Special Protection Area Program Annual Report 2010

SPECIAL PROTECTION AREAS
MONTGOMERY COUNTY, MARYLAND




"The County Council finds that streams, rivers, wetlands, and other sensitive environmental features in Montgomery County constitute an important natural resource. ... Protection of fragile watershed areas will help restore and maintain the integrity of the Anacostia River, Potomac River, and Patuxent River within Montgomery County and the Chesapeake Bay."

Article V. Water Quality Review in Special Protection Areas,
Sec. 19-60. Findings and purpose.




Prepared by the Montgomery County Department of Environmental Protection in Cooperation With the Department of Permitting Services and the Maryland-National Capital Park and Planning Commission

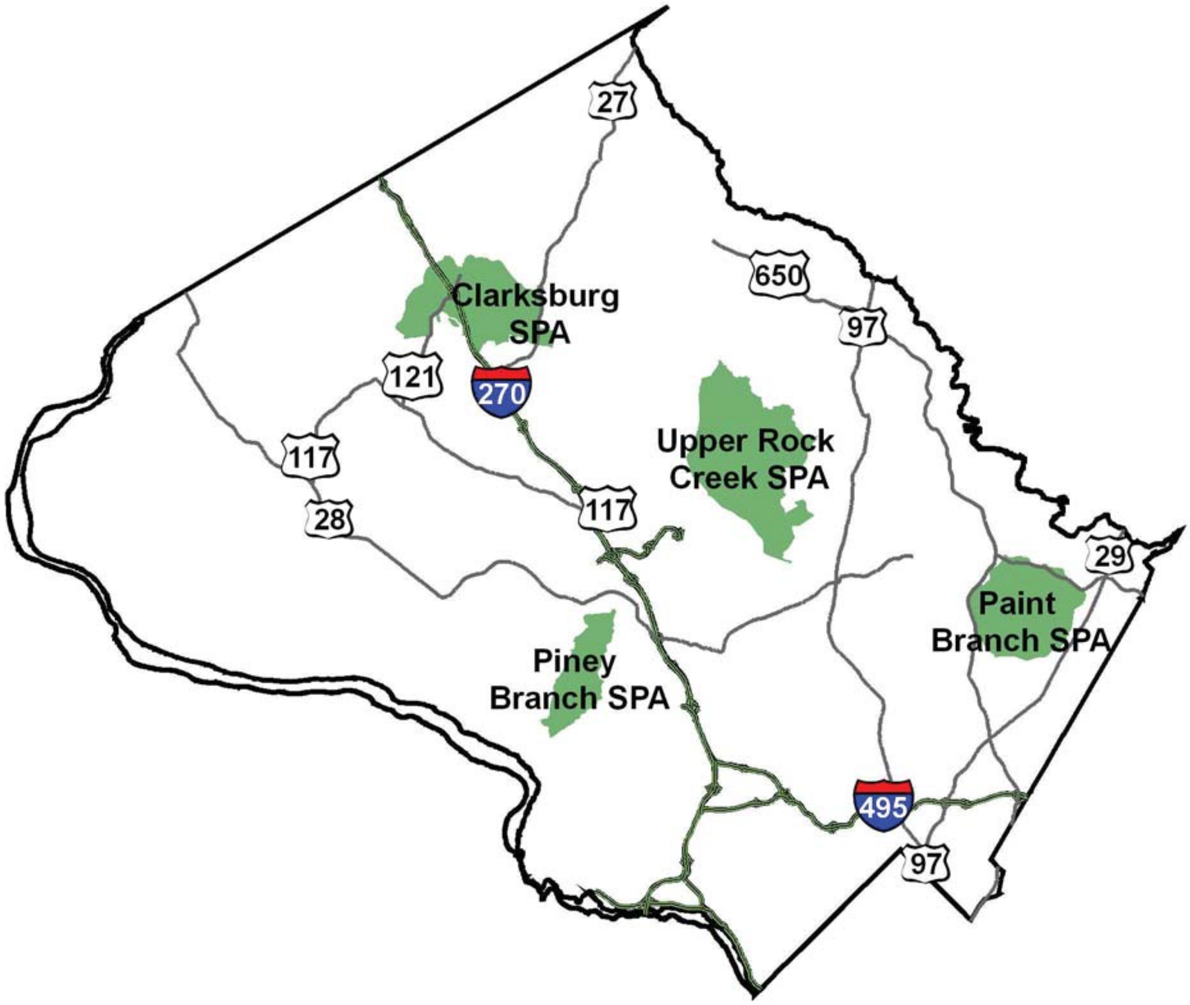
27
650
Clarksburg SPA
97
121
270
117
Upper Rock Creek SPA
117
28
29
Paint Branch SPA
Piney Branch SPA
495
97

Table of Contents

List of Figures

List of Figures (continued)

List of Tables

Executive Summary

This report fulfills the requirement in Montgomery County Code, Section 19-67(d) for the Departments of Environmental Protection (DEP) and Permitting Services (DPS) to prepare an annual report on “the effectiveness of best management practices and the observed impact of development on the biological integrity of streams in special protection areas.” The best management practices (BMPs) monitored for effectiveness were predominantly structural facilities such as sediment and erosion control (S&EC) basins that were monitored during construction, and stormwater management (SWM) facilities that were monitored after construction activity was completed. Special Protection Areas (SPAs) are areas designated by County Council where high quality water resources could be threatened by proposed land use changes. County Council has designated four SPAs: Upper Paint Branch, Piney Branch, Clarksburg, and Upper Rock Creek.

The DEP uses a stream condition rating system to determine the cumulative impact of development on the biological integrity of streams. The rating system establishes a numerical grade for a stream based on the type and number of organisms living in the stream. Stormwater runoff from development is one of the primary causes of reductions in the type and number of organisms in streams. Variations in the amount and distribution of precipitation and air temperature, however, also impact stream conditions. The results of the stream condition rating system indicate that there was a slight improvement in the biological integrity of SPA streams in 2010 compared to 2009.

The responsibility for monitoring the effectiveness of BMPs falls to the project developers who are required to monitor BMPs during and for a specified time after construction. The post-construction phase begins when land clearing activities, road construction and drainage infrastructure are complete, all of which help stabilize the conditions in the contributing drainage areas. A minimum of four years of post-construction monitoring is needed to be able to adequately interpret trends in stream conditions. The DEP and DPS identify the BMPs to be monitored by the project developer. The results of the BMP monitoring through 2010 indicate that both S&EC and SWM BMPs are performing well in reducing runoff volumes and pollutant loads during and after construction.

Biological Stream Monitoring

Clarksburg SPA

Within the Little Seneca and Cabin Branch portion of the Clarksburg SPA, stream conditions were rated *good* to *excellent* from 1995 to 2002. Construction began in the Clarksburg SPA Little Seneca area in 2002; the same year in which a record drought occurred. Stream conditions significantly deteriorated between 2002 and 2007, with some slight improvement in 2008. In 2009, the streams in Clarksburg stayed much as they were in 2008 with the exception of one station draining a portion of the Newcut Road development that improved from *fair* to *good*.

Of the 11 stations monitored in both 2009 and 2010 within the Little Seneca and Cabin Branch watersheds, stream conditions remained unchanged in eight, improved in two, and declined in one. One of the two stations with improved stream conditions in 2010 was in the Cabin Branch Neighborhood and the other was in the mainstem of Little Seneca Creek. No development occurred above the Cabin Branch monitoring station and only minor development occurred above the Little Seneca station. The station where stream conditions declined receives runoff from the Town Center Tributary and areas currently being developed.

Of the nine stations monitored in both 2009 and 2010 within the Ten Mile Creek watershed, stream conditions remained unchanged in six stations and improved in three. Of the three stations that improved, one is in the mainstem of Ten Mile Creek, one is the King Spring Tributary and the third is in the area of Ten Mile Creek that receives runoff from the Correctional Facility, I-270, and portions of Stringtown Road. What caused the improvements at these stations is not known, especially since the other stations in the watershed had no change in stream conditions.

Much of the development in Clarksburg is occurring within the drainage areas of small headwater streams. Benthic macroinvertebrates rather than fish tend to provide a better indication of water quality and stream health in these small streams because of physical habitat size and other limitations. The habitat, flow, and physical/chemical conditions of headwater streams can support a rich and diverse benthic macroinvertebrate community, but is unlikely to support a rich and diverse fish community; therefore the DEP used macroinvertebrates to assess the health of the small headwater streams.

The stream conditions in headwater areas in the Little Seneca Creek watershed undergoing development were compared to those in a nearby control set of headwater streams having drainage areas that were undeveloped. Mean stream conditions in the control and test stations were both *good* prior to development, but diverged in 2003 after development activities started in the drainage to the test stations (i.e., those areas under construction). In 2009, the mean stream conditions at the test stations were in *fair* condition for benthic macroinvertebrates. In 2010, the mean stream conditions improved to *good*. The improvement may be due to stabilization in the drainage areas to the test stations although other factors could also have contributed. For instance, conditions throughout the County improved in 2010 due to favorable meteorological factors.

Upper Paint Branch SPA

Most of the development within the Upper Paint Branch SPA occurred in the Right Fork of the Upper Paint Branch. Pre-development stream conditions (1994-1998) were predominantly *excellent*. The 2010 stream conditions in the Upper Paint Branch SPA were *good*. It is anticipated that post-construction stream conditions in the Right Fork are likely to recover to near pre-construction level stream conditions since the composition of the biological community has not been greatly altered.

In 2010, brown trout, one of the most sensitive fish species to stream degradation and water quality impairment in Montgomery County, were still present in the Upper Paint Branch SPA.

The Upper Paint Branch SPA had a 10 percent impervious cap per-project from 1995-2006 which was then reduced to an eight percent impervious surfaces cap.

Piney Branch SPA

Much of the development in the upper Piney Branch portion of the SPA has occurred since 1998. Stream conditions dropped from predominantly *fair* to *fair* and *poor* following SPA designation. In 2010, the stream conditions below the Traville area were *good*. Within the Traville area stream conditions were *fair*. It is difficult to draw conclusions about these changes as major portions of the Piney Branch SPA were either already developed or developing before the SPA Regulations became effective and therefore, no baseline data exists.

Upper Rock Creek SPA

Water quality in the small headwater streams monitored for the Upper Rock Creek SPA has remained consistently *good* since SPA monitoring began in 2004. These streams will receive drainage from the major developments planned for the Upper Rock Creek SPA. One of these developments, Phase 1 of the Reserve at Fair Hill, broke ground in 2007. A station below and to the east of the intersection of Muncaster Road and Willow Oak Drive has had no development, and improved from *fair* in 2008 to *good* in 2010. The Upper Rock Creek SPA has an eight percent impervious surface cap for the residential zones in the watershed.

BMP Monitoring

Of the 26 projects monitored for BMP effectiveness in 2010, seven were in pre-construction, 14 projects were in the "during construction" phase, and five projects were in the post construction phase. Much of the BMP monitoring in the Clarksburg SPA was in the "during construction" phase in 2010. Some properties had been stabilized with S&EC basins in the process of being converted to SWM facilities. In the Upper Paint Branch SPA, the majority of projects were in post-construction and monitoring has been completed. In the Upper Paint Branch SPA, post construction monitoring began in 2009 in Briarcliff Meadows for groundwater levels and water chemistry as well as pollutant removal efficiency. In the Piney Branch SPA, the only monitoring project still active during 2010 was Traville where post construction monitoring began.

The Clarksburg SPA is the only SPA which is slated for significant new development. It is also the SPA with the highest intensity of planned development and includes the most candidate projects for BMP monitoring. Currently, DEP has limited areas with post-construction monitoring within Clarksburg. The five areas having completed post-construction monitoring requirements are shown in Figure ES-1, and include All Souls Cemetery, Clarksburg Correctional Facility, Parkside, Running Brook, and Timbercreek. Gateway 270 and Summerfield Crossing are currently in post construction monitoring

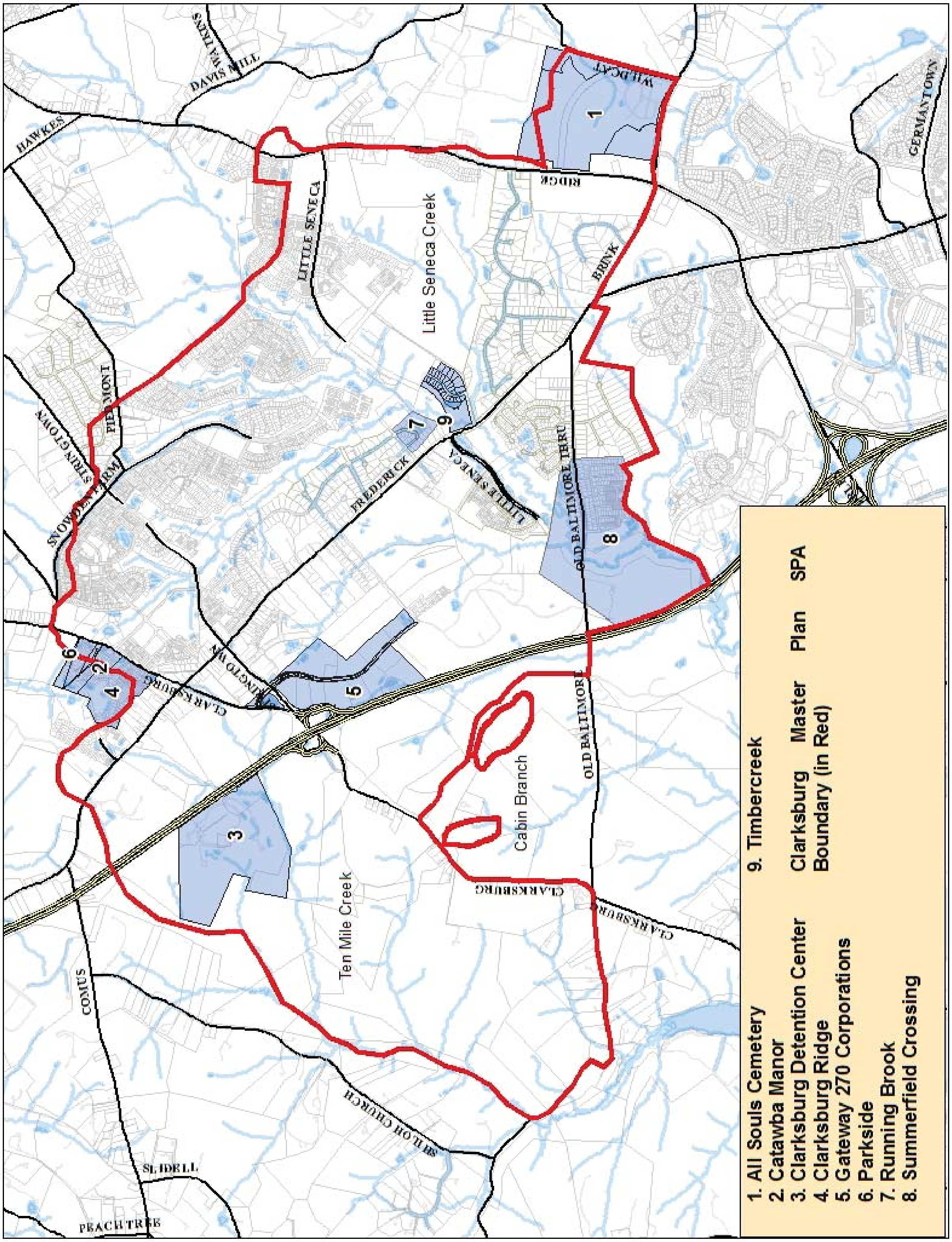

Figure ES- 1. All Properties (in blue) within the Clarksburg SPA where Stormwater Management BMP's have been monitored as of 2010. For a detailed map of BMP monitoring status in the Clarksburg SPA refer to Figure 3.2.

Two projects in the Upper Rock Creek SPA were monitored in 2010 for BMP effectiveness. The first project was the Reserve at Fair Hill, which began monitoring the "during construction" phase in May 2007. Hydrologic characteristics (groundwater elevation and chemistry, peak stream flow, and stream geomorphology) are being monitored. The second project is the Preserve at Rock Creek, which in 2010 completed pre-construction monitoring and data collection will continue once construction begins.

Conclusions

Many of the streams in the SPAs are small headwater streams that are extremely sensitive to changes in the surrounding soils, drainage features, groundwater recharge and diffuse rainfall infiltration as evidenced by changes in stream morphology and hydrology noted in Chapter 4. These changes become accentuated as the landscape alterations required for roads, utilities, lot grades, storm drains and other infrastructure increase to accommodate development.

The effects of impervious surface first become evident through the grading and compaction activities that occur throughout a site as noted in Chapter 4. Naturally pervious soils and a diffuse infiltration system are altered and/or lost through the cut and fill requirements.

BMP monitoring has demonstrated that the use of multiple or sequential features to create a treatment train for reducing stormwater runoff and decreasing pollutant loadings has been more effective than the use of individual structures. BMP feature placement in the treatment train is also an important consideration in optimizing BMP performance and mitigating impacts to receiving streams.

Stream conditions showed improvement during 2010 in the Clarksburg and Upper Paint Branch SPAs. However, post-construction monitoring has just begun for a large portion of the Clarksburg watershed. Although results are hopeful, it is unknown whether stream conditions will improve to pre-construction conditions.

1. Introduction

1.1 Purpose

The Special Protection Area Report summarizes the monitoring conducted in streams and on *Best Management Practices (BMPs)* within Special Protection Areas (SPAs). The SPA reports are submitted to the County Executive and County Council with a copy to the Planning Board. The report is also available on the DEP website at http://www.montgomerycountymd.gov/dectmpl.asp?url=/content/dep/water/spareports.asp. Reports follow standard scientific format and contain trend analysis including descriptive statistics and graphical interpretation of biological indices and habitat assessments. The biological condition of each station is compared to the appropriate reference condition.

This 2010 SPA Annual Report meets the requirements of Montgomery County Code Chapter 19, Article V (*Water Quality Review: Special Protection Areas*), Section 19-67. The Special Protection Area (SPA) program is implemented through Executive Regulation 29-95: *Water Quality Review for Development in Designated Special Protection Areas*.

1.2 Background

1.2.1 SPA Program

The SPA program was initiated in 1994 by County law. According to the Montgomery County Code, Section 19-61(h), a Special Protection Area is defined as:

> "a geographic area where":
> (1) existing water resources, or other environmental features directly relating to those water resources are of high quality or unusually sensitive; and
> (2) proposed land uses would threaten the quality or preservation of those resources or features in the absence of special water quality protection measures which are closely coordinated with appropriate land use controls."

Four areas within Montgomery County are designated as SPAs (Figure 1.1). In 1994, The Clarksburg Master Plan approved the creation of the first SPA with the establishment of the Clarksburg SPA. In 1995, Piney Branch and Upper Paint Branch were designated as SPAs by separate Council Resolutions. The Piney Branch SPA lies within the Potomac Master Plan and Great Seneca Science Corridor Master Plan (formerly Gaithersburg West Master Plan). The Upper Paint Branch SPA is covered by the Master Plans of Cloverly, Fairland, and White Oak. The Upper Rock Creek was designated as an SPA on February 24, 2004, with the adoption of the Upper Rock Creek Master Plan and on March 15, 2005 with the adoption of the Olney Master Plan. All four SPAs have existing water resources or other environmental features that are of high quality or unusually sensitive.

The Piney Branch SPA and the Clarksburg SPA were created with very limited or no *imperviousness* cap for new development (in the Clarksburg Master Plan, there is a 15% impervious limit recommended for industrial sites on the west side of I-270). As the importance of minimizing imperviousness levels to maintain healthy stream conditions became better understood, the establishment of the Upper Paint Branch SPA was accompanied by an *Environmental Overlay Zone*, adopted in July 1997. The 1997 environmental overlay zone included a 10% impervious cap on new development, as well as restrictions on specific land uses that typically have significant adverse environmental impacts on sensitive natural resources. This Overlay Zone was amended in 2007 to revise the imperviousness limit for new development downwards to 8%. The Upper Rock Creek SPA designation was accompanied by an Environmental Overlay Zone on October 26, 2004, which designates an 8% imperviousness limit on new private residential subdivisions that are served by community sewer.

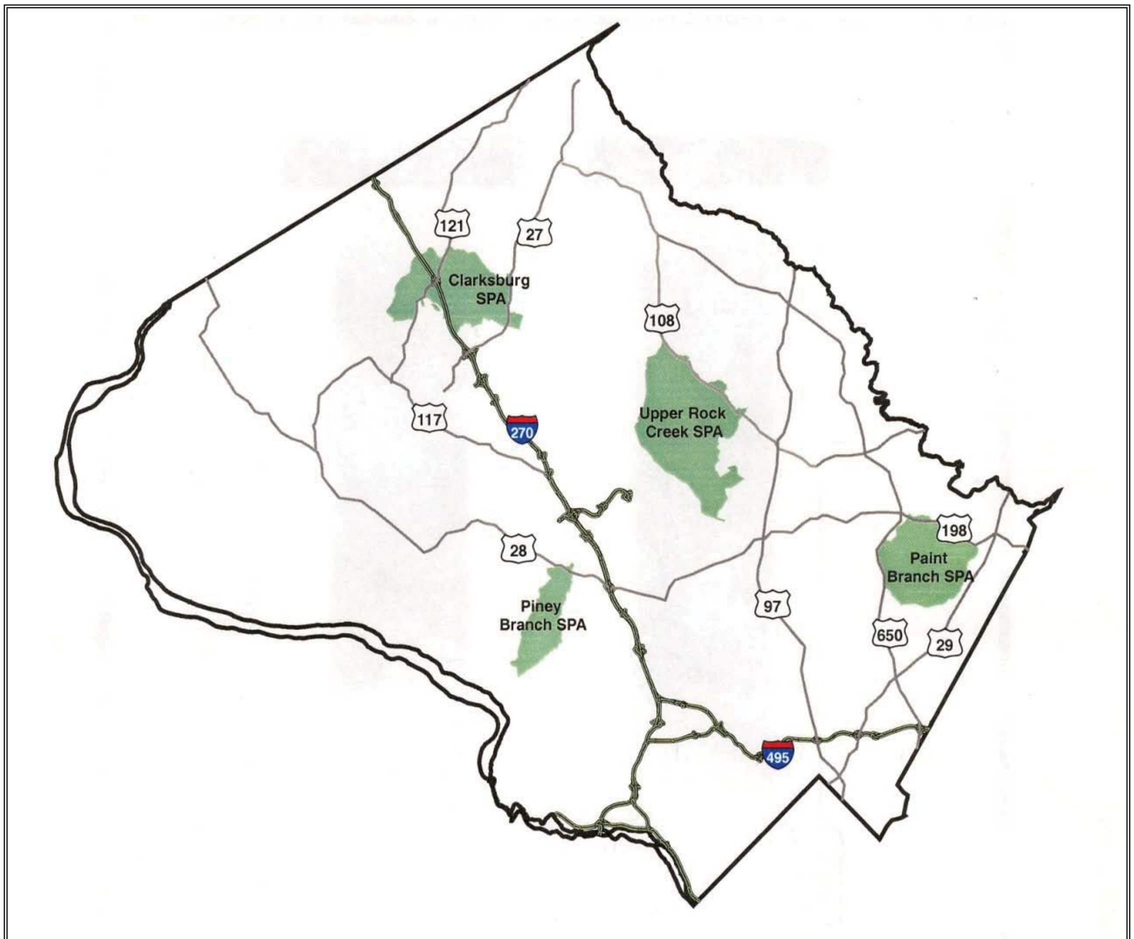

Figure 1.1. Location of Special Protection Areas in Montgomery County.

The SPA program requires the Montgomery County DPS, the DEP, and the Maryland-National Capital Park and Planning Commission (M-NCPPC) to work closely with project developers from the onset of the regulatory review process to avoid or minimize adverse impacts to SPA stream conditions. SPA permitting requirements guide the development of concept plans for site imperviousness, site layout, environmental buffers, forest conservation, *Sediment and Erosion Control (S&EC)*, and *Stormwater Management (SWM)*.

1.2.2 **Monitoring in Special Protection Areas**

Monitoring of S&EC and SWM BMP structures is required as part of the SPA program (Section 3). The SPA BMP monitoring program requires developers to evaluate the ability of BMPs to minimize development impacts to the receiving streams. S&EC BMPs are installed on the construction site before initial land disturbing activities begin. They are designed to capture sediment-laden runoff generated during construction. After construction is complete and the site is stabilized, S&EC BMPs are converted to SWM BMPs or separate SWM BMPs are installed to attenuate storm flows (quantity control) and capture *pollutants* (quality control).

In conjunction with the monitoring performed by the developer, DEP performs physical stream characteristic (Section 4) and biological stream monitoring (Section 5) to study the cumulative effects of development in the watershed.

The Clarksburg Monitoring Partnership (CMP) conducts additional monitoring within the Clarksburg Master Plan area. The CMP is a consortium of local and federal agencies and universities. The CMP offers a collaborative approach to monitoring the long term aquatic ecosystem changes resulting from the associated landscape transition from agricultural to medium and high density residential, commercial, and industrial land use. Results from the CMP are used to help support stormwater design manual monitoring requirements under the County's Municipal Separate Storm Sewer System (MS4) permit.

The CMP is using a *Before, After, Control, Impact (BACI) design* approach (Fig. 1.2) to assess the land use changes and the impacts to stream conditions. Three test areas were selected: two in the Newcut Road Neighborhood and one in the Cabin Branch Neighborhood (Fig. 1.2). An undeveloped control area was established in Little Bennett Regional Park and a final developed control area was set up in Germantown (Fig. 1.2). All the test and control areas have United States Geological Survey (USGS) flow gages installed and are collecting continuous stream flow data over time. Two rain gages monitor area rainfall and document local rainfall intensities to correlate rainfall to stream flow. Light Detection and Ranging (LiDAR) imagery will assist in the mapping of landscape changes as a result of the terrain alterations in Clarksburg.

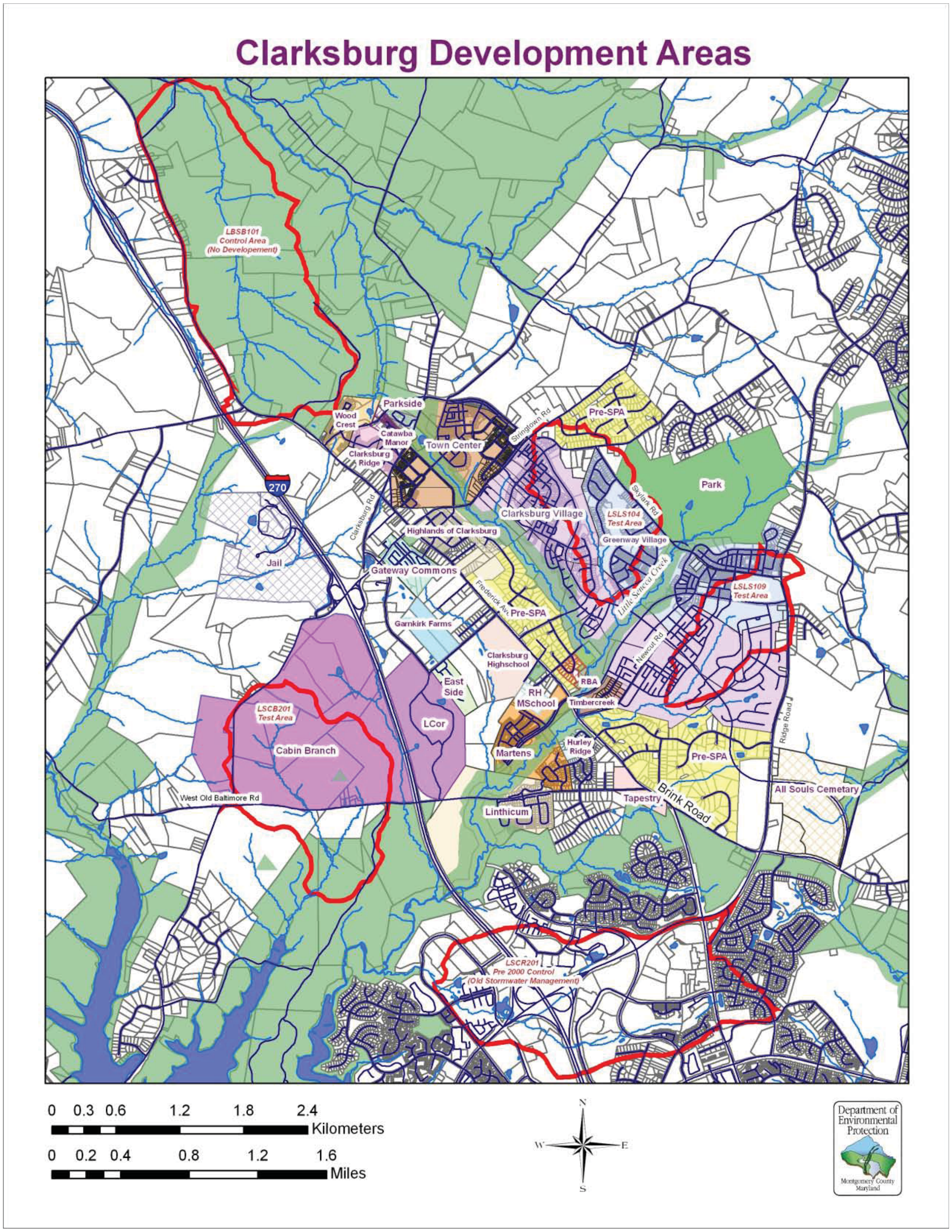

Figure 1.2. Location of the Clarksburg Monitoring Partnership BACI Three Test Areas and Two Control Areas.

2. SPA Water Quality Review Plan and BMP Monitoring Review Process

Any development activity on privately or publicly owned land (unless specifically exempted) must go through the water quality review process. This section summarizes the plan review process used to approve the design and layout of BMPs in an SPA. The section also provides a summary on development of monitoring plans and requirements. Additional details can be found in the Technical Appendix 3.

2.1 Water Quality Plan Review Process

2.1.1 Pre-application Meeting

Prior to submission of the *water quality inventory* and formal water quality plans for review and approval, an applicant for development must submit a written request and attend a pre-application meeting with DPS, DEP, and M-NCPPC. The meeting provides for advance discussion of:

- Proposed performance goals that are to apply to the development of the site;
- The conceptual approach and possible locations of preferred structural and non-structural BMPs and their estimated suitability for achieving the performance goals;
- Approaches to minimize impervious surfaces or in some cases limit these surfaces to a regulatory cap, maximize protection of environmentally-sensitive areas such as streams, wetlands, and their buffers, and meet or exceed Forest Conservation Law requirements; and
- Develop innovative site layouts and linked best management practice options to maximize protection of water quality, stream habitat, and aquatic life.

Performance Goals

Before the pre-application meeting, DPS reviews the plans and establishes site-specific performance goals. DEP then works with DPS to determine how achievement of these goals can be documented through monitoring. Some performance goals are met by the site design and cannot be directly measured. DEP also advises the applicant of any available results and analysis of stream monitoring in the subwatershed of interest. M-NCPPC evaluates the plans and aids the applicant in ensuring the development project meets the Planning Board's Environmental Guidelines, minimizes or meets regulatory limits on impervious surfaces, and meets Forest Conservation Law requirements. DPS provides recommendations on S&EC and SWM measures that are appropriate for the proposed development. Following this discussion, the applicant circulates minutes recorded during the meeting for the group's evaluation and approval.

Performance goals aim to:

1. **Protect stream/aquatic life habitat.**
2. **Maintain stream base flow.**
3. **Protect seeps, springs, and wetlands.**
4. **Maintain natural on-site stream channels.**
5. **Minimize storm flow runoff increases.**
6. **Identify and protect stream banks prone to erosion and slumping.**
7. **Minimize increases to ambient water temperature.**
8. **Minimize sediment loading.**
9. **Minimize nutrient loading.**
10. **Control insecticides, pesticides, and toxic substances.**

2.1.2 **Preliminary and Final Water Quality Plan Submission**

Following approval of the pre-application meeting minutes, preliminary and final water quality plans are developed and submitted to the respective lead agencies for their review and approval. Elements of these plans include preservation of *environmentally sensitive areas* and priority forest conservation areas, SWM concept plans, S&EC concept plans, documentation of impervious areas, BMP monitoring plans, and description of other mitigation practices including minimization of road widths and use of open section roads. Public notice of the submission of the preliminary water quality plan is made by DPS so that a public information meeting can be held if requested. The Planning Board gives approval to specific components of a water quality plan after DPS approves the plan components required under their review. Some plans can be submitted as a combined preliminary/final water quality plan.

With the exception of the Upper Paint Branch SPA and the Upper Rock Creek residential developments served by public sewer, only a water quality inventory instead of a full water quality plan is necessary if:

1) A project on agricultural, residential, or mixed use zoned property contains a proposed impervious area of less than 8% or a cumulative area of 10 or fewer acres and a proposed impervious area of less than 15% of the total land area.

2) A project on property zoned for industrial or commercial use consisting of a cumulative land area of two or fewer acres covered by the development approval application.

A water quality inventory consists of most of the information that is typically required in a water quality plan and includes a stormwater management concept plan, a sediment control concept plan, and documentation of impervious areas. A water quality inventory does not require a monitoring plan with anticipated performance goals and does not require a public noticing period. The SPA law and regulations also do not require Planning Board review and approval of the inventory.

Once DPS approves its components of a water quality plan, DPS issues a letter detailing its conditions of approval, including the BMP monitoring requirements. The Planning Board must also review and approve specific components of the water quality plan in order for a land development project to move forward. Applicants required to conduct monitoring must collect at least one year of data documenting baseline conditions prior to construction. DEP and DPS must approve the data and report submission documenting baseline conditions prior to any construction activities taking place on the site.

2.1.3 **Issuance of Permits and Bonds**

DPS is responsible for the issuance of permits and the enforcement of bonds. DEP works closely with DPS to ensure that monitoring is being completed as specified and that the construction site is in compliance. DPS sediment inspectors may issue a Notice of Violation if the site fails to remain in compliance. The sediment control permit is closed and released following final inspection and approval of SWM as-built plans.

As of 2008, DPS has been issuing a separate BMP monitoring permit after the sediment control permit has been closed at sites required to do post construction monitoring. The bond amount for the BMP monitoring permit is established by DEP based on the anticipated cost of monitoring. Previously, the original sediment control permit and bond was left in place until the post construction monitoring was completed. A separate post construction monitoring permit allows for the sediment control permit to be closed, the bond amount to be reduced, and adds an extra level of enforcement and assurance that the monitoring is being completed as required. If the owner of the property (or the owner's consultant) does not complete the monitoring and reporting according to the approved final water quality plan and county regulations, the bond can be used by the county to complete the required monitoring tasks. The bond is released after completion of post construction monitoring and approval of final data and report submissions to DEP and DPS. DPS continues to coordinate with DEP on the transfer of completed SWM facilities to DEP for structural maintenance and review and inspection of maintenance activities.

2.2 BMP Monitoring Review Process

The goal of the BMP monitoring program is to assess the effectiveness of SPA S&EC structures and SWM structures in maintaining water quality. A monitoring plan is designed to evaluate the effectiveness of BMPs, innovative site design and achievement of site performance goals. SPA BMP monitoring often includes monitoring of: groundwater elevations, groundwater chemistry, instream temperature, instream (surface water) chemistry, stream *base flow* and storm flow, *stream geomorphology*, *total suspended solids (TSS),* and pollutant loading reductions. Monitoring follows the procedures outlined in the DEP Best Management Practice Monitoring Protocols (DEP 1998).

The information collected, when combined with data from the County's biological stream monitoring program, is used to evaluate the effectiveness of the County's current BMP designs over a range of drainage areas, land use, and impervious levels in protecting water quality. Recognizing practical site conditions, feasibility, and cost considerations, BMP monitoring is not required for all SPA development projects. There are many projects where, because of the relatively small property sizes or other reasons, no BMP monitoring is required.

2.3 SPA BMP Technology

The requirements for design of S&EC structures in SPAs currently exceed the minimum requirements set forth by the Maryland Department of the Environment (MDE). Redundancy and over-sizing of structures are the primary measures used to improve performance.

2.3.1 **Sediment and Erosion Control (During Construction)**

Montgomery County has adopted a number of features for S&EC including:

- basins with *forebays*,
- filter fence baffles,
- floating skimmers,
- dual basins in series,
- greater storage volumes, and
- utilizing combinations in the form of a treatment train to improve performance.

The S&EC Plans in SPAs emphasize redundant treatment. The current standard design requirement for S&EC in SPAs is to provide oversized basins with forebays, extend the travel path of the runoff as it goes through the pond, and promote the use of super silt fencing.

2.3.2 **Stormwater Management (Post Construction)**

The MDE 2000 Maryland Stormwater Design Manual provides unified stormwater sizing criteria that specify how stormwater structures are designed. The three minimum components necessary to meet state stormwater management requirements are:

- *water quality volume (WQv)*
- *channel protection storage volume (Cpv)*
- *recharge volume (Rev)*

The water quality volume is approximately the first inch of rain over the impervious area and treats the "*first flush*" of contaminants coming off of impervious surfaces. In SPAs, redundant controls, also known as *treatment trains*, are required for stormwater quality control. Treatment trains utilize different types of non-structural and structural BMPs in series.

The allowable drainage area to any one filtering structure has decreased drastically since the SPA program started. Originally, there were only guidelines and no set limits for drainage areas to a filtering structure. The drainage area limit has decreased over the years to its current limit of three acres to a surface sand filter and one acre for all other water quality structures (including biofilters, *infiltration trenches*, and proprietary structures). This was done to increase the efficiency of the structures and to limit the area that is not treated (or is minimally treated) as the filtering structures become clogged and require maintenance. Additionally, runoff from areas intended for vehicular use must be pretreated prior to entering the water quality structure. This is typically done using a vegetated filter strip or a *hydrodynamic structure*.

The *channel protection storage volume* (also called the water quantity volume) is the volume necessary to hold the *one-year 24 hour storm,* approximately 2.6 inches of rainfall. Storage and slow release of the channel protection volume is intended to protect streams from erosion due to high velocity water scouring the banks. In the SPAs, the requirement for control of the one-year storm event was in place prior to the adoption of the 2000 MDE manual.

The *recharge volume* is intended to maintain the groundwater table and natural hydrology. Groundwater recharge has also been a requirement for developments in the SPAs from the beginning of the program. The adoption of the 2000 MDE Stormwater Design Manual provided additional methods to consider for providing groundwater recharge as well as the minimum recharge volume that must be provided.

The MDE has new regulations to implement the Stormwater Management Act of 2007. These regulations require the use of *Environmental Site Design (ESD)* practices wherever possible to control runoff and pollution from both new development and redevelopment. ESD requires integrating site design, natural hydrology, and smaller controls to capture and treat runoff, to better maintain natural drainage pathways and minimize development impacts to receiving streams.

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3. BMP Effectiveness

SPA BMP monitoring projects are evaluated based on BMP efficiency, performance, and effectiveness. Developers are responsible for funding the monitoring within their property's limits to document achievement of the SPA performance goals set at the beginning of the SPA development process as part of the Water Quality Review Process detailed in Section 2.1. They do this by paying a monitoring fee in order for DEP to evaluate stream characteristics (Section 4) and conduct biological monitoring (Section 5); and by hiring consultants to conduct BMP monitoring (Section 3).

BMP efficiency compares the amount of pollution entering the BMP to the amount of pollution leaving the BMP. Either pollutant concentrations from grab samples or loading values from flow-weighted samples collected by automated samples are used for this measure.

BMP performance evaluates how well the BMP is removing pollutants compared to literature values.

BMP effectiveness is the ability of the BMP and site design to meet one or more of the SPA program performance goals.

3.1 2010 SPA BMP Monitoring Status

There are a total of 51 monitoring projects as of 2010. Status of the BMP monitoring projects being conducted in 2010 as part of the SPA program is shown in Figure 3.1. A list of parameters monitored per project is located in Technical Appendix 3.

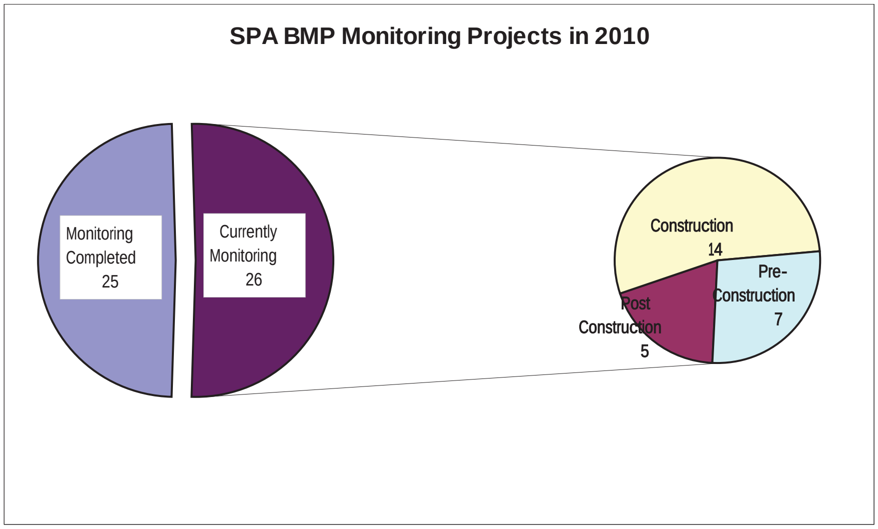


Figure 3.1. SPA BMP Monitoring Project Completion Status in 2010.

Completed Monitoring Projects

In 2010, two projects (Forest Ridge and Clarksburg Ridge) satisfied monitoring requirements, making for a total of 25 with completed monitoring. Monitoring at the Forest Ridge Development in the Paint Branch SPA consisted of cross-sections, embeddedness, ground water elevation, ground water chemistry, and stream temperature. Monitoring at the Clarksburg Ridge development consisted of stormwater management best management practice (SWM BMP) pollutant removal efficiency. TSS grab samples were also collected during construction for both projects. Results are discussed in Sections 3.2 to 3.4.

Ongoing Monitoring Projects

There were 26 ongoing SPA BMP monitoring projects in 2010. Seven of these projects are in the pre-construction monitoring phase, the majority of which have satisfied baseline monitoring requirements and are awaiting groundbreak. The Goddard School in Clarksburg and Laytonia Recreational Park (Upper Rock Creek SPA) were the only projects actively collecting baseline data in 2010.

Fourteen projects are classified as in the "during construction" monitoring phase in 2010. Six of these are undergoing active site construction. Groundbreak occurred at the following sites: Phase II of Clarksburg Village, Gallery Park (formerly known as "Eastside"), and Paint Branch High School. The following projects remain in various stages of construction: Greenway Village Phases III-V (Clarksburg SPA), Gateway Commons (Clarksburg SPA) and Reserve at Fair Hill (Upper Rock Creek SPA).

Three projects collected information on BMP efficiency during construction; TSS sampling was initiated at Paint Branch High School, while Clarksburg and Greenway Villages continued to conduct TSS sampling at representative sediment basins. The Maydale Stream Restoration Project (Paint Branch SPA) was completed in October 2010 and post-construction monitoring is expected to commence in 2011. The goals of the stream restoration project were to remove the fish blockages, improve instream and riparian habitat, and minimize sediment loadings.

The remaining projects considered in the "during construction" monitoring phase have been stabilized and converted to stormwater management. These seven projects are awaiting as-built approval and certification, and issuance of a post construction monitoring bond, to move into the post-construction monitoring phase.

Five projects are in the post construction monitoring phase: three in the Clarksburg SPA (Greenway Village – Phases I-II, Parkside, and Summerfield Crossing), one in the Upper Paint Branch SPA (Briarcliff Meadows), and one in the Piney Branch SPA (Traville). Three of these projects collected information on SWM BMP technology in 2010 (Parkside, Summerfield Crossing, and Briarcliff Meadows). Automated samplers were installed at one BMP structure at Traville, but no samples were collected. Greenway Village Phases I and II did not have automated samplers deployed in 2010 but are commencing structural monitoring in 2011.

3.1.1 **Clarksburg SPA Project Status**

Much of the Clarksburg Special Protection Area still remains in the during construction monitoring phase but many properties have largely been stabilized, with some S&EC basins converted to SWM facilities (Fig. 3.2).

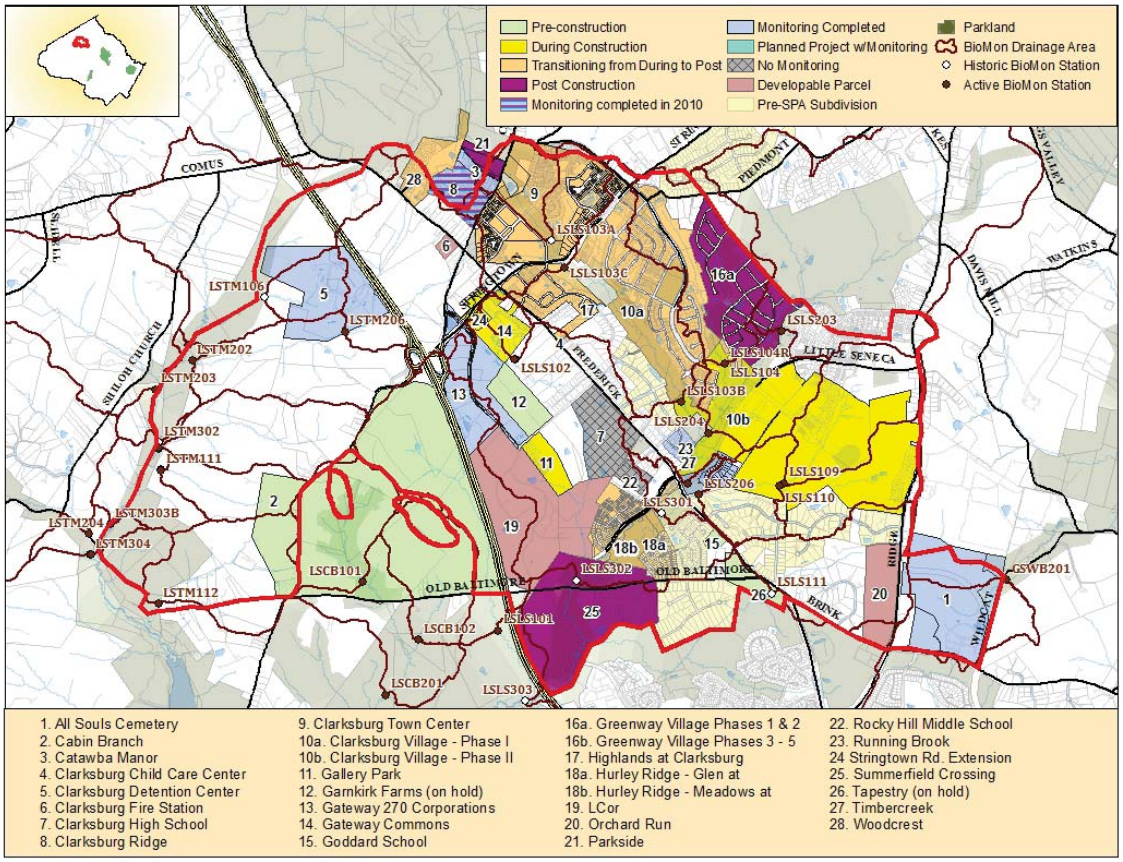


Figure 3.2. 2010 Status of Clarksburg SPA Monitoring Projects.

Four projects have not started construction, but one, the Cabin Branch Neighborhood, is anticipated to begin construction in 2011. Baseline monitoring requirements for the 530 acre Cabin Branch development (Fig. 3.2, property 2) were satisfied in December 2009. Development is scheduled to occur in phases but has been on hold. Currently, groundbreak is anticipated to take place in 2011. The Garnkirk and Tapestry developments (Fig 3.2; properties 12 and 26, respectively) also remained on hold in 2010. Baseline data collection on groundwater characteristics at the Goddard School began in late 2010 (Fig. 3.2; property 15). Two wells were drilled in September 2010, but have been reported as "dry" since the initiation of monitoring. The wells will continue to be monitored monthly and if water is noted, level loggers will be installed to continuously monitor water elevations. Ground water chemistry samples will be collected on a quarterly basis if water is present. During construction only the well closest to the largest turf filter will be monitored (as described above). A turf filter (a.k.a., filter strip) is a densely vegetated, uniformly graded area that treats sheet flow from adjacent impervious surfaces. Filter strips function by slowing runoff velocities, trapping sediment and other pollutants and providing some infiltration. They are frequently planted with turf grass or other types of grass that promote nutrient uptake. Sediment removal efficiency will be monitored at the largest active sediment trap using automated samplers to collect flow-weighted composite samples. Monitoring of a turf filter will commence during post construction to determine pollutant removal efficiency and to evaluate whether the turf filter promotes infiltration and ground water recharge.

Two major developments broke ground in 2010: Clarksburg Village Phase II (on the east side of Little Seneca Creek) and Gallery Park (formerly known as Eastside). Construction on Phase II in Clarksburg Village (Fig. 3.2; property 10b) began August 2010. Data collection on stream temperature, embeddedness, groundwater elevations, and discrete flow will begin in the spring of 2011. Construction on Gallery Park (Fig. 3.2; property 11) began in January 2010. All S&E facilities were completed by May. Mass grading activities were initiated and were still ongoing at the end of 2010. Data collection consisted of groundwater elevation at 1 location from August thru December, geomorphic surveys at 3 locations, and photo documentation at all outfalls. TSS sampling is a requirement during construction, but was not initiated in 2010 due to pond configuration issues which were not resolved until December; sampling is scheduled to begin in the spring of 2011. Automated, flow-weighted composite sampling for pollutant removal efficiency will commence at both properties once the sediment basins are converted to storm water management.

Of the remaining eight projects considered in the “during construction” monitoring phase only Clarksburg Town Center, Gateway Commons, and Greenway Village Phases III-V actively conducted monitoring. Five of these projects are awaiting as-built approval and certification, and issuance of a post construction monitoring bond, to move into the post-construction monitoring phase.

Three projects are in the post-construction monitoring phase. A temperature study begun in 2009 at the sand filter in Parkside continues in 2010. SWM BMP pollutant removal efficiency sampling which began in 2008 at a Clarksburg Ridge treatment train (surface sand filter with BaySaver BaySeparator™ pre-treatment) culminated in 2010. Problems collecting water samples in the inlet due to clogging of the structure, turbulence or uncertainty if the runoff went through the bypass outlet or into the BaySeparator made prior successful sampling collection extremely difficult despite the consultant’s best efforts. In 2010 a variety of technical issues were encountered with the equipment which precluded successful collection of any further storm samples. Based on the limited data obtained, the decision was made to release the bond and absolve the developer of any future post-construction monitoring requirements. Further monitoring of this structure is under consideration through a proposed joint funding agreement with USGS and USEPA with the intent that the data will be analyzed in future SPA reports. A Stormfilter® and a surface sand filter-dry pond treatment train were monitored in the Summerfield Crossing development starting in December of 2009. In 2010, data on pollutant removal efficiency was successfully collected for three storms. A temperature study to determine impacts to Little Seneca Creek from the Milestone tributary as a result of this project has also been underway since 2003. Running Brook had many monitoring problems, primarily due to structure design which limited sampler placement and no usable data were produced. Additional monitoring was not conducted since continued problems with data collection were anticipated.

3.1.2 **Upper Paint Branch SPA Project Status**

The majority of projects in the Upper Paint Branch SPA have completed monitoring (Fig. 3.3). Monitoring requirements at the Forest Ridge development were fulfilled in 2010. Monitoring results for this completed project are summarized in Section 3.1.

In 2009, a pre-application meeting was held for one of the last large developable parcels in Paint Branch, the Anselmo property. The Final Water Quality Plan for this project still has not been approved. All other recent development applications have been for small construction activities.

Two public school improvement and expansion projects, Fairland Elementary School and Paint Branch High School were initiated in 2010. Data on the existing SWM BMP system in the parking lot at Fairland Elementary School were collected, but sampling errors and a change in post construction SWM configuration caused the monitoring requirements to be dropped. Paint Branch High School is collecting data on during construction and post construction structural BMPs for the portion of the site lying in the SPA (2.75 acres). Groundbreak at Paint Branch High School took place in March 2010. Quarterly TSS monitoring was conducted at one S&EC structure. An issue with inlet pipe elevations resulted in an extremely small drainage area for a portion of the monitoring period, making sampling and analysis challenging. Construction on this property is taking place at a rapid rate and the structure being monitored is scheduled to be converted to SWM in the spring of 2011.

A stream restoration project at the Maydale Nature Center was completed in October 2010. Pre-restoration data collection and survey work occurred in 2009 and early 2010. The project involved removal of fish blockages and other stream habitat improvement measures, bank stabilization, and wetland protection. The first year of post construction monitoring is scheduled to begin in 2011.

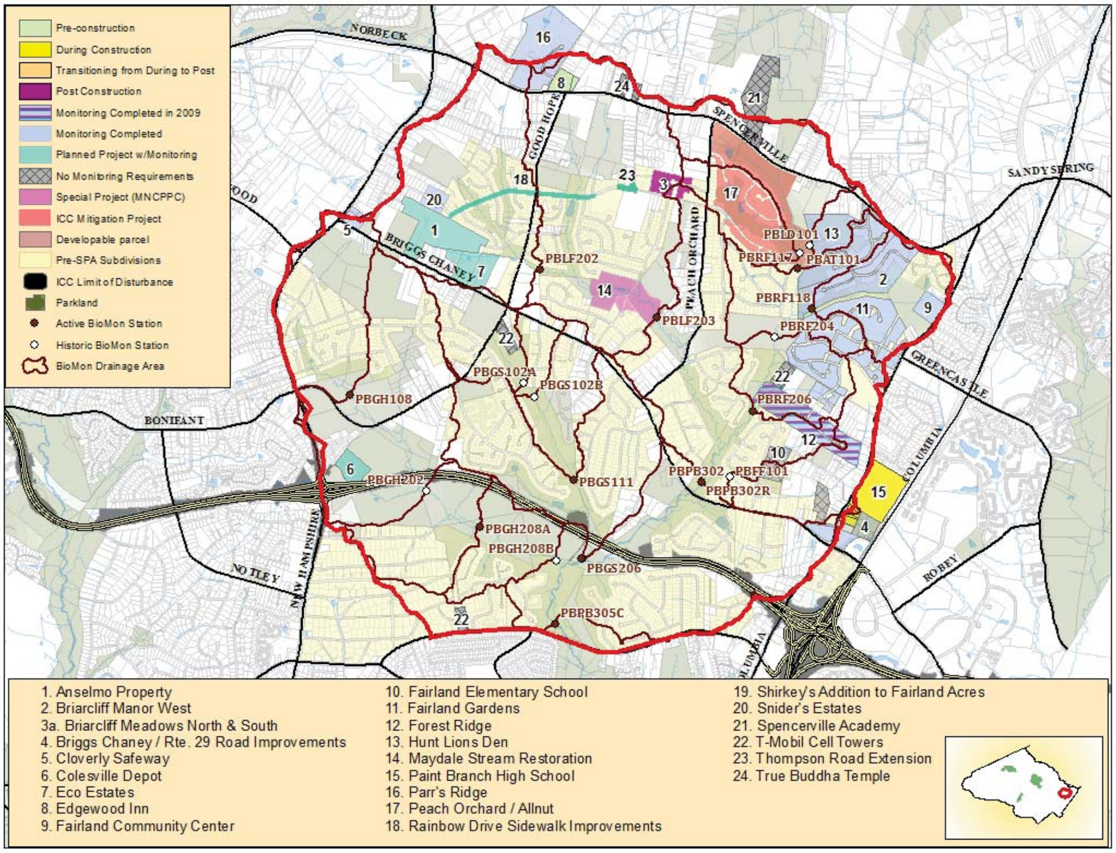


Figure 3.3. 2010 Status of Upper Paint Branch SPA Monitoring Projects.

One project (Briarcliff Meadows) is in the post-construction monitoring phase. A sand filter and a biofilter were monitored for pollutant removal efficiency starting in 2009. Data was collected for two storms in 2009 but the data could not be accepted because sampling requirements were not met. In 2010, data on pollutant removal efficiency was successfully collected for three qualifying storm events. Data collection on post construction groundwater levels and chemistry also continued during 2010.

A number of Intercounty Connector (ICC) stewardship and mitigation projects are being designed by the State Highway Administration (SHA) for the Upper Paint Branch SPA. The DEP, DPS, and MNCPPC are working with SHA for the ICC and associated projects to achieve SPA requirements. Long-term water quality monitoring data are being collected by SHA and consultants to evaluate the effect of the ICC on the surrounding streams. Data analysis is pending until after the highway has been opened and the SWM structures are online for a minimum of one year.

3.1.3 **Piney Branch SPA Project Status**

The Piney Branch SPA is near the maximum build out allowed under the Master Plan. Analysis conducted in 2005 by the MNCPPC found that 5%, or 121 acres, of the 2,369 total acres in the Piney Branch SPA remain available for development (M-NCPPC 2005). Two large developments (~433 acres), Willows of Potomac and Piney Glen Village (Fig 3.4), were constructed in the upper Piney Branch below Traville just prior to the establishment of the Piney Branch SPA and lack the special land use controls and water quality protection imposed under SPA requirements. Other pre-SPA developments include Piney Glen Farms, Glen Hills, Lakewood Glen, Lakewood Estates, and Glen Meadows, most of which were constructed during the 1970s and 1980s.

The only monitoring project still active in the Piney Branch SPA is Traville (Fig. 3.4). A post construction monitoring permit for the project was issued in April 2009. Post construction monitoring activities were initiated at one sand filter on Traville in September 2010, but no viable water chemistry samples were collected. The remainder of monitoring (water chemistry and groundwater recharge) is scheduled to be initiated in 2011. Samples will be analyzed for nitrate, nitrite, TKN (total Kjeldhal nitrogen), ortho-phosphate, total phosphorus, copper, cadmium, lead, and zinc.

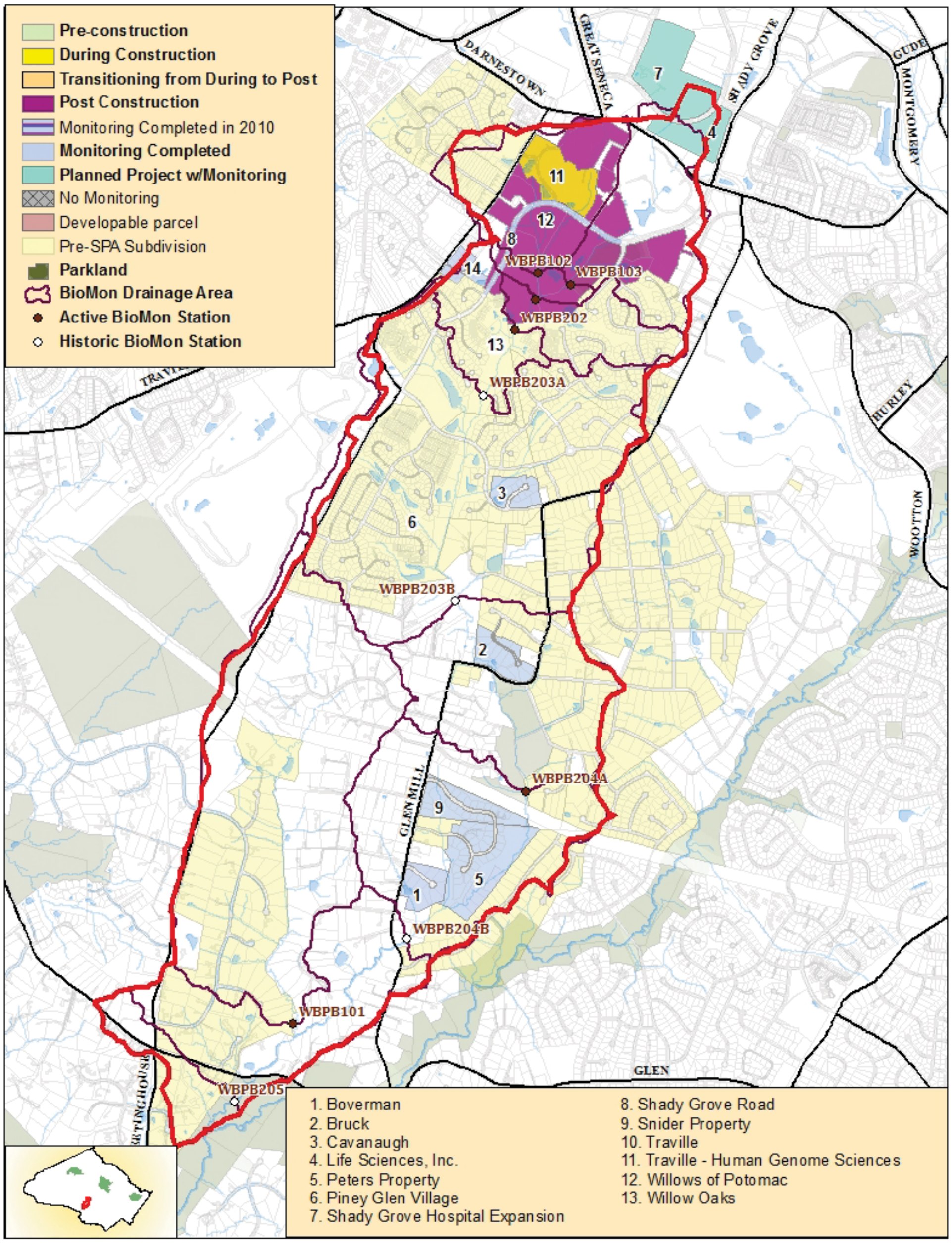


Figure 3.4. 2010 Status of Piney Branch SPA Monitoring Projects.

3.1.4 **Upper Rock Creek SPA Project Status**

Three projects are currently in the preconstruction phase. The Preserve at Rock Creek has completed pre-construction monitoring. This property is under new ownership and construction is anticipated to commence in 2011. Data collection will continue once construction begins.

A plan for the Laytonia Recreational (Rec) Park was approved in 2001 (prior to the creation of the SPA) with a total imperviousness of over 18% for the 49 acre parcel. Revised plans were submitted in 2009 to set aside seven acres for construction of a new Montgomery County Animal Shelter and reduce the original planned impervious levels. It is anticipated that the final site layout will still exceed the 8% impervious limit by around 2% in order to meet master plan and facility needs.

Development activities at the Laytonia Recreation portion include construction of several athletic fields (including one constructed from artificial turf) and extensive paved areas for access and parking. Baseline data collection on groundwater elevations and chemistry for the recreation park portion of the parcel commenced in January 2010. The Montgomery County Animal Shelter portion falls on the other side of the drainage divide from the park and drains primarily away from the SPA into Mill Creek. No pre-construction monitoring requirements were set for the Animal Shelter, but both portions of the parcel will have monitoring requirements for S&EC and SWM BMPs which will be determined during the final water quality plan submittal phase.

The Upper Rock Creek SPA has one project currently conducting monitoring (Fig. 3.5). The Reserve at Fair Hill began monitoring during construction conditions in May 2007. Hydrologic characteristics (groundwater elevation and chemistry, peak stream flow, and stream geomorphology) are being monitored. No sediment basin total suspended solids (TSS) removal efficiency monitoring was required.

Similar to the Piney Branch and Upper Paint Branch SPAs, the Upper Rock Creek SPA had extensive development prior to SPA designation. The majority of new development projects are subdivisions of existing lots or redevelopment projects. For example, a redevelopment of Norbeck Country Club involved land disturbance activities that were limited to construction of a pool house and tennis building (about six acres of disturbance). No monitoring requirements were set and a partial stream monitoring fee waiver was granted.

Two large parcels, the Hendry and Fraley properties (Fig. 3.5) remain available for development activities, but no development applications have been received. The Rickman Property is a re-development of commercial site from a landscaping company to a storage facility. Monitoring of the vegetated roof to be installed on sections of the warehouses is anticipated.

Water quality monitoring data are also being collected in Upper Rock Creek for the ICC. This includes both biological monitoring and water temperature measurements. Data analysis is pending until after the highway has been opened and the SWM structures are online for a minimum of one year.

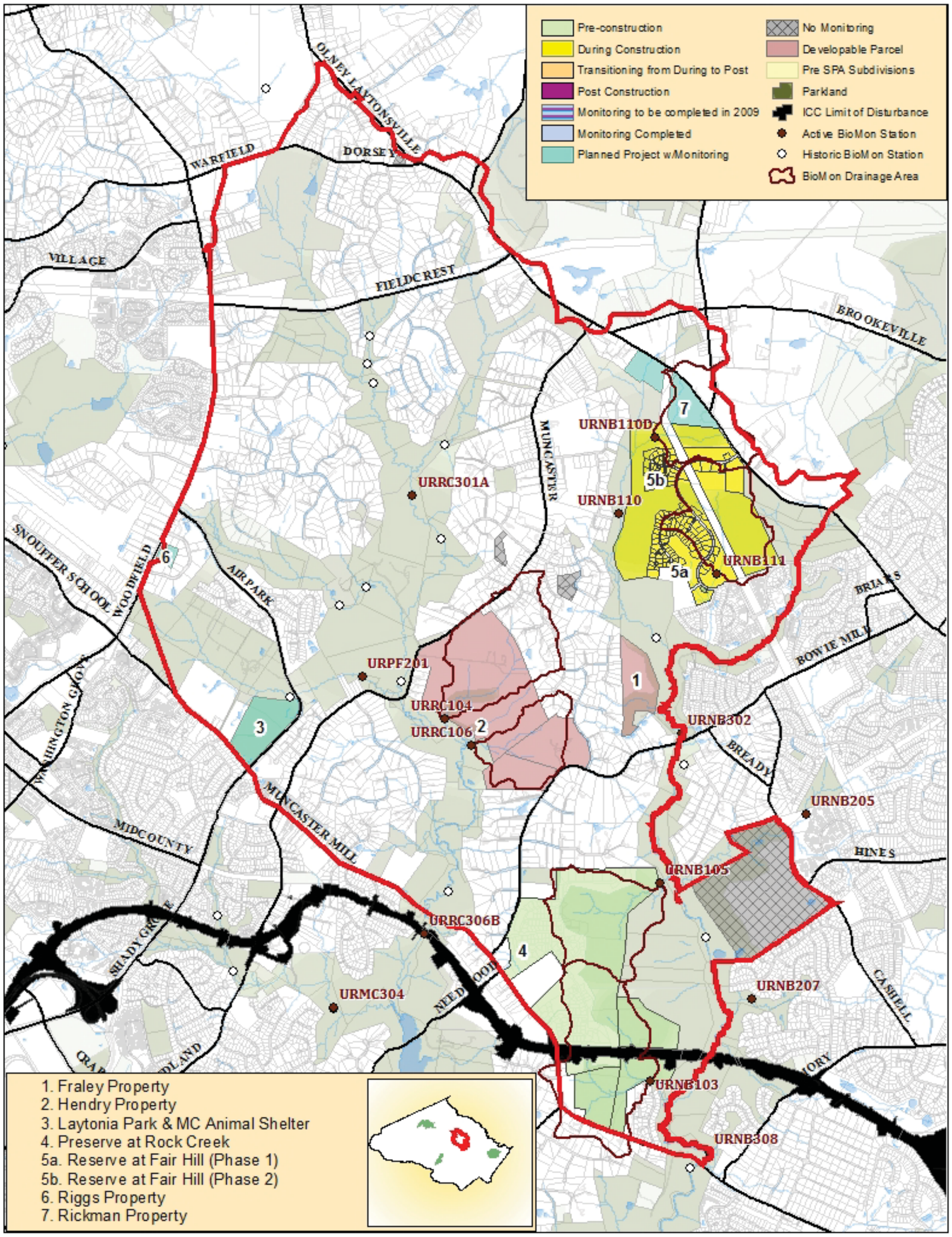


Figure 3.5. 2010 Status of Upper Rock Creek SPA Monitoring Projects.

3.2 <u>Water Quality Monitoring</u>

BMP monitoring prior to 2001 evaluated BMP effectiveness by monitoring stream and hydrological conditions as well as water quality parameters where the stormwater for the site discharges via outfall into the receiving stream. Later monitoring paired data collection on the stream's physical characteristics with an additional focus on specific structural BMP performance. Current BMP monitoring evaluates pollutant removal efficiency by measuring the amount of pollutant entering a BMP versus the amount of pollutant exiting a BMP Fig. 3.6 is a schematic which shows the relationship between development in a drainage area, typical outfall location, the installed BMPs, and possible monitoring stations.

Monitoring results of stream and hydrological conditions are presented when projects have fulfilled all requirements and the dataset is complete. This section presents the results of completed projects through 2010. Results of during construction TSS sampling are discussed in Section 3.3 and supporting data is presented in the Technical Appendix.

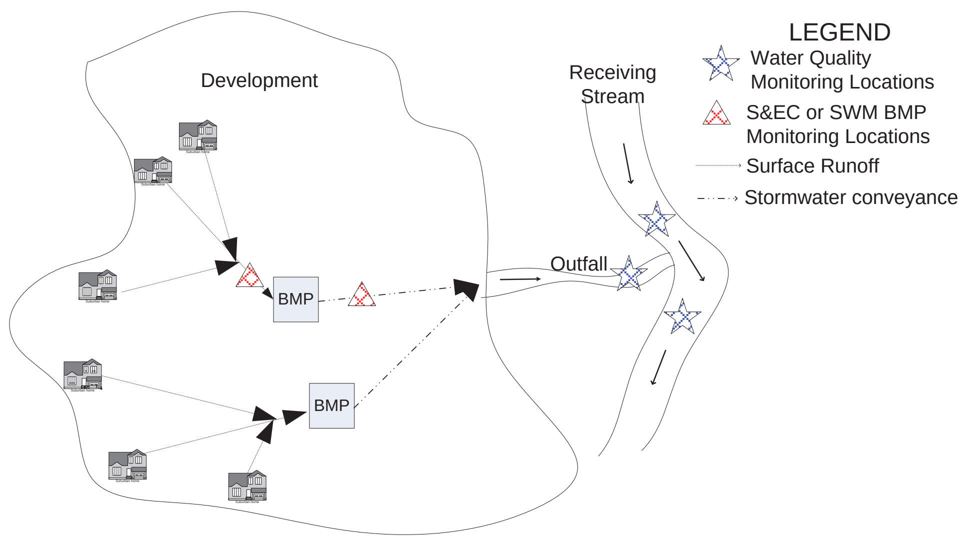


Figure 3.6. Schema Representing SPA BMP Monitoring Locations.

3.2.1 **Stream Temperature**

Monitoring of stream temperature at five stations in Forest Ridge was completed in 2008. Temperature was monitored continuously at two stations in the Right Fork of Paint Branch (RFPB) and at three stations in an unnamed tributary to RFPB from 2002 to 2008. Temperature meters were placed in RFPB upstream and downstream of the confluence with the unnamed tributary to monitor thermal impacts to the mainstem. Temperature meters were placed on the unnamed tributary upstream and downstream of a SWM BMP outfall for a paired study design to evaluate if the BMP was mitigating instream impacts. An additional temperature meter was placed on the unnamed tributary just above the confluence with RFPB to assess final water temperature before entering RFPB.

Results for the temperature monitoring show that stream temperature in the unnamed tributary is affected by rainfall events. However, similar temperature increases were noted both above and below the BMP outfall, suggesting that the BMP is effective at minimizing increases to stream temperature. In almost all instances, the temperatures observed at the most downstream location of the unnamed tributary were lower than those observed in RFPB. Property and monitoring station location maps are provided in the Technical Appendix. Data summary tables are also available in the Technical Appendix.

Twelve completed projects were required to monitor stream temperatures. The majority (nine properties) identified no thermal impacts, indicating that the goal of minimizing temperature impact was achieved. In some instances, it is possible that dilution effects may have buffered thermal impacts, as some properties release stormwater to larger, second order streams.

The results from All Souls Cemetery (Clarksburg SPA) and Cavanaugh (Piney Branch SPA) and at Hunt Lion's Den (Upper Paint Branch SPA) were inconclusive. A lack of conclusive results at Cavanaugh was due to inconsistencies with data collection, a lack of calibration records, and consultant coordination. Data from the downstream logger at Hunt Lion's Den were lost during the pre-construction period; confounding data interpretation.

3.2.2 **Embeddedness**

Embeddedness monitoring measures the extent to which sediment has covered the stream bottom and filled in spaces between rocks, cobble, and gravel. Data collected at Forest Ridge from 2002 through 2008 (presented in the Technical Appendix) indicate that the development did not have an impact on embeddedness.

One location in the unnamed tributary to the RFPB downstream of a SWM BMP outfall was monitored. Overall, embeddedness scores appear to be lowest in months with above average rainfall totals. The lowest embeddedness score was recorded during construction (2004). This corresponds with the month having the highest above average rainfall during construction. Baseline average embeddedness was 75%, during-construction average embeddedness was 60%, and post-construction average embeddedness was 59%. Lower embeddedness scores during construction suggest that the BMP may have limited sediment impacts to the stream.

Seven other projects completed prior to 2010 completed embeddedness monitoring. Five of these projects experienced no impacts while two others had embeddedness levels that were highest during construction and then declined post construction (DEP 2009).

3.2.3 **Groundwater Levels**

Four groundwater wells were monitored at Forest Ridge. Well #1 (18ft. deep) is downgradient from SWM Pond A and Well #2 (20ft. deep) is upgradient from SWM Pond A. Well #3 (40ft. deep) is downgradient from SWM Pond B. Well #4 (28ft. deep) is not associated with a SWM facility.

Groundwater elevations were maintained or increased during the construction period. This may be due in part to higher average rainfalls recorded during construction. Lower groundwater levels were observed near Pond A following conversion to SWM. It is likely that the conversion from a wet pond to a dry pond had an influence on the local water table. Ground water elevations in Well #3 show increased levels compared to baseline, indicating that SWM Pond B is effective at promoting infiltration. Table TA 3.7 provides a summary of groundwater elevation data for the period spanning baseline monitoring through the completion of post-construction monitoring.

3.2.4 **Groundwater Chemistry**

No additional monitoring results were produced during the 2010 monitoring year. As indicated in the SPA annual report for 2008, data collected from the two projects completed prior to 2010 produced inconclusive results.

3.2.5 **Instream Chemistry**

No projects completed in 2010 were required to monitor instream chemistry.

3.2.6 **Continuous Stream Flow**

Current SPA surface gages are operated by Montgomery County, USEPA, and the USGS through several joint funding agreements to improve data collection and availability. Locations of gages and data analyses are presented in Section 4.

Continuous stream flow monitoring is required at several developments in the Clarksburg SPA (Clarksburg Town Center, Clarksburg Village, Gateway Commons, and Greenway Village), as well as Traville in the Piney Branch SPA. Results of this monitoring will be presented as the monitoring requirements are fulfilled.

3.2.7 **Cross Sections**

Four completed projects monitored cross sections to document changes to the shape of the stream channel in response to changes to flows of water and sediment input. Monitoring was completed at Briarcliff Manor West (Paint Branch SPA) in 2006, All Souls Cemetery (Clarksburg SPA) in 2008, Hunt Lion’s Den (Paint Branch SPA) in 2009 and Forest Ridge in 2010. There was no impact to the shape of the stream channel in the monitored areas of Briarcliff Manor West and the stream channel geometry and flow regime were similar to pre-construction monitoring. Changes in the stream channel shape and area were observed during construction at the two cross sections monitored in Great Seneca Wildcat Branch on the All Souls Cemetery property. As reported in the SPA annual report for 2008, both stations were below the BMP outfall and appeared to stabilize post construction. Results for the monitoring done at the Hunt Lion’s Den were inconclusive. Changes in stream channel geomorphology were observed at all six stations. Most notably, fallen trees at two of the cross sections created scour pools and additional erosion in 2006. Changes due to the fallen trees make it difficult to interpret the degree of change resulting from construction and development activities versus natural occurrences. No outstanding trend was observed at the only cross-section below the outfall of the stormwater management pond.

Three cross sections along the unnamed tributary of the RFPB were monitored at Forest Ridge. Results for this monitoring indicated that the area immediately below the outfall experienced substantial change early on in the construction phase, but remained stable upon completion of construction. This suggests that the BMP was effective in controlling stormwater flow post-construction. The cross-section located furthest downstream from the outfall has been relatively unstable throughout the monitoring period, and has provided inconclusive data. Some of the observed change is due to deer traffic and formation of a debris dam immediately upstream.

3.3 Sediment and Erosion Control (S&EC) BMP Monitoring

S&EC BMP performance is evaluated during construction by measuring the removal efficiency of total suspended solids (TSS). Information on evaluating BMP efficiency using percent removal is provided in the Technical Appendix. The removal efficiency is calculated from either grab sampling or automated samples that collect storm flow entering and leaving an S&EC structure. Results of the two sampling methods cannot be directly compared and are discussed separately.

3.3.1 **Grab TSS Sampling**

A manual ***grab sample*** is collected by inserting a container into the flow at the inlet(s) and a separate container into the flow at the outfall of a structure. Data collected via the grab sample method can be used to represent pollutant removal efficiency as the difference (expressed as a percentage) between the concentrations of pollutants entering the structure (*influent*) versus the concentration leaving the structure (*effluent*), but is not representative of the entire storm event. Monitoring using grab samples in the SPAs is conducted within 24 hours after qualifying storm events (typically events yielding total rainfall of at least 0.5 inches). Concentrations of suspended sediment and chemical parameters can vary throughout a storm event, with the first inch of rain over the impervious area (known as the “first flush”) often being the most pollutant-laden portion of the runoff.

Grab sampling may not always capture the first flush at the inlet and offers an instantaneous pollutant concentration at a discrete point in time entering and leaving a structure. This approach was used to sample the inflow and the discharge of a structure to see how relatively ‘dirty’ the water was entering a structure and how relatively ‘dirty’ the water was leaving a structure. Later, monitoring of an entire storm event using an automated sampler was utilized in order to calculate a loading of pollutants. Over time, the difficulties experienced by crews attempting to use auto-samplers to derive load estimates from S&E structures have resulted in relatively few successful samples while the qualitative grab samples at least provide a picture of S&E structure efficiency. The practice of collecting grab samples or other types of samples as a substitute for automated flow-weighted composite samples is no longer acceptable for SPA BMP monitoring.

A total of 129 grab samples have been collected from 2002 to 2010 from SPA S&EC structures (Technical Appendix TA 3.3.1). 2010 data were collected for eight storm events at two basins in the Clarksburg Village Phase I (Table 3.1).

Monitoring results from grab samples (Fig. 3.7) continue to show S&EC structures receiving dirty, sediment-laden water are generally effective at reducing stormwater TSS concentrations, but with some variability in performance. Points above the diagonal line in Figure 3.7 indicate instances where a higher TSS concentration is measured in the water exiting the structure than entering.

Table 3.1. 2010 Total Suspended Solids (TSS) grab sample data.

Project and Structure	Project Phase	TSS Sampling Ongoing?	Sample Date	Inlet Conc. (average; (mg/L))	Outfall TSS Conc. (mg/L)	TSS removal efficiency (%)	Rain (in.)
Clarksburg Village Basin D	During	Yes	**7/14/2010**	135.5	72.67	46.37%	0.93
			8/12/2010	256.25	330.67	-29.00%	1.66
			8/16/2010	35.72	70.33	-93.88%	0.45
			9/28/2010	119.08	225.8333	-89.65%	0.42

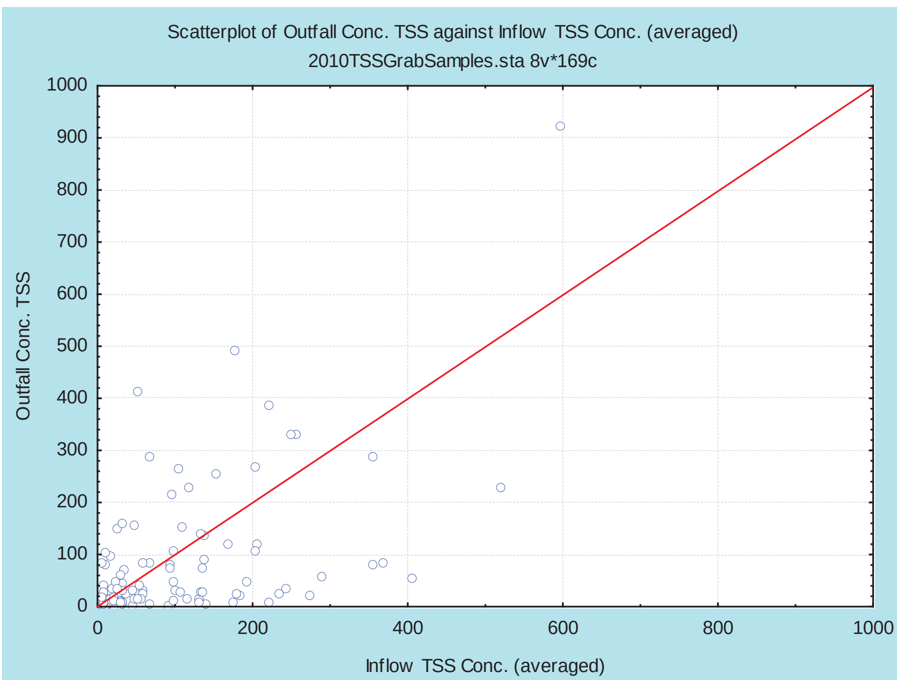


Figure 3.7. Inlet and Outfall TSS Concentrations (Grab Sample Data) From Monitored Sediment and Erosion Control Structures. For Some Structures, Inlet TSS Concentrations Represent a Calculated Average Value for Multiple Inlets.

S&EC structures receiving dirty, sediment-laden water (likely to occur during the early development periods involving cutting, filling, and grading) resulted in larger TSS concentration reductions than in samples with concentrations lower than 100 mg/L (which are often collected later in the construction process). For storm events where influent TSS concentrations were greater than or equal to 100 mg/L, the median TSS removal efficiency was 63.6 % (Fig. 3.8). At concentrations below 100 mg/L, the results were much more variable with a median removal efficiency of only 17.5% (Fig. 3.9). In some cases, water leaving the S&EC BMP contained higher concentrations of TSS than the entering water. The less polluted water (less than 100 mg/L) entering the S&EC structures could be the result of the sampling event taking place fairly late in the grading and site preparation process during the period where most of the cut and fill were completed. It may also be the result of soil compaction as final lot and road grades were completed to maintain the final surveyed grades. The higher outfall concentrations could be from the resuspension of fine clays and silts already in the control structure basin. As projects get closer to completion and less exposed earth is present on the site, there may be more sediment accumulated from prior storms being washed out of structures than is entering and settling in the trap.

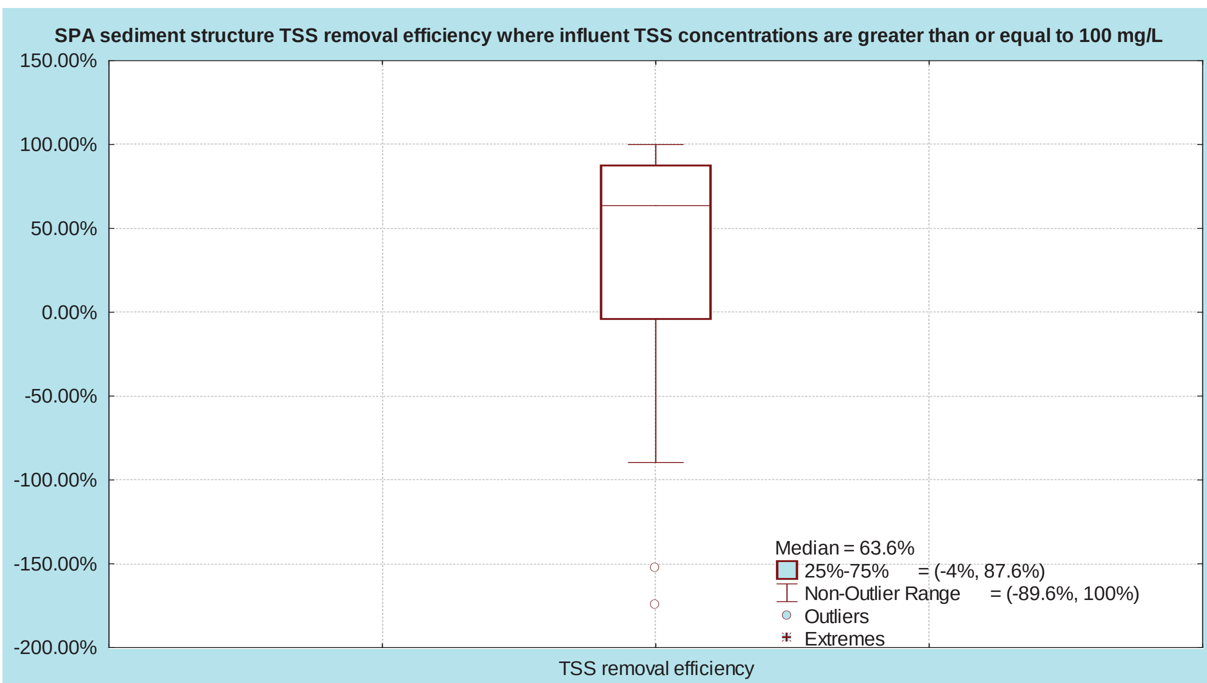


Figure 3.8. Percent Difference of Inlet and Outlet TSS Concentrations From Grab Samples Where Influent TSS Values are Greater Than or Equal to 100 mg/L.

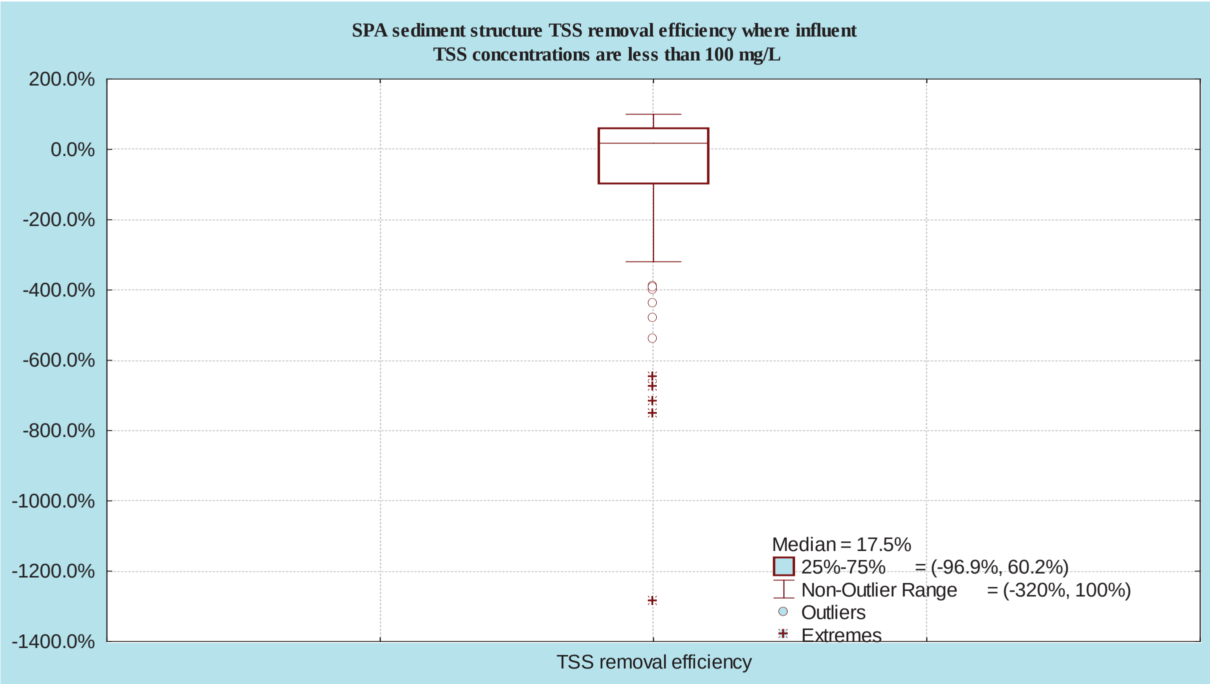


Figure 3.9. Percent Difference of Inlet and Outlet TSS Concentrations from Grab Samples Where Influent TSS Values are Less Than 100 mg/L.

3.3.2. Flow-weighted Composite TSS Sampling

Background

Automated samplers are used to collect stormwater samples at intervals based on the estimated duration of the storm event. Following the event, samples are manually composited based on the storm flow to characterize the quality of stormwater discharge. Storm load efficiencies are then calculated and BMP percent removal efficiency is used to compare the mass of pollutant entering the S&EC or SWM BMP structure versus the mass of pollutant leaving the structure.

Flow-weighted composite BMP sampling can be reported using several different methods (Strecker et al. 1999). Individual storm load efficiency was the method selected to analyze the SPA monitoring results. Load efficiency of a structure is considered more accurate than examining efficiency independent of water volume, as is the case for grab samples. Due to the limitations of grab sampling, data collected from the two methods cannot be directly compared.

Although a better measure of BMP efficiency, DEP and the consultants who perform the flow-weighted composite sampling for S&EC have found it extremely challenging to obtain quality data for a number of reasons including:

- Equipment problems,
- Structure configurations that do not allow for accurate sampling,
- Unaccounted for groundwater inputs, and
- Weather-related difficulties (i.e. insufficient rain amounts, storm events outside of normal business hours).

The configuration of a structure can change frequently as construction progresses, and occasionally some inlets stop receiving flow or additional inlets are installed between sampling events. Furthermore, some monitored structures were found to have intersected groundwater during installation. This resulted in continuous flow leaving the structure, making it difficult to define a storm flow event. Backwater at the inlets can make it impossible to capture a positive or accurate flow needed to calculate a pollutant load. Low flow entering or leaving the structure, as well as equipment anomalies and malfunctions, have also prevented the collection of flow-weighted data.

Automated Sampling Results

A limited amount of flow-weighted storm sampling data is available for S&EC basins. Automated sampling data from 32 storm events are now available from four basins in Clarksburg and one basin in Paint Branch (Table 3.2, Figure 3.10). Data and basin descriptions are in the Technical Appendix.

Currently, in 2010, sampling was conducted at two projects, Greenway Village and Paint Branch High School, producing data from four storm events. Automated TSS sampling concluded in 2009 for Gateway Commons.

Table 3.2. 2010 Total Suspended Solids (TSS) automated sample data.

Project and Structure	Project Phase	TSS Sampling Ongoing?	Sample Date	Inlet Loading (sum; (lbs.)	Outfall Loading (lbs.)	TSS removal efficiency (%)	Rain (in.)
Greenway Village – Basin 7/7A	During	Yes	**9/28/2010**	3.26	9.81	-200.9%	0.93
			10/14/2010	62.78	26.14	58.4%	0.86
Paint Branch High School – Basin 2	During	Yes	**9/28/2010**	23.14	7.23	68.8%	0.45
			10/14/2010	5.92	1.46	75.3%	0.42

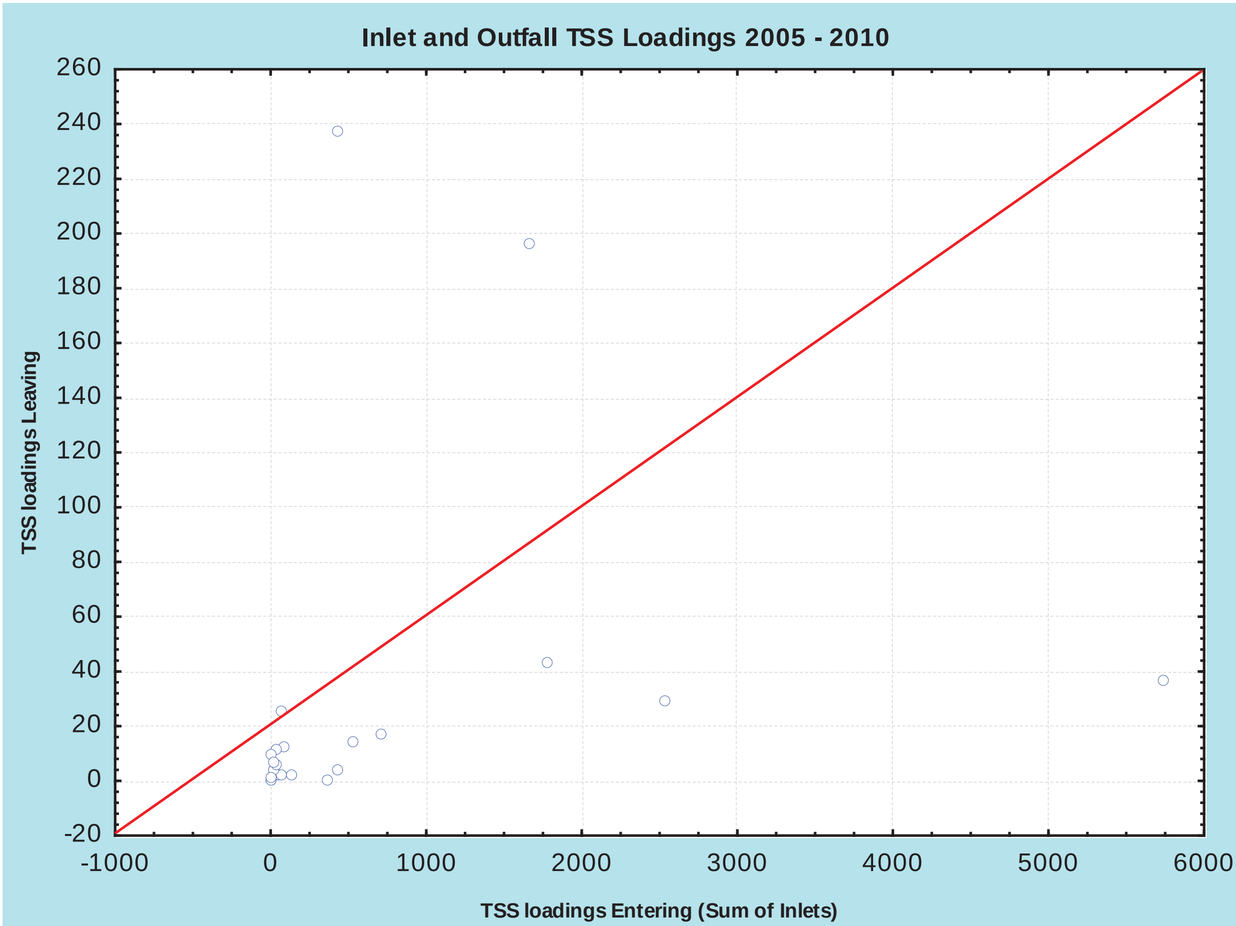


Figure 3.10. TSS Loadings Entering Versus Leaving for Four Sediment and Erosion Control Structures in Clarksburg and One in Paint Branch (Automated Sampling Data) for 32 storm events.

Generally, TSS removal efficiency was very high, with only three instances where loadings were reduced by less than 50%. Of the three, one storm event produced a negative percent removal of -44%, likely in response to an intense rain event. In 2009, median and average efficiency was greater than 70% overall (Fig 3.11).

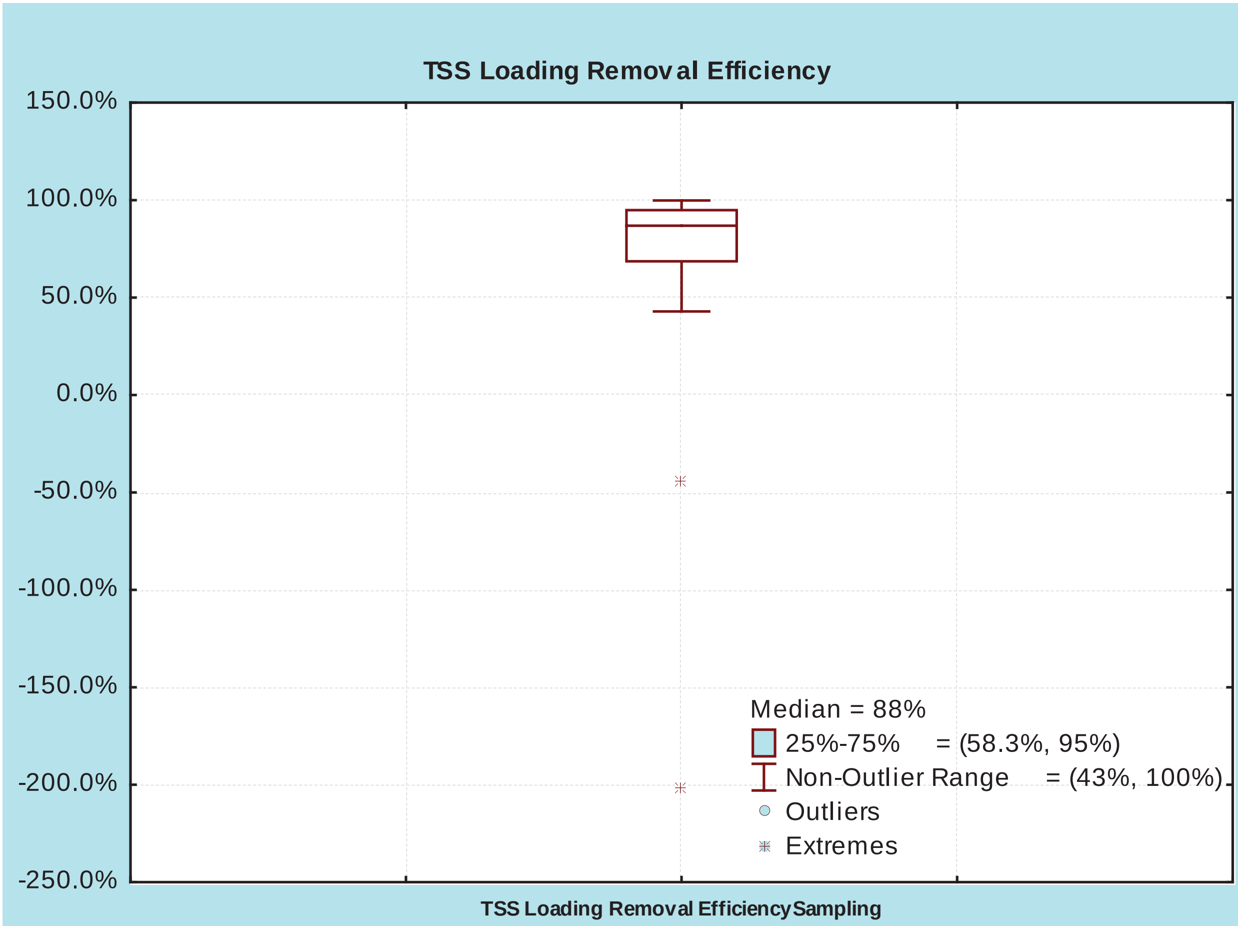


Figure 3.11. Average, Maximum, Minimum, and Median TSS Removal Efficiencies for monitored S&EC basins through 2010 (Automated Sampling Data).

Clarksburg Town Center Phase II-B Sediment Basin #3

Sediment Basin #3 was monitored for TSS during construction of Phase II-B of Clarksburg Town Center and consisted of two forebays and a main cell prior to conversion to SWM. Mass grading was initiated in late 2003, but TSS sampling did not begin until March 2005. Monitoring of Sediment Basin #3 concluded in March 2007. Site plans with monitoring locations and TSS concentration data from Sediment Basin #3 sampling are presented in the Technical Appendix.

The data from the eight storms indicate that the structure was overall effective at trapping sediment, but was somewhat variable in performance, as reported in 2008 (DEP 2010). It was previously reported that the eight monitored storms produced an average efficiency of 87%, with the highest removal efficiency reported at 97%. The lowest positive removal efficiency was reported at 43%. There was one occasion where a negative percent removal was reported, which is attributed sediment resuspension in response to a relatively intense rain event and low TSS concentrations entering the treatment system. A calculation error by the monitoring consultant caused a misrepresentation in the total loadings (in pounds) reported for Clarksburg Town Center TSS monitoring. Table 3.3

presents the previously reported and corrected loading data; there was no resulting change in the calculated removal efficiency.

Table 3.3. Clarksburg Town Center Phase II-B Sediment Basin #3 Total Suspended Solids (TSS) Loadings.

	Storm Characteristics			**Discharge Volume (cf)**		**Previously Reported TSS Loadings (lbs)**		**CORRECTED TSS Loadings (lbs)**		
Date of Event	**Total (in)**	**Duration (hrs)**	**Return Interval**	**Inlets** (combined, sum)	**Outfall**	**Inlets**	**Outfall**	**Inlets**	**Outfall**	**TSS Reduction**
4/30/05	0.82	22.25	< 1 yr	65,488.4	57,292.9	520.7	29.4	2530.9	143.1	94%
5/19/05	1.04	14.15	< 1 yr	43,992.0	35,813.4	366	43.2	1776.2	210.2	88%
5/23/05	0.84	29.25	< 1 yr	57,025.0	38,853.0	146	17.5	709.8	84.9	88%
5/11/06	1.76	13	< 1 yr	24,563.4	66,577.8	342.1	196.7	1662.8	956.0	43%
6/1/06	0.45	9	< 1 yr	64,989.2	78,096.6	1180	37.1	5734.1	180.4	97%
9/1/06	1.95	31.58	< 1 yr	114,413.1	114,048.6	3.1	4.4	14.8	21.4	-44% †
12/22/06	1.30	15.67	< 1 yr	62,710.9	16,393.2	108.4	14.3	526.8	69.6	87%
3/15/07	2.09	47	< 1 yr	127,003.4	83,313.6	87.2	4.3	424.0	20.8	95%
					Mean	**344.2**	**43.36**	**1672.4**	**210.8**	**87%**

† - Outlier. The negative TSS reduction during the September 1, 2006 storm was most likely due to low TSS concentrations in the runoff and resuspension of sediment in the trap

Sampling difficulties were encountered that limited the dataset. In addition to instrument malfunctions, there were difficulties determining the necessary sampling locations to account for all stormwater inputs, low flow at some inlet pipes, and difficulties accounting for flow caused by groundwater. Sediment Basin #3 intercepted groundwater, which made it difficult to determine when all the runoff from a storm event was discharged.

Table 3.4 presents data (previously reported data as well as data that has been corrected for the calculation error) for three sampling events from 2005 where monitoring was extended to account for continuous flow from the outlet. A decrease in efficiency was observed when the sampling was extended and the continued flow of groundwater through the structure slowly carried enough sediment to reduce structure efficiency. Results in Table 3.4 should be used cautiously when interpreting the efficiency of the structure and the TSS loadings delivered to the stream from individual storms, as the values may overstate the efficiency of the structure.

Table 3.4. Total Suspended Solids (TSS) Loadings and Percent Differences Observed During Extended Sampling at Clarksburg Town Center Phase II-B Sediment Basin #3.

Date of Event	**Rain** (in)	**Rainfall Duration** (hrs)	**Return Interval**	**Duration of Extended Outfall Sampling** (hrs)	**Previously Reported TSS Loadings for Extended Outfall Sampling** (lbs)	**CORRECTED TSS Loadings for Extended Outfall Sampling** (lbs)	**TSS Reduction for Extended Outfall Sampling** (%)
4/30/05	0.82	22.25	< 1 yr	339.6	89	431.7	83%
5/19/05	1.04	14.15	< 1 yr	88.75	68.5	332.8	81%
5/23/05	0.84	29.25	< 1 yr	170.5	34.3	166.9	77%

In 2009, the developer at Clarksburg Town Center, Newland Homes funded an independent study to evaluate sediment loadings beyond requirements of the Final Water Quality Plan. The additional monitoring included: 1) surface water chemistry sampling for total suspended solids using a paired catchment design, and 2) pond outfall monitoring in three locations for total suspended solids.

Two stream stations were selected by the monitoring consultant with DEP consultation. A station was selected in the Town Center Tributary of Little Seneca Creek, upstream of Stringtown Road. In order to reference an existing staff plate for long-term flow monitoring, this station was placed approximately 45 meters downstream of the existing stream chemistry monitoring (grab sampling) station. A comparison station was selected in an unnamed tributary to Little Seneca Creek situated east of Route 27 (approximately 0.2 miles west of Hawkes Road). The comparison tributary has a comparable drainage area (DA) acreage and similar land use to conditions prior to the Clarksburg Town Center Development. No new development was planned for the Route 27 catchment at the time of the study. Drainage Area characteristics are provided in Table 3.5. A station map is located in the Technical Appendix.

Automated samplers were deployed at the two stations to capture baseflow and stormflow TSS flow-weighted, composite samples. Baseflow sampling occurred monthly and storms were captured approximately twice per quarter year. Stream flow was logged continuously to compute a total annual loading of TSS.

Automated samplers were also deployed at the outfalls of the three largest/main ponds to obtain flow-weighted composite TSS storm samples. Two of these study ponds have been converted to SWM but may not be fully-functional. A description of the ponds is presented in Table 3.6. Table 3.7 presents a time table of construction and conversion activities associated with the ponds. The stream chemistry sampling station is downstream of the pond outfalls, below the confluence of the three tributaries (“west”, “center”, and “east”) that drain into the Town Center Tributary of Little Seneca Creek.

Table 3.5. Drainage area and land use compositions of the two stream chemistry monitoring stations established for the additional study independently-funded by the developer.

2007 Land Use		Clarksburg Town Center Tributary (DA = 240 acres)	Route 27 Tributary (DA = 169 acres)
Category	**Type**		
Residential	High Density	36.3%	-
	Medium Density	12.8%	2.6%
	Low Density	7.4%	12.0%
Commercial	Retail	0.4%	-
	Institutional	-	4.2%
Agricultural	Cropland & Pasture	1.2%	71.1%
Forested		-	10.1%
Other	Bare Ground	16.1%	-
	Open Area	11.7%	-

Table 3.6. Characteristics of the Three Ponds Monitored at the Outfall for Total Suspended Solids Loadings as Part of an Additional Developer-funded Study in Clarksburg Town Center.

Facility Designation	Location	Basin Description	Drainage Area	Capacity	Discharge Point
Pond 1 (Phase I-B)	East side of Clarks Crossing Drive	Converted SWM pond – Main cell (dry pond) + 3 sand filters	67.6 acres	359,805 cubic feet	Concrete outfall @ west side of Clarks Crossing Dr.; discharges to eastern tributary (one of three) of the Town Center Tributary, North of Stringtown Road
Pond 2 (Phase I-A)	West side of Overlook Park Drive	Dual Cell S&EC Basin	95.3 acres	398,295 cubic feet	Corrugated metal outfall to the western tributary of the Town Center Tributary, North of Stringtown Road
Pond 3 (Phase II-B)	Burdett Avenue	Converted SWM – Dry pond with sand filter, bioretention, vegetated swales, and StormCeptor pre-treatment	44.5 acres	89,280 cubic feet	Drains to the eastern tributary of the Town Center Tributary, North of Stringtown Road.

Table 3.7.Progress of Construction in the Drainage Areas (DAs) to the Three Monitored Ponds. Pond Characteristics are described in Table 3.4.

	Pond 1 (Phase I-B)	**Pond 2** (Phase I-A)	**Pond 3** (Phase II-B)
Initiation of Mass Grading	*Date not provided*	*Date not provided*	**2003** (3rd Quarter)
Completion of Mass Grading and Road Paving	*Date not provided*	*Date not provided*	**2004** (3rd Quarter)
0 to 30% units within DA constructed	*Date not provided*	*Date not provided*	**2004** (4th Quarter)
30 to 60% units within DA constructed	**2003** (4th Quarter)	**2005** (2nd Quarter)	**2005** (2nd Quarter)
60 to 100% units within DA constructed	**2006** (3rd Quarter)	*Planned –* 2011 (2nd Quarter)	**2008** (3rd Quarter)
S&EC Conversion to SWM	**2008** (2nd Quarter)	*Planned –* 2012 (3rd Quarter)	*Planned –* 2012 (3rd Quarter)

Monitoring for the additional study occurred from October 2008 to September 2009. Thirteen stream baseflow samples at both stream stations were collected over this period. Seven storm events were captured at both stream stations. Four other attempts to collect samples at both stations failed due to equipment malfunctions caused by rodent damage and issues with sampler tubing and sensor placement. Beaver activity in the Clarksburg Town Center Tributary downstream of the sampling station also created difficulty with obtaining reliable flow data.

A total loading estimate was calculated to include both baseflow and stormflow transport of TSS at the two instream chemistry stations. A description of this calculation is presented in the Technical Appendix. Estimated annual loadings are presented in Table 3.8. The total annual estimated loading at the Town Center Tributary was 117% higher than the loading at the comparison station. When normalized by acreage, the annual estimated loading per acre at the Town Center Tributary station site was 53% greater than at the comparison station. Statistical analysis performed on individual baseflow and stormflow loading data showed no significant differences in loadings between the two stations (Jones 2010b; Technical Appendix).

Table 3.8. Estimated Annual Average Loadings at Instream Stations Monitored for Additional Developer-funded Study in Clarksburg Town Center

Station	**Baseflow Load** (lbs); *n=7*	**Stormflow Load** (lbs); *n=7*	**Total Load** (lbs)	**Total Load** (lbs) **per acre**
Town Center Tributary (above Stringtown Rd)	536	11,616	12,151	51
Rte 27 Comparison Trib	1,032	4,568	5,599	33

Eight storm events were monitored as part of the pond TSS evaluation, but only one storm (9/5/2008) produced monitoring results at all three monitored outfalls (Table 3.9). This was the storm with the most rainfall of those monitored. Table 3.10 shows rain amounts, duration, and resulting total flows (discharge). The patterns in rain to discharge amount do not match and point to unreliable monitored flow rates and a therefore limited data set. Low discharge conditions are primarily attributed to the SWM structures attenuating flow (quantity control). Negative and unreliable flow values for Pond 2, the only S&EC basin monitored, are attributed to a backwater issue and irregularities in the structure of the piping. Four of the storms had a corresponding instream TSS sampling event, but not all ponds produced sampling data, making comparisons difficult.

Table 3.9.Results for TSS Sampling of Three Pond Outfalls in Clarksburg Town Center.

Storm date	Pond 1		Pond 2		Pond 3	
	Conc. (mg/L)	Load (lbs)	Conc. (mg/L)	Load (lbs)	Conc. (mg/L)	Load (lbs)
9/5/2008	10	71.8	35	496.6	69	302.1
9/25/2008	5	10.4	21	4.9	n.s.	
10/28/2008	n.s.		4	0.0	n.s.	
1/6/2009	3	17.6	n.s.		1	0.4
4/13/2009	4	2.1	n.s.		n.s.	
5/28/2009	3	14.2	n.s.		*	
9/26/2009	14	12.5	n.s.		n.s.	
10/14/2009	11	88.2	1	1.1	n.s.	
* - Concentration below detectable limit						

Table 3.10.Rainfall and discharge characteristics for TSS Sampling of Three Pond Outfalls.

Storm date	Rain (inches)	Rainfall Duration (hours)	Rainfall Return Interval (year)	Calculated Discharge (cubic feet)		
				Pond 1	Pond 2	Pond 3
9/5/2008	3.55	17.67	2	115,016.8	227,268.4	70,126.0
9/25/2008	1.88	62.25	< 1	33,220.2	3,707.1	10,498.5
10/28/2008	1.32	15.17	< 1	386.5	-777.0	9,730.1
1/6/2009	1.5	24.92	< 1	94,040.3	18,876.8	30,550.9
4/13/2009	0.52	48.42	< 1	8,536.8	0.0	7,216.9
5/28/2009	1.12	30.25	< 1	75,866.7	51,843.6	26,597.8
9/26/2009	1.24	16.5	< 1	14,255.2	-63.7	3,726.3
10/14/2009	2.9	88	< 1	128,445.7	17,257.7	46,574.7

This study was performed during conditions when very little construction was taking place and after conversion to SWM for two of the ponds. During the monitoring period, Pond 1 was a converted SWM designed to treat a built-out portion of the development, Pond 2 was a sediment basin below a roughly-graded area, and Pond 3 was a converted SWM basin in a nearly built-out, largely completed, portion of the development. SWM BMPs are not designed to treat stormwater with large amounts of TSS that are present during mass grading and large scale, widespread earth disturbance activities. Conversion to SWM occurs after site stabilization; less sediment is inherently present under these conditions.

The results of this study do not reflect the TSS conditions during earlier stages of construction, but indicate that TSS concentrations and loadings are present in higher amounts in the Town Center Tributary at the monitored station than at a comparison stream station that is with no new construction and predominantly agricultural land use with less dense residential development. Conclusions regarding whether sediment inputs were new, residual, or resulting from a chronic condition cannot be made with this study design. Furthermore, the impacts on water quality and aquatic life cannot be assessed due to the lack of a paired biological monitoring station. Although LSLS103C is approximately 100 meters downstream of the Town Center Tributary sampling station, the closest biological monitoring station to the Route 27 comparison station is over 1200 meters downstream of the chemistry station (LSLS202).

Stringtown Road Extension

Sediment Basin #3 is an oversized single cell basin located in the northwestern corner of the Gateway Commons development, adjacent to the Stringtown Road – Gateway Center Drive junction. A map and sampling diagram is in the Technical Appendix 3. The basin treats 12.9 acres of runoff from Stringtown Road Extension and Gateway Commons. It then discharges to an existing off-site stormwater management pond to the west of Gateway Center Drive before the stormwater reaches a tributary of Ten Mile Creek. This tributary flows into the second order tributary of Ten Mile Creek monitored by DEP at LSTM206. Biological monitoring results are presented in Section 5.

TSS sampling at the inlet and the outlet of Sediment Basin #3 took place from September 2006 through December 2007. Construction on the Stringtown Road Extension has been completed since November 2006, but Basin #3 will not be converted to SWM until construction is completed at Gateway Commons. As of 2010, greater than 60% of the housing units in Gateway Commons within the drainage area of Basin #3 have been completed, and 30 to 60% of the housing units have been permanently stabilized.

TSS loading removal efficiency for three storms at Stringtown Road Extension Basin #3 ranged from 89% to 100% with an average removal of 94% (Table 3.11). 100% efficiency is defined as occurring when no runoff leaves the BMP. A calculation error by the monitoring consultant under-represents actual loading data; corrected loadings from those reported in the 2008 Annual Report are also presented in Table 3.11.

The first two monitored storms did not produce measurable flow and a low flow strainer was installed prior to the third monitoring event. Measured TSS loadings at the outfall were very low, with only one event measuring over a full pound. Although the TSS loadings entering in the stormwater were also comparably low, the monitored storm event on June 28, 2007 demonstrates the capacity of this structure to also handle much larger sediment loads with excellent efficiency.

The high TSS load removal efficiency may be partially attributed to the reduction of flow leaving the structure due to the basin sizing. The basin has a capacity of 58,071 cubic feet (cf), which is 125% of what would normally be required in non-SPA developments. The basin was mucked out on May 30, 2006, prior to any sampling events. Due to the status of the Gateway Commons development, construction activities, and thereby sediment, entering the treatment system may have also been limited.

All storm events captured at Stringtown Road Extension were below the one year return interval. A backwater issue that occurred during the March 15, 2007, rain event suggests that performance of the basin could be diminished under larger storm events. Larger and more intense storms may cause re-suspension of existing sediment in the basin. TSS load removal capacity may also differ now that portions of the drainage area are under construction for Gateway Commons as of March 2008.

Table 3.11. Stringtown Road Sediment Basin #3 Total Suspended Solids (TSS) Loadings. Previously reported loadings are considered invalid due to calculation error.

	Storm Characteristics			**Discharge Volume (cf)**		**Previously Reported TSS Loadings (lbs)**		**CORRECTED TSS Loadings (lbs)**		**TSS Reduc-tion**
Date of Event	**Total (in)**	**Duration (hrs)**	**Return Interval**	**Inlet**	**Outfall**	**Inlets**	**Outfall**	**Inlets**	**Outfall**	
9/1/06	1.95	31.58	< 1 yr	7,852	1,402	1.51	n.s.	7.35	n.s.	n/a
9/28/06	0.79	5.5	< 1 yr	1,612	414	7.87	n.s.	38.25	n.s.	n/a
3/15/07 *	2.09	47	< 1 yr	**	10,872	**	2.09	**	10.18	n/a
4/11/07 *	0.84	7.42	< 1 yr	2,917	655	1.05	0.12	5.10	0.57	89%
6/28/07 *	0.79	0.67	< 1 yr	3,457	269	75.48	0.03	366.88	0.15	100%
12/2/07 *	0.57	8.33	< 1 yr	1,843	811	0.38	0.02	1.84	0.10	95%
									Mean	**94%**

* - Low flow strainer installed to facilitate sampling at the outfall (Jones 2008a)
** - Upstream discharge for 3/15/2007 event is inaccurate due to backwater in pipe. No loading could be calculated.
n.s. - No samples collected due to low water levels in outfall pipe.
n/a - not applicable. TSS reduction not calculated when inlet or outlet data missing.

Gateway Commons Sediment Basin #2 (Clarksburg SPA)

Monitoring for TSS at Sediment Basin #2, a dual cell structure, was ongoing in 2009. Sampling occurred from April through October 2006 and September 2008 through December 2009. A decision from DEP is pending to determine whether monitoring will be required annually or bi-annually for the remainder of the construction period. Site plans and additional monitoring information are in the Technical Appendix. The Monitoring of Sediment Basin #2 commenced over one year after the start of construction. All storm samples were collected after roads and storm sewers were in place, and the site was stabilized on February 15, 2006. Monitoring was initially delayed because of the need to finalize the basin configuration and to direct overland flows to the basin. Construction activities stopped in March 2006 and did not begin again until September 2008.

Three sampling stations were established to evaluate the redundancy features of this basin (see Technical Appendix). During the first year of sampling, low flow conditions at the outfall prevented acquisition of TSS samples at the outfall (Table 3.12). Backwater issues were also reported at the first sampling station, which may be due to the inefficient emptying of the upper cell through the dewatering device. Backwater issues were typically observed during the middle and concluding stages of the storm (Jones 2010a).

A total of 12 storms have been captured at Gateway Commons Basin #2, five of which were captured for the 2009 monitoring year (Table 3.12). Any data reported prior to the 2009 monitoring year were affected by a calculation error that caused loading amounts to be under-represented. Corrected results from those presented in the Annual Report for 2008 are presented alongside previously reported results where applicable (Table 3.13).

Table 3.12.Storm Characteristics for the 12 Monitored Events at Gateway Commons S&EC Basin #2. Events denoted in bold were sampled for the 2009 Monitoring Year.

	Storm Characteristics			**Discharge Volume (cf)**		
Date of Event	**Total (in)**	**Duration (hrs)**	**Return Interval**	**Station #1** (Inflow; Upstream of Upper Cell)	**Station #2** (Between upper and lower cell)	**Station #3** (Outfall of Lower Cell)
4/21/06	1.11	40.67	< 1 yr	127,646.4	4,598.4	n.s. *
5/11/06	1.76	13	< 1 yr	37,628.4	3,286.5	n.s. *
9/1/06	1.95	31.58	< 1 yr	21,450.6	703.2 *	n.s. *
9/28/06	0.79	5.5	< 1 yr	6,084.6	0.6 *	n.s. *
9/25/08	1.88	62.25	< 1 yr	33,122.4	5,161.2	492.6
12/16/08	0.64	19.1	< 1 yr	43,015.4	19,251.2	1,002.7
1/6/09	1.50	24.92	< 1 yr	28392.5 **	5,018.7	906.0
4/14/09	0.52	48.42	< 1 yr	2,869.0	68.5	28.4
5/28/09	1.12	30.25	< 1 yr	12910.2 **	36.2	1,233.9
9/26/09	1.24	16.5	< 1 yr	9,647.6	8.1	4.9
10/14/09	2.90	88	< 2 yr	38336.6 **	282.1	7,583.7
12/2/09	0.62	21.92	< 1 yr	7602.4 **	82.7	1,156.5

n.s. * - Low flow conditions prevented sampling for Total Suspended Solids.
** - Backwater conditions. Flow values represent calculated adjustments.

Table 3.13.TSS Monitoring Results for Gateway Commons Sediment Basin #2.

Date of Event	TSS Loadings Previously Reported (lbs)			TSS Loading Reduction Previously Reported (%)		CORRECTED TSS Loadings (lbs)			CORRECTED TSS Loading Reduction (%)	
	Station #1 (in)	**Station #2** (mid)	**Station #3** (out)	**Upper Cell** (#1 to #2)	**Overall** (In vs. Out; #1 to #3)	**Station #1** (in)	**Station #2** (mid)	**Station #3** (out)	**Upper Cell** (#1 to #2)	**Overall** (In vs. Out; #1 to #3)
4/21/06	18.0	3.4	n.s.	81%	*	87.7	16.4	n.s.	81%	*
5/11/06	10.6	0.8	n.s.	92%	*	51.7	3.9	n.s.	92%	*
9/1/06	0.3	n.s.	n.s.	*	*	1.3	n.s.	n.s.	*	*
9/28/06	2.4	n.s.	n.s.	*	*	11.8	n.s.	n.s.	*	*
9/25/08	38.3	9.9	0.5	74%	99%	128.2	48.3	2.5	62%	99%
12/16/08	9.9	37.1	0.5	-273% †	95%	48.3	108.3	2.4	-273% †	95%
1/6/09	42.0	2.0	0.4	95%	99%	69.1	10.7	2.1	85%	99%
4/14/09	n/a	n/a	n/a	n/a	n/a	3.2	n.s.	n.s.	*	*
5/28/09	n/a	n/a	n/a	n/a	n/a	17.7	0.1	4.5	99.6%	75%
9/26/09	n/a	n/a	n/a	n/a	n/a	8.4	n.s.	n.s.	*	*
10/14/09	n/a	n/a	n/a	n/a	n/a	33.5	n.s.	5.7	*	83%
12/2/09	n/a	n/a	n/a	n/a	n/a	90.2	n.s.	12.3	*	86%

TSS=Total Suspended Solids
n.s. - No samples collected due to low flow conditions.
n/a - Not applicable. Calculation error discovered during 2009 sampling; no prior values reported.
* - Not evaluated; no water samples collected at station.
† - Outlier. Negative removal efficiency for 12/16/2008 storm may be the result of resuspension of TSS in the first cell from previous rainfall occurring 12/10-12/12/2008 and a bypass of flow.

The data available from the 12 storm events show very little sediment (maximum 12.3 pounds during the December 2009 storm) leaving the structure (Table 3.12, Station #3). There are several instances where the automated samplers were unable to capture the flow needed to collect a stormwater sample. Discharge volume measurements at Station #3 show that the lower cell tends to trap any excess water released from the upper cell (Table 3.12).

Although previous monitoring results have suggested very high removal efficiency (over 90%) for the dual cell basin, 2009 monitoring results suggest a decline over time. Removal efficiencies ranged from 75% to 86% in 2009 for the three storms with measurable TSS at the outfall. This could be due to a need for maintenance of the structures being monitored, not necessarily because of a failure in performance.

A decline in the monitored performance of the upper cell alone was also observed. TSS loading reduction in the first cell could only be calculated for one storm monitored for the 2009 cycle. The event on 05/28/2009 produced a TSS reduction of 99.6%. However, this value is deceptively high. Minimal flow (36.2 cubic feet (cf)) was measured at Station #2), but much more substantial flow was measured entering the upper cell and leaving the lower cell (12,910.2 and 1,233.9 cfs, respectively). Flow during this monitoring event was very likely to have moved from one cell to the next by a means other than through the riser and sampling apparatus, perhaps by overtopping the riser. Water backing up from the first cell into the pipe containing the sampling apparatus may also have distorted the flow values collected at Station #1.

Backwater issues at the inlet sampling station caused by the reduced emptying of the upper cell through the dewatering device contributed to the declined performance, suggesting a need for maintenance. The apparent decline in efficiency appears to be attributable to greater flows leaving the structure than observed for previously monitored storms. In May 2010, the consultant doing the monitoring noted that the upper cell dewatering device was apparently in need of inspection. Over the course of monitoring, it was observed that very little flow comes from the upper cell to the lower and that any flow that does move between the cells overtops the riser or comes through its seams (T. Jones, personal communication).

It appears that the first cell is in need of maintenance and is contributing to the observed decrease in performance of the overall structure. However, the first cell is designed to back up as the basin fills with sediment. The redundancy feature provided by the lower cell compensates for the upper cell and decreases the loadings leaving the entire system. The overall removal efficiency and performance is better than the TSS load reduction of one cell alone.

Redundant cells are effective in reducing stormwater runoff and decreasing sediment loadings.

The majority of Gateway Commons drains to Little Seneca Creek and biological monitoring stations LSLS102 and LSLS302. LSLS102 was established and first monitored in 2005 to more closely monitor the effects of the Gateway Commons development. Monitoring at this station ceased in 2006 while construction was on hold. Monitoring was reinstated at LSLS102 in 2010 and results are presented in Section 5.2.1.

Greenway Village (Clarksburg SPA)

Greenway Village is a 374 acre mixed residential development immediately south of Skylark Road and west of Ridge Road (Route 27). The property was cropland and forest prior to development activities. Several tributaries of Little Seneca Creek run through the property.

Development is occurring in phases. Phases I-II are completed and post construction monitoring for that portion is anticipated to begin in the summer of 2011 once both post construction bonds have been posted. A two-celled sediment trap was monitored from June 2005 to October 2006 using grab sampling. Conversion from S&EC to SWM was completed by July 2007.

Phases III-V is in various stages of completion, with some portions undergoing active construction. As-builts for the Phase III are near submittal. Phases IV & V remain in various stage of construction. The rough grading of the proposed school site is complete and the area has been stabilized. Lot grading and street paving activities continued in phases IV & V. Clearing and sediment controls were begun for phase III of Little Seneca Parkway.

Monitoring of sediment basin #7/7A in Phases III-V began in August 2007 is ongoing. Sediment basin #7/7A is a two-celled basin consisting of a forebay and a main cell treating a 32.5 acre drainage area. The basin was installed in July 2007 and received maintenance in July 2009. Storm damage to this basin was repaired in August 2010. During the July 2009 maintenance, the trap was dewatered to remove sediment and clean out portions of the inflow pipes affected by a series of heavy rains. Conversion from sediment control to SWM began in November 2010.

Automated flow-weighted composite sampling data from Greenway Village is only available from four storms at sediment basin #7/7A. Equipment malfunction due to operator error, backwater, high flows that displaced the suction tube, and insufficient water levels were cited as the reasons for the lack of data. Calibrated *weirs* were installed in May 2009 to help create the water levels needed for sampling. Samples were successfully captured on October 27, 2009, September 28, 2010, and October 14, 2010 after the weir installation. The only other storm event producing flow-weighted composite sampling results occurred on November 15, 2007. The TSS removal efficiencies for the four monitored storm events were 43.8%, -200.9%, 58.4% and 71.6% respectively. More data are needed to evaluate this structure and reveal trends. A property map, sampling diagram, and table of storm data collection attempts to date are in the Technical Appendix.

Paint Branch High School (Paint Branch SPA)

Paint Branch High School produced data from 2 storm events in 2010 (Table 3-14). Reductions in loads ranged from 53% - 92%. For both events, the quantity of the water entering the facility was less than the quantity leaving the facility. The area draining to the facility was drastically different between the two storm events. For the October storm the size of the drainage area was dramatically reduced due to site grading. Failure to adjust the height of the inlet pipes after grading occurred prevented a substantial portion of sediment and water from entering the facility that would have otherwise been captured. The inflow volume during this storm was 126ft^3, while the effluent volume was 651 ft^3. This may be due to the influence of groundwater. This highlights the overall size of the facility in relation to the area being drained. The problem was corrected after the second storm and the basin is expected to receive runoff from a larger drainage area in 2011. The results of the October storm may not be representative of the effectiveness of the structure at reducing sediment loads to the stream.

Table 3.14. Storm Characteristics for the Two Monitored Events at Paint Branch High School S&EC Basin #2

Date of Event	Storm Characteristics Total (in)	Duration (hrs)	Return Interval	Discharge Volume (cf) Inlets (combined, sum)	Outfall	TSS Loadings (grams) Inlets	Outfall	TSS Reduction
7/12/10	1.87	8.33	< 1 yr	537.0	260.0	4,246.0	339.0	92%
7/13/10	2.05	16.33	< 1 yr	908.0	1,251.0	6248.0	2940.0	53%
10/01/10	3.89	25.16	3.5 yr	126.0	651.0	2,685.0	664.0	75%
					Mean	4,393.0	1314.33	73%

3.4 Stormwater Management (SWM) BMP Monitoring

Post construction BMP monitoring evaluates the efficiency of SWM BMPs in reducing pollutant loadings and the effectiveness of BMPs at achieving site performance goals. Detailed discussion on specific SWM BMP structures are provided in the Technical Appendix. The BMPs in the SPAs are configured in redundant treatment trains to optimize performance. A diagram of a labeled SPA site plan with redundant SWM BMPs is provided in the Technical Appendix. Post construction monitoring cannot begin until the construction on the property is complete, the site is stabilized, and the S&EC structures are converted to SWM structures. A post construction monitoring bond is posted and a permit is issued (Section 2.1.3). Monitoring can extend up to five years post construction on large projects.

Data are collected by using automated samplers to collect flow-weighted composite storm samples. Although not as difficult as sediment control structures, monitoring SWM structures is quite challenging. Ponding or backwater issues, equipment failure, or flow measurement distortion have continued to limit the amount of available flow-weighted composite data that can be evaluated for BMP efficiency of SWM structures.

In 2010, SWM BMP monitoring occurred at four properties; three (Clarksburg Ridge, Summerfield Crossing, and Parkside) in the Clarksburg SPA, and one in the Paint Branch SPA (Briarcliff Meadows). Structures to be monitored in the Clarksburg SPA include a BaySeparator™ and a two-cell surface sand filter at Clarksburg Ridge, a SWM treatment train of two sand filters and a dry pond at Summerfield Crossing, and a Stormfilter® on a different portion of the property. A temperature study on the surface sand filter at Parkside began June 2009.

Structures to be monitored in the Upper Paint Branch SPA include a "side-by-side" comparison of two SWM BMPs at Briarcliff Meadows, formerly referred to as Briarcliff Meadows North and South. Results from the monitoring of the surface sand filter on the north portion of the property will be directly compared to the monitoring results produced from the biofilter on the southern portion. Both SWM BMPs are designed to treat stormwater from the single-family houses in the development. The surface sandfilter has a 3.8 acre drainage area (DA); the biofilter has a 1.75 acre DA.

3.4.1 **Background on Monitored Technologies**

Surface Sand Filters

A surface sand filter is a media filter. It is best-suited for managing the high concentration of pollutants in the volume generated by the first inch of rain (also known as the first flush). The Montgomery County Sand Filter design is essentially a shallow, dry stormwater management facility which incorporates a sand filter and an underdrain. Montgomery County Sand Filter (MCSF) design details are provided in Figure 3.12. Photographs of representative sand filters in Montgomery County Special Protection Areas are also featured (Fig TA-3.19). Pre-treatment is provided by a grass filter strip (aka ‘Turf Filter’) or other structural means (DPS 2009).

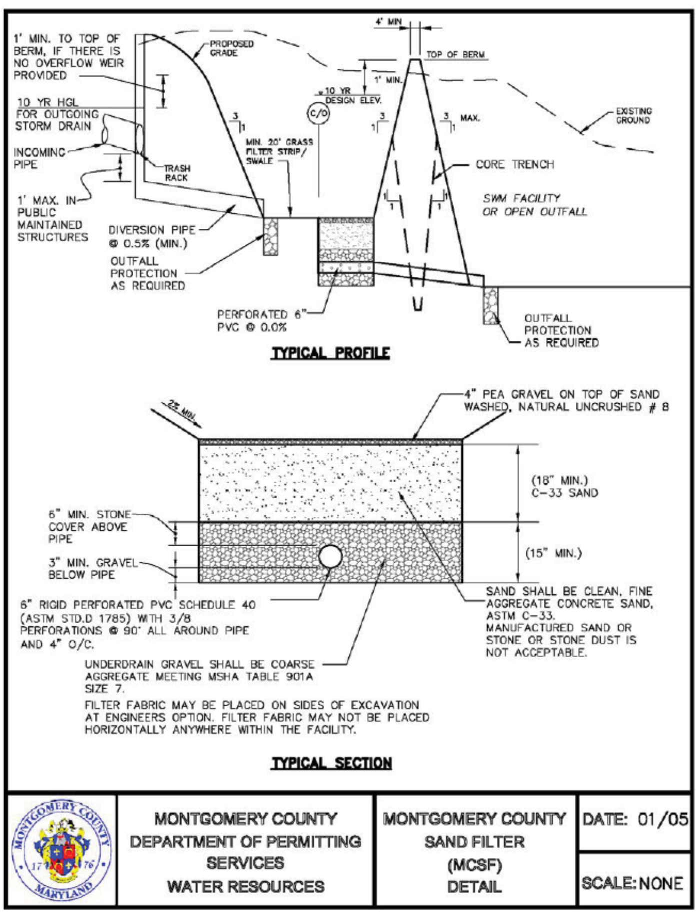


Figure 3.12. DPS Montgomery County Sand Filter detail diagram.

The sand filters in SPAs are typically designed to include a recharge area beneath the filter medium and underdrain pipe to promote infiltration into suitable soils. The water remaining in the structure below the level of the underdrain pipe will percolate into underlying soils with suitable infiltration rates. SPA performance goals encourage the use of infiltration to reduce storm flow runoff and recharge groundwater to help maintain stream base flows.

Sand filters have a range of removal efficiencies and are generally effective at removing total suspended solids, with removal efficiencies of 66% to 95% reported in the literature (Technical Appendix).

Surface sand filter performance was evaluated at two SPA developments. Monitoring results for Willow Oaks (Piney Branch SPA) and Snider's Estates (Paint Branch SPA) are discussed in detail in the 2008 SPA Annual Report and data are presented in the 2008 Section 3 Technical Appendix (DEP 2010). A summary of monitoring results follows.

Willow Oaks (Piney Branch SPA) is an 8 acre, 14 single family lot cluster option development. Two surface sand filters in series provide quality control for stormwater. Monitoring of metals, nutrients, and suspended solids was required at three locations: 1) upstream of the first sand filter following vegetated pre-treatment strips; 2) between the sand filters; 3) at the outlet of the second sand filter.

Monitoring results were produced from July 2005 through March 2008 for thirteen storms. Median removal efficiency for all monitored parameters was greater than 69% and consistent with literature reported values. Removal efficiency ranged from 20.2% to 99.6% for all parameters. Monitoring at Willow Oaks revealed that the monitored SWM BMPs achieved high pollutant removal efficiency success for the monitored storms and that two surface sand filters in series were more effective than the use of one structure alone. The design of the surface sand filters to promote infiltration and retain runoff in the sand layers is largely attributable to this success.

The 8.1 acre Snider's Estates subdivision consists of six residential lots in a medium-density residential layout. SWM consists of a sand filter and dry pond in series. The original monitoring hypothesis was limited to examining measured flows against the TR-20 model predictions. However, flow data were collected from the outfall of sand filter (quality control structure) and not from the outfall of the dry pond (quantity control structure), so this comparison could not be made. Instead, data were used for an assessment of the sand filter's flow reduction alone.

Post construction monitoring began in December 2004 and concluded in late 2007; 15 storms were measured and characterized; six storms had return intervals greater than one year. When examining the flow values of the sand filter alone, three out of the six characterized storms fell within the expected peak flow range of the design model for the entire pond 1 system (sand filter and SWM dry pond), suggesting that the sand filter was contributing to the flow attenuation in the entire treatment train. It appeared that factors such as a decrease in annual rainfall and accompanying extended dry periods and the growing lawns and vegetation in the residential lots may have also influenced measured flows entering the sand filter. The sand filter is primarily for quality control; primary quantity control was provided in a downstream SWM.

Data collection on several sand filters was occurring in 2010. A summary of the structures is provided in Table 3.15. Monitoring details and results are presented in Section 3.4.2.

Table 3.15. 2010 SPA BMP Monitoring Program Sand Filter Characteristics.

SPA	**Project**	**Design**	**Pretreatment**	**Capacity** (cubic feet (cf))	**Drainage Area** (acres)	**# of Reported Storm Monitoring Attempts ****
Clarksburg	Clarksburg Ridge	Dual Cell in Series	BaySeparator	9245 (for Pond C)	6.97 (5.53 pretreated)	13
	Parkside	Two sand filters in series	None	19,109	9.7	n/a*
	Summerfield Crossing	Two sand filters in parallel (flow splitter)	Vegetated swale, Bay Saver	582,250	39.8	3
Upper Paint Branch	Briarcliff Meadows	Single Cell	Vegetated Swales	3,206	3.8	3

* - The sand filter at Parkside is being monitored for continuous temperature from June through September, annually.
** - Monitoring attempts may not necessarily produce sampling data or results.

Biofilters

A biofilter is a landscaped area or shallow stormwater basin that utilizes soils (often engineered), vegetation, and microbes to capture and treat runoff. Stormwater then collects in an underdrain system at the bottom of the filter bed and is directed to the storm drain system. Biofilters are a type of bioretention area that emphasizes filtration. A diagram featuring components of a typical Montgomery County biofilter design is provided (Fig. 3.13). Fig. TA-3.21 features the biofilter monitored at Briarcliff Meadows South.

<u>*Bioretention areas*</u> like biofilters are a good option in cold water (trout) streams because they hold water for a short period of time, preventing potential thermal impacts from stormwater (SMRC 2010).

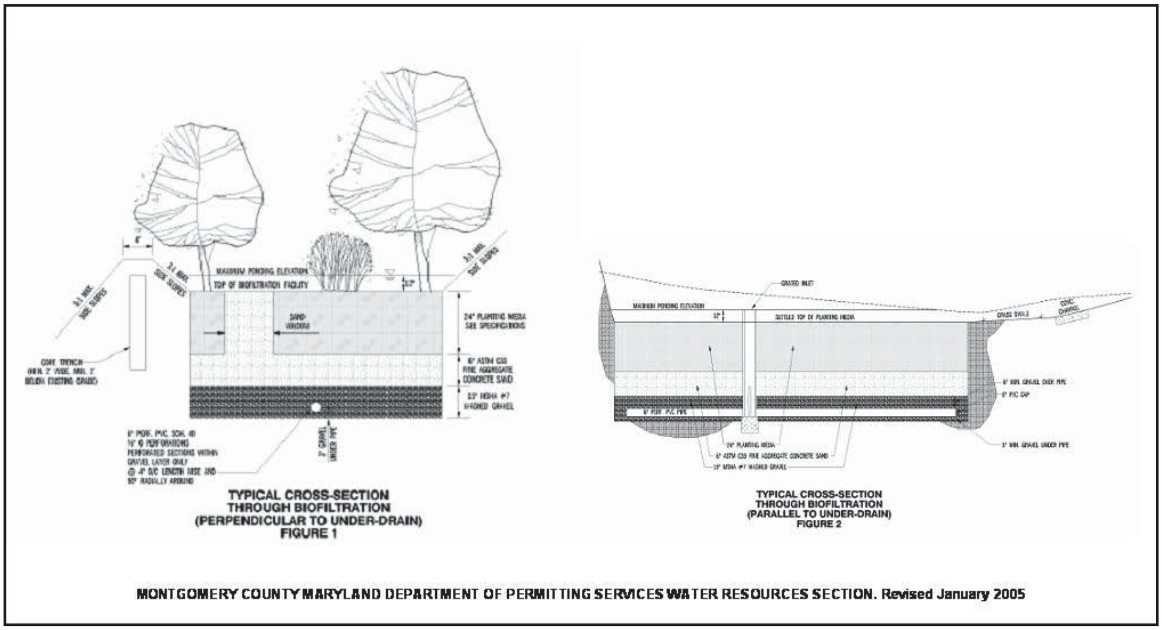


Figure 3.13. DPS Biofiltration diagram.

In Montgomery County, biofiltration is defined as a soil filtration system with these principal components (DPS 2005):

1) a pretreatment grass filter strip,
2) surface planting with woody and herbaceous plant species,
3) a surface 2 to 3 inch thick mulch layer,
4) a minimum two foot planting media,
5) a six inch thick sand layer, and
6) a perforated PVC pipe underdrain within a 15 inch gravel bed.

Montgomery County DPS restricts the use of biofiltration for the treatment of the water quality volume from drainage areas of 1.0 acres or less. The facility must be sized to store and treat the “first flush” of stormwater pollutants generated from impervious surfaces. An overflow structure is used to convey flow from large storms (that are not treated by the bioretention area) to the storm drain system.

Monitoring began on a biofilter at Briarcliff Meadows (Upper Paint Branch SPA) in 2009. Two storms events were monitored unsuccessfully in 2009. In 2010 four storm events were monitored, which produced data for three events. See section 3.4.2 for monitoring details.

Stormfilter®

The StormFilter® (hereafter “StormFilter”) is an underground BMP incorporated into the storm drain network and can be a standalone structure (Figure 3-14). It is a proprietary device (manufactured by Stormwater Management, Inc.) in which water flows through a filter media, or filter cartridges, to remove pollutants. The typical StormFilter unit is composed of three bays: 1) the inlet bay, 2) the filtration bay, and 3) the outlet bay. A structural diagram is provided in Figure 3.14. StormFilters are designed to trap and absorb sediments, oil and grease, soluble heavy medals, organics, and soluble nutrients from stormwater. The StormFilter cartridges can be filled with an array of media, which are typically selected to treat the specific pollutant loadings at each site in order to promote higher pollutant removal performance (Water Online, 2010; Contech 2009, Contech 2007). Montgomery County currently approves one type of filter media.

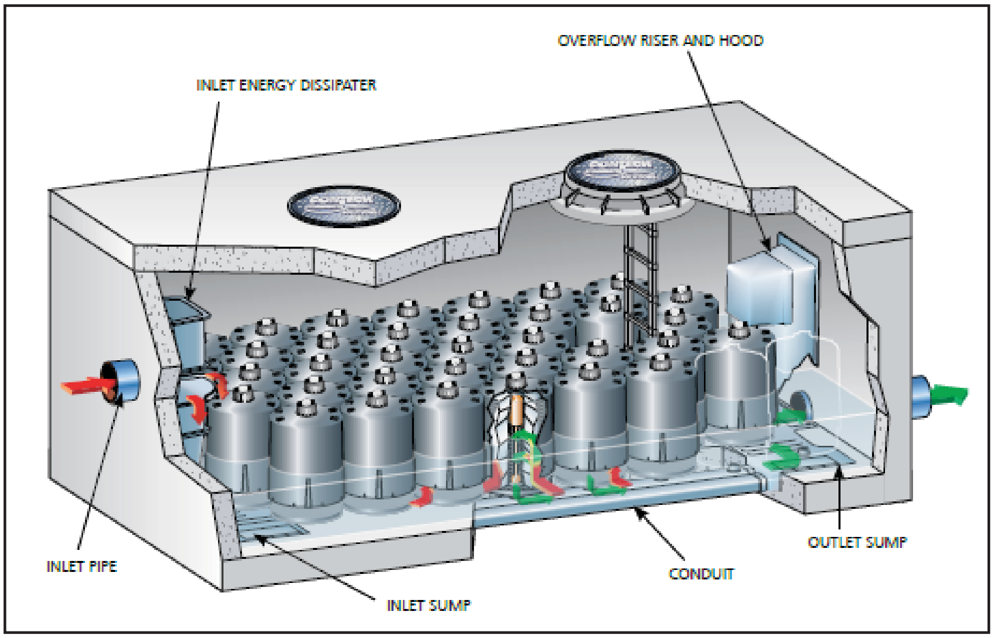


Figure 3.14. Basic design and function of "The Stormwater Management Stormfilter®" (Contech 2007).

Hydrodynamic Device*: (Typically use for stormwater management pretreatment prior to entering a filtering or infiltration structure)*

BaySeparator™

The BaySeparator™ (hereafter, "BaySeparator") is a *hydrodynamic device*. Hydrodynamic devices use the flow and direction of water to remove pollutants. Some pollutants, such as oils, rise and float, while others, like sediment, sink to the bottom and settle out from the stormwater. The BaySeparator serves as pre-treatment to other SWM BMPs in a treatment train. A structural diagram is provided in Figure 3.15.

The BaySeparator treatment system consists of three components: 1) the Primary Manhole, 2) BaySeparator unit, and 3) the Storage Manhole. A structure diagram is provided in the Technical Appendix. The BaySeparator component itself directs stormwater flow to the two manholes for pollutant removal. Stormwater influent passes through the primary manhole for initial separation, and coarse sediment (e.g., sand, gravel) is collected. The stormflow then enters the BaySeparator Unit by way of a weir and the BaySeparator re-directs the flow to a Storage Manhole. The Storage Manhole provides further treatment by collecting suspended solids, oils, grease and floating trash and debris. Treated stormwater re-enters the system through the Separator unit. Pollutants remain trapped in the two manholes until they are removed (by a vacuum truck or similar device) during routine maintenance.

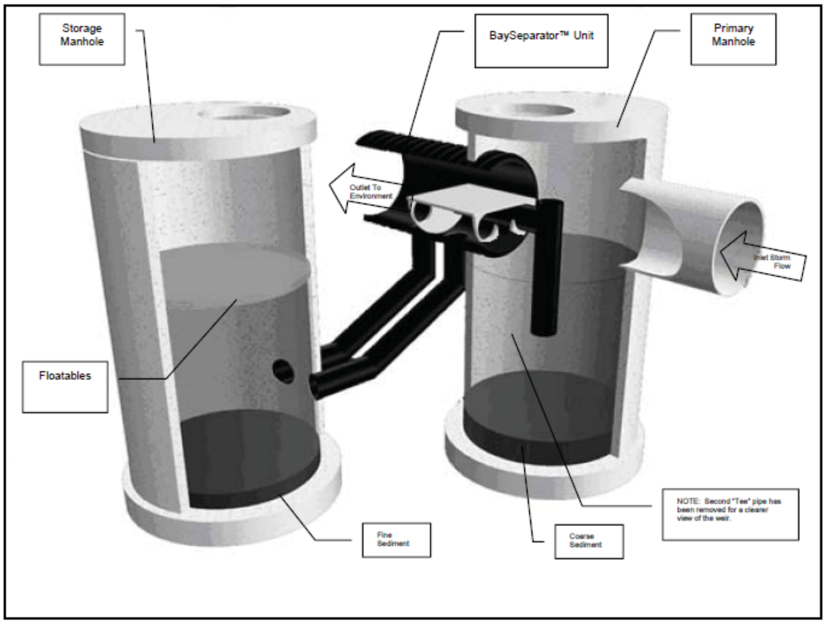


Figure 3.15. Basic design and function of the Baysaver BaySeparator (Baysaver Technologies, Inc 2008).

Typically, hydrodynamic separators perform better under low flow conditions than they do during high flows. The manufacturer, BaySaver Technologies, Inc. (2008), asserts that the BaySeparator unit is designed to prevent water from backing up in the storm drain system and resuspension of pollutants during high flow events. It is advertised that under frequent, low flow conditions, the BaySeparator system can remove "80% or more of the annual sediment load from a given site" (BaySaver Technologies, 2008).

Performance of a 3K (3,000 gallon) BaySeparator pre-treating a two-cell series sand filter (Pond C) was monitored in 2010 at Clarksburg Ridge (Clarksburg SPA).

Device: StormCeptor®

A Stormceptor® (hereafter "Stormceptor") is another hydrodynamic device that uses the flow and direction of water to remove pollutants. The Stormceptor slows incoming stormwater to reduce turbulence, allowing oils to rise and sediments to settle. All flows greater than the maximum allowed flow rate are bypassed. A structural diagram is provided in Figure 3.16.

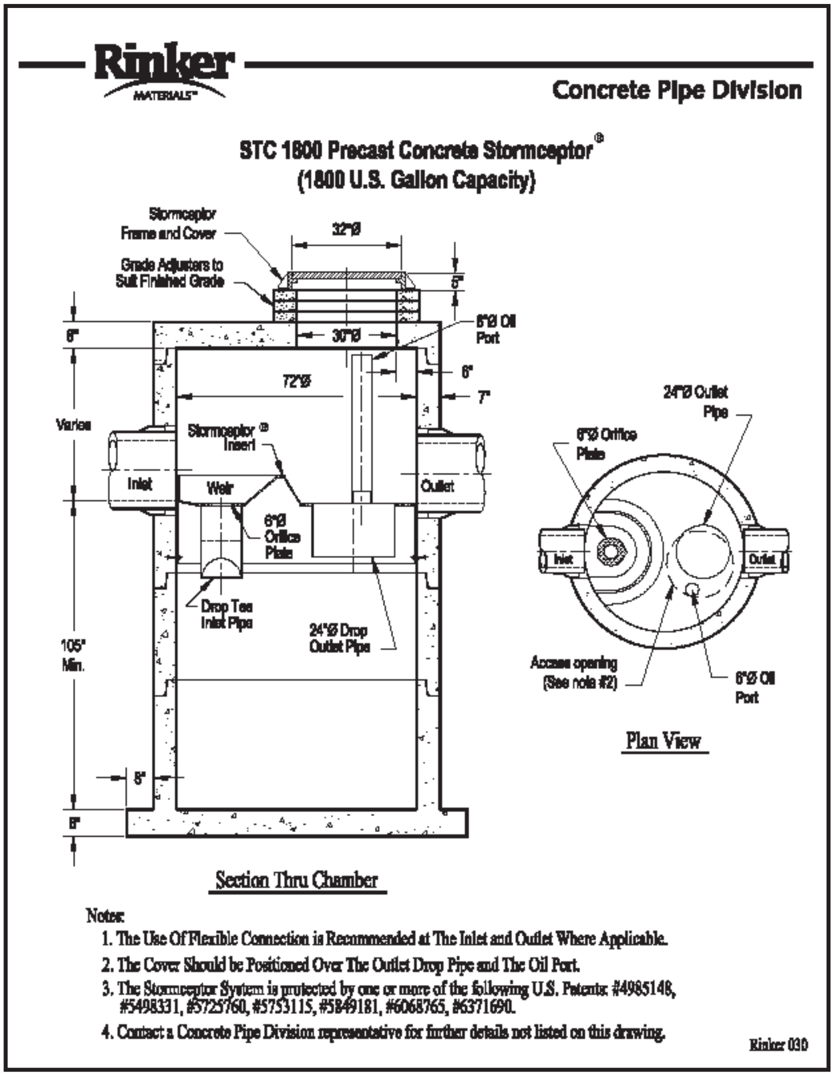


Figure 3.16. Stormceptor® 1800 Model (1800 U.S. Gallons) Schema (Imbrium Systems and Rinker Materials).

Monitoring at Cloverly Safeway is discussed in detail in the 2008 SPA Annual Report and data are available in the related appendix (DEP 2010). Overall it was found that pollutant concentrations entering the device were so low that they were below the reportable detection limit and could not be evaluated No other Stormceptors are currently being monitored or are planned to be monitored at this time but other types of hydrodynamic devices will be monitored.

3.4.2 **2010 SWM BMP Monitoring Results**

Clarksburg Ridge

Clarksburg Ridge is an approximately 34 acre residential neighborhood consisting of 101 single-family detached and 58 single-family attached townhouse units. Prior to development, the parcel was primarily forested and meadow with two existing on-site houses. The project broke ground in March 2003 and construction occurred through December 2004. Conversion of BMPs from S&EC to SWM was completed in September 2006 and SWM as-builts were approved in January 2008. The post construction monitoring permit was issued April 25, 2008.

The SWM BMP treatment train being monitored consists of a BaySeparator serving as pre-treatment for a two-cell series sand filter (Pond C). Post construction monitoring began in May 2008 at three sampling locations: 1) Upstream of the BaySeparator, 2) Downstream of the BaySeparator at the inlet to the upper sand filter, 3) at the Pond Outfall, after the second sand filter

Out of thirteen sampling events, only three were successfully captured and sent for laboratory analysis. Loadings for these storms could not be calculated due to unreliable flow rates at the first sampling station caused by head pressure at the flow splitter. Four other storm samples were discarded because the storm events did not meet the minimum of one inch of rainfall in a 24 hour period. The remainder of the monitoring attempts failed due to high flows causing equipment failures. The portable ISCO sampler was completely overturned during one of the sampling attempts. During the September 2010 storm event zero flow was measured at sample site 1and the sampler was returned for service.

SWM facility maintenance needs were also a problem at Clarksburg Ridge. The TSS concentration data and field observations suggest that the storage limit for sediment at the BaySeparator may have been met (CPJ 2010). TSS concentrations for the two analyzed storms (June 2009, August 2009) were twice as high at the outlet of the BaySeparator as at the inlet. TSS concentrations were lower at the outfall of Pond C than at either of the other monitoring stations, indicating that the sand filter portion of the treatment train reduced TSS concentrations. TSS concentrations were below the detectable limit of 1 mg/L suggesting very high removal performance.

In response to the 2009 sampling results and report, the monitoring consultant was instructed to delay further sampling attempts until the structure was inspected and maintained by DEP. The maintenance was scheduled for winter 2009, and the BaySeparator was inspected and maintenance was performed on April 7, 2010. DEP and DPS met with the engineer and monitoring consultant in May 2010 to resolve future monitoring difficulties.

Briarcliff Meadows

Briarcliff Meadows consists of a northern and southern tract, approximately 11.56 and 9.41 acres in size, respectively. Development activities at this former nursery began in July 2006. Home construction of ten single-family homes on the North portion and nine single-family homes on the South portion was completed in November 2007. The post construction monitoring permit was issued in March 2009 initiating data collection on groundwater levels and chemistry and pollutant removal efficiency sampling at two SWM BMPs. Results from the monitoring of the surface sand filter on the north portion of the property are to be directly compared to the monitoring results produced from the biofilter on the southern portion.

Table 3.16 shows the four storms monitored in 2010 at the Briarcliff Meadows sand filter and biofilter. On January 17 and March 13, 2010, neither storm event was captured in its entirety at both structures. Results for these two storms at these two structures cannot be compared, as required in the terms of the post construction monitoring permit. Recognizing that a great deal of effort went into collecting data for these two structures, DEP agreed to count the January and March events as one storm for purposes of meeting the monitoring requirements. Two other storms were successfully collected for both structures in 2010, one on April 26 and the other on September 30.

Table 3.17 shows the calculated pollutant load reductions for the BMPs at Briarcliff Meadows. As reported by Geo-Technology Associates, Inc., the consultant responsible for conducting the monitoring at this project "The calculated percent mass removal for the sand filter (North site) generally ranged from 42 to 85 percent when a positive removal percentage was calculated for orthophosphate, total phosphorus, TSS, and TKN. Low to negative removal rates apparently occurred for the North site during the April and September events for orthophosphate, nitrate, and TSS."

"Overall, removal percentages were calculated to be generally lower for the boiler (South site) relative to the sand filter, with positive boiler removal rates, when observed, estimated to range from about 24 to 55 percent for TKN, TSS, and nitrate. Relatively low or negative removal rates were apparent for the March and September events, and for nitrate during the April event. The negative removal rates suggest pollutants detained by the structure from previous storms events may be being released, and is a more or less regular occurrence with this type of structure."

Table 3.16. Precipitation Statistics for 2010 Storm Events Captured at Briarcliff Meadows.

Date of Sampling Event	Rainfall (inches)	Event Duration (hours)	Return Interval* (years)
January 17, 2010	0.74	13	<1
March 13, 2010	1.94	17	<1
April 26, 2010	0.89	8	<1
September 30-October 1, 2010	2.66	15	<2

* From NOAA website

Table 3.17. Briarcliff Meadows BMP Pollutant Load Reductions. Load reductions were calculated by examining the total load entering and leaving the system.

Storm Date	Location	Nitrate	Nitrite	Ortho-Phosphate	Total Phosphorus	TSS	TKN
1/17/2010	North	-	-	57%	52%	85%	42%
3/13/2010	South	-90%	-	-85%	-62%	-93%	-15%
4/25/2010	North	-30%	-	-57%	58%	85%	51%
4/25/2010	South	-80%	-	-59%	-55%	55%	24%
9/30/2010	North	-78%	-	9%	44%	-73%	49%
9/30/2010	South	50%	-	-10%	5%	41%	35%

Summerfield Crossing

Summerfield Crossing is a development of 255 mixed residential units consisting of single-family and town homes. A reach of Little Seneca Creek and associated tributaries and wetlands transect the site. The area was agricultural and consisted of farm fields and open land prior to development. Summerfield Crossing was developed in three phases, all of which broke ground in September 2004. Build out occurred in December 2006 for Phases 1 and 2 and in June 2009 for Phase 3. A post construction monitoring bond was issued January 2010. Monitoring of two SWM BMP treatment areas began just prior to the bond being posted (in December 2009), but the monitored facilities were online and functioning.

SWM Pond A consists of a treatment train of *vegetated swales*, a BaySeparator, parallel sand filters, and a dry pond. Stormwater enters a vegetated forebay/swale and then splits "evenly" to two sandfilters. Following quality treatment in the sand filters, stormflow discharges into the dry pond before being discharged to Little Seneca Creek by way of a rip-rap channel. According to the design plans, the elevations are close to equal (only 1/10 of an inch off in elevation) so stormwater is expected to be shunted evenly if the structure is functioning as designed. Samplers are located at: 1) the inlet to the sand filters prior to the flow splitter, 2) at the outlet of the parallel sand filters, and 3) at the outfall of the dry pond.

A Stormfilter (identified as storm filter 1) is being monitored on a separate portion of the property. It is an underground facility beneath a playground and common area. It has a drainage area of 3.5 acres (1.75 acres imperviousness) and stormwater is treated by a BaySeparator before entering the filter. Samplers were deployed at the inlet and outlet pipes of the Stormfilter.

Table 3.18 shows the three storm events captured at Summerfield Crossing. Two valid storm event samples were captured for the Pond A treatment train and Stormfilter 1- January 17, 2010 and September 27, 2010. Samples were collected for a third storm on September 30, 2010; although the magnitude of the storm exceeds the storm interval stated in the Attachment letter to the Final Water Quality Plan for this project the placement of the samplers allows for efficiency of the sand filters to be evaluated.

Apparent vandalism at one sampler location prevented successful collection of one planned storm event in the summer, and repairs were made.

Table 3.18. Precipitation Statistics for 2010 Storm Events Captured at Summerfield Crossing.

Date of Sampling Event	Rainfall (inches)	Event Duration (hours)	Return Interval* (years)
January 17, 2010	0.75	12	<1
September 27, 2010	0.72	11	<1
September 30-October 1, 2010	3.65	1 day	3.5

* From NOAA website

Table 3.19 provides a summary of load reductions at Stormwater Pond A and at Storm Filter 1 for the valid storms in 2010. As noted by Geo-Technology Associates, Inc., the monitoring consultant for this project, "the calculated percent mass removal for Pond A for the January 17, September 27 and September 30, 2010 events from AS1 (inflow to Pond A) to AS-3 (Pond A outfall) for detected parameters generally ranged from about 6 to 100 percent. Nitrate removal percentages were generally relatively low or negative, possibly due to nitrogen mineralization. It should be noted that outfall concentrations and percent mass removal calculations may be influenced by atmospheric precipitation, including dry-fall and/or other inputs such as fertilizers that occur between the SWM inflow and outfall at Stormwater Pond "A"."

The calculated percent mass removal for the monitored events from AS4-AS5 ranged from about 7 to 100 percent. Exceptions include orthophosphate and total suspended solid mass which appear to increase for the September 27, 2010 event, possibly in relation to release of constituents through the storm filter due to past influences." Instances where 100% efficiency are reported reflect a 'zero' flow measurement at the downstream sampler used to calculate efficiency. The assumption is made that if there was no flow leaving the facility then it was 100% efficient in reducing pollutant loads to the stream.

Table 3.19. Summerfield Crossing BMP Pollutant Load Reductions. Load reductions were calculated by examining the total load entering the system with the total load leaving.

Storm Date	Treatment Train	Nitrate	Nitrite	Ortho-Phosphate	Total Phosphate	TSS	TKN	Cadmium	Copper	Lead	Zinc
1/17/2010	Pond A-Sand Filters	Neg.	--	48%	67%	91%	95%	63% to 100%*	41%	Neg.*	99% to 100%
1/17/2010	Pond A-Net	Neg.	--	43%	67%	72%*	90%	63% to 100%*	15%	Neg.*	99% to 100%
1/17/2010	SW Filter 1	Neg.	--	27%	7%	86%	76%	--	33%	66%*	--
9/27/2010	Pond A-Sand Filters	Neg.	39% to 100%	62%	59%	29%	84%	--	67%	16%	67%
9/27/2010	Pond A-Net	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
9/27/2010	SW Filter 1	17%	--	Neg.	17%	Neg.	51%	--	12% to 100%	--	11%

-- = No reportable reduction (due to non-detect)
* Load assuming concentration is equal to detection limit
Neg. = Negative removal; increase
100% reduction reflects zero flow at the downstream sampler

Parkside

Parkside is an approximately 10.96-acre site developed for residential use. 4.1 acres drain to the Clarksburg SPA (and biological monitoring station LSLS103C), while the remainder of the drainage goes to Little Bennett Creek. Post construction monitoring consisted of photo documentation of bioretention areas and a temperature study at the dual sand filter treatment train.

Continuous temperature monitoring occurred from June through September for 2009 and 2010. Four loggers were deployed to monitor stormwater as it enters Sandfilter 1 (2 locations), enters Sandfilter 2 (1 location), and at the outfall of Sand Filter 2. The purpose of the monitoring is to evaluate if warm stormwater runoff is cooled as it is treated. . In 2009 temperature monitoring results were variable. No clear relationship between the temperature at the inflow locations and the outfall location could be seen. It was noted stormwater runoff from Clarksburg Road was mixing at the outflow of pond two. For the 2010 monitoring season the temperature probe was moved from the outfall of pond 2 and placed at the pond 2 riser to alleviate this variable.

Four storm events were examined closely during the 2010 study period. Thus far results show the treatment train to have a minimal effect of the temperature of stormwater runoff.

In respect to pond 1 inflow 1 receives cooler water which mixes with warmer water from inflow 2. Pond 1 successfully lowers the mean water temperature. Three of the four storms displayed a nominal increase of temperature between the inflow and outflow of pond two of approximately one tenth of a degree. The July 12-14 storm temperatures were lower from 73.14 to 72.71 for these outflows. Monitoring is to continue for 2011.

3.5 Discussion of SPA BMP Effectiveness

3.5.1 **Completed Monitoring Projects in 2010**

Monitoring is completed at 25 SPA projects and ongoing at 26. The majority of ongoing monitoring projects continue to be in the during construction phase, although approximately half of these projects are approaching build out. Four projects were collecting data on post construction conditions in 2008, seven were collecting data in 2009 and five were collecting data in 2010. Two projects fulfilled monitoring requirements in 2010: Forest Ridge in the Upper Paint Branch SPA and Clarksburg Ridge in the Clarksburg SPA.

Completed projects allow the evaluation of onsite conditions throughout the development process. Forest Ridge drains to Paint Branch Right Fork (PBRF). A tributary of PBRF was monitored for temperature, embeddedness, and cross-sections. Groundwater elevations were also monitored throughout the development process to assess whether groundwater recharge was being promoted. Temperature results indicated that there were no thermal impacts to Paint Branch from the development. Cross-section monitoring indicated that the area immediately below the outfall experienced substantial change early on in the construction phase, but remained stable upon completion of construction. This suggests that the BMP was effective in controlling stormwater flow post-construction. The cross-section located furthest downstream from the outfall has been relatively unstable throughout the monitoring period, and has provided inconclusive data. Mean embeddedness was observed to be lower during construction, suggesting the BMP was effective at reducing sediment loads. However, the lowest embeddedness values also were observed to correspond with the periods of highest rainfall. One well showed increased groundwater levels after construction was complete, suggesting that the BMP is successful at promoting groundwater recharge.

Clarksburg Ridge drains to a tributary of Little Seneca Creek. Results of post-construction monitoring for pollutant load reduction only produced data for three storms out of thirteen attempts. Loadings for these storms could not be calculated due to unreliable flow rates at the first sampling station caused by head pressure at the flow splitter. Problems collecting water samples in the inlet due to clogging of the structure, turbulence or uncertainty if the runoff went through the bypass outlet or into the BaySeparator made prior successful sampling collection extremely difficult despite the consultant's best efforts. In 2010, a variety of technical issues were encountered with the equipment which precluded successful collection of any further storm samples. Facility design precluded collection of samples. A good faith effort was made by the consultant to attempt collection of samples During construction monitoring consisted of TSS grab samples showed the sediment trap was efficient at removing sediment from the system.

3.5.2 **S&EC Monitoring During Construction**

Monitoring of TSS continued in 2010. Some projects still have requirements to monitor TSS using grab sampling. A total of 129 TSS grab samples have been collected through 2010. Grab sampling of TSS at S&EC structures continued to demonstrate that higher outfall concentrations are observed late in the construction process where less exposed earth is present on a site. Under these conditions, more sediment may be leaving the structure than entering in stormwater due to the resuspension of fine clays and silts already accumulated in the structure control basin. Additionally, the concentration of pollutants in runoff (i.e. how dirty it is) can influence the actual pollutant removal percentages. If the concentration is near an *irreducible level*, such that it is near or below a detectable limit, a low or negative removal percentage can be recorded (Schueler 2000). These findings have prompted DPS and DEP to push conversion from S&EC to SWM BMPs in developments when the disturbance to the majority of the drainage area to the structure has ceased and any residual construction and sediment control can be attained by individual “on lot” controls.

Automated flow-weighted composite sampling, which better represents pollutant concentrations over the duration of a storm event and the pollutant loadings delivered to receiving streams, showed that TSS was being reduced at the two S&EC basins monitored in Clarksburg and Paint Branch. The Greenway Village and Paint Branch High School monitoring basins had an overall TSS loading reduction ranging from -200% to 58.8% and 68% to 75%, respectively. The Clarksburg Town Center and Stringtown Road Extension monitoring basins had an overall average TSS loading reduction of 87% and 94%, respectively. The high TSS removal efficiencies were attributed to redundancy measures (dual cell basins) and over-sized basins.

Monitoring was ongoing at the two other basins. Gateway Commons had an average TSS removal of 90%, lower than the nearly 100% efficiency reported in 2008. There is evidence that the first cell is declining in performance and in need of maintenance, causing an overall decline in performance. Inspection and maintenance is likely needed at the dewatering device of the first cell. Despite experiencing a decline in performance, TSS removal efficiency remains above 70%, and the redundancy measure of two cells continues to reduce TSS loadings to protect the receiving streams. Only two storms were captured at Greenway Village using proper monitoring techniques. Pollutant removal efficiency was for the storms monitored on 11/15/2007 and 10/27/2009 at 71.6% and 43.8%, respectively.

There are very little data and scientific literature available for evaluating the efficiency of S&EC basins at capturing total suspended solids. More research is needed to reveal factors that cause S&EC or SWM structures to function well or poorly.

Several variables have been identified as sources of disparity (CWP 2007), including:

- the amount and type of sediment disturbing activities occurring at the site at the time of sampling;
- the number of storms sampled and the characteristics of each (i.e. rainfall and accumulation, duration, flow rate, particle size of each);
- the monitoring technique employed;
- the internal geometry and storage volume and design features of the structure;
- the size and land use of the contributing catchment.

An additional sediment loading study was conducted at Clarksburg Town Center in 2009 beyond the requirements of the Final Water Quality Plan. Monitoring occurred late in the development process and does not represent early stage construction conditions, when the largest amounts of sediment are expected to be generated.

3.5.3 **SWM BMP Monitoring (Post Construction)**

An increasing number of projects are beginning to collect SWM BMP Monitoring data. Projects are early in the process and the dataset is further limited by sampling challenges. Monitoring consultants are required to submit quarterly progress reports detailing whether monitoring is on schedule and what problems have been encountered. DEP and DPS have also continued to promote meetings and planning prior to the commencement of monitoring. Establishment of a separate post construction monitoring bond is an important measure in keeping developers, and their hired monitoring consultants, accountable and ensuring that monitoring requirements are being fulfilled.

3.5.4 **Conclusions**

DEP and DPS continue to strive towards improving consultant success at collecting automated flow-weighted composite samples at S&EC and SWM structures and to help minimize impacts through the development process Generating these data are important for providing a long term assessment of stream conditions throughout the development process. A limited amount of useable data is now available for the post construction monitoring conducted at several properties. A wide range of efficiencies have been reported, from negative removal to almost 100% efficiency. Some of the factors that may be responsible for the broad range of removal efficiencies include, but are not limited to the following observations: presence of groundwater, limited storage capacities, antecedent dry times, lack of scheduled maintenance, and varied storm intensities. As more data from the post-construction period becomes available DEP hopes to gain a clearer understanding of the reduction potential for these devices.

Evaluating BMP efficiency by presenting percent removal is one important assessment tool, but efficiency alone does not provide the entire picture to BMP effectiveness at protecting the stream resource. Measuring changes to stream geometry, habitat, and chemistry (Section 4), and ultimately the biological community (Section 5) must also be examined for success in protecting water quality.

With these factors in mind, great care should be taken, not just when examining the County's results alone, but when trying to make comparisons between results from the same types of BMPs employed locally and nationally.

With the exception of the Clarksburg SPA, all the other SPAs were fairly well-developed prior to being adopted as a SPA, making it difficult to separate the effects of additional development from those areas already developed. Ultimately, a conclusive evaluation of the effects of development cannot be completed until the watershed is built out or almost built out.

The evolution of Clarksburg from an undeveloped, rural environment to a dense suburban/urban environment makes it a perfect test site to evaluate the ability of structural BMPs to protect water quality.

4.Stream Characteristics

4.1 Background

Conversion of watersheds to urban areas has been shown to have major affects on stream hydrology as a result of vegetation removal, stream channel modification, and increases in impervious area. These alterations can lead to increased *stream flashiness* and hydrologic responses: faster onset and decay of storm flow *hydrographs*, reduction in base flow rates, and higher and earlier peak discharges (Bledsoe 2001; Paul and Meyer 2001; CWP 2003; Goonetilleka et al. 2005; Konrad and Booth 2005; Walsh et al. 2005; Farahmand et al. 2007). The effects of these hydrologic changes are most severe in headwater streams (Nehrke and Roesner 2001). This section builds on the work reported in previous SPA Annual Reports.

4.1.1 **Hydrologic Data Analysis and Interpretation**

The rain gages at Black Hill Regional Park and Little Bennett Regional Park have produced records of rainfall totals that allow the calculation of a number of useful statistics including storm durations, storm mean intensity, and storm peak intensity.

Stream flow gages continue to provide data that allows the calculation of instantaneous peak discharge and daily mean discharge. Information on the five gages is presented in Table 4.1.

Table 4.1. Descriptions of the Five Stream Gages in the Clarksburg Study Area.

Gage Id. Number	Name	Date Started	DA (mi^2)	DA (acres)
01644371	Little Seneca Creek Tributary Near Clarksburg, MD	5/2004	0.43	275.2
01643395	Sopers Branch at Hyattstown, MD	2/2004	1.17	748.8
01644375	Little Seneca Creek Tributary Near Germantown, MD	6/2004	1.35	864
01644372	Little Seneca Creek Tributary at Brink, MD	6/2004	0.37	236.8
01644380	Cabin Branch Near Boyds, MD	6/2004	0.79	505.6

Precipitation, Infiltration, and Annual Flows

Average annual precipitation is about 42 inches in the Baltimore-Washington area (NWS 2008). Average monthly precipitation varies throughout the year and spring and summer thunderstorms can cause significant variations in precipitation depending on location (Doheny et al. 2006; James 1986).

Annual runoff for the two USGS gages (01644371, 01643395) was used to determine how much average annual precipitation infiltrates into the groundwater or is released into the atmosphere through *evapotransporation* within the drainage areas of the gages. Data were obtained from the online *Water Year Reports* published by the USGS, Baltimore Office (Doheny 2009, personal communication) for water years 2005, 2006, 2007, 2008, 2009 and 2010. A copy of the 2010 USGS Water Data Report for the two aforementioned stream gages is located in the Technical Appendix.

The Sopers Branch had about 57.5% of the average annual precipitation either infiltrating into the ground or lost to evapotransporation during water year 2010 (Fig. 4.1). The tributary of Little Seneca Creek had about 46% of the average annual precipitation either infiltrating into the ground or lost to evapotransporation during water year 2010.

On average, the overall amount of precipitation infiltrating into the ground or lost via evapotransporation has steadily declined in the Newcut Road Neighborhood Tributary

(Fig. 4.1; blue line) as development continues while remaining fairly constant in the Sopers Branch (Fig. 4.1, red line).

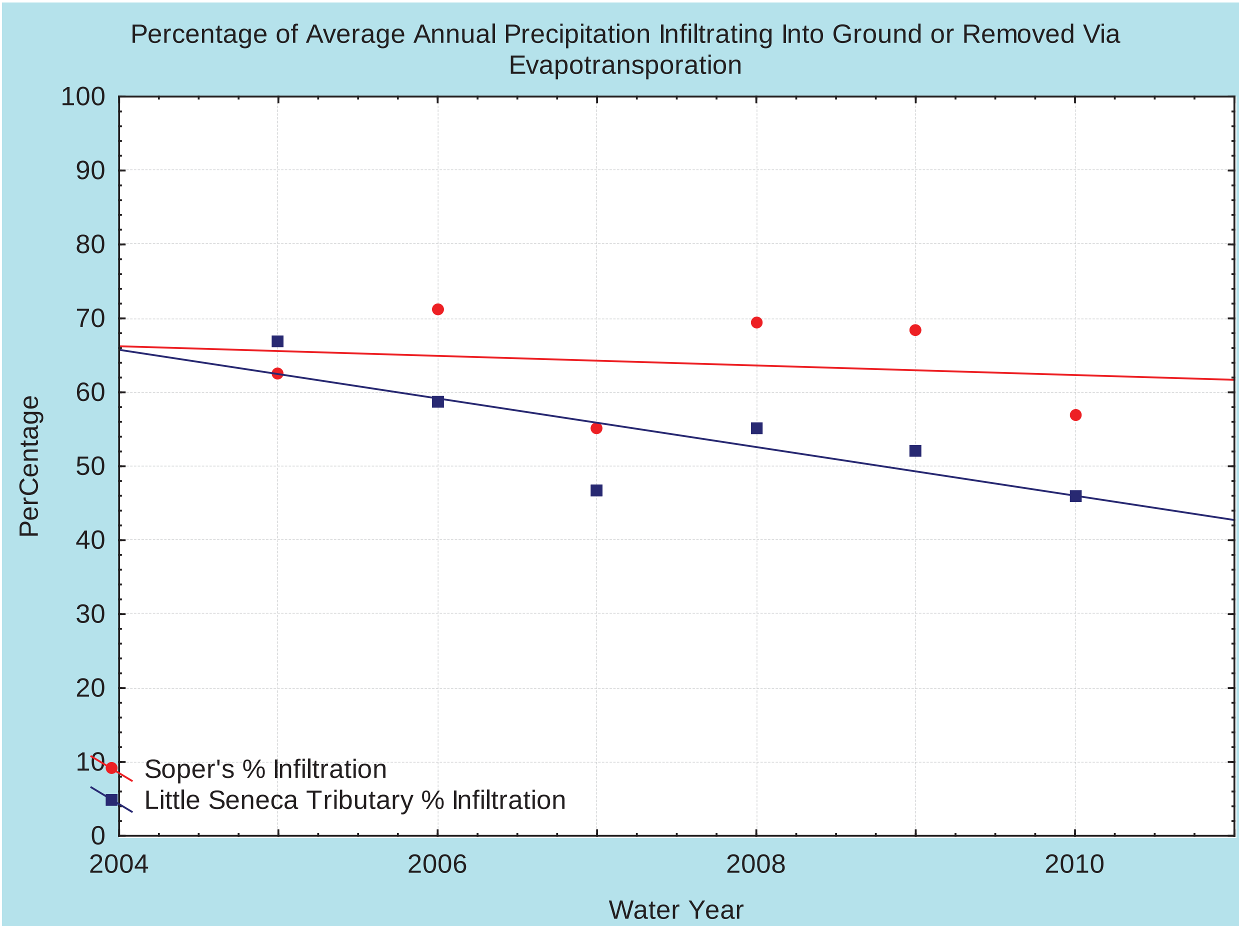


Figure 4.1. Percentage of Average Annual Precipitation Infiltrating into the Ground or Removed via Evapotransporation.

The overall amount of precipitation that directly entered the Newcut Road Neighborhood Tributary to Little Seneca Creek increased over this same time period (Fig. 4.2, blue line). Annual flows were adjusted for the differing drainage areas of the two gages to normalize the annual runoff amounts and to allow for comparison.

About twice as much rainfall is running directly into the Newcut Road Neighborhood Tributary stream as compared to the control stream, Sopers Branch, for the 2005, 2006, 2007, 2008, 2009 and 2010 water years. This is due to the changes in imperviousness that have occurred in the drainage area as a result of development.

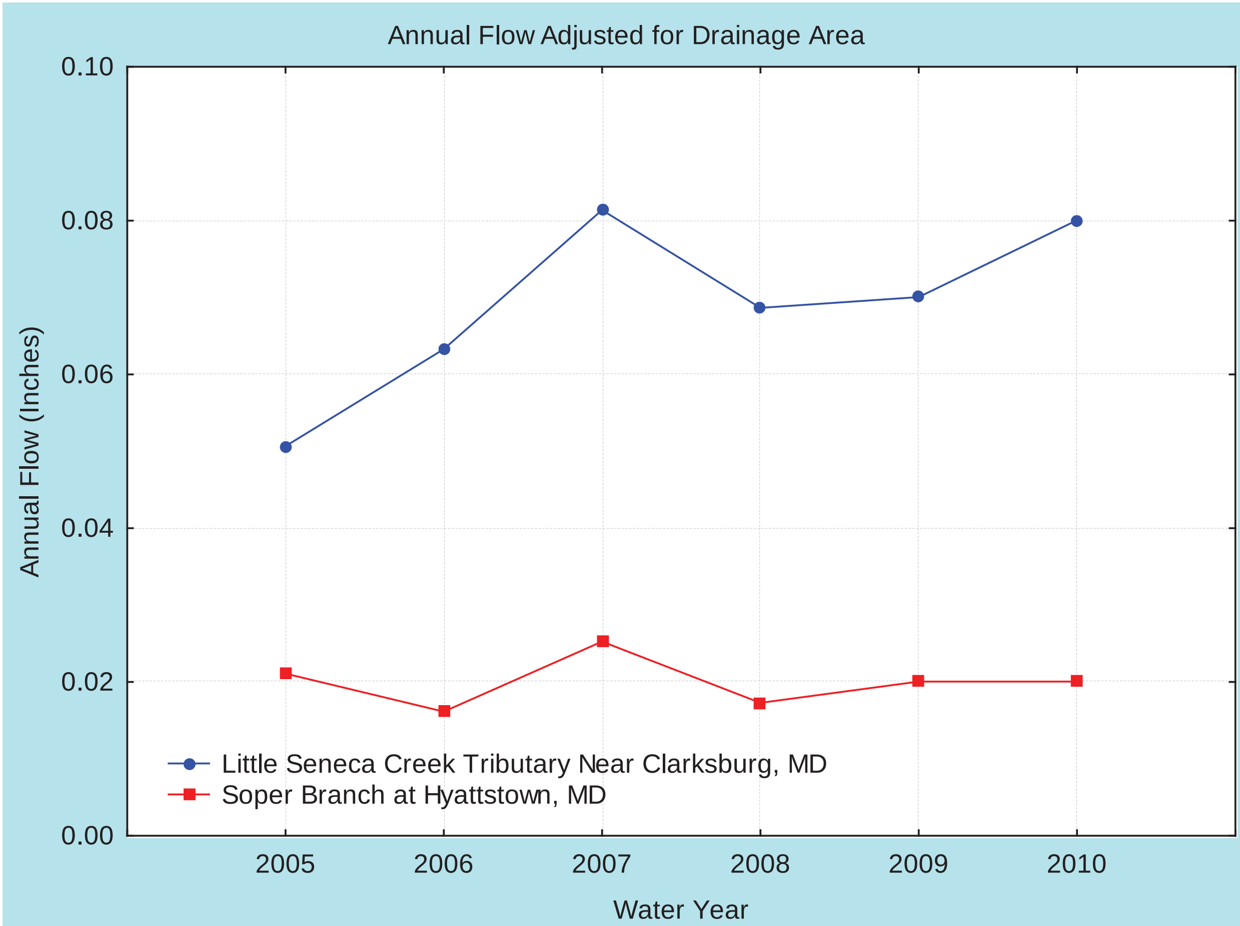


Figure 4.2. Annual Flow (Adjusted for Drainage Area) from 2005 through 2010.

Stream Flashiness

Stream flashiness refers to the stream flow response to storms. Conversion of watersheds to urban areas can lead to flashier hydrologic responses (Farahmand et al. 2007) with water levels that rise, peak, and fall very rapidly in response to storm precipitation (Doheny et al. 2006). An index was used in the 2007 SPA Annual Report to compare the flashiness of the Sopers Branch and Newcut Road Neighborhood Tributary streams (Doheny et. al. 2006). The index is described as the ratio between the instantaneous peak discharge (highest stream flow [IPD]) to the daily mean discharge (average stream flow [DMD]) that occurs during a storm event. When the discharge is divided by the size of the drainage area (acres), the ratios are normalized and the ratios from different streams can be compared. Daily mean discharge and instantaneous peak discharges for storm events from 2004 through 2010 are provided in the Technical Appendix.

During the construction period, the Newcut Road drainage was, on average, flashier than the Sopers Branch drainage. In 2010, the Newcut Road Neighborhood Tributary Flashiness Index was higher than the Sopers Branch tributary in 10 out of 14 rain events recorded. (Technical Appendix). The mean flashiness ratio was consistently higher for the Newcut Road tributary vs. Sopers during USGS water years, 2008, 2009, and 2010. A table of daily mean discharge and instantaneous peak discharges for storm events is provided in the Technical Appendix.

Time of Concentration

Time of concentration is defined as the difference in time between the start of rainfall and when discharge begins to increase at the gaging station (Doheny et al. 2006). Changes in the time of concentration of a watershed can be useful in understanding stream response to increases in imperviousness. In this report, we have evaluated Time of Concentration during the construction period (USGS Water Years 2008, 2009, and 2010 (Figure 4.3). When the conversion process to SWM BMPs has been completed, time of concentration will again be evaluated to determine if the Newcut Road tributary's response to rainfall has changed compared to the control station.

During 3 years of the construction Period (October 1, 2007 thru September 30th 2010) Time of concentration was evaluated for the Sopers Branch and Newcut Road Neighborhood Tributary. On average, the Newcut Road tributary responded twice as fast as Sopers Branch for the same range of storms exceeding ½" of rainfall. (See chart below).

Water Years 2008-2010			
		Sopers	**104**
	Mean	149	69
	Max	1045	550

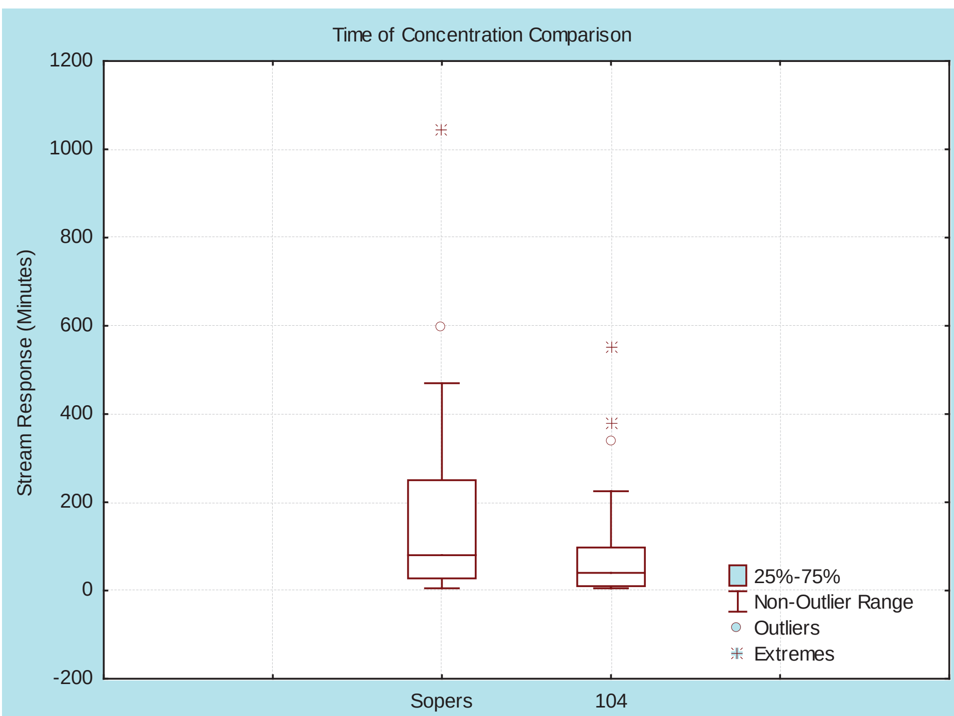


Figure 4.3. Time of Concentration Differences

4.2 Changes in Stream Geomorphology

Changes in the storm runoff amounts, directly and immediately reaching the stream, and the flashiness of the stream's response to storms can cause changes in stream geomorphology.

4.2.1 Study Design and Data Collection

Geomorphic surveys are conducted in the three test areas (Fig 4.4): two in the Newcut Road Neighborhood (Little Seneca 104 tributary) (Fig. 4.5.a), and one in the Cabin Branch Neighborhood as well as in the undeveloped control area in Little Bennett Regional Park (Soper's Branch) (Fig. 4.5.b) and the developed control in the Germantown area (Crystal Rock) (Fig. 4.5.c). Multiple surveys were completed in all areas to document the temporal change in stream channel morphology. Survey information includes longitudinal profiles, cross sections, bed composition (pebble counts), and sinuosity.

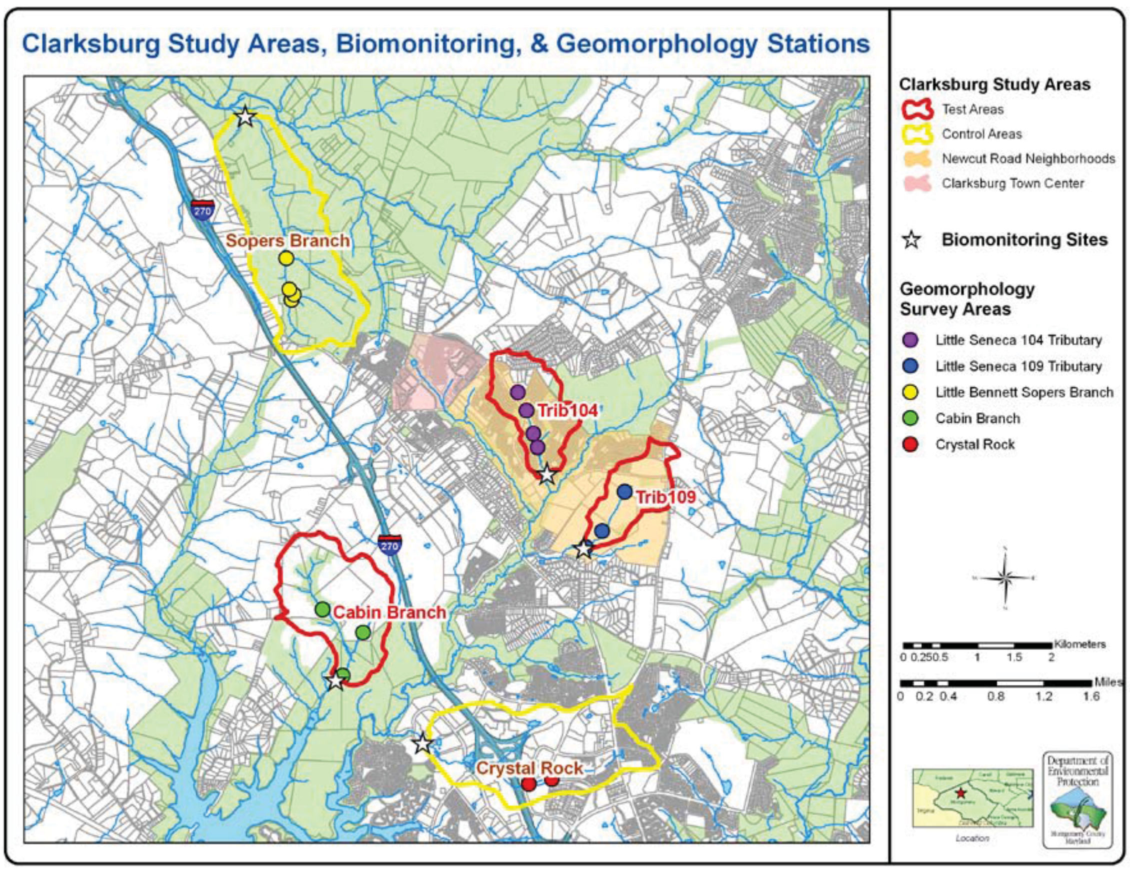
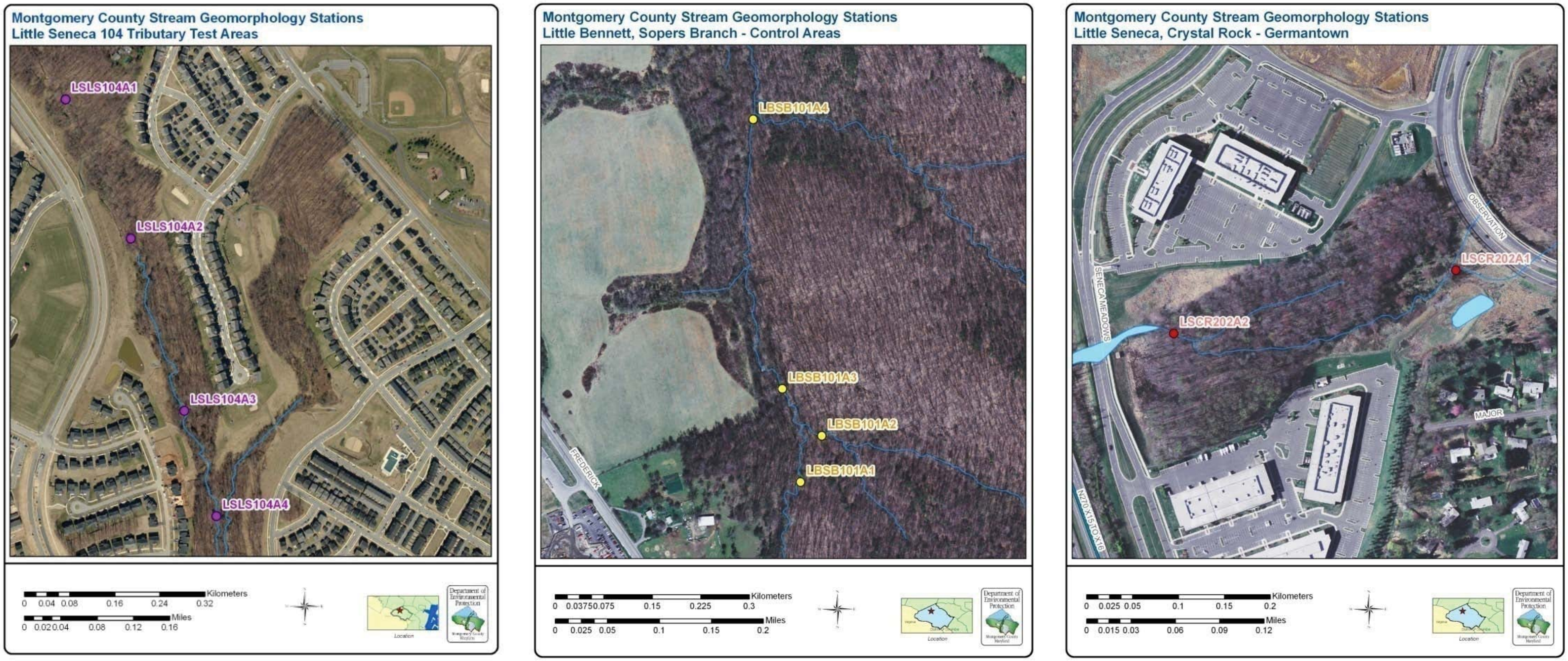


Figure 4.4. Location of the Clarksburg Monitoring Partnership BACI three test areas and two control areas. Also included are biological monitoring stations and geomorphic survey locations.

Surveys are located within similar habitat sections of the study streams. The first habitat section is a steeply-graded, straight channel (low sinuosity index) consisting mostly of *riffle* habitat. As sections were surveyed further downstream (areas two, three, and four), the slope of the stream slightly decreases, sinuosity increases, and runs and pools become more prevalent.



A B C

Figure 4.5. Little Seneca 104 tributary (Newcut Road neighborhood) geomorphology survey test areas (A), Little Bennett Creek survey control areas (B), and Germantown negative control survey areas (C).

4.2.2 **Data Analysis and Interpretation**

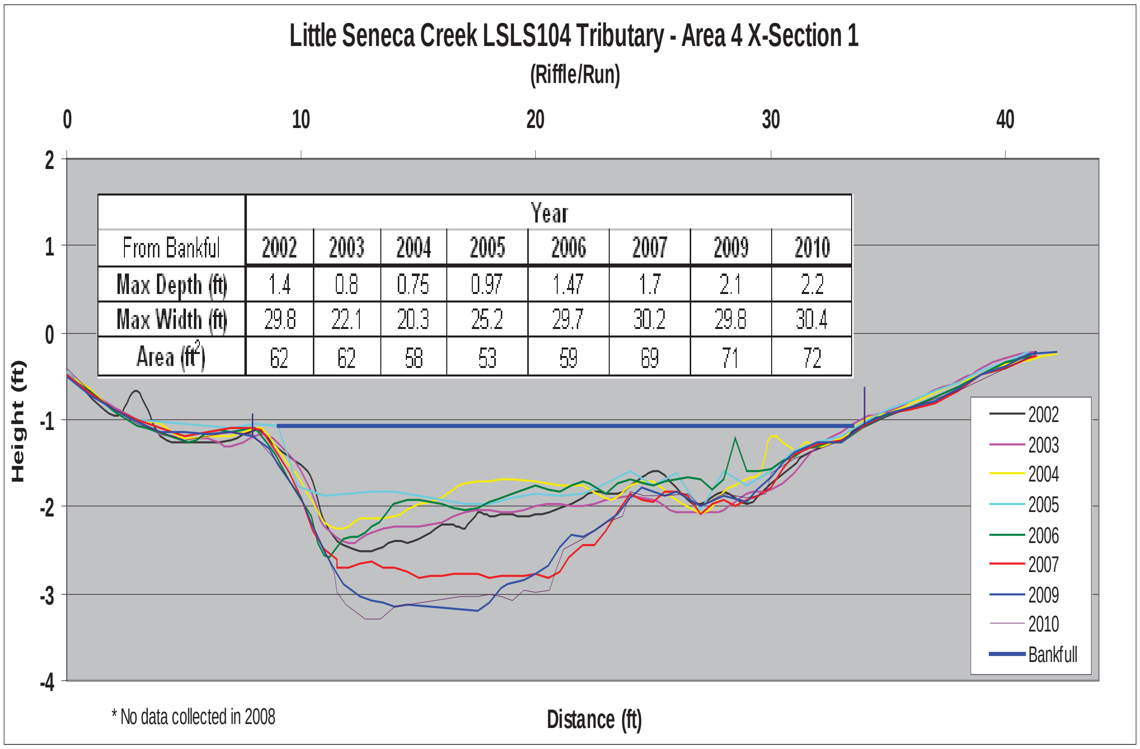
Preliminary results are presented in the Technical Appendix for cross sections established in the most downstream sections within the Newcut Road Neighborhood test area (area 4), the Little Bennett control (Sopers Branch area 4), and the Germantown control (area 2). All cross sections used in this comparison were measured in riffle/run stream areas. Riffle/run areas serve as grade control for the stream.

On average, cross sections from the Newcut Road Neighborhood area experienced channel aggradation corresponding to the most active years of construction (2004, 2005 and 2006), and then channel degradation and some widening from 2007 to 2010 as this area of the Newcut Road Neighborhood neared final elevations and stabilization (Fig. 4.6). On the other hand, the Little Bennett Regional Park (Fig. 4.7) and Germantown Crystal Rock cross sections show little yearly change.

Changes in cross section are most obvious in the lower half of each profile, corresponding to levels that frequent storms would impact. Surface hydrology analysis has shown that the amounts of annual runoff infiltrating the ground has decreased, annual stream runoff has increased and that the Newcut Road Neighborhood stream had a more rapid response to storms. These changes to surface hydrology would cause the stream to move more sands and gravels in the channel and aggrade (Paul and Meyer 2001). The S&EC BMPs on the development sites were functioning as designed and maintained. However, even the best maintained and functioning S&EC BMP are not 100% effective in removing fine clays and silts (unless no runoff leaves the BMP).

Evaluation of sinuosity over time documents a difference between the test and control stations. Sinuosity is the ratio between the length of the stream and the corresponding length of the stream valley. A ratio of 1:1 would indicate a very straight and often channelized stream. Sinuosity indices for the Newcut Road tributary reveal the stream has straightened over time (ratios went from 1.4 to 1.0 in just four years (Table 4.2). This would be consistent with the increased annual runoff of the Newcut Road Neighborhood stream. In 2009 and 2010 increased sinuosity was documented, possibly in response to the stabilization of this area. The sinuosity of the Sopers Branch channel has remained fairly consistent throughout the test period.

Changes in stream morphology would largely be a result of the changes reported in stream hydrology. An increase in runoff rate results in higher peak flows and increased scouring of the stream channel. The average particle size in the Newcut Road tributary has increased (increase in the diameter of 50% of the sampled particles (D-50) at the most downstream study area (Table 4.2). This could signify that increased runoff rates are flushing the finer particles downstream, while the coarser aggregates that characterize the parent material of the stream channel are left in place. The channel depth and channel width at the downstream study area continue to increase in response to changes in hydrology. An examination of the percent of riffle/run to percent pool at the test and the control sites revealed no observable trends.



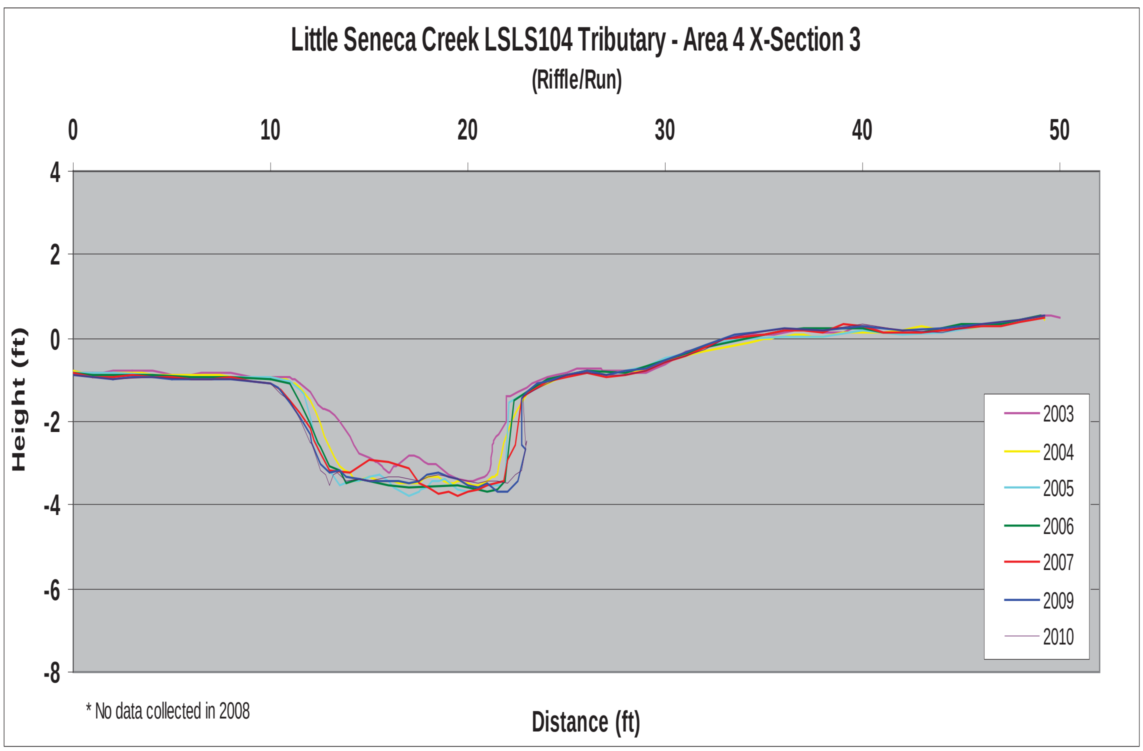
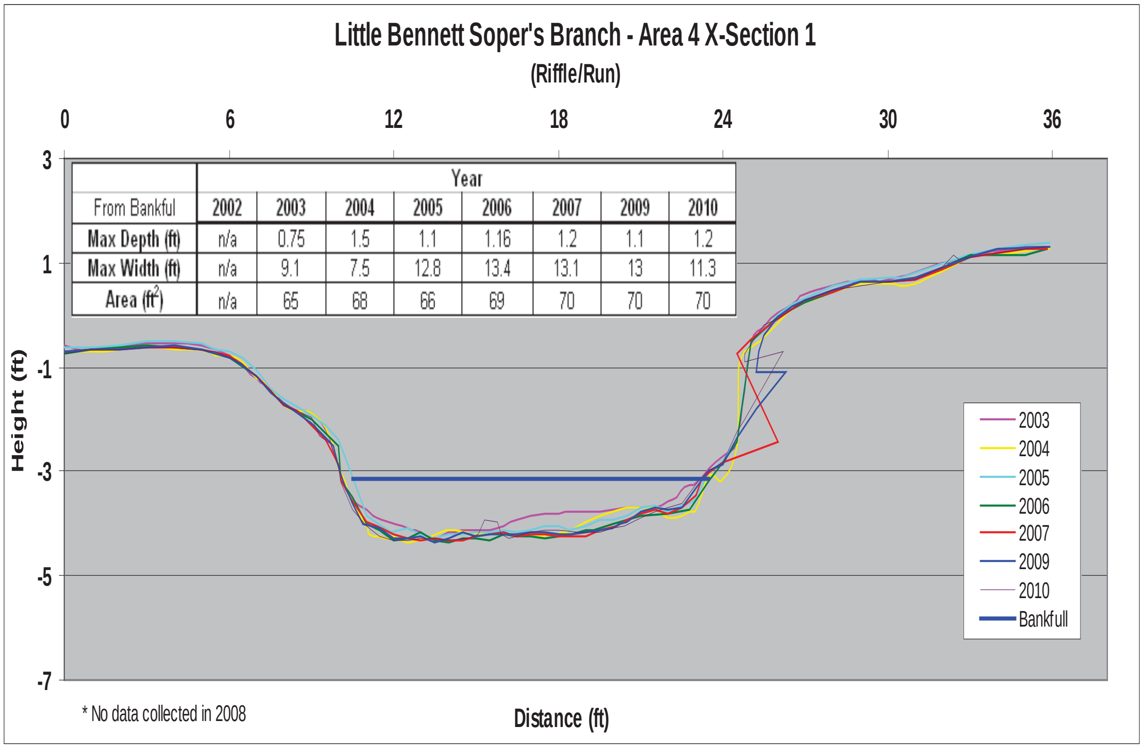


Figure 4.6. Representative cross sections from Newcut Road Neighborhood, Little Seneca 104 Tributary test location, Area 4. Cross sections are both measured in Riffle/run features.



From Bankful	2002	2003	2004	2005	2006	2007	2009	2010
	Year							
Max Depth (ft)	n/a	0.75	1.5	1.1	1.16	1.2	1.1	1.2
Max Width (ft)	n/a	9.1	7.5	12.8	13.4	13.1	13	11.3
Area (ft^2)	n/a	65	68	66	69	70	70	70

Figure 4.7. Representative cross sections from Little Bennett Creek, Sopers Branch control location, Area 4. Cross sections both measured in Riffle/run features.

Table 4.2. Sinuosity indices and survey information for Newcut Road Little Seneca 104 tributary test area, Little Bennett Soper's Branch control area, and Germantown Crystal Rock control area. Data are shown for furthest downstream areas within each test and control.

	Sinuosity						
Year	'03	'04	'05	'06	'07	'09	'10
LSLS104 A4	1.4	1.4	1.3	1.0	1.0	1.2	1.3
LBSB201 A4	1.1	1.1	1.0	1.2	1.2	1.1	1.2
LSCR201 A2	-	1.4	0.8	1.3	1.2	1.1	1.4

	Total Longitudinal Slope (%)						
Year	'03	'04	'05	'06	'07	'09	'10
LSLS104 A4	1.3	1.3	1.3	1.3	1.4	1.4	1.4
LBSB201 A4	1.1	0.9	1.5	1.4	1.4	1.5	1.2

	D50 (mm)						
Year	'03	'04	'05	'06	'07	'09	'10
LSLS104 A4	8.2	5.7	5.7	7.1	8.5	14	20
LBSB201 A4	16	0.062	8.7	14	9.2	0.062	0.062

There are many comparison studies yet to be done between the test and control areas to evaluate the effectiveness of stormwater BMPs. Results presented herein are preliminary as the S&EC control devices have not all been converted to SWM structures. However, from the preliminary results, the construction phase of development has impacted the 104 tributary channel morphology due to channel straightening, down-cutting, and enlargement. Final conclusions will be made once the development process has been completed in the test areas and when all of the S&EC BMPs have been converted to final SWM BMPs.

4.3 Special Protection Area (SPA) Stream Temperature Monitoring

The purpose for monitoring stream temperature within the SPA project sites is to determine how effective SPA site design and BMP's have been in minimizing elevated water temperatures as the surrounding land-use changed. Temperature data for test stations prior (baseline conditions), during, and after construction were compared to that collected for control stations that were not undergoing development over that same time interval.

4.3.1 Methods

Stream temperature data was collected using continuous recording meters from early June through the end of September. Temperature was recorded as the maximum temperature during every 24 minute interval over the course of the monitoring period.

Some of the temperature loggers that were deployed were lost or malfunctioned creating data gaps such that continuous stream temperature monitoring data at every SPA station every year was not always available. The available temperature data is presented in Appendix Tables 1-4 for each of the four SPA watersheds.

For each specific SPA watershed, the stations with the most number of years of data were selected and assigned as either test or control depending upon whether these stations represented areas that had or had not undergone development since the SPA program was established in 1995. During 2010, construction was still ongoing within each SPA.

4.3.2 Results

4.3.2.1 Stream Temperature Summary-temporal trends; 1995 – 2010 - Clarksburg SPA

For the Clarksburg SPA, five stations within the Clarksburg Town Center and New Cut Road Neighborhood development were selected as the test stations (see Technical Appendix 4) representing stations receiving runoff from construction that began in 2002. Conversely, stations within the Cabin Branch and Ten Mile Creek watersheds were selected as control stations whereby the surrounding land-use has not undergone any recent development. The current land-use within both of these watersheds, located west of I-270 is agricultural or low density residential, with the exception of the Clarksburg Correctional Center which is within the Ten Mile Creek watershed.

A summary of stream temperature data for the selected test and control stations within the Clarksburg SPA over a 13 year period is presented in Table 4.3. Overall, at the test stations, the mean annual stream temperature increased from one to one and one-half degrees Celsius after the start of development with the exception of a station within the New Cut Road Neighborhood development. The increase of the maximum temperature at the test stations between the pre and post construction eras was higher, ranging from three to five degrees Celsius.

Table 4.3. Summary of stream water temperature (°C) monitored during 1996 to 2010.

Era→	PRIOR to initiation of construction activity; 1995-2001			POST to initiation of construction activity; 2003-2010		
Station or tributary	Max	Mean	N	Max	Mean	N
Test Stations where construction commenced 2003 and was ongoing during 2010						
LSLS103	22.1	17.83	3196	27.4	18.86	82778
LSLS104	22.2	18.59	5423	25.2	17.88	27567
LSLS203	ND	ND	ND	26.9	19.46	33708
LSLS204	23.2	18.34	10510	26.6	19.85	41024
*LSTM206	25.2	19.22	21829	28.3	20.80	26818
Control stations where development will not occur or has not yet begun as of 2010						
Cabin Branch	21.1	17.91	7320	24.7	18.19	45176
Soper's Branch	ND	ND	ND	26.3	18.53	108524
LSTM203	21.7	17.28	1431	26.6	18.66	25521
LSTM303B	24.4	19.23	9707	25.9	19.66	40284

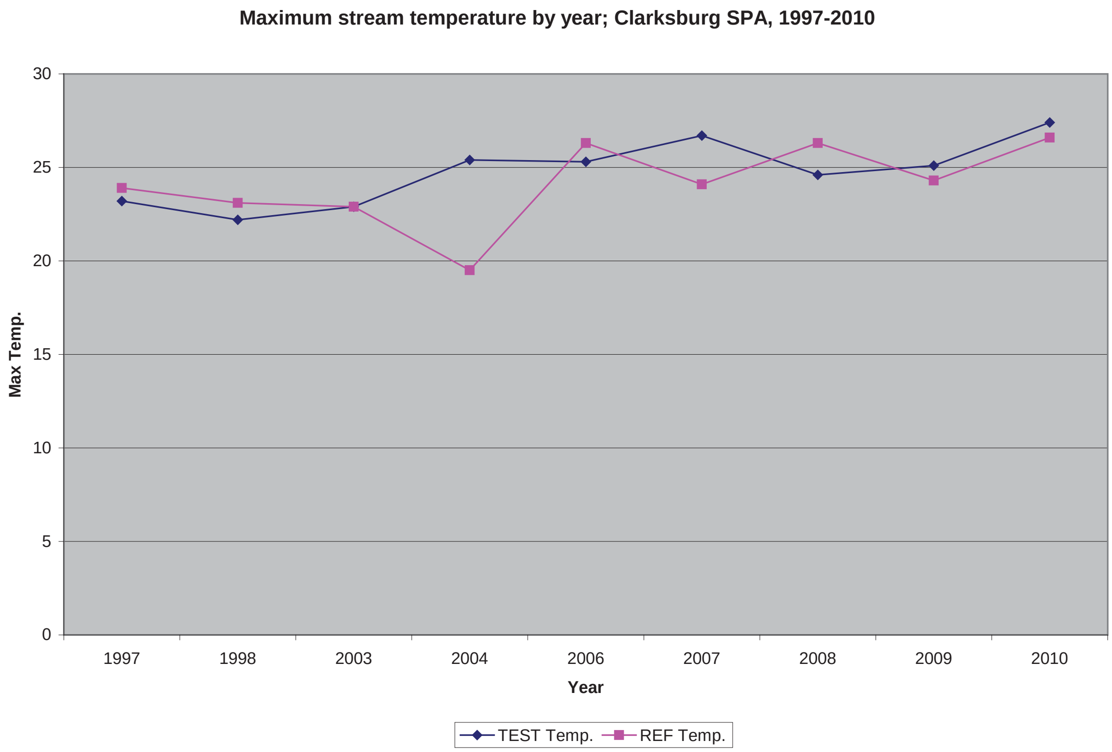
***Station within the drainage area of the Clarksburg Correctional Center.**

Overall, it appears that the mean stream temperature increased only marginally within both the test and control stations. Maximum stream temperature showed greater increases at the test stations.

Trend data from 1997 through 2010 for *maximum* and *mean* annual stream temperatures for the combined test and control station data are presented in Figures 4.8 and 4.9. Construction began in the Clarksburg test areas during 2003; during that year and previous years *maximum* stream temperatures were similar between the test and control stations (Figure 4.8), then in 2004 the test stations had higher *maximum* stream temperatures. During 2006 *maximum* stream temperatures were nearly identical between test and control stations, and then the higher *maximum* temperature alternated during 2007 and 2008 between test and control stations, respectively. From 2009 through 2010, most of the site disturbance and construction had been completed and *maximum* stream temperatures were again similar between the test and control stations.

There was more of a divergence of *mean* stream temperature between test and control stations from 2003 through succeeding years (Figure 4.9), with the greatest difference in mean temperature during 2004 and 2007, the test stations consistently exhibiting higher *mean* stream temperatures. From 2008 onward *mean* stream temperatures were essentially identical between test and control stations.

The Clarksburg SPA *maximum* stream temperature showed the greatest divergence between the test and control stations during the early stages of development (2004) whereby the test station *maximum* temperatures were about five degrees higher than at the control stations. However the greatest difference between test and control stations for *mean* temperature appeared during 2007 several years after ground breaking. After 2008 stream temperatures between test and control stations were nearly identical. This dampening and similarity of stream temperature, for both *maximum* and *mean* stream temperatures appears to be related with the later stages of development within the Clarksburg SPA after most of the construction has ended**.**



<u>Figure 4.8</u>. *Maximum* stream temperature for test and control stations within the Clarksburg SPA from 1997 through 2010.

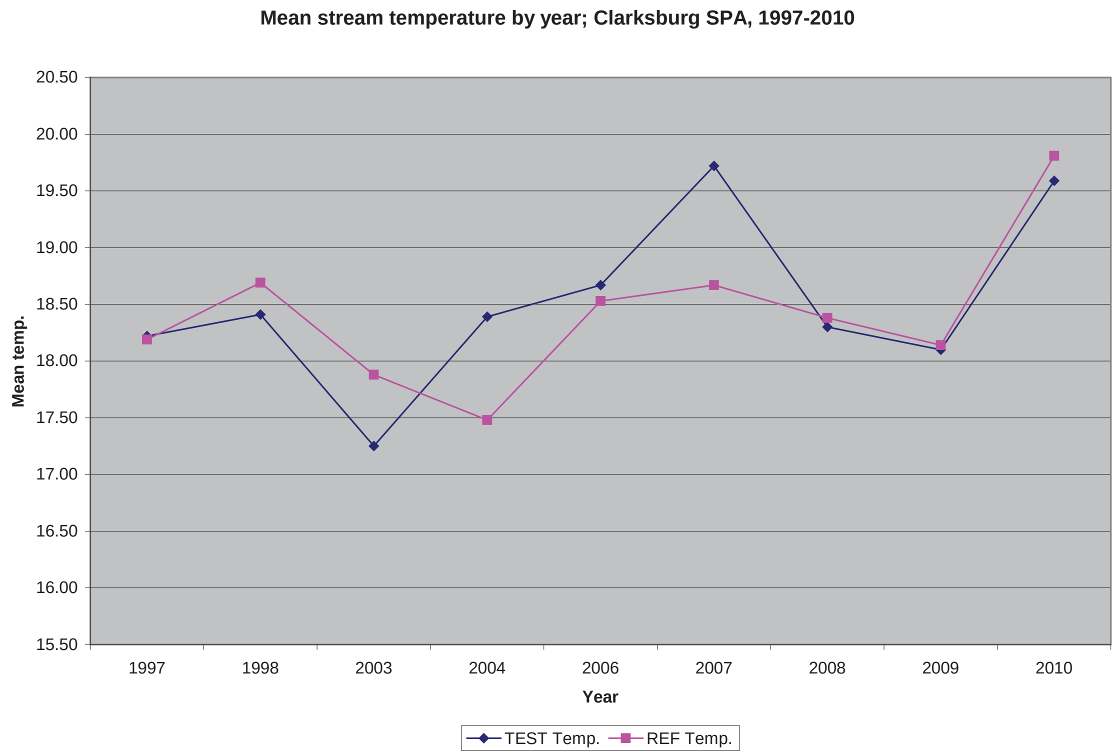


Figure 4.9. ***Mean* stream temperature for test and control stations within the Clarksburg SPA from 1997 through 2010.**

4.3.2.2 Stream Temperature Summary-Temporal Trends; 1995 – 2010 – Paint Branch SPA

The Right Fork sub-watershed is the area where the most development occurred during the 15-year time period between 1995 and 2010. Two Right Fork tributary stations (*PBRF117* and *PBRF204)* were identified as test stations because the surrounding land-use was converted from abandoned agricultural to low density suburban development (< 8% new imperviousness). The drainage to the Good Hope tributary station *PBGH108* had already been developed, mainly low to medium density single family residential housing that existed prior to the establishment of the SPA program. No construction occurred during the study period within this sub-watershed. The Good Hope tributary represents the control station.

An overall 12 year summary of stream temperature data for the representative test and control stations within the Paint Branch SPA is presented in Table 4.4. Overall, both the *maximum* and *mean* stream temperatures are comparable between the Good Hope and Right Fork tributaries.

Table 4.4. Summary of stream water temperature (°C) monitored during selected years from 1998 through 2010 within the Paint Branch watershed.

Station	Max	Mean	N
Test Stations where development occurred between 1995-2010			
PBRF117	24.5	18.66	42770
PBRF204	24.7	18.12	55205
Good Hope tributary control station			
PBGH108	24.7	18.96	28440

The yearly stream temperature trend data from the test and control stations at Paint Branch are displayed in Figures 4.10 and 4.11. A divergence in *maximum* stream temperature between the test and control stations is shown during 2000 and 2003, with high *maximum* stream temperatures exhibited at the Right Fork test stations (Figure 4.10). In 1998 and 2010 the *maximum* stream temperatures were essentially the same between the test and control stations. During the years between 2003 and 2010, fluctuations in *maximum* temperature at the test stations from year to year are apparent. By contrast, the *mean* stream temperatures between test and control stations are essentially the same (Figure 4.11).

The differences in *mean* and *maximum* stream temperature between the Good Hope control station and the Right Fork test stations are negligible**.** Development within the Right Fork of the Paint Branch watershed is low density because of the eight percent impervious cap within the Paint Branch watershed. This factor appears to be correlated with the negligible differences in stream water temperature for both test and control stations.

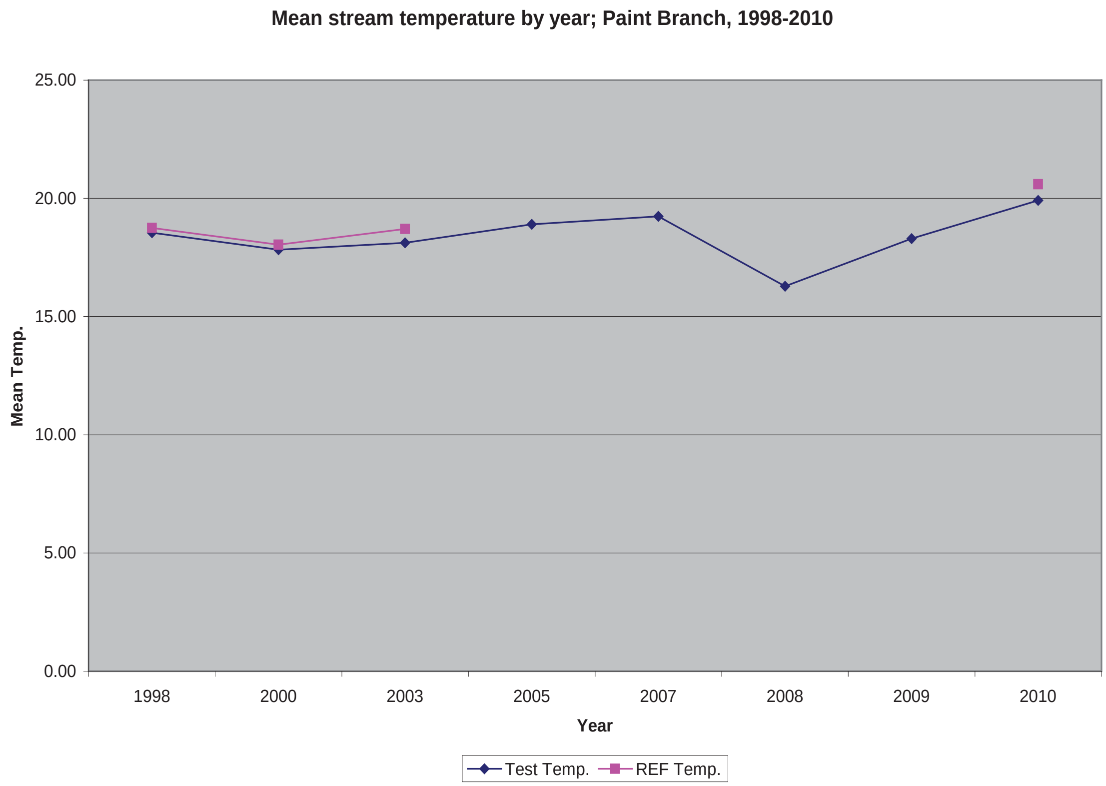


Figure 4.10. Yearly *maximum* stream temperature for test and control stations within the Paint Branch SPA from 1998 through 2010.

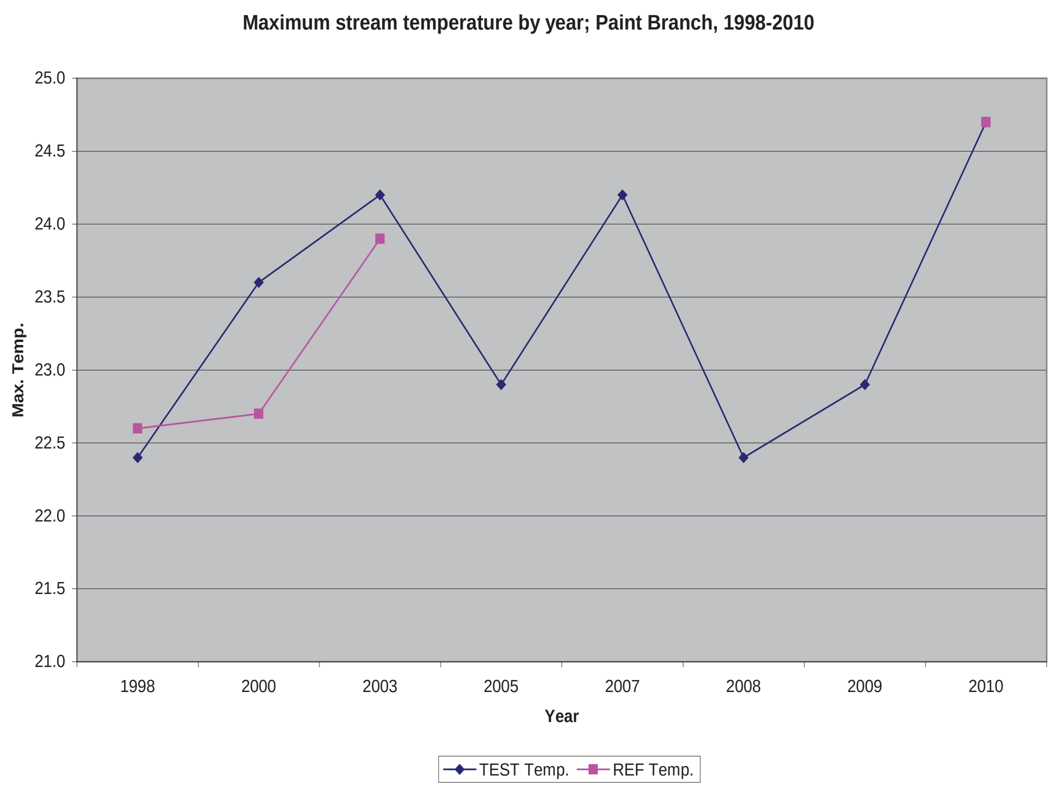


Figure 4.11. Yearly trend of *mean* stream temperature for test and control stations within the Paint Branch SPA from 1998 through 2010.

4.3.2.3 Stream Temperature Summary-temporal trends; 1995 – 2010 – Piney Branch SPA

The Piney Branch SPA was already undergoing development when this watershed was designated an SPA in 1995. Mixed use SPA residential development within the SPA began with the Traville tract. By contrast, the western tributary (represented by *WBPB101*) had no new development, having existing low density single family residential development. The western tributary is the control station and the two second order mainstem stations just below the Traville development are the test stations.

An overall summary of 15 years of stream temperature trend data is presented in Table 4.5. There is not an appreciable difference in the *mean* water temperature between the test stations and the western tributary. There is a substantial difference in the *maximum* temperature. The *maximum* temperature is nearly three degrees higher at the test stations than at the western tributary.

Stream temperature trend data over the 15-year study period for the test stations and the western tributary control stations at Piney Branch are shown in Figures 4.12 and 4.13. For all of the years that data are available the maximum and mean stream temperatures within the Western Tributary were consistently cooler than at the test stations. For *maximum* stream temperature, the Western Tributary and test stations were nearly the same until after 1998 when there were consistently higher temperatures at the test stations from 1999 through 2010 (Figure 4.12). The mean stream temperatures displayed a similar trend with the exception of 2010 when mean temperatures were identical (Figure 4.13).

The response of stream temperature to development within the Piney Branch watershed appears similar to the response of stream temperature to development that occurred within the Clarksburg SPA; in that stream temperatures between test and control stations were similar prior to the initiation or height of development, showed divergence during the development period, and then the differences in stream temperatures between test and control stations dampened during later stages of development and became nearly similar post construction.

Table 4.5. Summary of stream water temperature (^{o}C) monitored during selected years from 1995 through 2010 within the Piney Branch watershed.

Station	Max	Mean	N
Test Stations where development occurred between 1995-2010			
WBPB201A	27.8	20.06	60483
WBPB204A	28.3	21.22	61376
Western tributary control station			
WBPB101	25.4	19.37	76112

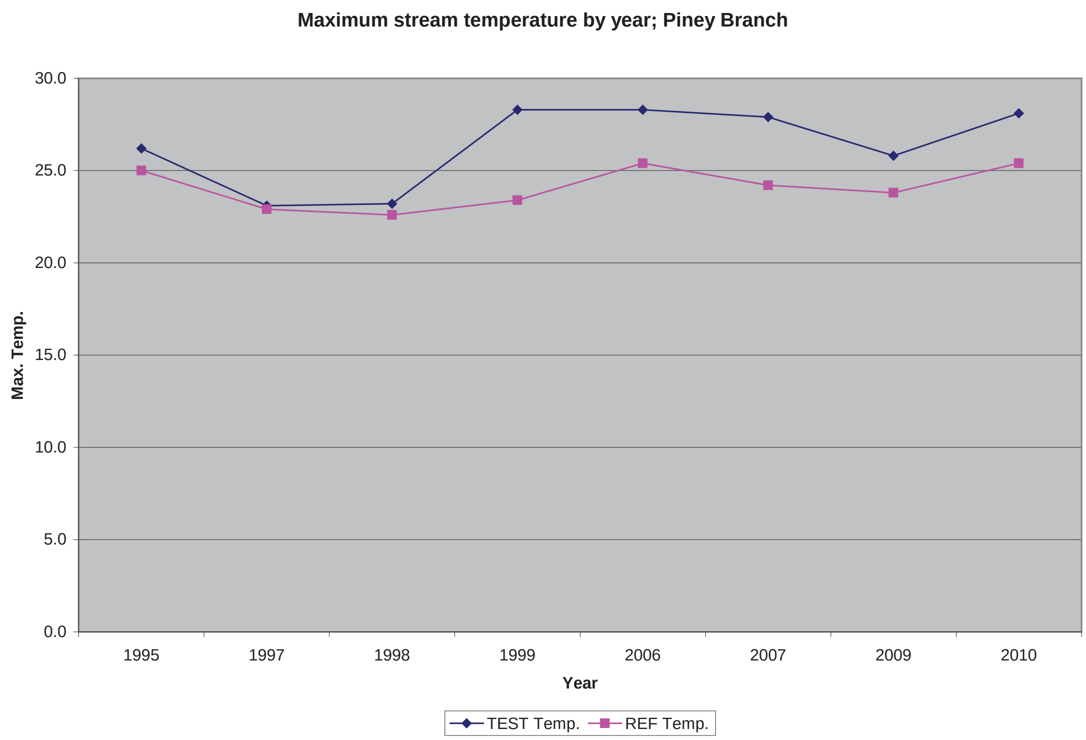


Figure 4.12. Yearly trend of *maximum* stream temperature for test and control stations within the Piney Branch SPA from 1995 through 2010.

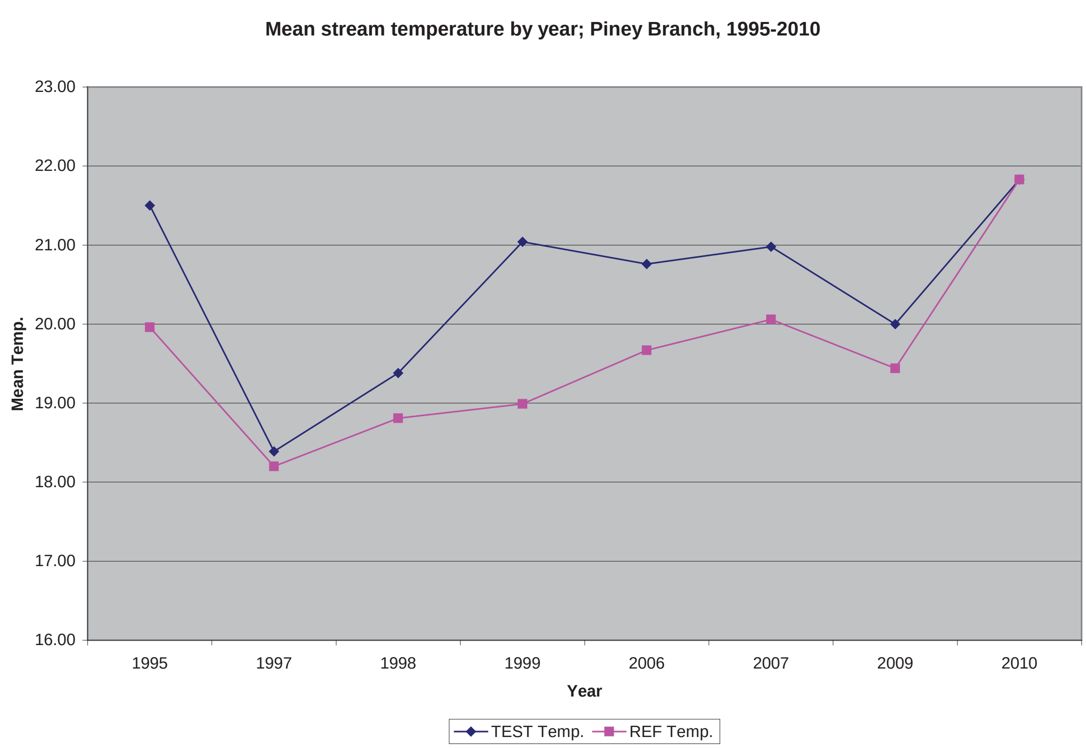


Figure 4.13. Yearly trend of *mean* stream temperature for test and control stations within the Piney Branch SPA from 1998 through 2010.

4.3.2.4 **<u>Upper Rock Creek SPA</u>**

There has not been enough development in this SPA to provide the type of temperature graphs and analysis as in the preceding sections. As development continues and is completed, future SPA Reports will have this type of analysis for the Upper Rock Creek SPA.

5. Biological Stream Monitoring

Stream biological communities respond to the cumulative and multiple stressors that occur in the stream. Careful monitoring and comparison of streams not impacted by new development and streams with ongoing development can isolate stressors caused by natural conditions (drought, flooding) from those caused by development (mass grading, sedimentation, increased impervious surface). Development-related landscape changes can alter stream hydrology and channel shape. SPA S&EC and SWM BMPs attempt to minimize these impacts.

5.1 Background

Minimization of the cumulative effects caused by development and land use change to streams is made through careful land use planning, protection of sensitive environmental features, and development practices that maintain natural hydrological and channel processes.

Biological monitoring evaluates stream condition and records changes in the stream community over time. The U.S. EPA (1990) recommends using two or more indicator groups to provide an evaluation of system *biological integrity*. The monitoring of fish and *benthic macroinvertebrate* communities is used nationally and regionally to measure the overall health of a stream, as documented in the 2008 report. Both biological communities provide information on short-term and long-term impacts.

Fish and benthic macroinvertebrate populations display a range of tolerances within each community and will survive or die in relation to the degree of cumulative impacts in the stream. Adults may survive initially, but the cumulative impacts can affect reproductive success to the point where there are not enough viable offspring produced to maintain the population. For examples of *tolerance values* and *functional feeding groups*, see the Technical Appendix. DEP developed an index to compare the stream community (fish and benthic macroinvertebrates) to those found in the least impaired streams located in the County and surrounding areas.

Measures (*metrics*) of each biological community are assembled to form an *Index of Biological Integrity (IBI).* The metrics used for benthic macroinvertebrate and fish IBIs can be found in the Technical Appendix. Metrics are selected that respond in a predictable way to increasing degrees of cumulative impacts. Metrics are scored in comparison to the least impacted streams in the region. The final IBI creates an index that compares any stream within the County against conditions found in these least impacted streams. Streams are rated as *excellent*, *good*, *fair,* or *poor*.

Benthic macroinvertebrates tend to be stronger indicators of stream health in headwater areas where impacts to the stream are much more concentrated in time and space. Fish, with longer life-spans and increased mobility, give stream health information on a larger scale both spatially and temporally. The composition of the fish community is a strong indicator of stream health in large streams. Fish are not as strong an indicator in smaller more headwater streams. The fish community found in these headwater streams tends to be very tolerant of rapidly changing flows, are adapt at recolonizing streams areas that have dried up seasonally, and are tolerant of the natural stressors that occur in these headwater environments. The predominance of highly oxygenated riffles is ideal habitat for benthic macroinvertebrates. The close proximity of vegetation provides the food for most of the benthic macroinvertebrates. Taken together and carefully analyzed, these benthic and fish metrics give a very inclusive, holistic evaluation of a stream's overall biological condition.

DEP has been performing county-wide biological monitoring since 1994. DEP began stream monitoring within three SPAs, Clarksburg, Piney Branch, and Upper Paint Branch in 1995 and within the newly-designated Upper Rock Creek SPA in 2004. Stream monitoring includes biological sampling of benthic macroinvertebrate and fish, as well as amphibian and reptile populations. Stream monitoring also includes habitat assessment, stream channel measurements, and water quality readings (dissolved oxygen, temperature, pH, and conductivity), which were discussed in Section 4. For a table of available stream monitoring data (Table TA 5.3) and a discussion of stream monitoring protocols, see the Technical Appendix.

A Stream Salamander IBI has been developed for Maryland and has undergone several validations (Southerland et al. 2004; Southerland and Franks 2008). Stream salamanders spend their entire lives instream or closely associated with the stream channel. Because of their longevity, small *home ranges*, relatively stable populations, abundance and ubiquity, salamanders have been identified as promising indicators of water quality. Furthermore, they replace fish as top predators in small, headwater streams (Jung et al. 2004; Southerland and Stranko 2006). DEP is examining the use of stream salamanders as indicators of water quality in small streams (less than 300 acres drainage area) to complement the benthic macroinvertebrate IBI scoring results. Beginning in 2010, DEP will use the benthic IBI as the measure of stream conditions in headwater streams until the stream side salamander IBI is completed by Maryland. The fish and benthic IBI will be used for all other streams.

Presently, there are 57 SPA stream monitoring stations throughout the four SPAs: 27 in Clarksburg; 14 in Upper Paint Branch; 10 in Piney Branch and six in the Upper Rock Creek SPA. Because of staff constraints, not all 57 stations are able to be monitored each year; 45 stations were monitored in 2010. For maps showing the location of all 2010 active SPA biological monitoring stations in the four SPAs, see the Technical Appendix.

5.2 Stream Condition Comparison

This section compares the stream conditions at each SPA station over time. Stream conditions in the pre-construction period were previously reported as an average of the benthic and fish IBI scores. Studies have shown that the fish community represented in first order streams does not provide as reliable of an indicator for assessing stream condition as does the benthic community. For example, The Maryland Biological Stream

Survey does not calculate a fish IBI for headwater streams. Fish assemblages in first order streams tend to be dominated by pioneering species that have the ability to readily enter or exit a given segment of stream much more rapidly than organisms in the benthic community. For this reason, beginning in 2010 only the benthic IBI scores will be used to rate stream quality for first order, headwater streams.

Some streams are starting to respond positively to the stage of development that has occurred in the various watersheds. Cut and fill and grading has stopped, many developments are almost built out. Conversion of BMP facilities from sediment & erosion control over to stormwater management has started. Stream response would be obscured if it were averaged with data collected during periods corresponding to more intense development activities. For this reason, the 2010 data is presented separately from previous years. A stream condition map representing pre-development conditions is presented for comparison. Percent scores give a better sense of where stations are within the categories of *excellent*, *good*, *fair*, or *poor*. Maps showing the average stream condition change from 2006 to 2010 can be found in the Technical Appendix if the reader is interested to see the changes from year to year. Additionally, maps showing the year to year change (2006-2010) in Benthic IBI narratives for each SPA can be found in the Technical Appendix. Data used to create the maps is also provided in the technical appendix.

Current stream condition trend changes in the four SPAs are presented and discussed. These changes are from cumulative impacts – not always from impacts directly related to SPA development or from activity occurring only in the year prior to sampling. Changes to SPA stream conditions are presented along with possible stressors related to the change. Section 5.3 presents changes in stream conditions associated with SPA development impacts.

According to Morgan and Cushman (2005), small (1^{st} to 3^{rd} order) *headwater streams* are particularly at risk from development impacts. Altered flow regimes from urbanization can affect fish assemblage structure and biodiversity by re-shaping the streams physical habitat on too short a time scale (years to decades) to allow populations to adjust. Miltner et al. (2003) suggested that poorly regulated construction practices constitute the first step toward declining stream health in suburbanizing landscapes.

5.2.1 **Clarksburg SPA**

Clarksburg SPA stream conditions were predominantly *good* to *excellent* before development occurred (Fig. 5.1). During development , stream conditions in the Clarksburg Town Center (mostly above Stringtown Road, LSLS103C), an eastern tributary of Ten Mile Creek (mostly east of I-270, LSTM206), and a small developing area of the Catawba Manor development (north of Stringtown Road, formerly LSLS103A) all declined into the *fair* category (TA 5.1- TA 5.3). In 2009 the stream condition in these areas all improved, returning to the *good* category, except LSTM206. Scores continue to improve in 2010, with the exception of a monitoring station below Stringtown Road which receives runoff from portions of the developing Clarksburg

Village. This drainage area had a fair stream condition (Figure 5.2) Scores are still below what was observed prior to construction.

The majority of new development in the Town Center and Newcut Road Neighborhoods began in 2006, resulting in degradation of stream conditions as areas underwent intensive widespread construction. Development activities have progressed in phases from east to west, with more intense construction in 2006 and 2007 and corresponding biological impairment. In 2008 and 2009, there was less intense development due to the economic downturn, which may have allowed less active construction sites to stabilize and for some completed developments to begin to convert to SWM. A few stream conditions during this time improved their average ratings, perhaps as a result of site stabilization and limited SWM conversion.

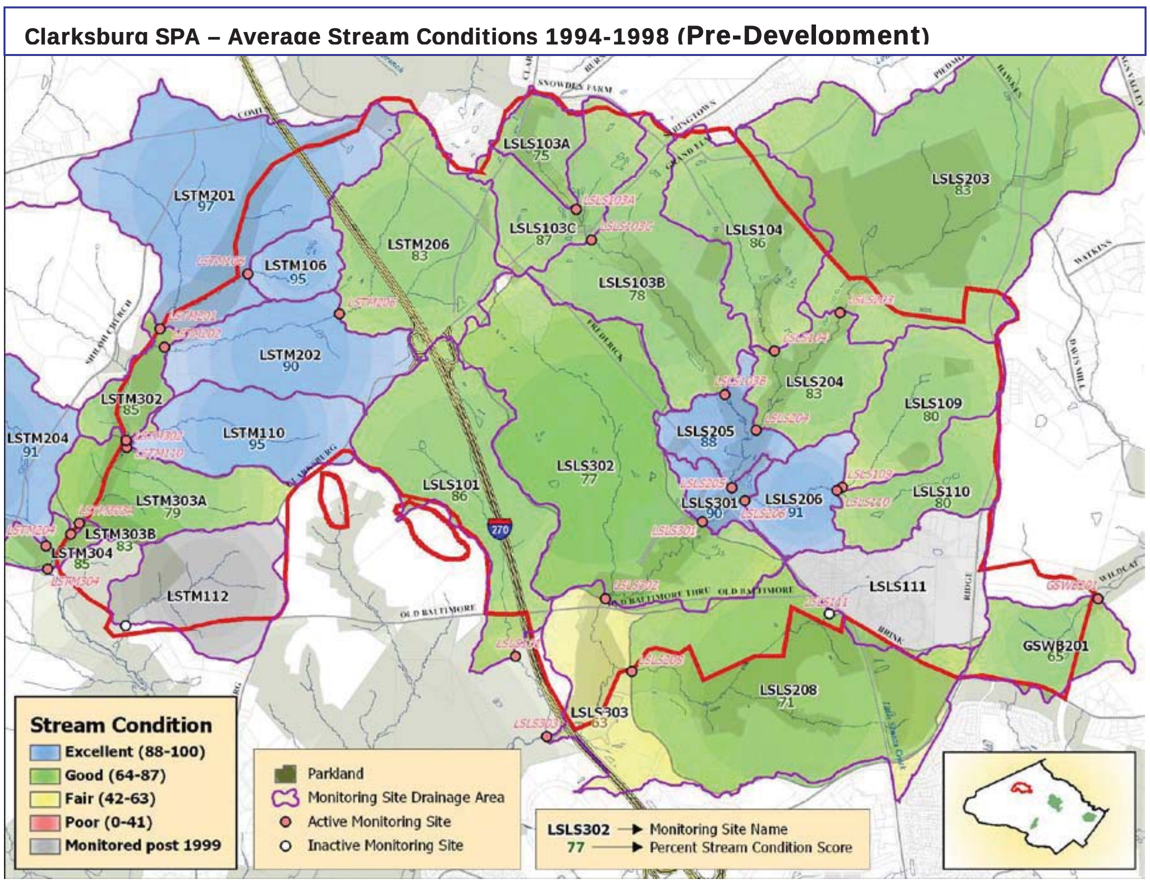


Figure 5.1. Pre-development (1994-1998) Stream Conditions in the Clarksburg SPA.

The farthest downstream Town Center Tributary site (LSLS103B) is located below Foreman Boulevard near the confluence with Little Seneca Creek. This area drains portions of the Newcut Road and Town Center developments, Highlands of Clarksburg development, and some older pre-SPA large-lot neighborhoods. The Highlands of Clarksburg development has completed construction and is generally stable, although monitoring of post construction conditions has not yet commenced. In 2010, LSLS103B was rated *fair* (Fig. 5.2). The decline in the stream condition score at this station is discussed in more detail in Section 5.3.1.

The LSLS104 tributary provides drainage for a large portion of the Newcut Road development. The station was rated *fair* in 2007 and 2008, but improved to *good* in 2009 and remains *good* in 2010. Construction is still ongoing in the lower portion of the drainage area, with some of the S & E devices in the upper portions of the area in the process of being converted to storm water management. The monitoring station is located within the Snowden Farm Parkway right-of-way, and massive changes were made to this area late in 2010, after monitoring was complete. The site will need to be reevaluated and possibly relocated in 2011.

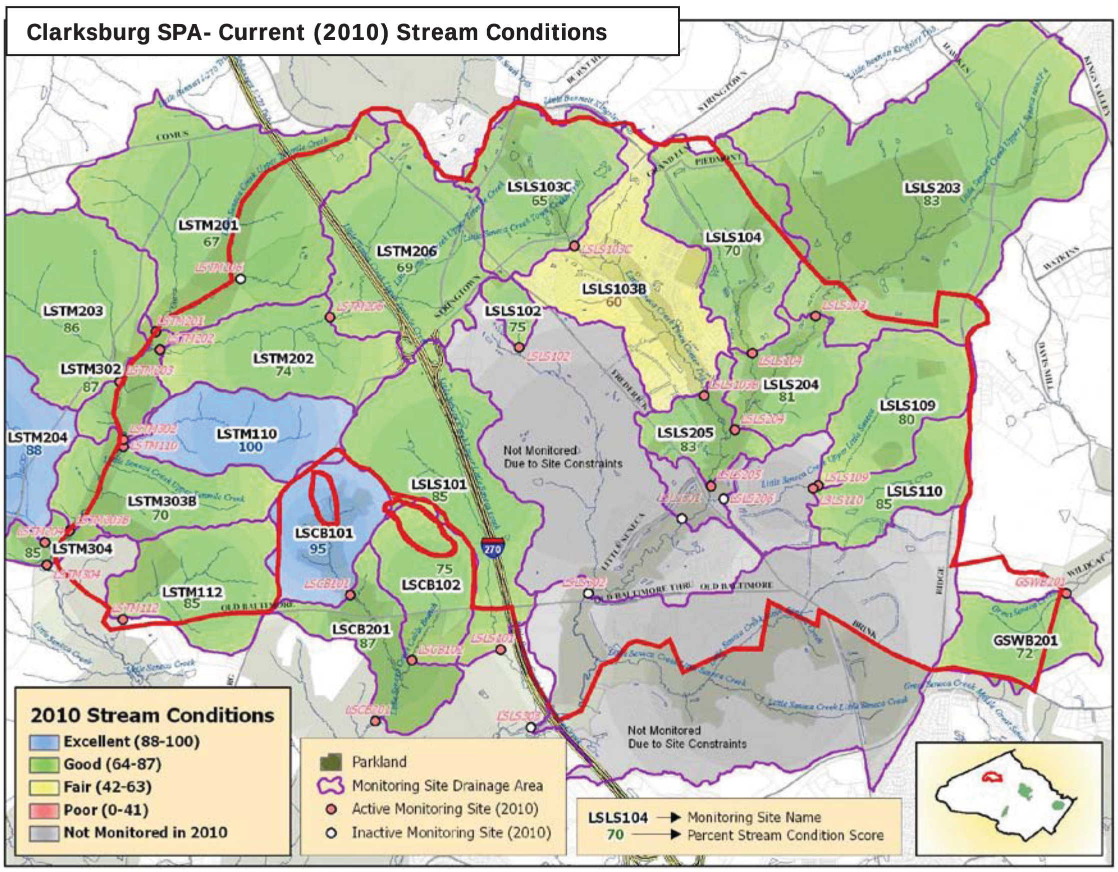


Figure 5.2. Current (2010) Stream Conditions in the Clarksburg SPA.

LSLS109 and LSLS110 are located in the eastern headwaters to Little Seneca Creek. These stations were rated *good* in 2009 and 2010. Development activity to date has been limited to the upper portion of the LSLS109 drainage. However, the next phase of development within this portion of the Newcut Road neighborhood is scheduled to begin early in 2011.

Stream conditions at GSWB201 improved from *fair* in 2007 to *good* in 2008 and have remained *good* through 2010. The SWM structures received as-built approval in June 2007, following site stabilization and completion of development. Development of this formerly agricultural site consisted of construction of a cemetery, mausoleum, small chapel and maintenance facilities. The majority of the cemetery is open space. BMP monitoring indicated that changes to the stream channel occurred during construction activities but that the channel was relatively stable from 2007 to 2009 (Section 3.2.7).

The average stream condition in the mainstem of Little Seneca Creek has generally remained in the *good* category throughout the development phase, although a dip in benthic scores was observed from 2004 to 2007.

The eastern headwater area of Ten Mile Creek (LSTM206) was rated *fair* in 2009, but has improved to *good* in 2010. Current imperviousness is 12%. This area receives runoff from part of the Clarksburg Detention Center, the new Stringtown Road widening west of Route 355, some commercial development in the I-270 Gateway Center area, portions of the Town Center development, a part of Gateway Commons, as well as runoff from portions of I-270. Most of this area has been stabilized. An investigation was made into possible reasons for the decline (as reported in the 2006 SPA Annual Report) and high conductivity readings were found throughout the drainage area to the station. No specific cause for the high conductivity readings could be identified, but the sensitivity of Ten Mile Creek to change is apparent.

5.2.2 **Paint Branch SPA**

Paint Branch stream conditions were predominantly *good* to *excellent* before the development period (Fig. 5.3). Current stream conditions in the Right Fork tributaries have dropped from *excellent* to *good* overall (Fig. 5.4). Most of the SPA development within Paint Branch has occurred in the Right Fork of the Upper Paint Branch.

Current stream conditions in the left fork are *fair* (Fig. 5.4). PBLF202 was rated *good* in 2009 with an average score of 65 (lowest possible score for a *good* rating). Snider's Estates, an 8 acre residential subdivision, is the only new SPA development in this area. SWM at Snider's Estates has been functional and online since December 2004. It is unclear whether a correlation exists between SPA development activities and the stream condition in this watershed since the amount of new SPA development is so small and the surrounding development was completed almost 20 to 30 years ago. However, it appears the small scale of development and the quick conversion likely helped mitigate any new impacts to stream conditions.

PBLF203 was not monitored for fish in 2010 because the immediate upstream area was undergoing in-stream restoration activities which required the relocation of fish from the project area. Information was received as part of the required quarterly report with respect to the best recollection of staff of the fish species relocated. Actual numbers and/or lengths and weight of salmonids were not received. These restoration activities would skew the scoring for this station. PBPB302 was not monitored in 2010 due to site constraints.

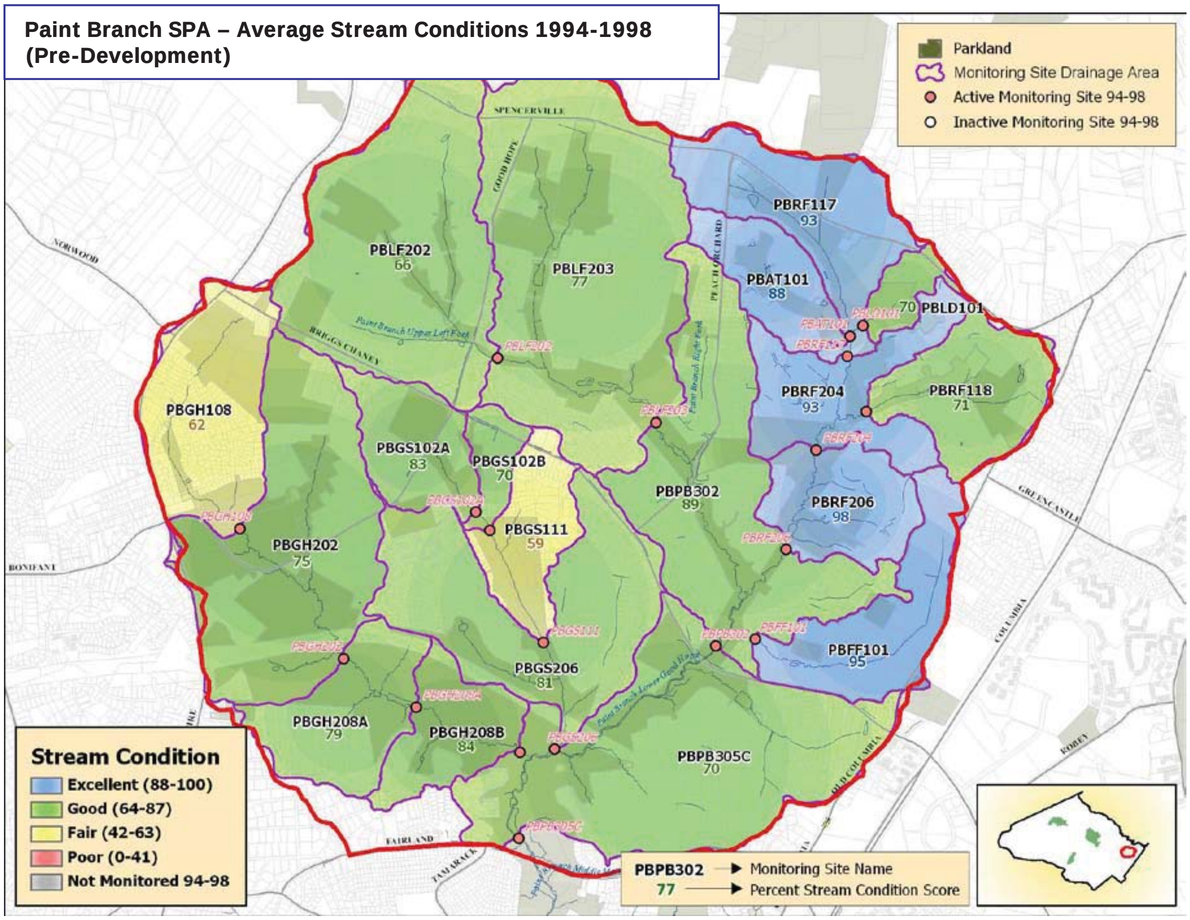


Figure 5.3. Pre-development (1994-1998) Stream Conditions in the Paint Branch SPA.

Presently, one station in the headwaters of the Good Hope Tributary, PBGH108, is in *good* condition. PBGH208A, located downstream, is rated as *excellent* (Fig. 5.4). The headwaters of the Good Hope (in the vicinity of Peachwood Park) have been in *fair* condition since the County monitoring began in 1994 (Fig. 5.3).

The Good Hope relies on clean, cool waters as spawning grounds for its naturally-reproducing brown trout population. In 2010, twelve adult brown trout, one of the most sensitive fish species in Montgomery County to stream degradation and water quality impairment, were found in the Upper Paint Branch SPA. Further discussion of Paint Branch Brown Trout is located in the Technical Appendix. Both the Upper Rock Creek SPA and Paint Branch SPA have an 8% impervious surface cap.

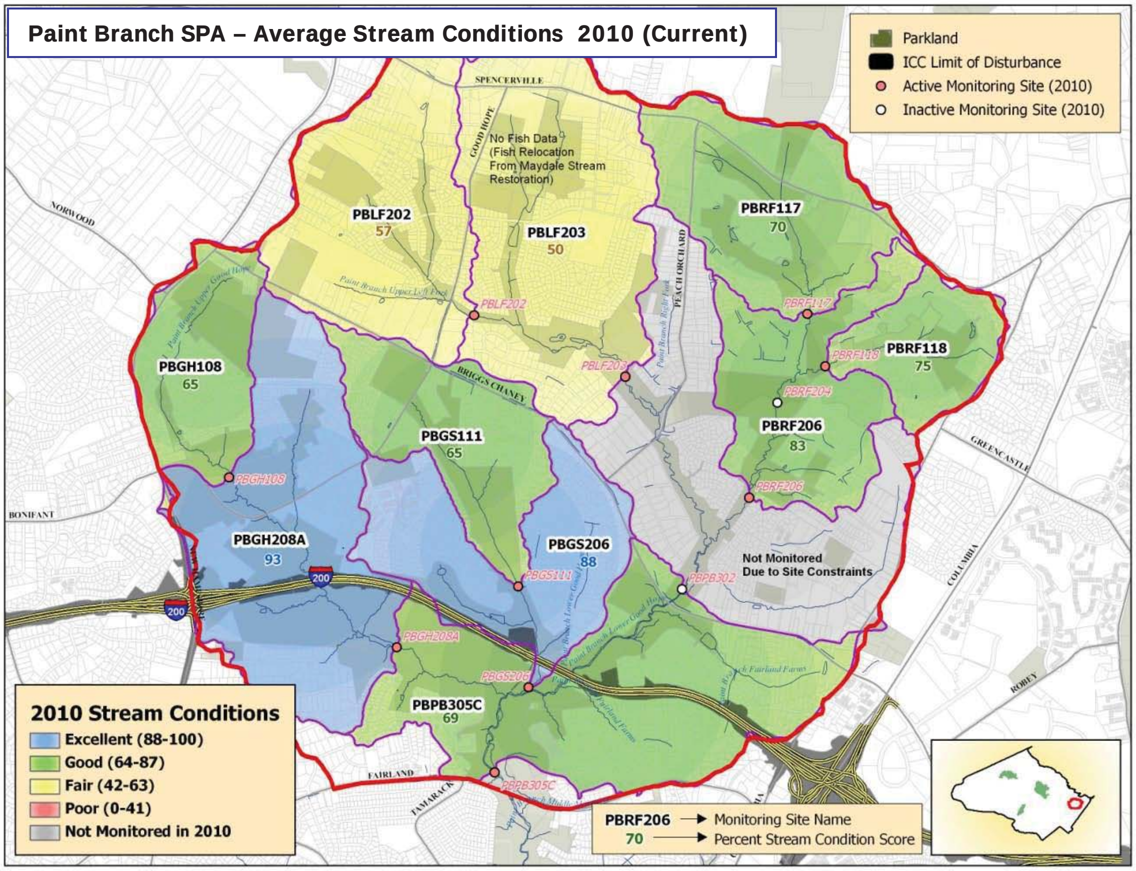


Figure 5.4. Current (2010) Stream Conditions in the Paint Branch SPA.

5.2.3**. Piney Branch SPA**

The stream conditions in the upper headwaters area of the Piney Branch SPA went from predominantly *fair* before development (Fig. 5.5) to *fair* and *poor* during development. In 2010 all stations in the Upper Piney Branch were rated *fair* (Fig. 5.6). No new development has occurred in this portion of Piney Branch since the Traville project was completed in 2008.

WBPB201 remains in *fair* condition in 2010 after improving in 2008 from a *poor* condition. WBPB202 and WBPB203A, located downstream, are in a portion of the Piney Branch within the older Piney Glen Village and Willows of Potomac developments. These developments started before the SPA program began. Due to the age of the developments and proximity to other monitoring stations these two stations will no longer be monitored

The upper station (WBPB201) is also partially within these older developments. In addition, it receives flow from the Gudelsky SWM pond and areas of the Traville development. WBPB102, which drains a major portion of Traville, was consistently rated *poor* during the construction period. In 2009 and 2010, the rating for this station improved to *fair*. WBPB103, which also drains a portion of Traville, was also rated *fair* in 2010.

Traville (approximately 140 acres of land) represents a consortium of projects. While construction on some properties has been completed and S&EC converted to SWM since 2000, other portions just began stabilization and conversion in 2007 and 2008. Furthermore, the majority of the individual properties are linked by a large SWM facility which was converted in April 2009. Monitoring of pollutant removal efficiency of this SWM BMP is anticipated to begin in 2011. Stream conditions will be monitored as new SPA developments are completed and SWM controls are functioning as designed.

In the lower portion of the Piney Branch watershed, WBPB204B improved from *fair* to *good* in 2003 and has remained in *good* condition up through 2009. Three SPA developments drain to this site, and they were built in the late 1990s and early 2000s, with SWM controls online in 2002. This station was not monitored in 2010.

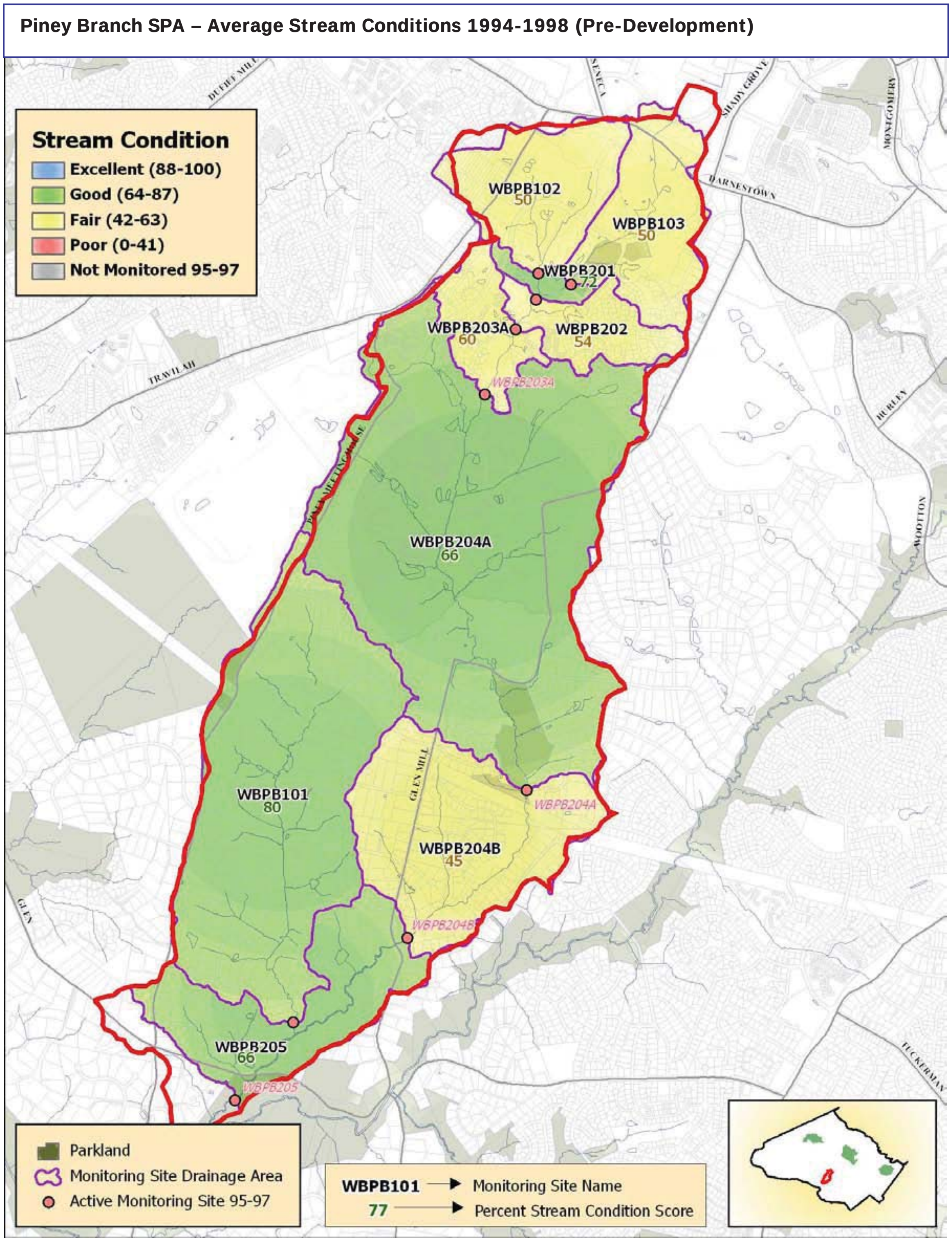


Figure 5.5. Pre-development (1995-1997) Stream Conditions in the Piney Branch SPA.

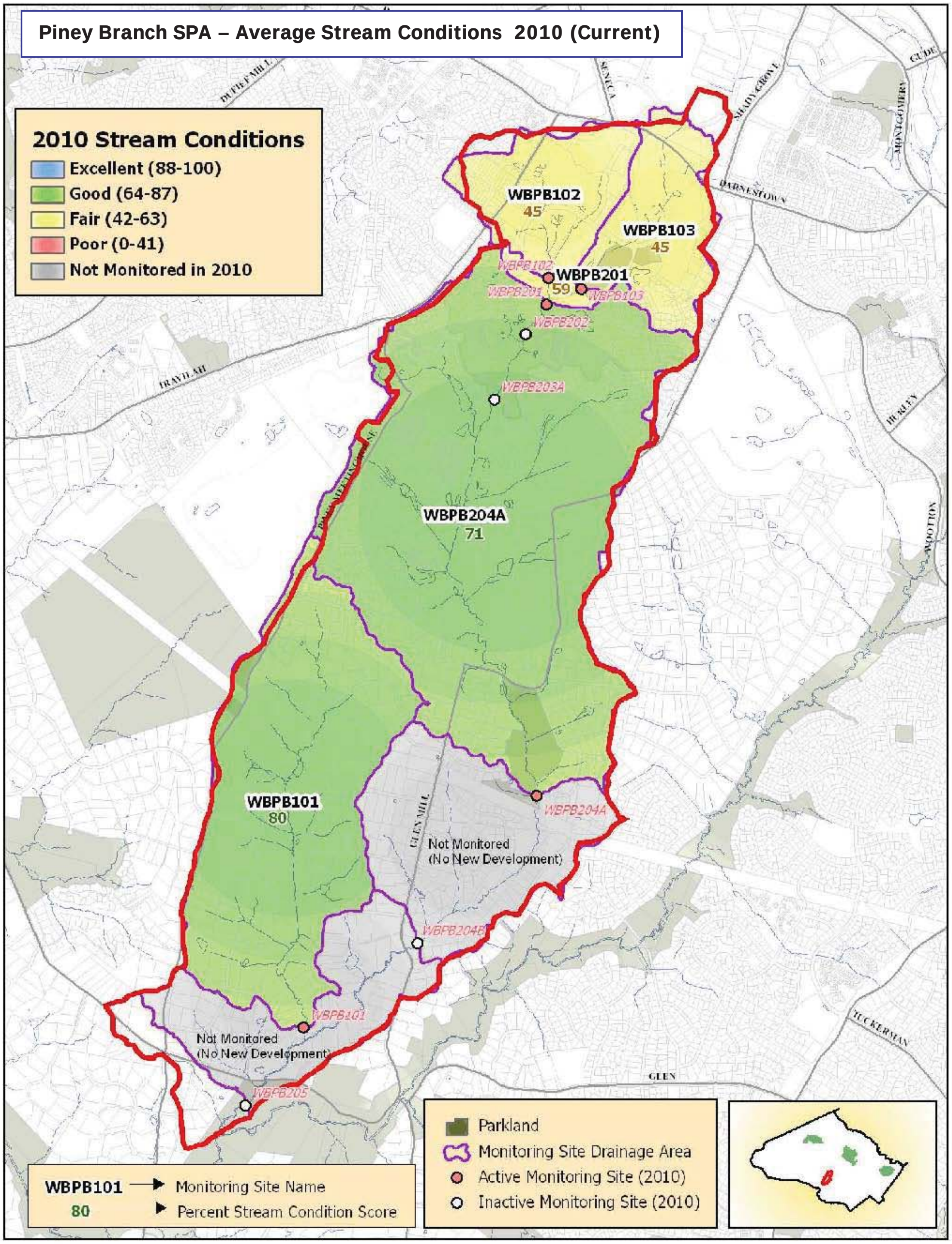


Figure 5.6. Current (2010) Stream Conditions in the Piney Branch SPA.

5.2.4 **Upper Rock Creek SPA**

Annual monitoring of six SPA stations began in 2004 in Upper Rock Creek. The six annually monitored SPA sites were targeted downstream of the six large developable parcels within the Upper Rock SPA. These station drainage areas are too small for fish to offer a reliable indication of water quality, so these stations are sampled for benthics only. Until 2007, no new SPA development had occurred within any of the six station drainage areas.

Phase I of the Reserve at Fair Hill began in May 2007. This project occurs north of the intersection of Wickham Road and Tackbrooke Drive in Olney (Fig. 5.7). Station URNB111 (about 200 feet upstream from this intersection in a small headwater stream) has maintained a *good* condition (Figs. 5.8 and 5.9) throughout the construction period. Only 40% of the current development for the Reserve at Fair Hill is within the drainage area for URNB111. Approximately 32 acres (20%) of this drainage area has been disturbed as part of Phase I of construction. Much of the suitable benthic habitat was buried by approximately one foot of fine sediment in 2008.

URRC104, downstream and to the east of the intersection of Muncaster Road and Willow Oak Drive, has had no SPA development. The stream rating has generally been *good*, but scores have occasionally dropped into the *fair* category (Fig. 5.9). The site has received lower habitat scores due to silt deposits.

URNB110D and URNB103 both declined from *excellent* to *good* in 2008. The stations have remained *good* through 2010. URNB110D declined the most though going from *excellent* to a very low *good* score (almost in the *fair* category). This stations has a very small portion (1.4 acres, or 1.1%) of its drainage area affected by the construction activities at of the Reserve at Fair Hill beginning in 2007 (Fig. 5.7), which could have resulted in the drop in stream condition. URNB103's decline was much less being in the higher numeric range of *good* and may be related to the nearby construction of the Inter-County Connector (ICC).

In November 2007, contract A for the ICC began construction (which extends through the lower portion of the Upper Rock Creek SPA). In addition to the stream monitoring conducted by DEP, the State Highway Administration (SHA) is funding monitoring to determine potential impacts to the streams.

All drainage areas are shown on Figure 5.9

URNB111, URNB110D, and New Development Activities

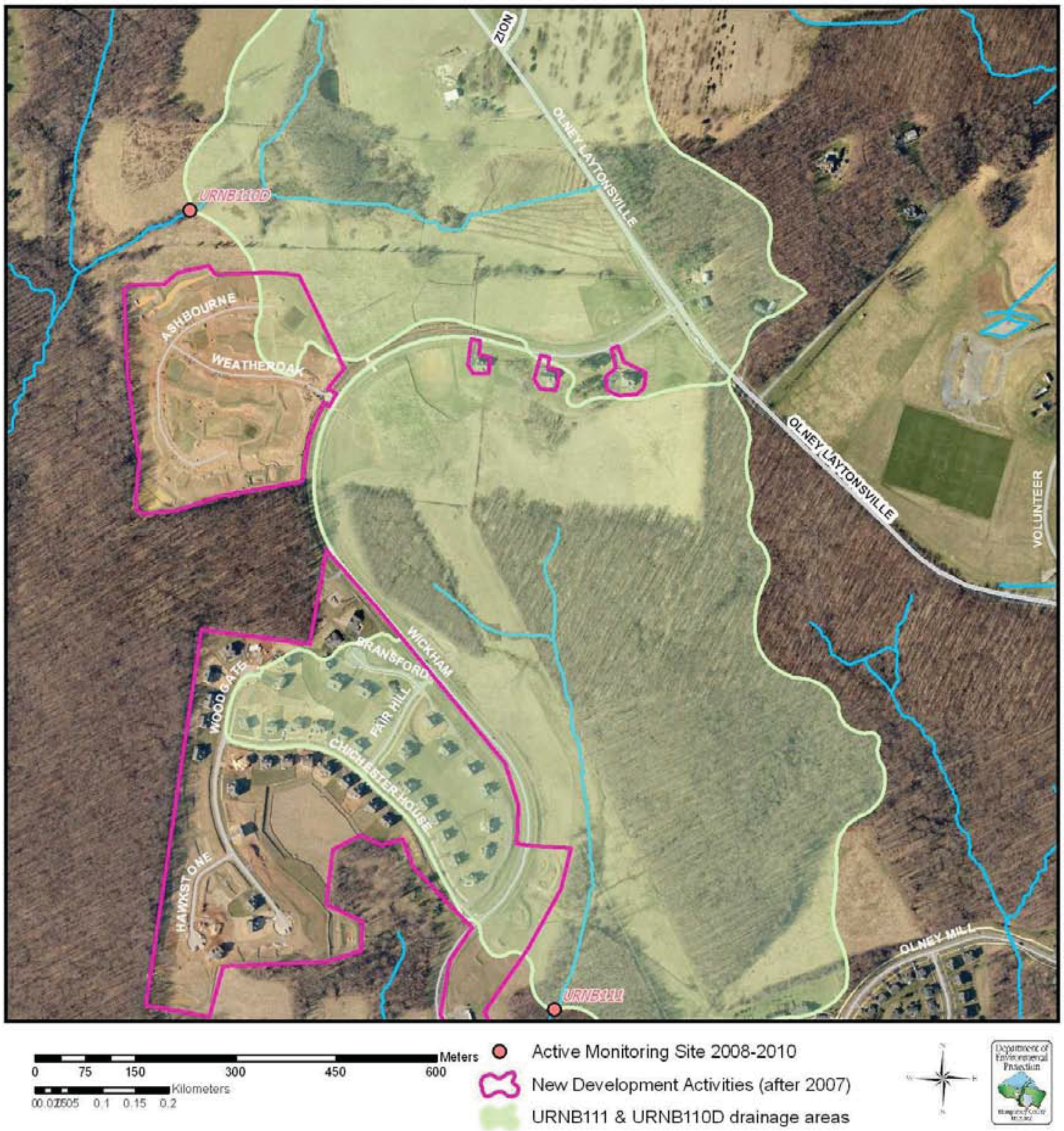


Figure 5.7. Potential (post-2007) Development impacts from Reserve at Fair Hill Project to Biological Monitoring Site URNB111 and URNB110D in Upper Rock Creek SPA. Full drainage areas are shown on Figure 5.9.

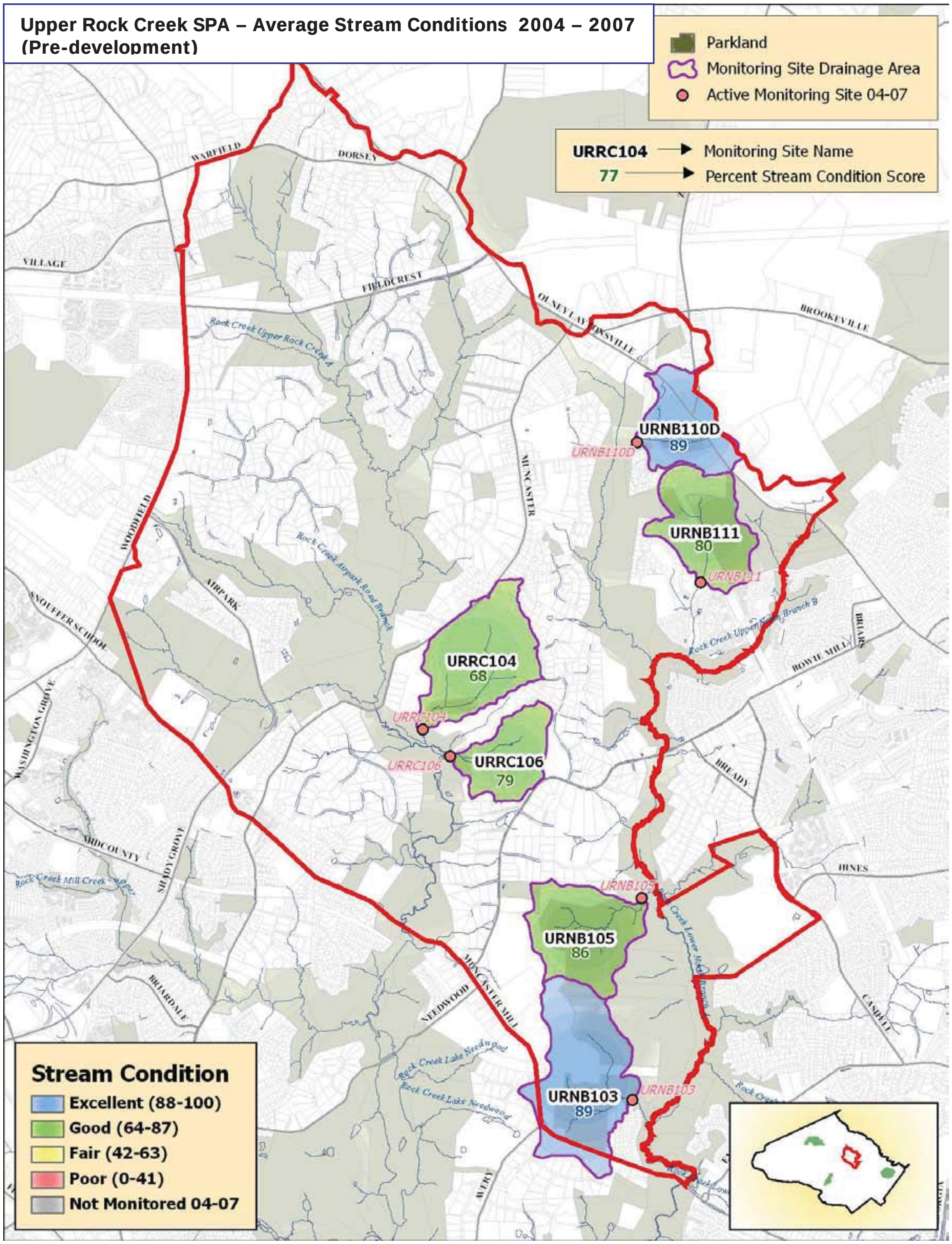


Figure 5.8. Pre-development (2004-2007) Stream Conditions in the Upper Rock Creek SPA.

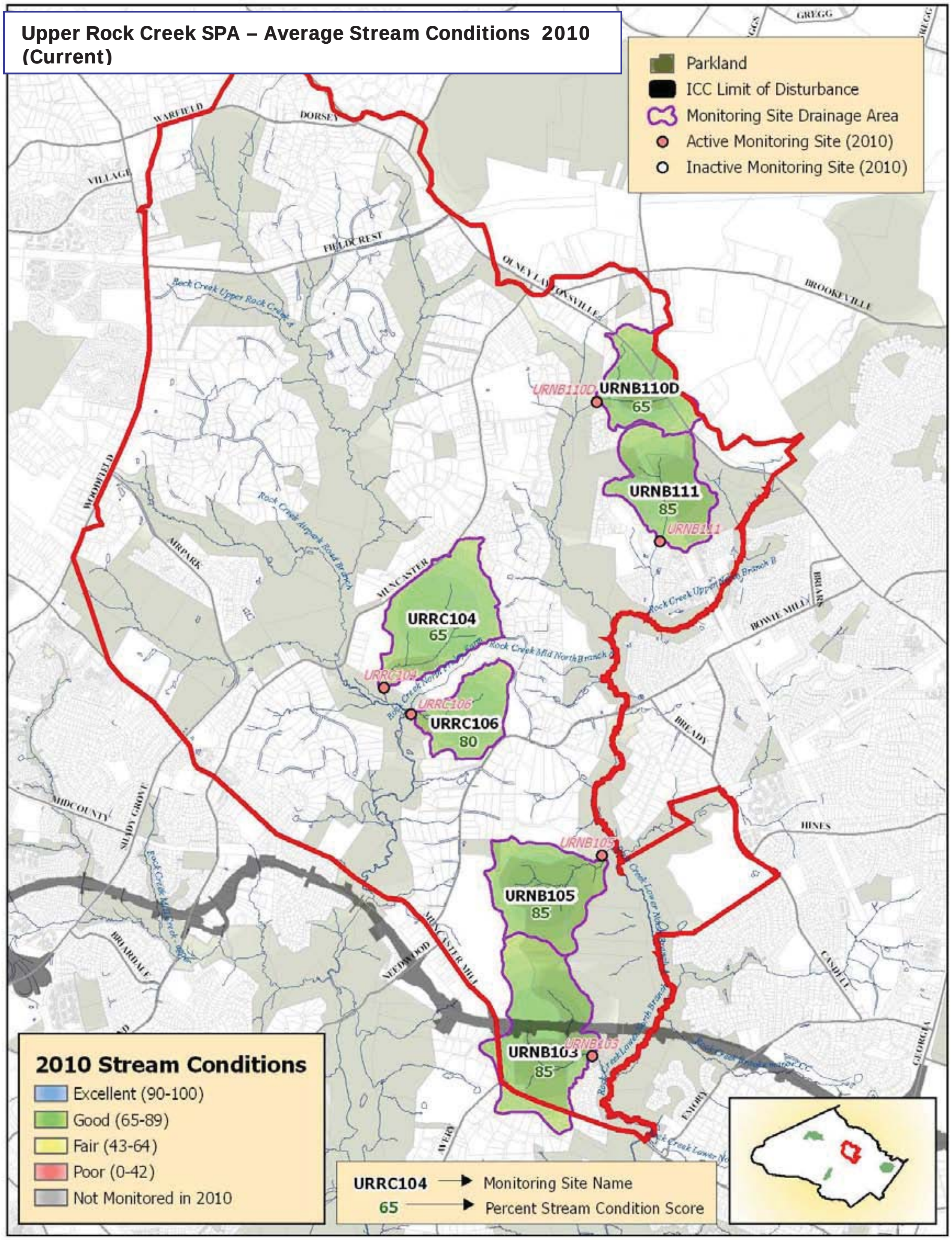


Figure 5.9. Current (2010) Stream Conditions in the Upper Rock Creek SPA.

5.3 Benthic Macroinvertebrate IBI Score Comparison

In order to evaluate how effective the SPA methods, facilities, and practices utilized through the construction phase of development are in protecting the water quality of streams in the SPAs, changes in benthic IBI scores of a control set of monitoring stations and a test set of monitoring stations were compared over time before and during the development period for the Clarksburg Master Plan, Upper Paint Branch, and Piney Branch SPAs (Table 5.1).

The control set of stations had no SPA development (i.e. no new areas of disturbed land) occur in station drainage areas; the test set of stations had the majority (greater than 50%) of their drainage areas disturbed through the SPA development process.

Monitoring was done at the same time of year using the same methods. Each SPA was analyzed separately because different levels of development land use controls were in place for each SPA. Stations within each SPA are in close proximity so that the same naturally occurring events within each SPA would affect all stations. Benthic samples were collected in the spring of the year, so summer/fall drought impacts would be reflected in the results of the following year.

The rationale for concentrating on benthic macroinvertebrate scores is that most of the stations used for this comparison are small headwater streams, where benthic macroinvertebrates are expected to be a more responsive indicator group. Fish species that live in the smaller headwater streams tend to be able to survive in the available habitat and are called *pioneer species*. Pioneer fish species are generally more tolerant to disturbance and are able to survive a wider range of stressors than the benthic macroinvertebrate community and respond differently overall. Maps showing the year to year change (2006-2010) in Benthic IBI narratives for each SPA can be found in the Technical Appendix.

Table 5.1. Control and Test Stations.

SPA	Control Station Watersheds	Control Stations	Test Station Watersheds	Test Stations
Clarksburg	Ten Mile Creek, Little Seneca Creek	8	Little Seneca Creek (primarily Newcut Road & Town Center Neighborhoods)	9
Piney Branch	Western Tributary of Piney Branch	1	Stations above Glen Hill Road	5
Upper Paint Branch	Good Hope, Gum Springs	4	Right Fork	6
Upper Rock Creek	Portions of Upper Rock Creek North Branch and mainstem of Upper Rock Creek	5	N/A *(no watershed has ≥50% new SPA development as of 2009)*	0

5.3.1 **Clarksburg**

Land use in the control area is predominately rural agricultural and *topography* has not changed. Many of the control stations are from Ten Mile Creek. The test set of stations had the majority of its drainage areas disturbed through the SPA development process. Most of the test stations are in the Town Center and Newcut Road Neighborhoods.

Clarksburg median benthic index scores for both the control and test stations were very similar from 1995 to 2002 (Fig. 5.10). Median scores were in the *good* to *excellent* range during this period. Construction began in the Clarksburg test areas in 2002; a record drought also occurred during 2002. The median scores diverged in 2003. The stations under construction dropped to a *fair* condition, while the stations without the development dropped but remained in the *good* benthic IBI category. From 2003 onwards, the benthic scores at streams within the test areas remained in *fair* condition. In 2010 the average score showed signs of improvement and increased to a *good* condition for the first time since construction was initiated. Benthic scores in 2010 are still lower than preconstruction and lower than scores in the control areas.

The Town Center tributary's farthest downstream test station (LSLS103B) was rated *good* in 2008. In 2009 it received the lowest possible score to be rated *good* and in 2010 the station was rated in *fair* condition. The recent declining trend in benthic scores may be related to increased disturbance in the vicinity of Foreman Boulevard. The upstream Town Center test station (LSLS103C) has shown an opposite trend. It was rated *poor* in 2008 and 2009, but in 2010 it improved, receiving the lowest possible *good* score. This improvement may be related to greater stabilization within the Town Center development, and completion of construction and stabilization of the Highlands of Clarksburg. A substantial improvement in the benthic IBI score was observed at the Newcut Road Neighborhood development test station (LSLS104) between 2008 and 2009. The stream condition improved from *fair* to *good* as a result and it remained in *good* condition for 2010.

The lines, or "whiskers" on the graph, which extend above and below the median points, indicate the range of scores for each group of stations during each monitoring year (25^{th} and 75^{th} percentiles). As the median score of the test and control stations diverge, the range of scores recorded for the two groups also diverge until they no longer overlap in 2005 (and are considered statistically significantly different). The scores of the undeveloped control and developed test stations were significantly different from 2005 to 2007 and 2009 to 2010. A slight overlap occurred in 2008.

During the 2008 and 2009 sampling periods, one of the control stations was dry and was not sampled. This station is on the King Spring. Upon further investigation in 2009, staff found that a beaver dam had been built upstream of the station and had diverted the King Spring flow into a new channel. The new station is above the channel split, since there was no defined stream channel. The new station is in an older, more defined channel, consistent with what was monitored in previous years.

Based on the available data, the development process during this time had a measurable impact on stream conditions in the Little Seneca Creek watershed. There is a slight recovery seen for the test group as a whole in 2008, but 2009 median benthic scores drop again. In 2009 some stations improved allowing the 25 and 75 percentiles benthic scores to be entirely above the *poor* category for the first time since 2005. In 2010 the median scores improved to 70, the best point since construction began. Five of the seven impacted stations had an increase in their score. The most noticeable increases were in the scores of LSLS103C (40 to 65), LSLS203 (45 to 70), LSLS204 (30 to 70) and LSLS205 (45 to 70).

Most metrics of the four sites generally improved but the greatest increase was seen in the proportion of shredders which moved from the lowest category of one to the highest category of five. Shredders such as stoneflies (plecoptera) feed on plant material and some animal material and break it into smaller particles through their feeding and digestive process. Specialized feeders, such as shredders, are the more sensitive organisms and are thought to be well represented in healthy streams (http://www.epa.gov/bioiweb1/html/invertclass.html). LSLS103C increased from 2.62% in 2009 to 53.61% in 2010; LSLS203 increased from 0.57% to 11.43%; LSLS204 increased from 1.88% to 19.83% and LSLS205 from 0.88% to 10.78%. LSLS103C also had another large increase in the proportion of EPT individuals, rising from category one at 23% to category five at 65%. EPT is an abbreviation for the insect orders **E**phemeroptera, **P**lecoptera, and **T**ricoptera. The common names for these insect orders are Mayfly, Stonefly, and Caddis fly. They represent some of the most sensitive insects found in local streams.

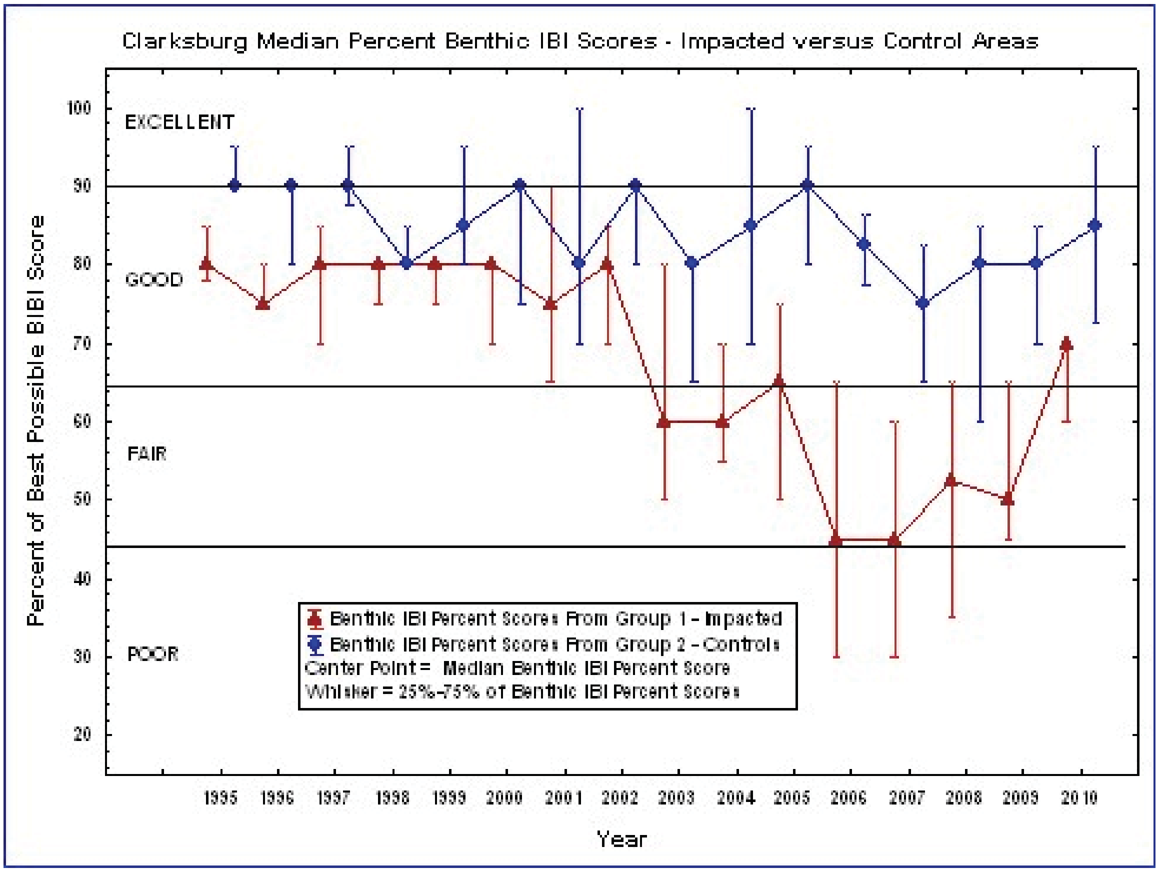


Figure 5.10. Median Benthic IBI Scores for Clarksburg Control and Test Areas.

5.3.2 **Piney Branch SPA**

Results are different in the Piney Branch SPA as compared to the Clarksburg SPA for the control and test stations in the Piney Branch SPA (Fig. 5.11). Changes in median stream conditions among test stations and the control station followed each other closely until 1998. Much of the new SPA development in the upper Piney Branch has occurred since 1998. From 1998, benthic IBI scores in the control station stayed in the *good* range. Benthic conditions in the test stations declined to *poor* in 1999 and stayed in the *poor* range since 2003. Again, naturally occurring events such as drought and rainfall affected all stations at the same time. The test stations had the majority of their drainage areas in the development process during this time. Due to the extensive development prior to the establishment of Piney Branch SPA (Section 3.1), only one control station is available for analysis.

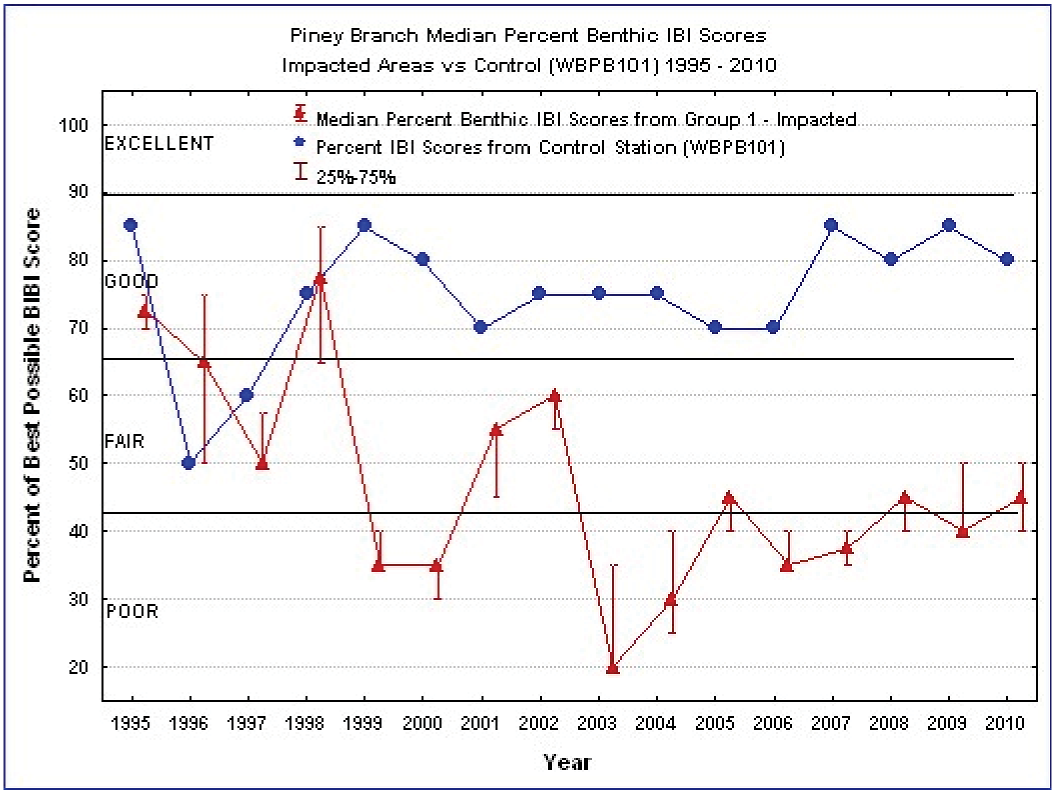


Figure 5.11. Median Benthic IBI Scores for Piney Branch Control and Test Areas.

5.3.3 **Upper Paint Branch SPA**

The time series between control and test stations for the Upper Paint Branch SPA stations are quite different from the Clarksburg and Piney Branch SPAs (Fig. 5.12). Annual changes in both the test and control stations show similar benthic community ratings. There is no significant difference between the test and control stations that can be attributed to the development processes occurring in the test stations drainage areas, as the percentiles of both the test and control stations fully overlap.

The 2002 drought had a major impact to the Upper Paint Branch SPA as shown in the benthic scores beginning in 2003. Substantial improvement to the Good Hope tributary has occurred, as evident from the benthic scores at PBGH108 and PBGH208A. The Right Fork of the Upper Paint Branch is likely to recover to near pre-construction level stream conditions because the new imperviousness from the new developments was limited to 8% and the development occurred fairly rapidly from start to finish. Although measurable impacts are present in the test stations, the benthic community structure remains intact and basically unchanged after the majority of the development in the Right Fork subwatershed has been completed and BMPs converted from S&EC to SWM facilities. This recovery will be monitored after the new SWM controls are functioning as designed.

According to monitoring data going back to 1994, brown trout populations have persisted in the Upper Paint Branch SPA. See the Technical Appendix for more information.

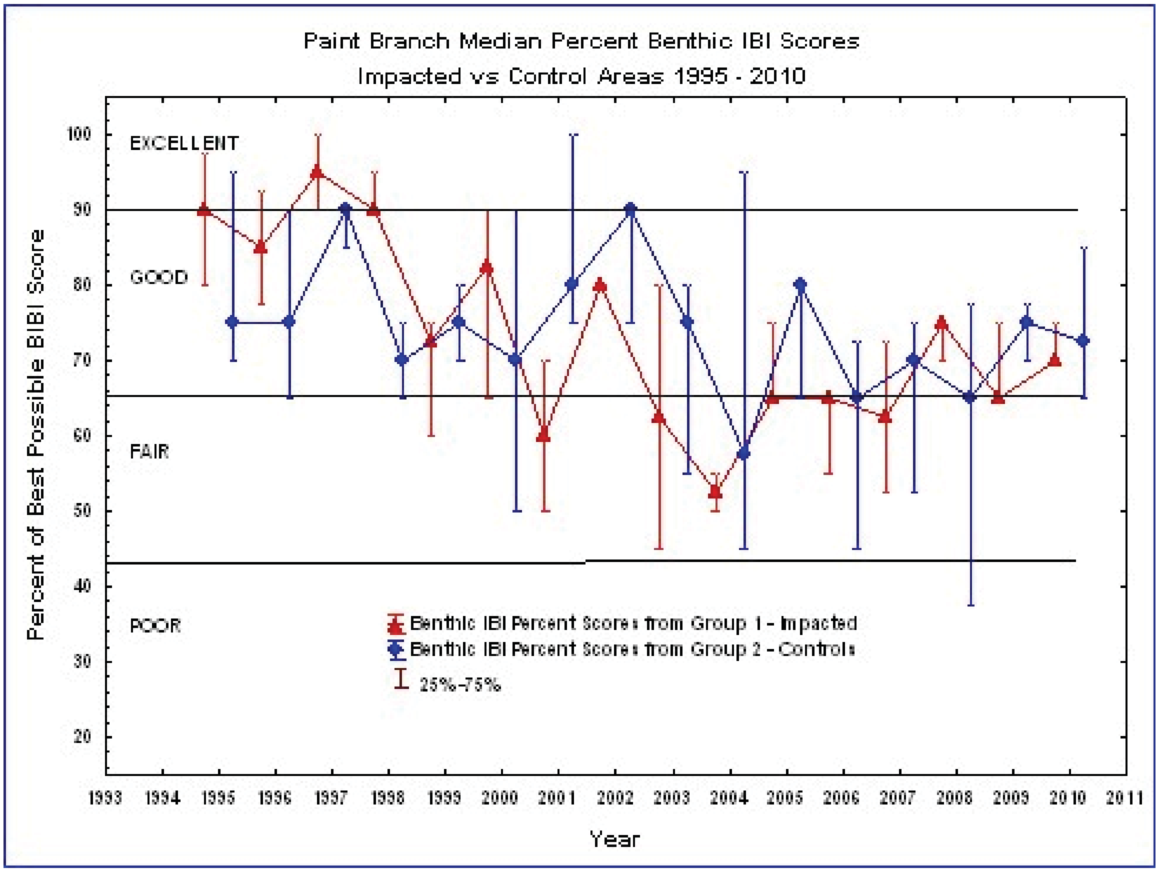


Figure 5.12. Median Benthic IBI Scores for Upper Paint Branch Control and Test Areas.

5.3.4 **Upper Rock Creek SPA**

Benthic IBI scores in the small headwater streams monitored for the Upper Rock Creek SPA have consistently been *good* since 2004 (Fig. 5.13). Stations are not separated into control and test areas at this time. One drainage area (URNB111) has had new construction activities occur since the last report, but not over the majority (≥50%) of its drainage area. In May 2007, mass grading and the construction of S&EC facilities have occurred for Phase I of the Reserve at Fair Hill development. Although the benthic habitat was noted in 2008 to be predominantly buried in fine sediment at URNB111, there was no observed response to the benthic community in 2009 or 2010.

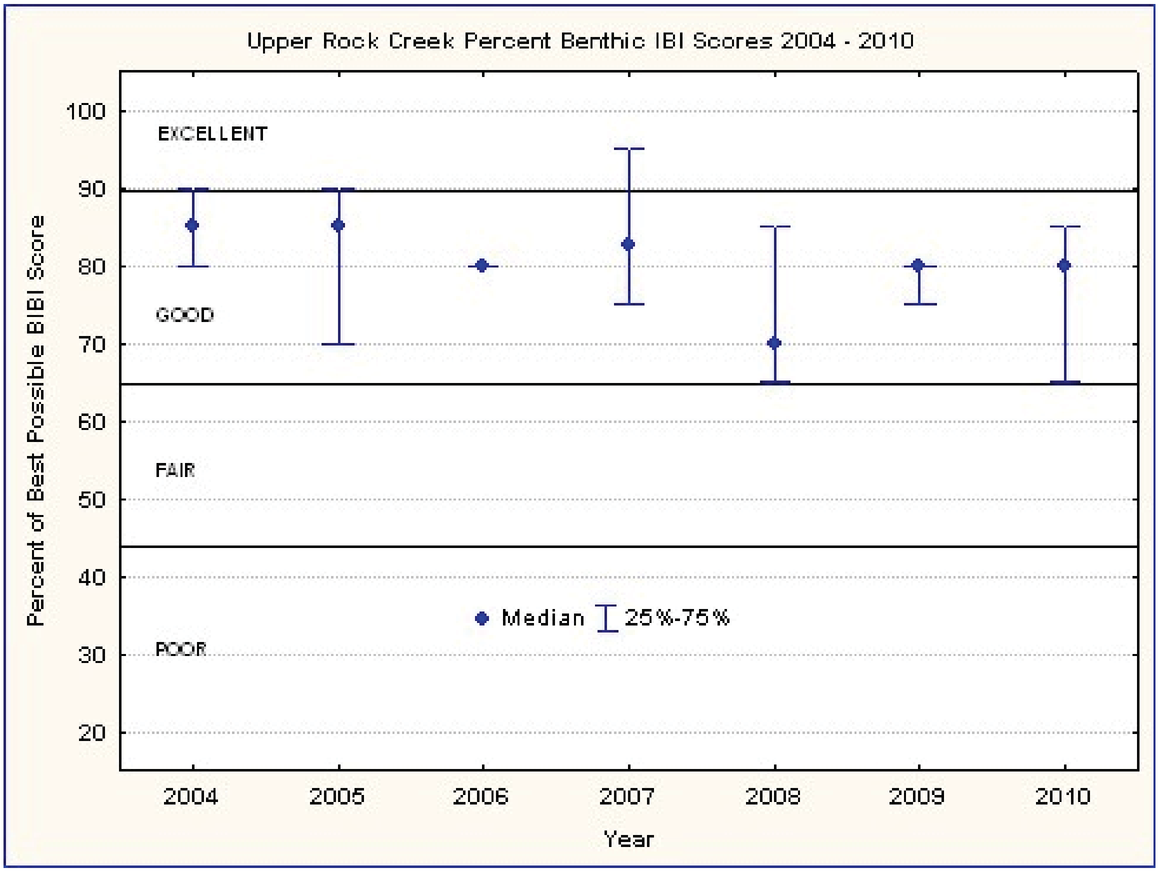


Figure 5.13. Median Benthic IBI Scores for Upper Rock Creek Control Area.

5.4 <u>Changes in Benthic Macroinvertebrate Community Structure and Function</u>

<u>5.4.1 **Introduction**</u>

Previous SPA reports discussed the expectation that the stream conditions in the watershed will recover to pre-development levels once the development process in the watershed is completed. Predicting the recovery potential requires understanding the shifts within the biological community. Examinations of individual metrics were used to determine the cause of the changes to the biological community rating. See the Technical Appendix for a complete list of metrics that comprise both the fish and benthic IBIs.

This section of the report examines changes over time using metrics of community structure (dominant *taxa*) and community function (functional feeding groups) for the benthic macroinvertebrate community. Dominant taxa are those organisms that make up the majority of the sampled community. Functional feeding groups are designations that characterize how organisms in the community obtain food and function in the ecosystem. For more discussion on functional feeding groups and dominant taxa, see the Technical Appendix.

One of the uses of the IBI is to detect differences in individual metrics and determine impacts using additional information such as habitat, chemistry, and land use (Simon and

Lyons 1995). Additionally, examining the composition and function of the community supplements the score and provides insight into the direct effects of environmental change and decline (Pederson & Perkins 1986).

5.4.2 **Changes in Community Structure and Function**

A shift in functional feeding group composition is noted in the test areas of all SPAs and coincides with development activities (see Technical Appendix for more in-depth analyses of these shifts). The shift from sensitive and specialized feeders, such as *shredders*, to generalist and more tolerant groups, such as *collectors* and *filterers*, are characteristic of disturbed streams that have been altered by urbanization processes. Similarly, a dominance of pollution-tolerant and less sensitive Chironimidae (true flies in the midge family) seen in the SPAs is frequently observed at disturbed sites like those in altered landscapes (Pedersen and Perkins 1986; Jones and Clark 1987; Moore and Palmer 2005; Diana et al. 2006).

This suggests that habitat, as well as food quality and availability, changed in these areas as a result of development activities, thereby negatively impacting the benthic fauna. Good quality habitat (such as stable and vegetated banks, wide, sinuous stream channels with coarse substrates, and ample and diverse cover and substrate) is associated with a diverse biological community. Conversely, unvegetated and eroding banks and deep channels with predominantly fine substrates are associated with *poor* biology (Pedersen and Perkins 1986; Jones and Clark 1987; Heitke et al. 2006; Moerke and Lamberti 2006).

Changes in community feeding structure and function were most obvious in the Clarksburg and Piney Branch SPAs, particularly with the dominance of more tolerant collectors and Chironimidae. Clarksburg and Piney Branch both underwent high-density, rapid development, but differ in that Clarksburg is undergoing development from a predominantly rural landscape while Piney Branch had previous high-density developments exerting *legacy effects*. Legacy effects from urbanization, agriculture, and other human impacts produce different, and generally degraded, biological assemblages from those in undisturbed systems (Wang et al. 2006). The development in the Clarksburg Newcut Road and Town Center neighborhoods exposed land, shifting biological community structure and function and limited recovery. Post 2008, the pace of new construction slowed, and some areas were converted to SWM. This may have resulted in a slight improvement in benthic communities. However, conditions are still a long way off from what they were pre-construction. The two improved Clarksburg SPA stations, LSLS103B and LSLS104, are examples where more sensitive benthic groups are returning, but have not approached pre-construction numbers.

The level of disturbance in each SPA during development periods was an important influence on benthic community structure and function. The Upper Paint Branch and Upper Rock Creek SPA stream conditions and biological communities in areas undergoing development did not differ considerably from the control areas. For Upper Paint Branch, it appears that the 8% impervious cap restricting the amount and impacts of development, sediment and erosion controls, stormwater management, and the relatively short time to complete development (from 2003 to 2006) have limited some impacts to these areas.

In Upper Rock Creek, the phasing of development in addition to the 8% impervious cap has deterred construction impacts to the stream at this time, although it is relatively early in the development process. Changes to biological community structure and function generally take more than a year to materialize and although construction began in 2007 it has been confined to a limited portion within each subwatershed.

5.4.3 **Future Stream Conditions and Potential for Recovery**

The changes to the structure and function of the benthic macroinvertebrate community are reflected in the declining stream condition scores. The frequent, intense, and ongoing disturbances through the construction period, particularly in the Clarksburg Town Center and Newcut Road areas, may have impacted the ability of the benthic communities to recover (Moore and Palmer 2005) to near pre-construction conditions. Disruption to the natural system through the conversion of rural land use to urban land use may prevent a full recovery to pre-construction conditions (Konrad and Booth 2005; Wang et al. 2006). The results of the 2009 and 2010 sampling suggest that some improvement to habitat, and thereby benthic communities, may occur upon conversion to SWM.

Stream communities demonstrate some ability to recover following the flushing of deposited materials (Jones and Clark 1987). Some recovery of benthic macroinvertebrates is expected as the pace of new construction slows, and areas are converted to SWM (Miltner et al. 2004). However, the level of recovery and the influence of BMPs are unclear at this time, and should be considered preliminary. Some findings indicate that large-scale and long-term disturbances in a watershed limit the recovery of stream communities for many decades (Harding et al. 1998) and that the impacts to the form and function of the aquatic systems occur rapidly and are very difficult to avoid or correct (Booth and Jackson 1997).

If sensitive organisms are no longer present or if the habitat no longer supports these more sensitive taxa, the stream condition may not be able to fully improve.

Although promising, the more stringent stormwater regulations and BMPs such as those utilized by the County have not been in place long enough to test whether they will minimize loss of aquatic life through development and build out. However, as development activities are completed, the stream conditions within areas developed under SPA regulations have improved. Most of these areas have recovered stream conditions in the '*good*' range. Full recovery to '*excellent*' still remains to be seen but as development is completed, recovery is noticeable. In addition to protecting streams by managing adjacent land use (e.g. leaving riparian zones intact, floodplains under-developed, and adjusting for potential hydrological impacts; described in Miltner et al. (2004)), it may be necessary to preserve entire watersheds, not just fragments or pieces of them (Harding et al. 1998).

6. Conclusions

6.1 BMP Monitoring

BMP monitoring has demonstrated that the sequential and redundant features used in reducing stormwater runoff and decreasing pollutant loadings have been more effective than the use of individual structures. BMP feature placement in the treatment train is also an important consideration in optimizing BMP performance and mitigating impacts to receiving streams. Since the inception of the SPA program, DPS has consistently refined BMP design plans and reduced the size of the area draining to individual structures to improve pollutant removal efficiency and mitigate development impacts.

However, SWM BMPs alone, even when redundant, cannot provide all the solutions for minimizing impacts to streams and protecting water quality.

Many of the streams in the SPAs are small headwater streams that are extremely sensitive to changes in the surrounding soils, drainage features, groundwater recharge and diffuse rainfall infiltration. These changes become accentuated as the landscape alterations required for roads, utilities, lot grades, storm drains and other infrastructure increase due to approved densities. Imperviousness levels resulting from the approved densities can be important indicators of the degree of impacts that will result to the headwater streams.

6.2 Stream Characteristics

The Newcut Road Neighborhood development has been monitored by the Clarksburg Monitoring Partnership since 2002 (See Sections 4.1 and 4.2). BMPs designed for use in this area were state-of-the-art at the time of design but do not meet current ESD standards. Relatively few sediment and erosion control devices have been converted to SWM BMPs (ES-1).

In this portion of the Newcut Road:

- Natural drainage patterns have almost been eliminated;

- Overall topography, natural drainage patterns, and natural infiltration have been altered due to the cut and fill requirements necessary to meet the development requirements of these neighborhoods; and,

- Most of the stormwater runoff is now diverted into stormwater inlets and drains rather than infiltrating into the ground over a wide area as it did before.

The greater the impervious surfaces that cover a watershed, the less amount of precipitation infiltrates into the groundwater system and the more runoff enters the streams directly.

The effects of impervious surface first become evident through the grading and compaction activities that currently occur throughout a site as a result of development. Naturally pervious soils and a diffuse infiltration system are altered and/or lost through the cut and fill requirements currently being followed to develop a property. The County DPS encourages that SPA SWM filtering BMPs typically incorporate groundwater recharge in the design.

6.3 Biological Stream Monitoring

During 2010, stream conditions have improved over those previously reported in the SPAs. Stream conditions in areas of Clarksburg and Upper Paint Branch have improved in areas where cut and fill and grading has been completed. In 2008 and 2009, there was a decreased amount of development reflecting the economic downturn which may have allowed less active construction sites to stabilize and for some completed development areas to begin to convert to SWM. The conversion of former sediment and erosion control devices to stormwater management BMPs continues and these structures continue to be accepted into the County's maintenance program.

Stream conditions in Ten Mile Creek remain in *good* condition.

6.4 Maintenance of SWM BMPs

The monitoring of SWM BMPs has highlighted an issue that, while obvious to some, still needs to be emphasized in this report. SWM BMPs will continue to function as designed only if they are regularly cleaned and maintained. With the current emphasis on smaller structures, the maintenance of these many small structures will become an important factor in how well the structures perform over time. Current structural maintenance is done once a year; other jurisdictions perform structural maintenance every 3 years. Once a SWM structure becomes clogged, filled with road grit, or blocked, it no longer functions as designed, if at all.

Nonstructural maintenance of SWM BMPs (lawn mowing, trash pickup) is done much more frequently. However even the simple practice of mowing the grass around a SWM BMP can reduce the effectiveness of the BMP. For example, mowing the grass around a sand filter can blow the mowed grass onto the sand media. The grass clippings can form a mat that prevents water from infiltrating and the sand media will either have to be replaced or the organic mat has to be removed. Long term and proactive SWM facility maintenance is a critical issue with regards to protecting our streams in developed landscapes.

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8. Glossary

Base flow – The portion of the stream discharge that is derived from natural storage (i.e., groundwater outflow and the draining of large lakes and swamps or other sources outside the net rainfall that create surface runoff); discharge sustained in a stream channel, not a result of direct runoff, and without the effects of regulation, diversion, or other works of man. Also called sustaining, normal, ordinary, or groundwater flow.

Before-After, Control-Impact (BACI) Design – An experimental design used to assess environmental impacts. Data is collected Before and After a change and the data is compared between Control and Impacted stations. BACI design is used to account for extraneous factors (such as natural variation). In the Clarksburg SPA, test areas are monitored before and after development and compared to an area where no activity is to occur (Sopers Branch control) and an area where build out is complete and older SWM controls are in place (Germantown/Crystal Rock control).

Benthic macroinvertebrate – Bottom-dwelling aquatic animals lacking a backbone that are visible to the naked eye. This group of organisms includes aquatic insects, worms, crustaceans, and mollusks in streams, rivers, lakes, estuaries, and oceans.

Best Management Practices (BMPs) – Technique, measure or structural control used to manage pollution or other detrimental impacts to a watershed or wetland.

Biological integrity – The condition of the biological communities of a water body based on a comparison to the biological communities in a reference water body that represents the best conditions to be expected for that region.

Bioretention structure/area/facility – A stormwater best management practice (BMP) that uses physical, chemical and biological properties of soils, microbes, and plants to filter pollutants from stormwater runoff. Some reduction in stormwater velocity can also be achieved. Bioretention cells are designed to collect, and store stormwater runoff from on- lot impervious areas such as parking lots and allow it to infiltrate into soils. Cells can be incorporated into median strips, parking lot islands and swales.

Catchment – The area of land draining to a BMP or by a stream or stream system.

Channel protection volume (Cpv) – A design criteria which requires 24 hour detention of the one year post-developed, 24 hour storm event for the control of stream channel erosion.
http://www.mde.state.md.us/assets/document/sedimentstormwater/Glossary.pdf

Collectors – Organisms that consume fine or dissolved pieces of organic matter (e.g., leaf fragments or other material on the stream bottom).
http://www.epa.gov/bioindicators/html/invertclass.html

Cut and fill – Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

Effluent – (Outflow) Stormwater that leaves the outfall of a S&EC or SWM BMP or sewer.

Environmental Overlay Zone – A zone or district created to conserve natural resources or promote certain types of development. The environmental overlay zones in SPAs aim to protect water quality and quantity and biodiversity. This is accomplished by regulating the amount and location of impervious surfaces in order to maintain groundwater levels, control erosion and allow the ground to filter water naturally, thereby minimizing the temperature and volume of stormwater runoff.

Environmentally sensitive areas – Refers to areas having beneficial features to the natural environment, including but not limited to: steep slopes; habitat for Federal and/or State rare, threatened, and endangered species; 100-year ultimate floodplains; streams; seeps; springs; wetlands, and their buffers: priority forest stands; and other natural features in need of protection.

Environmental Site Design (ESD) – A stormwater management strategy aimed at maintaining or restoring the natural hydrologic functions of a site to achieve natural resource protection objectives and fulfill environmental regulatory requirements. Under this premise, stormwater discharges are to be controlled to the maximum extent practicable and nonstructural BMPs and other better site design techniques must be implemented.

Ephemeral stream – A stream channel located above the water table and thereby only carries water during and immediately after periods of precipitation or snowmelt.

Evapotransporation – The loss of water by evaporation from water surfaces and by transpiration from plants.

Filterers – Organisms that are suspension feeders or filter dissolved particles from the water column; a subcomponent of the group of organisms known as collectors.
http://www.epa.gov/bioiweb1/html/invertclass.html

First flush – The first inch of rain over the impervious area creating stormwater with the highest pollutant loading.

Flow splitter – An engineered, hydraulic structure designed to divert a percentage of storm flow to a BMP located out of the primary channel, or to direct stormwater to a parallel pipe system or to bypass a portion of base flow around a BMP.

Flow-weighted composite sample – A mixed or combined sample that is formed by combining a series of individual and discrete samples at specific intervals and characterized by the flow rate of the discharge. This sampling method characterizes the entire storm event and the measured flow is used to calculate the loading of pollutants in the stormwater sample.

Forebay – Storage space located near a stormwater BMP inlet that serves to trap incoming coarse sediments before they accumulate in the main treatment area.
http://www.mde.state.md.us/assets/document/sedimentstormwater/Glossary.pdf

Functional feeding groups – designations that characterize how organisms in the community obtain food.

Geomorphology – See “Stream morphology”.

Grab sample – A single sample of stormwater representing the concentration of pollutants at a discrete point in time. This method of sampling does not represent an entire storm event.

Headwater streams – These small streams are the origins of larger streams and rivers and the place from which the water in the downstream water bodies originates. The health of the larger systems depends upon the condition of the headwater areas. Headwater streams are small and typically fed by groundwater, however some may be ephemeral / intermittent, drying seasonally or just under drought conditions. Because of their small size and variability, they tend not to support a well-balanced fish community.

Home range – The area in which an animal carries out its normal activities.

Hydrodynamic device – See “Hydrodynamic structure”.

Hydrodynamic structure – (also hydrodynamic device or separator) is a class of SWM BMPs that treat stormwater by slowing flow to remove sediment and other pollutants. Depending on the device, treatment may be accomplished by swirling the water or through settling and indirect filtration. Due to these processes, hydrodynamic structures are most effective at treating heavy particulates (such as suspended solids) or “floatables” (such as oil). They are often used as pre-treatment in SPAs and can be either proprietary (trademarked/patented by a corporation) or non-proprietary.

Hydrograph – A graph showing variation in stage (depth), discharge, flow, or velocity over time in a stream of water.

Hydrology – The study of water and its occurrence, dynamics, and function in the environment.

Imperviousness (Impervious surface or area) – Impervious surfaces are those that are impenetrable to rainwater, snow melt, and runoff and prevent the natural infiltration of water into the soil. Impervious surfaces include parking lots, roads, rooftops, and sidewalks as well as soils compacted during the development process.

Index of biotic integrity (IBI) – A measurement of the aquatic community's structure and function within Special Protection Areas as compared to the aquatic community inhabiting the least impaired reference streams within a specific region.

Infiltration – The movement of water through the ground surface into the soil. Also the technique of applying large volumes of waster or stormwater to land to penetrate the surface and percolate through the underlying soil.

Infiltration trench – A SWM BMP designed to manage stormwater quantity and quality by allowing stormwater to infiltrate through permeable soils into the groundwater. Generally, it is a shallow excavated trench filled with gravel or a similar material and lined with filter fabric that treats water as it percolates into the groundwater. Pollutants are filtered out as runoff infiltrates the surrounding soils. Infiltration trenches also provide groundwater recharge and preserve base flow in nearby streams.

Influent – (Inflow) stormwater runoff flowing into a S&EC or SWM BMP or sewer.

Irreducible level/concentration – A limit to how much pollutant removal can be achieved; it is a level in which sediment and nutrient concentrations exist at such low levels that they cannot be reduced further, regardless of how much more surface area, treatment volume, or additional treatment types are provided.

Land use – The way in which land is zoned, delineated, and used. Categories include urban (open space and low, medium, and high density), forest (including wetlands), agriculture (pasture/hay, cultivated crops), open water, and other (i.e. barren land, unconsolidated shore).

Legacy Effect – Residual impacts to an environmental system remaining from previous land use practices.

Limit of Disturbance – Boundary containing all development and construction activities.

Metrics – Attribute or measurable characteristics of a biological assemblage that provides reliable and relevant signals about the effects of environmental and anthropogenic stresses.

Oil-grit separator – also known as a water quality inlet (WQI), consist of a series of chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from storm water. WQIs typically capture only the first portion of runoff for treatment and are generally used for pretreatment before discharging to other best management practices (BMPs). http://www.epa.gov/owm/mtb/wtrqlty.pdf

One-year (1-year) storm – A storm that has a recurrence interval (or frequency) of one year or statistically has a 100% chance on average of occurring in a given year; approximately 2.6 inches rainfall in 24 hours.

Outfall – The end/outlet of a structural BMP, drain, or sewer.

Paired catchment (watershed) design – A study design that pairs control and test drainage areas along similar natural characteristics. See “Before-After, Control-Impact (BACI) Design”

Pioneer species – The first species or groups of species to colonize or re-colonize a barren or disturbed environment. A high number of these types of species typically indicates a stressed environment or one that is lacking features necessary for more specialized or sensitive species, thereby reflecting lower biotic or biological integrity.

Pollutant – Generally, any substance introduced into the environment that adversely impacts a natural resource or the health of humans, animals, plants, or ecosystems.

Recharge volume (Rev) –The requirement to have a specific volume of stormwater runoff or water quality volume (WQv) recharged into the groundwater in order to reverse the impacts of paved surfaces on groundwater infiltration. The recharge volume is based on the hydrologic soil groups and the amount of impervious area.

Regulatory weir – device acting like an obstruction (such as a wall or plate) that controls the flow of stormwater in a treatment train.

Riparian/ Riparian zone – An area of land and vegetation adjacent to a stream that has a direct influence on the stream. This includes woodlands, vegetation, and floodplains.

Sediment and Erosion Control (S&EC) – Sediment and Erosion Controls are BMPs installed prior to construction and land disturbance activities to capture and treat sediment-laden runoff. Examples utilized in SPAs include supersilt fences and sediment basins outfitted with additional treatment features.

Sedimentation – Sedimentation is the process of sediment loads entering the stream system and covering the stream bed. An excessive loading of fine sediment degrades and eliminates riffle and pool habitats available for benthic macroinvertebrates, fish, and stream salamanders. Excessive sediment loads can smother these organisms and their eggs. The movement of sediment can actually scour the stream bottom, accelerate erosion, and diminish bank stability.

Seep – Water feature fed exclusively by groundwater. Seeps typically do not flow.

Shredders – Organisms that consume coarse organic matter such as leaves.
http://www.epa.gov/bioindicators/html/invertclass.html

Spring – Water feature fed by groundwater that flows intermittently or constantly.

Stormwater Management (SWM) – Stormwater Management is a BMP utilized on properties after construction is complete to control the quantity and quality of stormwater runoff. Stormwater Management in the SPAs includes treating the first inch of rain over the impervious/developed surface (also known as the "first flush") as quality control and controls stormwater flows by storing the one-year, 24 hour storm (about 2.6 inches of rain). Quality treatment is aimed at minimizing pollutant loadings of receiving streams whereas quantity control functions primarily as maintaining natural stream flows, groundwater infiltration, and bank stability.

Stream flashiness – The stream flow response to storms. Increased stream flashiness means stream flow and water elevations increase (peak) and decrease rapidly in response to storm events. This increased response can erode stream channels and impair stream habitat and aquatic communities.

Stream morphology – The study of the changes to stream channel form, shape, structure, and area over time.

Taxa – The plural form of taxon. A category or group of organisms.

Tolerance values – A rating assigned to an organism that represents its ability to tolerate various environmental stressors (such as low dissolved oxygen levels, high amounts of siltation or salinity, or varying amounts of toxic chemicals).

Topography The physical features of the land's surface area including elevations and positions of natural and man-made features.

Total Kjeldahl nitrogen (TKN) – The sum-total of organic and ammonia nitrogen in a sample, determined by the Kjeldahl method.

Total Petroleum Hydrocarbon (TPH) – Measure of the concentration or mass of petroleum hydrocarbon constituents present in a soil or water sample. TPH is a family of chemical compounds (exclusively hydrogen and carbon) found in petroleum products that originally come from crude oil. Some chemicals that may be found in TPH are gasoline and fuel components, mineral oils, hexane, benzene, toluene and fluorine.

Total Suspended Solids (TSS) – The weight of particles that are suspended in water. Suspended solids in the water clog the gills of fish, invertebrates, and larval amphibians, reduce the ability of light to penetrate the water column, and decrease stream habitat availability and quality when they settle on the stream substrate. Suspended solids also bind to metals and other contaminants which can be toxic in aquatic systems.

Transfer of Development Rights (TDR) – A method for protecting land by transferring the "rights to develop" from one area and giving them to another. The TDR program in Montgomery County allows developers to increase residential density in designated areas outside of the Agricultural Reserve to compensate farmers for the land equity lost through the down-zoning that created the Ag. Reserve.

Trash rack – Grill, grate or other device installed at the intake of a channel, pipe, drain or spillway for the purpose of preventing oversized debris from entering the structure. http://www.mde.state.md.us/assets/document/sedimentstormwater/Glossary.pdf

Vegetated swale – A SWM BMP designed to trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. It is a broad, shallow channel with vegetation covering the side slopes, and bottom. They can be natural or man-made. Vegetated swales can serve as part of a storm water drainage system and can replace curbs, gutters and storm sewer systems. Therefore, swales are best suited for residential, industrial, and commercial areas with low flow and smaller populations. http://www.epa.gov/owm/mtb/vegswale.pdf

Water Quality Inventory – All persons proposing to disturb land within an SPA, except as provided by law, must submit, for review and approval, a water quality inventory which covers any portion of the project located within the SPA. The inventory includes a stormwater management concept plan, a sediment control concept plan, documentation of impervious areas, additional documentation to show avoidance, minimization, or proposed mitigation for impacts on environmentally sensitive areas, and on priority forest conservation areas as specified in the Planning Board's Environmental Guidelines, and rationale for any proposed encroachment on said areas (per Montgomery County Regulation on Water Quality Review for Development in Designated Special Protection Areas).

Water Quality Volume (WQv) – The volume needed to capture and treat 90% of the average annual stormwater runoff volume equal to 1 inch times the volumetric runoff coefficient (Rv) times the site area.
http://www.mde.state.md.us/assets/document/sedimentstormwater/Glossary.pdf

Water Year Reports – The U.S. Geological Survey "water year" in reports that deal with surface-water supply is defined as the 12-month period October 1, for any given year through September 30, of the following year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 1999 is called the "1999" water year. http://water.usgs.gov/nwc/explain_data.html

Weir- A structure used to raise water level or divert flow. A calibrated weir is used in conjunction with a sampling apparatus to raise water level in a pipe or channel at a known amount in order to calculate sediment and pollutant loadings.

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- USGS, Environmental Resources Center, Reston, VA
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- George Mason University
- United States Environmental Protection Agency (U.S. EPA) Landscape Ecology Branch, Research Triangle Park, NC
- U.S. EPA National Risk Management Research Laboratory, Cincinnati, OH
- U.S. EPA Office of Research and Development, Atlanta, GA
- U.S. EPA Environmental Science Center, Ft. Meade, MD

RELATED DOCUMENTS:

- SPA Annual Report, 2009
- SPA Annual Report, 2008
- SPA Annual Report, 2007
- SPA Annual Report, 2006
- SPA Annual Report, 2005
- SPA Annual Report, 2004
- SPA Annual Report, 2003
- SPA Annual Report, 2002
- SPA Annual Report, 2001
- SPA Annual Report, 2000
- SPA Annual Report, 1999
- SPA Annual Report, 1998
- Clarksburg Conservation Plan
- Piney Branch Conservation Plan
- Upper Paint Branch Conservation Plan

All of the documents cited above are available online in PDF format on our website:
http://www.montgomerycountymd.gov/dectmpl.asp?url=/content/dep/water/spareports.asp
In addition, the Department of Environmental Protection maintains an extensive collection of annual, technical, and general reports, public information factsheets, and related publications. Many are available in both PDF and HTML format, and in some cases, print copies of documents are available. Please contact us for more information.

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