Sam's Branch Tributary Watershed Assessment and Baseline Stream Monitoring

Assessment and Baseline Report

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1.0 INTRODUCTION

Biohabitats is conducting baseline upland assessment and stream monitoring services for the Sam's Branch tributary. The purpose of this study is to assess watershed conditions and monitor stream health with the goal of improving water quality in the Sam's Branch watershed. The study limits extend from the headwaters to the confluence with Otter Creek, a total study length of approximately 5,000 linear feet. Assessment and monitoring activities include a community awareness survey, an upland assessment including the identification of stormwater retrofit opportunities, physical/geomorphic condition survey, riparian condition survey, baseline water quantity and quality levels, and instream biological condition surveys.

This report serves as an interim deliverable outlining our progress to date. Include in this report for each of the categories of assessment and monitoring, is a description of the assessment methodology and baseline condition summary results. Included in the appendices, are all the monitoring data collected to date including Appendix A-Photographs of the project area; Appendix B-Unified Subwatershed and Site Reconnaissance (USSR) data sheets; Appendix C-Community Awareness Survey, Appendix D- Surveyed Cross Sections, Particle Size Measurements and Thalweg Surveys; Appendix E- Benthic Macroinvertebrate and Fish Survey Data Sheets; and Appendix F-Water Quantity and Water Quality data collected from the flow logger, barometric pressure logger, temperature loggers, and tributary baseflow and storm event water quality sample analytical results.

1.1 Project Location and Description

Figure 1-1 Project vicinity map depicts the location of the drainage area of Sam's Branch relative to other Edgewood landmarks. Figure 1-2 Project site map, again shows the drainage area and the Sam's Branch stream channel on aerial photograph – the drainage area boundary delineates the limits of the project area. The study limits extend from the headwaters to the confluence with Otter Creek, a total study length of approximately 5,000 linear feet. The study area along the Sam's Branch stream channel was divided into four discrete study reaches with the primary reach boundaries including culverted road crossings of the Sam's Branch stream channel.

1.2 Project Objectives

Sam's Branch baseline monitoring objectives include the documentation of drainage area conditions through the collection of stream monitoring data and upland field observations throughout the drainage area. Through data analysis and processing of field observations, several retrofit and restoration opportunities have been identified with the intent of improving water quality conditions of Sam's Branch. Following the implementation of select retrofit and restoration opportunities identified through this study, post-implementation conditions will be established and compared to the baseline (pre-implementation) conditions. In summary, this study will assess watershed conditions and monitor stream health with the goal of improving water quality in the Sam's Branch watershed.

Figure 1-1 Project Vicinity Map

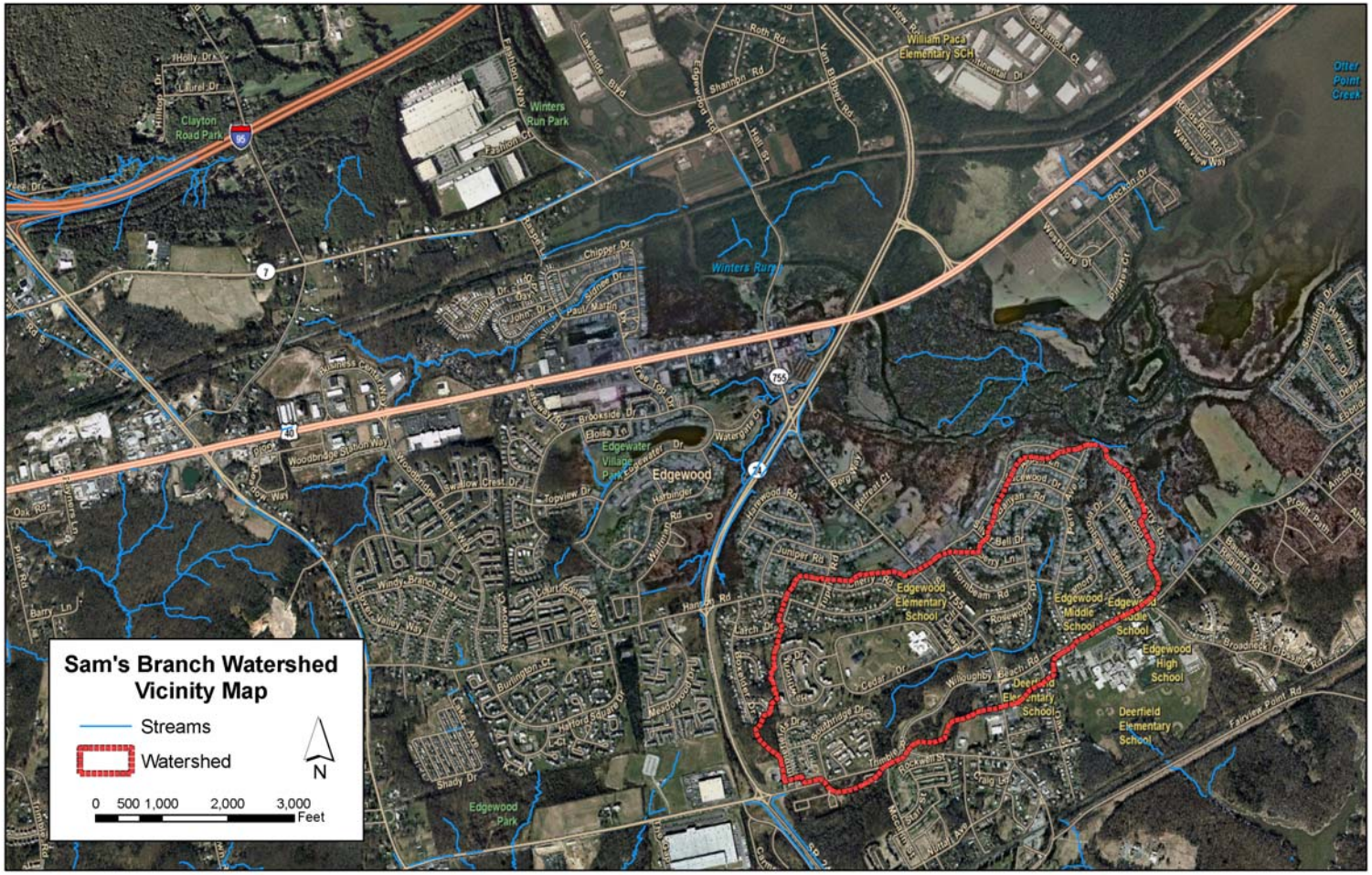
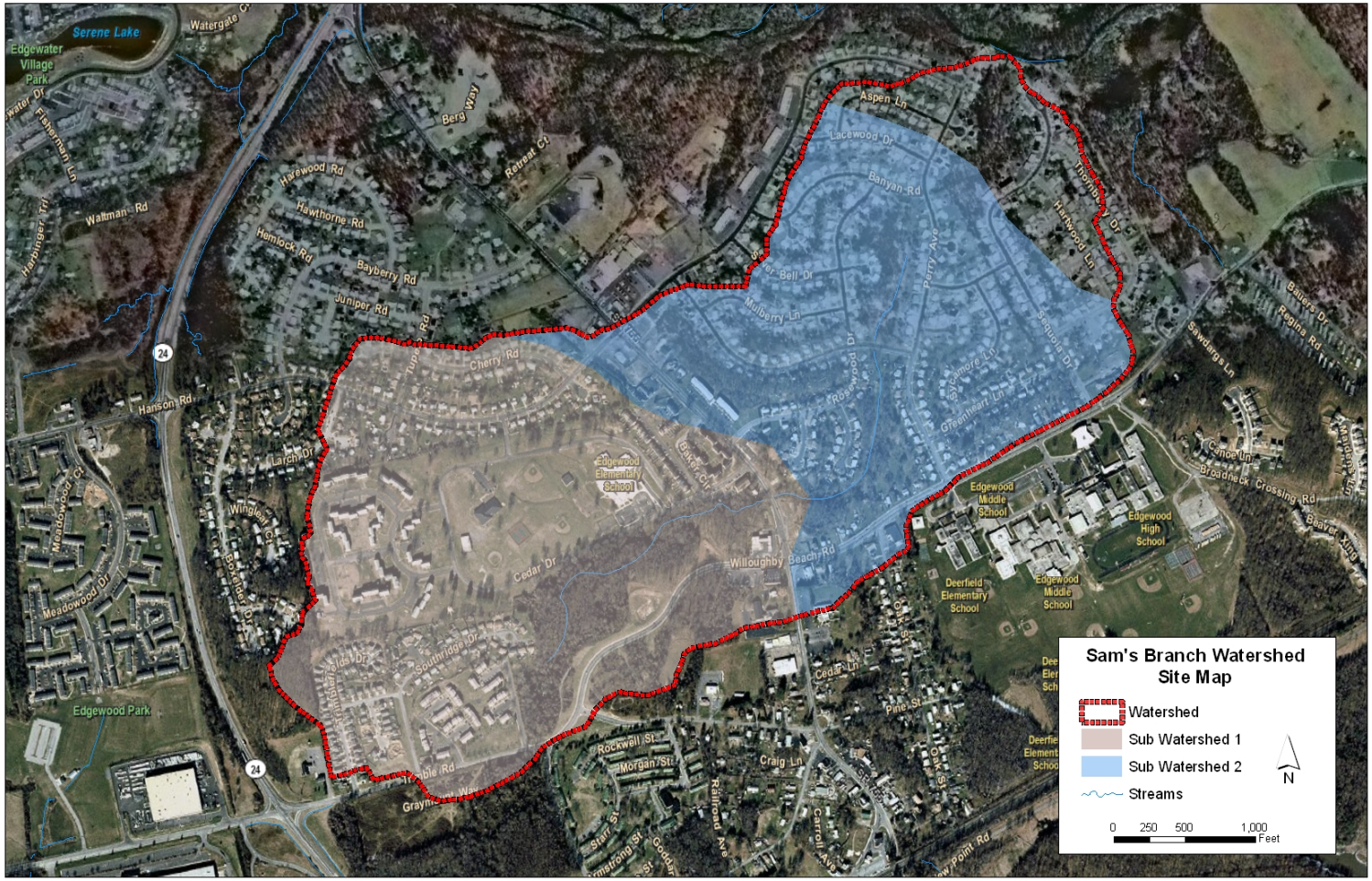


Figure 1-2 Project Site Map



2.0 UPLAND CONDITION AND RETROFIT SURVEY

2.1 Unified Subwatershed and Site Reconnaissance (USSR) and Stormwater Management Retrofit Survey

A suite of upland assessments were carried out over the time period of May of 2008 through April of 2009. These efforts resulted in the identification of simple and cost effective stormwater retrofit opportunities throughout the Sam's Branch drainage area. Some of these observations and recommendations include source reduction such as downspout disconnection (i.e., directing downspouts to pervious areas to promote recharge and runoff volume reduction) and bioretention installation opportunities, and impervious cover reduction (opportunities for alternative paving material, etc.). Other observations will be used toward recommendations of public outreach efforts toward improving community watershed behaviors, and programmatic opportunities for Harford County Government to pursue toward improved water quality.

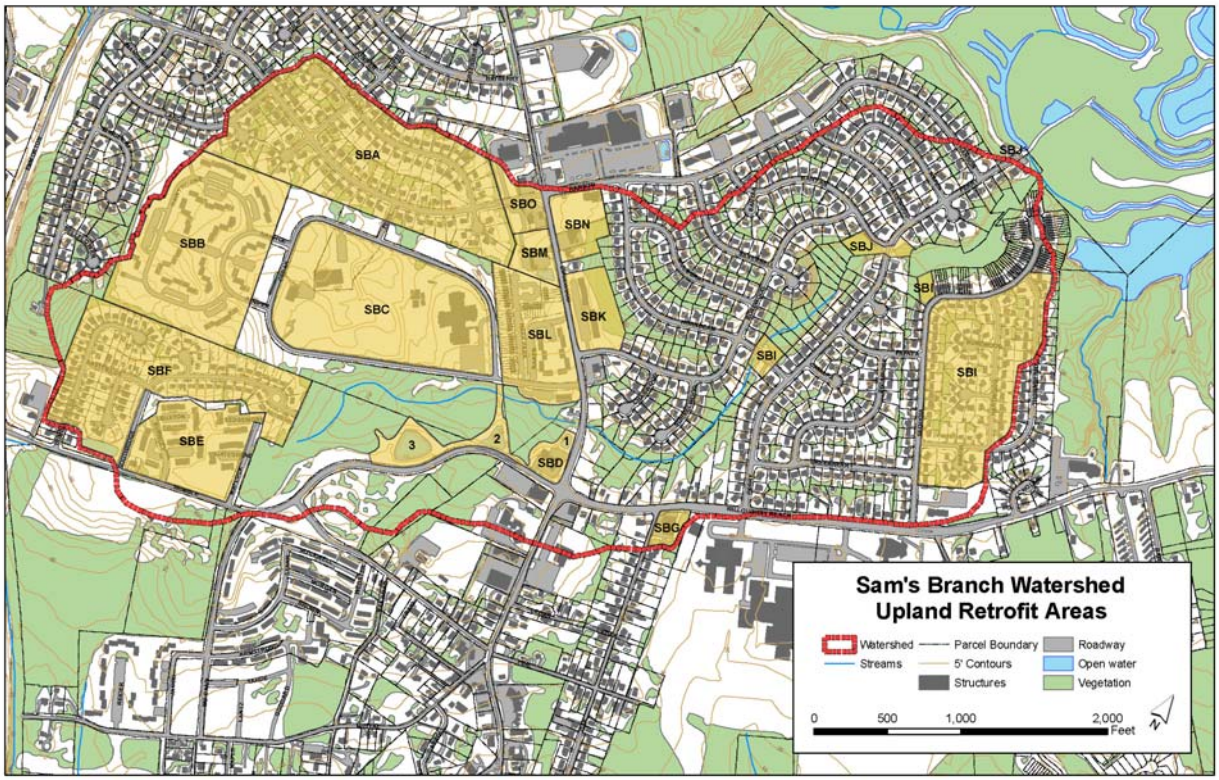


Figure 2-1 Upland Retrofit Study Areas

2.1.1 Methods

A map of the site was generated using GIS digital mapping data. The upland areas of the watershed were grouped by land use and assigned letter codes with Sam's Branch (SB) SBA through SBO as shown in Figure 2-1. Biohabitats conducted a survey of these upland areas over

three field days to determine stormwater retrofit opportunities using Retrofit Reconnaissance Investigation (RRI) data forms from the Unified Subwatershed and Site Reconnaissance (USSR) Manual with accompanying photo documentation. Retrofit recommendations were prioritized by cost, level of benefit, and land ownership. Appendix B contains the USSR data sheets that were completed during this upland assessment survey.

Other upland assessments included inspection of existing stormwater management facilities for conditions leading to poor performance. Conditions such as excessive sedimentation, waterfowl presence, and lack of littoral zone vegetation will be assessed with an eye towards looking at potential stormwater and restoration opportunities such as new facilities, retrofit of existing facilities, reforestation opportunities, and maintenance measures. Additional retrofitting opportunities will be explored such as providing treatment to parking lots in the high density residential areas.

2.1.2 Summary of Baseline Upland Conditions and Retrofit Opportunities

The majority of the watershed area is medium density (single family home) residential neighborhoods with some high density (apartment) neighborhoods. Edgewood Elementary School occupies a significant portion of the western subwatershed with a corridor of commercial uses including three gas stations, a public library, and various other commercial uses along Edgewood Road. The delineated upland areas include:

SBA – Medium density residential neighborhood
SBB – Abandoned high density residential
SBC – Edgewood Elementary School and sports field
SBD – Gas station and three stormwater detention basins
SBE – Harford Commons high density residential neighborhood
SBF – Medium density residential neighborhood
SBG – Commercial/retail single detached building and parking lot
SBH – Edgewood High School and Deerfield Elementary School (determined to be outside of watershed limits)
SBI – Medium density residential
SBJ – Culvert under Perry Road with surrounding wetland and buffer potential
SBK – Commercial/retail single detached building and parking lot
SBL – High Density Residential
SBM – Car wash and stormwater detention basin
SBN – Public library and commercial/retail building with hair salon, restaurant, and mini-mart
SBO – Two corner gas stations

Within these upland areas, sixteen specific locations are recommended for retrofits to improve the quality and reduce quantity of stormwater runoff impacting Sam's Branch. Where applicable, Figures 2-2 through 2-20 show drainage areas and retrofit areas are delineated on an aerial plan with a photo from the survey showing a view of the site. Issues, strategies, and

expected benefits are listed on these sheets for each site in the appendix as well. The retrofit sites include:

SBA – Bioretention along the medium density residential Hanson Road: This lengthy residential road is directly draining to Sam's Branch through several large curb inlet drains. Lawn clippings were visible in the gutter from the lawns on either side of the sidewalks. Replacing the lawn areas between the road and sidewalk with vegetated bioswales could intercept road runoff before it reaches the curb inlets. The expected benefits of this strategy include enhanced quality and quantity control for frequently-occurring storms as well as educational benefit as a demonstration project for residents.

***SBB - Abandoned high density residential*:** Existing abandoned/unused impervious surface on Hawthorne Drive are currently in poor condition. Strategies for improvement include removal of unused impervious surface (24,630 ft^2), and stabilization of area with soil amendment and native vegetation. Depending on the approach toward removal or rehabilitation of the buildings at this site, additional pavement area could these areas could also be stabilized with soil amendments and native vegetation. The benefits of this strategy would be to reduce the volume of stormwater runoff and promote infiltration.

SBC – Bioretention and revegetation along Cedar Dr. at Edgewood Elementary School: The parking lot of Edgewood Elementary School drains through large drain inlets directly under Cedar Drive and into Sam's Branch. The two drainage areas in the parking lot could be redirected into proposed bioretention cells in the existing lawn area between the parking lot and Cedar Drive. A swale which runs through the large lawn area to the southwest of the school building is another major source of drainage into Sam's Branch from the SBC site. This channel had standing water in portions during the survey. This swale could be vegetated with native vegetation and engineered media could be selectively added to create a bioswale. Through these strategies, the stormwater runoff from this edge of the SBC site, adjacent to Sam's Branch, could have improved water quality and quantity control for frequently occurring storms, enhanced habitat and aesthetic appeal, and educational benefit as a demonstration project for students and residents.

SBD – Gas station and three stormwater detention basins: This site includes a gas station and 3 existing stormwater basins. Basin #1 lacks vegetation aside from grass and water quality benefit based on the existing stormwater treatment. Recommendations at this site include replacement of the pond bottom with engineered media and an underdrain, and plant with native vegetation. The expected benefits include alleviation of minor standing water problem, improvement of water quality leaving the existing basin and enhanced aesthetic appeal.

The outfall channel downstream of Basin #2 has eroded banks and is actively head-cutting, contributing accelerated sediment loading to Sam's Branch and Otter Creek. Restoration strategies include stabilizing the channel using regenerative stormwater conveyance, as a stepped outfall system. The expected benefits of this approach include reduced sediment yield from channel erosion, improved hydrologic behavior (increasing groundwater recharge), and habitat improvement.

At Basin #3, a lack of vegetation, bare and eroded soils, trash deposition and lack of maximized water quality benefit were noted. Retrofit strategies include stabilization of bare and eroded soil, and native vegetation installation, construction of a water quality forebay, and a modified mowing program for any portion that remains grassy. Expected benefits include improved trash management and water quality, as well as, enhanced habitat and aesthetic appeal.

***SBE – Harford Commons high density residential neighborhood*:** Along the headwater portion of the stream corridor near Harford Commons, an abandoned high density residential neighborhood, there is significant debris accumulation and impaired water quality. Strategies for improvement and restoration of this area include moving a residing dumpster away from the drainage network and the creation of a sand seepage wetland with native vegetation. This wetland area would encompass approximately 0.8 acres and capture approximately 9 acres of drainage area. This strategy would result in improved water quality and hydrologic conditions in this critical headwater area of Sam's Branch, increasing habitat and aesthetic appeal.

SBF – Bioretention along the medium density residential Southridge Drive turn-around island: Southridge Drive has asphalt in poor condition, direct drainage to the headwaters of Sam's Branch, and is highly visible to residents who live on this street as a potential educational opportunity. There is currently a lack of water quality control for the runoff on this street. By lowering the grade of the raised turn-around island, cutting the curbs, and constructing a bioretention cell to capture road runoff, there is the potential to enhance the quality and quantity control for frequently-occurring storms as well as use this project for demonstration for residents.

SBG - Commercial/retail single detached building and parking lot: This commercial area houses a basement waterproofing company and did not exhibit much available area or opportunity in the way of significant stormwater management opportunities.

SBH – Edgewood High School and Deerfield Elementary School: Much of the drainage area at these locations drains to another tributary. Further investigation of the stormdrain network will be conducted; however, no current recommendations are included in this report.

SBI – Sequoia Drive Cul-de-sac Parking Lot: Sequoia Drive Cul-de-sac parking lot is currently in fair condition, but results in directly connected drainage that lacks any water quality treatment. A retrofit strategy would include replacing existing pavement with permeable pavement covering an area approximately 13,570 ft^2. The expected benefits would include quality and quantity control for more frequent storms, and enhanced aesthetic appeal.

SBJ – Culvert under Perry Road with surrounding wetland and buffer potential: This area captures roadway surface along Rosewood Drive, Banyan Road, and Perry Avenue that currently runs directly into two concrete channels into Sam's Branch. Retrofit opportunities include a terraced bioretention facility in a grassy area adjacent to the roadway near the intersection of Banyon Road and Perry Avenue. Benefits of this retrofit would include enhanced water quality and quantity treatment.

SBK – Bioretention for the parking lot for two high density apartment buildings: The parking lot for the two apartment buildings on the corner of Edgewood Road and Rosewood Drive has no visible drain inlets but has a steady grade towards Rosewood Drive. The area of lawn to the north of the entry road into the parking lot could be used to construct a bioretention cell adjacent to the entrance. This bioretention could solve the issues of the directly connected drainage, lack of water quality control, and low vegetation diversity. Expected benefits include enhanced quality and quantity control for frequently-occurring storms, enhanced aesthetic appeal, and educational benefit as a demonstration project for residents.

***SBL – High Density Residential*:** At this high density residential site, the asphalt is in poor condition and much of the existing soil is compact, barren and in some areas, there is evidence of erosion. In addition, the drainage is directly connected and lacks any water quality treatment. Strategies for water quality enhancement include replacement of the entire paved area, including the pavement between the buildings, with permeable pavement. Soil amendment or augmentation is also recommended at this location, with native revegetation. Benefits gained by the implementation of these measures include enhanced water quality and quantity control, enhanced habitat and aesthetic appeal, and the alleviation of erosion and standing water. In addition, at this location there is an opportunity for regenerative stormwater conveyance replacing an existing rip-rap channel, and capturing parking lot drainage prior to discharging into Sam's Branch.

***SBM – Car wash and stormwater detention basin*:** No recommendations have been made at this time, additional evaluation of the stormwater pond as-built drawings and modeling information are necessary to determine if retrofit of the existing stormwater detention basin would be recommended.

***SBN1 – Pollution/trash prevention strategies for the commercial site*:** This commercial site contains a mini mart store in the southeast portion of the building. A drainage channel runs along the entire length of the southeast edge of the property line. Significant amounts of trash were seen on this site along the fence between the building and the ditch as well as in the ditch. Oil from road runoff can also be seen in the water within the channel. This channel and the trash it carries flow into a tributary to Sam's Branch. By providing more trash cans, repairing holes in the fence, and other trash control methods, this trash may be prevented from entering the waterways within this watershed.

SBN2 – Bioretention and outreach opportunities at Public Library: Existing rooftop drainage drains through downspouts and that are either directly connected to the stormdrain system or drain directly into a grass swale and enters an inlet draining to the storm drain. Water quality benefit is not maximized by the portion of the rooftop drainage that currently runs through the grassy swale area. A bioretention facility could be built near the entrance to the public library to capture a portion of the rooftop runoff by disconnecting the connected downpouts and redirecting the existing drainage into the facility. Educational signage could be established near the entrance to the library to educate the community on watersheds, stormwater management and the health of their local water resources. Benefits include enhanced water quality and quantity control for frequently-occurring storms and educational outreach opportunities.

SBO – Bioretention opportunity at Commercial Center: Existing parking lot drainage enters an inlet and the stormdrain system along the east corner. No water quality treatment of this drainage is currently provided. Strategies for improvement include the use of adjacent down gradient lawn area for a bioretention facility. Educational signage could be established near the entrance to the library to educate the community on watersheds, stormwater management and the health of their local water resources. Benefits include enhanced water quality and quantity control for frequently-occurring storms and educational outreach opportunities.

Figure 2-2 SBA – Bioretention along the medium density residential Hanson Road

Bioretention - Residential - SBA - Hanson Rd.

Low point along Hanson Rd.; Flooding in road has been alleviated by the curb inlets according to resident

Typical shoulder configuration; turf clippings flowing into curb inlet

Issues:
- Directly connected drainage
- Lack of water quality control
- Lawn clippings in gutter

Strategies:
- Replace lawn in areas between sidewalks and roads with vegetated bioswales to intercept road runoff before reaching curb inlets

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Educational benefit as demonstration project for residents

Implementation Priority

Cost	Medium
Level of Benefit	Medium
Land Ownership	Public (to be verified
Overall Priority	High

Figure 2-3 SBB – Hawthorne Drive - abandoned high density residential

Remove Impervious Surfaces - SBB - Hawthorne Drive

Proposed Impervious Surface Removal
Area: 24,630 sq. ft.

0 400

Existing pavement on Hawthorne Drive

Issues:
- Abandoned/unused impervious surfaces in poor condition

Strategies:
- Remove unused impervious surfaces in the delineated area
- Stabilize area with soil amendment and native vegetation
- Depending on the approach to building demolition, additional driveways, parking areas, or roads could also be removed

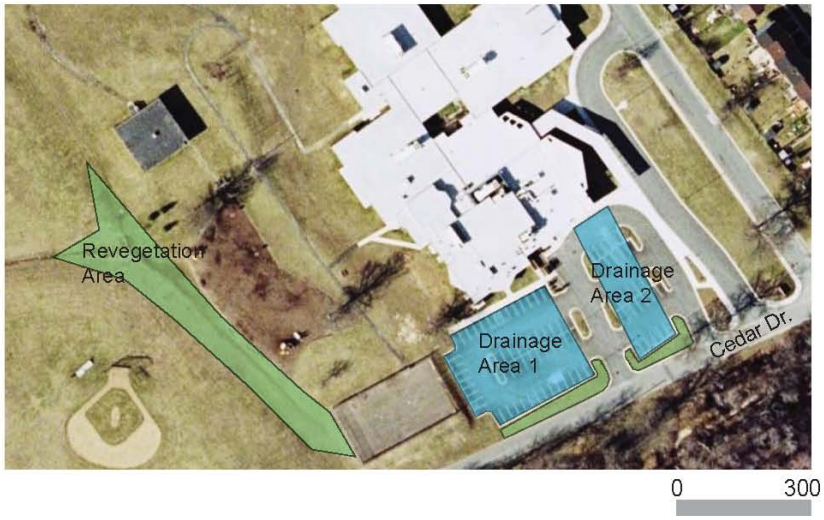
Expected Benefits:
- Reduced stormwater runoff volume
- Infiltration is promoted

Implementation Priority

Cost	Medium
Level of Benefit	Medium
Land Ownership	Private
Overall Priority	Medium

Figure 2-4 SBC - Edgewood Elementary School – Bioretention and Revegetation

Bioretention & Revegetation - Public/Educational - SBC - Edgewood Elementary School



Drainage Area 1:
15,880 sq. ft.

Drainage Area 2:
7,981 sq. ft.

Proposed Bioretention Cell Area 1:
1,850 sq. ft.

Proposed Bioretention Cell Area 2:
1,041 sq. ft.

Revegetation Area:
14,370 sq. ft.

Issues:
- Directly connected drainage
- Lack of water quality control
- Some standing water in existing swale

Strategies:
- Replace lawn areas with bioretention cells and redirect parking lot drainage into cells
- Plant existing lawn swale with native vegetationand selectively add engineered media

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Enhanced habitat and aesthetic appeal
- Educational benefit as demonstration project for students and residents

Portion of existing swale

Proposed bioretention location, Drainage Area 1

Implementation Priority

Cost	Medium
Level of Benefit	Medium
Land Ownership	Public
Overall Priority	High

Figure 2-5 SBD – Basin 1

Retrofit Existing Stormwater Basins - SBD - Basin 1

Outflow riser with de-watering device

Issues:
- Lack of vegetation besides grass
- Water quality benefit not maximized

Strategies:
- Replace pond bottom with engineered media and underdrain
- Plant with native vegetation

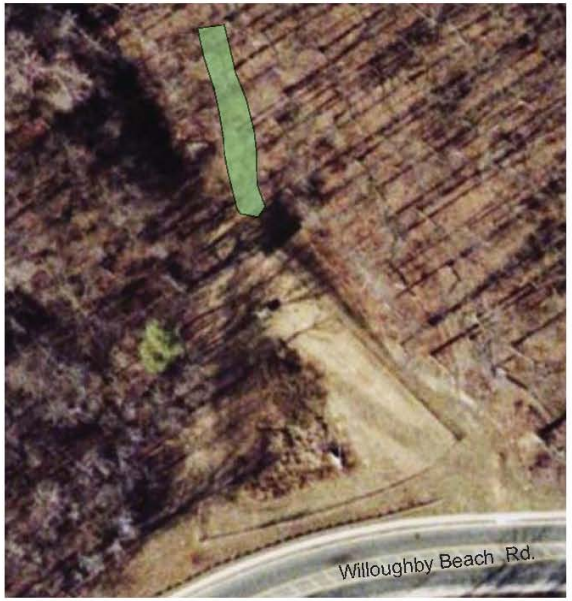
Expected Benefits:
- Alleviate minor standing water problem
- Improved water quality leaving basin
- Enhanced aesthetic appeal

Implementation Priority

Cost	Low
Level of Benefit	Medium
Land Ownership	Public (to be verified)
Overall Priority	High

Figure 2-6 SBD – Basin 2

Regenerative Stormwater Conveyance - SBD - Basin 2 Outfall



Proposed Regenerative Stormwater Conveyance Channel

0 150

Eroded outfall channel

Issues:
- Channel connection basin outfall to Sam's Branch has eroded banks, and active head-cut, and is deeply incised

Strategies:
- Stabilize channel using regenerative storm-water conveyance (step pool system)

Expected Benefits:
- Reduced sedimentation from channel erosion
- Improved hydrologic behavior
- Habitat enhancement

Implementation Priority

Cost	Medium
Level of Benefit	Medium
Land Ownership	Public
Overall Priority	High

Figure 2-7 SBD – Basin 3

Retrofit Existing Stormwater Basins - SBD - Basin 3

Partial view of eroded areas

Issues:
- Lack of vegetation
- Bare/eroded areas
- Trash deposition
- Water quality benefit not maximized

Strategies:
- Stabilize bare/eroded areas
- Plant with native vegetation
- Construct water quality forebay
- Modify mowing practices to avoid exacer-bating erosion

Expected Benefits:
- Improved trash managment
- Improved water quality leaving basin
- Enhanced habitat and aesthetic appeal

Implementation Priority

Cost	Low
Level of Benefit	Medium
Land Ownership	Public
Overall Priority	High

Figure 2-8 SBE – Harford Commons

Sand Seepage Wetland - SBE - Harford Commons High Density Residential

Drainage Area: 9 acres

Proposed Sand Seepage Wetland Area: 0.8 acre

0 400

Existing channel

Trash deposition

Issues:
- Impaired water quality and severe trash deposition in headwater area below Harford Commons

Strategies:
- Move dumpster away from drainage culvert
- Create sand seepage wetland with native vegetation

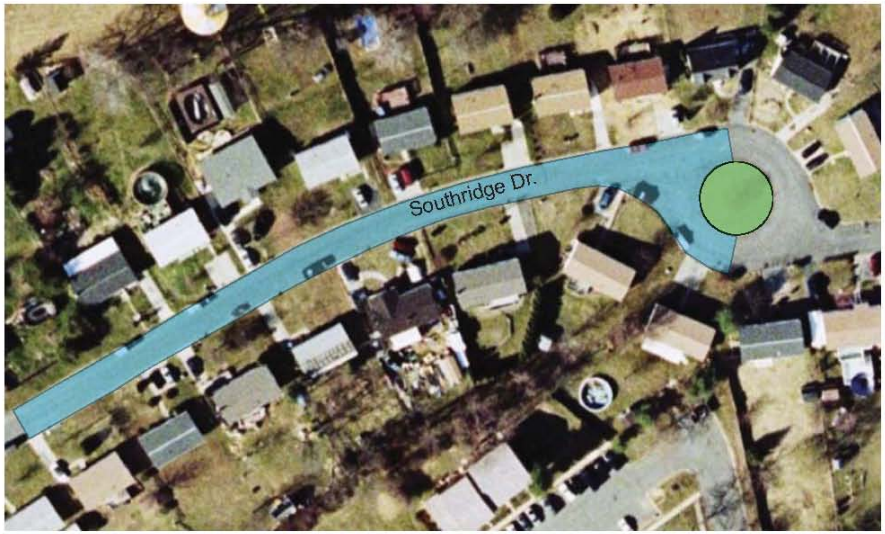
Expected Benefits:
- Improved water quality and hydrologic behavior in critical headwaters area of Sam's Branch
- Enhanced habitat and aesthetic appeal

Implementation Priority

Cost	High
Level of Benefit	High
Land Ownership	Public (to be verified)
Overall Priority	High

Figure 2-9 SBF – Southridge Drive Turn-around

Bioretention - Residential - SBF - Southridge Dr. Turn Around Island



Drainage Area: 18,150 sq. ft.

Proposed Bioretention Cell Area: 2,376 sq. ft.

0 150

Turn-around island

Issues:
- Directly connected drainage
- Lack of water quality control

Strategies:
- Lower grade of raised turn around island, cut curbs, and construct bioretention cell to capture road runoff

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Educational benefit as demonstration project for residents

Implementation Priority

Cost	Medium
Level of Benefit	Low
Land Ownership	Public (to be verified
Overall Priority	Low

Figure 2-10 SBI – Sequoia Drive Cul-de-sac

Permeable Paving and/or Biofiltration - SBI - Sequoia Drive Cul-de-sac Parking

Proposed Permeable Pavement Area:
13,570 sq. ft.

0 150

Parking in center of cul-de-sac on Sequoia Dr.

Issues:
- Pavement in fair condition
- Directly connected drainage
- Lack of water quality control

Strategies:
- Replace existing pavement with permeable pavement

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Enhanced aesthetic appeal

Implementation Priority

Cost	High
Level of Benefit	Medium
Land Ownership	Private
Overall Priority	Medium

Figure 2-11 SBJ - Bioretention

Bioretention - SBJ

One of two existing channels from road into Sam's Branch

Issues:
- Directly connected road drainage into Sam's Branch via two concrete channels
- Lack of water quality control

Strategies:
- Terraced bioretention in existing grass area

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms

Implementation Priority

Cost	Medium
Level of Benefit	Medium
Land Ownership	TBD
Overall Priority	Medium

Figure 2-12 SBK - Biorention

Bioretention - Residential - SBK

Proposed bioretention location

Issues:
- Directly connected drainage
- Lack of water quality control
- Low vegetation diversity

Strategies:
- Construct bioretention cell adjacent to entrance

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Enhanced aesthetic appeal
- Educational benefit as demonstration project for residents

Implementation Priority

Cost	Medium
Level of Benefit	Medium
Land Ownership	Private
Overall Priority	Medium

Figure 2-13 SBL High Density Residential

Permeable Pavement + Soil Amendment & Revegetation - SBL - High Density Residential

Existing Pavement

Existing inlet at east corner of lot

Proposed Permeable Pavement Area: 33,250 sq. ft.

Proposed Soil Amendment and Revegetation Area: 5,000 sq. ft. (could be expanded to the whole internal lawn area)

0 200

Issues:
- Asphalt paving in poor condition
- Bare, compacted and eroded common area
- Directly connected drainage
- Lack of water quality control

Strategies:
- Replace entire paved area (including pavement between buildings) with permeable pavement.
- Amend or replace soil in common area and revegetate

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Enhanced aesthetic appeal
- Alleviate erosion and standing water

Implementation Priority

Cost	Medium
Level of Benefit	Medium
Land Ownership	Private
Overall Priority	Medium

Figure 2-14 SBL – Regenerative Stormwater Conveyance

Regenerative Stormwater Conveyance - SBL - High Density Residential

Drainage Area: 10,000 sq. ft.

Proposed RSC Area

0 150

Riprap channel at southwest corner of parking lot

Issues:
- Parking lot runoff drains into small riprap channel flowing directly to Sam's Branch
- Trash deposition

Strategies:
- Replace existing channel with Regenerative Stormwater Conveyance (step pool system)

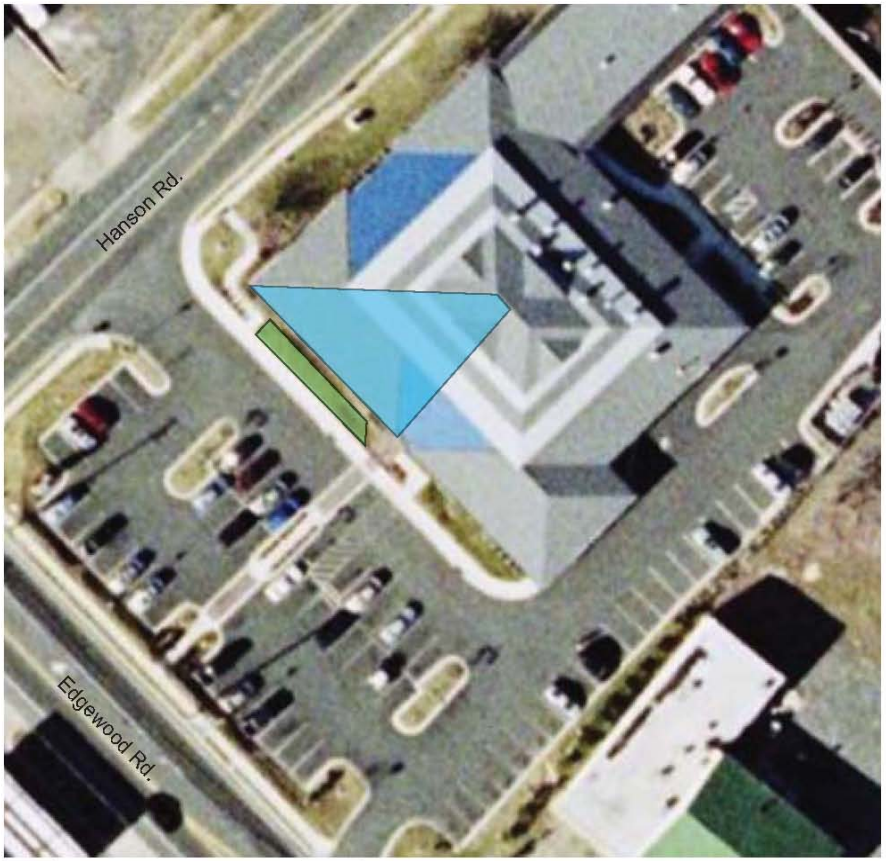
Expected Benefits:
- Improved hydrologic behavior
- Improved runoff water quality
- Enhanced habitat and aesthetic appeal

Implementation Priority

Cost	Medium
Level of Benefit	Low
Land Ownership	Private
Overall Priority	Medium

Figure 2-15 SBN – Library - Bioretention

Bioretention - Public/Educational - SBN - Library



Drainage Area: 2,859 sq. ft.

Proposed Bioretention Cell Area: 300 sq. ft.

0 100

Existing swale and downspouts

Issues:
- Water quality benefit not maximized

Strategies:
- Construct bioswale
- Disconnect downspouts into bioswale
- Add educational signage

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Excellent educational opportunity

Implementation Priority

Cost	Medium
Level of Benefit	Low
Land Ownership	Public
Overall Priority	High

Figure 2-16 SBN – Commercial Site

Pollution Prevention Strategies - SBN Commercial Site

Trash accumulation along fence

Trash deposition and poor water quality in channel

Issues:
- Drainage channel conveys trash from parking lot into tributary of Sam's Branch

Strategies:
- Provide more trash cans, repair holes in fence, and employ other trash control methods to prevent trash from entering drainage channel

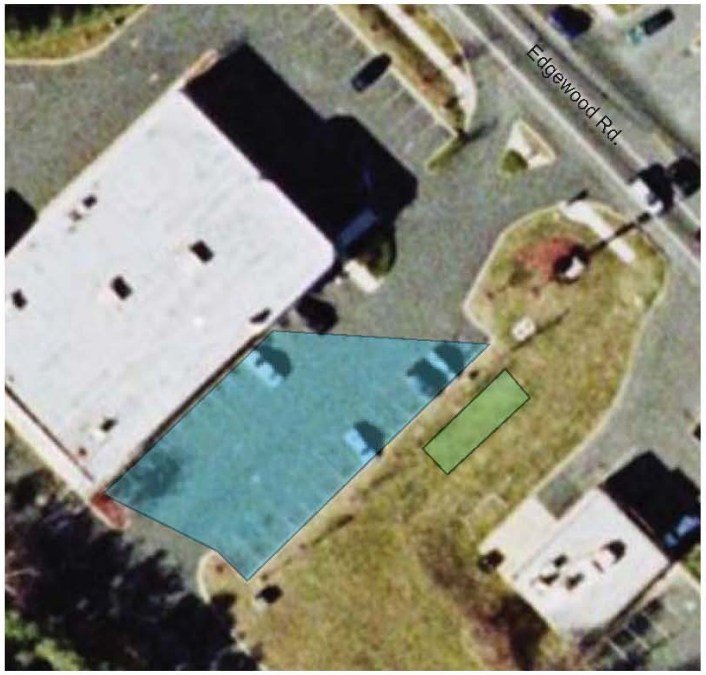
Expected Benefits:
- Reduced trash in tributary

Implementation Priority

Cost	Low
Level of Benefit	Medium
Land Ownership	Private
Overall Priority	High

Figure 2-17 SBO – Commercial Bioretention

Bioretention - Commercial - SBO



Drainage Area: 7,000 sq. ft.

Proposed Bioretention Cell Area: 525 sq. ft.

0 100

Lawn area below parking lot

Existing inlet at east corner of lot

Issues:
- Directly connected drainage
- Lack of water quality control

Strategies:
- Use adjacent lawn area for bioretention

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms

Implementation Priority

Cost	Medium
Level of Benefit	Low
Land Ownership	Private
Overall Priority	Low

Figure 2-18 Typical Bioretention Section

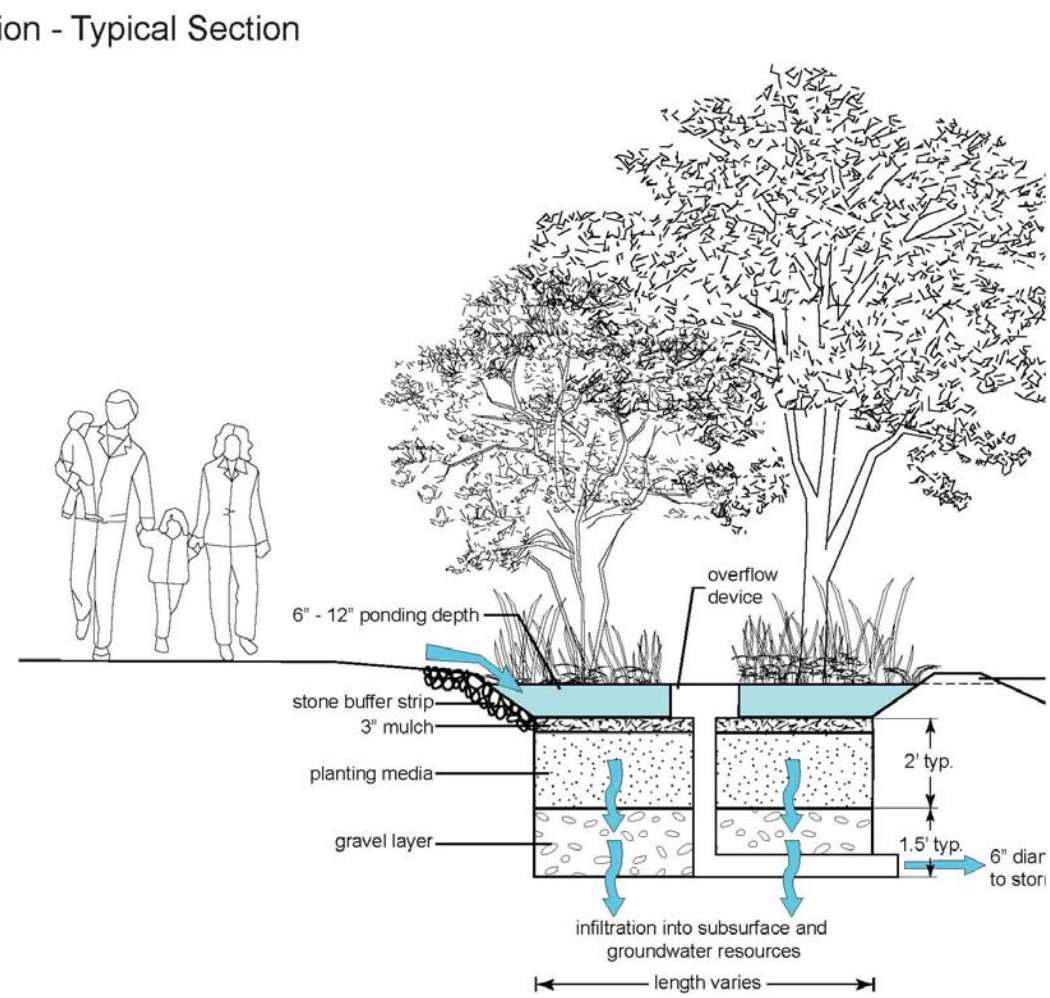


Figure 2-19 Typical Regenerative Stormwater Conveyance Section

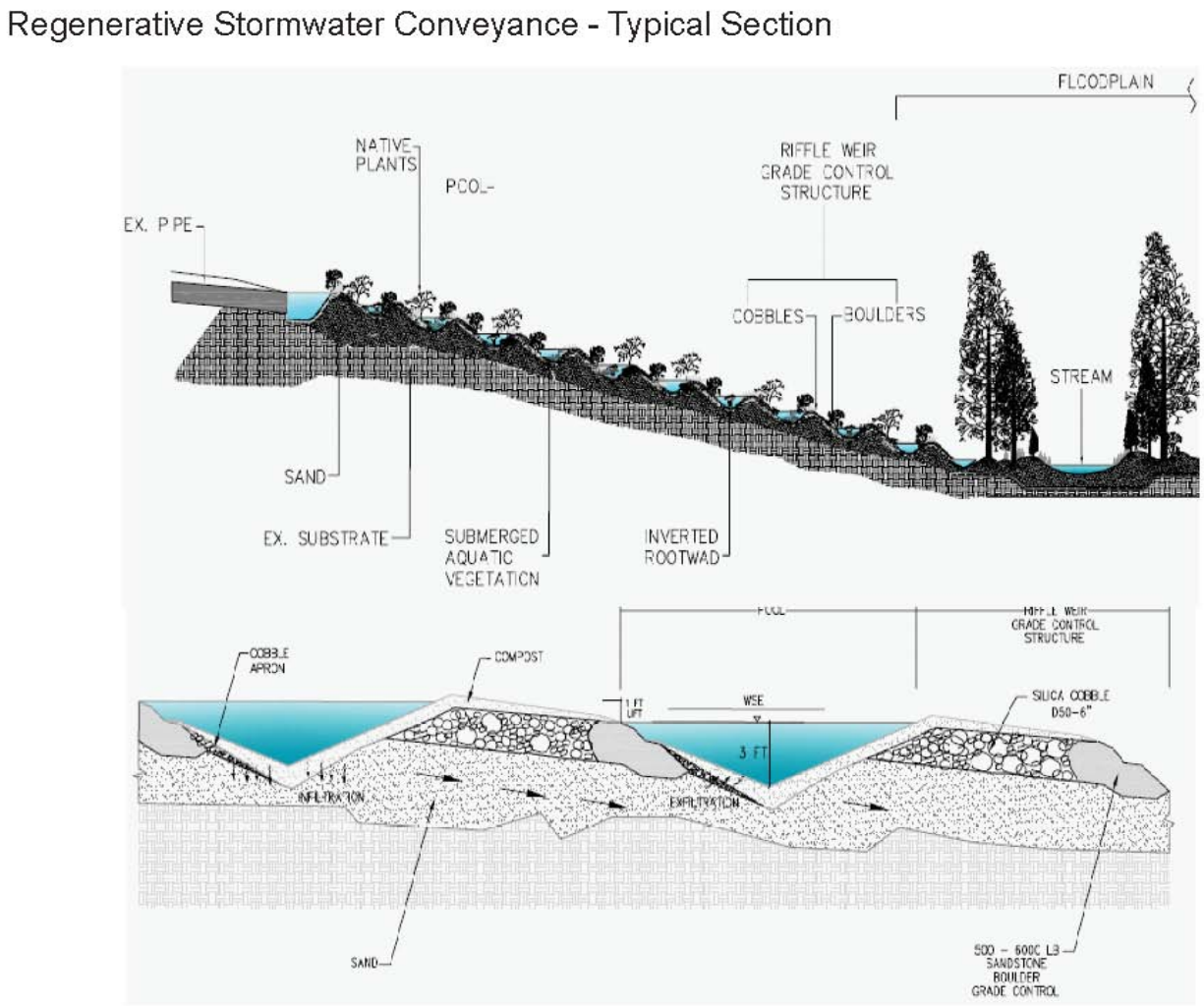
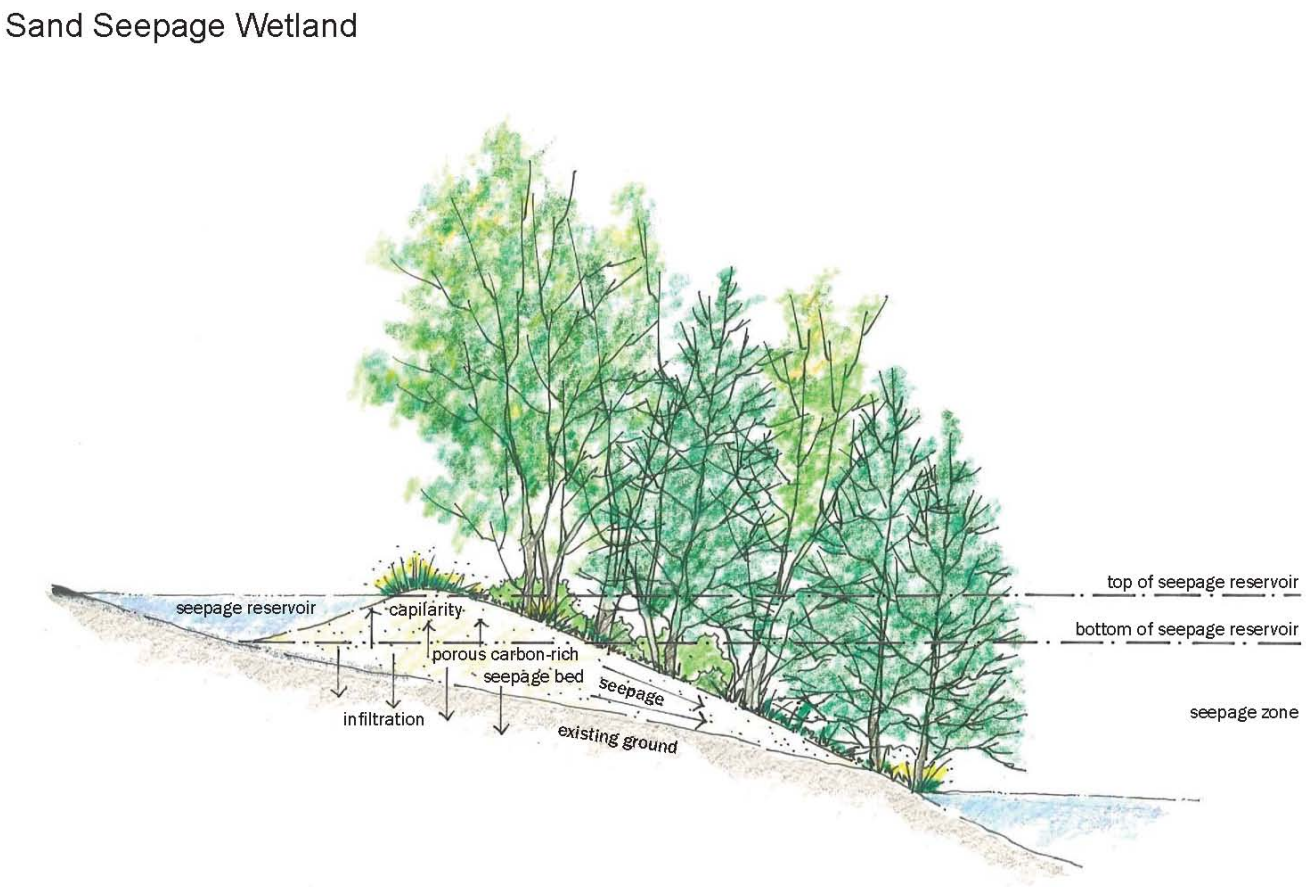


Figure 2-20 Typical Sand Seepage Wetland Schematic Section



2.2 Community Awareness Survey

A key approach to truly assessing the health of a watershed requires information and input from the inhabitants of the watershed. It is important to establish dialogue with the communities, to understand their watershed behaviors and to seek input early on the development of any management approaches and restoration/implementation strategies.

2.2.1 Methods

A residential survey was developed for Harford County to supplement the windshield survey carried out during the upland survey. The residential survey, the purpose of which is to seek input from the residents toward characterizing current watershed awareness, and relevant watersheds behaviors will be distributed by the Harford County to the neighborhoods within the Sam's Branch drainage area within the next several months. In part, the survey results will serve as an indicator of the willingness to change behaviors where they are shown to contribute to degraded instream conditions. The findings of the community awareness survey will be summarized and specific recommendations will be made to address certain behaviors observed. Over the next year, Biohabitats will work with County staff and community stakeholders to explore incentives to increase the amount of participation and promote better "watershed" behaviors.

2.2.2 Summary of Baseline Community Awareness Survey

The residential survey will be distributed by the Harford County to the neighborhoods within the Sam's Branch drainage area within the next several months. A copy of the survey is included in Appendix C. The survey results will serve as an indicator of the willingness to change behaviors where they are shown to contribute to degraded in-stream conditions. The findings of the community awareness survey will be summarized and specific recommendations will be made to address certain behaviors observed.

3.0 RIPARIAN CONDITION SURVEY

3.1 Establish Baseline Riparian Condition

Biohabitats walked the entire length of each restoration reach photographing and noting existing condition of the stream corridor including a riparian condition survey, and mapping outfall locations. A GPS point location was also recorded for each baseline condition photograph taken for comparison to future conditions. These photographs are included in Appendix A. In addition, outfall locations were also GPS located along each reach (Figure 4-2). Plant community types were identified with the dominant plant species recorded and impacts (i.e., invasive species) to those communities noted.

3.1.1 Methods

On April 25, 2008 Biohabitats, Inc. staff performed a visual assessment of the forested areas immediately adjacent to the stream channel along the length of the study area. Biohabitats conducted a riparian condition survey along the entire length of the study area, mapping invasive species, plant community types, riparian widths, and areas of encroachment, location of yard waste dumping, and documenting the general health of the plant community along the length of the study area.

3.1.2 Summary of Baseline Riparian Conditions

The upper reaches of Sam's Branch originate in a highly degraded forested wetland fed by stormwater outfalls. Much of the overstory here is composed of black willow and silver maple.

Progressing further downstream Sam's Branch cuts its way through a mixed hardwood forest dominated by tulip poplar, red maple and black cherry with an occasional beech, black locust and pin oak. The understory in this area is dominated by seeps and depressions. The forested area to the south of Sam's Branch is vegetated with sweet gum, sycamore, holly, sweet bay, spicebush, highbush blueberry and various ferns.

The lower portions of Sam's Branch pass through a forest floodplain wetland that is dominated by green ash with other floodplain tree species found in this association such as sycamore, black walnut, silver maple, river birch, red maple and willow oak.

Riparian vegetation species are listed below:

Common Name (*Latin Name*)

Tulip poplar (*Liriodendron tulipifera*)
Red maple (*Acer rubrum*)
Black cherry (*Prunus serotina*)
Locust (*Robinia* sp)
Southern magnolia (*Magnolia grandiflora*)
Sweet bay (*Magnolia virginiana*)
American beech (*Fagus americana*)
Pin oak (*Quercus palustris*)
Red oak (*Quercus falcata*)
Sweet gum (*Liquidambar styraciflua*)
Sycamore (*Platanus occidentalis*)
Poison ivy (*Toxicodendron radicans*)
Virgins bower (*Clematis virginiana*)
Virginia creeper (*Parthenocissus cinquefolia*)
Skunk cabbage (*Symplocarpus foetidus*)
Sensitive fern (*Onoclea sensibilis*)
Mayapple (*Podophyllum peltatum*)
Grape (*Vitis* sp)
Violet (*Viola* sp)
Greenbriar (*Smilax* sp)
Chickweed (*Stellaria* sp)
Red-osier dogwood (*Cornus sericea*)
Highbush blueberry (*Vaccinium corymbosum*)
Arrowwood (*Viburnum dentatum*)
Flowering dogwood (*Cornus florida*)
Spicebush (*Lindera benzoin*)
Blackhaw (*Viburnum prunifolium*)
Holly (*Ilex opaca*)
Sweetpepperbush (*Clethra alnifolia*)
Rubus
Elderberry (*Sambucus canadensis*)

Sassafras (*Sassafras albidum*)
Willow oak (*Quercus phellos*)
Black willow (*Salix nigra*)
Silver maple (*Acer saccharinum*)
Black walnut (*Juglans nigra*)
Jewelweed (*Impatiens capensis*)
Cinnamon fern (*Osmunda cinnamomea*)
Mulberry (*Morus* sp)
Hobblebush (*Viburnum lantanoides*)
Bittersweet (*Celastrus* sp)
Multiflora rose (*Rosa multiflora*)
Japanese honeysuckle (*Lonicera japonica*)
Japanese knotweed (*Polygonum cuspidatum*)
Winged euonymus (*Euonymus alatus*)
English ivy (*Hedera helix*)
Privet (*Ligustrum* sp)
Wisteria (*Wisteria* sp)
Garlic mustard (*Alliaria petiolata*)
Wineberry (*Rubus phoenicolasius*)

4.0 STREAM MORPHOLOGY

A geomorphic survey of four reaches was conducted within the study area to document a range of representative conditions and establish baseline conditions. Field measurements and observations focused on the survey of monumented cross sections and longitudinal profile; measurement of bed material size; and assessment and photo documentation of overall site conditions and channel stability.

4.1 Monumented Cross Sections and Longitudinal Profiles

Measurements of stream cross sections and longitudinal profiles were taken to provide baseline information regarding stream shape and elevation. Future adjustments to the channel bed and banks can be identified when contrasted with these baseline data.

Baseline measurements and observations were stratified within the context of four representative reaches within the project area (Figure 4-1). Reach 1 extends from upstream limit to Edgewood Road. Reach 2 extends between Edgewood Road and Hornbeam Road. Reach 3 includes the portion of the channel between Hornbeam Road and Perry Avenue. Reach 4, the downstream-most reach, is bounded by Perry Avenue and Otter Creek downstream.

4.1.1 Methods

Biohabitats used a laser level instrument and rod to survey stream cross sections within the four restoration reaches using standard geomorphic techniques (Harrelson et al., 1994). Within each of the four reaches, Biohabitats surveyed two riffle cross sections and one pool cross section, for a total of twelve cross sections. Photographs were taken of the upstream, downstream, left bank and right bank of each surveyed cross section. Cross-sectional characteristics were recorded including top of bank, bankfull elevation, water surface elevation, thalweg and other notable features. Rebar pins were used to monument the left and right ends of the cross sections approximately 20 feet from top of bank. GPS coordinates of the rebar monuments were recorded. A stream longitudinal profile was also surveyed along the full extent of each of the four reaches. Longitudinal profiles extended approximately 20 channel widths or greater to best characterize topographical variation. Top of riffle, bottom of riffle, run, maximum pool depth, and glide features were recorded along the channel thalweg. Bankfull features, top of bank, and water surface elevation also were surveyed along the longitudinal profile. Elevations were recorded relative to an arbitrary benchmark of 100 feet. For each reach we also developed a geomorphic sketch, which identified key features and noted general channel stability. Appendix D contains data from this survey.

4.1.2 Summary of Baseline Stream Morphology Conditions

Photographs of the monumented cross sections are presented in Appendix A. Cross section and profile survey results and reach geomorphic sketches for each survey are presented in Appendix D. In general, the upstream reaches were more incised and unstable due to tall, nearly vertical bank slopes, and poor floodplain access. Stream hydraulics (e.g., discharge) and associated channel morphology (e.g., bank slopes) appear to be strongly controlled by three road crossings:

Edgewood Road, Hornbeam Road, and Perry Avenue. Additionally, water surface elevations in Reach 4 are controlled by backwater conditions in Otter Creek.

The Reach 1 longitudinal profile demonstrates pool-riffle morphology with an average pool-to-pool spacing of 21 ft. The reach has an overall thalweg slope of 1%. The surveyed cross sections document the deep incision of the channel into floodplain sediments, with entrenchment ratios of 1.2 and 1.4. Bankfull discharge is estimated between 49 and 55 cfs based on measurements at the riffle cross sections.

Reach 2 extends between Edgewood Road and Hornbeam Road. The reach exhibits pool-riffle morphology, with relatively less variability than other reaches in riffle and pool spacing and depth (pool-to-pool spacing is 58 feet). The surveyed longitudinal profile has an average slope of 1.5%. The reach cross sections are moderately incised with entrenchment ratios between 1.7 and 2.6. Bankfull discharge is estimated between 68 and 72 cfs.

Reach 3 shows the most variability in the longitudinal profile with pool-to-pool spacing ranging from 22 to 172.5 ft. The variability is attributed to the transition between the relatively straight upstream portions (with little riffle-pool morphology) to the downstream meandering reach (with more developed, deeper pools). Appendix D includes a geomorphic sketch of the reach illustrating the transition. Overall channel slope is 0.5%. The reach is moderately incised with entrenchment ratios between 1.7 and 2.4. The bankfull discharge is estimated to be between 47 and 49 cfs.

Reach 4, the downstream-most reach, is bounded by Perry Avenue and Otter Creek downstream. Average pool-to-pool spacing is 46 feet. The overall profile slope is 0.4%. The channel was generally stable with good floodplain access and entrenchment ratios greater than 2.2. The bankfull discharge is estimated between 125 and 157 cfs.

4.2 Particle Size Measurements at Cross Section Locations

Biohabitats characterized the particle-size distribution of stream bed on a reach basis and at selected riffle cross sections. These baseline data can be used to identify future textural changes in the channel bed material, as well as characterize channel competency as it may relate to overall channel stability.

4.2.1 Methods

Particle size distribution of bed material was completed using a modified Wolman pebble count procedure. Within each reach, stream bed particle-size distribution was characterized using a Wolman pebble count of 100 particles within the wetted-width of the best representative riffle cross section. A reach-wide 100-particle pebble count was also performed by selecting particles from reaches and pools based on these features' relative abundance (Rosgen, 1996). Particles were taken from the wetted-width, except one particle from every other transect was taken outside the wetted-width but within the bankfull width along the stream bank. The competency of the channel (i.e., the ability of the channel to entrain a particle of a given size) was estimated by comparing the D_{84} (the particle size for which 84% of the grain-size distribution is equal or finer) to the threshold particle size according to the Shield's equation (as presented in

Mecklenburg, 2006):

$D_s = T / ((R_s - R)* g* 0.06)* (304.8)$

D_s = diameter of sediment particle (mm or ft)

T = shear stress (lb/ft^2 or N/m^2)
R_s = density of sediment (5.15 slugs/ft^3 or 2560 kg/m^3)
R = density of water (1.94 slugs/ft^3 or 1000 kg/m^3)
g = gravitational acceleration (32.2 ft/s^2 or 9.81 m/s^2)
0.06 = Shield's parameter
Conversion Constant 304.8 mm/ft or 1000 mm/m

4.2.2 Summary of Baseline Particle Size Measurement

Particle size distributions from selected riffle cross sections and reach-wide pebble counts are included in Appendix D. Photographs of the bed material are included with the cross section photographs in Appendix A.

Reach 1 has a median riffle particle size of 10 mm (medium gravel). The median particle size of the reach-wide pebble count is 3 mm (very fine gravel). Given that the threshold particle size estimated as 30 mm is larger than the D_{84} (24 mm), the potential for entrainment of bed materials is high.

Reach 2 has a median riffle particle size of 21 mm (coarse gravel). The reach-wide median particle is 16 mm (medium gravel). Threshold particle size is between 44 and 46 mm, similar to the D_{84} of 43 mm. In the absence of any quantified sediment supply rates, the results suggest that channel bed material would be generally stable with a moderate erosion risk. This is consistent with field observations suggesting that the reach is largely stable.

Reach 3 has a median riffle particle size of 11 mm (medium gravel). The reach-wide median particle is 6 mm (fine gravel). The threshold particle size is estimated at 15 mm, which is smaller than the measured D_{84} of 24 mm. This is corroborated by observations of a generally reach stability and an apparent low potential for bed erosion.

Reach 4 has a median riffle particle size of 3 mm (very fine gravel) and reach-wide median particle of 0.2 mm (fine sand). The threshold particle size is estimated between 15 to 17 mm. Due to the smaller D_{84} (10 mm), the reach has a high potential for erosion. However, given the hydraulic control of Otter Creek downstream, the stream bed is generally considered stable. backwater from Otter Creek during elevated stages would generally protect Reach 4 from excessive sediment transport.

Figure 4-1 – Reach Boundaries and Cross Sections Locations for Sam's Branch Tributary

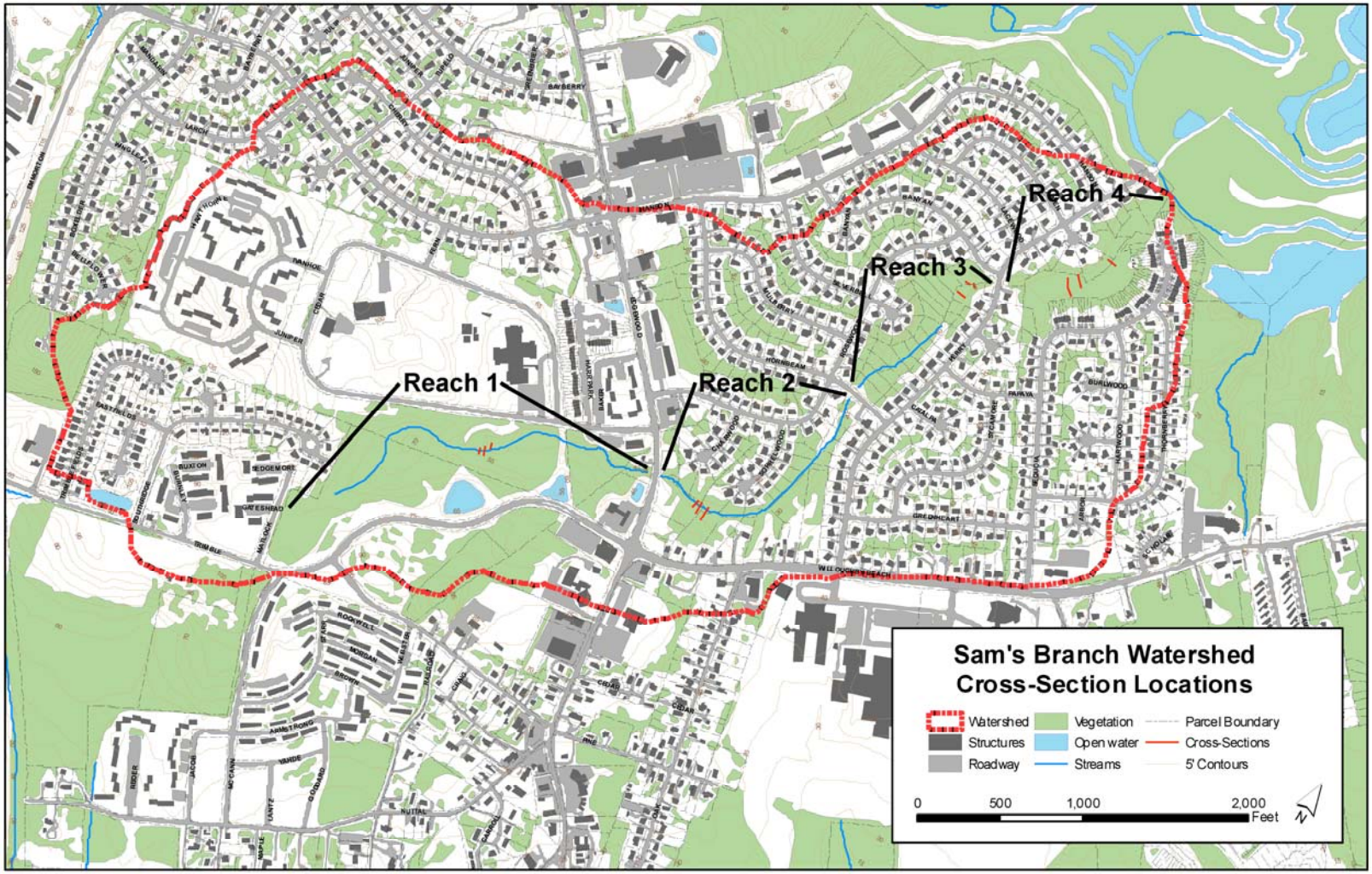
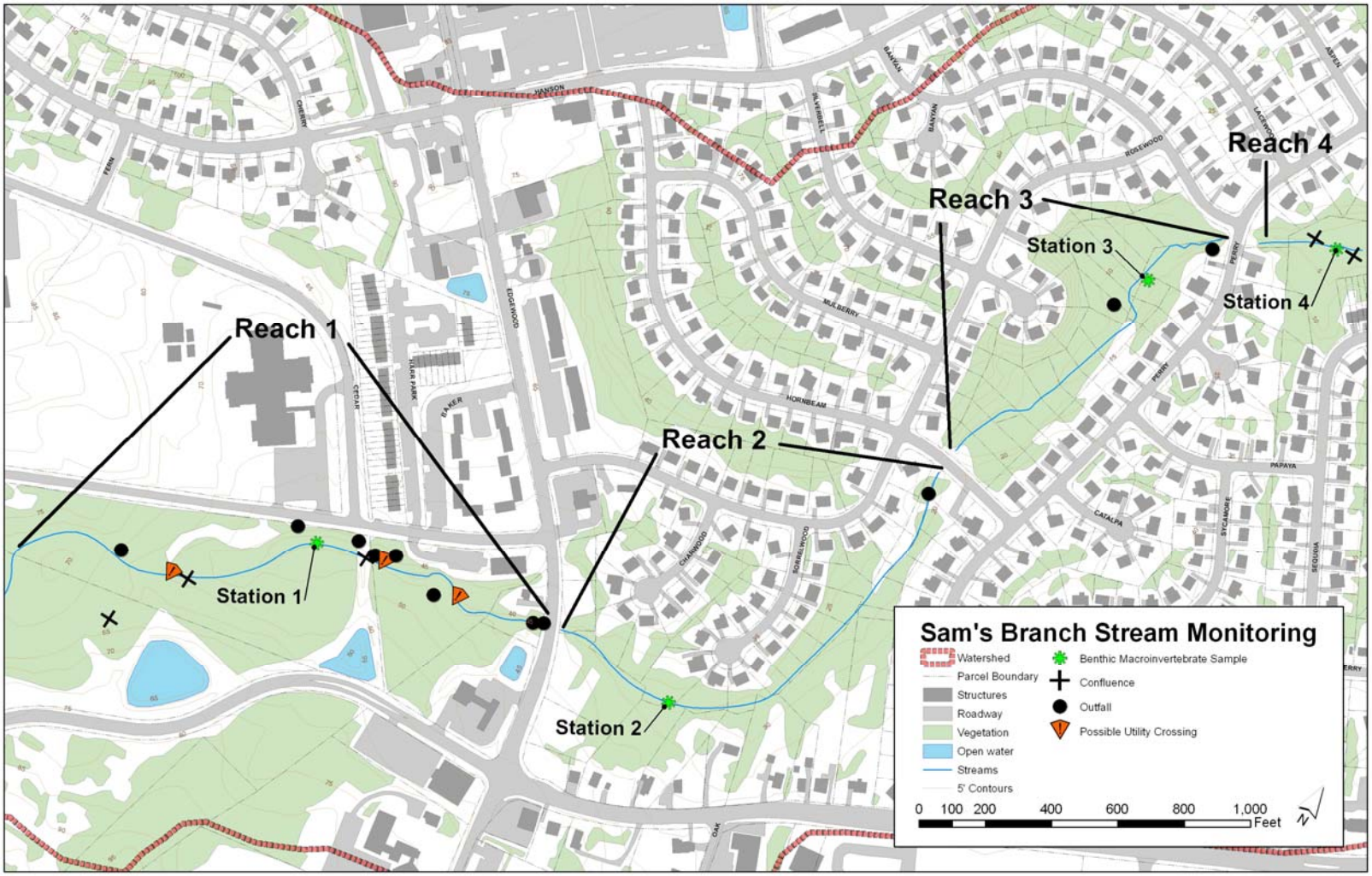


Figure 4-2 – Reach Boundaries and Monitoring Locations for Sam's Branch Tributary



5.0 STREAM BIOLOGICAL SURVEY

5.1 Benthic Macroinvertebrates

5.1.1 Methods

During April 2008, Biohabitats collected benthic invertebrate samples at each of the four (4) sampling stations, shown in Figure 4-2, using a D frame net in riffle areas. Collected organisms were identified to the lowest taxon possible and their relative abundance was tabulated.

Station 1 is located approximately 800ft upstream of Edgewood Road parallel to Cedar Drive. Station 2 is approximately 400ft downstream of Edgewood Road. Station 3 is approximately 300ft upstream of Perry Ave and Station 4 is approximately 300ft downstream of Perry Ave. Appendix E contains the field data sheets from the benthic sampling.

5.1.2 Summary of Baseline Benthic Conditions

On April 24, 2008 the benthic macroinvertebrate community was sampled at each of the four monitoring stations. Invertebrates were sampled in 20 square feet of the best suitable habitat utilizing Maryland Biological Stream Survey protocols. Gravel and cobble substrate as well as riparian vegetation root matter and aquatic vegetation was thoroughly disturbed to dislodge invertebrates which were then washed into the net by water current. The contents of the net were washed into a sample jar and preserved with isopropyl alcohol. Samples were evaluated under a microscope with 10X to 30X magnification. Invertebrates were identified to the lowest positive taxonomic level (generally, family or genus) and their relative abundance was noted.

Station 1 yielded 29 organisms comprised of just 4 taxa. Two taxa included chironomid midges (Tanypodinae, and Orthocladiinae), while the other two included a crane fly (*Tipula* sp.) and an aquatic beetle (*Stenelmis* sp.).

Station 2 contained 115 individual organisms from 5 taxa. This included four dipteran taxa and one caddisfly (*Cheumatopsyche* sp.). Of the 115 total organisms collected, 109 were from the family Chironomidae.

Station 3 yielded 69 individual organisms representing 3 taxa. One oligocheate and 68 chironomidae (orthocladiinae and chironomini) were identified.

Station 4 contained only two organisms from two taxa. This included one chironomid midge (orhocladiinae) and one oligocheate worm.

Based on the dominance by Oligocheate and Chironomidae larvae, the invertebrate community is clearly not representative of a diverse healthy aquatic community. Generally, the dipterans have a short life cycle to take advantage of ephemeral and undesirable habitats. Excess sediment, lack of riffle habitat, and a poor riparian corridor would appear to be the primary factors that influence the poor species composition within the study area.

5.2 Fish Survey

5.2.1 Methods

In the summer of 2008, Biohabitats sampled a 75-m section of stream for fish at each of the four (4) stream sampling stations. Block nets were erected at the ends of each sampling reach and the reach was sampled with a Smith-Root electro-fishing apparatus. Fish were identified by species at the site.

Station 1 is located approximately 800ft upstream of Edgewood Road parallel to Cedar Drive. Station 2 is approximately 400ft downstream of Edgewood Road. Station 3 is approximately 300ft upstream of Perry Ave and Station 4 is approximately 300ft downstream of Perry Ave. Appendix E contains the data sheets from the fish survey.

5.2.2 Summary of Baseline Fish Survey Conditions

At Station 1, 75 blacknose dace *(Rhinichthys atratulus)* and 66 creek chub *(Semotilus atromaculatus)* were collected. This sampling reach appears to be at the uppermost headwaters of the stream. The entire channel had discernable flow and was sample able, however; no fish were collected from above a significant (>1.5') headcut in the final 10 meters of the 75m reach.

At Station 2, 191 blacknose dace and 88 creek chub were captured over the 75 m length. Fish mortality was 0% and no anomalies were noted on any of the individuals that were captured.

At Station 3, six species of fish were collected. These included 122 blacknose dace, 185 creek chub, 5 white sucker (*Catostomus commersoni*), 2 creek chubsucker (*Erimyzon oblongus*), 2 American eel (*Anguilla rostrata*) and 1 rosyside dace (*Clinostomus funduloides*).

At Station 4, nine species of fish were collected. These included 76 blacknose dace, 125 creek chub, 23 white sucker, 4 creek chubsucker, 9 American eel, 6 pumpkinseed sunfish (*Lepomis gibbosus*), 2 redbreast sunfish (*Lepomis* auritus), 1 yellow bullhead (*Ameiurus nebulosus*) catfish, and 2 tesselated darter (*Etheostoma* olmstedi). The higher number of species at this station may be due to its close proximity to the confluence with Otter Creek (a larger stream). Here there are no obstructions such as roads or culverts and fish can migrate feely between the two streams.

Several factors can be seen as contributing to the generally poor fish community composition in the sampling reaches. Excessive sedimentation in the lower reaches would reduce reproductive success, while a poor macroinvertebrate community would force fish to populate other stream reaches where food resources are more plentiful. Fish barriers throughout the project site include vertical drops in the stream elevation, most notably at the Edgewood Road and Perry Avenue culverts which limit fish passage between Stations 1 through 4.

Limited physiochemical parameters (dissolved oxygen, pH, water temperature, and conductivity) were observed during each sampling event. The preliminary indication is that water quality is

not a significant limiting factor to the fish and macroinvertebrate communities. The chemical parameters were well within accepted ranges.

These initial results indicate that habitat, fish blockages, and reduced baseflow due to watershed development, are limiting the fish and macroinvertebrate communities in the Sam's Branch tributary.

6.0 STREAM WATER QUANTITY AND QUALITY MONITORING

6.1 Water Quantity Monitoring

Biohabitats installed and maintained two (2) Solinst © stage loggers (shown in Figures 6-1 and 6-2) with temperature measurement, and one (1) Solinst © barometric pressure logger with air temperature recorder at an upstream and downstream location along the length of the study area for establishing baseline water quantity conditions. Biohabitats also established and maintained an Infinity © rain gauge at the site. Throughout the year, Biohabitats monitored and maintained the equipment to ensure reliable and consistent results. The flow logger with temperature measurement, the barometric pressure logger with air temperature, and the rain gage monitor continuously and were downloaded approximately every 80 days.

Biohabitats established a stage discharge rating curve using the stage data collected over the course of the monitoring period. A combination of hand held weir for low flow measurements and Pygmy current velocity meter for higher flow were used to measure flow during a series of dry-weather and storm events at two, pre-established cross sections. An established rating curve for the cross sections was used to calculate discharge from the continuous stage recordings.

6.1.1 Methods

The stage loggers were employed to monitor the stage height continuously over time. Since these loggers use absolute pressure transducers to monitor stage, the results were corrected for barometric pressure. The following figures illustrate the location of the stage loggers. Manual measurements were used to establish a relationship between stage and discharge for the specific cross sections using the USGS cross section method (USGS, 1982). Approximately 99 total discharge points were taken at two cross sections during 7 different flow conditions to establish the curve. A power curve regression equation was fitted to the data (see Appendix F).

Figure 6-1 Photo from the Reach 2 stage logger (April 09, 2009). The photo shows field personnel during water quality sampling using the handheld meter.

Figure 6-2 Photo from the Reach 4 stage logger. The photo shows the Reach 4 cross section with some debris build-up after the August 28, 2009 event (September 09, 2009).

6.1.2 Summary of Water Quantity Baseline Conditions

The rating curve analysis resulted in best-fit lines with coefficients of determination (R^2) of 0.93 and 0.95 for the Reach 2 and Reach 4 stage loggers, respectively. These regression equations should yield accurate measurements of flow between baseflow and the maximum discharge recorded which occurred at 0.5-foot and 1.7-foot for Reach 2 and Reach 4 cross sections, respectively. Discharge calculated at stages greater than these maximum measurements are approximations only based on the extrapolated curves.

Discharge at the Reach 2 cross section ranged from zero to 177 cfs with an average of 0.5 cfs. Zero discharge was recorded for a period of 4 days, total. Reach 4 discharged had a similar range, from zero to 181 cfs, with and average of 0.7 cfs. Zero discharge was recorded only for one, 15-minute interval. Observation of the discharge hydrograph illustrates a flashy hydrologic system, where by the discharge quickly rises in response to rainfall, but quickly diminishes to baseflow conditions. The peak discharges were recorded on August 28, 2009 with peak, 30-minute rainfall intensity of 0.93 in/hr. This intensity corresponded roughly to the 1-year, 30-minute rainfall intensity (Bonnin, et al., 2004). The total recorded rainfall for the year was 24.5 inches through September 9, 2009.

6.2 Water Quality Monitoring

Biohabitats collected water quality samples at two (2) locations along the length of the study area. Monitoring of the stream included one (1) base flow and two (2) flow-weighted stormwater samples in Spring of 2009 at each of the two (2) locations, for one (1) year (total of 6 samples), for the following parameters:

- Total suspended solids (TSS)
- Alkalinity, SO4, chloride and hardness
- Total Kjedahl Nitrogen, Nitrate
- Total Phosphorus, Ortho Phosphorus
- Metals (Cu, Zn, Pb, Ca, Cd, Ni, Hg)
- Biochemical Oxygen Demand (BOD_5)
- Petroleum Hydrocarbons
- Herbicides/Pesticides
- Fecal Coliform/ E. Coli

Water samples were collected manually at each of the two (2) monitoring stations. The water samples were sent to a qualified laboratory for analysis. During the baseflow sample collection we also measured the physicochemical conditions (conductivity, pH, and dissolved oxygen) of the water using a hand held instrument.

6.2.1 Methods

Manual water samples were taken at the two monitoring cross sections facing upstream, at the area of maximum flow, within the middle of the water column, being careful to kick up as little

sediment as possible from the stream bottom. Depending on the analyte, different sampling techniques were employed:

Fecal coliform samples were collected by opening the sample bottle below the water surface to allow some water to flow in. The amount of water in the bottle was checked by closing the bottle and raising it above the water surface in order to see the approximate volume. Exposure to ambient air was limited as much as possible. After 100 ml was collected, leaving a small headspace in the bottle, the bottle was capped and locked.

For TPH or Oil and grease, we used glass, wide-mouth 1-liter bottles with preservative already in. When we sampled, we held the bottle 1/2 in and 1/2 out to maximize the surface floating material that enters the bottle. Since oil and grease and TPH tend to float on water surfaces, the bottle mouth should be immersed just halfway into the water, so that the maximum surface area of the stream (on which floats the analyte) enters the bottle.

The remaining analytes ("general water quality parameters") were collected by immersing the open bottle in the water until the container is filled.

Baseflow sampling resulted in one sample at one time per cross section. For storm events, we collected one flow-weighted sample (rising, peak and receding limb of the hydrograph) at each of the 2 logger locations. Samples were composited at the end of the storm, with the volume of sample weighted by the discharge measured at the time of sampling.

6.2.2 Summary of Water Quality Baseline Conditions

The general water quality parameters of alkalinity, BOD, nutrients, sulfate, hardness, and TSS did not result in abnormal levels. TSS was higher upstream at Reach 2 on average than downstream at Reach 4. This is most likely due to road culvert construction at Edgewood Road, directly upstream of the Reach 2 sample location. Other water quality parameters taken using the handheld device during dry weather showed good dissolved oxygen (12.2 ppm at Reach 2 and 11.3 ppm at Reach 4), normal conductivity (347 ppm at Reach 2 and 212 ppm at Reach 4), and slightly acidic pH (6.8 at Reach 2 and 6.8 at Reach 4).

The results from the bacterial analysis show elevated levels of total coliforms at both sampling locations. Low levels of E. coli were also found at each location. This could be a result of natural background due to wildlife, or anthropogenic input due to sewer main leaks or failing septic systems. Further source tracking of bacteria is the only method to determine if the bacteria in the stream resulted from natural or anthropogenic inputs.

Elevated levels of diesel range organics were found at both sample locations. One sample during wet weather at Reach 2 also revealed gasoline range organics. The source is most likely due to road runoff during storm events. However, the dry weather sample also revealed diesel range organics, which may be associated with the road culvert construction at Edgewood Road, and heavy equipment access to the stream. See Appendix F for a full summary of water quality results.

REFERENCES

Bonnin G.M., D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley. 2004. "Precipitation-Frequency Atlas of the United States," NOAA, National Weather Service; Silver Spring, Maryland: NOAA Atlas 14, Volume 2, Version 3.

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream channel reference sites: An illustrated guide to field technique. General Technical Report RM-245. Fort Collins, CO: US Department of Agricultutre, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

Mecklenburg, D. 2006. "The Reference Reach Spreadsheet for Channel Survey Data Management, version 4.2L," Ohio Department of Natural Resources.

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

USGS. 1982. USGS Cross-sectional method, manual technique, USGS Water-Supply Paper 2175, "Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge", U.S. Government Printing Office.

7.0 APPENDICES

7.1 Appendix A – Photographs

7.2 Appendix B –Unified Subwatershed and Site Reconnaissance (USSR) Data Sheets

7.3 Appendix C – Community Awareness Survey

7.4 Appendix D - Surveyed Cross Sections, Particle Size Measurements and Thalweg Surveys

7.5 Appendix E – Benthic Macroinvertebrate and Fish Survey Data Sheets

7.6 Appendix F – Water Quantity and Water Quality Sampling