershed Restoration and Retrofit Study
   - Examples of types of potential projects
   - Process for site selection
   - How the public can help
   - Introduction to the Potential Project Identification Exercise

3. Potential Project Identification Exercise
   - Break out into several groups and gather around duplicate stations to discuss and suggest public ideas
   - Each station will have:
     - A large format map of Lower Bush Creek watershed
     - Project suggestion cards to fill out; Project Team staff will plot location on map with the help of those making suggestions
     - Project Team staff with which to discuss candidate sites, concerns, etc.

We Appreciate Your Participation!

Project Team:

Frederick County, Division of Public Works	***Versar, Inc.***	
Shannon Moore	Morris Perot	Nancy Roth
Betsy Smith	Sanjay Chandra	Jennifer Shore

For periodic project updates and additional information on the County's efforts to preserve and protect clean water, visit the County's new web site:

www.co.frederick.md.us/NPDES/

Or, contact: Shannon Moore, Frederick County NPDES Program Coordinator, at (301)694-1413, or smoore@fredco-md.net.

Project Suggestion Card
Lower Bush Creek - Watershed Restoration Site Selection Project

Suggestion No.: _____

Please provide the following contact information should we have additional questions regarding your suggestion:

Name: _____

Organization: _____

Street: _____

Would you like to be added to the mailing list?
☐ yes
☐ no

City: _____ State: _____ Zip: _____

Phone: _____ Email: _____

Location of Suggested Project (address, street, nearest cross-street, property owner, etc.):

_____

_____

Description of Suggested Project (sketch on back): _____

_____

_____

_____

Project Suggestion Card
Lower Bush Creek - Watershed Restoration Site Selection Project

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Please provide the following contact information should we have additional questions regarding your suggestion:

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☐ yes
☐ no

City: _____ State: _____ Zip: _____

Phone: _____ Email: _____

Location of Suggested Project (address, street, nearest cross-street, property owner, etc.):

_____

_____

Description of Suggested Project (sketch on back): _____

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_____

_____

Insert hardcopy PowerPoint handout – 6 slides per page from:
02-13-03 FredCo R&R workshop - final.ppt