Draft

South River Watershed Study Summary Report

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Potential In-stream Regenerative Conveyance Stormwater Control Treatment Areas

SECTION 1

Introduction

Watershed management planning is a holistic approach to managing, protecting, and restoring aquatic resources. Part of the watershed-planning process and an essential piece of the management plan is establishing a baseline condition, or describing the current condition, of a watershed. A current-conditions assessment will provide planners with the data necessary to plan for management strategies specific to the watershed's unique environmental and land use.

Anne Arundel County initiated a comprehensive stream assessment as part of their Watershed Management Master Plan for the South River. This full-scale assessment was designed to catalog infrastructure, assess stream habitat, inventory biological assemblages, characterize channel geomorphology, and assess chemical water quality conditions of watershed streams. The assessment of the physical, biological, and chemical conditions of the watershed took place over approximately 246 miles of perennial, intermittent, and ephemeral streams. The collected data will allow County planners to understand the current environmental conditions of the South River watershed's waterways.

In addition to the stream assessment, indicators of watershed condition related to land use, stormwater best management practices (BMPs), and pollutant-loading models were compiled in a prioritization model that ranks and prioritizes the watershed at the stream reach and catchment scales. The prioritization model was developed by the Watershed Assessment and Planning group in previous County watershed-planning efforts and was refined for the South River. The results allow for targeted protection of high-quality environmental features and restoration of areas with significant degradation.

The County convened a working group, the Professional Management Team (PMT), to provide input for and review most phases of the assessment and planning process, including the stream and watershed assessments, water quality–modeling procedures and results, the prioritization model, and ultimately the recommendation of future studies and an implementation framework. This collaborative team was made up of technical experts from CH2M HILL and KCI Technologies as well as County staff from several departments.

The next steps in the watershed management–planning process are to use the baseline conditions to assess existing and project potential concerns and use modeling and analysis to propose restoration and preservation improvements with a systematic watershed perspective. The proposed improvements are examined to determine if they aid the County in meeting its regulatory requirements. The cost-benefit effectiveness of each improvement is also determined. And finally, when these potential improvements have been established, the County will adopt an implementation plan to move the South River watershed forward in protecting, enhancing, and restoring its aquatic living resources and their habitats.

This report serves to summarize the procedures and results to date of the South River Watershed Management Master Plan. Full descriptions of methodologies, data analysis and results per stream reach, subwatershed or catchment are reported separately in a series of technical memoranda and are referenced where appropriate.

SECTION 2

Field Data Collection: Baseline Assessment Methodology and Overall Watershed Results

The South River watershed was subdivided into 59 subwatersheds for the Watershed Study. Subdividing into a smaller working unit allows for greater detail and specificity in data analysis and reporting. For presentation purposes, the watershed was divided into three clusters: Headwaters, North Shore, and South Shore. A map providing an overview of these divisions is shown in Figure 2-1. All baseline assessment data are presented in a series of fact sheets for the three major clusters. These fact sheets can be found in Appendix A. Data presented in the body of this report are often provided for the whole watershed.

The City of Annapolis has a separate legal boundary from Anne Arundel County. It includes area in the Church Creek, Crab Creek, Aberdeen Creek, and Harness Creek subwatersheds. These portions of the City have been included in the South River watershed management study both in data gathering and modeling where possible. For instance, although detailed land cover information was obtained for the City of Annapolis, the presence of BMPs was not, and so the water quality model may not fully reflect the BMPs' function in those portions of those watersheds. The City of Annapolis is currently collecting additional watershed information that will be added to the model when available.

2.1 Physical Conditions

The procedures for the field assessments of the stream layer updates, physical habitat and the environmental and infrastructure inventory for all streams followed the same methodology that was outlined by Anne Arundel County (2002) and has been adopted by the Anne Arundel County Watershed Management Program (WMP) as a protocol for assessing all of the County's watersheds. The following sections contain a brief summary of this methodology. For a detailed description of these methods, see Anne Arundel County (2006, Appendix B).

The physical condition assessment is a record of the field conditions as observed during the study period, from March 2006 to August 2006.

2.1.1 Stream Layer Update

A major function of the physical condition assessment was to field verify and update the County's GIS stream layer for the South River watershed. Channel location, type, and thread (single or multiple) were updated during the assessment. Changes in location included additions and deletions of line work to match the GIS to the field-observed channel or hydrologic connection. Changes in channel location were limited to major discrepancies.

A total of 246 miles of streams was examined during the physical condition assessment of the South River Watershed Study. The main stem of the South River was not included in this physical assessment. Perennial streams were the most prevalent type, with 144 miles of channel or 59 percent of the total amount of stream miles assessed. Ephemeral and intermittent streams made up another 25 percent of the total. Table 2-1 shows the resulting stream miles and percent by type.

2.1.2 Habitat Assessment

Physical habitat assessments were conducted following the methods described in the Physical Habitat Index for Freshwater Wadeable Streams in Maryland, developed by the Maryland Department of Natural Resources (DNR) (Paul et al., 2003). The field and data analysis methods used for this study are described in Anne Arundel County (2006, Section 4.1 of Appendix B). Maryland Physical Habitat Index (MPHI) scores were developed for each perennial stream reach, and subsequently, scores weighted by stream length were developed for each subwatershed. The MPHI score was generated on the basis of the following physical parameter metrics: bank stability, woody debris, in-stream habitat, epifaunal substrate, total shade, and remoteness. The MPHI metrics and the actual formula to calculate the MPHI score changed between the completion of the Severn River Watershed Management Plan and the initiation of the South River Watershed Study. (The changes in the MPHI scoring process are outlined in the technical memorandum "Changes in Maryland Physical Habitat Index from Severn River Study to Now," in Appendix B.)

TABLE 2-1
Percent of Total Stream Miles by Type

Type	Stream Miles	Percent of Total
Perennial	144.2	59
Intermittent	39.8	16
Ephemeral	21.9	9
Wetland	20.3	8
Ditch	6.2	3
Pond/lake	4.3	2
Tidal[a]	3.3	1
SWM	3.2	1
Floodway	2.5	1
Other	0.1	0

[a] Does not include main stem of South River.

Habitat assessments were conducted on only perennial streams. A total of 143 miles of perennial streams, including 696 distinct reaches, was assessed, with approximately 1 mile of stream (four individual reaches) not assessed owing to inaccessibility: reaches BC5003, BD1010, FC5022, and GC2032.

The mean MPHI score for the entire watershed is 77.01, with a condition category of "partially degraded." The median MPHI score for the watershed is 77.84, partially degraded. The overall mean stream length weighted MPHI score for the watershed is also in the partially degraded condition category, with a score of 77.46.

Figure 2-2 presents the number of stream miles within each MPHI category. The partially degraded category rating has the highest percentage of stream miles and also the highest number of reaches, 375 out of 696. "Minimally degraded" streams make up 35 percent of the total in terms of both stream miles and number of reaches (241). "Degraded" and "severely degraded" make up only 11 percent of the reaches assessed, with 40 reaches in each category.

Legend

- Clusters
- Subwatersheds
- Streets

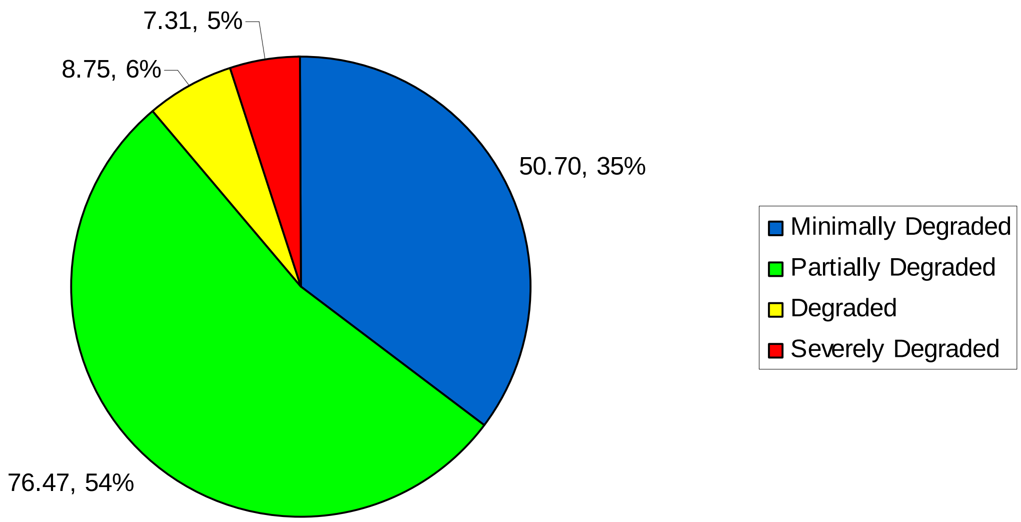
N

1 0.5 0 1 Miles

Figure 2-1
South River Watershed Map

CH2MHILL

FIGURE 2-2
Number of Stream Miles per MPHI Category



2.1.3 Infrastructure and Environmental Features Inventory

In-stream and riparian features were inventoried during the course of the stream assessments for all perennial, intermittent, and ephemeral channels. Each feature was assessed for impact on the stream channel and given an impact score. The features assessed included buffers, erosion, obstructions, crossings, utilities, dump sites, head cuts, pipes, and ditches. Field methods of data collection and scoring are described in Anne Arundel County (2006, Section 4.1 of Appendix B). A Final Habitat Score (FHS) was generated for each reach incorporating the MPHI score and the infrastructure inventory into the calculation. This calculation is explained in Anne Arundel County (2006, Section 4.2 of Appendix B).

Table 2-2 presents the total impact score per inventory category (the sum of all impact scores for each category) for the entire South River Watershed, excluding head cuts, which are scored based the height of the head cut. These impact scores are for only the assessed reaches, and therefore these scores were used in the determination of the FHS. Erosion has a total impact score for assessed reaches of 3,843, significantly higher than any other category, an indication that stream bank erosion is a major factor in overall watershed condition. Riparian buffer degradation, stream crossings, and channel obstructions also seem to be factors in channel degradation based on the impact scores. The impact scores at this summary level provide an indication of factors that may be causing habitat degradation within the watershed.

TABLE 2-2
Total Impact Score per Inventory Category, for Entire South River Watershed

	Buffer	Crossings	Ditches	Erosion	Dumpsites	Pipes	Obstructions	Utilities
Overall	1,078	871	155	3,843	272	240	906	40

The FHS indicates the impact of infrastructure and environmental features on the South River watershed streams. The mean FHS is 71.77, or "partially degraded," for the entire watershed. The median FHS for the watershed is 74.29, also "partially degraded." The overall mean stream length weighted FHS value for the watershed is lower, with a score of 69.80, but also in the partially degraded category.

Table 2-3 summarizes the difference between the MPHI and FHS scoring category results for the entire watershed. A majority of the degraded and severely degraded condition category reaches falls along the western portions of the watershed.

TABLE 2-3
Watershed Summary of MPHI and FHS Category Ratings

	MPHI		FHS	
Category	Percent of Stream Miles	Percent of Reaches	Percent of Stream Miles	Percent of Reaches
Minimally degraded	35	35	22	24
Partially degraded	53	54	45	48
Degraded	6	6	20	19
Severely degraded	5	6	13	8

2.2 Base Flow Sampling

Dry weather grab samples and discharge estimates were collected between August 16, 2006, and October 16, 2006, throughout the South River watershed to identify unusual pollutant loads and to characterize base flow pollutant loadings for water quality modeling. (For a complete description of study methods and results, see the "South River Baseflow Sampling" technical memorandum, in Appendix B.)

Fifty-four sampling sites were distributed among 36 subwatersheds and were generally located on the most downstream main stem reach but upstream of tidal influence. Subwatersheds not sampled did not have perennial flow present during either the physical condition assessment or the base flow–sampling period. Data collected at each site included in-stream water quality, grab sample, GPS location, cross-section and longitudinal profile, discharge measurements, roughness estimate, and site photographs.

2.2.1 Methods Summary

In-stream sampling (pH, temperature, dissolved oxygen, conductivity, total dissolved solids) was conducted using a YSI ® 6920 multiprobe and a YSI ® 650 MDS data logger. Turbidity measurements were collected using a Hach 2100 Turbidimeter.

Grab samples were collected at each site for laboratory analysis of the following parameters:

Nutrients:	total nitrogen (TN), total Kjeldahl nitrogen (TKN), nitrate (NO_3), nitrite (NO_2), total phosphorus (TP)
Solids:	total suspended solids (TSS)
Metals:	copper (Cu), lead (Pb), zinc (Zn)
Bacteria:	fecal coliform

Concentrations were applied to the base flow discharge rates for each site and converted to a pounds-per-year load. When the concentration was below the detection limit, a value of half of the detection limit was applied to generate the load. The exception was nitrite, which oxidizes to nitrate and was therefore assumed to be 0.0 when below the detection limit.

2.2.2 Base Flow Results

Summarized results of the base flow sampling are presented in Table 2-4. Each parameter is shown with the number of sites below the method detection limit (nondetects) and the minimum, maximum, median, and mean values for the concentration and base flow load. Because fewer criteria for pollutant loads exist, this discussion will focus on the results of the pollutant concentrations. Overall, the results were typical of Coastal Plain freshwater tributaries.

While there are currently no specific nutrient criteria for Maryland surface waters, EPA (2000) has developed a set of nutrient criteria guidelines for each nutrient ecoregion of the United States. The Maryland Western Shore Coastal Plain falls within Nutrient Ecoregion IX; therefore, ambient water quality criteria recommendations from this region were used for total phosphorus and total nitrogen comparisons. Maryland Biological Stream Survey (MBSS) has set water quality thresholds for nutrients based on data collected statewide. Table 2-5 shows ranges developed from data from 2000 to 2004.

Based on comparison to these ranges, nutrient levels in the South River base flow sampling are considered to be low and in acceptable ranges. Nitrate values were typically low, with a mean value of 0.37 mg/L, and all but three sites were less than 1.0 mg/L. Similarly, nitrite values were also low, and only one site was above the detection limit of 0.02 mg/L. Total Kjeldahl nitrogen (TKN), which provides a measure of the ammonia and ammonium, was above detection at only four sites and had a watershed average of 0.31 mg/L. Comparison to the DNR Core/Trends (Southerland et al., 2005a) dataset shows only these four detection sites were above the lowest range, and the overall watershed mean of 0.31 mg/L was in the low range.

With both nitrate and TKN low, it follows that levels of total nitrogen (the sum of these two parameters) were also low. Only four sites had values over 1.0 mg/L (three of which were in the Beards Creek subwatersheds), and the mean total nitrogen value was 0.40 mg/L. EPA

(2000) sets a recommended criterion for TN of 0.69 mg/L. Five sites in the South River study were above this threshold.

Total phosphorus (TP) levels were in more moderate to high ranges. There was only one nondetect, and the study mean fell in the high range compared to MBSS sites across the state. Only five sites were at 0.07 mg/L or less. EPA (2000) recommended criterion for TP is 0.036 mg/L. All but one site were above this threshold.

TABLE 2-4
Base Flow Monitoring Summary Results

	TP	TN	TKN	NO_2	NO_3	TSS	Cu	Pb	Zn	Fecal Coliform
Nondetects	1	2	50	48	2	0	4	53	10	0
Concentrations	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**µg//L**	**µg//L**	**µg//L**	**MPN/ 100mL**
Min	0.01	0.01	0.25	0.00	0.01	1.00	0.005	0.005	0.005	15.00
Max	0.97	1.90	1.50	0.05	1.90	23.00	0.022	0.060	0.110	4600.00
Median	0.20	0.31	0.25	0.00	0.31	5.00	0.005	0.005	0.025	230.00
Mean	0.23	0.40	0.31	0.00	0.37	6.52	0.006	0.006	0.027	619.69
Loads	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	
Min	3	3	5	0	3	1670	0.0000	0.0000	0.0000	NA
Max	858	1236	3091	28	1250	673471	0.1000	0.0000	0.2000	NA
Median	174	252	222	0	273	61286	0.0000	0.0000	0.0000	NA
Mean	230	330	368	2	346	94487	0.0019	0.0000	0.0167	NA

MPN, most probable number.

TABLE 2-5
MBSS Water Quality Thresholds for Nutrients Measured in 2000–2004

Parameter	Low	Moderate	High
Nitrate (mg/L)	< 1.0	1.0–5.0	> 5.0
Nitrite (mg/L)	< 0.0025	0.0025–0.01	> 0.01
Total nitrogen (mg/L)	< 1.5	1.5–7.0	>7.0
TKN (mg/L)[a]	< 0.48	0.48–0.62	>0.62
Total phosphorus (mg/L)	< 0.025	0.025–0.070	> 0.070

Source: Southerland et al. (2005b).
[a]Tercile ranges from DNR Core/Trends, 1986–2004. (Southerland et al. 2005a)

MDE has established numerical criteria for several water chemistry parameters measured as part of this water quality monitoring program (e.g., lead, copper, and zinc). These standards are listed in the Code of Maryland Regulations (COMAR) 26.08.02.03-2 Numerical Criteria for Toxic Substances in Surface Waters. Applicable state and federal water quality criteria for laboratory chemistry parameters are shown in Table 2-6. Measured levels of lead, copper, and zinc fell well below both the chronic and acute criteria.

While all sites were well below the TSS criteria shown in Table 2-6, comparison against DNR Core/Trends data puts the South River in the moderate range between 5.44 mg/L and 7.80 mg/L with a mean value of 6.52. Eighteen South River sites are in the in the highest third of sites across the state, while 31 sites are in the lowest third.

Fecal coliform bacteria were variable across the watershed with a mean value close to 620 MPN/100 mL. Twenty sites had values above 400, and eight sites were above 1,000, indicating some bacteriological issues in those streams.

TABLE 2-6
State Water Quality Standards

Parameter	Chronic	Acute	Reference
Lead (μg/L)	2.5	65	COMAR 26.08.02.03-2
Copper (μg/L)	9	13	COMAR 26.08.02.03-2
Zinc (μg/L)	120	120	COMAR 26.08.02.03-2
Fecal coliform[a] (MPN/100 mL)	400		—

[a]No longer listed in COMAR for bacteriological criteria; however, previous standard for fecal coliform was applied to allow for comparisons.

2.3 Bioassessments

The biological-monitoring program for the South River included chemical, physical, and biological assessments conducted throughout the watershed at 30 sites between March 22, 2006, and April 18, 2006. The sampling methods used are compatible with the Sampling and Analysis Plan for Anne Arundel County Biological Monitoring (SAP) (Tetra Tech, 2005a) and the Quality Assurance Project Plan (QAPP) for Anne Arundel County Biological Monitoring and Assessment Program (Tetra Tech, 2004). All data were entered into an Ecological Data Application System (EDAS) database. These methodologies and the results of the 2006 monitoring are summarized below.

Biological assessment methods within Anne Arundel County are designed to be consistent and comparable with the methods used by DNR in its MBSS. The County has adopted the MBSS methodology to be consistent with statewide monitoring programs and programs adopted by other Maryland counties. The methods have been developed locally and are calibrated to Maryland's physiographic regions and stream types. MBSS physical habitat assessment parameters were collected to calculate the MPHI score. Physical habitat for the South River watershed was also assessed using EPA's Rapid Bioassessment Protocol (RBP) (Barbour et al., 1999) habitat assessment for low-gradient streams. Additionally, several in-stream water quality parameters were recorded at the time of the assessment. (For full data results of the biological assessment and a complete description of the study methods, see the

"South River Bioassessment" technical memorandum, in Appendix B.) Results summarized by each sampled subwatershed are presented in Table 2-7.

The physical habitat in the South River watershed was rated by RBP as "supporting" or higher and by the PHI as "partially degraded" or higher. However, sampling of the benthic macroinvertebrate community was rated primarily as "poor" to "very poor." All field-tested water quality parameters except pH were within the required levels. The biological assessment study mean pH of 6.36 was just below acceptable COMAR limit of 6.5.

Habitat scores for the RBP and PHI assessments were fairly well correlated, and both indicate good available habitat throughout the majority of the watershed. There were no sites receiving the lowest physical habitat rating under either RBP or PHI. The PHI had 13 sites in the highest category of "minimally degraded" while the RBP had 19 sites in the highest category of "comparable to reference." The study mean PHI was rated as "partially degraded" and the mean RBP was rated as "comparable to reference."

The benthic index of biotic integrity (BIBI) macroinvertebrate study mean of 2.7 is in the "poor" category. There was only one site that received the BIBI rating of "good," and 11 sites that received the next highest BIBI rating of "fair." Most sites (14) were in the "poor" category and four additional sites were in the "very poor" category. There was a clustering of both good habitat scores and good to fair BIBI scores in the BR3, BR4, and BR5 subwatersheds.

TABLE 2-7
Bioassessment Summary Results

Subshed	*n*	BIBI Narrative Rating	PHI Narrative Rating	RBP Classification	Subshed	*n*	BIBI Narrative Rating	PHI Narrative Rating	RBP Classification
BC3	1	Fair	Degraded	Comparable to reference	FC5	1	Fair	Partially degraded	Supporting
BC4	1	Poor	Partially degraded	Partially supporting	GC1	1	Poor	Partially degraded	Supporting
BC5	1	Poor	Degraded	Partially supporting	GC2	1	Poor	Minimally degraded	Comparable to reference
BD3	2	Poor	Partially degraded	Comparable to reference	GVC	1	Very poor	Minimally degraded	Comparable to reference
BR1	3	Poor	Partially degraded	Comparable to reference	NR1	1	Very poor	Minimally degraded	Comparable to reference
BR3	1	Fair	Minimally degraded	Comparable to reference	NR2	2	Fair	Partially degraded	Supporting
BR4	2	Good	Minimally degraded	Comparable to reference	NR3	1	Poor	Partially degraded	Supporting
BR5	1	Fair	Minimally degraded	Comparable to reference	NR4	1	Poor	Minimally degraded	Comparable to reference
CHR	1	Poor	Partially degraded	Supporting	NR6	1	Fair	Minimally degraded	Supporting

TABLE 2-7
Bioassessment Summary Results

Subshed	*n*	BIBI Narrative Rating	PHI Narrative Rating	RBP Classification	Subshed	*n*	BIBI Narrative Rating	PHI Narrative Rating	RBP Classification
FC1	1	Poor	Partially degraded	Comparable to reference	TNB	2	Poor	Partially degraded	Supporting
FC2	1	Fair	Minimally degraded	Comparable to reference	WHC	1	Very poor	Degraded	Partially supporting
FC3	2	Poor	Minimally degraded	Comparable to reference	Study Mean		Poor	Partially degraded	Comparable to reference

n, number of sites per subwatershed.

2.4 Channel Geomorphology

A Rosgen Level I stream-type classification completed earlier by the County's Watershed Management Program used a series of desktop analyses to generate a classification for select individual stream reaches. (Detailed methods for the desktop Level I classification and results can be found in the Anne Arundel County Watershed Management Program Internal Memorandum "Task 3.5 Rosgen Level II Site Selection," in Appendix B).

The County then selected 54 sites throughout the watershed for Rosgen Level II geomorphic assessments. The sites selected were done so on the basis of achieving a balanced spatial distribution and the proportion of all channel types present within the watershed.

The Rosgen Level II geomorphic characterization of perennial reaches was performed at the selected field sites during winter 2006. The geomorphic assessment followed the methodology described by Rosgen. (See the Anne Arundel County Watershed Management Program Internal Memorandum "Task 3.5 Rosgen Level II Site Selection," in Appendix B.) Field data collected for the Level II classification included longitudinal profile and cross-section surveys, sinuosity measurements, and particle size distribution. After the field assessment, all field survey data were entered into the reference reach spreadsheet (Mecklenburg, 2004).

The Level II geomorphic assessment of the selected reaches within the watershed yielded predominantly B, E, F, and G channel types, which are typical of the coastal plain. A qualitative assessment of available mapping showed that the F and G (impacted) channel types were typically associated with areas of new development activity and areas with high proportions of impervious surfaces. Of the 54 channels assessed in the field, 24 (44 percent) were an exact channel type match with the County's Level I desktop assessment procedure results. The remaining sites deviated from the desktop procedure in both entrenchment and width/depth ratio values enough that the field assessment channel type was different from that of the desktop assessments.

The collected field data allowed the County to refine the desktop procedure to improve its potential as a planning level assessment tool. The County identified refinements to be made to the TR20 model run pertaining to catchment size. In the initial TR20 run, the high number of small catchments was artificially increasing the peak channel flow. The catchment layer was refined to reduce the overall number of catchments and on average increase the size of catchments so that 80 percent of them fell into the 50- to 150-acre range. Some catchments are larger due to their unique characteristics. The County reran the TR20 model for the 1.2-year return period with the updated catchment layer. After the desktop procedure was refined, the percentage of exact channel type match increased to 80 percent.

2.5 Stormwater Runoff Controls

Anne Arundel County is managing its stormwater runoff in the South River watershed through both urban stormwater management facilities and agricultural BMPs. Both of these types of management technique were documented during this study.

2.5.1 Stormwater Management Facilities

In order for the County to accurately model the conditions within the South River watershed, it is important to understand the current stormwater management activities—the number of facilities and their location, the type, and the drainage area that each of them treats. An ArcGIS Personal Geodatabase of stormwater management facilities in the watershed was developed along with an attribute database, which contains the information needed for modeling these facilities.

The main source of the information was the inspections database maintained by Anne Arundel County Inspections and Permits. County staff had led an effort in 2006 to update this database to meet MDE permit standards; much of the work performed related to the location of each BMP.

The first step in developing the BMP coverage for the watershed was to examine the County's databases and determine if there was enough information in the attributes to locate each BMP properly. If there was not, the next step was to research Anne Arundel County's offices and review the as-built drawings related to that particular BMP.

A series of different steps was performed to rectify the BMP coordinates in the main database. After these steps were complete, approximately 1,300 BMPs in the County were still without a location and were therefore assigned a location in the center of the County. (Incidentally, the County centroid fell within the South River watershed.) Based on this work, two different sets of steps were developed for determining the locations of the BMPs in the main database.

The first steps in determining a BMP's location was to look at the zip code and the watershed boundary. In addition, a series of spatial overlays and joins were performed to further confirm the location of the BMP point. Additional layers used in this process include the consolidated property file database (comparing the zip codes listed in the Consolidated Property File (CPF) database to the zip codes in the urban BMP database) and the ADC map grids. The overall guiding principle in this effort was that if two pieces of location information were correct or matched, then it can be assumed that the location is correct.

A personal geodatabase provided to the County in July 2007 included BMP location, type, and drainage area. Approximately 13 percent of the drainage area of the South River watershed is treated by a stormwater management facility. Table 2-8 characterizes these data.

TABLE 2-8
Summary of South River BMPs

Type	Number	Drainage Area (Acres)
Detention dry	76	960
Extended detention dry	76	767
Filtration	116	224
Infiltration	869	899
Wet structures	88	1840
Other	131	42

2.5.2 Agricultural Best Management Practices

The significant acreage of agricultural land in the South River watershed prompted the need to carefully consider how to evaluate runoff quality and BMP effectiveness in these areas of the watershed. The purpose of this task was to collect and organize data on agricultural practices in the watershed as an input to the county's watershed management process.

Agricultural conservation practices, or "agricultural BMPs," are most often related to land management practices, such as conservation tillage and contour tillage operations, which reduce the amount of pollutants at the source, whereas urban BMPs are often structural treatment devices placed to capture and treat surface runoff at a single point downstream. However, certain agricultural BMPs, such as using grass swales and buffers, act in a manner similar to that of urban BMPs by treating pollutants in agricultural runoff after it has left the field. This distinction means that agricultural BMPs need to be treated somewhat differently than stormwater management facilities, both in terms of mapping and modeling.

State and County conservation and agricultural agencies were contacted to establish data sources and collection methods that, to some extent, satisfy the task requirements while preserving confidential provisions of the state's nutrient management program. A windshield survey was conducted to verify the existing land-use layer and to supplement the data on farmland practices that were provided by the county's Soil Conservation District. Thirteen crop/animal farming activities, 11 conservation practices, and five types of agricultural point BMPs were identified in the South River watershed (Table 2-9). Tables 2-10 through 2-12 summarize these activities, practices, and BMPs on an acreage basis. (For a complete description of the study methods and results see the "South River Watershed Study Task 2.5 Agricultural Best Management Practices" technical memorandum in Appendix B).

TABLE 2-9
Crop/Animal Farm Activities, Conservation Practices and BMPs in the South River Watershed

	Practice
Crop/animal activity	Corn, fallow, garden, grapes, horse farm, open space, pasture/hay, row crops, soy, sod, wildlife, flowers, vegetables
Conservation practice	Strip cropping, no-till, contour cropping, cover crop, rotation, nutrient management[a]
BMP	Grass filter strip, grass drainage ditch, pond, possible manure storage, wooded buffer

[a]This conservation practice could not be verified in the field.

TABLE 2-10
Summary of Crop/Animal Activities

Category	Acreage[a]	N		P		K		Agricultural Land (%)
		lb/ac/yr	lb/yr	lb/ac/yr	lb/yr	lb/ac/yr	lb/yr	
Corn	172	131	22,576	38	6,549	86	14,821	8.2
Cover crop	10	—	—	—	—	—	—	0.5
Fallow[b]	226	45	10,159	7	1,580	34	7,675	10.8
Garden[c]	11	190	2,091	23	253	45	495	0.5
Grapes	13	14	176	0	—	0	—	0.6
Horse farm[d]	135	81	10,427	14	1,862	55	7,076	6.4
Open space	166	—	—	—	—	—	—	7.9
Pasture/hay[b]	260	45	11,717	7	1,823	34	8,853	12.4
Row crops[e]	495	60	29,719	18	8,916	66	32,691	23.6
Soy	259	5	1,296	3	777	51	13,214	12.4
Sod	98	70	6,873	11	1,080	11	1,080	4.7
Wildlife	0.1	—	—	—	—	—	—	0.0
Multicrop[f]	—	—	—	—	—	—	—	—
Corn	119	131	15,564	38	4,515	86	10,217	5.7
Flowers	8	38	308	38	308	38	308	0.4
Soy	108	5	542	3	325	51	5,527	5.2
Vegetables[‡]	15	190	2,844	23	344	45	674	0.7
Total	***2,095***	***—***	***114,291***	***—***	***28,332***	***—***	***102,631***	***100.0***

[a]Acreages based on County's land-use polygons.
[b] Nutrient application rates (lb/ac/yr) are based on the area-weighted average of that for hay and wheat.
[c]Estimated from weighted averages of garden crops (mainly vegetables).
[d]Nutrient rate (lb/ac/yr) is derived from USDA (1996, Chapter 4).
[e]Nutrient application rates (lb/ac/yr) are based on the area-weighted average of that for corn and soy.
[f]Total acreages of farmlands with multiple crops were split evenly among the crops.

TABLE 2-11
Summary of Conservation Practices

Practice Category	Acreage	Agricultural Land (%)
Contour cropping	14	1
Cover crop	124	6
Multipractice	432	21
No-till	13	1
Rotation	110	5
Strip cropping	28	1
Total	**721**	**34**

TABLE 2-12
Summary of BMPs

Practice Category	Acreage	Agricultural Land (%)
Pond	0.1	0.01
Wooded buffer	25	1
Possible manure storage	57	3
Grass filter strip	248	12
Multi-BMP	272	13
Total	**603**	**29**

SECTION 3

South River Water Quality Model

3.1 Methodology

Anne Arundel County staff developed a spreadsheet water quality model for the County based on the Simple Method Equation to calculate pollutant loading. This spreadsheet is based on the PLOAD model developed during the Severn River watershed project, but it allows the County the flexibility to do additional analysis (such as using the new TMDL categories and incorporating some of the MDE SWM regulations as BMPs). The current model serves as a template for calculating existing, ultimate, and alternative scenario water quality models pertaining to the nitrogen and phosphorous loads. In addition, the information will be utilized by the County in computing its TMDL and NPDES load reduction requirements.

As with PLOAD, the water quality model uses GIS coverages for land use (2004), subwatershed boundaries, and BMP locations that are intersected and then extracted back into the spreadsheet for calculation purposes. This model uses an impervious cover delineation from 2004 rather than an impervious rating based on land cover. Event mean concentrations and BMP removal efficiencies are also used, but some have been adjusted since the Severn River project. Detailed information on the background of the modeling can be found in Anne Arundel County (2002) and in the water quality model instructions. Changes to the water quality model from the one used for the Severn River plan are described in the following subsections.

3.1.1 Changes to Input Information

While the new water quality model spreadsheet needs the same basic input information as PLOAD, the County has made some updates to the individual files and values. These are described below. (Appendix C contains tables of information of the current Event Mean Concentration values, BMP pollutant removal efficiencies, and land cover prioritization.)

- Land use information/event mean concentration values
  - Groupings of land cover types now match the categories used in the TMDL analyses (“NPS Agriculture,” “NPS Urban,” “Other NPS”).
  - EMCs for TN, TP, and TSS have not changed.
  - EMCs for metals and fecal coliform have been updated with new information.
  - The City of Annapolis has been modeled on the basis of land cover data obtained for the City.
  - Zoning classifications changed since the Severn River project, and appropriate adjustments have been made.

- BMP pollutant removal efficiencies
  - Values have been updated to reflect additional BMP types and groups of BMP types that match the Chesapeake Bay Program Office recommendation.
  - Values have been updated based on recent literature review of TN, TP, and TSS done by the University of Maryland for the Chesapeake Bay Program.
  - These updated values have been reviewed and vetted by the Professional Management Team.
  - A BMP inventory does not currently exist for the City of Annapolis, so the water quality model does not reflect the presence of BMPs performing a water quality function in the portions of the South River that are within City limits.
- Future land use
  - The County has developed a land cover prioritization lookup table to be used with the water quality model. The table provides a method to determine future land use based on existing land use and the zoning classification for a particular area. Based on a set of modeling rules, future land use will match the zoning classification if zoning priority is higher than existing priority; zoning priority is greater than 2 (i.e., zoned land use is not woods, water, wetland, forested wetland, open space, or utility R/W); and the area is not flagged with a development restriction.
  - Development restrictions were based on a series of conditions, including steep slopes (over 25 percent) for 5,000 ft^2 or larger areas, wetlands, FEMA floodplain, stream buffers, potential for redevelopment, land ownership, and public/private right of way.
  - The Professional Management Team agreed that this approach to determining future land use was well thought out and a good expansion on the original approach used for the Severn River Watershed Management Master Plan.
- Septic system loads
  - Septic loads have been included in the model and are based on Anne Arundel County (2008).

3.1.2 Alternative Scenario Modeling Techniques

The flexibility of the spreadsheet approach allows the County to include measures that provide water quality benefits but are not traditional BMPs and therefore could not be included in the PLOAD model structure. These measures included applying the new Maryland stormwater regulations, including certain stream restoration techniques and septic system upgrades as best management practices, and including a variety of additional BMPs.

Maryland has instituted a series of stormwater regulations that all future development in the County must comply with. It is anticipated that these regulations will have a positive impact on the water quality within the South River watershed. For instance, because new development and future BMPs will have a recharge element to them, the County has worked a recharge volume credit into the model by reducing the amount of rainfall on those new development and redevelopment areas to account for the recharge volume. This method recognizes that the regulation requires a certain recharge volume in those areas and that amount of recharge will infiltrate into the soil instead of running off and adding to pollutant loading.

Additional steps were taken in the model to properly reflect the stormwater management guidelines regarding the various categories of development (none, new, redevelopment areas, or critical areas). These steps included general BMPs in areas of new development that met an average of the BMP efficiency requirements of the regulations and a reduction of imperviousness (rather than a BMP application) in the redevelopment areas. Chesapeake Bay regulations govern development in the critical areas (intense development areas, or IDAs; limited development areas, or LDAs; and resource conservation areas, or RCAs), and this was reflected in the model as well.

The County is examining the possibility of utilizing regenerative conveyance as a stream restoration tool. This method creates wetland seepage systems as storage adjacent to the stream within the floodplain. This measure was included as a BMP and the wetland pollutant removal efficiencies were used.

Septic system loads were based on the onsite sewage disposal systems (OSDS) study (Anne Arundel County, 2008). For future conditions scenarios, two alternatives were considered: One assumes that all existing and future septic systems are retrofitted for higher nitrogen removal, which reduces the load by 50 percent per the OSDS study; the other incorporates all of the recommended improvements to the septic systems as per the OSDS study. These improvements could include sewer extension to an existing water reclamation facility (WRF) (in areas of no public service and in areas with an existing sewer system), cluster type of community sewer service, OSDS upgrades with enhanced nitrogen removal, and no action, meaning maintain existing septic system. Sewer extension will reduce the nitrogen load of those facilities in the South River watershed to zero because the wastewater load is diverted to WRFs in other watersheds. Cluster treatment will reduce the load by 92 percent. An OSDS upgrade will reduce the load by 50 percent.

Additional alternative scenarios are listed in Section 3.3.

3.2 Current Conditions

Pollutant loading from the South River watershed was modeled for total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), and fecal coliform. The resultant loads for the current conditions are presented in Figure 3-1.

3.3 Future Conditions and Alternative Scenarios

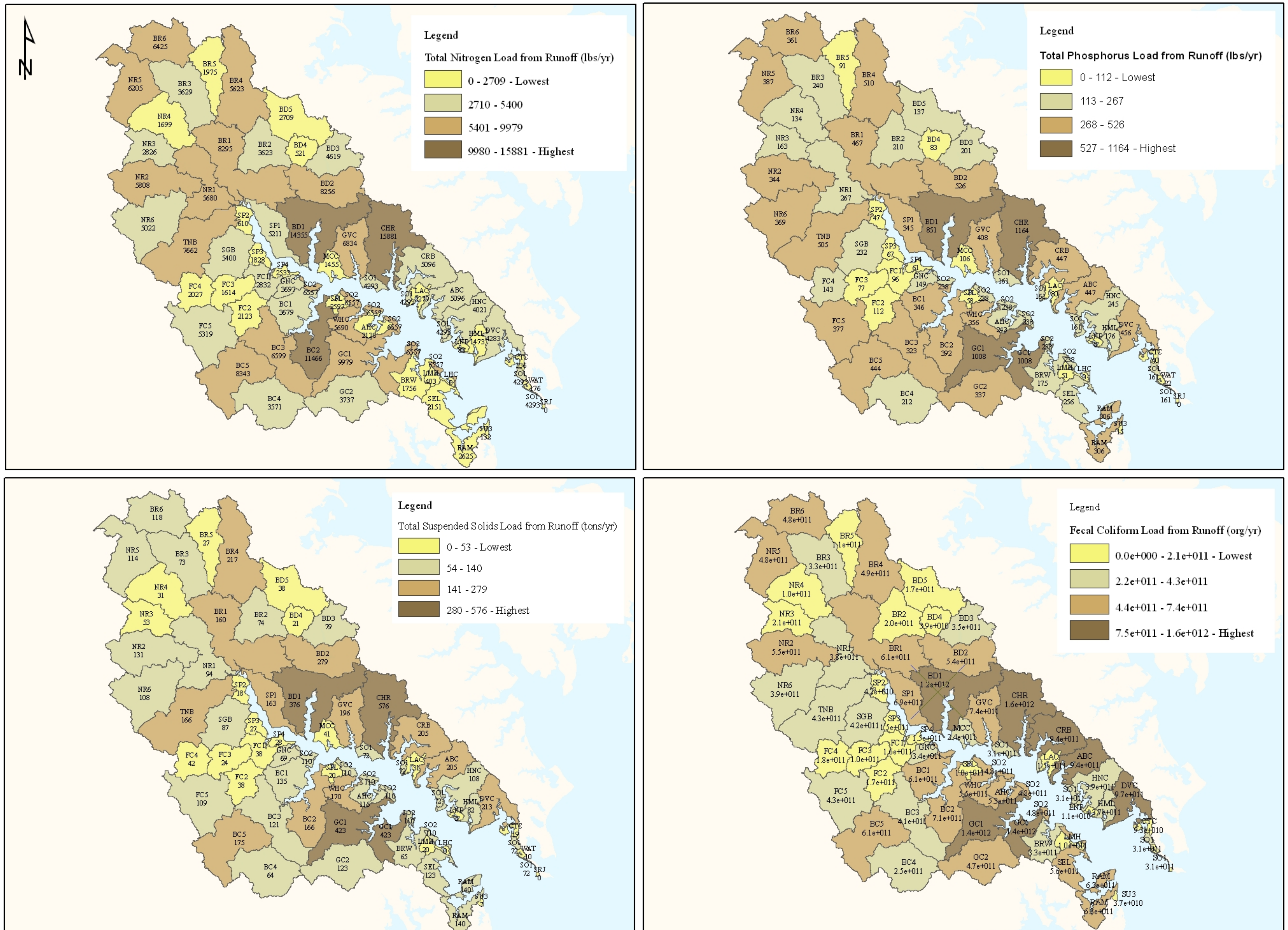
A variety of alternative scenarios was evaluated during the course of this project. None of these scenarios are recommended in this report; nor will it be likely that any one scenario will be implemented wholesale. More than likely, individual scenarios or BMPs will be applied in certain subwatersheds where they are the most effective. However, all of the alternative scenarios evaluated are methods that Anne Arundel County has available to improve the water quality in the South River. Alternative scenarios modeled for future conditions are listed below:

- **Regenerative conveyance** (detailed in Section 3.1.2)
- **Septic system upgrades** or implementation of the OSDS study (detailed in Section 3.1.2)
- **Wet pond retrofits:** converting several categories of dry structures to a structure type that combines the benefits of wet ponds and perimeter filter strips
- **Greenway creation:** changes to land use and imperviousness based on the creation of greenways
- **Buffer expansion:** buffers expanded to 300 feet in areas with no planned sewer service, which reduces potential for septic system short circuiting
- **Combination of greenways and buffer expansion**
- **Cluster development:** change in EMC based on the lots having more open space on part of the lot and denser houses/driveways/etc. on the other part
- **Bioretention retrofits on public lands:** two scenarios assuming different implementation percentages
- **Bioretention retrofits on private lands:** two scenarios assuming different implementation percentages
- **Concrete and asphalt public ditch retrofit:** ditches with lengths exceeding 100 feet are targeted for retrofit; BMP efficiency was assumed to be similar to bioretention area
- **Street sweeping:** All public roads with more than 50 percent curb coverage are assumed to be closed-section roadways that could be swept. An average 100-foot-wide section was assumed. The pollutant removal efficiency was obtained from a Center for Watershed Protection report.
- **Inlet cleaning:** The number of inlets included was based on inspection reports. The drainage area for these inlets was delineated and the pollutant removal efficiency was obtained from a Center for Watershed Protection report.

Pollutant loading from the South River watershed was modeled for TN, TP, TSS, and fecal coliform. The information presented includes the base future loading conditions—i.e., future conditions with fully maintained existing BMPs, all stormwater management regulations implemented, and the sewer master plan implemented. The alternative scenarios listed above are not shown in Figure 3-2.

FIGURE 3-1
Summary Nutrient Loads for South River Watershed: Existing Conditions

Shed Code	Subwatershed Name
ABC	Aberdeen Creek
AHC	Almshouse Creek
BC1	Beards Creek 1
BC2	Beards Creek 2
BC3	Beards Creek 3
BC4	Beards Creek 4
BC5	Beards Creek 5
BD1	Broad Creek 1
BD2	Broad Creek 2
BD3	Broad Creek 3
BD4	Broad Creek 4
BD5	Broad Creek 5
BR1	Bacon Ridge Branch 1
BR2	Bacon Ridge Branch 2
BR3	Bacon Ridge Branch 3
BR4	Bacon Ridge Branch 4
BR5	Bacon Ridge Branch 5
BR6	Bacon Ridge Branch 6
BRW	Brewer Creek
CHR	Church Creek
CRB	Crab Creek
CTC	Cherrytree Cove
DVC	Duvall Creek
FC1	Flat Creek 1
FC2	Flat Creek 2
FC3	Flat Creek 3
FC4	Flat Creek 4
FC5	Flat Creek 5
GC1	Glebe Creek 1
GC2	Glebe Creek 2
GNC	Granville Creek
GVC	Gingerville Creek
HML	Hillsmere Lake
HNC	Harness Creek
LAC	Little Aberdeen Creek
LHC	Limehouse Cove
LMH	Limehouse Creek
LNP	Loden Pond
MCC	Maccubins Cove
NR1	North River 1
NR2	North River 2
NR3	North River 3
NR4	North River 4
NR5	North River 5
NR6	North River 6
RAM	Ramsey Lake
SEL	Selby Bay
SGB	Saint George Barber Mars
SO1	South River Tidal
SO2	South River Tidal
SP1	Sheppards Cove
SP2	Sheppards Cove
SP3	Sheppards Cove
SP4	Sheppards Cove
SPL	Spring Lake
SRJ	Chesapeake Bay
SU3	Chesapeake Bay
TNB	Tarnans Branch
WAT	Watergate Cove
WHC	Warehouse Creek



Anne Arundel County
Department of Public Works
Watershed and Ecosystem Services and Restoration
Watershed Assessment and Planning

ANNE ARUNDEL COUNTY MARYLAND

Date: September 2, 2008
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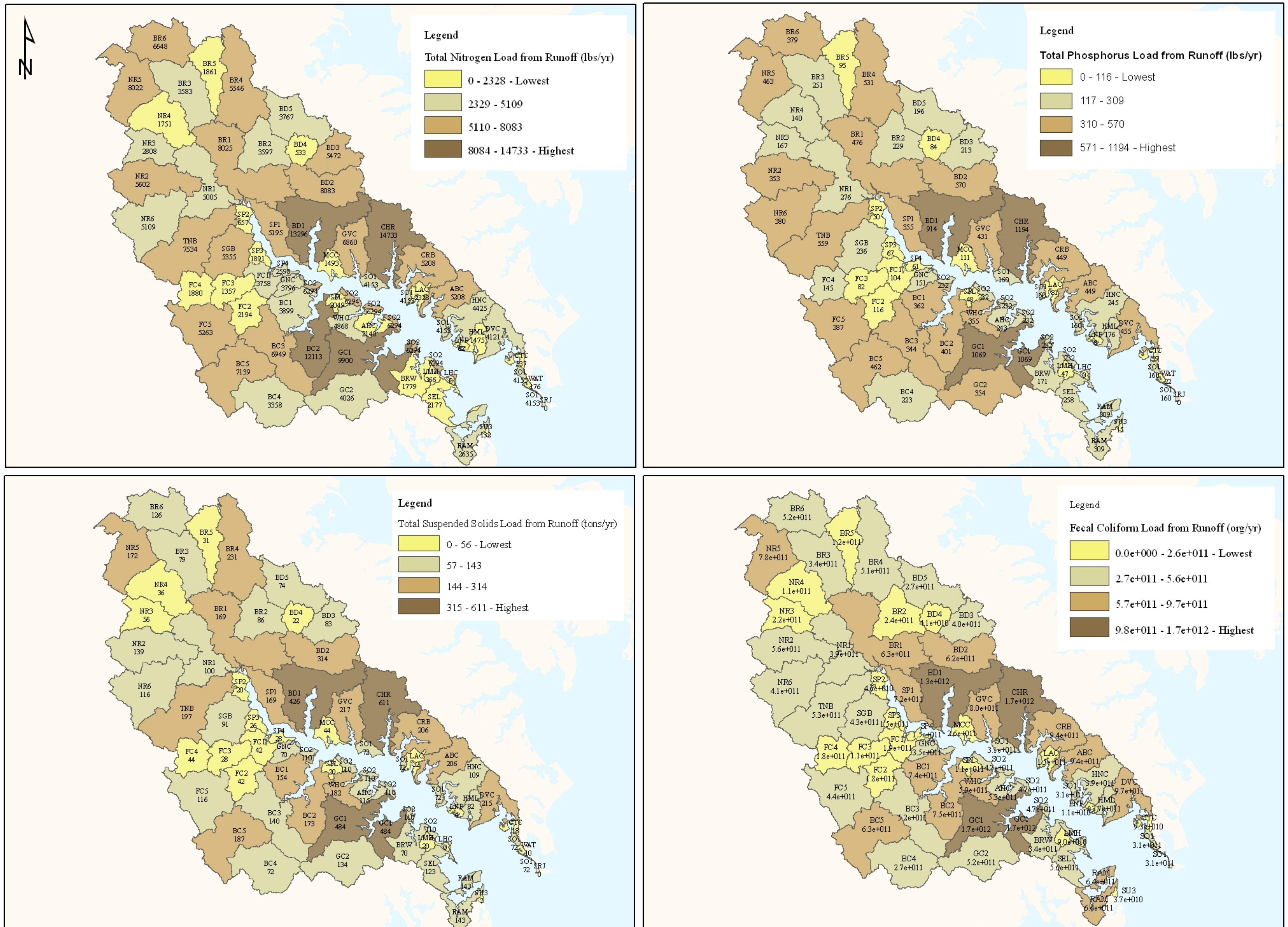
FIGURE 3-2
Summary Nutrient Loads for South River Watershed: Future Conditions

Shed Code	Subwatershed Name
ABC	Aberdeen Creek
AHC	Almshouse Creek
BC1	Beards Creek 1
BC2	Beards Creek 2
BC3	Beards Creek 3
BC4	Beards Creek 4
BC5	Beards Creek 5
BD1	Broad Creek 1
BD2	Broad Creek 2
BD3	Broad Creek 3
BD4	Broad Creek 4
BD5	Broad Creek 5
BR1	Bacon Ridge Branch 1
BR2	Bacon Ridge Branch 2
BR3	Bacon Ridge Branch 3
BR4	Bacon Ridge Branch 4
BR5	Bacon Ridge Branch 5
BR6	Bacon Ridge Branch 6
BRW	Brewer Creek
CHR	Church Creek
CRB	Crab Creek
CTC	Cherrytree Cove
DVC	Duvall Creek
FC1	Flat Creek 1
FC2	Flat Creek 2
FC3	Flat Creek 3
FC4	Flat Creek 4
FC5	Flat Creek 5
GC1	Glebe Creek 1
GC2	Glebe Creek 2
GNC	Granville Creek
GVC	Gingerville Creek
HML	Hillsmere Lake
HNC	Harness Creek
LAC	Little Aberdeen Creek
LHC	Limehouse Cove
LMH	Limehouse Creek
LNP	Loden Pond
MCC	Maccubins Cove
NR1	North River 1
NR2	North River 2
NR3	North River 3
NR4	North River 4
NR5	North River 5
NR6	North River 6
RAM	Ramsey Lake
SEL	Selby Bay
SGB	Saint George Barber Mars
SO1	South River Tidal
SO2	South River Tidal
SP1	Sheppards Cove
SP2	Sheppards Cove
SP3	Sheppards Cove
SP4	Sheppards Cove
SPL	Spring Lake
SRJ	Chesapeake Bay
SU3	Chesapeake Bay
TNB	Tarnans Branch
WAT	Watergate Cove
WHC	Warehouse Creek



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Date: September 2, 2008
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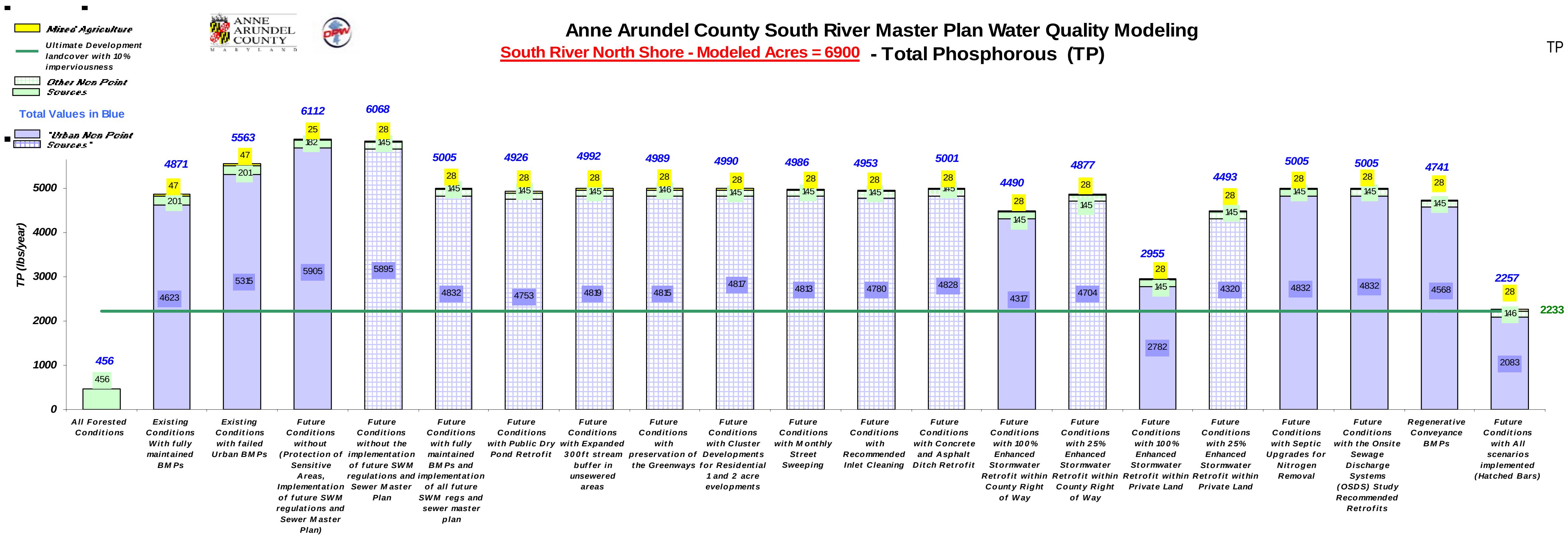
3.4 Modeling Results

In examining the overall South River watershed, four alternative scenarios are shown to provide the biggest impact to reducing pollutant loadings from urban sources. These scenarios are the enhanced stormwater controls, expanded stream buffer, greenways, and regenerative conveyance. While these scenarios show the biggest impact if implemented fully across the watershed, it is important to note that other types of BMPs might be more appropriate for or have a bigger impact on the loading of an individual subwatershed. These factors, as well as others such as cost benefit analysis, will impact the final decision on which scenario to implement in an individual subwatershed. The water quality model allows for this analysis at the subwatershed level in order to make the appropriate local decisions.

TN and TP modeling results by cluster are shown for three areas within the watershed in Figures 3-3 through 3-5. These figures show the incremental effects of each alternative scenario.

FIGURE 3-3
TP and TN Modeling Results for
the North Shore Area



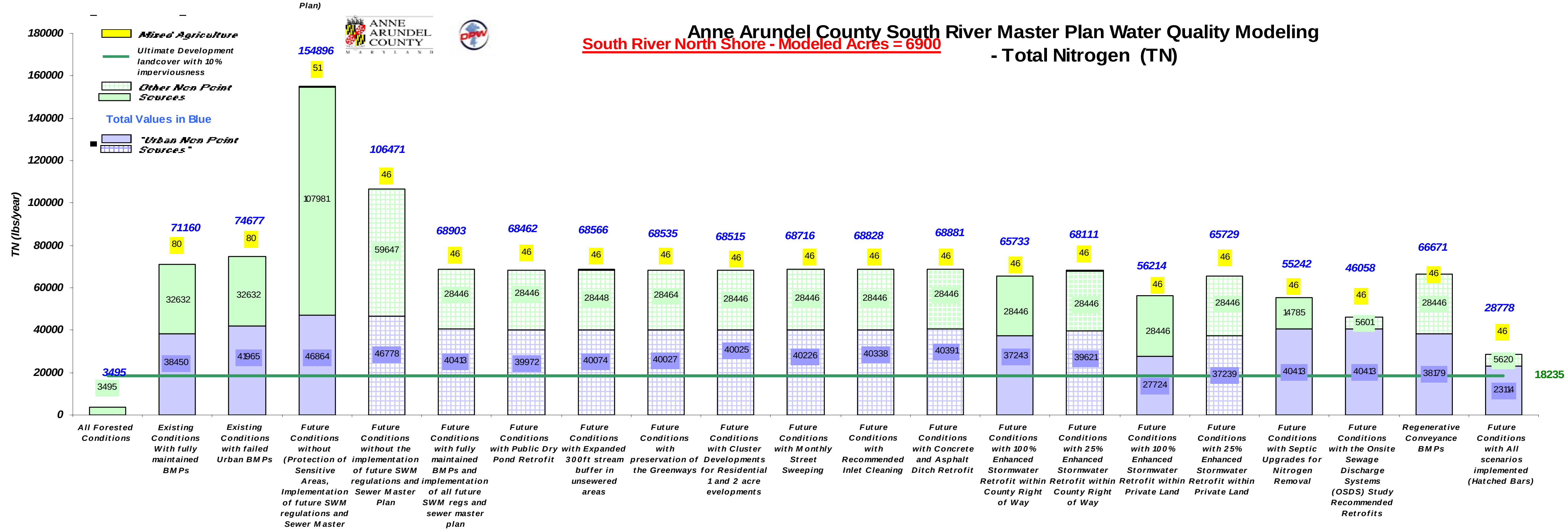
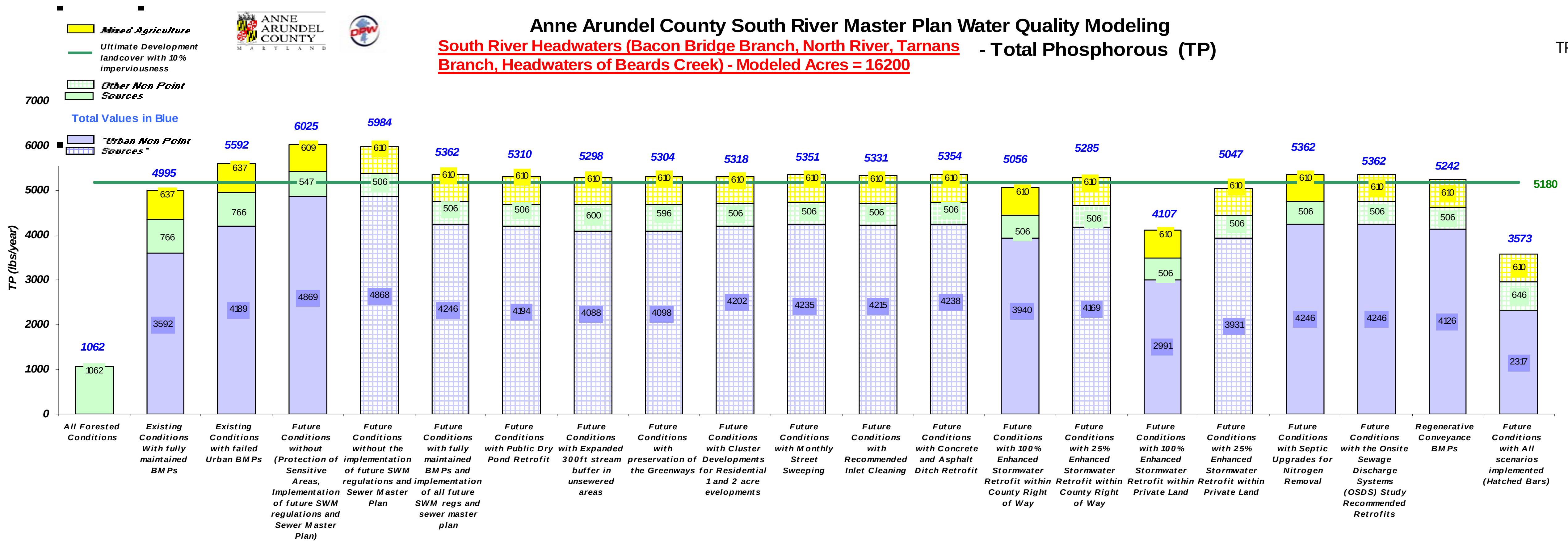


FIGURE 3-4
TP and TN Modeling Results for
the Headwaters Area



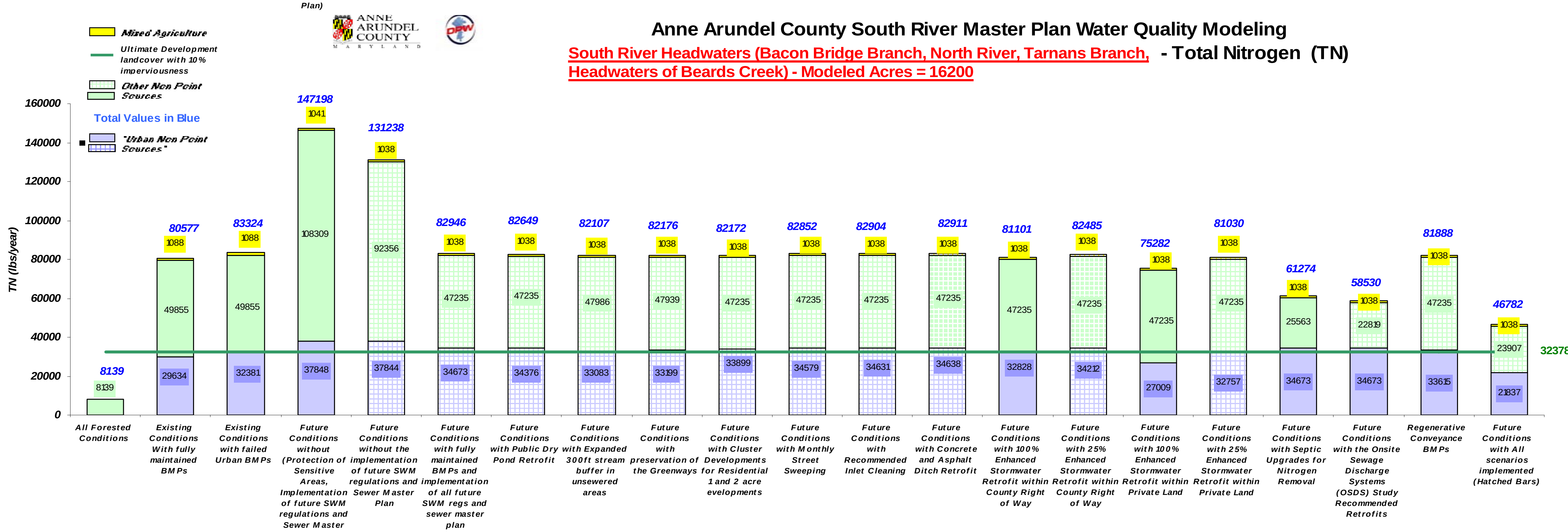
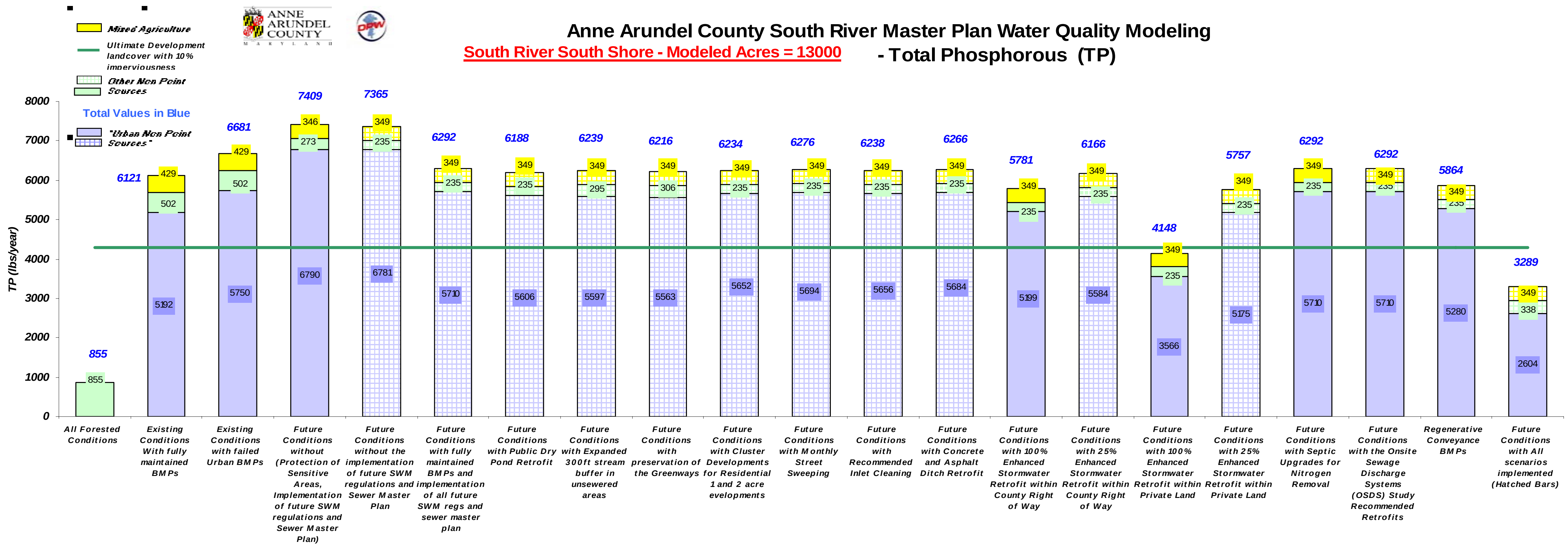
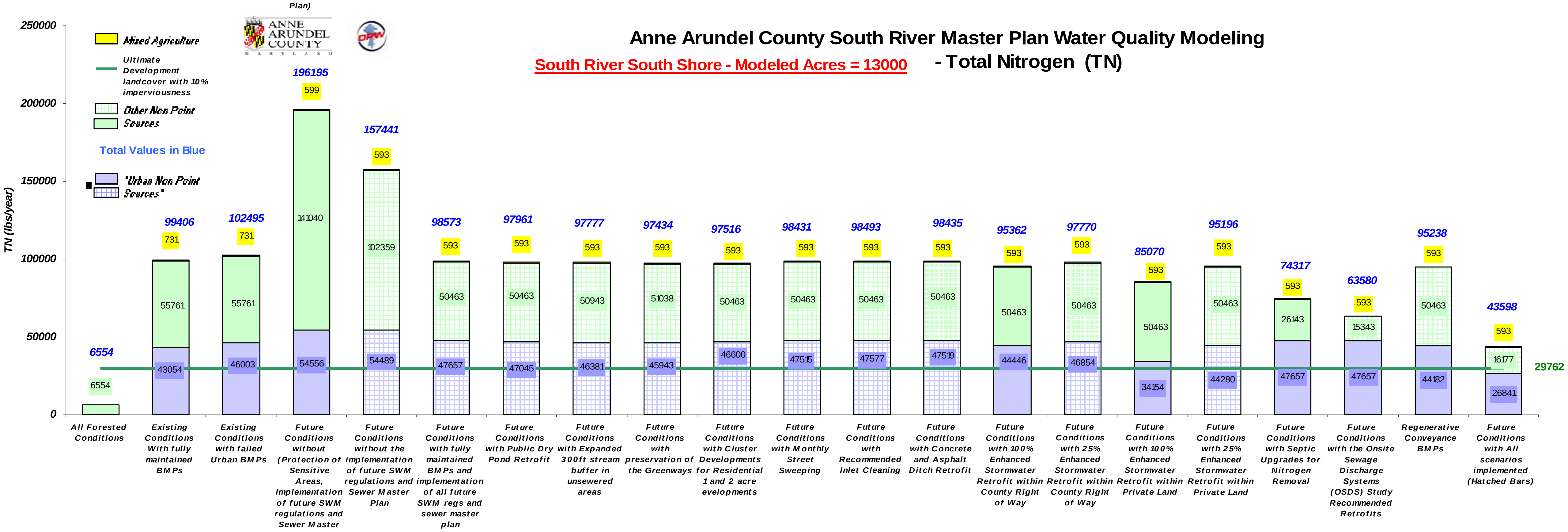


FIGURE 3-5
TP and TN Modeling Results for the South Shore Area





SECTION 4

Analysis of Data and Management Decisions

The next step in watershed management and implementation planning for the South River is to examine the data in light of County and watershed goals and to provide a framework to achieve those goals.

Currently, there are no direct goals for the overall stream health of the South River. The regulatory issues discussed in Section 4.1 describe approaches to remediate fecal coliform impairments for shellfish harvesting and nutrient and sediment reductions to reduce impairments in tidal waters and the Chesapeake Bay. Goals are discussed in more detail in Section 4.2.

In addition to aiding to meet the watershed goals, the prioritization described in Section 4.3 is also guided by a need for the County to plan its expenditure of funds. While the prioritization for watershed restoration can guide funding decisions, it is not the only element in the process. For instance, although septic fixes and upgrades may be a very beneficial BMP for the South River watershed, funding for them could come from the Maryland "flush tax" and not from the County capital improvement program. Therefore, septic issues do not need to be explicitly included in any ranking because they will get funded elsewhere.

4.1 Regulatory Issues

There are several regulatory requirements that have an impact on managing water resources in the South River watershed. These range from federally mandated programs, to interstate and state-level issues, to changes in local ordinances.

4.1.1 NPDES

Section 402(p) of the Clean Water Act requires EPA to add Municipal Separate Storm Sewer System (MS4) discharges to the NPDES permit program. The resulting permits govern discharges from all storm drains owned and operated by local governments. The MS4 permit is not a comprehensive non-point-source (NPS) pollution control approach, since it regulates only the types of pollutants that discharge through a storm drain.

Anne Arundel County's NPDES permit requires the County to retrofit stormwater treatment for 10 percent of the County's untreated impervious area during every 5-year permit cycle. From an implementation standpoint, this will bring a higher priority to projects and programs that deal with older developed areas the in South River watershed.

The permit also requires the County to inspect storm drain outfalls for dry weather illicit discharges and where identified to correct them. This program will help improve watershed conditions by finding improper cross-connections between sanitary and storm drain systems, or identifying evidence of long-term dumping or spills and allowing these sources to be removed.

4.1.2 Total Maximum Daily Loads

Total maximum daily loads (TMDLs) are a requirement of the Clean Water Act, which calls on each state to list its impaired water bodies (303(d) list) and develop a plan to reduce the pollutant load. For each combination of water body and pollutant, a state must estimate the maximum allowable pollutant load, or TMDL, that the water body can receive and still meet water quality standards.

MDE has been designated regulatory authority by the EPA for TMDLs in Maryland. MDE's TMDL summary for South River is as follows:[1]

> South River (basin number 02-13-10-03) was first identified on the 1996 303(d) List submitted to U.S. Environmental Protection Agency (EPA) by the Maryland Department of the Environment (MDE) as impaired by nutrients, sediments, and fecal coliform, with listings of biological impacts in specified non-tidal portions added in 2002 and 2004, and a listing of PCB impairment in fish tissue added in 2002 for the tidal portion. On the 2004 303(d) List, the fecal coliform impairment was clarified with the identification of four specific restricted shellfish harvesting areas within the basin. The document available below addresses the fecal coliform impairment listings of the areas identified: South River; Duvall Creek; Selby Bay; and Ramsey Lake. The nutrient, sediment, biological, and toxic impairments within the South River basin will be addressed at a future date.

The Final TMDL states that there are no NPDES-permitted discharges in South River, so that the fecal coliform impairment is entirely from nonpoint sources, primarily pets (53.6 percent) and livestock (29.9 percent), which was determined from modeling efforts. As an implementation plan is developed, the County will be required to target and develop BMPs to remediate the sources. These could include agricultural and livestock conservation practices, marina and boating practices, including sewage handling, and education and outreach for pet waste management.

4.1.3 Chesapeake 2000 Agreement

The Chesapeake 2000 agreement was adopted by the Chesapeake Bay Program partners in June 2000. It calls for watershed planning in the region as follows:[2]

> By 2010…develop and implement locally supported watershed management plans in two-thirds of the Bay watershed covered by this Agreement. These plans would address the protection, conservation, and restoration of stream corridors, riparian forest buffers and wetlands for the purposes of improving habitat and water quality, with collateral benefits for optimizing stream flow and water supply.

The South River Watershed Management Plan meets the description of the watershed management plan described above and will fulfill part of Anne Arundel County's obligation under this agreement.

[1] http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/TMDL_final_southriver_fc.asp.

[2] http://www.chesapeakebay.net/pubs/chesapeake2000agreement.pdf, p. 4.

4.1.4 Baywide Tributary Strategies

Tributary strategies are improvement strategies that detail the specific actions needed to reduce the amount of nutrients and sediment flowing into the Chesapeake Bay, from both point and nonpoint sources. Pollutant reduction goals were set for the entire watershed by the Bay states in 2003, with annual allocations for nitrogen, phosphorus, and sediment. The allocations were further subdivided into nine major river basins, and then allocated to each Bay state.

South River falls under the responsibility of the Lower Western Shore Tributary Team. A series of improvement measures has been undertaken. Regarding point sources in the Lower Western Shore, as of 2005, five of seven wastewater facilities have active biological nutrient removal (BNR) technology, and the rest will be updated by 2010. These facilities are all located outside the South River watershed.

To help reduce non-point-source loads, a series of BMPs have been planned. As of 2004, tributary strategy goals had been met for agricultural practices such as nutrient management plans and tree planting (agriculture) and urban erosion and sediment control.

However, as of 2004, implementation of urban BMPs, notably those dealing with stormwater management, had not been as successful. Implementation of the urban stormwater retrofits proposed in the South River Watershed Management Plan would help meet these goals.[3]

4.1.5 Maryland House Bill 1141

In 2006, the Maryland General Assembly added new requirements for local comprehensive plans to incorporate the effects of proposed land use on streams and wetlands, forest and agricultural conservation lands, water supplies and water quality to avoid negative impacts to our natural resources.

The bill added a water-resources-planning element to ensure that existing and future development would be adequately served with

- Drinking water supplies
- Areas to meet stormwater management
- Wastewater treatment and disposal

It is anticipated that the South River Watershed Management Plan will provide data and information which the County can use to develop its water-resources-planning element required by HB 1141.[4]

4.2 Watershed Goals

As mentioned previously, there are currently no published regulatory goals for the overall stream health of the South River. The previous section describes the regulatory framework the County is under. There is currently no TMDL levied by the EPA on the South River. There is, however, a goal within the County's 5-year NPDES permit to achieve a 10 percent

[3] http://www.chesapeakebay.net/wqctributarytech.htm.

[4] http://www.mde.state.md.us/ResearchCenter/Publications/General/eMDE/vol2no2/growth.asp.

reduction of imperviousness (or to treat an additional 10 percent of imperviousness currently untreated by BMPs). In addition, the County recognizes the value of the work that the Center for Watershed Protection (1998) published regarding the amount of imperviousness in a watershed and its impact on stream health. In accordance with that work, a goal of less than 10 percent imperviousness within a subwatershed is an internal goal when possible but it is not enforceable under current County regulations. These are the goals that will guide the County in making future watershed decisions and capital improvement projects.

The regulatory goals discussed in Section 4.1 describe approaches to remediate fecal coliform impairments for shellfish harvesting and nutrient and sediment reductions to reduce impairments in tidal waters and the Chesapeake Bay. These and other water quality goals are fairly straightforward: sources can be identified and remediated, and water quality improvements can be measured over time.

In the case of biological impairments, goal-setting is less certain. Research is still needed to determine what watershed conditions lead to a healthy biological community. The most frequently referenced work is from the Center for Watershed Protection, which identified thresholds of 10, 25, and 40 percent imperviousness where streams were degraded or stressed. Imperviousness, however, is not the only watershed variable affecting stream health. Booth et al. (2004) showed that urbanization does not affect all streams identically. The location of imperviousness within a watershed can be as important as the amount. Their paper showed a correlation between the flashiness of urban streams and biological condition.

Targets should also take into account existing conditions. It is possible to set goals consistent with a basinwide target such as the tributary strategy goal of 0.28 lbs/ac/yr for phosphorus, or replicating forested conditions for stream flow or pollutant loads. These goals would protect ecosystems, but reductions to this degree from a built-out community are at the technical limit of stormwater retrofits currently available.

Other approaches to a phosphorus goal that could be considered include loading the equivalent of a 10 percent reduction in impervious area, or loads equivalent to 25 percent imperviousness. In any case, it would be best to keep the watershed goals simple; for example, improving base flow, reducing flashiness, and reducing phosphorus loads. Current levels of these targets can be measured with relatively simple monitoring efforts, and they can also be forecasted with models.

4.3 Professional Management Team

The Watershed and Ecosystem Services and Restoration Department of Anne Arundel County performed the hydrologic, hydraulic, water quality, and statistical models in order to identify problem areas and make recommendations for environmentally sound management of the land. The County also formed a Professional Management Team (PMT) made up of key members from their department and others in the county as well as technical experts from CH2M HILL and KCI Technologies to peer review the work. Specifically, the PMT was asked for their professional input, assessment, and other expertise as it related to watershed management planning, assessment, modeling, and BMP implementation. Group decisions made during various aspects of the project have been documented in this report. The PMT and the information contained in this report is not an implementation plan but it includes the guidance and background that the County needs in order to move forward with a detailed implementation plan. All meeting minutes from this team have been included in Appendix D.

4.4 Prioritization and Ranking

The problem area prioritization and ranking task is one of the first steps in integrating historical environmental data, stream assessment monitoring, and watershed-modeling results to begin identifying problems and determine which are the most significant. The purpose of this task is to determine which subwatersheds and stream reaches are most in need of restoration or protection and serve as a guide to future project implementation to make improvements and satisfy the County's goals.

The prioritization effort involved three separate models:

- Stream reach restoration
- Subwatershed restoration
- Subwatershed preservation

The County's prioritization models were initially developed during the Severn River Watershed Management Master Plan Project. Details on the procedures of the models and input information is described by Anne Arundel County (2006, Appendix B). The County began the modeling process for the South River by reviewing the previously developed prioritization models and making appropriate adjustments and changes as necessary. These changes were reviewed with and agreed upon by the full PMT. Full descriptions of each indicator are given by Anne Arundel County (2006). Descriptions of the changes to the models and ultimate results are in the following sections.

The stream restoration prioritization model is guided by the County's need to plan its expenditure of funds. This model will provide the County a plan of where they should direct their stream restoration funds.

In addition, the subwatershed restoration prioritization can be used for stormwater management and other capital project purposes. The overall ranking directs the County to the areas where efforts and funds should be focused. The individual indicators may help direct a particular strategy needed. The weightings of each indicator and each category of indicators reflect the priorities of the County.

4.4.1 Stream Prioritization and Ranking

Stream Reach Indicator Details

The prioritization model includes only stream reaches that have an MPHI score and therefore excludes intermittent and ephemeral channels. This provides the County with a tool for looking at all the worst cases, where all parameters of interest intersect for capital improvement program (CIP) prioritization. It was decided that for individual parameters, the source of data would be the stream assessment tool (SAT). For instance, if a group were interested in doing a stream cleanup, the data they would receive would come directly from the SAT and could include streams potentially with or without MPHI scores.

Buffer and erosion raw value scores are now calculated slightly differently than in previous studies to recognize that buffer and erosion occur along both sides of the stream. For emergency road crossings, it was decided that only reaches that met the isolate criteria would be included.

All inventory indicators were segregated using natural breaks (instead of using quartiles)—this allows the County to better understand how to improve a particular point from one category to the next. The PMT suggested that when more data are gathered across multiple watersheds, it might be possible and useful for the County to establish absolute values of what is "good" or "bad" for different inventory points rather than use a natural-breaks segregation scheme.

It was decided that the head cuts inventory points would not be normalized based on reach length because a bad head cut can have a detrimental effect on the stream reach, regardless of how long or short that stream segment may be. Similarly, it was decided that dumpsite inventory points would not be normalized based on reach length.

Two additional indicators were added to the stream reach prioritization tool: the land cover (measured by the amount of imperviousness in the drainage area to a particular stream reach) and stream morphology (measured by the Rosgen Level I scores for each reach). For imperviousness, the raw values of the stream reaches were grouped according to the Center for Watershed Protection's threshold categories on imperviousness versus stream health. For the Rosgen Level I indicator, it was agreed by the PMT that channel types F and G would receive the lowest score (1) while all other types of channels would receive the highest (10).

Adding two new indicators forced the team to reduce the existing indicator category weights. The final indicator category weights are as follows:

- MPHI, 30
- Stream morphology, 5
- Imperviousness, 5
- Infrastructure, 40
- Road crossings, 10

The PMT decided to reduce the MPHI category weighting, recognizing that stream restoration projects are typically performed for the stability of the stream, nearby utilities, structures in danger, etc., and not for habitat reasons.

Although the stream prioritization model takes in specific indicator information in order to provide a final ranking of streams, the County has data available through the SAT and through other sources that could aid in final project decisions. For example, stream order could be used as a last step to look at the larger context of the prioritization and could help DPW in making capital project decisions. The restoration potential of an inventory point was captured during the stream assessment efforts. This information could also be used during final project decisions but would not be included in the prioritization.

Stream Prioritization Results

The final stream prioritization model was provided to the CH2M HILL and KCI field teams for review. This quality control assessment provided an evaluation of whether the rankings matched what the field teams saw while performing the field work—essentially, it provided a "reality check" on the data. The field teams found that the South River stream reach prioritization model matched well with field recollections and recommended that this prioritization model be adopted by the County.

The final ranking was also shared with the South River Federation to see if it aligned with what they knew of the streams. In most cases, the ranking did compare well. However, as a further way of prioritizing capital expenditures, it was decided that the County would link the stream and subwatershed prioritizations (described in Section 4.4) and so focus its efforts on streams in the worst condition in subwatersheds in the worst condition. The PMT agreed with this path forward but also recommended that the County continue to keep the worst-condition streams in the best-condition subwatersheds in the forefront. These streams may have a very localized problem today, but fixing or stopping the problem could help ensure that additional streams do not become poor-condition streams and ultimately turn the subwatershed into a poor-condition one.

The overall results of the prioritization model are included in the cluster fact sheets, in Appendix A. The fact sheets also show the weights of each indicator of the model.

4.4.2 Subwatershed Restoration Ranking

Subwatershed Restoration Indicator Details

The previous prioritization model considered water quantity indicators (peak flows and runoff volume for the 1- and 2-year storms) as a departure from the undeveloped conditions. It was decided by the PMT that the actual current values (normalized by subwatershed area) would be used in the model moving forward.

TN and TP are the only parameters considered in the water quality category. These results are measured in pounds per acre. The source is the County's water quality model's (discussed in Section 3) existing conditions without BMPs or septic loads.

The BMP treatment indicator is essentially a measure of the percentage of impervious area treated in a subwatershed. Some additional work was performed to cap the percentage at 100 percent (i.e., if the BMPs' drainage area in the subwatershed is greater than the impervious area, assume that there is 100 percent treatment) and to assume that if there is no impervious acreage in a subwatershed, then the treatment is 100 percent.

The amount of forested stream buffer was calculated using a 100-foot buffer (50 feet on each side).

Previously, information regarding critical area was calculated by the following: (LDA + IDA)/total critical area. It was decided that this percentage was not as important as the total amount of LDA and IDA, so this calculation was changed to the simple addition of the two areas.

Two additional indicators were added to the subwatershed restoration prioritization tool: the septic load (measured by the number of septic systems per acre of subwatershed and divided by natural breaks) and TMDL listing (measured by the number of TMDL impairments in the watershed). The TMDL listing would be useful only for comparison at the County level since TMDL impairments are assigned at the watershed level, not at the subwatershed level.

Subwatershed Restoration Prioritization Results

The final ranking was also shared with the South River Federation to see if it aligned with what they knew of the subwatersheds. The South River Federation qualitatively compared these rankings to their score cards and especially to the snapshot, which is a sampling event performed in the watershed by volunteers sampling for a variety of different water quality parameters. The South River score card consists of 10 parameters representing the overall health of the South River watershed, but not relying solely on water quality. The ranking results from the subwatershed restoration model aligned well with the South River Federation's score card and snapshot.

The overall results of the prioritization model are included in the cluster fact sheets in Appendix A. The fact sheets also show the weights of each indicator of the model.

4.4.3 Subwatershed Preservation Ranking

Several additional indicators have been added to the subwatershed preservation tool: the soil erodability factor (measured by the average NRCS *K* factor and segregated by natural breaks) and water quality indicators for TN and TP (measured by the departure of future conditions from the existing conditions and segregated by natural breaks). The impervious cover change indicator was deleted from the model.

Unlike the stream reach prioritization and the subwatershed restoration prioritization models, the subwatershed preservation prioritization model does not relate to expenditure of fund or ranking of potential projects. This model provides the County guidance on future land use decision making and future regulations. It will prove useful in the long term and can be utilized when examining the land use plan and general development plan or when handling requests for rezoning or zoning amendments. The model results will provide information so that they do not make decisions that could undermine the high quality that a subwatershed has currently.

The overall results of the prioritization model are included in the cluster fact sheets in Appendix A. The fact sheets also show the weights of each indicator of the model.

4.4.4 Synthesis of the Prioritization Models

An implementation plan for the South River watershed would include a closer examination of the three prioritization models before any particular projects were undertaken or any subwatersheds were worked in. It is in those steps that localized problems and individual indicators may become more important. For instance, as mentioned in Section 4.4.1, although the overall path is for the worst-condition streams in the worst-condition subwatersheds to be high priorities, the County will continue to keep the worst-condition streams in the best-condition subwatersheds in the forefront. Also, individual indicators may be examined in more detail to determine an appropriate implementation plan. For instance, if a "worst condition" stream is in a "worst condition" subwatershed but the individual impervious area treated indicator is actually in good condition, then the implementation plan may focus on stream restoration techniques rather than on stormwater runoff controls.

These models are very useful tools to move the County towards a healthier watershed and to help it meet its goals. Not only do the results of the model provide an overall path forward, but each indicator and combination of factors provides insight into potential project specifics.

SECTION 5
Future Studies

5.1 Bacteria Source Tracking

MDE, in support of the implementation of the shellfish bacteria TMDL, will be conducting a 1-year bacteria source tracking study for South River. Details of the study are not yet available. It is recommended that County staff be involved in the study as stakeholders to provide independent review of the procedure and results.

5.2 Wet Weather Monitoring

Storm sampling at one storm drain outfall and at an in-stream location below the outfall has been an element of the County's MS4 NPDES for many years. In the intervening time, the County has begun implementing innovative treatment systems, among them regenerative conveyance. It is recommended that the County meet with MDE to discuss changing its monitoring site to take samples upstream and downstream of the treatment system and begin collecting data on its effectiveness.

SECTION 6

Recommendations and Next Steps, Implementation Framework

The field assessment, modeling, and prioritization tasks provided the initial information needed to begin the process of formulating an implementation plan for the South River watershed and its individual subwatersheds. The next major steps include looking at the modeling results relative to the County's goals, understanding the cost–benefit of each practice, and identifying individual projects and developing concept plans for those projects.

Four practices were identified during the modeling as having the best pollutant removal results across the watershed:

- Enhanced stormwater controls
- Expanded stream buffers
- Greenways
- Regenerative conveyance

These practices need to be developed further into an implementation plan showing specific projects with costs, estimated benefits, an understanding of the relative ease of implementation of the individual BMP, and a schedule for completion.

6.1 Modeling Results

The County's water quality model was presented and detailed in Section 3. This model also allows the analysis of the various alternative scenarios and their pollutant-loading reductions relative to the County's watershed goals. Modeling is the tool the County needs to develop an understanding of complex watershed processes and forecast the impacts of future conditions or potential improvements.

Figure 6-1 shows the pollutant load results for TP and TN. The orange line shows what loading the South River will need to achieve in order to meet the County's NPDES requirement of reducing untreated imperviousness by 10 percent. This was calculated by assuming 10 percent of the existing load. The green line reflects setting the imperviousness in the study area to 10 percent (recommendation on aquatic health from the Center for Watershed Protection, although not enforceable in the County now).

All opportunities for projects in each alternative scenario are included in the model results. Individual projects in each subwatershed still need to be identified—in processes similar to those described in Section 6.1.3.

6.2 Cost–Benefit Analysis

In order to understand the impact of a particular scenario and to prioritize them across the watershed, it is important to not just know the pollutant loading of a scenario but also the cost. The objective is to provide evaluation criteria that should allow alternatives to be compared economically on the basis of a cost–benefit ratio. Table 6-1 reflects this information. As shown, the higher the number in the last column, the more cost effective it is to reduce the pollutant loading.

These results show that it is twice as cost effective to reduce pollutant loads by enhanced stormwater retrofits on private lands as it is on public lands. Data like this aids in the decision process of choosing the appropriate alternative and then particular project for a subwatershed.

TABLE 6-1
Cost–Benefit Analysis Results

Alternative Scenario	Reduction in TP + TN (lbs/yr)	Retrofit Cost ($)	Pounds Removed per $1,000 Spent
OSDS-recommended septic retrofit strategy	82,254	5,481,199	15.01
Dry pond retrofit	1,585	1,500,000	1.06
Street sweeping	469	1,160,400	0.40
Regenerative storm conveyance BMPs	7,438	20,900,000	0.36
100% enhanced stormwater retrofit in private lands	39,305	177,374,900	0.22
Concrete/asphalt ditch retrofit	233	1,410,600	0.17
100% enhanced stormwater retrofit in public lands	9,558	98,809,100	0.10
Greenway master plan preservation	2,427	114,867,300	0.02
Expanded 300-foot stream buffer in unsewered areas	2,102	102,082,800	0.02

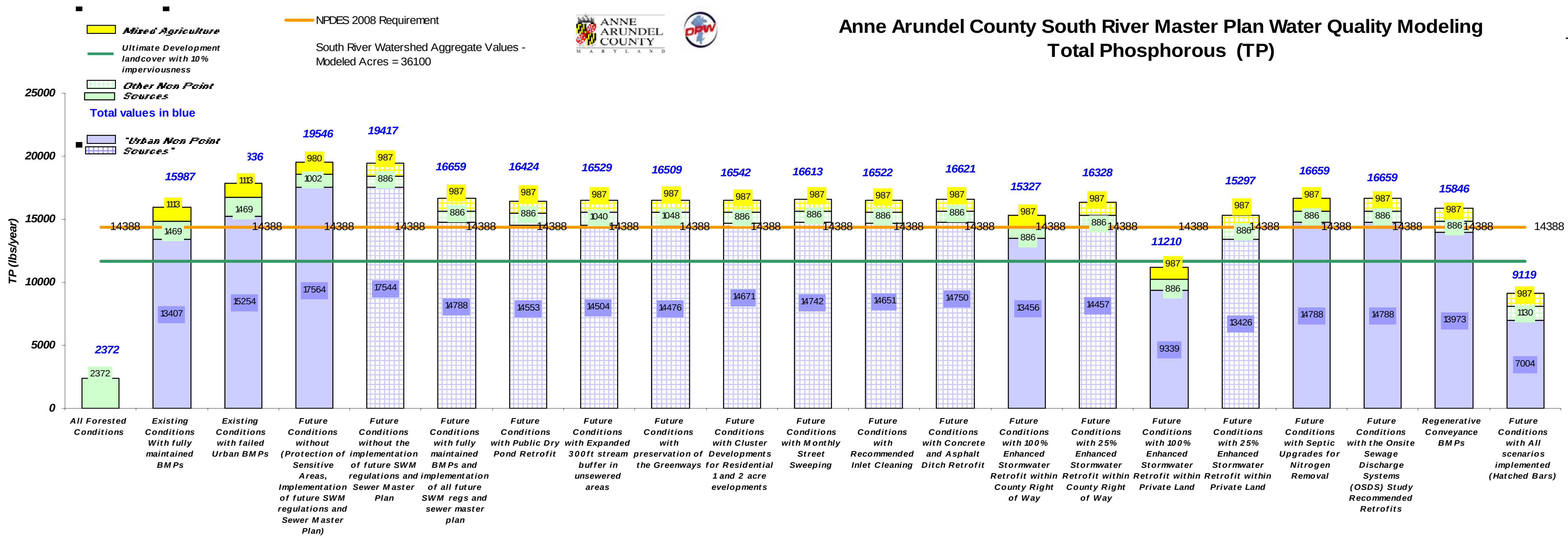
6.3 Concept Plans

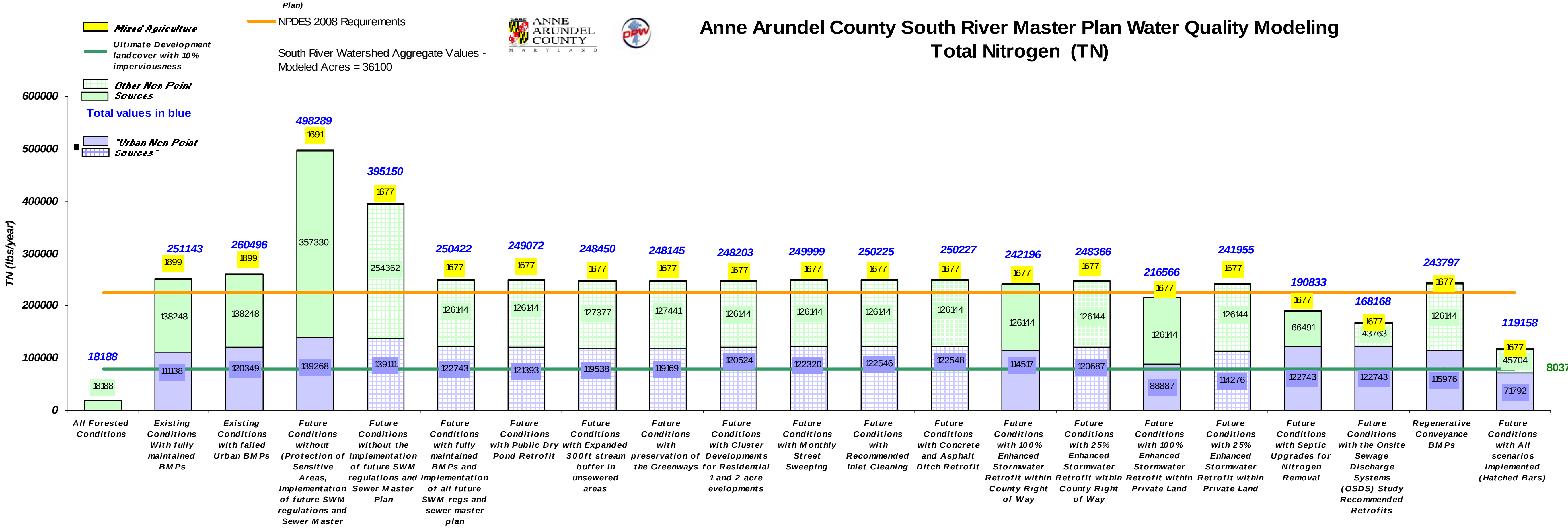
In order to further develop the scenarios into potential sites for projects which can be implemented, several additional steps are required. These steps are described for two of the scenarios in the following sections.

6.3.1 Stormwater Retrofit Sites

The first step in identifying potential retrofit sites is analysis using the GIS coverages prepared as part of this watershed plan. The procedure identifies specific areas in the watershed where retrofits are feasible and effective.

FIGURE 6-1
TP and TN Modeling Results for the South River Watershed





1. Determine areas where retrofit is appropriate. For the initial analysis, it is assumed that any areas that have the different land use for existing and future conditions will be redeveloped. In this case, stormwater management improvements will be made during the redevelopment process, and retrofits will not be necessary. Areas where existing and future land use are the same are assumed to be suitable for retrofits. Additional detailed "rules" on development were coordinated with appropriate County planning staff and incorporated into the GIS layers developed for the water quality model. These layers should be used here. Overlay the areas for retrofit with a land use layer reflecting publicly owned versus privately owned land.

2. Identify higher priority potential sites. The restoration ranking integrated land use, monitoring data, and pollutant loading to show the highest priority areas for restoration.

3. Identify areas currently untreated by BMPs. This coverage will come from the restoration indicator "Percent Impervious Area Treated by BMPs." The current BMP coverage and area-treated percentage shows how well an area is treated by existing BMPs. Any catchment with a low percent treated is a good potential site for retrofit.

4. Overlay the coverages described above to find high-priority, untreated sites which will not be redeveloped. These will be the focus for stormwater retrofits.

5. Using aerial photography, property mapping, topography, and storm drain mapping, identify specific sites for potential retrofits. These can include the following:

   – Runoff reduction: Disconnecting impervious areas, reconstructing drainage systems with swales and filters, replacing lightly used parking areas with permeable pavement, retrofitting infiltration systems

   – Storage: Reconstructing older ponds to current WQv and Cpv standards, constructing underground vaults, culvert retrofits, or other small storage systems.

   – Onsite treatment: bioretention, swales, filters, rain gardens, or green roofs

6. Perform field assessments as part of this task to identify specific areas of concern that may be too detailed to be picked up through mapping or modeling, including constraints such as significant utility conflicts, potential hazards to adjacent residents, impacts from construction that might outweigh the benefits, and unusual design or construction issues.

6.3.2 Regenerative Conveyance Sites

For these sites, GIS coverages are analyzed to identify specific stream reaches where construction of a regenerative conveyance BMP may be feasible and effective. The exhibit following page 6-2 shows potential locations for regenerative conveyance, based on the methodology described below.

1. Overlay the high stream reach restoration sites that fall in high-priority restoration subwatersheds. This combined approach was discussed in Section 4.4.1.

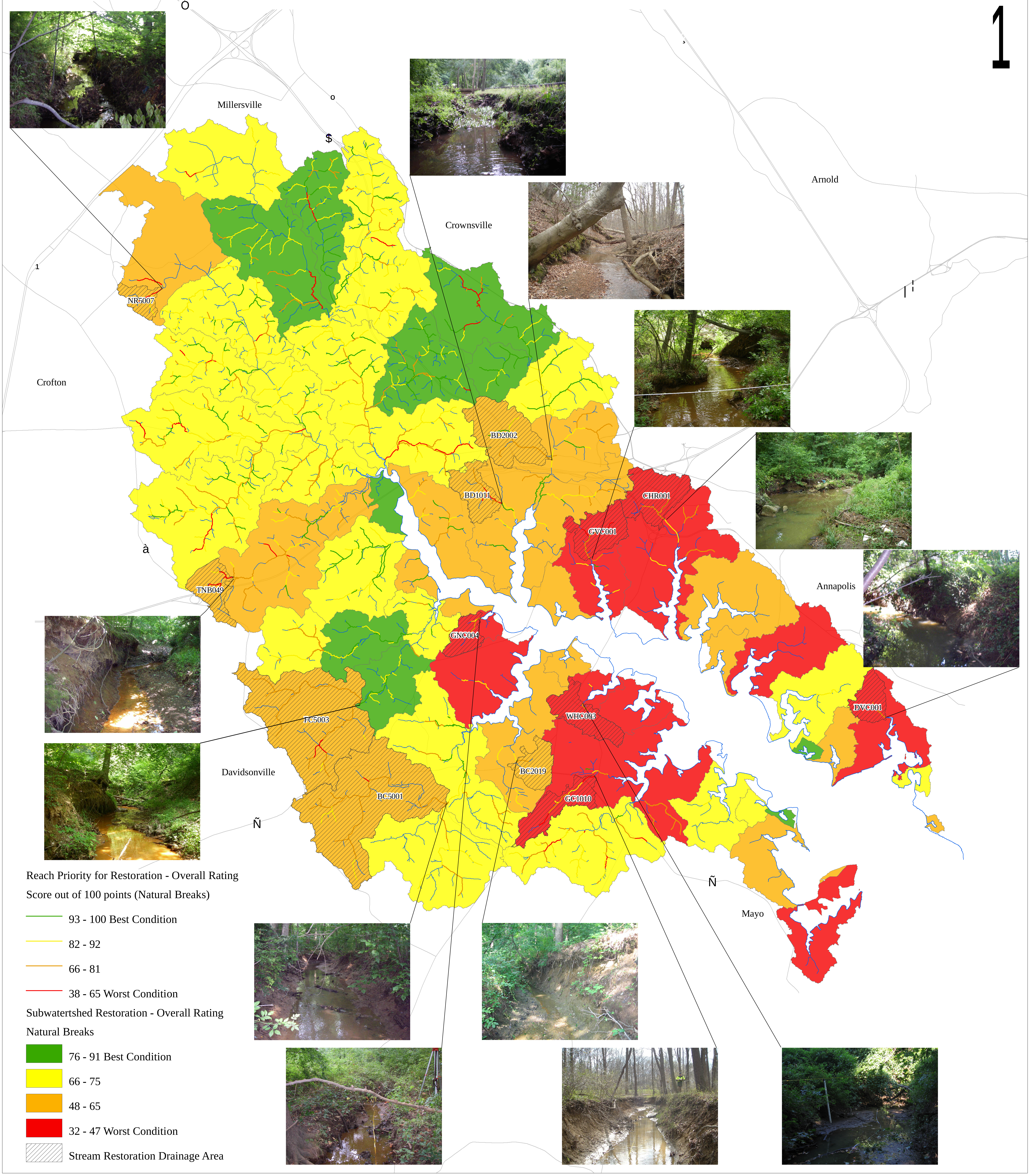
2. Identify high-priority stream restoration sites. The stream reach prioritization model combines and weights the assessment data collected in the field, to show which stream reaches were in the worst current condition. Individual indicators should be reviewed to

see if the cause of impairment can be remediated by reconstructing the reach as a regenerative conveyance. In particular, Rosgen F and G channels with poor MPHI assessment are better candidates.

3. Overlay the coverages described above to find high-priority sites for stream restoration. These will be the focus for regenerative conveyance retrofits.

4. Perform a field assessment of potential sites. Assessment is intended to assess the engineering and construction feasibility, environmental constraints, impacts to adjacent properties, and impacts from construction that could outweigh the benefits.

South River Watershed
Potential Instream Regenerative Conveyance
Stormwater Control Treatment Areas



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Map Production: Watershed Assessment and Planning

SECTION 7

References and Bibliography

Anne Arundel County. 2002. Severn River Watershed Management Master Plan Current Conditions Report, December 2002. Prepared by KCI Technologies, Inc. and CH2M HILL for Anne Arundel County Department of Public Works Watershed Management Program. Anne Arundel County, Maryland.

Anne Arundel County. 2006. Severn River Watershed Management Master Plan, Final Report. Prepared by KCI Technologies, Inc. and CH2M HILL for Anne Arundel County Department of Public Works Watershed Management Program. Anne Arundel County, Maryland.

Anne Arundel County. 2008. Onsite Sewage Disposal Systems: Evaluation Study and Strategic Plan, March 2008. Prepared by CH2M HILL, John E. Harms, Jr. & Associates, and Stearns and Wheeler LLC for Anne Arundel County Department of Public Works. Anne Arundel County, Maryland.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. *EPA 841-B-99-002*. U.S. Environmental Protection Agency, Office of Water; Washington D.C.

Booth, Derek B., et al., 2004. Reviving Urban Streams: Land Use, Hydrology, Biology, and Human Behavior. *Journal of the American Water Resources Association*. Vol. 40, no. 5. pp. 1351–1364.

Boward, D. and E. Friedman. 2000. Maryland Biological Stream Survey Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy. *CBWP-MANTA-EA-00-6.* Maryland Department of Natural Resources Monitoring and Non-Tidal Assessment Division. Annapolis.

Center for Watershed Protection. 1998. Better Site Design: A Handbook for Changing Development Rules in Your Community. Ellicott City, Md.

Cowan, W.L. 1956. Estimating Hydraulic Roughness Coefficients. *Agricultural Engineering*. Vol. 37, no.7. pp. 473–475.

EPA (U.S. Environmental Protection Agency). 2000. Ambient Water Quality Criteria Recommendations, Rivers and Streams in Nutrient Ecoregion IX. *EPA 822-B-00-019*. Office of Water and Office of Science and Technology, Health and Ecological Criteria Division. Washington D.C.

Harrelson, Cheryl C., C.L. Rawlins, and John P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. *Gen. Tech. Rep. RM-245*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colo. 61 pp.

Kazyak, P.F. 2001 Maryland Biological Stream Survey Sampling Manual. Maryland Department of Natural Resources Monitoring and Non-Tidal Assessment Division. Annapolis.

Maryland Department of the Environment. Code of Maryland Regulations (COMAR). Continuously updated. Code of Maryland Regulations, Title 26, Department of the Environment. 26.08.02.01—Water Quality.

Mecklenburg, D. 2004. The Reference Reach Spreadsheet for Channel Survey Data Management, version 4.0L. Ohio Department of Natural Resources.

Merritt, R.W., and K.W. Cummins. 1996. *An Introduction to the Aquatic Insects of North America*. 3rd ed. Kendall/Hunt Publishing.

Paul, M.J., J.B. Stribling, R.J. Klauda, P.F. Kazyak, M.T. Southerland, and N.E. Roth. 2003. A Physical Index for Freshwater Wadeable Streams in Maryland. July. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis.

Southerland, M.T., L. Erb, G.M. Rogers, R.P. Morgan, K. Eshelman, M.J. Kline, K. Kline, S.A. Stranko, P.F. Kazyak, J. Killian, J. Ladell, and J. Thompson. 2005a. *Maryland Biological Stream Survey, 2000–2004*. Volume 14: Stressors Affecting Maryland Streams. CBWP-MANTA-EA-05-11. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis.

Southerland, M.T., G.M. Rogers, M.J. Kline, R.P. Morgan, D.M. Boward, P.F. Kazyak, R.J. Klauda, S.A. Stranko. 2005b. New Biological Indicators to Better Assess the Condition of Maryland Streams. *DNR-12-0305-0100*. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis.

Stribling, J.B., E.W. Leppo, and C. Daley. 1999. Biological Assessment of the Streams and Watersheds of Prince George's County, Maryland. Spring Index Period 1999. *PGDER Report No 99-1*. Prince George's County, Department of Environmental Resources, Programs and Planning Division. Largo, Md.

Tetra Tech, Inc. 2004. Quality Assurance Project Plan for Anne Arundel County Biological Monitoring and Assessment Program. January 2004, Revision 1. Prepared for the Anne Arundel County Office of Environmental & Cultural Resources, Annapolis, Maryland.

Tetra Tech, Inc. 2005a. Sampling and Analysis Plan for Anne Arundel County Biological Monitoring and Assessment Program. January 2005. Prepared by Tetra Tech, Inc., Owings Mills, Maryland for the Anne Arundel County Office of Environmental & Cultural Resources, Annapolis, Maryland.

Tetra Tech, Inc. 2005b. Documentation of Method Performance Characteristics. April 2005. Prepared by Tetra Tech, Inc., Owings Mills, Maryland for the Anne Arundel County Office of Environmental & Cultural Resources, Annapolis, Maryland.

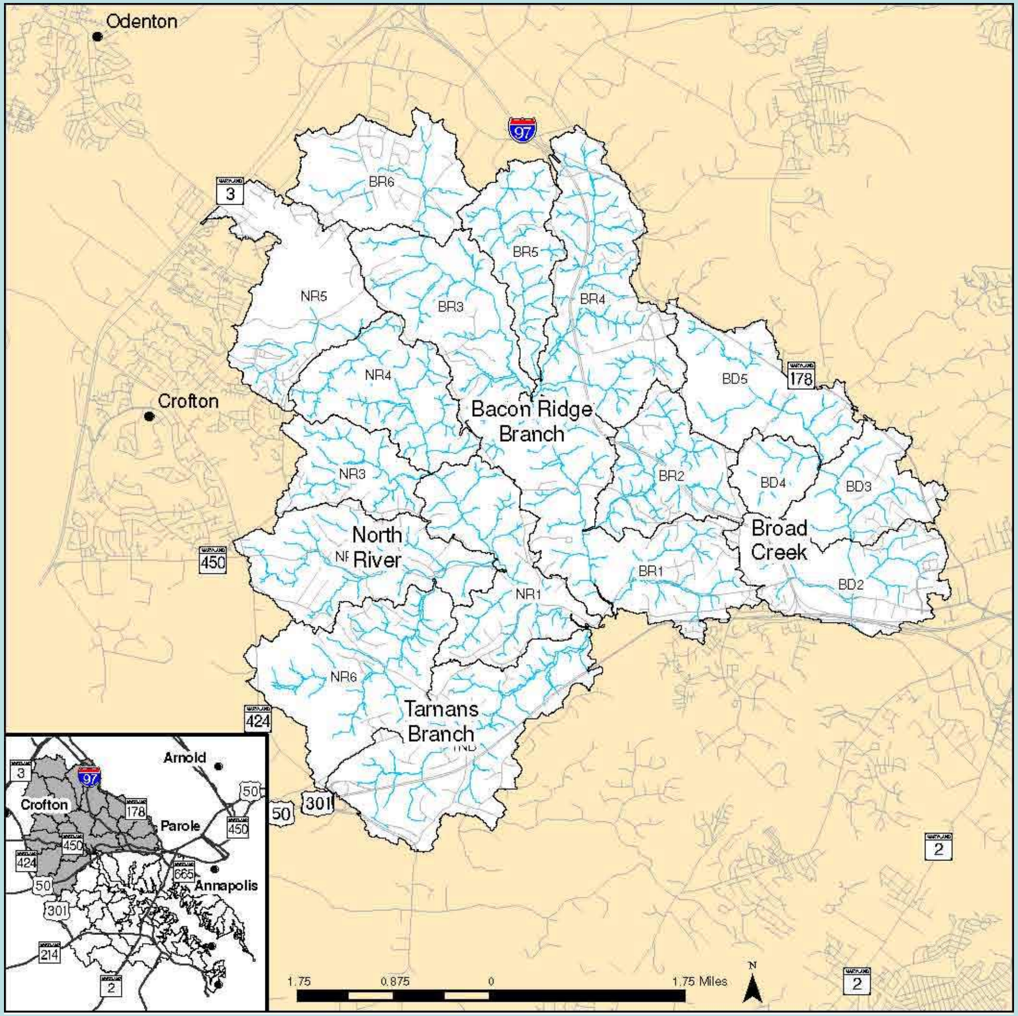
Tetra Tech, Inc. 2006. Random Subsample Routine. Developed by Eric W. Leppo.

USDA (U.S. Department of Agriculture). 1996. *National Engineering Handbook.* Part 651. Agricultural Waste Management Field Handbook. Soil Conservation Service.

Appendix A
Fact Sheets

South River Watershed: Headwaters Cluster

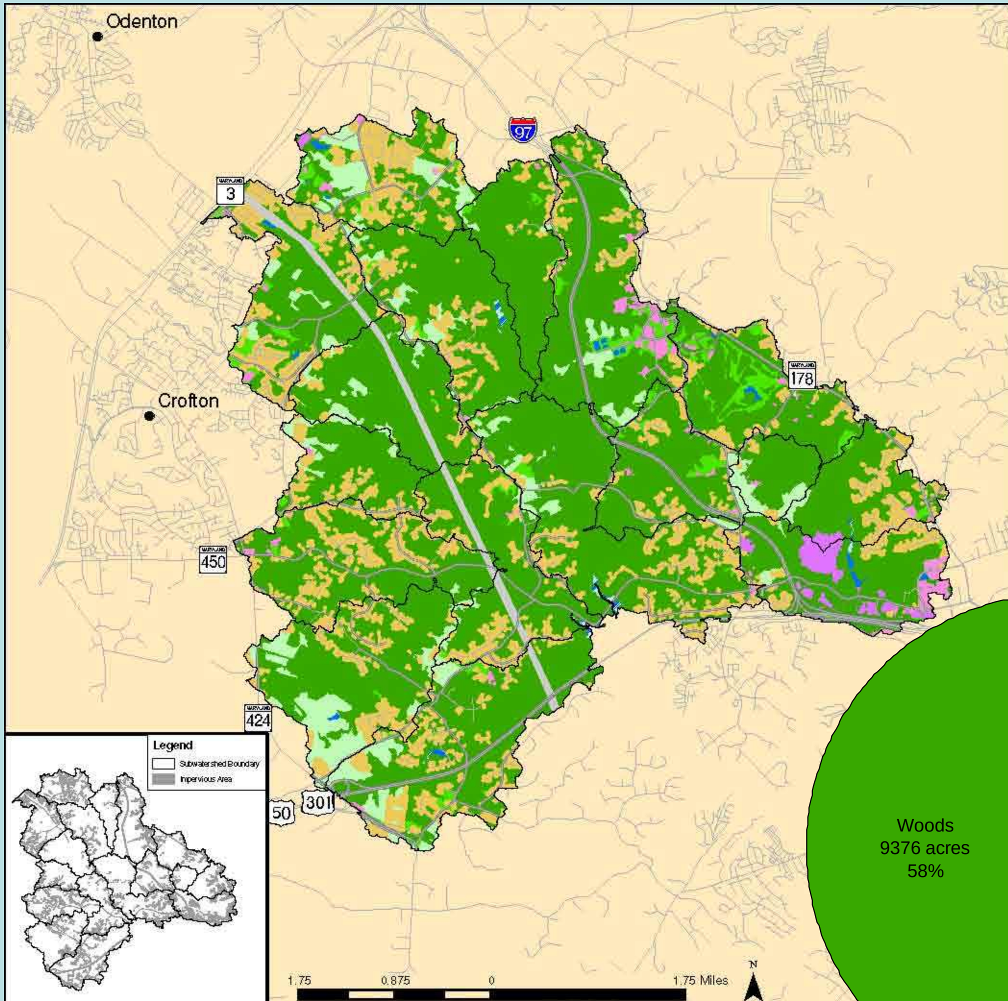
Overview



The headwaters of the South River Watershed lie completely within Anne Arundel County. The waters within this portion of the watershed drain either directly or indirectly to the South River, which discharges to the Chesapeake Bay. Therefore the activities that occur within this portion of the watershed have a direct impact on the Chesapeake.

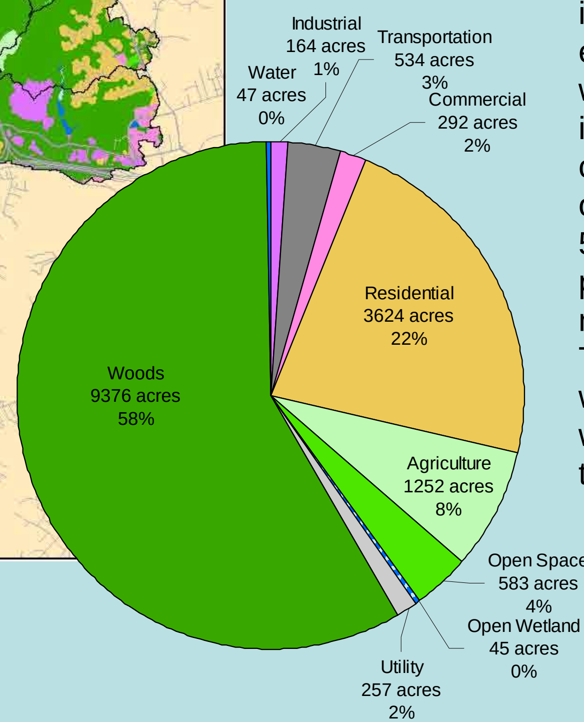
The headwaters cluster of the South River Watershed is approximately 16,200 acres in size and has 151.4 miles of waterways. This cluster contains 4 major streams including the Bacon Ridge Branch, North River, Tarnans Branch, and portions of Broad Creek watersheds. The headwater cluster area is less populated than either the south shore or north shore clusters. This cluster is comprised of several areas of residential development as well areas of agriculture, but most notably in this cluster are the large tracts of contiguous forested land.

South River Watershed: Headwaters Cluster



Land Cover

Land cover conditions play an important role in non-point source pollutant loading to streams. Agricultural and residential lawns may be sources of nutrients and bacteria, while urban development increases the potential for runoff. Land cover can also affect pollutant removal. In a forested watershed, precipitation is absorbed by the tree canopy, lost to the air through evapotranspiration, and infiltrates into the ground to recharge ground water. Surface runoff is usually much higher in agricultural watersheds than in forested watersheds and even higher in urban watersheds, which leads to increased pollutant loads. Land cover in the headwaters cluster of the South River Watershed is 58% forest which has a greater pollutant removal capability than many of the other land covers. Twenty-two percent of the watershed has residential cover which may contribute pollutants to the receiving waterways.

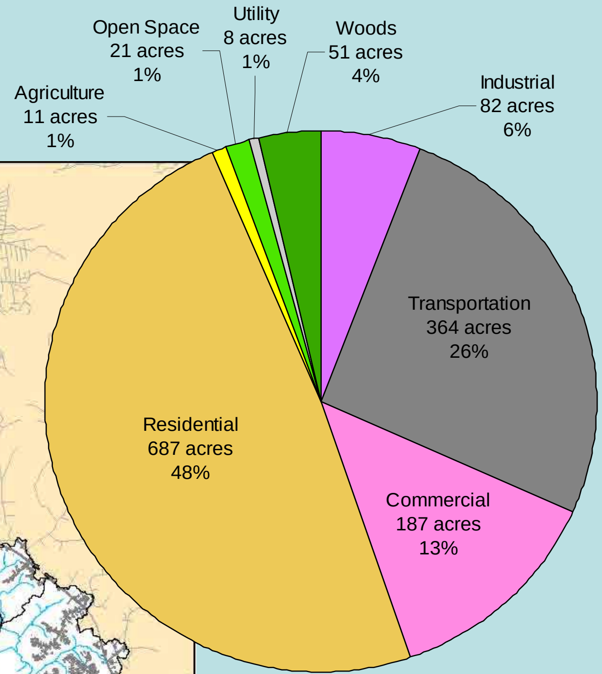


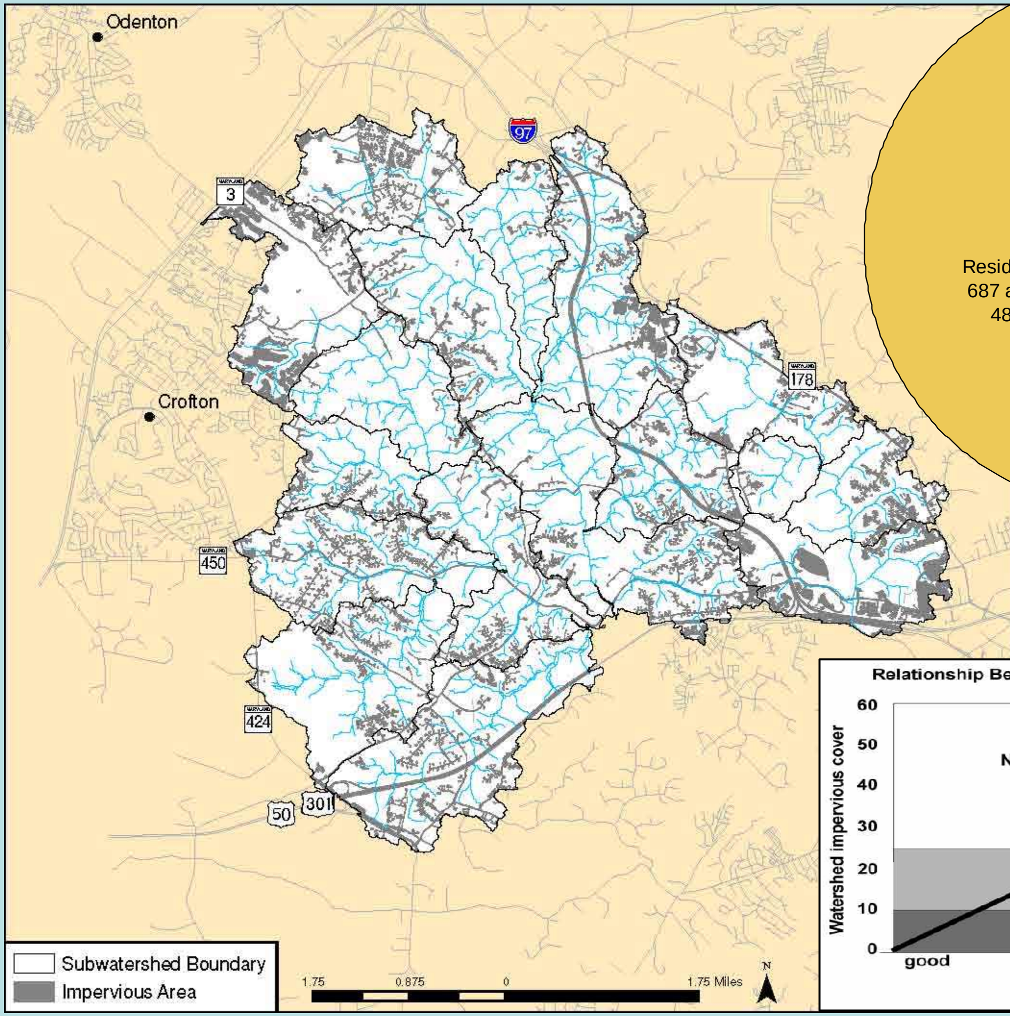
ANNE ARUNDEL COUNTY
MARYLAND

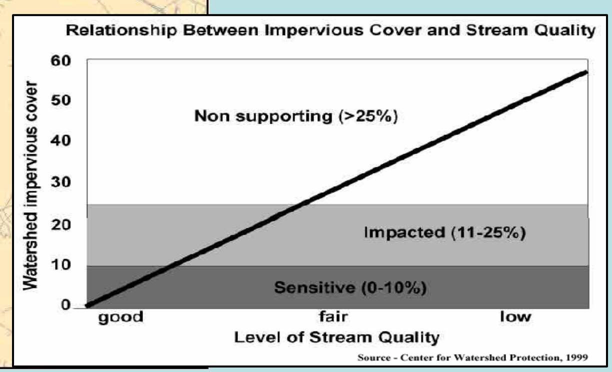
South River Watershed: Headwaters Cluster

DPW

Impervious Area







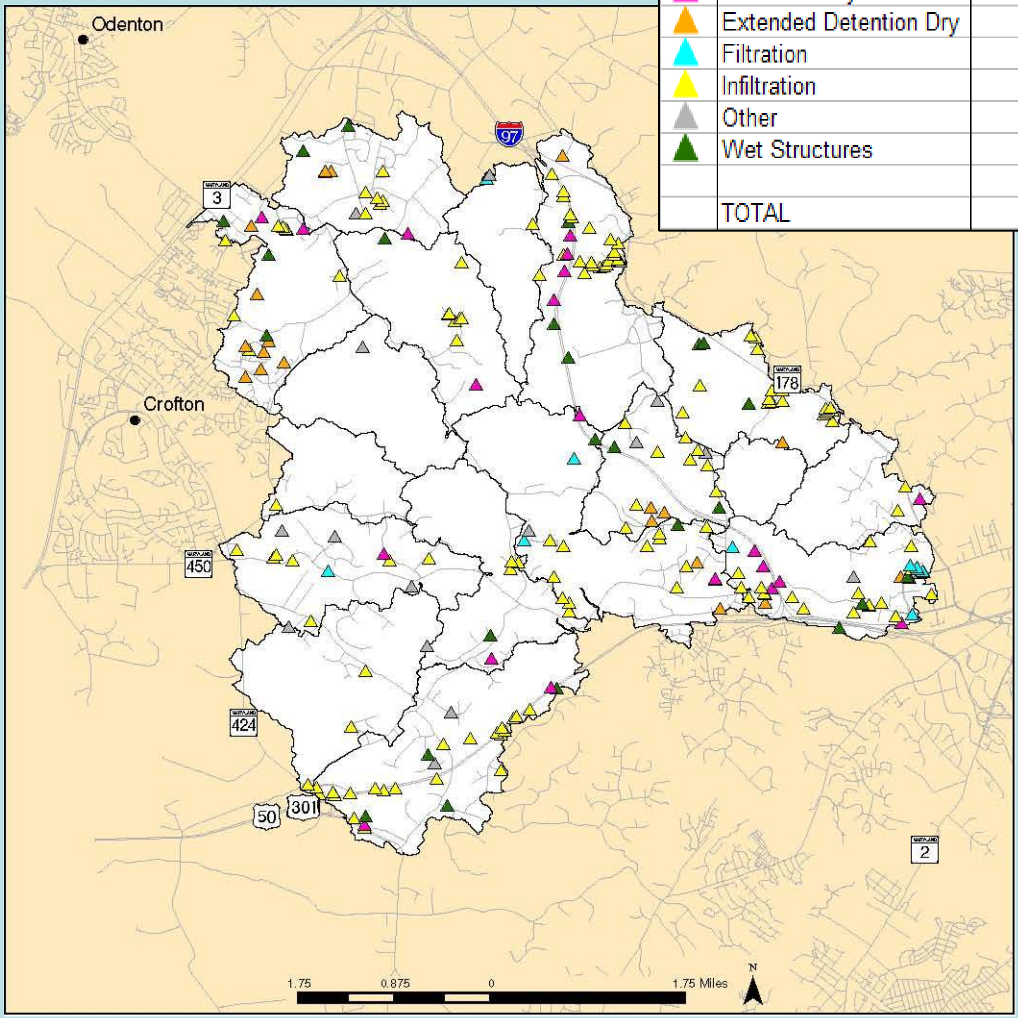
Impervious surfaces, such as pavements and rooftops, prevent rainfall from seeping into the ground, resulting in the potential for large volumes of stormwater to run off more rapidly and more directly into receiving streams. Pollutants carried with this runoff can reduce water quality and negatively impact stream health. Research shows that as the impervious surface area in a watershed increases, the ecological integrity of streams deteriorates. Streams that receive large volumes of rapidly flowing stormwater are also susceptible to flooding and channel erosion. The land in the headwaters cluster is 9% impervious, meaning that the conditions are supportive of aquatic and plant life, and the stream quality level is good. Approximately half of the impervious land cover is found in residential areas and over a quarter is transportation, which can be attributed to the major road corridors that bisect this cluster such as Interstate 97 and State Route 450.

CH2MHILL KCI TECHNOLOGIES

South River Watershed: Headwaters Cluster

Stormwater Controls

	TYPE	NUMBER	DRAINAGE AREA (acres)	% of TOTAL CLUSTER TREATED
▲	Detention Dry	24	263.7	1.63%
▲	Extended Detention Dry	20	242.5	1.50%
▲	Filtration	19	21.3	0.13%
▲	Infiltration	194	285.7	1.77%
▲	Other	15	5.8	0.04%
▲	Wet Structures	34	1254.5	7.76%
	TOTAL	306	2073.5	12.82%



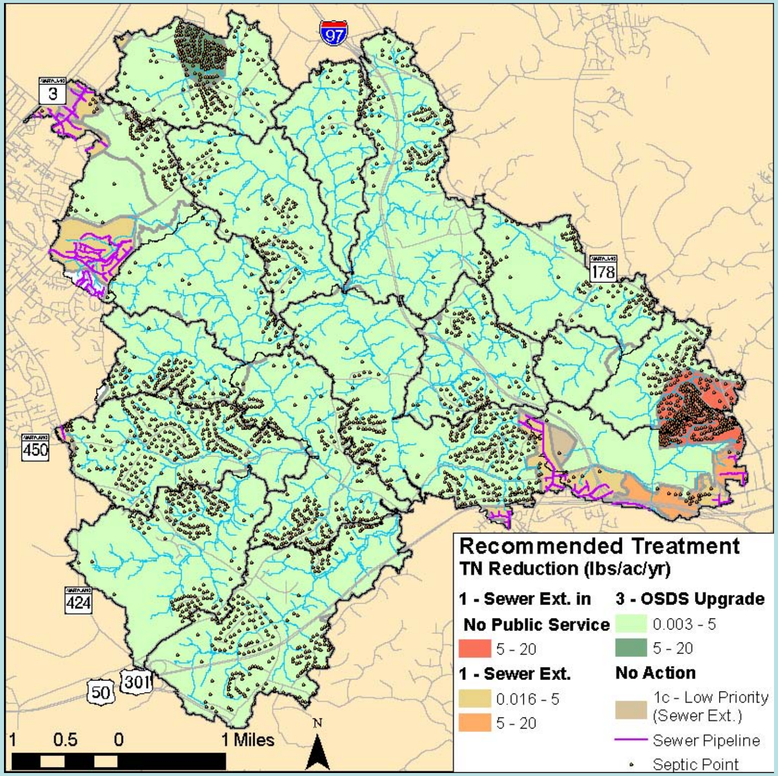
Stormwater controls are engineered structures or landscape enhancements that are used to manage local stormwater. They are important for controlling and minimizing the effects of excess stormwater runoff including flooding, erosion, and stream pollution. The controls in the headwaters treat approximately 13% of the land in this cluster which equates to 45% of the urban land cover. Wet structures treat the largest area while infiltration practices are the most numerous.

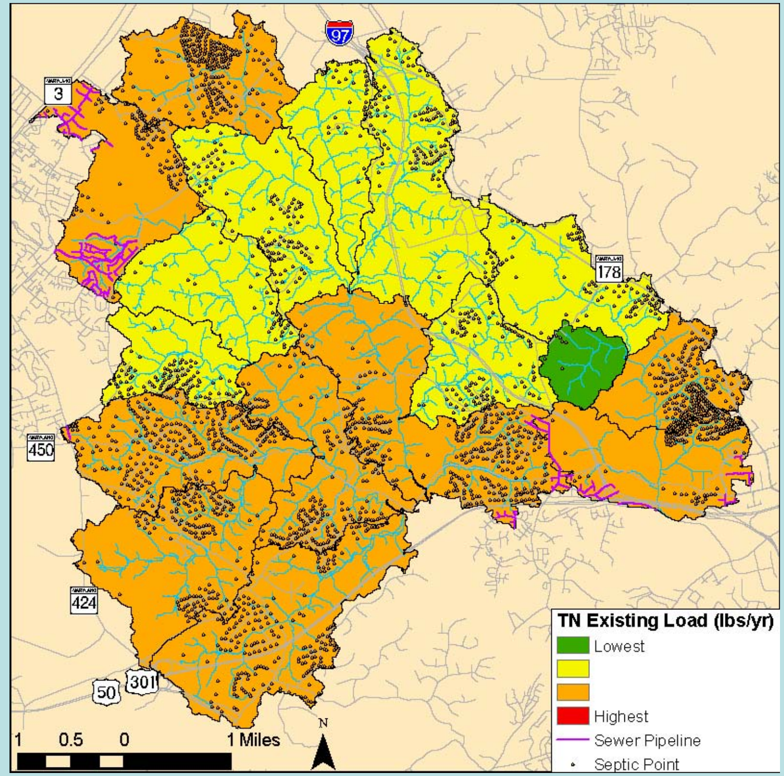
Stormwater detention ponds are wet structures that are often used to capture and detain stormwater runoff from residential and commercial areas.

Filtration practices capture stormwater and allow it to seep into a treatment media then infiltrate to the groundwater. This rain garden helps capture and filter runoff from a parking lot.

South River Watershed: Headwaters Cluster

Septic System Issues



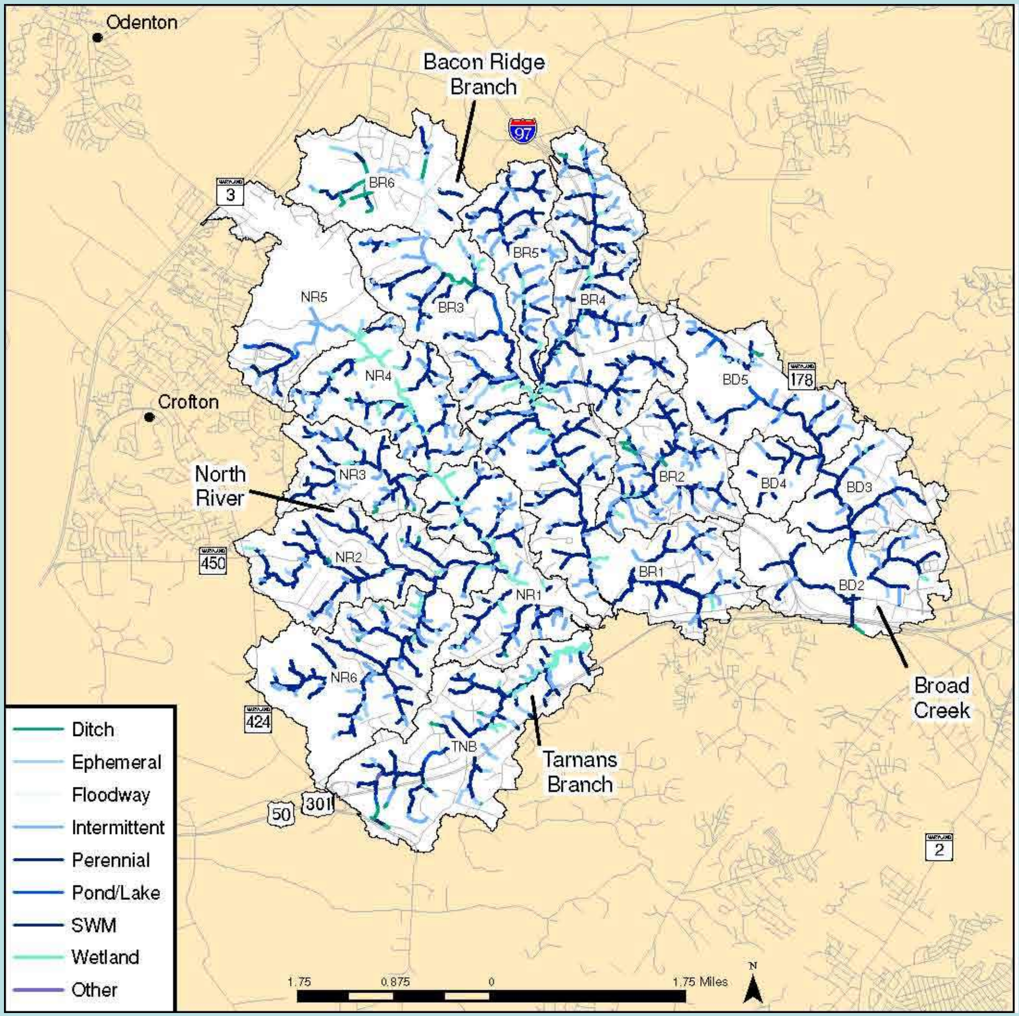


There are 2,436 OSDS in the Headwaters Cluster, contributing 45,100 lbs per year of nitrogen. 80% are recommended for an OSDS upgrade with enhanced nitrogen removal.

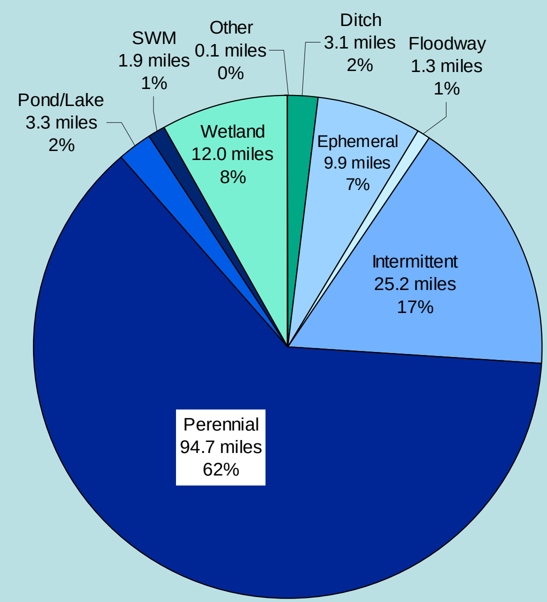
Anne Arundel County completed a countywide evaluation of service options for properties with Onsite Sewage Disposal Systems (OSDS or septic systems) in March 2008. The evaluation and resulting strategic plan identified the most cost-effective approach to reducing nitrogen loads from OSDS systems that is consistent with the County's goals. Treatment alternatives examined included sewer extension to an existing water reclamation facility (WRF) (both in areas of no public service and areas with sewer system existing), cluster type of community sewer service, OSDS upgrades with enhanced nitrogen removal, and no action meaning maintain existing septic system. Sewer extension will reduce the nitrogen load of those facilities to zero because there are no WRFs in the South River watershed. Cluster treatment will reduce the load by 92%. An OSDS upgrade will reduce the load by 50%.

South River Watershed: Headwaters Cluster

Stream Reach Overview



The stream planimetric layer of 2002 was updated in 2006 during the stream walks. The headwaters cluster of the South River Watershed contains 151.4 miles of waterways. Based on a comprehensive field survey conducted in 2006 it was determined that over 60% of the streams are perennial (those that flow year round). Wetland and streams which flow only during part of the year are called intermittent (fed by groundwater) and ephemeral (flow in response to precipitation) streams and make up the remaining portion of the streams found in the headwaters cluster. The assessed waterways exclude the mainstem of the South River as well as all tidally influenced stream channels.



ANNE ARUNDEL COUNTY
MARYLAND

South River Watershed: Headwaters Cluster

DPW

Inventory of Infrastructure and Environmental Features

Significant infrastructure and environmental features were inventoried in 2006 along the assessed streams and scored based on their impact on overall stream health. Of the 1216 total data points only 3%, largely deficient buffer and erosion sites, were considered to have an extreme impact, while overall 79% were considered moderate to minor. Twenty-eight percent of the points were pipes and ditches with only minor impact, however there is the potential for a negative cumulative effect from these points on the physical stability and biological health of the South River stream system.

		Impact Score			
Feature Type	**Total**	*Extreme*	*Severe*	*Moderate*	*Minor*
Deficient Buffer	118	17	40	61	
Crossing	246	6	12	38	190
Pipes and Ditches	397		7	40	350
Dumpsites	102		7	46	49
Erosion	349	18	143	188	
Utility	4			2	2

Deficient Buffer with extreme impact score located east of Rutland Road.

Crossing with extreme impact score located under St. Stephens Church Road.

Pipe/Ditch with severe impact score located just south of Mount Tabor Road.

Dumpsite with severe impact score located off MacKibeth Court.

Erosion with extreme impact score located just south of Defense Highway.

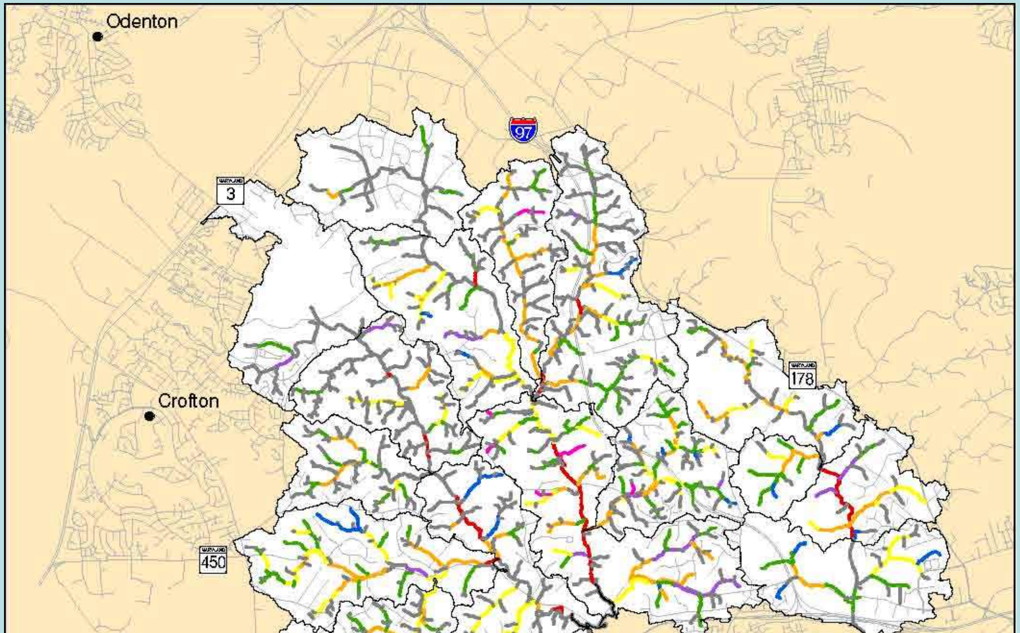
Utility with moderate impact score located on Walden Golf Club golf course.

CH2MHILL KCI TECHNOLOGIES

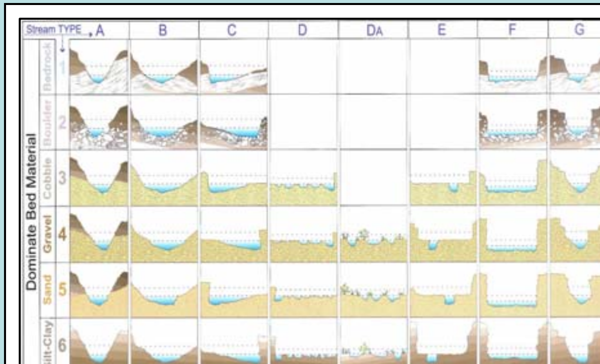
South River Watershed: Headwaters Cluster

Channel Geomorphology

Rosgen stream classifications are a widely used method of classifying channel types based on similar morphological characteristics, with the goal of predicting hydrologic behavior. Thirty-seven percent of the assessed perennial streams in the headwaters cluster are Type B channels, which are very stable, moderate gradient channels with low sinuosity and low erosion rates. Twenty-four percent are Type C channels, which exhibit a well developed floodplain, higher sinuosity and susceptibility to de-stabilization when flow regimes are altered. A majority of the remaining channels are classified as Type F and G channels, which are generally not stable and are related to high sediment supplies which is generated from accelerated stream bank erosion and channel incision process.



Typical Type B Channel in the headwater cluster, South River Watershed

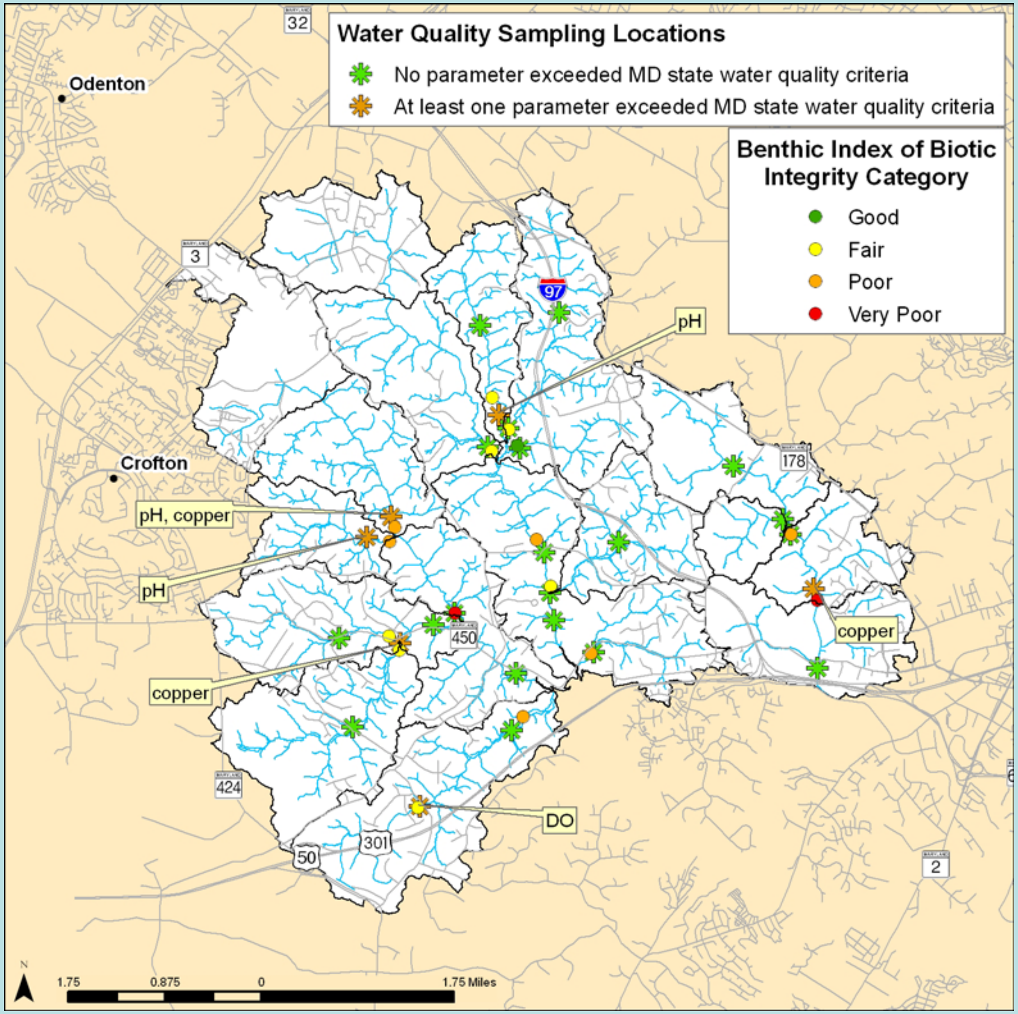


	A	B	C	D	DA	E	F	G
Entrchmnt.	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.2	n/a	variable	> 1.5	> 1.2	> 1.2
Slope	.04-.099	.02-.039	< .02	< .04	<.005	< .02	< .02	.02-.039

Rosgen Channel Type Definitions

South River Watershed: Headwaters Cluster

Water Quality and Bioassessment



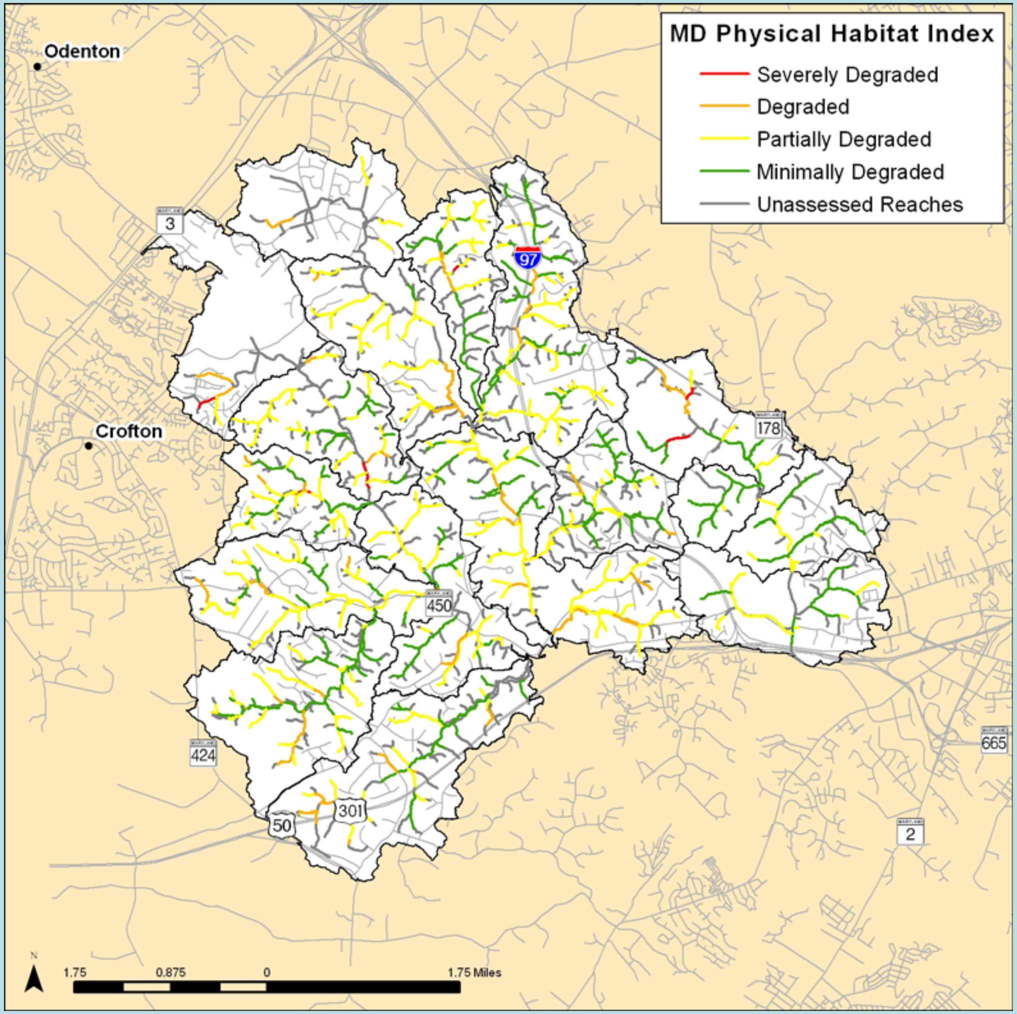
The County assessed the baseflow chemical water quality for each subwatershed in the Spring of 2006. Samples were taken to characterize pollutant concentrations and estimate baseflow pollutant loads. In general, water quality was fair; however, there were three sites where copper exceeded MD state water quality criteria, three sites where pH exceeded criteria, and one site where DO fell short of the minimum criteria.

Parameter	Average Concentration		MD State Water Quality Criteria
TKN	0.344	mg/l	n/a
Total Nitrogen	0.305	mg/l	n/a
Total Phosphorus	0.154	mg/l	n/a
Total Suspended Solids	5.62	mg/l	n/a
Copper	6.654	ug/l	13 (acute) 9 (chronic)
Lead	5.00	ug/l	65 (acute) 2.5 (chronic)
Zinc	29.32	ug/l	120
Fecal coliforms	410	col/100 ml	n/a
pH	7.04		6.5 - 8.5
Dissolved Oxygen	7.80	mg/l	>5.0 mg/l

In the spring of 2006, the County assessed the aquatic macro-invertebrate community by sampling at the most downstream, perennial location in each subwatershed. Typically as the quality of the water or habitat declines, the diversity and abundance of aquatic macroinvertebrates also declines, with pollution tolerant types becoming dominant. A Benthic Index of Biotic Integrity combines measures of diversity, numbers of intolerant types, and forms of feeding and locomotion to assess a stream's health. Headwater cluster streams were generally in the fair to poor Biological Index score range with one site in good condition, seven in fair condition, seven in poor condition and one in very poor condition.

South River Watershed: Headwaters Cluster

Habitat Assessment



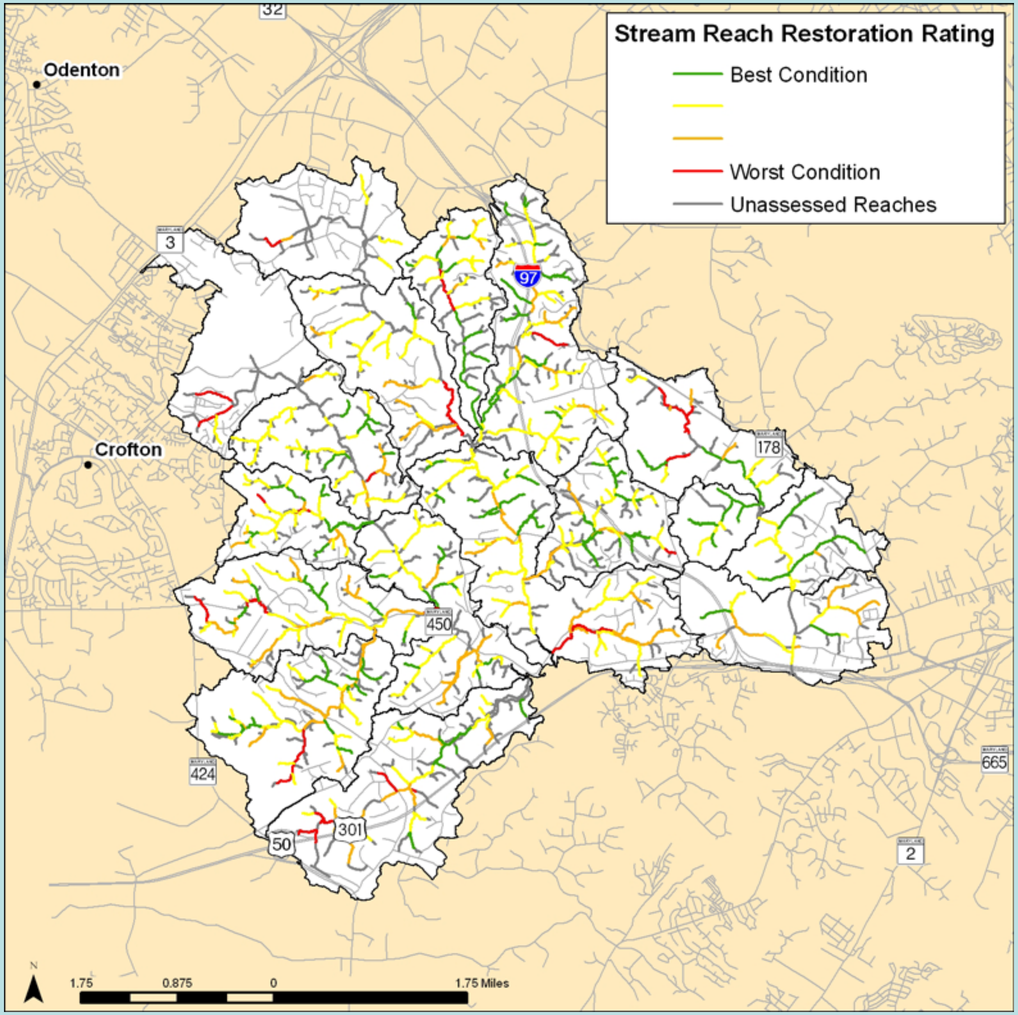
The Maryland Physical Habitat Index (MPHI) was used to assess the condition of perennial stream habitat in 2006. The MPHI incorporates measures of fish and aquatic macroinvertebrate habitat availability and quality, shading, remoteness and bank stability. For the headwaters cluster, habitat quality was good with only 1% of perennial streams in the severely degraded category. Fifty-three percent were in the partially degraded category, 35% were minimally degraded and 11% were degraded. Thirty-eight percent of the total stream miles within the headwaters cluster were not assessed because they were not perennial streams. Of this unassessed portion, 82% was wetland, intermittent or ephemeral channels. The remaining 18% were primarily stormwater related.

Severely degraded stream reach in the headwater cluster of South River (NR5)

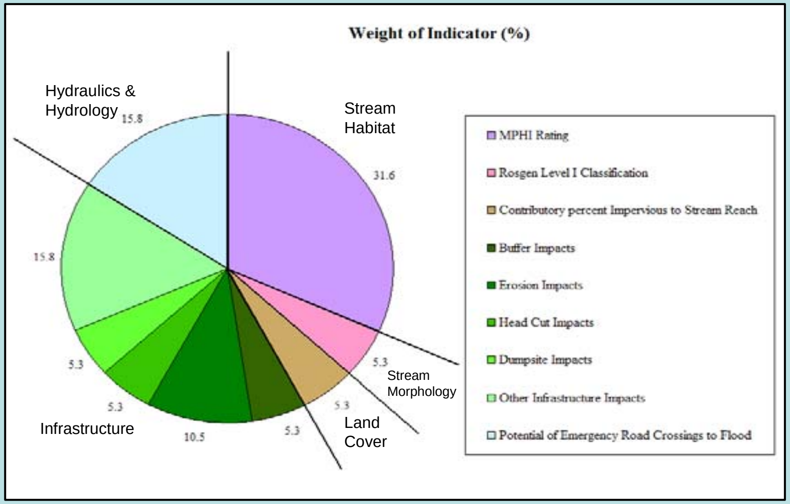
Minimally degraded stream reach in the headwater cluster of South River (BD5)

South River Watershed: Headwaters Cluster

Reach Restoration Assessment

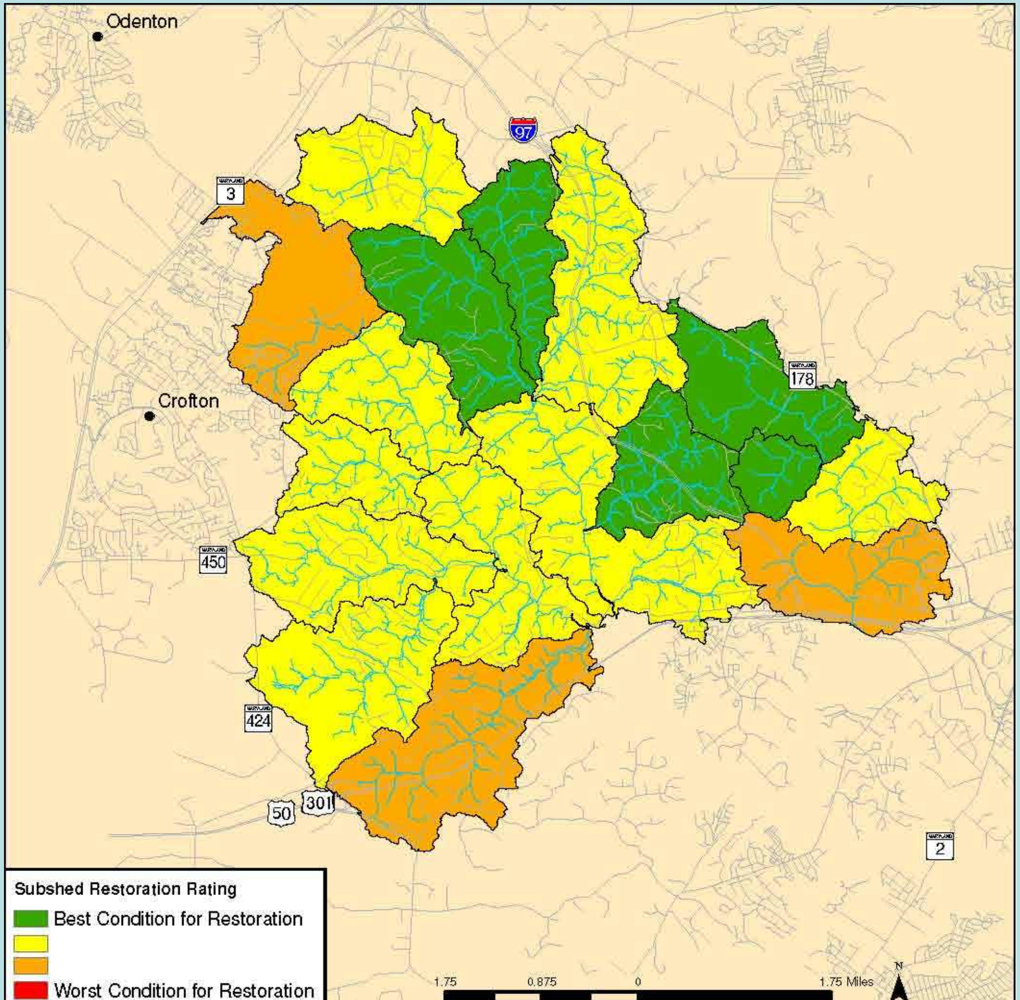


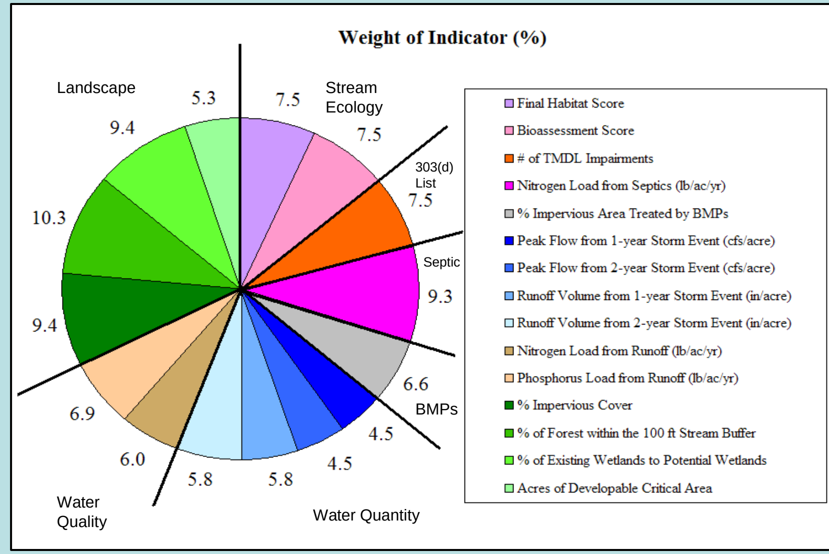
In 2006, the County assessed individual stream reaches in the South River watershed and rated them according to physical habitat quality, channel morphology, impervious land cover and the impact of infrastructure features such as dumpsites and deficient stream buffers. Indicators were weighted based on their impact on stream integrity. In the headwaters cluster of the South River, approximately 8% of the assessed stream reaches were determined to be in the "worst condition" and 25% were in the "best condition" rating group as compared to other streams in the South River Watershed. The individual ratings are used to guide the County in allocating financial resources to both restore impaired stream reaches and meet environmental regulatory requirements.



South River Watershed: Headwaters Cluster

Subwatershed Restoration Assessment

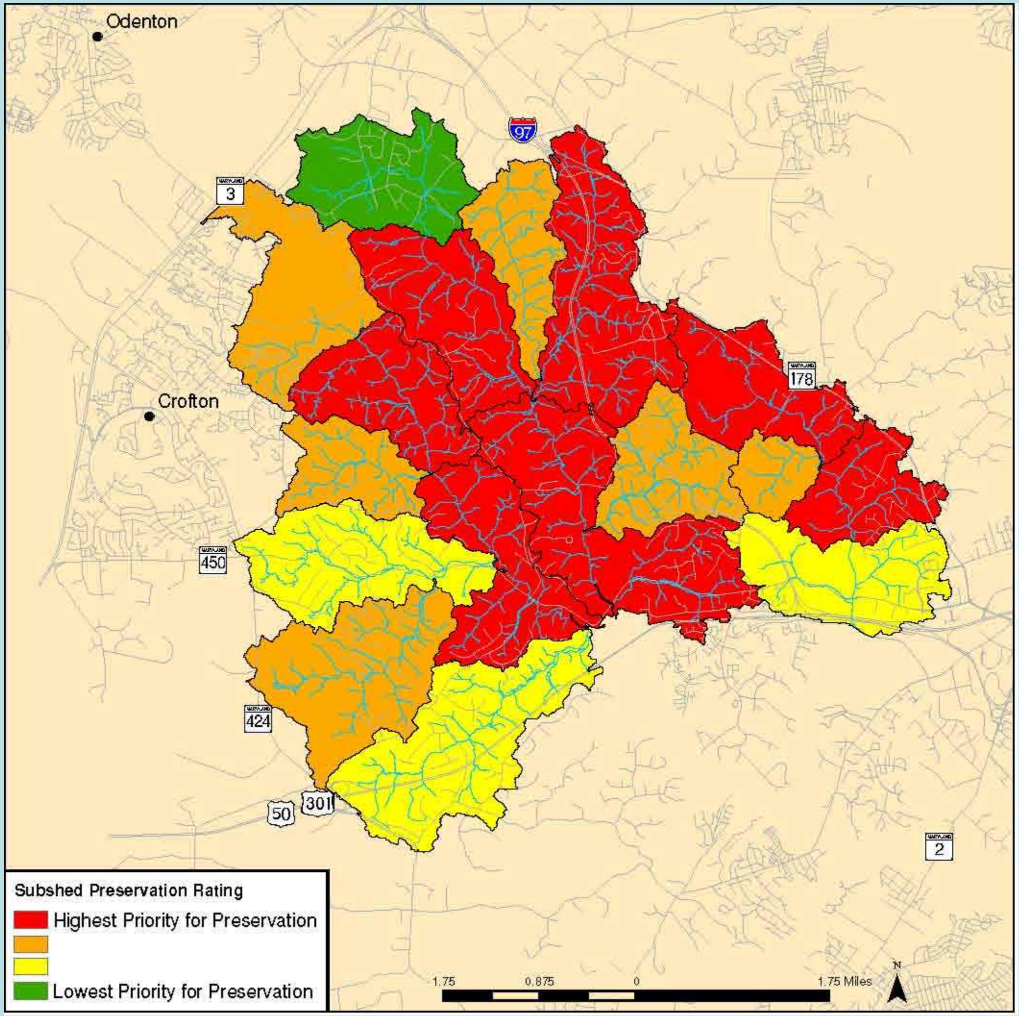


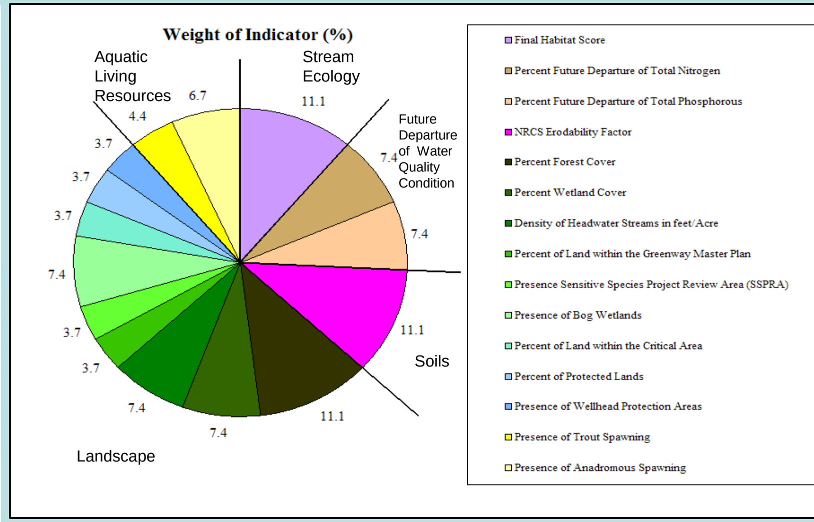


By examining indicators such as water quality and quantity, landscape, stream ecology and percent impervious treated by stormwater controls, the county assessed each subwatershed to focus resources based on a subwatersheds rating. None of the subwatersheds in the headwaters cluster were rated in the "Worst Condition" category as compared to other subwatersheds within this watershed. Three subwatersheds were within one level of the "Worst Condition" category. The northernmost subwatershed in this category is adjacent to Town of Crofton and the southernmost subwartershed is bisected by US Highway 301.

South River Watershed: Headwaters Cluster

Subwatershed Preservation Assessment

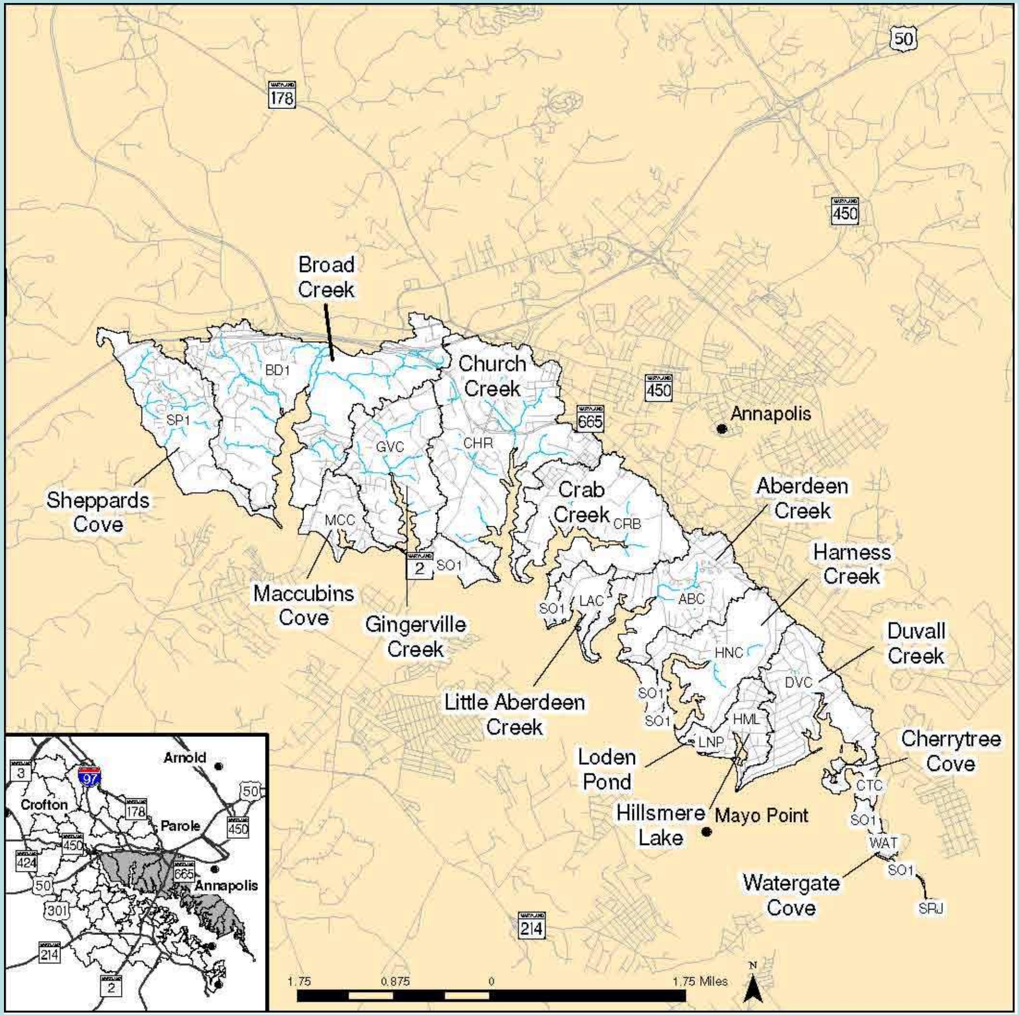




By examining indicators such as stream habitat, water quality, and the presence of sensitive land types such as wetlands, greenways, and protected habitats among others, the County assessed individual subwatersheds and rated them to help focus resources for preserving those that are most sensitive. Nearly 40 percent of the subwatersheds in the headwaters cluster fall within the highest priority for preservation category and 30 percent are within the next highest priority. The results of this assessment can be attributed in a large part to the limited amount of development and large contiguous tracts of forest cover within the subwatersheds of this cluster.

South River Watershed: North Shore Cluster

Overview

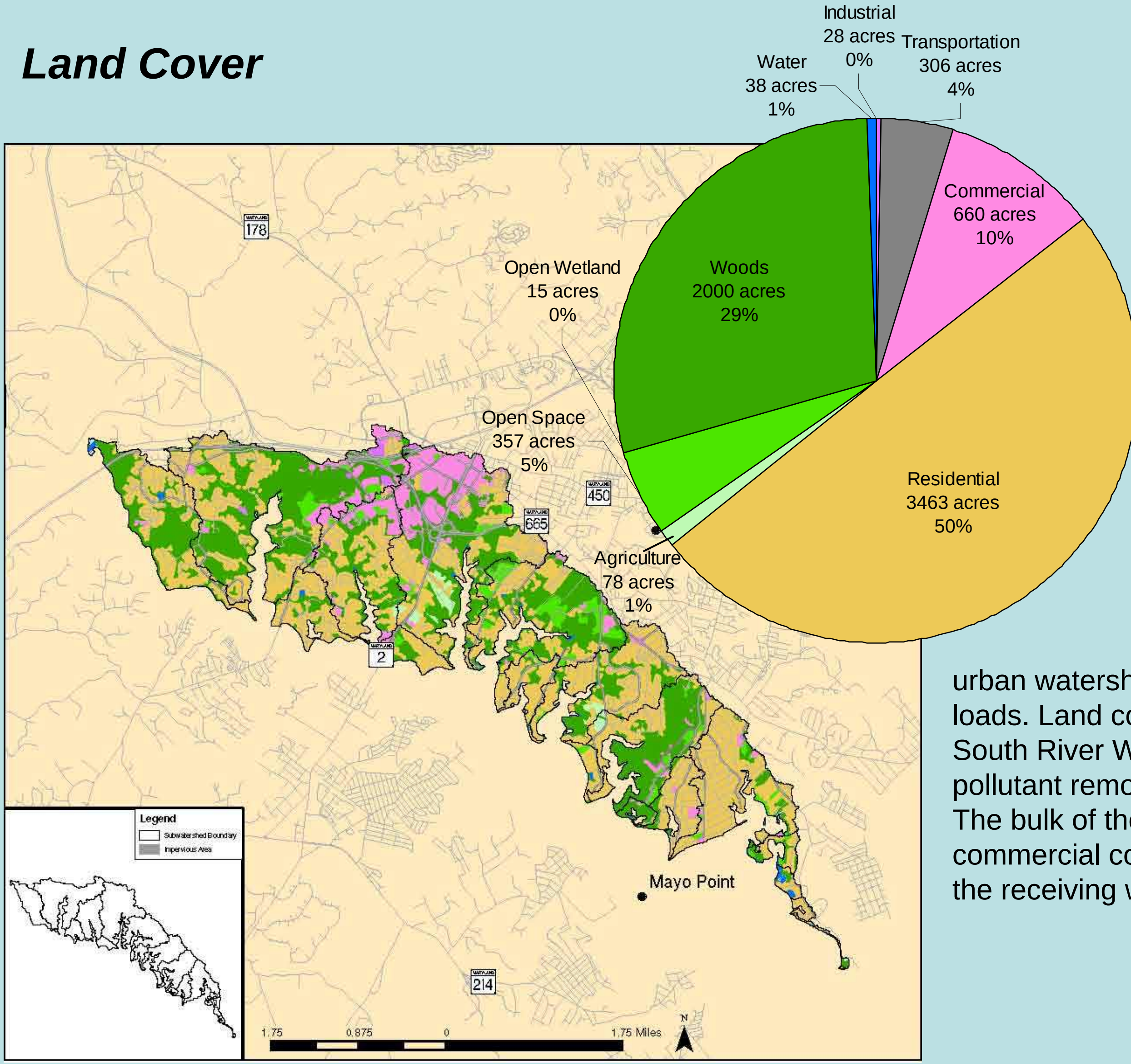


The north shore cluster of the South River Watershed lies completely within Anne Arundel County. The waters within this portion of the watershed drain either directly or indirectly to the South River, which discharges to the Chesapeake Bay. Therefore, the activities that occur within this portion of the watershed have a direct impact on the Chesapeake.

The north shore cluster of the South River Watershed is approximately 6,900 acres in size and has 21.3 miles of waterways. At least half of these subwtersheds contain streams that are completely-influenced by tides. This area is highly populated and includes a portion of the City of Annapolis. The north shore cluster is dominated by residential and commercial development. However, this cluster is also comprised of a large percentage of forested land, but this land is much more fragmented than in the headwaters cluster.

South River Watershed: North Shore Cluster

Land Cover



Land cover conditions play an important role in non-point source pollutant loading to streams. Agricultural and residential lawns may be sources of nutrients and bacteria, while urban development increases the potential for runoff. Land cover can also affect pollutant removal. In a forested watershed, precipitation is absorbed by the tree canopy, lost to the air through evapotranspiration, and infiltrates into the ground to recharge ground water. Surface runoff is usually much higher in agricultural watersheds than in forested watersheds and even higher in urban watersheds, which leads to increased pollutant loads. Land cover in the north shore cluster of the South River Watershed is 29% forest, which has larger pollutant removal capability than other land covers. The bulk of the watershed (60%) is residential and commercial cover which may contribute pollutants to the receiving waterways.

ANNE ARUNDEL COUNTY
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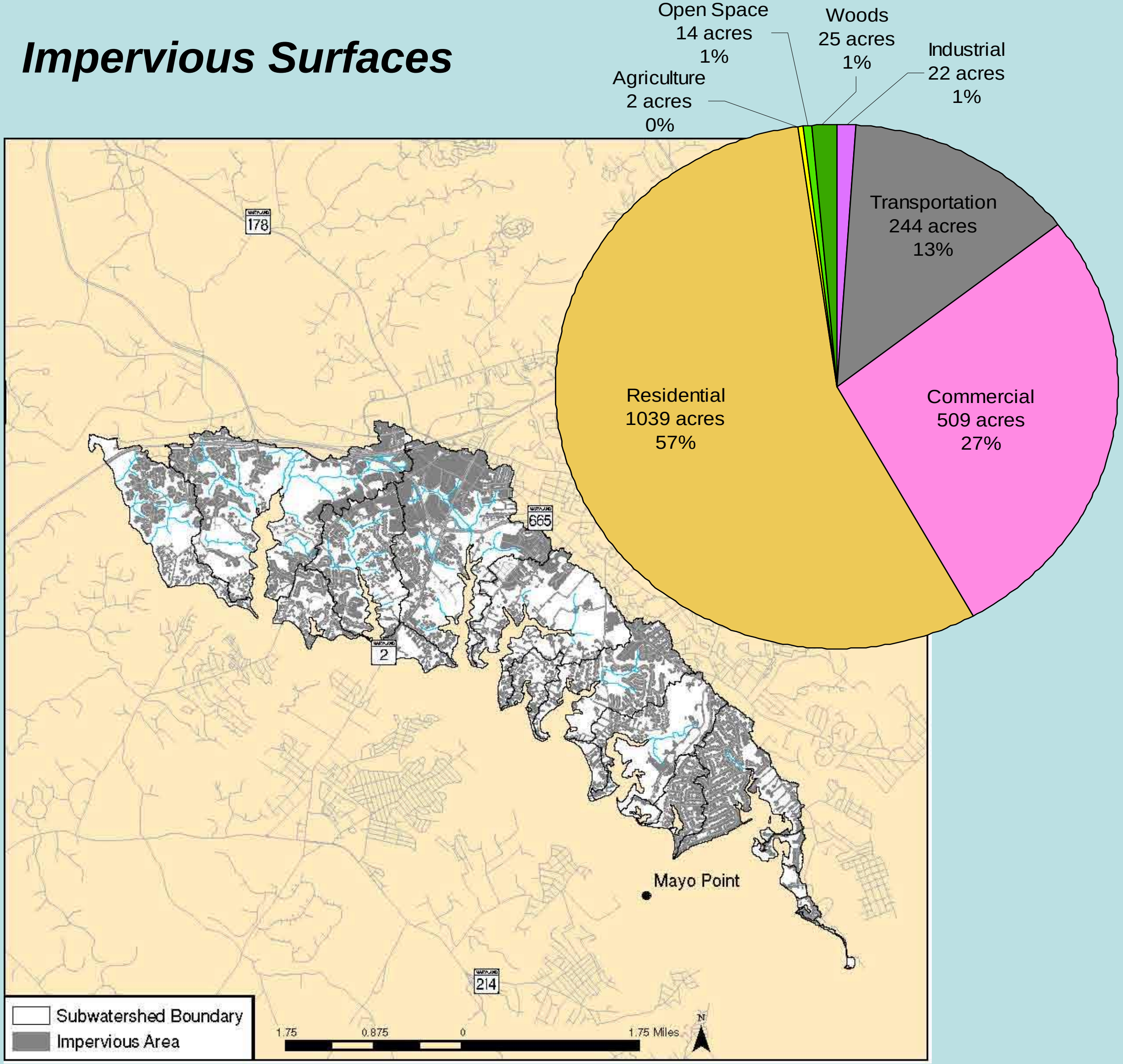
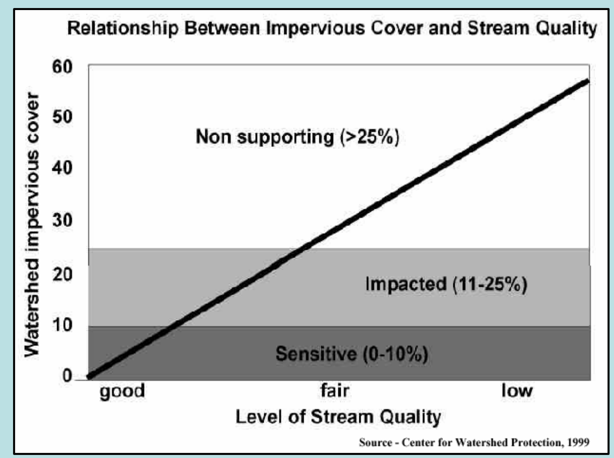
South River Watershed: North Shore Cluster

DPW

Impervious Surfaces



Impervious surfaces, such as pavement and rooftops, prevent rainfall from seeping into the ground, resulting in the potential for large volumes of stormwater to run off more rapidly and more directly into the receiving streams. Pollutants carried with this runoff can reduce water quality and negatively impact stream health. Research shows that as the impervious surface area in a watershed increases, the ecological integrity of streams deteriorates. Streams that receive large volumes of rapidly flowing stormwater are also susceptible to flooding and channel erosion. The land in the north shore cluster is 27% impervious, which is non-supportive for optimal stream health and the level of stream quality is fair. The majority of the impervious land cover (74%) is in residential areas.



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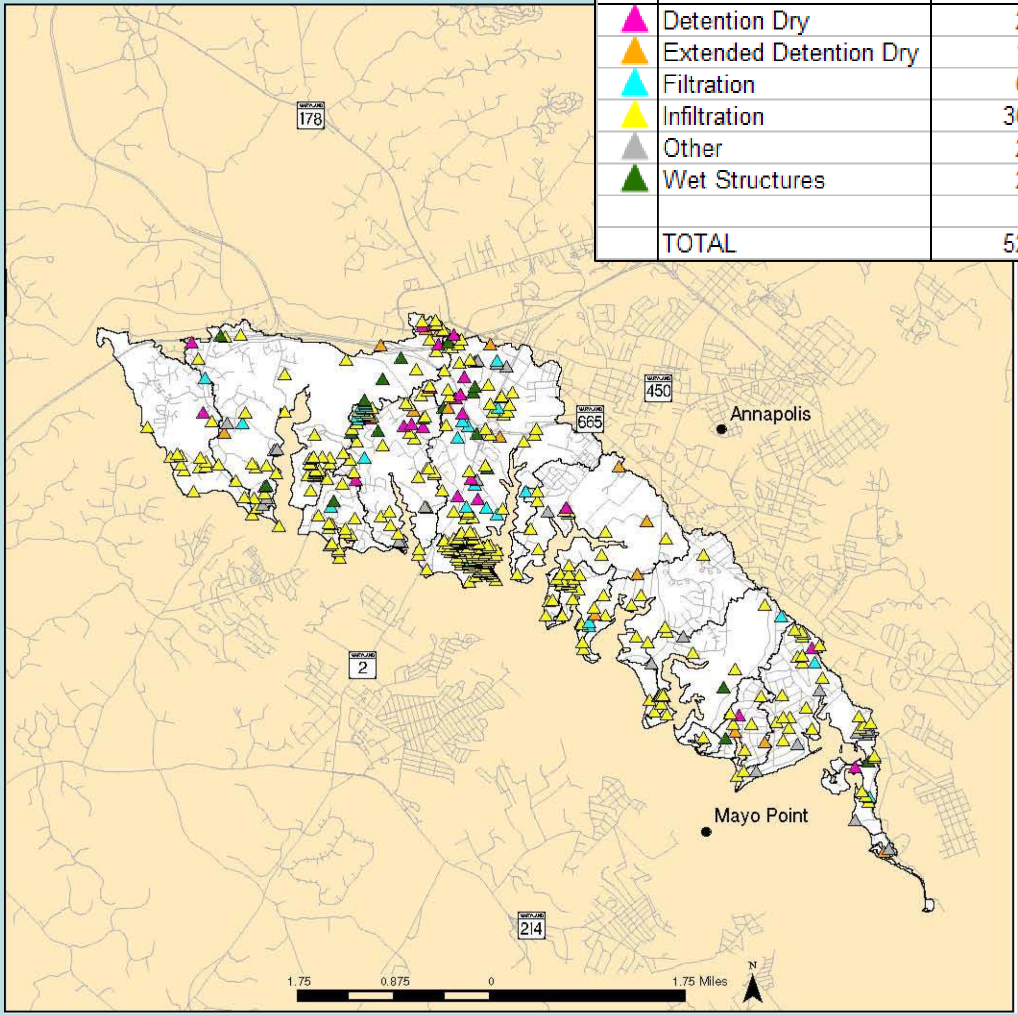
KCI TECHNOLOGIES

South River Watershed: North Shore Cluster

Stormwater Controls

	TYPE	NUMBER	DRAINAGE AREA (acres)	% of TOTAL CLUSTER TREATED
▲	Detention Dry	29	349.7	5.07%
▲	Extended Detention Dry	19	206.3	2.99%
▲	Filtration	60	142.8	2.07%
▲	Infiltration	362	345.6	5.01%
▲	Other	28	15.3	0.22%
▲	Wet Structures	23	288.4	4.18%
	TOTAL	521	1348.2	19.54%



Stormwater controls are engineered structures or landscape enhancements that are used to manage local stormwater. They are important for controlling and minimizing the effects of excess stormwater runoff including flooding, erosion, and stream pollution. The controls in the north shore cluster treat approximately 20% of the land in this cluster which equates to 30% of the urban land cover. Of the 4,500 acres of urban land cover in this cluster, 40% is impervious. Infiltration practices dominate the controls found in this cluster.

Stormwater detention ponds are wet structures that are often used to capture and detain stormwater runoff from residential and commercial areas.

Filtration practices capture stormwater and allow it to seep into a treatment media then infiltrate to the groundwater. This rain garden helps capture and filter runoff from a parking lot.

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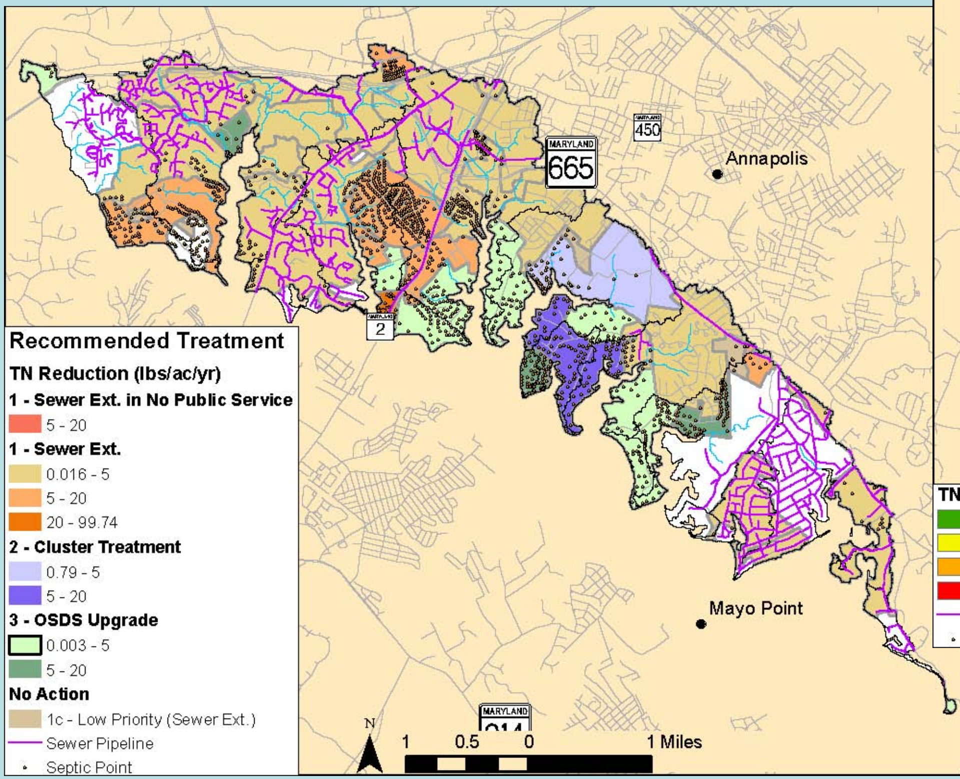
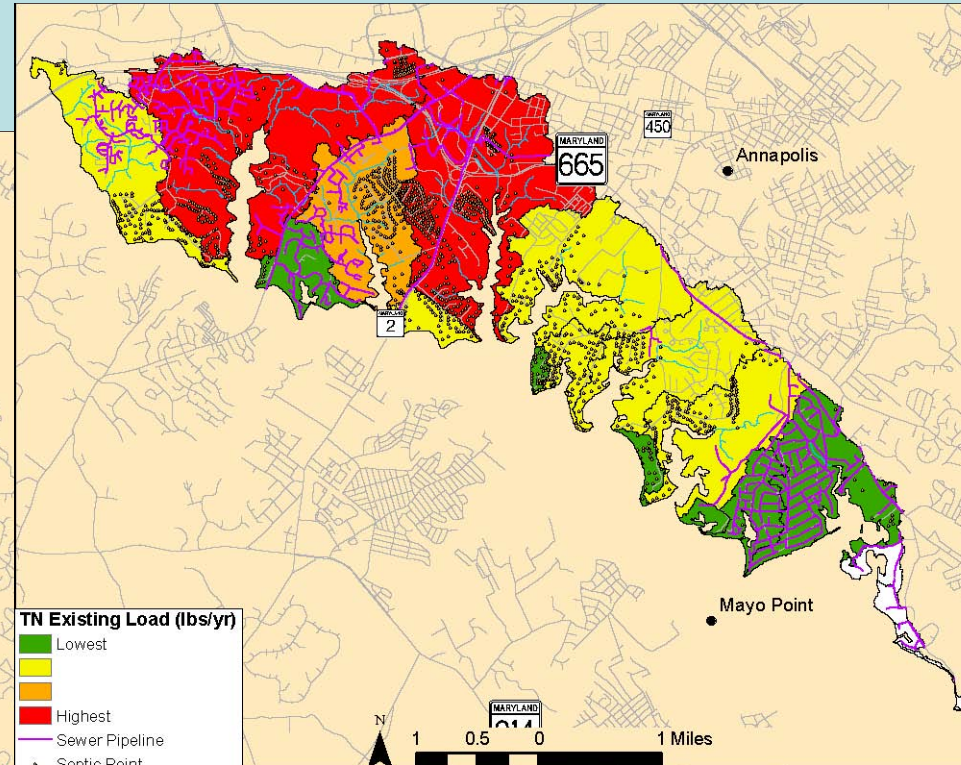
KCI TECHNOLOGIES

South River Watershed: North Shore Cluster

Septic System Issues





The North Shore Cluster has the least number of OSDS (and therefore the smallest TN load at 31,000 lbs) because of the higher density of sewer pipeline in this cluster. As one would expect, the sewer extension is the most recommended treatment for 59% of the systems.

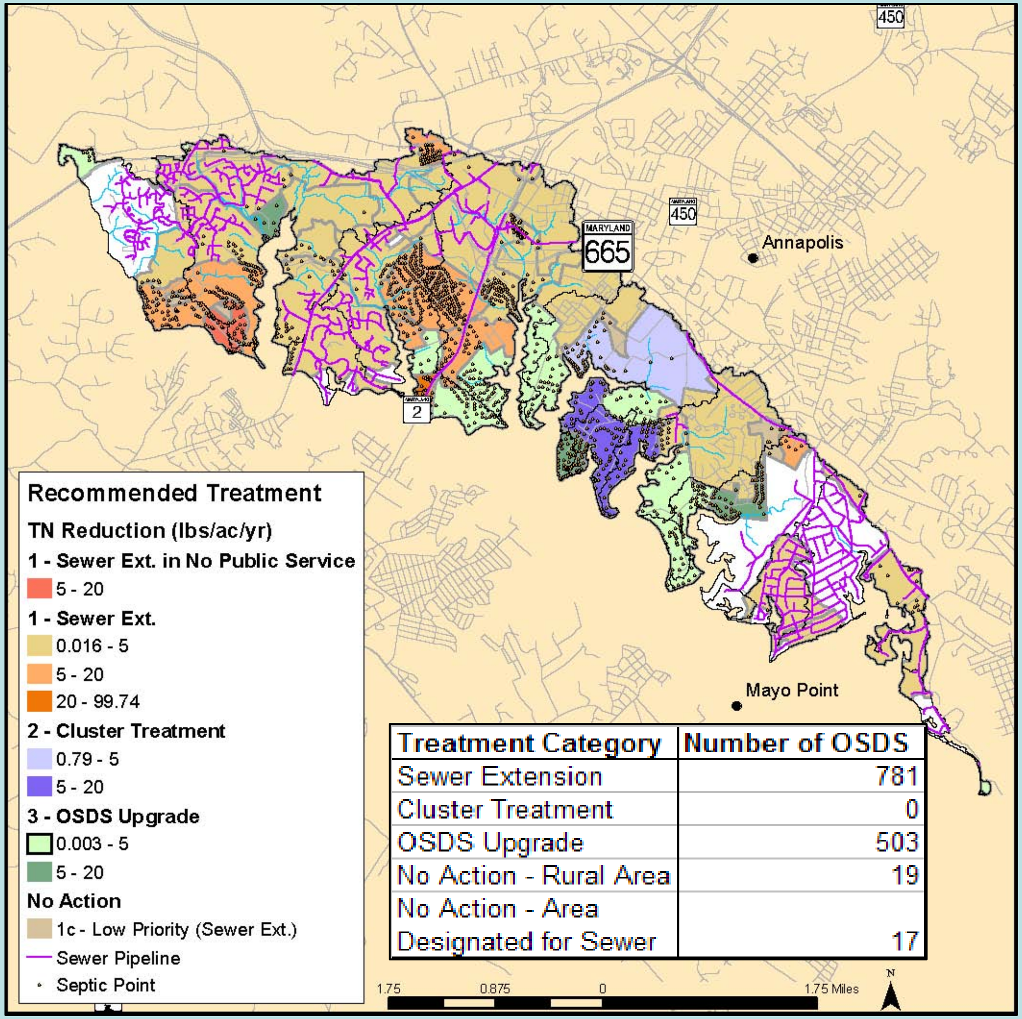
Anne Arundel County completed a countywide evaluation of service options for properties with Onsite Sewage Disposal Systems (OSDS or septic systems) in March 2008. The evaluation and resulting strategic plan identified the most cost-effective approach to reducing nitrogen loads from OSDS systems that is consistent with the County's goals. Treatment alternatives examined included sewer extension to an existing water reclamation facility (WRF) (both in areas of no public service and areas with sewer system existing), cluster type of community sewer service, OSDS upgrades with enhanced nitrogen removal, and no action meaning maintain existing septic system. Sewer extension will reduce the nitrogen load of those facilities to zero because there are no WRFs in the South River watershed. Cluster treatment will reduce the load by 92%. An OSDS upgrade will reduce the load by 50%.

South River Watershed: North Shore Cluster

ANNE ARUNDEL COUNTY
M A R Y L A N D

DPW

Septic System Issues



Treatment Category	Number of OSDS
Sewer Extension	781
Cluster Treatment	0
OSDS Upgrade	503
No Action - Rural Area	19
No Action - Area Designated for Sewer	17

Anne Arundel County completed a countywide evaluation of service options for properties with Onsite Sewage Disposal Systems (OSDS or septic systems) in March 2008. The evaluation and resulting strategic plan identified the most cost-effective approach to reducing nitrogen loads from OSDS systems that is consistent with the County's goals. Treatment alternatives examined included sewer extension (both in areas of no public service and areas with sewer system existing), cluster type of community sewer service, OSDS upgrades with enhanced nitrogen removal, and no action meaning maintain existing septic system. Although OSDS upgrades had the least up front capital investment, all 3 treatment approaches are similar in cost over the long term and sewer extensions and cluster treatment approaches are more cost-effective on a per total nitrogen (TN) removal unit basis and obtain a higher level of TN removal.

The North Shore Cluster has the least number of OSDS because of the higher density of sewer pipeline in this cluster. As one would expect, the sewer extension is the most recommended treatment for 59% of the systems. The next highest recommendation was for OSDS upgrades to 38% of the systems. Pollutant loading before treatment = x, pollutant loading after treatment = y.

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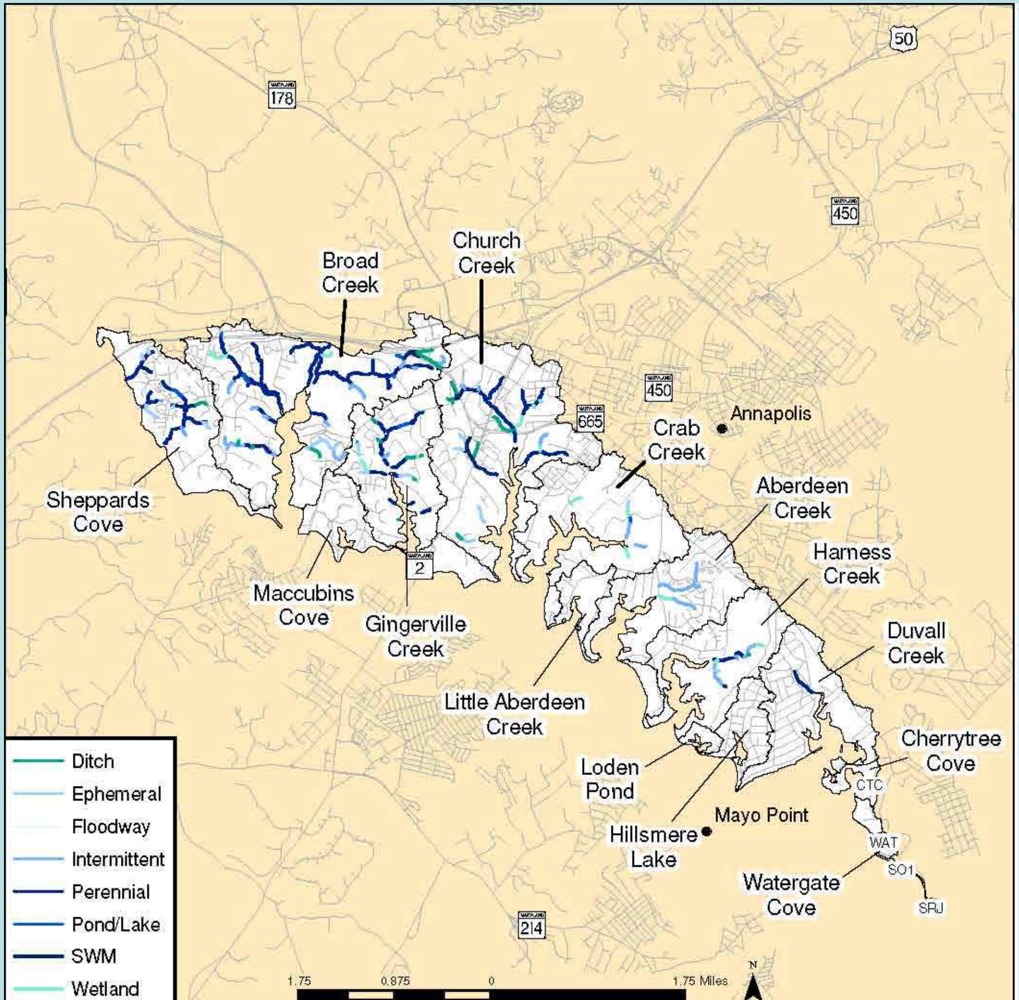
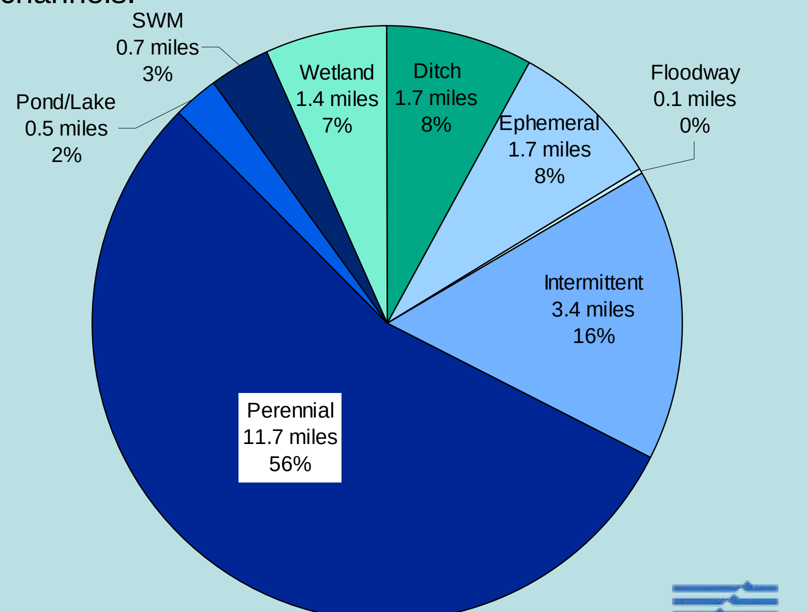
KCI TECHNOLOGIES

South River Watershed: North Shore Cluster

Stream Reach Overview



The stream planimetric layer of 2002 was updated in 2006 during the stream walks. The north shore cluster of the South River Watershed contains 21.3 miles of waterways. Over half (56%) of the streams are perennial (those that flow year round). Wetland and streams which flow only during part of the year are called intermittent (fed by groundwater) and ephemeral (flow in response to precipitation) streams and make up the remaining portion of the streams found in the north shore cluster. The assessed waterways excludes the mainstem of the South River as well as all tidally influenced stream channels.



South River Watershed: North Shore Cluster

Inventory of Infrastructure and Environmental Features

Significant infrastructure and environmental features were inventoried in 2006 along the assessed streams and scored based on their impact on overall stream health. Of the 274 total data points 4%, primarily deficient buffer and erosion sites, were considered to have an extreme impact. Overall 86% were considered moderate to minor. Forty-six percent of the total number of points were pipes and ditches with only minor impact, however there is the potential for a negative cumulative effect from these points on the physical stability and biological health of the South River stream system.

		Impact Score			
Feature Type	**Total**	*Extreme*	*Severe*	*Moderate*	*Minor*
Deficient Buffer	16	3	5	8	
Crossing	35	1	2	1	31
Pipes and Ditches	146		4	16	126
Dumpsites	12		3	4	5
Erosion	60	5	14	41	
Utility	5	1		1	3

Deficient Buffer with extreme impact score located off Scenic Hills Way.

Crossing with extreme impact score located near Riva Road in the vicinity of Riva Drive.

Pipe/Ditch with severe impact score located off Cinnamon Lane.

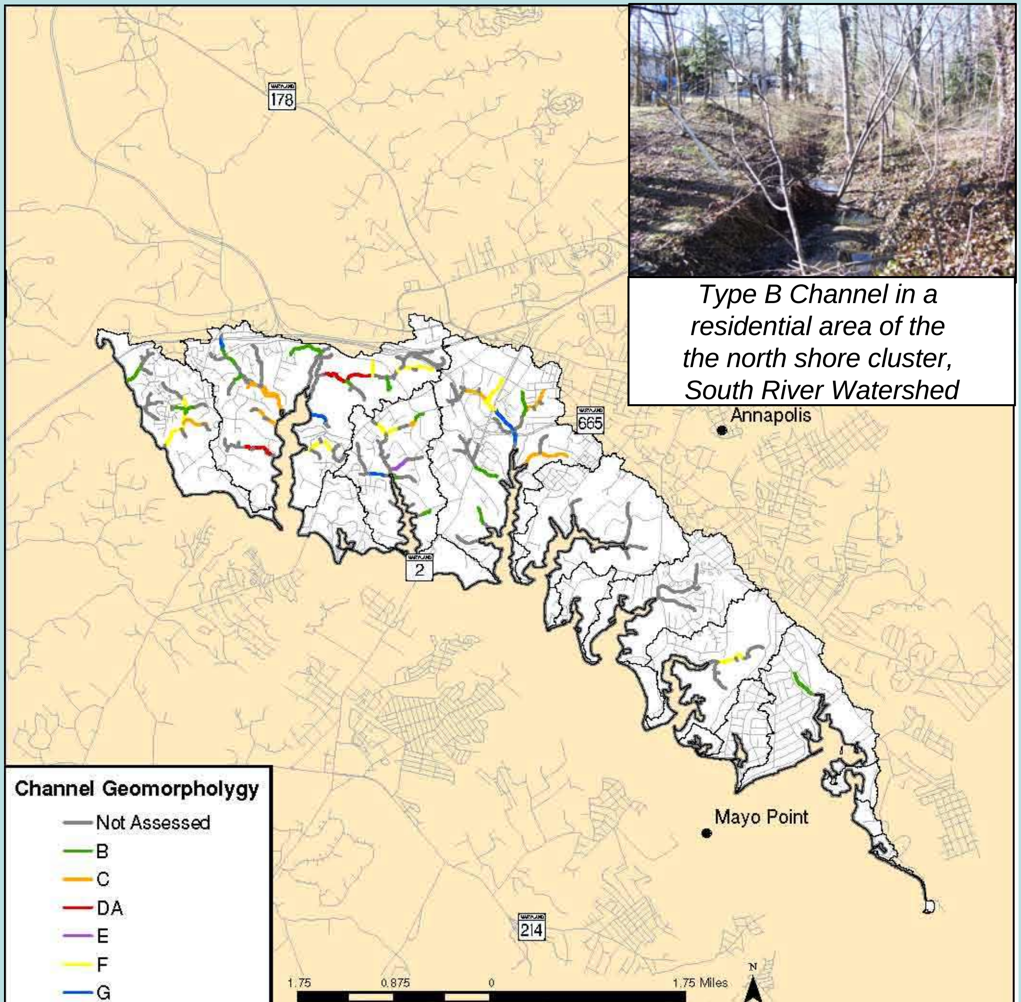
Dumpsite with severe impact score located near Allen Drive.

Erosion with extreme impact score located near Riva Road in the vicinity of Riva Dr.

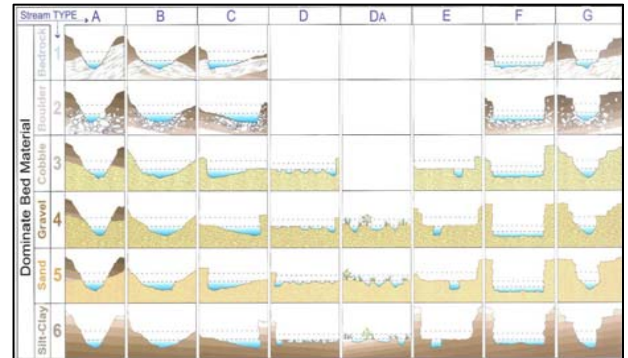
Utility with extreme impact score located next to Shady-water Way.

South River Watershed: North Shore Cluster

Channel Geomorphology



Type B Channel in a residential area of the the north shore cluster, South River Watershed



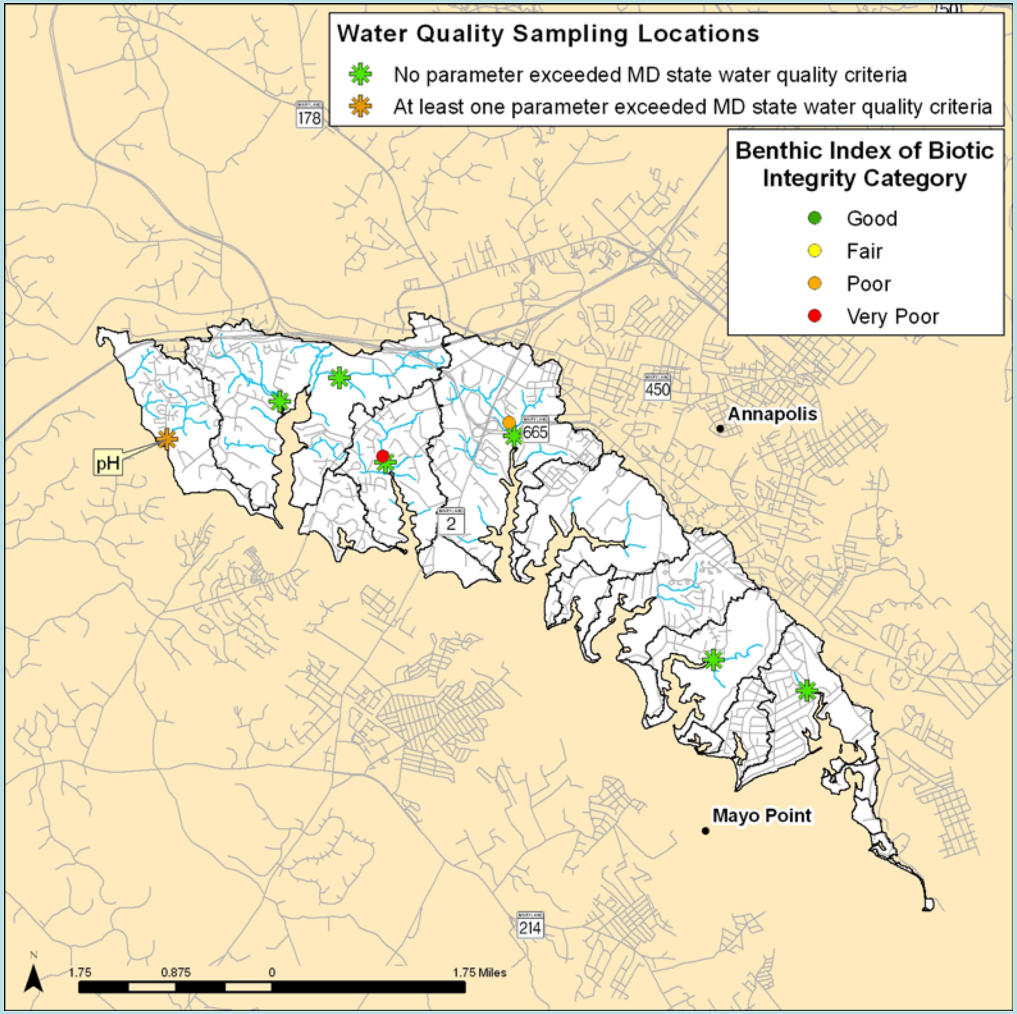
	A	B	C	D	DA	E	F	G
Entrchmnt.	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.2	n/a	variable	> 1.5	> 1.2	> 1.2
Slope	.04-.099	.02-.039	< .02	< .04	<.005	< .02	< .02	.02-.039

Rosgen Channel Type Definitions

Rosgen stream classifications are a widely used method of classifying channel types based on similar morphological characteristics, with the goal of predicting hydrologic behavior. Thirty-eight percent of the assessed perennial streams in the north shore cluster are Type B channels, which are very stable, moderate gradient channels with low sinuosity and low erosion rates. Twenty-five percent are Type C channels, which exhibit a well developed floodplain, higher sinuosity and susceptibility to de-stabilization when flow regimes are altered. The remainder are Type E, F and G channels, of which the later two channel types are generally not stable and are related to high sediment supplies which generates from accelerated stream bank erosion and channel incision process.

South River Watershed: North Shore Cluster

Water Quality and Bioassessment



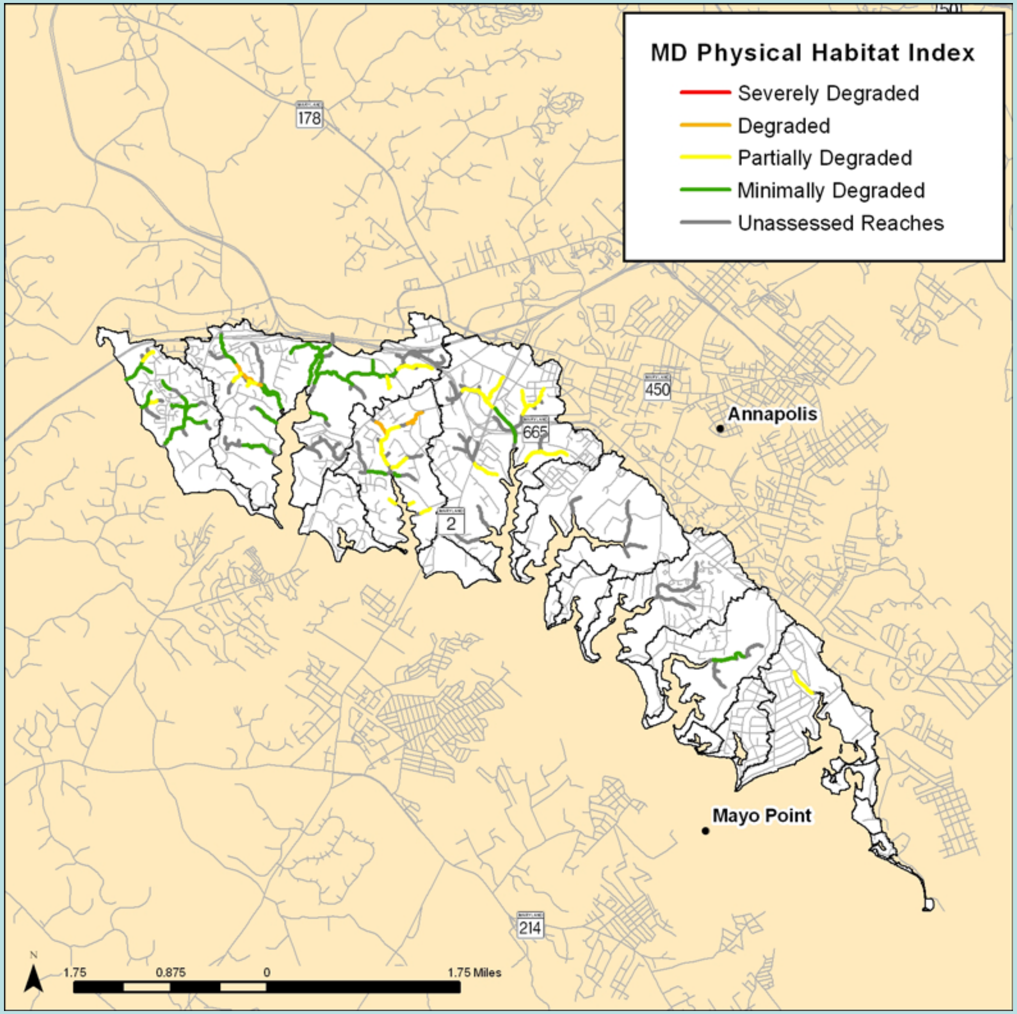
The County assessed the baseflow chemical water quality for each subwatershed in the Spring of 2006. Samples were taken to characterize pollutant concentrations and estimate baseflow pollutant loads. In the north shore cluster of South River, the average concentration of Fecal coliforms was elevated due to high single sample concentrations at two of the seven sampling locations. Otherwise, water quality was good with only one site where the pH fell below acceptable MD state water quality criteria.

Parameter	Average Concentration		MD State Water Quality Criteria
TKN	0.250	mg/l	
Total Nitrogen	0.270	mg/l	
Total Phosphorus	0.246	mg/l	
Total Suspended Solids	9.00	mg/l	
Copper	5.000	ug/l	13 (acute) 9 (chronic)
Lead	5.00	ug/l	65 (acute) 2.5 (chronic)
Zinc	27.29	ug/l	120
Fecal coliforms	1210	col/100 ml	
pH	7.61		6.5 - 8.5
Dissolved Oxygen	7.14	mg/l	

In the spring of 2006, the County assessed the aquatic macro-invertebrate community by sampling at the most downstream, perennial location in each subwatershed. Typically as the quality of the water or habitat declines, the diversity and abundance of aquatic macroinvertebrates also declines, with pollution tolerant types becoming dominant. A Benthic Index of Biotic Integrity combines measures of diversity, numbers of intolerant types, and forms of feeding and locomotion to assess a stream's health. There were only two biological sampling sites in the north shore cluster of the South River, one rated in very poor condition and the second rated in poor condition.

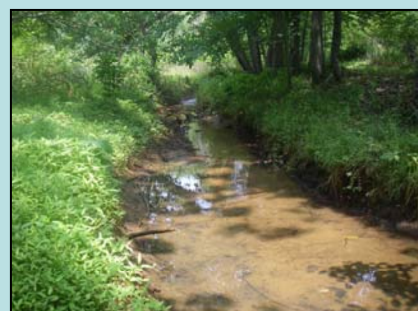
South River Watershed: North Shore Cluster

Habitat Assessment



The Maryland Physical Habitat Index (MPHI) was used to assess the condition of perennial stream habitat in 2006. The MPHI incorporates measures of fish and aquatic macroinvertebrate habitat availability and quality, shading, remoteness and bank stability. For the north shore cluster, habitat quality was good with 58% of perennial streams in the minimally degraded category. Thirty-six percent were in the partially degraded category, and the remaining 6% were degraded. Forty-seven percent of the total stream miles within the north shore cluster were not assessed because they were not perennial streams. Of this unassessed portion, 49% were ephemeral or intermittent channels and 13% were wetlands. The remaining 38% were primarily stormwater related.

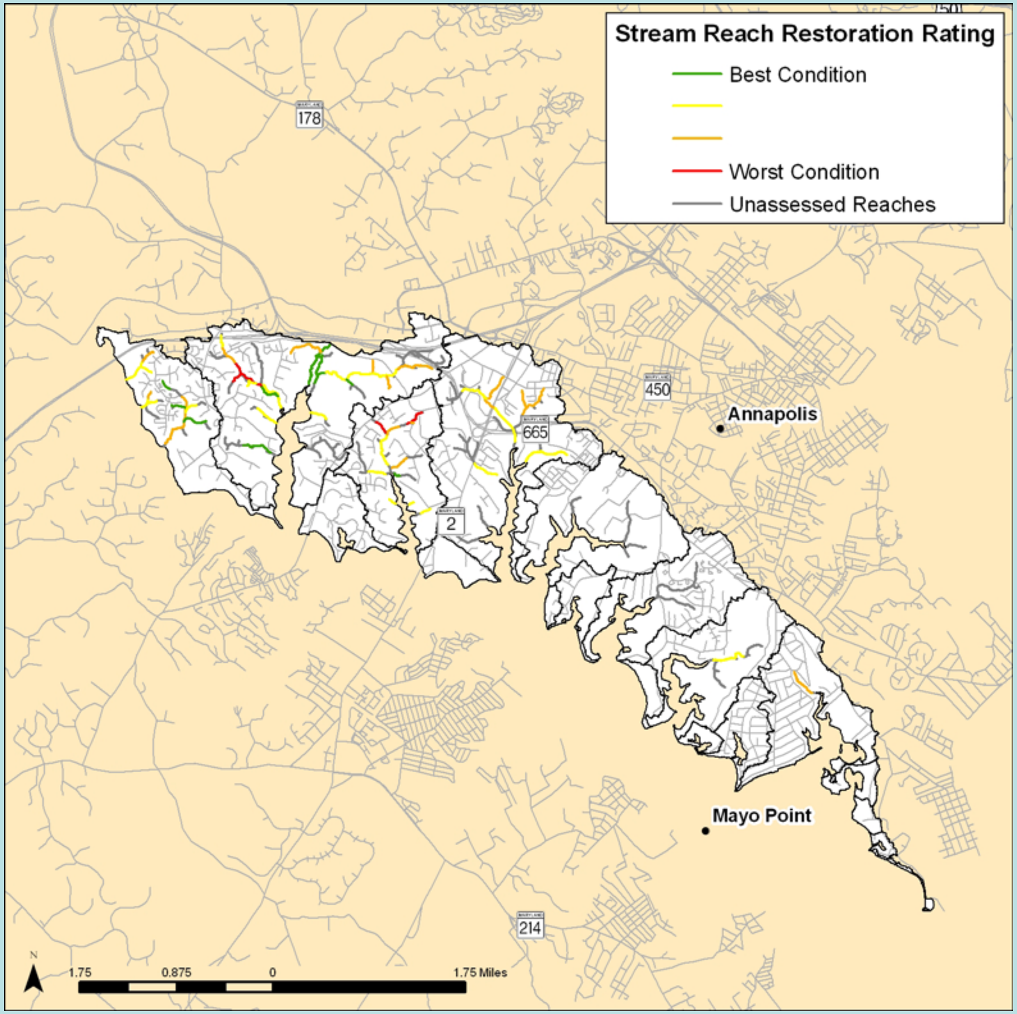
Degraded stream reach in the north shore cluster of South River (GVC)



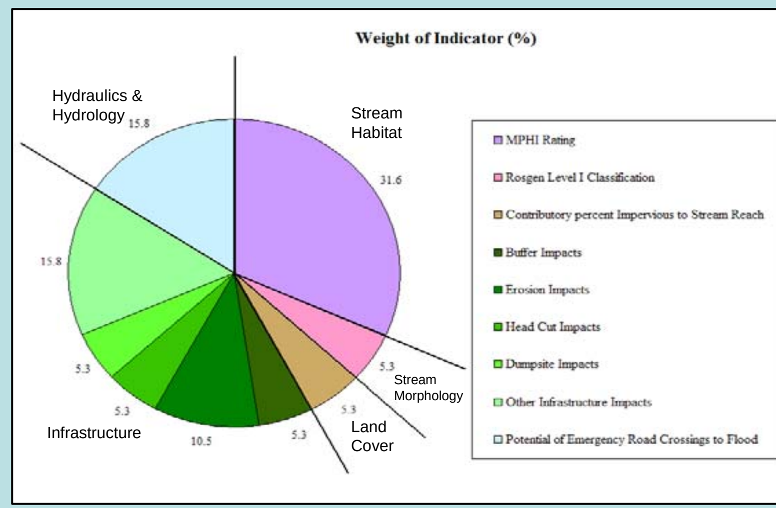
Minimally degraded stream reach in the north shore cluster of South River (BD1)

South River Watershed: North Shore Cluster

Reach Restoration Assessment

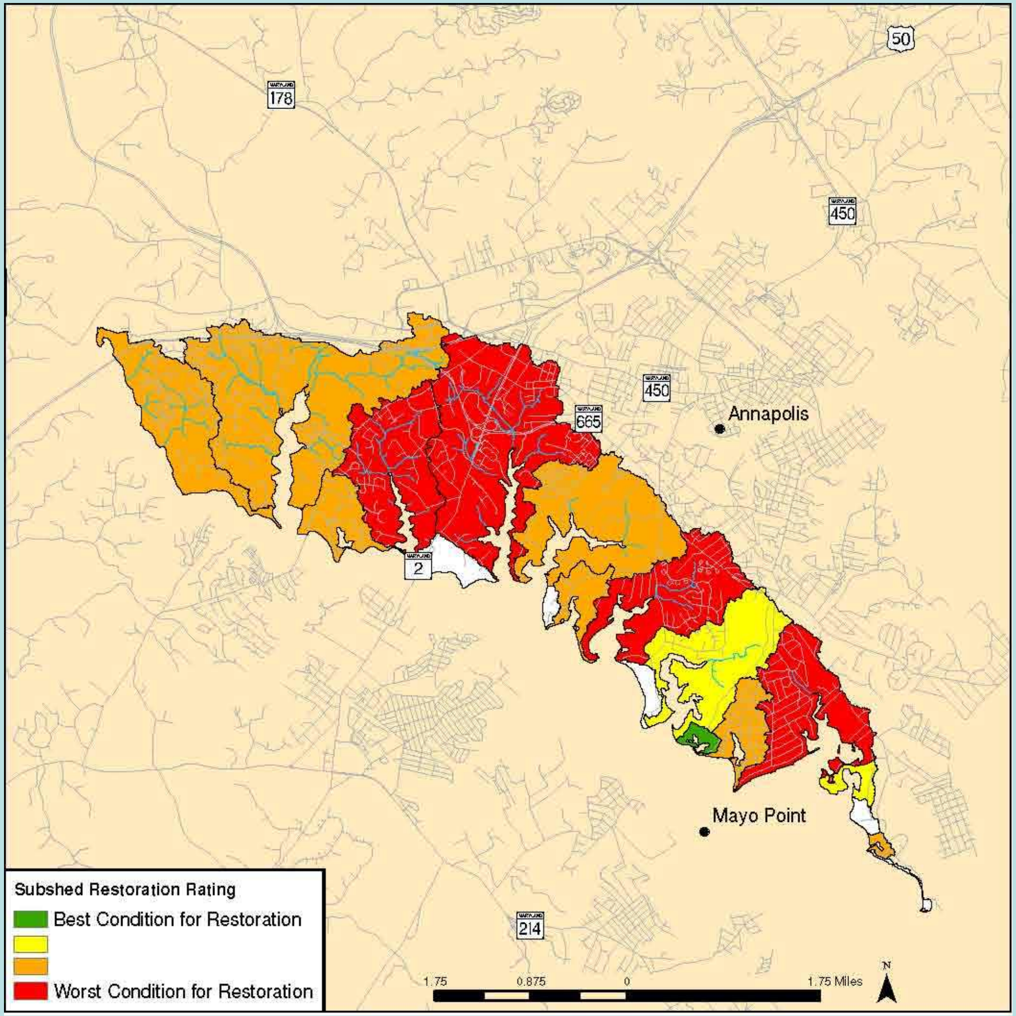


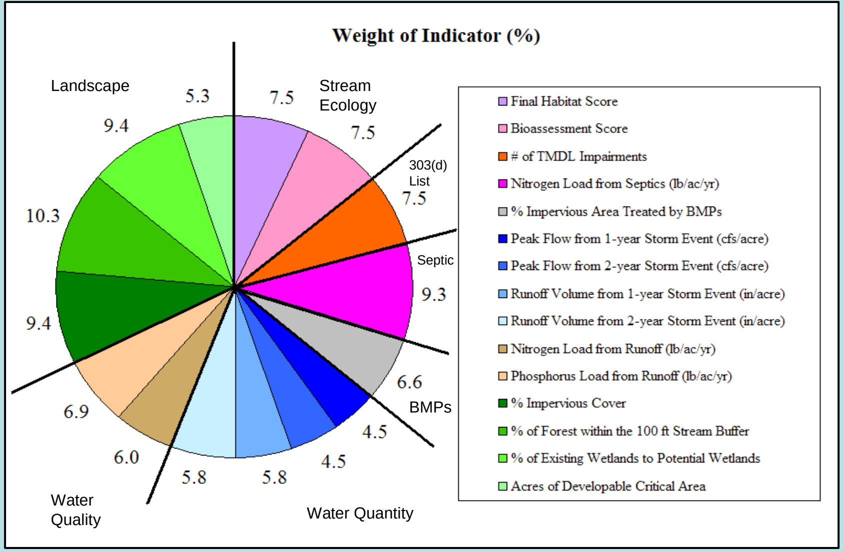
In 2006, the County assessed and rated individual stream reaches in the South River watershed and rated them according to physical habitat quality, channel morphology, impervious land cover and the impact of infrastructure features such as dumpsites and deficient stream buffers. Indicators were weighted based on their impact on stream integrity. In the north shore cluster of the South River, approximately 6% of the assessed stream reaches were determined to be in the "worst condition" and 18% were in the "best condition" rating group as compared to other streams in the South River Watershed. The individual ratings are used to guide the County in allocating financial resources to both restore impaired stream reaches and meet environmental regulatory requirements.



South River Watershed: North Shore Cluster

Subwatershed Restoration Assessment

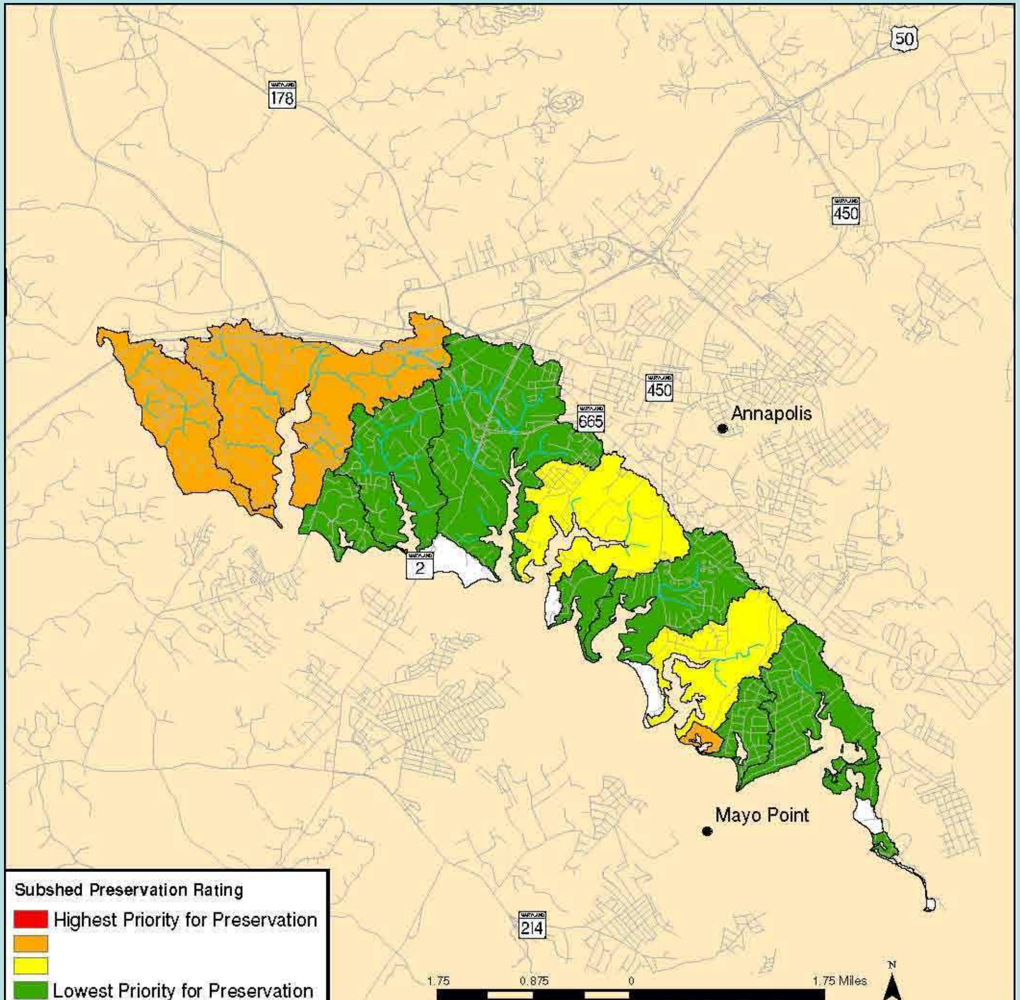


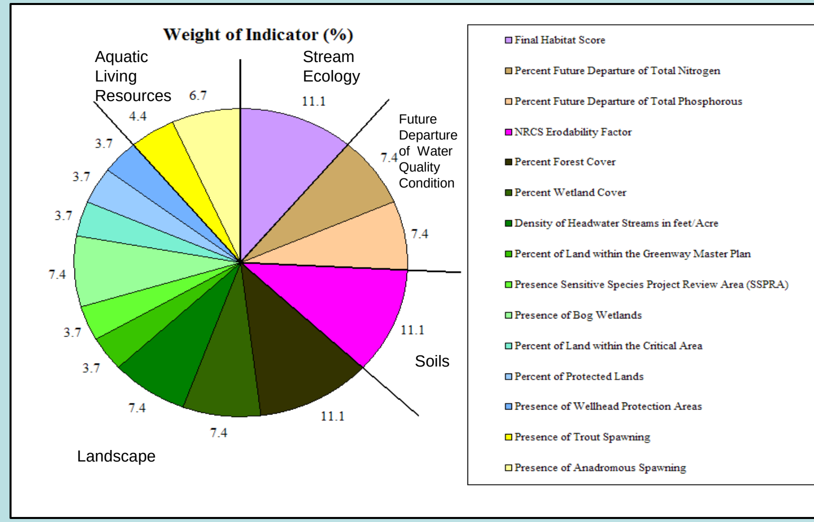


By examining indicators such as water quality and quantity, landscape, stream ecology and percent impervious treated by stormwater controls, the county assessed each subwatershed to focus resources based on a subwatershed rating. Four subwatersheds are rated in the "Worst Condition" category within the north shore cluster. These four subwatersheds have the highest residential and commercial development percentages when compared with the remainder of the cluster.

South River Watershed: North Shore Cluster

Subwatershed Preservation Assessment

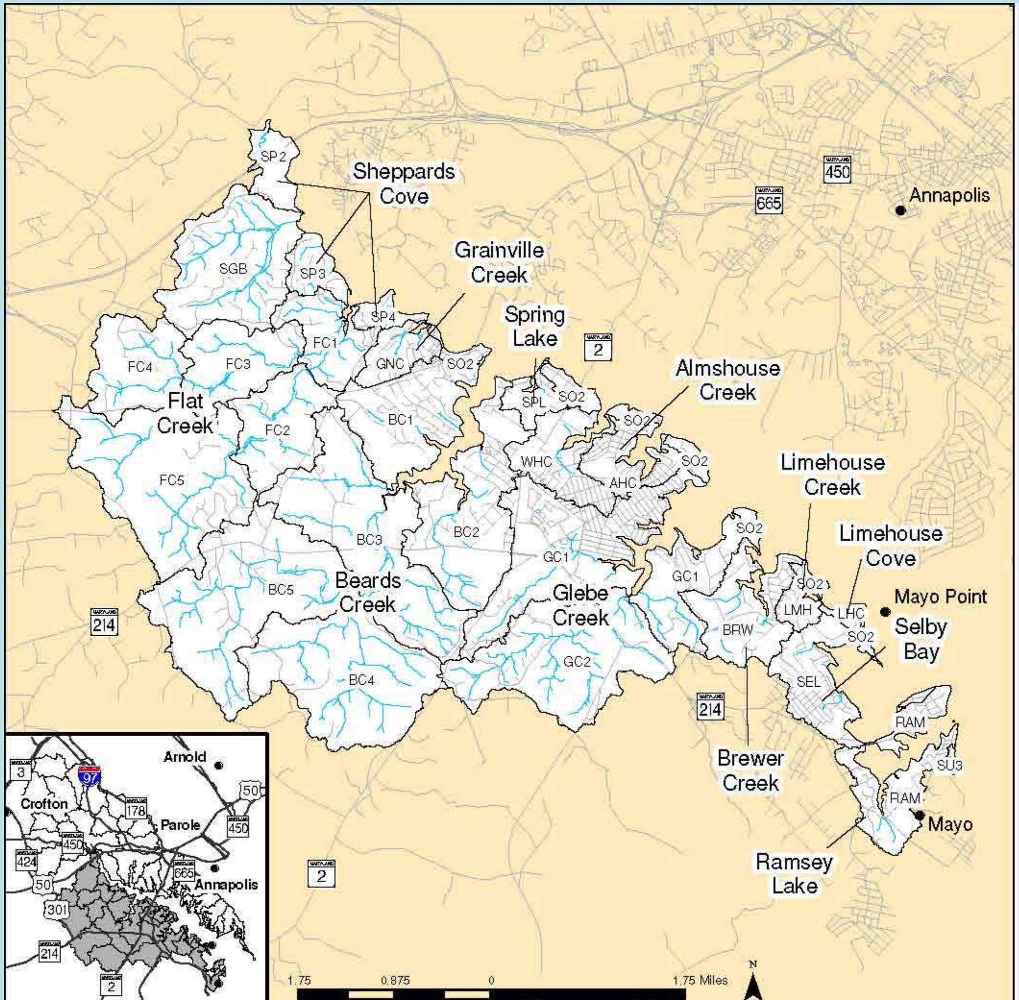




By examining indicators such as stream habitat, water quality, and the presence of sensitive land types such as wetlands, greenways, and protected habitats, among others, the County assessed individual subwatersheds and rated them to help focus resources for preserving those that are most sensitive. None of the subwatersheds in the north shore cluster fall within the highest priority for preservation group. The results of this assessment can be attributed to the significant amount of development within the subwatersheds of this cluster.

South River Watershed: South Shore Cluster

Overview

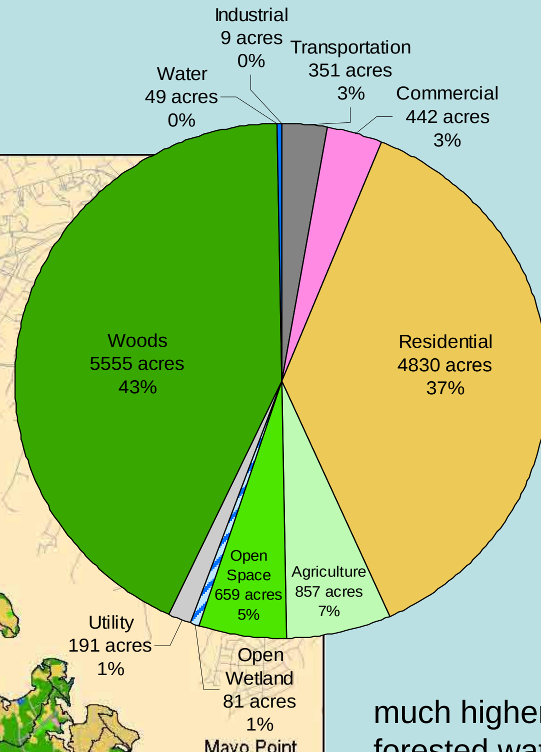


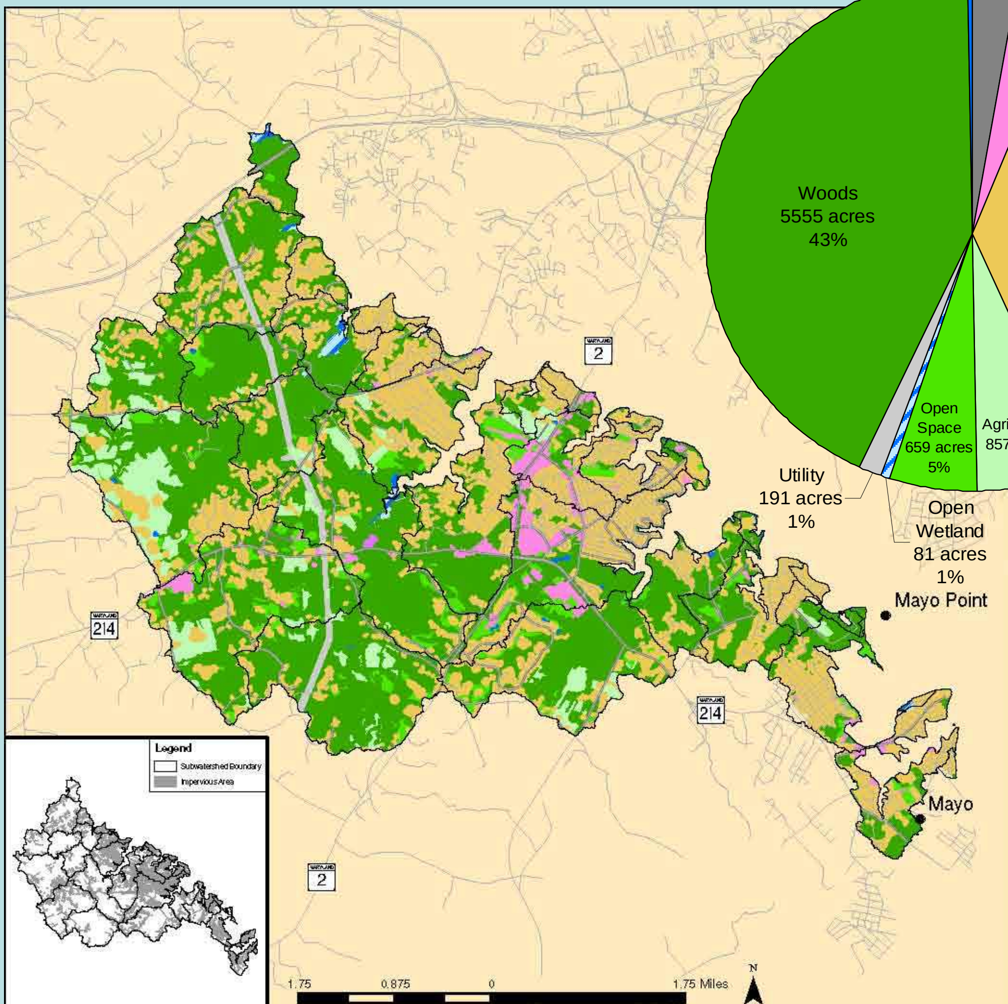
The south shore cluster of the South River Watershed lies completely within Anne Arundel County. The waters within this portion of the watershed drain either directly or indirectly to the South River, which discharges to the Chesapeake Bay. Therefore the activities that occur within this portion of the watershed have a direct impact on the Chesapeake.

The south shore cluster is approximately 13,000 acres in size and has 69.8 miles of waterways. This cluster contains 12 major streams. The area is highly populated and includes a number of small parks and a small regional airport. There is a high residential concentration in the subwatersheds that are directly adjacent to the South Rive. There is also a significant utility corridor that bisects several of the subwatersheds within this cluster. The remainder of the land area of this cluster has a significant amount of contiguous forested land.

South River Watershed: South Shore Cluster

Land Cover





Land cover conditions play an important role in non-point source pollutant loading to streams. Agricultural and residential lawns may be sources of nutrients and bacteria, while urban development increases the potential for runoff. Land cover can also affect pollutant removal. In a forested watershed, precipitation is absorbed by the tree canopy, lost to the air through evapotranspiration, and infiltrates into the ground to recharge ground water. Surface runoff is usually much higher in agricultural watersheds than in forested watersheds and even higher in urban watersheds, which leads to increased pollutant loads. Land cover in the south shore cluster of the South River Watershed is 43% forest which has a larger pollutant removal capability than other land covers. Thirty-seven percent of the watershed has residential cover which may contribute pollutants to the receiving waterways.

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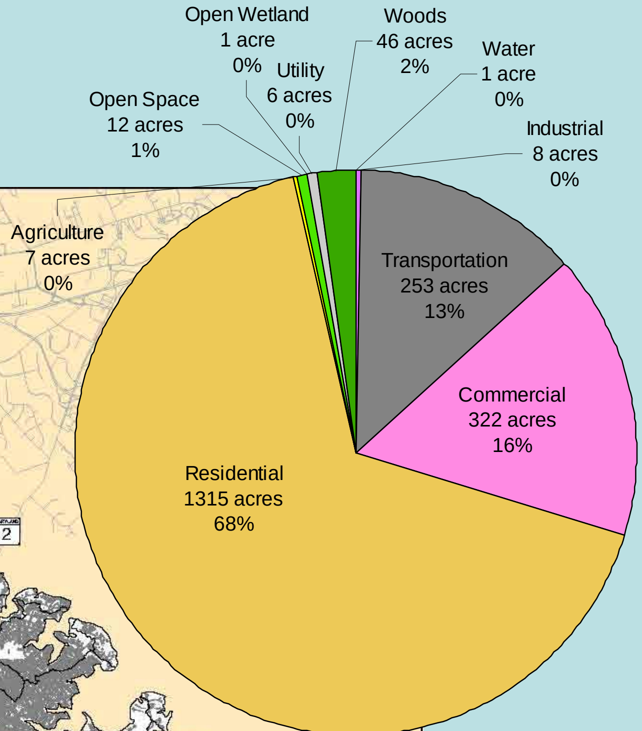
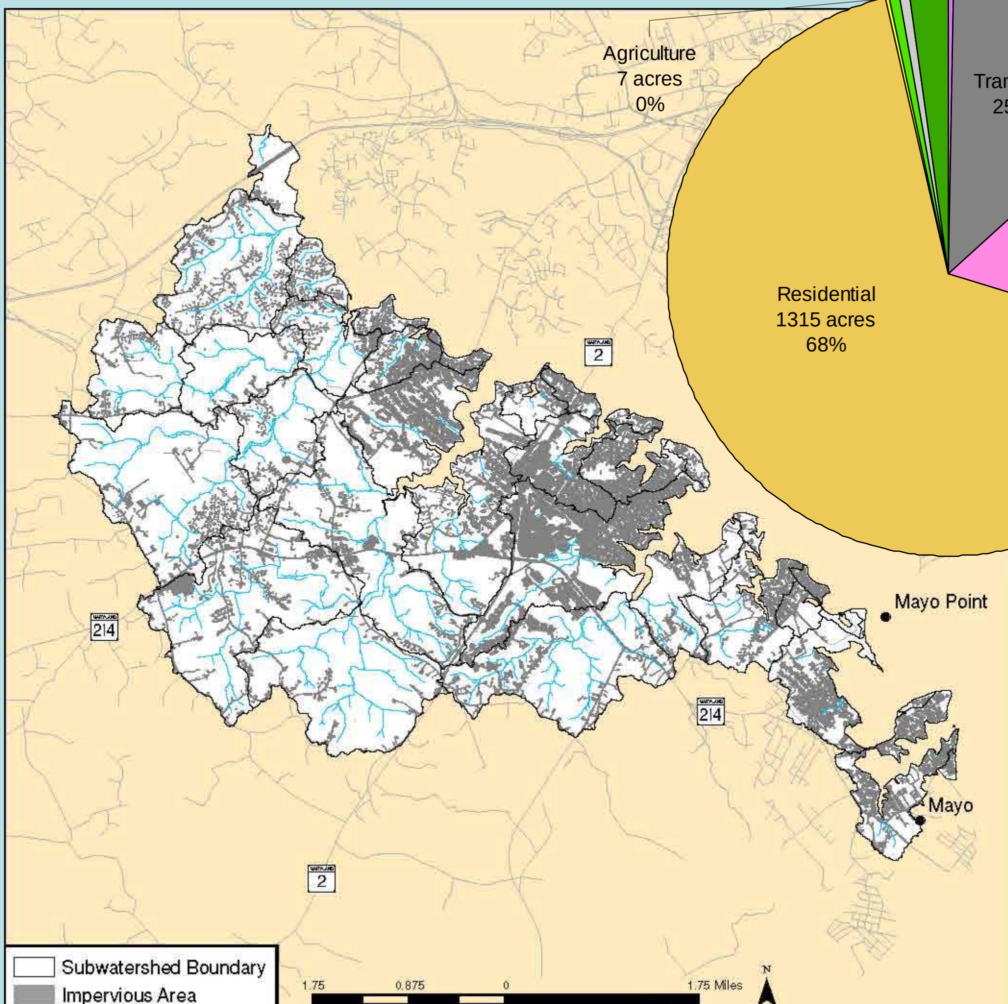
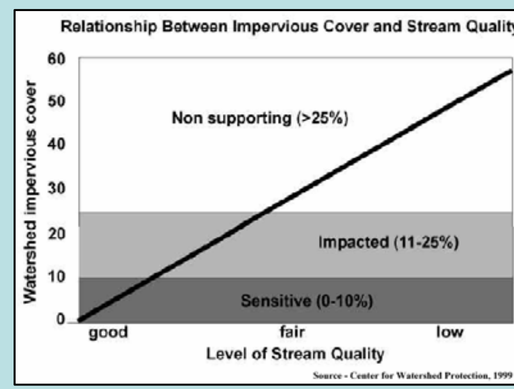
South River Watershed: South Shore Cluster

Impervious Surfaces





Impervious surfaces, such as pavements and rooftops, prevent rainfall from seeping into the ground, resulting in the potential for large volumes of stormwater to run off more rapidly and more directly into the receiving streams. Pollutants carried with this runoff can reduce water quality and negatively impact stream health. Research shows that as the impervious surface area in a watershed increases, the ecological integrity of streams deteriorates. Streams that receive large volumes of rapidly flowing stormwater are also susceptible to flooding and channel erosion. The land in the south shore cluster is 15% impervious, signifying that the stream health is impacted by the surrounding impervious surface and the level of stream quality is fair. The majority (68%) of the impervious land cover is within residential areas. The most significant impervious areas are those in subwatersheds adjacent to the South River maintstem.



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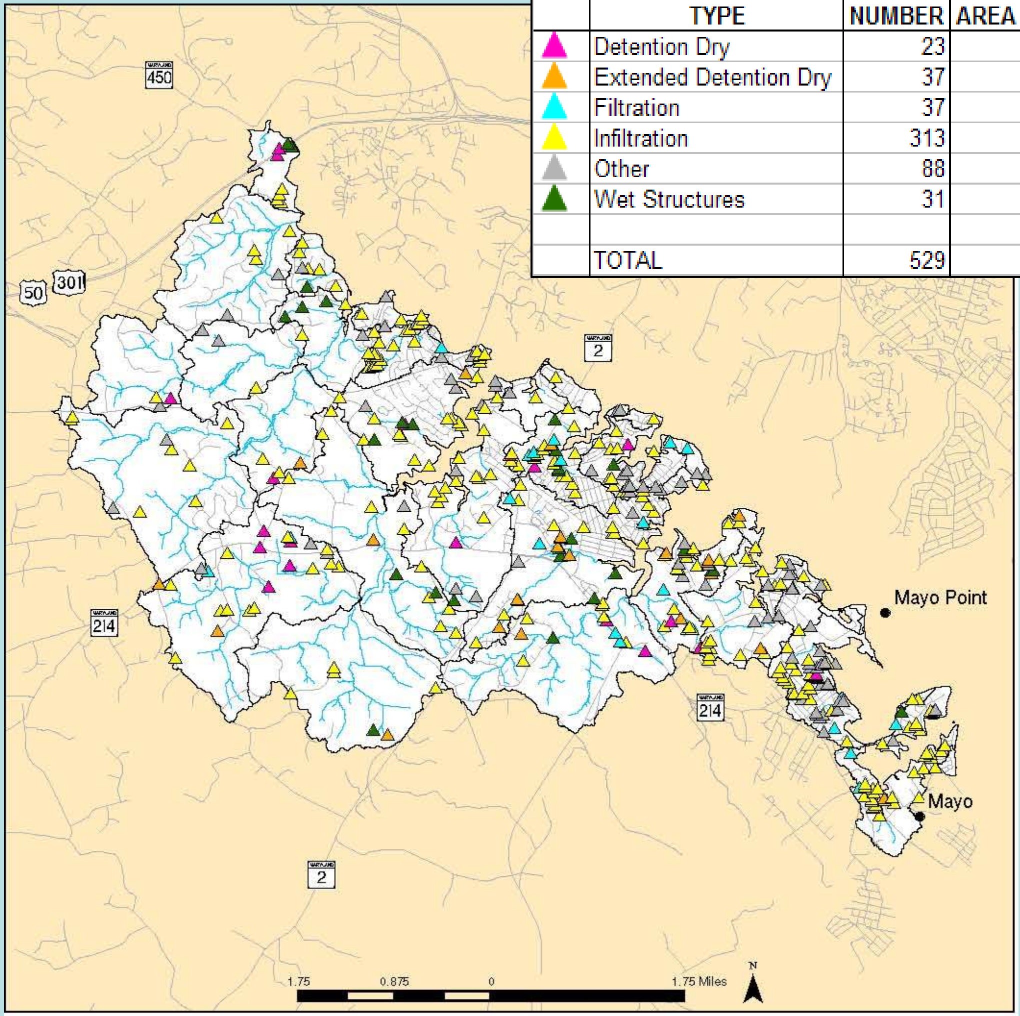
South River Watershed: South Shore Cluster

Stormwater Controls

	TYPE	NUMBER	DRAINAGE AREA (acres)	% of TOTAL CLUSTER TREATED
▲	Detention Dry	23	346.4	2.66%
▲	Extended Detention Dry	37	318.7	2.45%
▲	Filtration	37	59.7	0.46%
▲	Infiltration	313	267.5	2.06%
▲	Other	88	20.8	0.16%
▲	Wet Structures	31	296.9	2.28%
	TOTAL	529	1309.9	10.08%



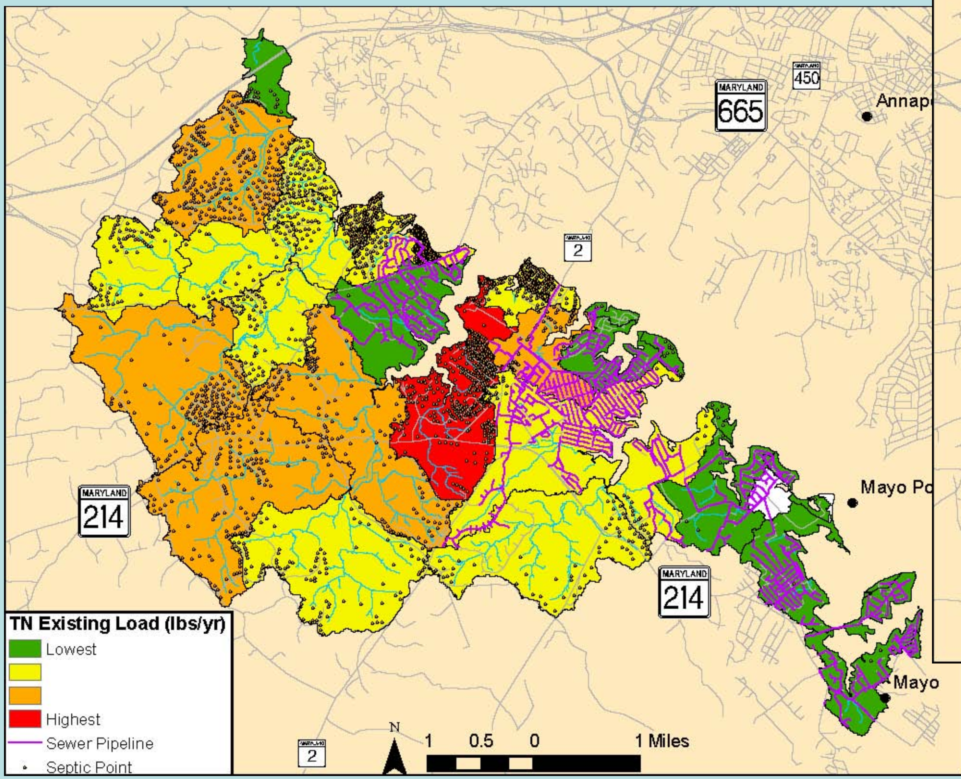
Stormwater controls are engineered structures or landscape enhancements that are used to manage local stormwater. They are important for controlling and minimizing the effects of excess stormwater runoff including flooding, erosion, and stream pollution. The controls in the south shore cluster treat approximately 10% of the land in this cluster which equates to 23% of the urban land cover in this region. Of the 5,600 acres of urban land cover in this cluster, 33% is impervious.

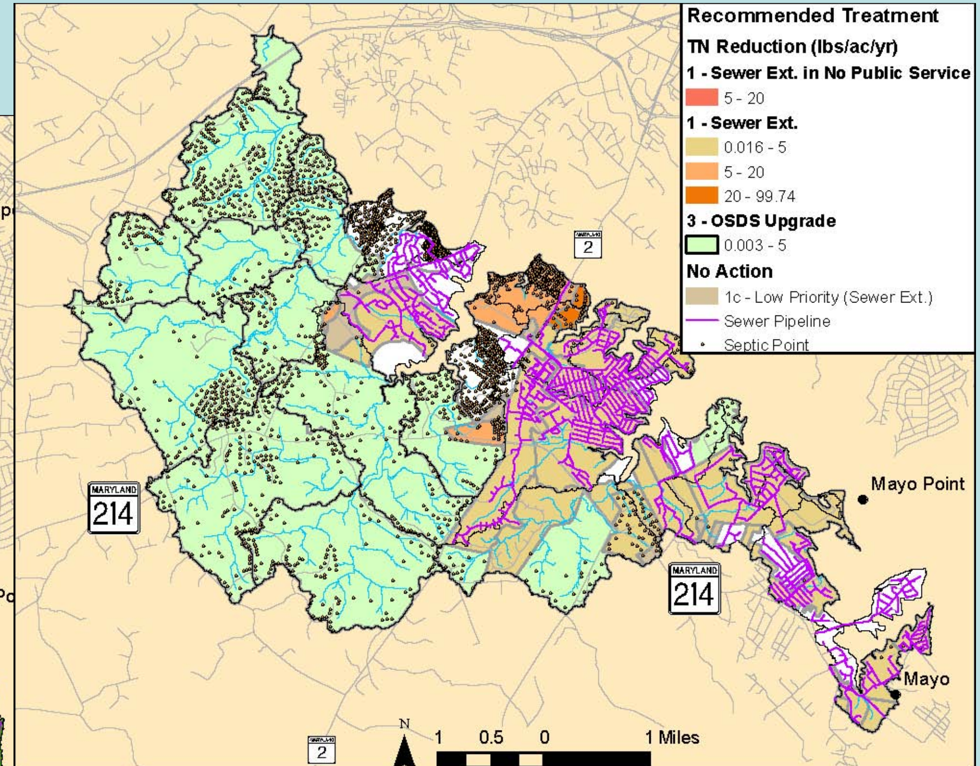
Stormwater detention ponds are wet structures that are often used to capture and detain stormwater runoff from residential and commercial areas.

Filtration practices capture stormwater and allow it to seep into a treatment media then infiltrate to the groundwater. This rain garden helps capture and filter runoff from a parking lot.

South River Watershed: South Shore Cluster

Septic System Issues





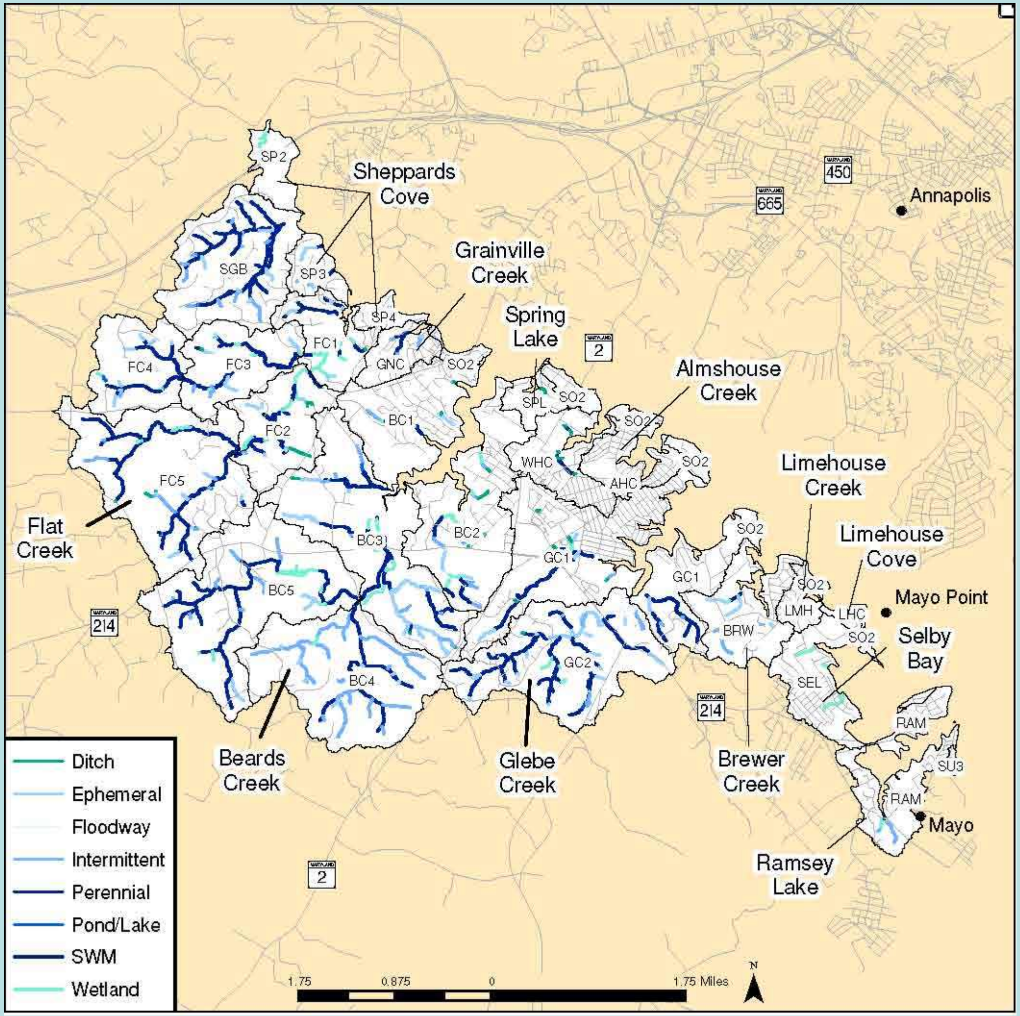
There are 2,334 OSDS in the South Shore Cluster, contributing 51,900 lbs per year of nitrogen. More than half of them are recommended for an OSDS upgrade with enhanced nitrogen removal.

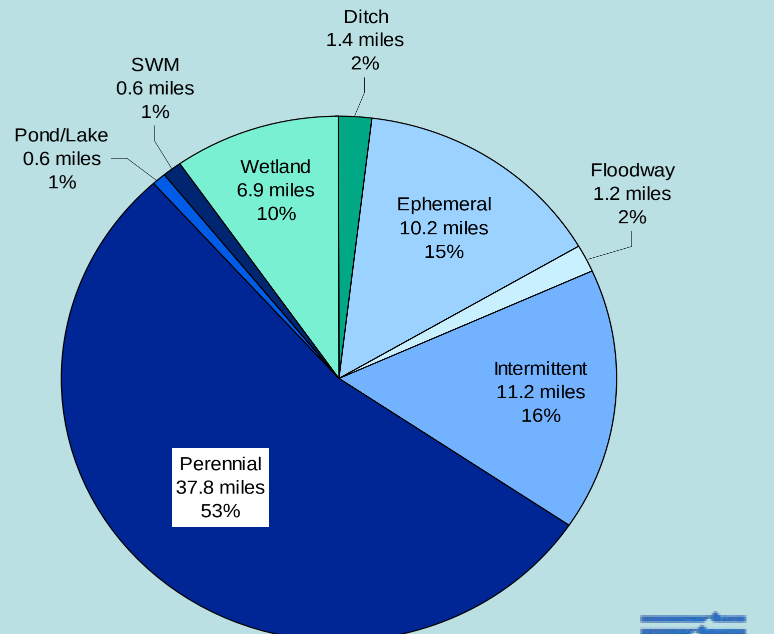
Anne Arundel County completed a countywide evaluation of service options for properties with Onsite Sewage Disposal Systems (OSDS or septic systems) in March 2008. The evaluation and resulting strategic plan identified the most cost-effective approach to reducing nitrogen loads from OSDS systems that is consistent with the County's goals. Treatment alternatives examined included sewer extension to an existing water reclamation facility (WRF) (both in areas of no public service and areas with sewer system existing), cluster type of community sewer service, OSDS upgrades with enhanced nitrogen removal, and no action meaning maintain existing septic system. Sewer extension will reduce the nitrogen load of those facilities to zero because there are no WRFs in the South River watershed. Cluster treatment will reduce the load by 92%. An OSDS upgrade will reduce the load by 50%.

South River Watershed: South Shore Cluster

Stream Reach Overview

The stream planimetric layer of 2002 was updated in 2006 during the stream walks. The south shore cluster of the South River Watershed contains 69.8 miles of waterways. Over half of the streams are perennial (those that flow year round). Wetland and streams which flow only during part of the year are called intermittent (fed by groundwater) and ephemeral (flow in response to precipitation) streams and make up the remaining portion of the streams found in the south shore cluster. The assessed waterways exclude the mainstem of the South River as well as all tidally influenced stream channels.





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South River Watershed: South Shore Cluster

Inventory of Infrastructure and Environmental Features

Significant infrastructure and environmental features were inventoried in 2006 along the assessed streams and scored based on their impact on overall stream health. Of the 942 total data points only 3%, primarily erosion sites, were considered to have an extreme impact. Overall 78% were considered to have moderate to minor impact. Thirty percent of the total number of points were pipes and ditches with only minor impact. There is the potential for a negative cumulative effect from these pipe and ditch points on the physical stability and biological health of the South River stream system.

		Impact Score			
Feature Type	**Total**	*Extreme*	*Severe*	*Moderate*	*Minor*
Deficient Buffer	122	3	31	88	
Crossing	175	1	4	26	144
Pipes and Ditches	309		3	27	279
Dumpsites	23		3	10	10
Erosion	310	26	138	146	
Utility	3			1	1

Deficient Buffer with extreme impact score located near North Carolina Avenue.

Crossing with extreme impact score located east of Brick Church Road.

Pipe/Ditch with severe impact score located near the end of Aisquith Farm Road.

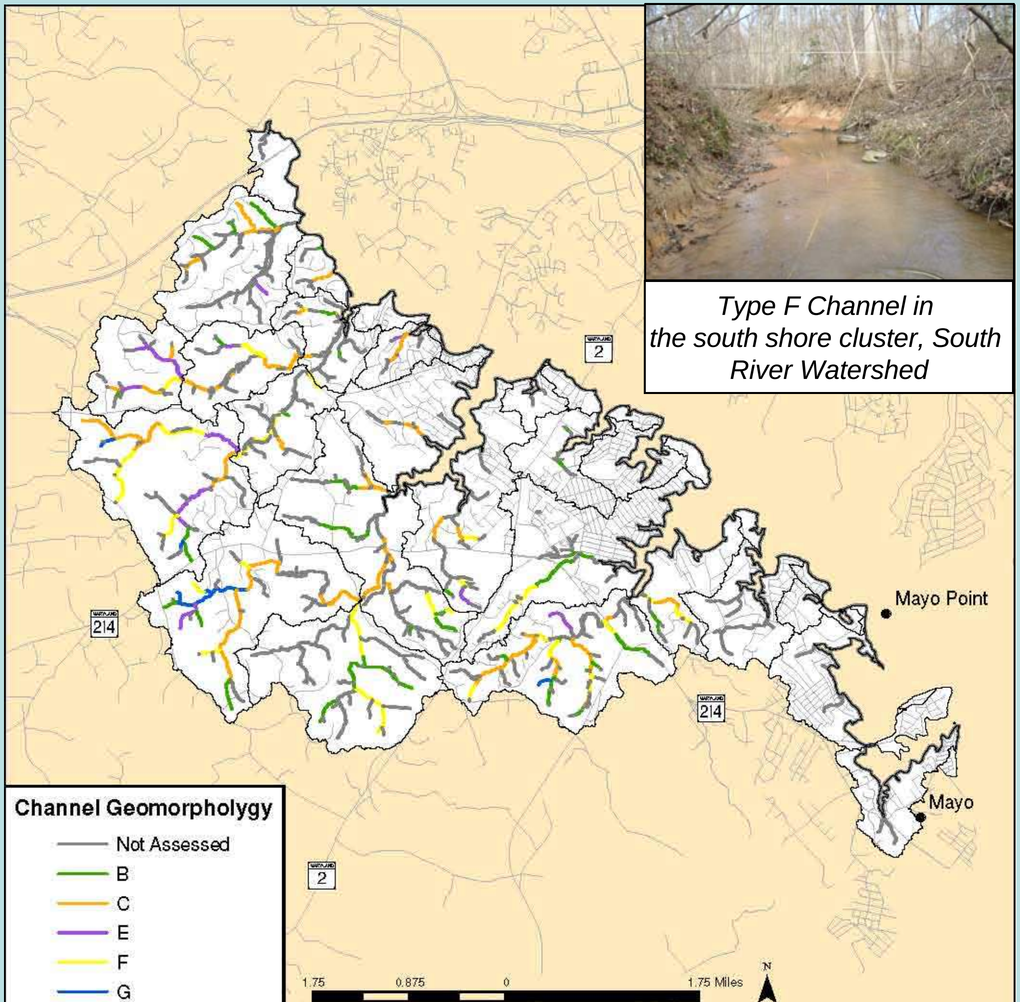
Dumpsite with severe impact score located southeast of Brick Church Road.

Erosion with extreme impact score located south of Governor Bridge Road.

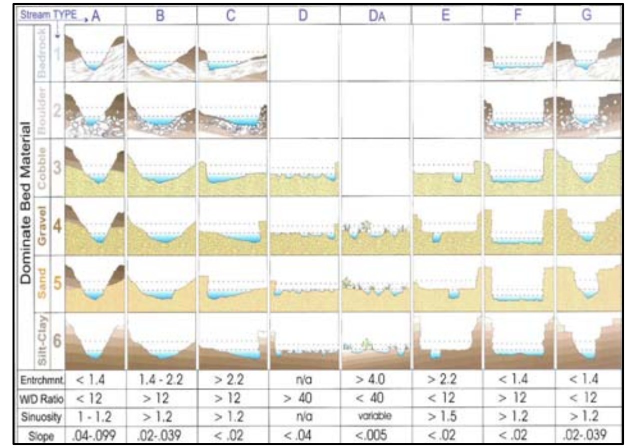
Utility with moderate impact score located near the end of Cove Road.

South River Watershed: South Shore Cluster

Channel Geomorphology



Type F Channel in the south shore cluster, South River Watershed

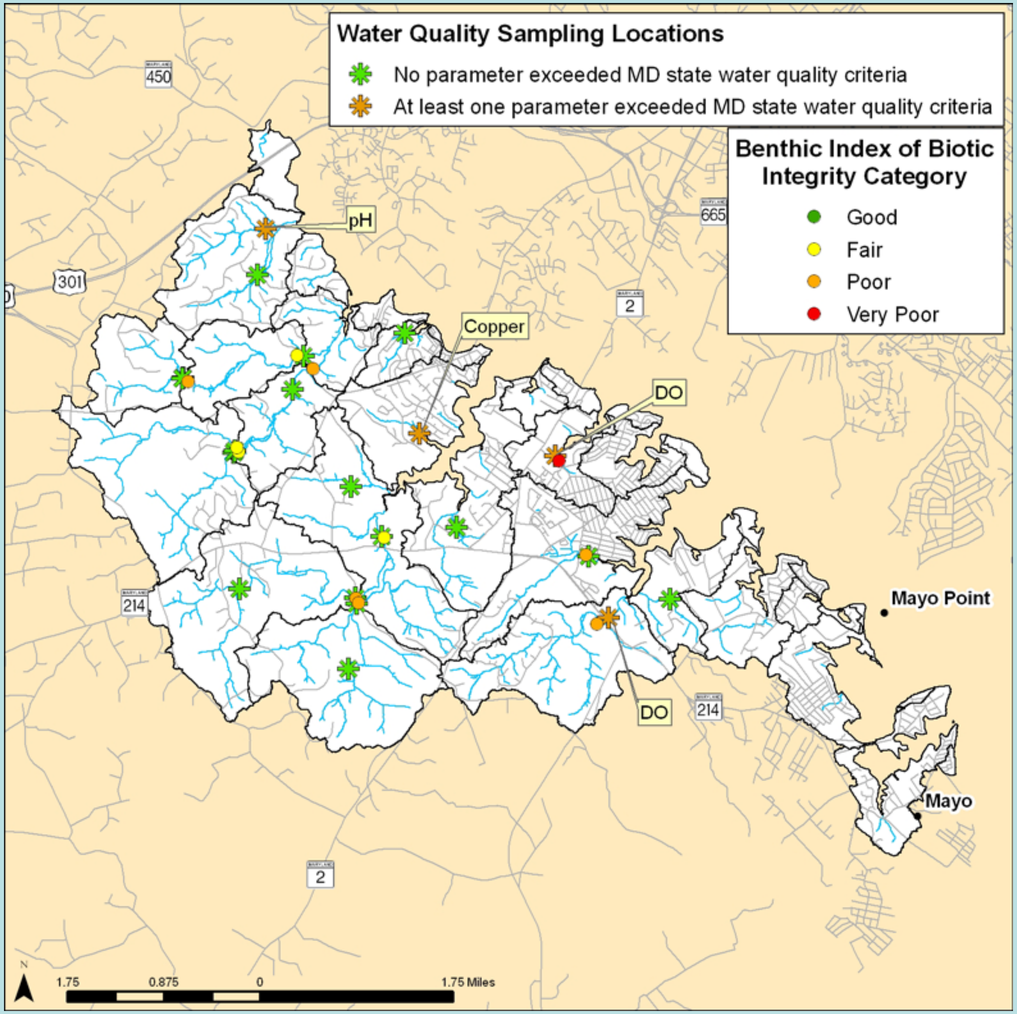


Rosgen Channel Type Definitions

Rosgen stream classifications are a widely used method of classifying channel types based on similar morphological characteristics, with the goal of predicting hydrologic behavior. Twenty-nine percent of the assessed perennial streams in the south shore cluster are Type B channels, which are very stable, moderate gradient channels with low sinuosity and low erosion rates. Thirty-three percent are Type C channels, which exhibit a well developed floodplain, higher sinuosity and susceptibility to de-stabilization when flow regimes are altered. The remainder are Type E, F and G channels. Type E channels are very stable channels with a wide well developed floodplain and high sinuosity, whereas Type F & G channels are generally not stable and are related to high sediment supplies which generates from accelerated stream bank erosion and channel incision processes.

South River Watershed: South Shore Cluster

Water Quality and Bioassessment



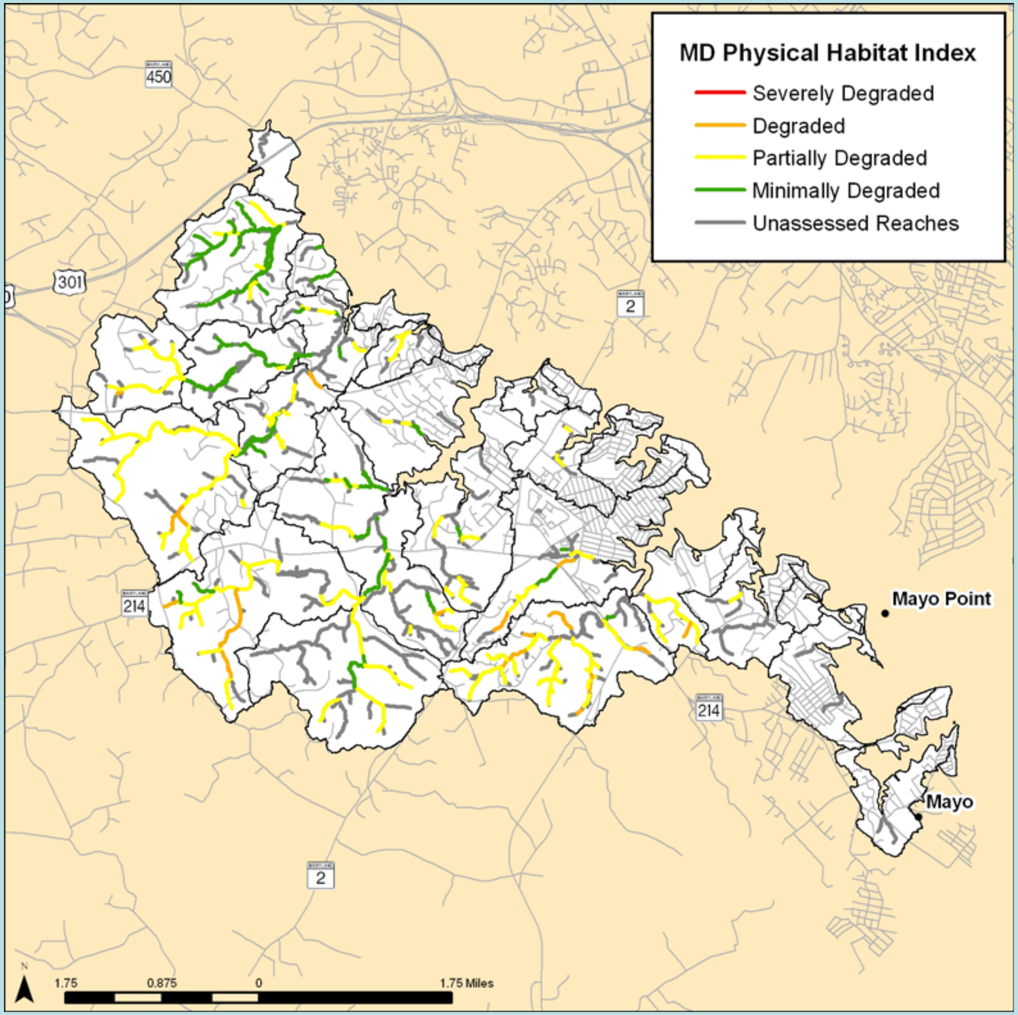
The County assessed the baseflow chemical water quality for each subwatershed in the Spring of 2006. Samples were taken to characterize pollutant concentrations and estimate baseflow pollutant loads. In general, water quality was good in the south shore cluster. Total nitrogen levels were higher than in the headwaters and north shore clusters. There was one site where pH exceeded criteria, and two sites where DO fell short of the minimum criteria. There was one site where copper exceeded MD state water quality criteria, was near to the exceedence level for lead, and also had a high level of zinc.

Parameter	Average Concentration		MD State Water Quality Criteria
TKN	0.276	mg/l	
Total Nitrogen	0.527	mg/l	
Total Phosphorus	0.312	mg/l	
Total Suspended Solids	6.81	mg/l	
Copper	5.571	ug/l	13 (acute) 9 (chronic)
Lead	7.62	ug/l	65 (acute) 2.5 (chronic)
Zinc	23.03	ug/l	120
Fecal coliforms	711	col/100 ml	
pH	7.36		6.5 - 8.5
Dissolved Oxygen	6.99	mg/l	

In the spring of 2006, the County assessed the aquatic macro-invertebrate community by sampling at the most downstream, perennial location in each subwatershed. Typically as the quality of the water or habitat declines, the diversity and abundance of aquatic macroinvertebrates also declines, with pollution tolerant types becoming dominant. A Benthic Index of Biotic Integrity combines measures of benthic community health to assess a stream's quality. south shore streams were generally in the poor range with seven sites rated poor, four rated fair condition and one in very poor condition. No sites had the highest level of biological health.

South River Watershed: South Shore Cluster

Habitat Assessment



The Maryland Physical Habitat Index (MPHI) was used to assess the condition of perennial stream habitat in 2006. The MPHI incorporates measures of fish and aquatic macroinvertebrate habitat availability and quality, shading, remoteness and bank stability. For the south shore cluster, habitat quality was acceptable. There were no perennial streams in the severely degraded category. Sixty percent of perennial streams were in the partially degraded category and 28% were minimally degraded. The remaining 10% were degraded. Forty-eight percent of the total stream miles within the south shore cluster were not assessed because they were not perennial streams. Of this unassessed portion, 62% was intermittent or ephemeral channels and 20% was wetland. The remaining 17% were primarily stormwater related.

Degraded stream reach in the south shore cluster of South River (GC2)

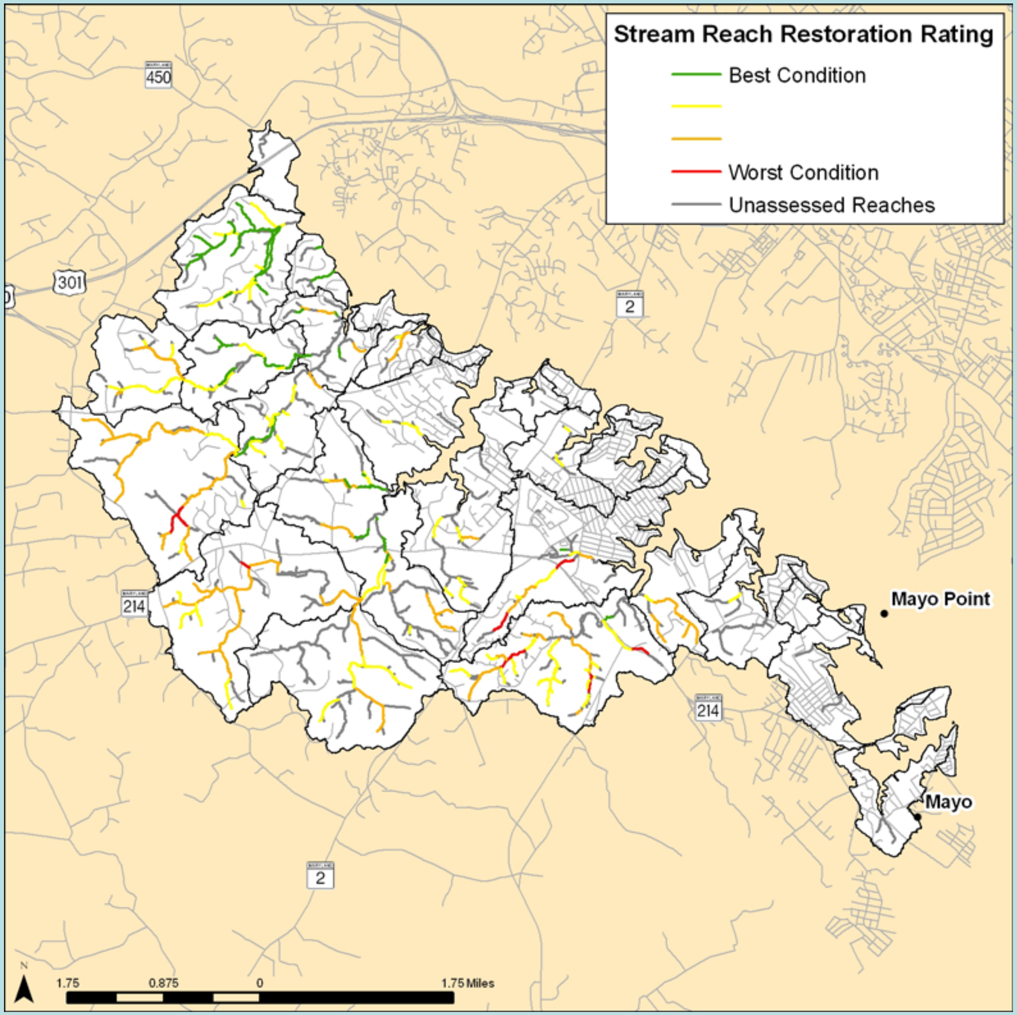
Minimally degraded stream reach in the south shore cluster of South River (BC3)

ANNE ARUNDEL COUNTY
MARYLAND

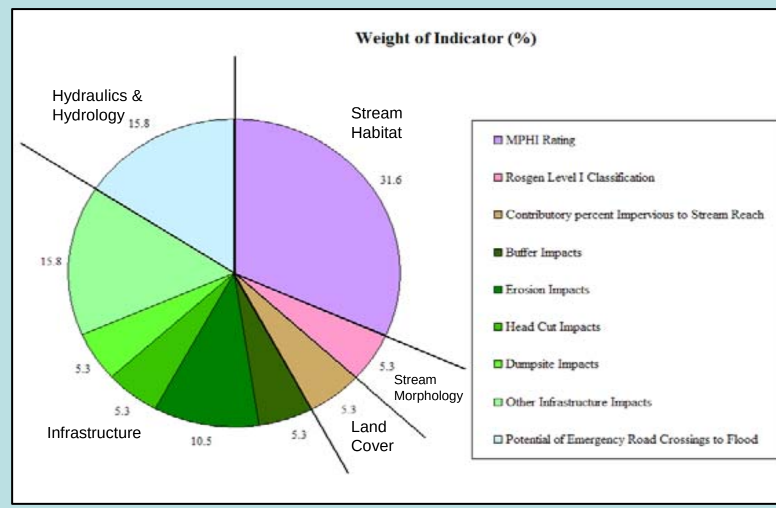
South River Watershed: South Shore Cluster

DPW

Reach Restoration Assessment



In 2006, the County assessed and rated individual stream reaches in the South River watershed and rated them according to physical habitat quality, channel morphology, impervious land cover and the impact of infrastructure features such as dumpsites and deficient stream buffers. Indicators were weighted based on their impact on stream integrity. In the south shore cluster of the South River, approximately 5% of the assessed stream reaches were determined to be in the "worst condition" and 18% were in the "best condition" rating group as compared to other streams in the South River Watershed. The individual ratings are used to guide the County in allocating financial resources to both restore impaired stream reaches and meet environmental regulatory requirements.



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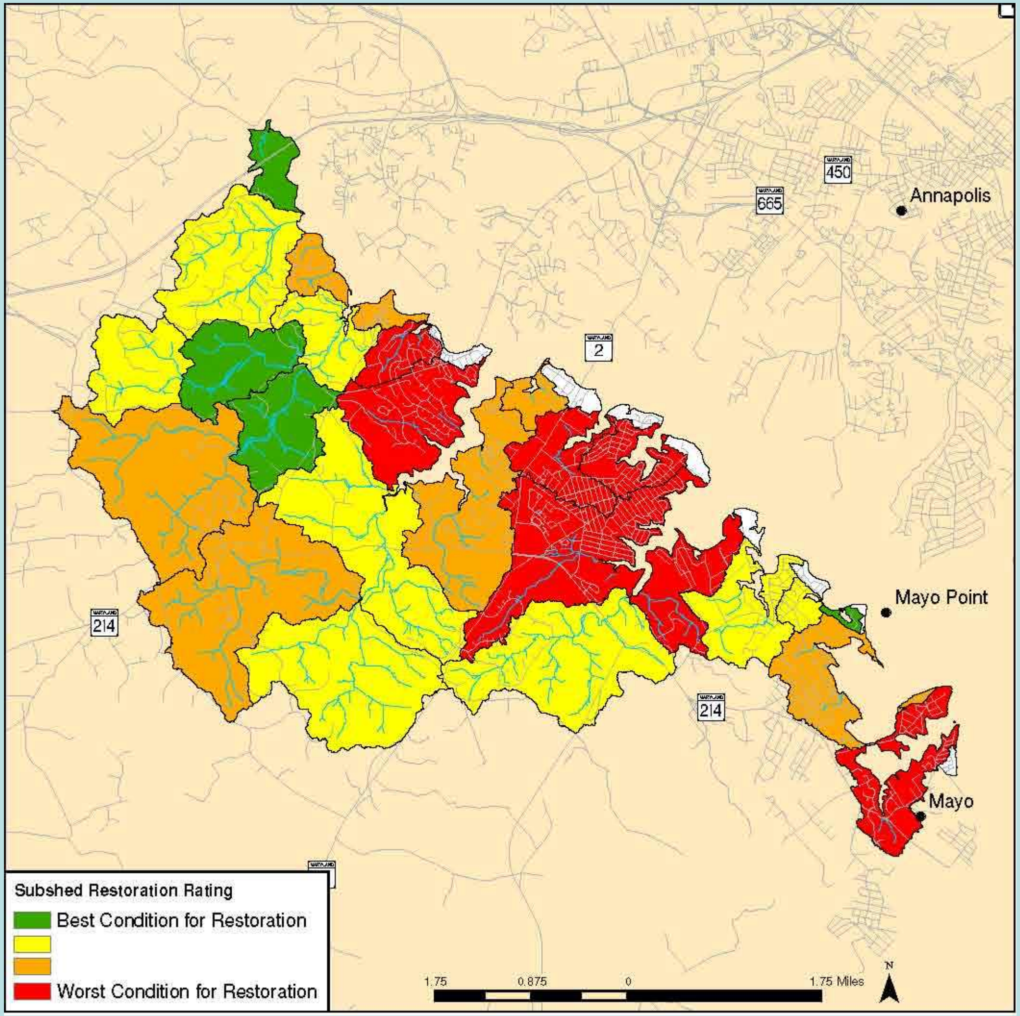
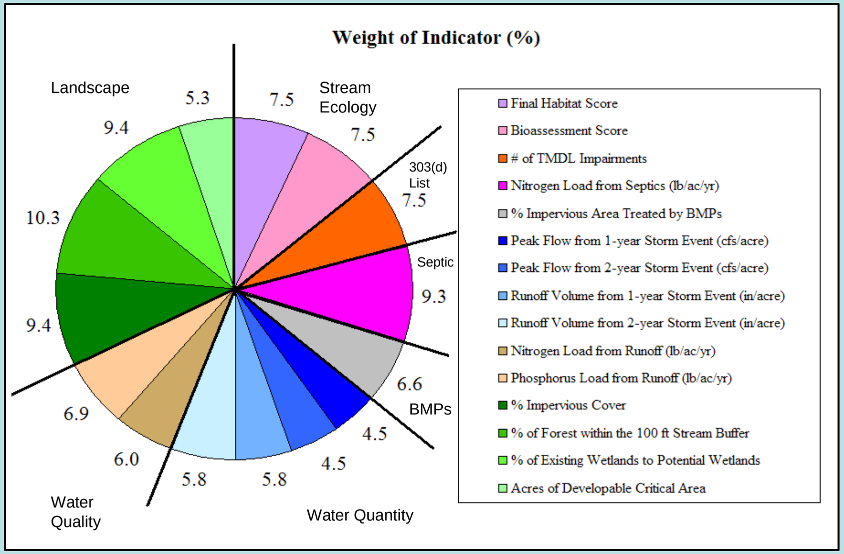
South River Watershed: South Shore Cluster

Subwatershed Restoration Assessment

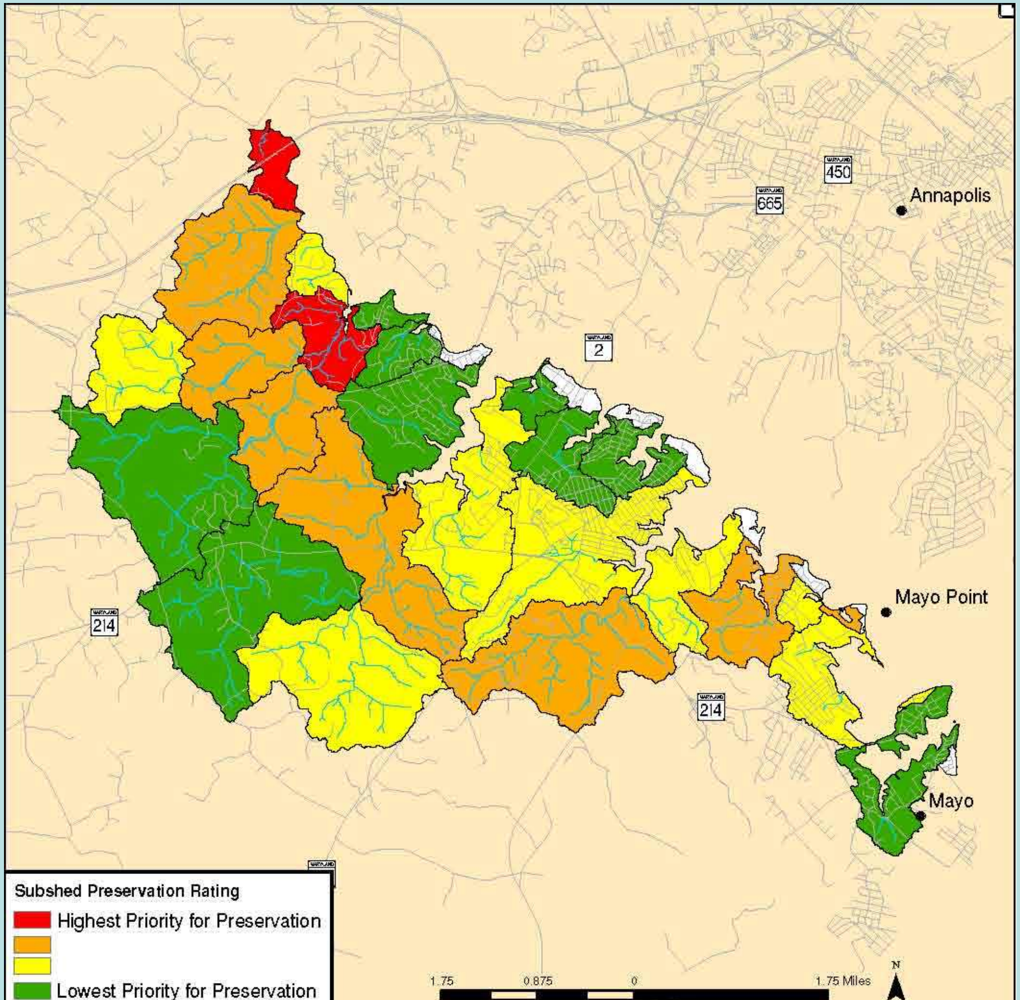


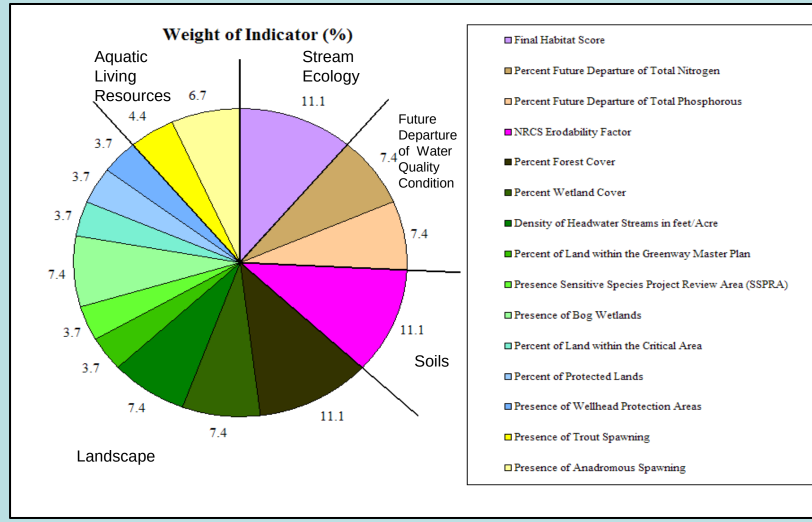


By examining indicators such as water quality and quantity, landscape, stream ecology and percent impervious treated by stormwater controls, the county assessed each subwatershed to focus resources based on a subwatersheds rating. Six subwatersheds are rated in the “Worst Condition” category within the south shore cluster. These six subwatersheds have the highest residential development and impervious surface percentages, when compared with the remainder of the cluster.

South River Watershed: South Shore Cluster

Subwatershed Preservation Assessment





By examining indicators such as stream habitat, water quality, and the presence of sensitive land types such as wetlands, greenways, and protected habitats among others, the County assessed individual subwatersheds and rated them to help focus resources for preserving those that are most sensitive. Only two of the subwatersheds in the north shore cluster fall within the highest priority for preservation group. The results of this assessment can be attributed to the significant amount of development within the subwatersheds of this cluster.

Appendix B
Supplementary Technical Memorandums

Changes in Maryland Physical Habitat Index from Severn River study to now

TO: Mary Searing/ OECR Anne Arundel Co.

COPIES: Mike Pieper/ KCI

FROM: Tara Ajello/ CH2M HILL

DATE: February 22, 2006

From the time the stream walks were begun during the Severn River Watershed Study to the time the last round of bioassessments were performed for that project, the Maryland Physical Habitat Index (MPHI) method had changed. At the time, the project team (County, KCI, and CH2M HILL) decided to keep with the 1999 MPHI methodologies and calculations so that data was consistent rather than take on the new calculations outlined in the 2003 MPHI methodology. A few years later, the new MPHI methodologies have become more established and accepted and many other municipalities are moving towards using them.

Below is a table describing some of the differences between the MPHI method developed in 1999 and used in the Severn stream walks, and the 2003 method. In addition to the differences in metrics that are collected between the 1999 version of MPHI and the 2003 version of MPHI, there are also differences in how the calculation is performed to get the actual habitat score.

Adding the 4 additional required metrics at the bottom of the table should not require additional field time. However, it will require additional office work regarding training and calculation the watershed area for each assessment point, or in this case, each habitat assessment reach. In addition, there will be compatibility issues with the current version of the Stream Assessment Tool as well as the data in the SAT. Additional programming of the SAT to include the additional fields (metrics) as well as to update the calculations could easily be performed under the current WMT Maintenance contract as needed. However, inconsistency of data would still exist because those bottom 4 metrics were not collected during the Severn River stream walks and new calculations could not be performed on that existing data. The regression equation, 2003 MPHI = 0.2368(1999 MPHI) + 53.331 can be used to calculate the new MPHI from the old, however there is error associated with this method and DNR recommends calculating the new MPHI value directly from the data.

Some of the major changes improvements between the two methods include

- A drainage area transformation for those metrics that are area dependent (epifaunal substrate, instream habitat, instream woody debris). The 1999 version rated small streams unfairly low.

- Metrics are now based on three regions (coastal plain, piedmont, highlands) rather than two as in the 1999 version (coastal plain, non-coastal plain).
- Embeddedness was removed as a metric, since there is naturally a lack of coarse sediments in coastal plain streams.
- More MBSS data was available for the metric development.
- Introduction of a measure of channel stability with the bank stability parameter.

TABLE: DIFFERENCES IN METRICS COLLECTED AND CALCULATED FOR MPHI METHODOLOGY

Metric	**Collected for Severn Stream Walk (2002)**	**Used In 1999 PHI Calculation**	**Collected for Severn Bioassessment (collected in 2003 but used 1999 PHI Calc)**	**In 2003 PHI Calculation**	**Recommended Collected for South River**
Instream Habitat	×	×	×	×	×
Epifaunal Substrate	×		×	×	×
Velocity/Depth Diversity	×	×	×		×
Pool/Glide/Eddy Quality	×	×	×		×
Riffle/Run Quality	×		×		×
Embeddedness	×	×	×		×
Shading	×		×	×	×
Trash Rating	×	×	×		×
Maximum Depth	×	×	×		×
Remoteness			×	×	×
Woody Debris/Rootwads*			×	×	×
Bank Stability**			×	×	×
Watershed Area***			×	×	×

* Woody Debris/Rootwads is a total number per a 75 meter reach, this metric would either be estimated from a representative 75m reach within the entire habitat reach, or be calculated by totaling all of the occurrences for the entire habitat reach and calculating the ratio

** a basic bank stability measure of stable, moderately stable, moderately unstable and unstable was collected during the Severn River stream walks, the bank stability measure listed here is measured more quantitative on a 0-20 scale.
*** calculated in office following fieldwork

The following provides more background on the changes in the 2003 PHI metrics as well as detail on the differences between the 1999 and 2003 calculations.

Taken from *Maryland Biological Stream Survey 2000-2004 Volume 6: Laboratory, Field and Analytical Methods. 2005.*

Physical Habitat Indicator
Physical stream habitat is the physical template upon which the biological structure of stream communities is built. Degradation of the physical habitat has serious consequences for stream communities and is among the leading cause of stream impairment nationwide (USEPA 2000). Therefore, an important component of the MBSS assessment program is developing a reference-based indicator of physical habitat conditions.

The MBSS has been collecting a variety of physical habitat measures for streams in the state since 1994. In 1999, the MBSS developed a provisional physical habitat index (PHI) to synthesize those extensive data into a single multimetric indicator of physical habitat quality.

The provisional PHI has been used to assess the physical condition in Maryland streams, but several aspects of the index needed refinement. In 2002, the MBSS updated and revisited the provisional PHI (Paul et al. 2002). Additional habitat metrics were investigated for their potential to improve the characterization, especially the extent to which they might help predict biological condition (Table 6-13).

The new PHI provides a valuable physical habitat assessment tool that addresses concerns associated with the provisional PHI. It discriminates between reference and degraded sites and is correlated to biological condition. The new PHI is an improvement over the provisional PHI in that it (1) removed the use of fish IBI scores in the reference criteria and thus the bias toward sites with high fish scores, (2) removed the watershed area effects implicit in many of the habitat measures, (3) removed the trash metric from the PHI which was considered nonhabitat, (4) removed embeddedness from the coastal plain sites, which naturally lack coarse sediments, and (5) was better correlated with both fish and benthic biological indices. The new PHI has yet to be validated. In addition, the MBSS is considering adding sediment texture and bed stability metrics in the future as both were significantly correlated with biological condition in streams from two Maryland counties where these measures were made – one Piedmont and one Coastal Plain.

TABLE 6-13 THE NEW PHYSICAL HABITATINDEX (PHI) METRICS BY REGION

Coastal Plain	Eastern Piedmont	Highlands

Total Bank Stability	Riffle Quality	Embeddedness
Wood	Total Bank Stability	Total Bank Stability
Instream Habitat	Wood	Epifaunal Substrate
Epifaunal Substrate	Instream Habitat	Total Shade
Total Shade	Epifaunal Substrate	Riparian Width
Remoteness	Total Shade	Remoteness
	Remoteness	

1999 PHI calculation, from *Development of a Provisional Physical Habitat Index for Maryland Freshwater Streams. 1999.*

In order to calculate the PHI it is necessary to first derive a raw score using the following equation:

Raw Score = (Instream Habitat + Velocity/Depth Diversity + Pool/Glide/Eddy Quality – Embededdedness/10 + Maximum Depth/10 + Trash Rating/2)/6.

PHI is then calculated by transforming the Raw Score to a scaled score using the following equation:

PHI = 100*(1/(1+EXP((-(Raw Score-6.0051249))/1.5126126))).

The PHI Categories are as follows: (as reported in *MBSS 2000-2004 Statewide and Basin Conditions. 2005.*)

- 72 to 100 Good
- 42 to 71.9 Fair
- 12 to 41.9 Poor
- 0 to 11.9 Very Poor

2003 PHI calculation, taken from *A Physical Habitat Index for Freshwater Wadeable Streams in Maryland: Final Report. 2003.* This method requires that the drainage area to each site be calculated.

Coastal Plain Region
1. Prepare Metric Values

REMOTE = Remoteness Score
TSHADING = arcsine(square root(percent shading/100))
RESEPISUB = epibenthic substrate score - (3.5233+2.5821(Log(Watershed Area in acres))
RESINSTRHAB = instream habitat score - (0.5505 + 4.2475(Log(Watershed Area in acres))
RESWOOD = total number of instream woody debris and rootwads - (-12.24+8.8120(Log(Watershed Area in acres))
TBANKSTAB = square root of the final value calculated
BANKSTAB = if bank stability on 0-20 score = 0-20 score
BANKSTAB = if erosion extent is used = [((erosion extent)/-15) x severity] for each bank + 20
N.B. severity is altered so that original severity 0 = 0, 1 = 1, 2 = 1.5, and 3 = 2.0

2. Scale Metric Values from 0 to 100
REMOTE = (value)/(18.570)
TSHADING = (value - 0.226)/(1.120)
RESEPISUB = (value + 13.199)/(17.213)
RESINSTRHAB = (value + 15.094)/(18.023)
RESWOOD = (value + 28.903)/(33.803)
TBANKSTAB = (value)/(4.472)

3. Final Score
Coastal Plain PHI = (sum of metric scores)/6

The PHI Categories are as follows (as reported in *MBSS 2000-2004 Statewide and Basin Conditions. 2005.*)

- 81 to 100 Minimally Degraded
- 66 to 80 Degraded
- 51 to 65 Partially Degraded
- 0 to 50 Severely Degraded

South River Watershed Study
Task 2.5 Agricultural Best Management Practices

TO: Mary Searing/ AA County Bureau of Engineering, Watershed and Ecosystem Services

FROM: CH2M HILL

DATE: May 7, 2007

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Executive Summary

The significant acreage of agricultural land in the South River watershed prompted the need to carefully consider how to evaluate runoff quality and BMP effectiveness in the South River watershed. The purpose of this task was to collect and organize data on agricultural practices in the South River watershed as an input to the county's watershed management process.

A windshield survey was conducted to verify the existing Land-Use layer and also supplement the data on farmland practices that were provided by the county's Soil Conservation District. Thirteen crop/animal farming activities and eleven Conservation

Practices, which include five types of agricultural point BMPs, were identified in the South River watershed. A list of these farming activities and practices are given in Table 4 in the proceeding text. Also given in Tables 5 through 7 of the proceeding text are summaries of these activities, practices, and BMPs on an acreage basis.

Due to laws that preserve the confidentiality of farmers' activities, information on nutrient applications and production at farmland level could not be obtained. However, the Maryland (MD) Department of Agriculture provided data on fertilizer application for various croplands and manure production in the South River watershed for the year 2005. Maps showing field locations and cropping data associated with those fields that was requested from MD Farm Services Agency could not be obtained because the data are currently being digitized and is due to be complete and made available to the public by the start of the year.

A Personal Geodatabase was developed that includes attributes for crop/animal farmlands, conservation practices, and BMPs in the South River watershed. The dataset, in conjunction with nutrient management factors that could be developed from nutrient retention rate associated with crop/animal farming activities, conservation practices and BMPs, could be used in the county's choice of watershed management model.

Introduction

Agricultural Conservation Practices are most often related to land management practices, such as conservation tillage and contour tillage operations, whereas urban BMPs are often point treatment devices placed to capture and treat surface runoff. However, certain agricultural conservation practices, which we refer to here as agricultural BMPs such as grass swales and buffers, will act in a manner similar to that of urban BMPs by treating pollutants in agricultural runoff after it has left the field. Agricultural BMPs need to be treated somewhat differently from storm water management facilities, both in terms of mapping and modeling.

There is the need to carefully consider the choice of model used to evaluate runoff quality and BMP effectiveness in the South River watershed since there are significant amounts of agricultural land in the watershed. PLOAD was created to handle treatment BMPs that will remove sediment and nutrients from runoff and will work well for agricultural BMPs such as grass swales and other point BMPs, but would not be directly applicable to the land management BMPs. GWLF allows nutrient loads to be estimated for agricultural land uses, including both row crops, pasture and confined animal feeding operations. While GWLF may be a better option for evaluating the effectiveness of land management BMPs, data with the level of detail required by the model may not be readily available. However data from literature sources could be used to augment general watershed data for use in GWLF.

The purpose of this task includes the aggregation of data on agricultural practices in the South River watershed that relates to Agricultural Conservation Practices and BMPs that will be useful in the county's watershed management tools. State and county conservation and agricultural agencies were contacted to establish data sources and collection methods that, to some extent, satisfy the task needs while preserving confidential provisions of the state's nutrient management program. The procedure and sources for the data aggregated for agricultural nutrient management modeling purposes in the South River watershed are presented below.

Existing Data

Existing data includes data from previous tasks that were useful to this task. It also includes data that the county has in their database that could be used for this task. County GIS layers including the watershed boundary, Land-Use, parcels, and aerial photos were available from previous tasks. The County's Land-Use layer identifies almost all of the agricultural lands in the watershed but puts them in only two agricultural practice categories, namely Pasture/Hay and Row Crops. Moreover not all the areas identified as agricultural lands on the Land-Use layer are really used for agricultural purposes as evidenced during the windshield survey.

Data Requested/Received

Listed below are data requested and that which were received from the respective agricultural and natural resource conservation agencies. The availability, format, and level of detail of the data requested varied by agency. In most cases data on individual farmland level could not be obtained due to confidentiality reasons. A list of contact persons at the various agencies contacted for information is provided in Appendix E.

Anne Arundel County Soil Conservation District:

The following data were requested from the Soil Conservation District (SCD):

- Data on Soil Conservation Practices and BMPs including but not limited to conservation tillage, contour farming, and riparian buffers on farmlands in the South River Watershed
- A marked-up Land-Use map that identifies current farmland in the South River watershed; since the Land-use layer currently being used dates back to 2004.
- Data on nutrient retention rates associated with conservation practices and BMPs employed.
- Scanned copies of information on about 378 farm ponds in the South River watershed including GIS file showing the locations of all 378 ponds. These ponds are, however, usually not designed to provide water quality functions. Although this data may not be useful in this particular task, it may be applicable for future efforts of the County to consider these ponds for retrofit opportunities.

The County's SCD provided CH2M HILL with data on farmlands within the South River watershed that were current in their database. The data include, among other things, Farm and Parcel numbers and Farm Practices planned/applied. The data were useful in the windshield survey. Appendix A shows data on farmland that were received from the County's SCD.

Several conversations occurred between the CH2M HILL team and the County's SCD in an attempt to obtain information on the ponds in the South River watershed that require Code 378 permit. Although additional detailed information is available from the SCD, it is not in an easily researched format and the County decided the effort required to obtain this information is not necessary at this time.

The County's SCD could not produce a marked-up map that identified the current farmlands in the South River watershed for use in the windshield survey. For data on nutrient retention rates associated with conservation practices and BMPs employed on farmlands in the county, the SCD redirected CH2M HILL to the Assistant State Soil Scientist, Dean Cowherd for information. Correspondence with the Assistant State Soil Scientist indicated that while local information on the subject is believed not to be available, federal and state conservation partners have been working on the Conservation Effects Assessment Project (CEAP) for a number of years. CEAP is a national assessment of the impact conservation practices have on a number of resource issues. While significant progress has been made, local information for Maryland is not available yet. Initial data for the program is based on specific watersheds scattered throughout the U.S. The Choptank River, Cambridge, MD is among the watersheds studied. A bibliography has been compiled from these studies and is available through the National Agricultural Library website.

Maryland Department of Agriculture:

MD Department of Agriculture has jurisdiction over Nutrient Management Plans (NMPs) in the state of Maryland and it is estimated that Anne Arundel County (A. A. Co.) has about 80 – 90% participation in the NMPs. Data requested from MD Department of Agriculture includes;

- Data on total Nutrient Application and Management Practices on farmlands in the South River Watershed including but not limited to the following;
  - Animal Waste
  - Fertilizer
  - Biosolids

The Department's current database contains the initial nutrient management plan information. Farmers recently (March 2005) started submitting annual Implementation Reports, which have not been incorporated into the database. The Department is working with the University of MD to update their database with this new information but there is no estimate as to when the updated database will be ready. The Department however was able to extract the 2005 Implementation Data for the South River watershed for the purpose of this project.

As stated above, confidentiality provisions in the NMP does not permit the MD Department of Agriculture (MDA) to share nutrient management plans on individual farmland to a third party so the data were summarized on the watershed Level. The data includes fertilizer application for various croplands and manure production in the watershed for the 2005 calendar year. Tables 1 through 3 presents the data received from the MD Department of Agriculture.

TABLE 1
Nutrient Management Plan

	No. of Plans	Acres
NM Plans in Watershed	29.0	1,348
AIR* Submitted	29.0	1,348
Remaining in NR DB	0.0	0

* Annual Implementation Report. *Source: MD Department of Agriculture*

TABLE 2
Breakdown of Fertilizer Usage (lbs) per Crop in the South River Watershed for 2005

Crop	Acres	N		P		K	
		Lb/yr	Lb/Acre/yr	Lb/yr	Lb/Acre/yr	Lb/yr	Lb/Acre/yr
Corn	175.0	22,869	131	6,649	38	15,035	86
Soybeans	222.0	1,121	5	570	3	11,217	51
Sweet Corn	6.0	996	166	84	14	168	28
Tomatoes	1.0	100	100	35	35	70	70
Cucumbers	0.5	35	70	18	36	35	70
Squash	0.5	35	70	18	36	35	70
Melons	0.5	588	1,176	18	36	35	70
Peppers	0.5	50	100	18	36	35	70
Watermelons	1.0	100	100	35	35	70	70
Pumpkins	12.0	790	66	0	0	0	0
Wheat	145.3	7,805	54	0	0	1,650	11
Hay	248.4	9,892	40	2,725	11	11,751	47
Cut Flowers	10.0	379	38	379	38	379	38
Rye	27.2	972	36	0	0	62	2
Sod	98.0	6,888	70	1,115	11	1,115	11
Greenhouse	17.5	96	5*	96	5*	101	6*
Barley	18.0	1,602	89	0	0	1,080	60
Millet	9.0	487	54	487	54	487	54
Christmas Trees	10.0	0	0	0	0	0	0
Grapes	9.0	122	14	0	0	0	0

TABLE 2
Breakdown of Fertilizer Usage (lbs) per Crop in the South River Watershed for 2005

		Horse		Beef			
	Acres	**Tons**	**Tons/Ac**	**Tons**	**Tons/Ac**		
Pasture	247.0	1724	7.2	1	0.1		
Total	**1,258.0**	**54,927**		**12,247**		**43,325**	

* Unable to calculate due to reporting error. *Source: MD Department of Agriculture*

TABLE 3
Nutrients Applied in 2005

Nutrients	Lbs	Lbs Per Acre
N	54,927	54
P	12,247	12
K	43,325	43

Manure	Tons	Tons Per Acre
Horse Manure Produced	1,724	7.2
Beef Manure	1	0.1
Total Tons of Manure	**1,725**	**6.9**

Source: MD Department of Agriculture

Maryland Farm Services Agency:

The following data were requested from the Farm Services Agency:

- Maps showing field locations over an aerial, and cropping data associated with those fields.
- Data on Common Crop Rotation\Tillage\Fertilizer Schedules

No data were obtained from the Farm Services Agency. However, the Agency indicated that maps showing field locations and their associated cropping data are currently being digitized and due to be complete and available to the public by the start of the year.

Regulatory Constraints

The County's Soil Conservation District (SCD) keeps copies of data on Nutrient Management Plans in the county but the Nutrient Management Program falls under the jurisdiction of the MD Department of Agriculture. As a result, the SCD has no authority to share the documents with a third party.

Laws of the Nutrient Management Program protect the confidentiality of the data, and this provision prohibits the department from sharing information on individual farmlands with a third party (County included). Due to the confidentiality restrictions the department can only provide data on the NMP at the watershed level.

Windshield Survey

A windshield survey was conducted to verify farmland data in the Land-Use layer and the data provided by the County's SCD against what could be observed in the field. The windshield survey was also an opportunity for the survey team to familiarize itself with the South River watershed.

Field Data

Existing Land Use data and that obtained from the County's SCD were preprocessed into a form that could be used in the field for the windshield survey. The County's SCD farm data had no spatial information associated with it so it was joined to the County's CPF layers by virtue of Map Number and Parcel ID which are common attributes in both sets of data. As a result the CPF spatial information was applied to the farm data supplied by the County's SCD. The dataset resulting from the data join was laid over the County's Parcel, Land-Use, street center line, and Aerial photo layers and then clipped to the South River watershed boundary. The resulting map could be used to identify a farm parcel and the associated land use type and conservation practices. This map could be used during the windshield survey to easily identify changes in land use, for example, from farmland to residential.

Survey Results

Data collected in the field includes types of crops grown; farming practices including conservation practices (e.g. No-till, Strip, and Contour cropping); and types of BMPs employed (e.g. Grass Strip, Buffer, Grass Swale). There was no information on the types of crops grown in the data on farmlands provided by the County's SCD and the Land-Use layer only identifies farmland as either Pasture/Hay or Row Crops.

The SCD-supplied farmland practice data were used as the base map and were updated and supplemented where necessary, with the information from field observations. Areas that were identified on the land use layer as crop fields but not included in the SCD's list of farmlands were verified and the types of activities observed were added to the data. Areas that were identified on the basemap as farmland, but were no longer farmed, and areas that were identified in the field as farmland, but were not included on the basemap were updated.

Conservation practices and BMPs employed listed in the SCD data were verified and identified wherever possible. One of the conservation practices listed in the SCD data was Nutrient Management. This practice could not be verified in the field. It should be noted that although the state could not provide data to the CH2M HILL team on which particular farms had Nutrient Management Plans because of the confidentiality laws, the data provided by the SCD listed parcels for which nutrient management is being implemented. It is not known if this is a comprehensive list.

The scope of the task did not permit the survey team to walk on private property; hence data on farmlands that could not be seen from public roads were not updated. In such instances information from the County's farmland data and Land-Use data were maintained. Therefore these landuse polygons are identified as Row Crops and Pasture/Hay, rather than more specific cropping. In addition, several properties could be identified as actively farmed, however because crops were already harvested, the specific crop type could not be identified. These properties were identified as Fallow.

Data Processing

GIS Data Layer Development

Crop Type Data: A dataset of all farmlands with agricultural activity was created from the Land-Use layer. The Land-Use layer was updated to include polygons of farmlands and three additional attributes including Crop Category, Crop1, and Crop2. The Crop Category attribute indicates whether a particular farmland polygon has a single or multiple crops/ animal (Multicrop) farming associated to it. Crop1 and Crop2 attributes indicate the kinds of crops/animals farmed on a Multicrop farmland.

Conservation Practice Data: This is data of the farmlands employing some form of conservation practices (Contour and Strip Cropping, Rotation, Cover Crops, etc.). Management Factors such as nutrient retention rates could be applied to these conservation practices when data are available. The Conservation Practice Layer contains farmland polygons and five additional attribute including Practice Category and Practice1 through Practice4. The Practice Category attribute indicates whether a particular farmland polygon has a single or multiple conservation practice associated to it. Practice1 through Practice4 attributes lists the types of conservation practice on the farmland.

BMP Data: The BMP attributes identifies farmlands with BMPs (Buffers, Grass Strips, Ponds, etc.). Polygons in this layer are exclusive to farmlands with BMPs. Since there were no existing data on BMPs, it is of interest to note that information in this layer is limited to farmlands that were accessible during the windshield survey. The BMP Layer contains polygons of farmland with BMPs and three additional attribute including BMP Category and BMP1 and BMP2. The BMP Category attribute indicates whether a particular farmland polygon has a single or multiple BMP associated to it. BMP1 and BMP2 attributes list the types of BMP on the farmland. Management Factors such as nutrient retention rates could be applied to these BMPs.

The attribute table containing the data inventory is presented in Appendix C and the Metadata for the GIS dataset is also provided in Appendix D

Summary of Data

There were thirteen kinds of crop/animal farming activities and six types of conservation practices identified in the South River watershed during the windshield survey. There were farmlands with multiple crop/animal farming activities as well as some with multiple conservation practices. Five types of agricultural BMPs were identified in the watershed during the windshield survey. A list of crop/animal farming activities, conservation practices and agricultural BMPs identified in the watershed is given in Table 4.

TABLE 4
Crop/Animal farm Activities, Conservation Practices and BMPs in the South River Watershed

Crop/Animal	Conservation Practice	BMP
Corn	Strip Cropping	Grass Filter Strip
Fallow	No-till	Grass Drainage Ditch
Garden	Contour Cropping	Pond
Grapes	Cover Crop	Possible Manure storage
Horse Farm	Rotation	Wooded Buffer
Open Space	Nutrient Management*	
Pasture/Hay		
Row Crops		
Soy		
Sod		
Wildlife		
Flowers		
Vegetables		

* This conservation practice could not be verified in the field

Based on the County Land-Use layer updated through the windshield survey, there are approximately 2100 acres of agricultural lands within the South River Watershed. The Maryland Department of Agriculture data lists a total of 1260 acres of agricultural land. The discrepancy between these data sets can be attributed to a combination of factors. The MDA data limits the reported acreage to areas of active farming in 2005. The portion of the property designated for residence and recreation, would not be included in the MDA data, but is encompassed by the GIS landuse polygons. The MDA data may not include reports from all farmers in the South River Watershed, and therefore may not be comprehensive. Land that is used for multiple crops is accounted for differently between the two data sources.

A summary of crop/animal farming activities is provided in Table 5. The acreages in these tables are based on the updated land use layer. The acreages of individual crops cultivated on a particular multi-cropped farmland are not known. If crops associated with a multi-crop landuse area could be identified during the windshield survey the acreage of that land was distributed evenly among those crops identified. In addition to the acreage of each agricultural landuse, nutrient application is summarized in Table 5. The application rates for each landuse type were taken from the SCD data, and applied to the acreages determined during the windshield survey.

Conservation practices and agricultural BMPs in the South River Watershed are summarized in Table 6 and 7, respectively. Conservation practices and BMPs were associated with the total area of the parcel. Therefore the acreage identified for a given BMP, such as Grass strip, is the acreage of the farm, which is not always the same as the acreage of the actual BMP. This also implies that the total acreage of a farm parcel with multiple conservation practices will be counted multiple times. This may be appropriate in some cases (e.g. a field is both contour farmed and has nutrient management) but may not be appropriate in all cases (e.g. a portion of the property is contour farmed and another portion has a cover crop). Because of this discrepancy, the data provided in Table 6 reflects multi-practice and multi-bmp rather than counting the acreage multiple times. It should be noted that the MDA provided information that in 2005, 29 Nutrient Management Plans existed on 1,348 acres of farm. The data provided by SCD listed the nutrient management on each individual farm. Applying that information to the farm parcel acreage provides approximately 341acres. This data is provided in the Personal Geodatabase.

The maps in Appendix B display the resulting GIS layers of agricultural lands and associated crop/animal farming activities, conservation practices and BMP. Appendix C provides all the data attributes of the data collected from the County SCD associated with the field data and GIS layers. Appendix D provides the metadata of the delivered Personal Geodatabase.

TABLE 5
Summary of Crop/Animal Activities

Category	**Acreage**[1]	**N**		**P**		**K**		**Agricultural Land**
	ac	Lb/ac/yr	Lb/yr	Lb/ac/yr	Lb/yr	Lb/ac/yr	Lb/yr	%
Corn	172	131	22,576	38	6,549	86	14,821	8.2
Cover Crop	10		-		-		-	0.5
Fallow[2]	226	45	10,159	7	1,580	34	7,675	10.8
Garden[3]	11	190	2,091	23	253	45	495	0.5
Grapes	13	14	176	0	-	0	-	0.6
Horse Farm[4]	135	81	10,427	14	1,862	55	7,076	6.4
Open Space	166		-		-		-	7.9
Pasture/Hay[2]	260	45	11,717	7	1,823	34	8,853	12.4
Row Crops[5]	495	60	29,719	18	8,916	66	32,691	23.6
Soy	259	5	1,296	3	777	51	13,214	12.4
Sod	98	70	6,873	11	1,080	11	1,080	4.7
Wildlife	0.1		-		-		-	0.0
MultiCrop[6]								
Corn	119	131	15,564	38	4,515	86	10,217	5.7
Flowers	8	38	308	38	308	38	308	0.4

TABLE 5
Summary of Crop/Animal Activities

Category	Acreage[1]	N		P		K		Agricultural Land
	ac	Lb/ac/yr	Lb/yr	Lb/ac/yr	Lb/yr	Lb/ac/yr	Lb/yr	%
Soy	108	5	542	3	325	51	5,527	5.2
Vegetables‡	15	190	2,844	23	344	45	674	0.7
Total	**2,095**		**114,291**		**28,332**		**102,631**	**100.0**

[1]Acreages based on County's land use polygons
[2] Nutrient application rates (Lb/ac/yr) are based on the area weighted average of that for Hay and Wheat
[3]Estimated from weighted averages of garden crops (mainly vegetables)
[4]Nutrient rate (Ld/ac/yr) is derived from Chapter 4 Part 651, Agricultural Waste management Field Handbook, 1996.
[5] Nutrient application rates (Lb/ac/yr) are based on the area weighted average of that for Corn and Soy
[6]Total acreages of farmlands with multiple crops were split evenly among the crops.

TABLE 6
Summary of Conservation Practices

Practice Category	Acreage	Percent of Agricultural Land
Contour Cropping	14	1
Cover Crop	124	6
Multipractice	432	21
No-till	13	1
Rotation	110	5
Strip Cropping	28	1
Total	**721**	**34**

TABLE 7
Summary of BMPs

Practice Category	Acreage	Percent of Agricultural Land
Pond	0.1	0.01
Wooded Buffer	25	1
Possible Manure Storage	57	3
Grass Filter Strip	248	12
MultiBMP	272	13

TABLE 7
Summary of BMPs

Practice Category	Acreage	Percent of Agricultural Land
Total	**603**	**29**

Appendix A
Data on Farmlands in the South River Watershed Received from Anne Arundel County Soil Conservation District

Owner	Operator	Acres	Farm	Tract	Map	Parcel	Practices Planned	Practices Applied	Plan Date
Anita Baase - tax # 0200090007663, 0200002221630, 0200090007662, 0200000295000	Anita Baase & Ralph Devaughn	110	553	539	43	45, 168, 6, 148	forest stand improvemt, nutr mgmt, pasture and hay planting, pest mgmt, cons cover, nutr mgmt, prescribed grazing		Sep-05
Diana Kimm	Allen Gertz	99.1	773	822	43	7	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	residue mgmt-no till, nutr mgmt, cover crop	Sep-00
Edward Hall III	Edward Hall III	72	853	907	43	85, 86	woodland mgmt, wildlife area improvemt		Jan-85
Frank Machande	Mark Scible	42	103	648	49	131, 24	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till	Aug-99
J. Howard Beard III	J. Howard Beard III		84	86	49	26	cons crop rotation, cover crop, grade stabilization structure, nutr mgmt, upland wildlife habitat mgmt, residue mgmt-no till, natural area protection, forage harvest mgmt, roof runoff mgmt, cons cover, field border, pasture and hay planting, field stripcropping	cons crop rotation, pasture and hay planting, field stripcropping	Aug-02
Joel Greenwell - tax # 0200090010109	Joel Greenwell	10.5	954	1009	49	92	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till	cons crop rotation, residue mgmt-no till	Jun-02
John Cramer	Allen Gertz	31.9	88	90	49	77, 78, 213, 70	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	residue mgmt-no till, nutr mgmt, cover crop, cons crop rotation	Sep-00
Julian Beard	Allen Gertz	11.4	92	94	49	41	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till	Sep-00

Owner	Operator	Acres	Farm	Tract	Map	Parcel	Practices Planned	Practices Applied	Plan Date
Karen Davis - tax # 0200004253900, 0200090100733, 0200090100734	Joel Greenwell	10	953	1008	49	71	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till	cons crop rotation, residue mgmt-no till	Jun-02
Kathleen Harjess - Equilibrium Horse	Kathleen Harjess-Equilibrium Horse	83	560	546	43	120	pasture and hay planting, nutr mgmt, waste storage facility, cons cover, pest mgmt, prescribed grazing, recreation area imporovemt, upland wildlife habitat mgmt		Oct-04
Louis Boehm - tax # 0200001528800	Louis Boehm	132	581	565	43	13	cons cropping sequence, cons tillage system, contour farming, critical area planting, grassed waterway, woodland improvemt, access road	contour farming, critical area planting	Dec-90
Marie Jorden	Allen Gertz	175	585	569	43	214	cons crop rotation, field stripcropping, wetland wildlife habitat mgmt, woodland improved harvesting, access road, cover crop, nutr mgmt, residue mgmt-no till, woodland mgmt	cons crop rotation, field stripcropping, cover crop, cons tillage, nutr mgmt, residue mgmt-no till	Nov-00
Mildred Anderson - tax # 0200001589000	Mark Scible	210	100	102	49	2	cons crop rotation, nutr, mgmt, residue mgmt-no till, residue mgmt-seasonal, cove rcrop,row arrangemt	cons crop rotation, nutr, mgmt, residue mgmt-no till, residue mgmt-seasonal, cove rcrop,row arrangemt	Aug-99
Mildred Anderson - tax # 0207690053617	Mark Scible		100	102	49	204	same farm as above	same farm as above	
Mildred Anderson - tax # 0207690053616	Mark Scible		100	102	49	204	same farm as above	same farm as above	
Mildred Anderson - tax # 0200090076043	Mark Scible		100	102	49	51	same farm as above	same farm as above	

Owner	Operator	Acres	Farm	Tract	Map	Parcel	Practices Planned	Practices Applied	Plan Date
Mildred Anderson - tax # 0200090109629	Mark Scible	35	363	360	49	6	cons crop rotation, critical area planting, cons tillage, nutr mgmt, residue mgmt-no till, woodland mgmt		Mar-02
Mildred Anderson - tax # 0200090109633	Mark Scible		363	360	49	6	same farm as above		
Mildred Anderson - tax # 0200090109632	Mark Scible		363	360	49	6	same farm as above		
Paul Gaug	Joel Greenwell	same farm as Karen Davis, above							
Presley Taylor III	Presley Taylor III	40		713	49	130	cons cropping sequence, wildlife upland habitat mgmt		Dec-90
William Doepkins	William Doepkins	233	674	103	49	54, 52, 74	cons cropping system, cross slope farming, cover crop, permanent cover, contour farming, field stripcropping, stream crossing	cons cropping system, cover crop, permanent cover	Dec-88
Allen Gertz	Gertz Brothers	48.7	558	544B	37	257, 326	cons crop rotation, cover crop, nutr mgmt, pest mgmt, forest land mgmt		Apr-99
Churchview Farm Inc - tax # 0414890010163, 0400090097132	William & Meade Baldwin	200.5	758	803, 805	37	14, 166	cons crop rotation, nutr mgmt, surface drainage, fishpond mgmt, pond, pasture and hay mgmt, grassed waterway, trough, upland wildlife habitat mgmt	cons crop rotation, nutr mgmt, surface drainage, pasture and hay mgmt, grassed waterway, trough	Jun-00
Donald Gertz	Donald Gertz	10	558	544D	37	189	cons crop rotation, cover crop, nutr mgmt, pest mgmt, forest land mgmt		May-99

Owner	Operator	Acres	Farm	Tract	Map	Parcel	Practices Planned	Practices Applied	Plan Date
E. Francis Jones Family	Allen Gertz	61.6	559	545	37	298, 305, 299, 306, 317, 302	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till	Nov-00
Richard Forney	Allen Gertz	153.8	557	543	37	86	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till	Sep-00
Robert Gertz	Allen Gertz	82.3	561	547	43	46	cons crop rotation, cover crop, nutr mgmt, residue mgmt-no till, upland wildlife habitat mgmt, woodland mgmt	cons crop rotation, cover crop, nutr mgmt, residue mgmt-no till	Sep-00
Roger Gertz	Gertz Brothers	30	558	544C	37	84	cons crop rotation, cover crop, nutr mgmt, pest mgmt, forest land mgmt		May-99
William Gertz	Gertz Brothers	32.8	558	544A	37	153, 327	cons crop rotation, cover crop, nutr mgmt, pest mgmt, forest land mgmt		May-99
Carol Carr - tax acct # 0100003410303	Carol Carr	23.9		54-104	54	191	diversion, nutr mgmt, waste mgmt system, waste storage facility, prescribed grazing, spring development, trough, pond, wetland wild life habitat mgmt, woodland mgmt	diversion, spring development, trough	Aug-01
Carol Carr - tax acct # 0100003410305	Carol Carr	same farm as above		54-104	54	104	same farm as above	same farm as above	
Charles Ripley	Mark Scible	146.7	38	38	54	19	cons crop rotation, nutr mgmt, residue mgmt-no till, row arrangemt, upland wildlife habitat mgmt	cons crop rotation, nutr mgmt, residue mgmt-no till, row arrangemt	Jan-00

Owner	Operator	Acres	Farm	Tract	Map	Parcel	Practices Planned	Practices Applied	Plan Date
Clara Brown - tax # 0200007241800	Clara Brown	17.5	359	356	54	136	pipeline, roof runoff structure, heavy use area protection, pest mgmt, waste storage facility, diversion, windbreak/shelterbreak establishment, grassed waterway, pasture and hay planting, nutr mgmt, watering facility, prescribed grazing, fishpond mgmt		Aug-03
Ken Wilson - tax # 0200090051428 lot # 6	Joel Greenwell	4.5		54-90-6	54	90	pasture and hayland mgmt, nutr mgmt	pasture and hayland mgmt	Jun-02
Lezlie Carter - tax acct # 0200090062322	Mark Scible	22			54	265	nutr mgmt, pasture and hay planting, pasture and hayland mgmt, wildlife upland habitat mgmt, cons cropping sequence, cons tillage, cross slope farming	pasture and hay planting	Nov-97
Max Covington (George Carr Property)	Joel Greenwell	36.3	89	91	55	95	nutr mgmt, residue mgmt-no till		Aug-99
Maxwell Covington	Maxwell Covington	20.5	7	6	54	32	cons crop rotation, critical area planting, nutr mgmt, reside mgmt-no till, residue mgmt seasonal, row arrangemt	cons crop rotation, nutr mgmt, reside mgmt-no till, residue mgmt seasonal, row arrangemt	May-97
Maxwell Covington - tax acct # 0100090002260, 0100001724650, 0100001724600	Maxwell Covington	228.5	7	670	54	20, 146, 39	cons crop rotation, cover cro, critical area planting, cons tillage, nutr mgmt, pasture and hay planting, residue mgmt seasonal, field stripcropping, fence, pasture and hayland mgmt, trough, wildlife upland habitat mgmt, filter strip, grassed waterway, grasses and legumes in rotation, residue mgmt-no till	cover crop, field stripcropping, cons crop rotation, grassed waterway, nutr mgmt, pasture and hay mgmt, residue mgmt-no till, residue mgmt seasonal	May-97

Owner	Operator	Acres	Farm	Tract	Map	Parcel	Practices Planned	Practices Applied	Plan Date
B. F. Bausum Jr	B. F. Bausum Jr	104	234	234	55	355	cons cropping sequence, cons tillage, grassed waterway, pasture and hay mgmt, wildlife upland habitat mgmt, woodland improved harvesting, field border, nutrient mgmt		Sep-90
Charles Tucker	Charles Tucker	39.9	272	271	59	105	upland wildlife habitat mgmt, natural area protection, nutr mgmt, pest mgmt, conservation cover		Apr-03
Florence Phebus	Ricky Davis	14.3	230	230B	59	19	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till, woodland mgmt		Jun-99
Friend Nagle Jr	Ricky Davis	14.5	230	230C	59	267	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till, woodland mgmt		Jun-99
Friend Nagle Jr	Ricky Davis	14.4	230	230A	59	266	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till, woodland mgmt		Jun-99
Joseph Aisquith	Ricky Catterton	156.8	973	1024	59	5	nothing planned		
Oscar Grimes	Oscar Grimes	105.5	239	239	58	23	fence, pasture and hay planting, nutr mgmt, pest mgmt, prescribed grazing, pipeline, watering facility, water well	fence, nutr mgmt, pest mgmt, pipeline, watering facility, water well	Aug-04
Peggy Eichlman	Ricky Davis	65.2	19	18	59	96	cons crop rotation, critical area planting, nutr mgmt, pest mgmt, residue mgmt, upland wildlife habitat mgmt, grassed waterway, woodland mgmt	cons crop rotation, nutr mgmt, residue mgmt	Jul-99
Ralph & Patricia Lavers	Ralph & Patricia Lavers	20.4			55	240	pasture & hayland mgmt, pasture & hayland planting, farmstead and feedlot windbreak, woodland improvement	pasture and hayland planting	Jun-91

Owner	Operator	Acres	Farm	Tract	Map	Parcel	Practices Planned	Practices Applied	Plan Date
Robert Rossback Sr	Robert Rossback Sr	53.1	354	351	54	85	comprehensive nutr mgmt plan, upland wildlife habitat mgmt, waste storage facility, cons crop rotation, forage harvest mgmt, nutr mgmt, pest mgmt,residue mgmt-no till, waste utilization, critical area planting, prescribed grazing, conservation cover, field border, filter strip, pasture and hay planting, riparian forest buffer, riparian herbaceous buffer, shallow water mgmt for wildlife, field stripcropping, surface drainage, trough, wetland wildlife habitat mgmt, grade stabilization structure, heavy use area protection, pipeline, roof runoff mgmt, waste mgmt system, fence, pond, stream crossing, well	trough, upland wildlife habitat mgmt, well, pipeline, stream crossing, riparian forest buffer, pasture and hay planting, nutr mgmt, fence, waste mgmt system, roof runoff structure, heavy use area protection, grade stabilization structure, wetland wildlife habitat mgmt, field stripcropping, shallow water mgmt for wildlife, filter strip, field border, conservation cover	Nov-05
Robert Rossback Sr	Robert Rossback Sr	107.8	354	351	49	57	same farm as above	same farm as above	Nov-05
Robert Scrivener	Robert Scrivener	87	293	292	59	281	Cons crop rotation, nutr mgmt, pasture and hay planting	nutr. Mgmt, pasture and hay planting	Aug-99
Joseph Aisquith	Ricky Catterton	55.1	974	1025	59	86	cons crop rotation, cover crop, nutr mgmt, residue mgmt-no till, forest stand improvemt, critical area planting	forest stand improvemt, critical area planting	Mar-04
Kenneth Carr	Kenneth Carr	67.1	97	99	55	343	cons crop rotation, cover crop, critical area planting, cons tillage, grassed waterway, nutr mgmt, row arrangemt, woodland improved harvesting, wildlife upland habitat mgmt	wildlife upland habitat mgmt, nutr mgmt, grassed waterway, critical area planting, cover crop	Nov-97

Owner	Operator	Acres	Farm	Tract	Map	Parcel	Practices Planned	Practices Applied	Plan Date
Milly Welsh	Milly Welsh	20	828	883	54	203, 139	cons cover, heavy use area protection, fence, nutr mgmt, pest mgmt, pond, prescribed grazing	heavy use area protection	Apr-05
Robert Chase - tax acct # 0200011761400	Robert Chase	77.4	201	204	54	83	cons crop rotation, cover crop, critical area planting, nutr mgmt, residue mgmt-no till, forest stand improvemt, cons cover, natural area protection	cons crop rotation, cover crop, critical area planting, nutr mgmt, residue mgmt-no till, forest stand improvemt, cons cover, natural area protection	Sep-03
Terry McGuire - tax acct # 0280600255144 lot # 17	Joel Greenwell	4.8		54-199	54	199	pasture and hayland mgmt, nutr mgmt	pasture and hayland mgmt	Jun-02
Terry McGuire - tax acct # 0280608092100 lot # 18	Joel Greenwell	same farm as above		54-199	54	199	same farm as above	same farm as above	
William Enright - tax acct # 0200008164950 lot # 8	Joel Greenwell	5.9		54-90-8	54	90	pasture and hayland mgmt, nutr mgmt	pasture and hayland planting	Jun-02
William Mueller Jr	Allen Gertz	29.8	847	901	44	97	cons crop rotation, cover crop, nutr mgmt, pasture and hay planting, residue mgmt-no till, woodland mgmt	cons crop rotation, cover crop, nutr mgmt, residue mgmt-no till	Sep-00
Don Riddle Jr (Homestead Gardens Inc)	Don Riddle Jr	101.3	351	348	54	77	conservation tillage, grasses waterway, subsurface drainage, structure for water control, pond, access road, pipeline, rocklined waterway, stripcropping, hayland	pond	Nov-87

Owner	Operator	Acres	Farm	Tract	Map	Parcel	Practices Planned	Practices Applied	Plan Date
Maurice Carr - tax acct # 0100090078313, 0100090078312, 0100090078045, 0100090048473, 0100001262400	Maurice Carr	56	49	50	55	77, 218	pasture and hayland mgmt, windbreak/shelterbreak establishment, upland wildlife habitat mgmt, forest stand improvement	pasture and hayland mgmt	Feb-90
Richard Evans	Richard Evans	57.66			59	15	clearing, contour farming, land smoothing, diversion, woodland harvest improvemt, pond, sediment trap, grassed waterway		Jan-87
Don Segal (Harness Creek)	Byron Wates	3.5			56	208	conservation cover, contour farming, cover crop, critican area planting, nutr mgmt, pest mgmt, riparian herbaceous cover		May-03
Robert Giffen III	Robert Giffen III	26	209	212	51	245	land clearing, nutr mgmt, tree/shrub establishment, chesapeake bay critical area requiremts, land clearing, woodland mgmt	tree/shrub establishment	Aug-00

Appendix B
Figures Showing Areas with Agricultural Activities, Conservation Practices and BMPs

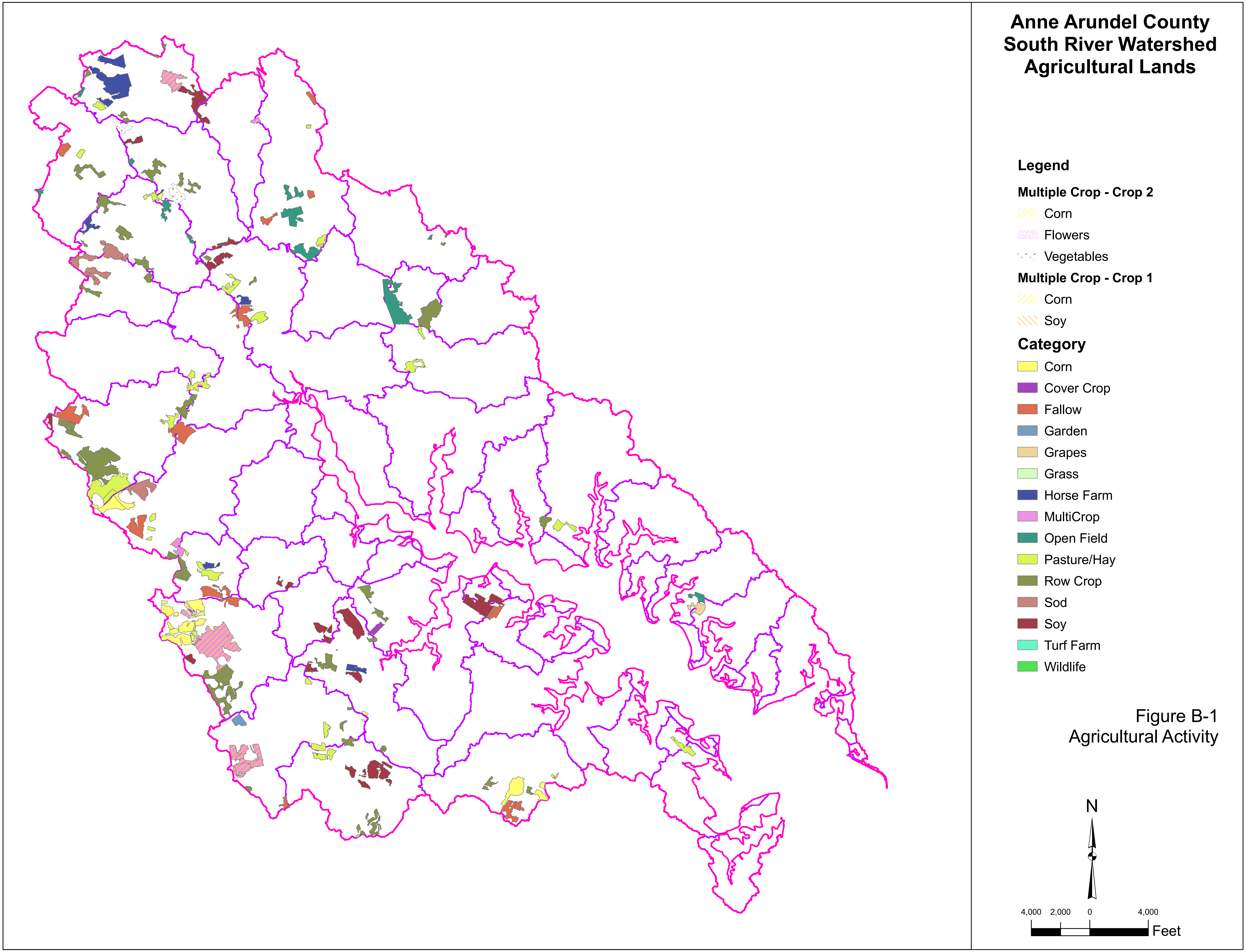

Figure B-1
Agricultural Activity

Anne Arundel County
South River Watershed
Agricultural Lands

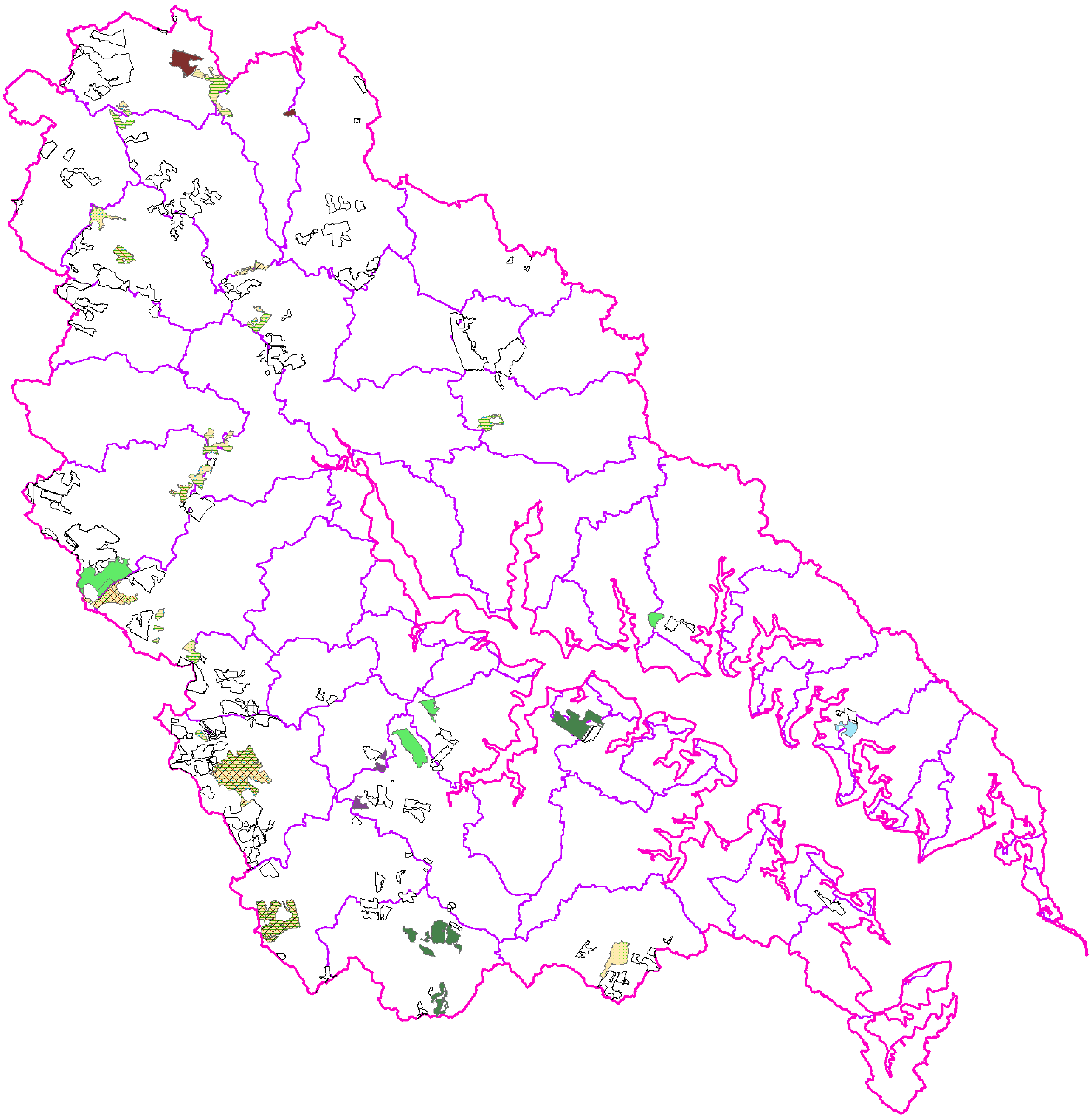

Figure B-2
Agricultiural Lands with
Conservation Practices

Anne Arundel County South River Watershed Agricultural Lands

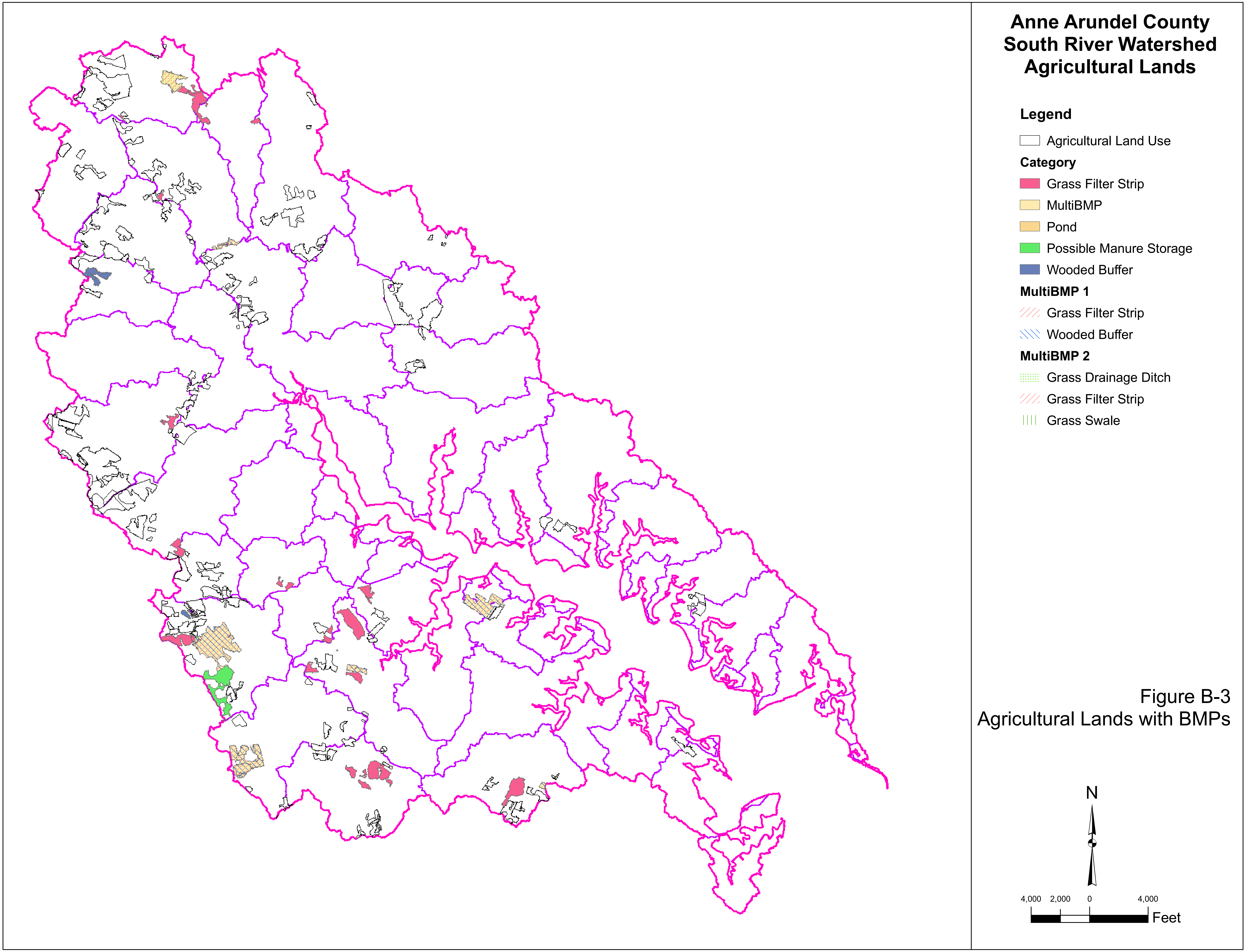

Figure B-3
Agricultural Lands with BMPs

Appendix C
Table of Gathered Inventory – Associating SCD Data with Field Data and GIS Layers

OBJECT ID	CLASSNAME	CLASSNO	PCNT_ IMPV	Shape_Leng	LU_CODE	CH_ID	Category	Crop_1	Crop_2	Crop_3	Owner	Operator	Farm	Tract	Map	Parcel	Practices_	Practices1	Plan_Date	State_Wshd	Co_Wshd_ID	Practice_C	Practice_1	Practice_2	Practice_3	Practice_4	BMP_Catego	BMP_1	BMP_2	Shape_Le_1	Shape_Area	NM_Plan
1	Pasture/Hay	11	8	2,852	PAS	64	Pasture/Hay*						-		-	184				-	-									2,852	340,435	
2	Row Crops	12	-	9,197	SRC	84	MultiCrop	Soy	Corn				-		-	28				-	-	Strip Cropping					MultiBMP	Grass Filter Strip	Grass Drainage Ditch	9,197	1,223,193	
3	Row Crops	12	-	2,133	SRC	32	MultiCrop	Soy	Corn		Charles Ripley	Mark Scible	38	38	54	19	cons crop rotation, nutr mgmt, residue mgmt-no till, row arrangemt, upland wildlife habitat mgmt	cons crop rotation, nutr mgmt, residue mgmt-no till, row arrangemt	1/1/00	244	650	Multipractice	Rotation	No-till			Wooded Buffer			2,133	185,763	NMP
4	Row Crops	12	1	7,170	SRC	59	Soy				Kenneth Carr	Kenneth Carr	97	99	55	343	cons crop rotation, cover crop, critical area planting, cons tillage, grassed waterway, nutr mgmt, row arrangemt, woodland improved harvesting, wildlife upland habitat mgmt	wildlife upland habitat mgmt, nutr mgmt, grassed waterway, critical area planting, cover crop	11/1/97	248	676	Cover Crop					Grass Filter Strip			7,170	1,577,119	NMP
5	Row Crops	12	4	4,874	SRC	80	Grapes						-		-	151				-	-	No-till								4,874	548,452	
6	Row Crops	12	3	10,421	SRC	9	Row Crop*				Kathleen Harjess - Equilibrium Horse	Kathleen Harjess-Equilibrium Horse	560	546	43	120	pasture and hay planting, nutr mgmt, waste storage facility, cons cover, pest mgmt, prescribed grazing, recreation area imporovemt, upland wildlife habitat mgmt		10/1/04	242	631									4,464	346,252	
7	Row Crops	12	1	3,083	SRC	10	Soy				Louis Boehm - tax # 0200001528800	Louis Boehm	581	565	43	13	cons cropping sequence, cons tillage system, contour farming, critical area planting, grassed waterway, woodland improvemt, access road	contour farming, critical area planting	12/1/90	242	631	Multipractice	Contour Cropping	Cover Crop			MultiBMP	Wooded Buffer	Grass Filter Strip	3,083	152,237	
8	Row Crops	12	-	1,575	SRC	10	Soy				Louis Boehm - tax # 0200001528800	Louis Boehm	581	565	43	13	cons cropping sequence, cons tillage system, contour farming, critical area planting, grassed waterway, woodland improvemt, access road	contour farming, critical area planting	12/1/90	242	631	Multipractice	Contour Cropping	Cover Crop			MultiBMP	Wooded Buffer	Grass Filter Strip	1,575	57,980	
9	Row Crops	12	-	1,187	SRC	9	Row Crop*				Kathleen Harjess - Equilibrium Horse	Kathleen Harjess-Equilibrium Horse	560	546	43	120	pasture and hay planting, nutr mgmt, waste storage facility, cons cover, pest mgmt, prescribed grazing, recreation area imporovemt, upland wildlife habitat mgmt		10/1/04	242	631									1,187	43,373	
10	Row Crops	12	-	4,212	SRC	10	Soy				Louis Boehm - tax # 0200001528800	Louis Boehm	581	565	43	13	cons cropping sequence, cons tillage system, contour farming, critical area planting, grassed waterway, woodland improvemt, access road	contour farming, critical area planting	12/1/90	242	631	Multipractice	Contour Cropping	Cover Crop			MultiBMP	Wooded Buffer	Grass Filter Strip	4,212	212,587	
11	Row Crops	12	-	5,391	SRC	11	Row Crop*				Marie Jorden	Allen Gertz	585	569	43	214	cons crop rotation, field stripcropping, wetland wildlife habitat mgmt, woodland improved harvesting, access road, cover crop, nutr mgmt, residue mgmt-no till, woodland mgmt	cons crop rotation, field stripcropping, cover crop, cons tillage, nutr mgmt, residue mgmt-no till	11/1/00	242	631	Multipractice	Rotation	Strip Cropping	No-till	Cover Crop				5,391	604,474	NMP
12	Row Crops	12	-	7,751	SRC	85	Row Crop*				Diana Kimm	Allen Gertz	773	822	43	7	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	residue mgmt-no till, nutr mgmt, cover crop	9/1/00	242	631	Multipractice	No-till	Cover Crop						7,751	766,266	NMP
13	Pasture/Hay	11	-	1,204	PAS	5	Pasture/Hay*				Joel Greenwell - tax # 0200090010109	Joel Greenwell	954	1009	49	92	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till	cons crop rotation, residue mgmt-no till	6/1/02	242	631	Multipractice	Rotation	No-till						1,204	66,612	
14	Row Crops	12	5	1,628	SRC	20	Row Crop*				Presley Taylor III	Presley Taylor III	-	713	49	130	cons cropping sequence, wildlife upland habitat mgmt		12/1/90	242	631									1,628	142,178	
15	Pasture/Hay	11	-	20,187	PAS	30	Row Crop*				Carol Carr - tax acct # 0100003410303	Carol Carr	-	54-104	54	191	diversion, nutr mgmt, waste mgmt system, waste storage facility, prescribed grazing, spring development, trough, pond, wetland wild life habitat mgmt, woodland mgmt	diversion, spring development, trough	8/1/01	244	650						Possible Manure Storage			19,941	2,485,124	
16	Pasture/Hay	11	-	2,300	PAS	69	Soy						-		-	79				-	-	Contour Cropping					Grass Filter Strip			2,300	194,132	
17	Pasture/Hay	11	1	1,617	PAS	69	Soy						-		-	79				-	-	Contour Cropping					Grass Filter Strip			1,617	119,879	
18	Pasture/Hay	11	10	1,779	PAS	71	Soy						-		-	1				-	-						Grass Filter Strip			1,779	162,211	
19	Pasture/Hay	11	-	4,056	PAS	78	Horse Farm						-		-	94				-	-									4,056	312,837	
20	Pasture/Hay	11	1	7,269	PAS	35	Pasture/Hay				Lezlie Carter - tax acct # 0200090062322	Mark Scible	-		54	265	nutr mgmt, pasture and hay planting, pasture and hayland mgmt, wildlife upland habitat mgmt, cons cropping sequence, cons tillage, cross slope farming	pasture and hay planting	11/1/97	244	650									7,269	829,520	
21	Pasture/Hay	11	-	1,542	PAS	8	Pasture/Hay				Karen Davis - tax # 0200004253900, 0200090100733, 0200090100734	Joel Greenwell	953	1008	49	71	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till	cons crop rotation, residue mgmt-no till	6/1/02	242	631	Multipractice	Rotation	No-till						1,542	114,431	
22	Pasture/Hay	11	-	1,884	PAS	8	Pasture/Hay				Karen Davis - tax # 0200004253900, 0200090100733, 0200090100734	Joel Greenwell	953	1008	49	71	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till	cons crop rotation, residue mgmt-no till	6/1/02	242	631	Multipractice	Rotation	No-till						1,884	174,533	
23	Pasture/Hay	11	2	6,415	PAS	4	Pasture/Hay				J. Howard Beard III	J. Howard Beard III	84	86	49	26	cons crop rotation, cover crop, grade stabilization structure, nutr mgmt, upland wildlife habitat mgmt, residue mgmt-no till, natural area protection, forage harvest mgmt, roof runoff mgmt, cons cover, field border, pasture and hay planting, field stripc	cons crop rotation, pasture and hay planting, field stripcropping	8/1/02	242	631	Multipractice	Rotation	Strip Cropping			Grass Filter Strip			6,415	475,804	
24	Pasture/Hay	11	1	7,559	PAS	44	Pasture/Hay*				William Mueller Jr	Allen Gertz	847	901	44	97	cons crop rotation, cover crop, nutr mgmt, pasture and hay planting, residue mgmt-no till, woodland mgmt	cons crop rotation, cover crop, nutr mgmt, residue mgmt-no till	9/1/00	246	637	Multipractice	Rotation	No-till	Cover Crop					7,559	580,978	NMP
25	Pasture/Hay	11	1	3,836	PAS	82	Horse Farm						-		-	289				-	-									3,836	382,372	
26	Pasture/Hay	11	1	8,019	PAS	27	Pasture/Hay				Robert Gertz	Allen Gertz	561	547	43	46	cons crop rotation, cover crop, nutr mgmt, residue mgmt-no till, upland wildlife habitat mgmt, woodland mgmt	cons crop rotation, cover crop, nutr mgmt, residue mgmt-no till	9/1/00	243	624	Multipractice	Rotation	No-till	Cover Crop					8,019	626,783	NMP
27	Pasture/Hay	11	-	6,534	PAS	81	Sod					American Turf	-		-	-				-	-						Wooded Buffer			6,534	565,872	
28	Pasture/Hay	11	-	3,482	PAS	83	Horse Farm						-		-	32				-	-									3,482	308,599	
29	Row Crops	12	8	5,758	SRC	70	Row Crop*						-		-	55				-	-	Cover Crop					Grass Filter Strip			5,758	526,277	
30	Row Crops	12	-	3,012	SRC	65	Row Crop*						-		-	104				-	-	Cover Crop								3,012	432,301	
31	Row Crops	12	-	8,176	SRC	79	Sod						-		-	53				-	-									8,176	1,413,651	
33	Row Crops	12	1	1,896	SRC	75	MultiCrop	Corn	Flowers				-		-	89				-	-	Strip Cropping					Grass Filter Strip			1,896	155,726	
34	Row Crops	12	-	10,218	SRC	26	Soy				Richard Forney	Allen Gertz	557	543	37	86	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till	9/1/00	243	624	Multipractice	Rotation	Cover Crop			Grass Filter Strip			10,218	1,201,709	NMP
35	Row Crops	12	-	2,255	SRC	26	Soy				Richard Forney	Allen Gertz	557	543	37	86	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till	9/1/00	243	624	Multipractice	Rotation	Cover Crop			Grass Filter Strip			2,255	210,480	NMP
36	Row Crops	12	-	1,515	SRC	48	Row Crop*				Florence Phebus	Ricky Davis	230	230B	59	19	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till, woodland mgmt		6/1/99	247	699									1,515	84,927	

OBJECT ID	CLASSNAME	CLASSNO	PCNT_ IMPV	Shape_Leng	LU_CODE	CH_ID	Category	Crop_1	Crop_2	Crop_3	Owner	Operator	Farm	Tract	Map	Parcel	Practices	Practices1	Plan_Date	State_Wshd	Co_Wshd_ID	Practice_C	Practice_1	Practice_2	Practice_3	Practice_4	BMP_Catego	BMP_1	BMP_2	Shape_Le_1	Shape_Area	NM_Plan
37	Row Crops	12	-	11,982	SRC	53	Row Crop*				Peggy Eichlman	Ricky Davis	19	18	59	96	cons crop rotation, critical area planting, nutr mgmt, pest mgmt, residue mgmt, upland wildlife habitat mgmt, grassed waterway, woodland mgmt	cons crop rotation, nutr mgmt, residue mgmt	7/1/99	247	699	Rotation								11,904	658,727	NMP
38	Row Crops	12	-	6,663	SRC	58	Corn				Joseph Aisquith	Ricky Catterton	974	1025	59	86	cons crop rotation, cover crop, nutr mgmt, residue mgmt-no till, forest stand improvemt, critical area planting	forest stand improvemt, critical area planting	3/1/04	248	676	Multipractice	Cover crop				Grass Filter Strip			6,663	1,308,700	
40	Pasture/Hay	11	-	8,842	PAS		Fallow						-		-	-				-	-									4,459	230,928	
42	Pasture/Hay	11	-	2,226	PAS		Pasture/Hay						-		-	-				-	-									2,226	72,473	
43	Pasture/Hay	11	1	1,640	PAS		MultiCrop	Soy	Corn		Oscar Grimes	Oscar Grimes	239	239	58	23	fence, pasture and hay planting, nutr mgmt, pest mgmt, prescribed grazing, pipeline, watering facility, water well	fence, nutr mgmt, pest mgmt, pipeline, watering facility, water well	8/1/04	247	699	Multipractice	Rotation	Strip Cropping	Contour Cropping		MultiBMP	Wooded Buffer	Grass Filter Strip	1,640	85,590	NMP
44	Pasture/Hay	11	-	3,541	PAS		Pasture/Hay*						-		-	-				-	-									3,541	305,395	
45	Row Crops	12	-	4,504	SRC		Corn						-		-	-				-	-									4,293	550,276	
46	Row Crops	12	-	2,385	SRC		Corn						-		-	-				-	-									2,385	109,114	
47	Row Crops	12	-	4,059	SRC		Row Crop*						-		-	-				-	-									4,059	481,102	
48	Row Crops	12	-	1,419	SRC		Row Crop						-		-	-				-	-									1,419	106,032	
49	Row Crops	12	-	8,039	SRC		Soy						-		-	-				-	-									8,039	860,794	
50	Row Crops	12	-	960	SRC		Cover Crop						-		-	-				-	-									960	54,153	
51	Row Crops	12	-	2,289	SRC		Row Crop*						-		-	-				-	-									2,289	63,290	
52	Row Crops	12	-	648	SRC		Row Crop*						-		-	-				-	-									648	24,750	
53	Row Crops	12	1	1,234	SRC		Open Space						-		-	-				-	-									1,234	62,617	
54	Row Crops	12	4	7,890	SRC		Horse Farm						-		-	-				-	-									7,890	535,166	
55	Row Crops	12	-	2,888	SRC	28	Row Crop*						-		-	-				-	-									2,888	137,643	
56	Row Crops	12	-	3,181	SRC	28	Row Crop*						-		-	-				-	-									3,181	208,433	
57	Row Crops	12	-	2,065	SRC		Row Crop*						-		-	-				-	-									2,065	155,357	
58	Pasture/Hay	11	-	4,596	PAS		Fallow						-		-	-				-	-									4,596	362,656	
59	Row Crops	12	11	4,036	SRC		Row Crop*						-		-	-				-	-									4,036	339,062	
60	Pasture/Hay	11	-	5,342	PAS		Fallow						-		-	-				-	-									5,342	749,972	
61	Row Crops	12	-	3,536	SRC		Fallow						-		-	-				-	-									3,536	175,047	
62	Pasture/Hay	11	-	3,355	PAS		Pasture/Hay*						-		-	-				-	-									3,355	287,286	
63	Pasture/Hay	11	1	6,310	PAS		MultiCrop	Soy	Corn		Oscar Grimes	Oscar Grimes	239	239	58	23	fence, pasture and hay planting, nutr mgmt, pest mgmt, prescribed grazing, pipeline, watering facility, water well	fence, nutr mgmt, pest mgmt, pipeline, watering facility, water well	8/1/04	247	699	Multipractice	Rotation	Strip Cropping	Contour Cropping		MultiBMP	Wooded Buffer	Grass Filter Strip	6,310	717,673	NMP
64	Pasture/Hay	11	-	3,322	PAS		Pasture/Hay*						-		-	-				-	-									3,322	404,944	
65	Pasture/Hay	11	-	6,372	PAS		Pasture/Hay*						-		-	-				-	-									6,372	564,293	
66	Pasture/Hay	11	-	3,807	PAS		Pasture/Hay*						-		-	-				-	-									3,807	315,604	
68	Row Crops	12	-	1,605	SRC		Corn						-		-	247				-	-						Grass Filter Strip			1,605	79,803	
69	Pasture/Hay	11	-	1,986	PAS		Pasture/Hay*						-		-	-				-	-									1,986	101,337	
70	Pasture/Hay	11	-	6,554	PAS		Fallow						-		-	-				-	-									6,554	527,656	
72	Pasture/Hay	11	-	5,306	PAS		Fallow						-		-	-				-	-									5,306	260,897	
73	Pasture/Hay	11	-	1,216	PAS	6C	Pasture/Hay*						-		-	-	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	residue mgmt-no till, nutr mgmt, cover crop, cons crop rotation		-	-									1,216	53,044	NMP
74	Pasture/Hay	11	2	5,081	PAS	6B	MultiCrop	Soy	Flowers				-		-	-				-	-	Multipractice	Rotation	No-till	Cover Crop		Grass Filter Strip			5,081	551,045	
75	Pasture/Hay	11	-	2,579	PAS		Pasture/Hay*						-		-	-				-	-									2,579	165,580	
76	Pasture/Hay	11	-	8,416	PAS		Fallow						-		-	-				-	-									8,416	1,182,097	
78	Pasture/Hay	11	1	4,986	PAS	21C	Corn						-		-	-	cons cropping system, cross slope farming, cover crop, permanent cover, contour farming, field stripcropping, stream crossing	cons cropping system, cover crop, permanent cover		-	-	Multipractice	Contour Cropping	Strip Cropping	Cover Crop					4,986	933,323	
80	Pasture/Hay	11	-	12,175	PAS	21B	Pasture/Hay*						-		-	-	cons cropping system, cross slope farming, cover crop, permanent cover, contour farming, field stripcropping, stream crossing	cons cropping system, cover crop, permanent cover		-	-	Cover Crop								11	5	
81	Row Crops	12	-	3,785	SRC		Row Crop*						-		-	-				-	-									3,785	453,119	
82	Pasture/Hay	11	-	1,718	PAS		Pasture/Hay*						-		-	-				-	-	Multipractice	Rotation	No-till						1,718	99,980	
83	Pasture/Hay	11	-	9,085	PAS	3B	Pasture/Hay						-		-	-		cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till		-	-	Multipractice	Rotation	No-till						9,085	778,358	NMP
84	Pasture/Hay	11	-	2,672	PAS		Pasture/Hay*						-		-	-				-	-									2,672	164,915	
85	Pasture/Hay	11	-	753	PAS		Fallow						-		-	-				-	-									753	35,324	
86	Pasture/Hay	11	1	4,944	PAS		Pasture/Hay*						-		-	-				-	-									4,944	583,196	
87	Pasture/Hay	11	2	6,224	PAS		Sod						-		-	-				-	-									5,913	686,603	
88	Pasture/Hay	11	-	7,705	PAS		Open Space						-		-	-				-	-									7,705	1,084,420	
89	Pasture/Hay	11	2	8,462	PAS		Sod						-		-	-				-	-									8,462	1,260,705	
90	Pasture/Hay	11	-	1,049	PAS		Open Space						-		-	-				-	-									1,049	65,482	
91	Pasture/Hay	11	-	1,235	PAS		Open Space						-		-	-				-	-									1,235	81,140	
92	Pasture/Hay	11	-	3,929	PAS		Pasture/Hay*						-		-	-				-	-									3,929	345,242	
93	Pasture/Hay	11	-	6,154	PAS		Open Space						-		-	-				-	-									6,154	505,033	
94	Pasture/Hay	11	-	2,096	PAS		Fallow						-		-	-				-	-									2,096	216,799	
95	Pasture/Hay	11	-	4,690	PAS		Pasture/Hay						-		-	-				-	-									4,690	286,736	
96	Pasture/Hay	11	4	1,511	PAS		Open Space						-		-	-				-	-									1,511	121,438	
97	Pasture/Hay	11	-	2,035	PAS		Pasture/Hay*						-		-	-				-	-									2,035	207,754	
98	Pasture/Hay	11	-	1,560	PAS		Pasture/Hay*						-		-	-				-	-									1,560	64,624	
99	Pasture/Hay	11	-	2,577	PAS		Pasture/Hay						-		-	-				-	-									2,577	306,706	
100	Pasture/Hay	11	-	3,642	PAS		Open Space						-		-	-				-	-									3,715	161,728	
101	Pasture/Hay	11	-	12,377	PAS	23A	Horse Farm						-		-	-				-	-									12,377	2,920,635	
102	Pasture/Hay	11	1	5,935	PAS		Horse Farm						-		-	-				-	-									5,935	877,739	
103	Row Crops	12	-	1,248	SRC		Corn						-		-	-				-	-									1,248	78,810	
104	Row Crops	12	-	8,899	SRC		Corn						-		-	-				-	-									8,899	886,675	
105	Pasture/Hay	11	10	2,712	PAS		Soy						-		-	1				-	-						Grass Filter Strip			2,712	130,615	
107	Row Crops	12	-	9,359	SRC		Row Crop*						-		-	-				-	-									8,914	1,119,875	
109	Pasture/Hay	11	1	2,606	PAS		Corn						-		-	-				-	-	Multipractice	Contour Cropping	Strip Cropping	Cover Crop					1,630	83,599	
111	Pasture/Hay	11	1	5,173	PAS		Corn						-		-	-				-	-	Multipractice	Contour Cropping	Strip Cropping	Cover Crop					5,173	461,544	
112	Pasture/Hay	11	-	2,933	PAS		Pasture/Hay*						-		-	-				-	-	Cover Crop								2,933	332,930	
113	Row Crops	12	-	3,078	SRC		Row Crop*				Mildred Anderson - tax # 0200090076043	Mark Scible	100	102	49	51	same farm as above	same farm as above		242	631									3,078	142,040	
114	Row Crops	12	-	34,590	SRC		Row Crop*				Mildred Anderson - tax # 0200090076043	Mark Scible	100	102	49	51	same farm as above	same farm as above		242	631									3,459	224,724	
115	Row Crops	12	-	4,434	SRC		Row Crop*						-		-	-				-	-									4,434	313,007	
116	Row Crops	12	2	7,765	SRC		Fallow						-		-	-				-	-									7,765	1,402,265	
118	Row Crops	12	2	6,434	SRC	3A	Row Crop*						-		-	-		cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till		-	-	Multipractice	Rotation	No-till						6,434	656,806	NMP
119	Row Crops	12	1	14,806	SRC		Fallow						-		-	-				-	-									9,788	1,512,056	
120	Row Crops	12	1	31,703	SRC		Soy						-		-	-				-	-									3,054	236,509	
121	Row Crops	12	2	7,616	SRC		Fallow						-		-	-				-	-									7,616	867,779	
122	Row Crops	12	-	8,050	SRC		Row Crop*						-		-	-				-	-									8,050	1,764,101	
123	Row Crops	12	5	14,532	SRC		Open Space						-		-	-				-	-									14,532	2,868,516	
124	Pasture/Hay	11	-	2,079	PAS		Sod					American Turf	-		-	-				-	-						Wooded Buffer			2,079	163,603	
125	Row Crops	12	-	1,883	SRC		Row Crop*						-		-	-				-	-									1,883	117,559	
126	Row Crops	12	-	2,039	SRC		Row Crop*						-		-	-				-	-									2,039	244,988	
127	Row Crops	12	-	8,076	SRC		Row Crop*						-		-	-				-	-									8,076	823,125	
128	Row Crops	12	-	3,726	SRC		Fallow						-		-	-				-	-									3,624	471,666	
129	Row Crops	12	-	3,901	SRC		Soy						-		-	-				-	-									3,901	346,615	

OBJECT ID	CLASSNAME	CLASSNO	PCNT_ IMPV	Shape_Leng	LU_CODE	CH_ID	Category	Crop_1	Crop_2	Crop_3	Owner	Operator	Farm	Tract	Map	Parcel	Practices	Practices1	Plan_Date	State_Wshd	Co_Wshd_ID	Practice_C	Practice_1	Practice_2	Practice_3	Practice_4	BMP_Catego	BMP_1	BMP_2	Shape_Le_1	Shape_Area	NM_Plan
130	Row Crops	12	-	1,417	SRC	25F	Row Crop*						-		-	-	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till		-	-	Multipractice	Rotation	No-till	Cover Crop					1,417	96,051	
131	Row Crops	12	3	4,466	SRC	25C	MultiCrop	Corn	Vegetables				-		-	-	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till		-	-	Multipractice	Rotation	No-till	Cover Crop					4,466	454,822	
132	Row Crops	12	-	987	SRC	25A	Row Crop*						-		-	-	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till		-	-	Multipractice	Rotation	No-till	Cover Crop		Grass Filter Strip			987	38,602	
133	Row Crops	12	-	1,449	SRC	25B	Row Crop*						-		-	-	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till		-	-	Multipractice	Rotation	No-till	Cover Crop					1,449	97,346	
134	Row Crops	12	-	2,912	SRC		Fallow						-		-	-				-	-									3,112	276,621	
135	Row Crops	12	1	7,622	SRC		Row Crop*						-		-	-				-	-									2,152	137,116	
136	Row Crops	12	-	4,062	SRC		Row Crop*						-		-	-				-	-									1,778	56,498	
138	Row Crops	12	-	1,064	SRC		Row Crop*						-		-	-				-	-									1,064	46,708	
139	Row Crops	12	-	12,448	SRC		Fallow						-		-	-				-	-									12,342	1,058,386	
141	Row Crops	12	3	1,463	SRC		Row Crop						-		-	-				-	-									1,463	110,986	
142	Row Crops	12	-	1,594	SRC		Row Crop*						-		-	-				-	-									1,594	70,331	
143	Row Crops	12	-	2,562	SRC		Soy				Joseph Aisquith	Ricky Catterton	973	1024	59	5	nothing planned			247	699	Rotation					Grass Filter Strip			2,562	235,853	
144	Row Crops	12	-	1,743	SRC		Soy				Joseph Aisquith	Ricky Catterton	973	1024	59	5	nothing planned			247	699	Rotation					Grass Filter Strip			1,743	98,611	
145	Row Crops	12	-	3,276	SRC		Row Crop*						-		-	-				-	-									3,276	212,413	
146	Pasture/Hay	11	1	1,955	PAS		MultiCrop	Soy	Corn		Oscar Grimes	Oscar Grimes	239	239	58	23	fence, pasture and hay planting, nutr mgmt, pest mgmt, prescribed grazing, pipeline, watering facility, water well	fence, nutr mgmt, pest mgmt, pipeline, watering facility, water well	8/1/04	247	699	Multipractice	Rotation	Strip Cropping	Contour Cropping		MultiBMP	Wooded Buffer	Grass Filter Strip	1,955	97,989	NMP
147	Row Crops	12	-	2,824	SRC		Soy				Joseph Aisquith	Ricky Catterton	973	1024	59	5	nothing planned			247	699	Rotation					Grass Filter Strip			2,824	90,866	
148	Row Crops	12	-	3,102	SRC		Soy				Joseph Aisquith	Ricky Catterton	973	1024	59	5	nothing planned			247	699	Rotation					Grass Filter Strip			3,102	314,039	
149	Row Crops	12	-	3,664	SRC		Soy				Joseph Aisquith	Ricky Catterton	973	1024	59	5	nothing planned			247	699	Rotation					Grass Filter Strip			3,664	477,934	
150	Pasture/Hay	11	1	4,964	PAS		MultiCrop	Soy	Corn		Oscar Grimes	Oscar Grimes	239	239	58	23	fence, pasture and hay planting, nutr mgmt, pest mgmt, prescribed grazing, pipeline, watering facility, water well	fence, nutr mgmt, pest mgmt, pipeline, watering facility, water well	8/1/04	247	699	Multipractice	Rotation	Strip Cropping	Contour Cropping		MultiBMP	Wooded Buffer	Grass Filter Strip	4,964	627,833	NMP
151	Row Crops	12	-	2,157	SRC		Soy						-		-	-				-	-									2,157	119,611	
152	Row Crops	12	-	4,180	SRC	51	Soy				Joseph Aisquith	Ricky Catterton	973	1024	59	5	nothing planned			247	699	Rotation					Grass Filter Strip			4,180	835,256	
153	Row Crops	12	-	3,555	SRC	76	Soy						-		-	-				-	-						Grass Filter Strip			3,555	402,130	
154	Row Crops	12	4	3,878	SRC	68	Soy						-		-	-				-	-	Contour Cropping					Grass Filter Strip			3,878	317,364	
155	Row Crops	12	-	7,682	SRC	73	Corn						-		-	247				-	-						Grass Filter Strip			7,274	1,032,026	
156	Row Crops	12	-	3,033	SRC	36	Soy				Max Covington (George Carr Property)	Joel Greenwell	89	91	55	95	nutr mgmt, residue mgmt-no till		8/1/99	244	650									3,033	400,806	
157	Pasture/Hay	11	1	10,625	PAS	52	MultiCrop	Soy	Corn		Oscar Grimes	Oscar Grimes	239	239	58	23	fence, pasture and hay planting, nutr mgmt, pest mgmt, prescribed grazing, pipeline, watering facility, water well	fence, nutr mgmt, pest mgmt, pipeline, watering facility, water well	8/1/04	247	699	Multipractice	Rotation	Strip Cropping	Contour Cropping		MultiBMP	Wooded Buffer	Grass Filter Strip	10,625	988,917	NMP
158	Pasture/Hay	11	-	4,365	PAS	26	Soy				Richard Forney	Allen Gertz	557	543	37	86	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till, woodland mgmt	cover crop, cons crop rotation, nutr mgmt, residue mgmt-no till	9/1/00	243	624	Multipractice	Rotation	Cover Crop			Grass Filter Strip			4,365	176,777	NMP
159	Row Crops	12	-	34,590	SRC	15	Row Crop				Mildred Anderson - tax # 0200090076043	Mark Scible	100	102	49	51	cons crop rotation, nutr, mgmt, residue mgmt-no till, residue mgmt-seasonal, cove rcrop,row arrangemt	cons crop rotation, nutr, mgmt, residue mgmt-no till, residue mgmt-seasonal, cove rcrop,row arrangemt		242	631									18,392	4,054,182	NMP
160	Row Crops	12	1	11,597	SRC	66	Soy						-		-	124				-	-	Rotation					MultiBMP	Wooded Buffer	Grass Filter Strip	11,274	2,071,431	
161	Row Crops	12	-	22,765	SRC	67	Corn						-		-	-				-	-						MultiBMP	Wooded Buffer	Grass Drainage Ditch	1,796	139,274	
162		0	-	-		54	Pasture/Hay				Ralph & Patricia Lavers	Ralph & Patricia Lavers	-		55	240	pasture & hayland mgmt, pasture & hayland planting, farmstead and feedlot windbreak, woodland improvement	pasture and hayland planting	6/1/91	247	699									1,506	143,704	
163		0	-	-		77	Corn						-		-	184				-	-									1,189	76,337	
164	Row Crops	12	-	5,478	SRC	50	Corn				Friend Nagle Jr	Ricky Davis	230	230A	59	266	cons crop rotation, nutr mgmt, pest mgmt, residue mgmt-no till, woodland mgmt		6/1/99	247	699						MultiBMP	Wooded Buffer	Grass Filter Strip	1,090	30,016	
165		0	-	-		72	Garden					Homestead Garden / Davidsonville Garden Center	-		-	-				-	-									2,919	479,319	
166	Pasture/Hay	11	1	1,369	PAS		MultiCrop	Soy	Corn		Oscar Grimes	Oscar Grimes	239	239	58	23	fence, pasture and hay planting, nutr mgmt, pest mgmt, prescribed grazing, pipeline, watering facility, water well	fence, nutr mgmt, pest mgmt, pipeline, watering facility, water well	8/1/04	247	699	Multipractice	Rotation	Strip Cropping	Contour Cropping		MultiBMP	Wooded Buffer	Grass Filter Strip	1,369	48,168	NMP
167	Pasture/Hay	11	1	2,039	PAS		MultiCrop	Soy	Corn		Oscar Grimes	Oscar Grimes	239	239	58	23	fence, pasture and hay planting, nutr mgmt, pest mgmt, prescribed grazing, pipeline, watering facility, water well	fence, nutr mgmt, pest mgmt, pipeline, watering facility, water well	8/1/04	247	699	Multipractice	Rotation	Strip Cropping	Contour Cropping		MultiBMP	Wooded Buffer	Grass Filter Strip	2,039	173,928	NMP
168	Row Crops	12	-	1,197	SRC		Row Crop*						-		-	-				-	-									1,197	60,245	
169	Row Crops	12	-	1,261	SRC		Row Crop*						-		-	-				-	-									1,261	74,450	
170	Row Crops	12	2	3,438	SRC		Row Crop*						-		-	-				-	-									3,438	346,002	
171	Row Crops	12	-	2,295	SRC		Row Crop*						-		-	-				-	-									2,295	140,969	
172	Row Crops	12	-	1,174	SRC		Row Crop						-		-	-				-	-									1,174	64,723	
174	Row Crops	12	-	2,905	SRC		Row Crop*						-		-	-				-	-									2,905	192,950	
175	Row Crops	12	1	2,311	SRC	38	Soy						-		-	-				-	-									2,339	282,926	
176	Row Crops	12	1	4,325	SRC		Row Crop*						-		-	-				-	-									4,325	576,658	
177	Row Crops	12	-	2,376	SRC		Row Crop*						-		-	-				-	-									2,376	148,191	
178	Row Crops	12	-	2,439	SRC		Corn						-		-	-				-	-									2,439	213,065	
179	Row Crops	12	1	20,807	SRC	38A	MultiCrop	Soy	Corn				-		-	-	cons crop rotation, cover cro, critical area planting, cons tillage, nutr mgmt, pasture and hay planting, residue mgmt seasonal, field stripcropping, fence, pasture and hayland mgmt, trough, wildlife upland habitat mgmt, filter strip, grassed waterway, g	cover crop, field stripcropping, cons crop rotation, grassed waterway, nutr mgmt, pasture and hay mgmt, residue mgmt-no till, residue mgmt seasonal		-	-	Multipractice	Rotation	No-till	Contour Cropping	Strip Cropping	MultiBMP	Wooded Buffer	Grass Filter Strip	20,807	4,741,304	
180	Row Crops	12	2	3,497	SRC		Cover Crop						-		-	-				-	-									3,497	381,995	
181	Row Crops	12	-	1,595	SRC		Corn						-		-	-				-	-									1,595	116,385	
182	Row Crops	12	-	7,863	SRC		Corn						-		-	-				-	-									7,863	923,524	
183	Row Crops	12	-	8,738	SRC		Row Crop*						-		-	-				-	-									8,738	749,491	
184	Pasture/Hay	11	1	4,276	PAS		Open Space						-		-	-				-	-									2,847	125,265	
185	Pasture/Hay	11	-	1,435	PAS		Horse Farm						-		-	-				-	-									1,435	52,524	
186	Row Crops	12	-	1,396	SRC	29A	Corn						-		-	-	cons crop rotation, cover crop, nutr mgmt, pest mgmt, forest land mgmt			-	-						Grass Filter Strip			1,396	105,613	
187	Pasture/Hay	11	-	5,949	PAS		Open Space						-		-	-				-	-									5,949	573,623	
188	Pasture/Hay	11	1	6,663	PAS		Open Space						-		-	-				-	-									6,663	1,181,851	
189	Pasture/Hay	11	5	3,584	PAS		Open Space						-		-	-				-	-									3,584	349,724	
190	Pasture/Hay	11	5	1,002	PAS		Open Space						-		-	-				-	-									1,002	36,631	

OBJECT ID	CLASSNAME	CLASSNO	PCNT_ IMPV	Shape_Leng	LU_CODE	CH_ID	Category	Crop_1	Crop_2	Crop_3	Owner	Operator	Farm	Tract	Map	Parcel	Practices_	Practices1	Plan_Date	State_Wshd	Co_Wshd_ID	Practice_C	Practice_1	Practice_2	Practice_3	Practice_4	BMP_Catego	BMP_1	BMP_2	Shape_Le_1	Shape_Area	NM_Plan
191	Row Crops	12	7	3,053	SRC		Fallow						-		-	-				-	-									3,053	378,500	
193	Pasture/Hay	11	-	4,474	PAS	39B	Row Crop*						-		-	-	cons cover, heavy use area protection, fence, nutr mgmt, pest mgmt, pond, prescribed grazing	heavy use area protection		-	-									4,474	339,593	
194	Row Crops	12	-	3,874	SRC		Row Crop*						-		-	-				-	-									3,874	162,591	
195	Row Crops	12	4	8,843	SRC	22A	Row Crop*						-		-	-	cons crop rotation, cover crop, nutr mgmt, pest mgmt, forest land mgmt			-	-									2,842	226,086	
196	Row Crops	12	4	8,843	SRC	29B	MultiCrop	Corn	Vegetables				-		-	-	cons crop rotation, cover crop, nutr mgmt, pest mgmt, forest land mgmt			-	-									6,007	849,437	
202	Row Crops	12	-	4,062	SRC		Row Crop*						-		-	-				-	-									1,119	48,500	
207	Pasture/Hay	11	-	10,421	PAS		Sod					American Turf	-		-	-				-	-						Wooded Buffer			2,896	186,505	
213	Pasture/Hay	11	-	2,606	PAS		Pasture/Hay*						-		-	-				-	-	Cover Crop								846	26,855	
214	Pasture/Hay	11	-	12,175	PAS	21B	Pasture/Hay*						-		-	-	cons cropping system, cross slope farming, cover crop, permanent cover, contour farming, field stripcropping, stream crossing	cons cropping system, cover crop, permanent cover		-	-	Cover Crop								11,804	2,521,694	
215	Row Crops	12	1	11,597	SRC		Fallow						-		-	-				-	-									2,234	124,796	
219	Row Crops	12	-	22,765	SRC		Corn						-		-	-				-	-									3,309	353,401	
220		0	-	-			Corn						-		-	-				-	-									659	25,275	
221		0	-	-		60B	Wildlife						-		-	-	pasture and hayland mgmt, windbreak/shelterbreak establishment, upland wildlife habitat mgmt, forest stand improvement	pasture and hayland mgmt		-	-						Pond			292	5,693	
222	Row Crops	12	-	5,478	SRC		Row Crop*						-		-	-				-	-									1,634	60,513	
223		0	-	-		60A	Horse Farm						-		-	-	pasture and hayland mgmt, windbreak/shelterbreak establishment, upland wildlife habitat mgmt, forest stand improvement	pasture and hayland mgmt		-	-						MultiBMP	Wooded Buffer	Grass Filter Strip	4,171	471,074	

Appendix D
Metadata of the GIS Dataset

AG_Landuse

Metadata also available as

Metadata:

- Identification_Information
- Data_Quality_Information
- Spatial_Data_Organization_Information
- Spatial_Reference_Information
- Entity_and_Attribute_Information
- Distribution_Information
- Distribution_Information
- Metadata_Reference_Information

Identification_Information:
Citation:
Citation_Information:
Originator:
Mary L. Searing, Anne Arundel County, Bureau of Engineering, Watershed and Ecosystem Services
Publication_Date: 05/05/2007
Title: AG_Landuse
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publication_Place: Anne Arundel County, MD
Publisher: Anne Arundel County, MD
Online_Linkage:
\\PERSEUS\Projects\AnneArundel\339418_Run_Off_Assessment\GIS_DATA\
Description:
Abstract:
Anne Arundel County, Maryland is interested in acquiring data on practices that influences nutrient management processes in the South River watershed for environmental protection purposes. The significant acreage of agricultural land in the South River watershed prompted the need to carefully consider how to evaluate runoff quality and BMP effectiveness in the South River watershed. The county's 2004 landuse layer was used as the base layer for the development of this dataset. Attributes were added to the landuse layer to include data on farmlands in the watershed received from the county's Soil Conservation District (SCD). A windshield survey was conducted to verify and augment the data in the landuse layer and that provided by the county's SCD. The resulting data of farming activities, conservation practices and BMPs were are presented in this dataset.
Purpose:
The purpose of this task was to collect and organize data on agricultural practices in the South River watershed as an input to the county's watershed management process.
Time_Period_of_Content:
Time_Period_Information:

Single_Date/Time:
Calendar_Date: 2006
Currentness_Reference: Base on a 2004 Landuse data and 2006 Windshield Survey
Status:
Progress: Draft
Maintenance_and_Update_Frequency: Mass needed
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -76.673423
East_Bounding_Coordinate: -76.511330
North_Bounding_Coordinate: 39.050434
South_Bounding_Coordinate: 38.900646
Keywords:
Theme:
Theme_Keyword_Thesaurus: None
Theme_Keyword: Agricultural BMP
Theme_Keyword: Conservation Practice
Theme_Keyword: CropCategory
Theme_Keyword: PracticeCategory
Theme_Keyword: BMPCategory
Place:
Place_Keyword_Thesaurus: None
Place_Keyword: South River Watershed, Anne Arundel County, MD
Access_Constraints:
Access to this dataset should be authorized by the Anne Arundel County government.
Use_Constraints:
Usage of this dataset should be authorized by the Anne Arundel County government.
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Mary L. Searing
Contact_Organization:
Anne Arundel County, Bureau of Engineering, Watershed and Ecosystem Services
Contact_Address:
Address_Type: mailing and physical address
Address: 2664 Riva Road 4th Floor (MS 6402)
City: Annapolis
State_or_Province: MD
Postal_Code: 21401
Country: USA
Contact_Voice_Telephone: 410.222.4240 ext. 6
Contact_Electronic_Mail_Address: msearing@aacounty.org
Hours_of_Service: Monday through Friday 7:30 AM - 4:00 PM
Native_Data_Set_Environment:
Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 9.1.0.722

Data_Quality_Information:

Lineage:
Process_Step:
Process_Description: Metadata imported.
Source_Used_Citation_Abbreviation: C:\TEMP\xmlBF.tmp

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: G-polygon
Point_and_Vector_Object_Count: 191

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Map_Projection:
Map_Projection_Name: Lambert Conformal Conic
Lambert_Conformal_Conic:
Standard_Parallel: 38.300000
Standard_Parallel: 39.450000
Longitude_of_Central_Meridian: -77.000000
Latitude_of_Projection_Origin: 37.666667
False_Easting: 1312333.333333
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: coordinate pair
Coordinate_Representation:
Abscissa_Resolution: 0.000128
Ordinate_Resolution: 0.000128
Planar_Distance_Units: survey feet
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222
Vertical_Coordinate_System_Definition:
Altitude_System_Definition:
Altitude_Resolution: 0.000010
Altitude_Encoding_Method:
Explicit elevation coordinate included with horizontal coordinates

---

Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: AG_Landuse

Entity_Type_Definition:
AgriculturalLandUse is dataset of agricultural lands and the types of farming activities and conservation practices employed.
Entity_Type_Definition_Source: MD Department of Agriculture
Attribute:
Attribute_Label: Shape
Attribute_Definition: Feature geometry.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain: Coordinates defining the features.
Attribute:
Attribute_Label: Shape_Leng
Attribute_Definition: Perimeter in linear feet of cultivated land use for agriculture
Attribute:
Attribute_Label: CLASSNAME
Attribute_Definition:
Attributes have been carried over from the Anne Arundel County 2004 Land Use GIS data file. Refer to Landcover_2004 metadata for additional information.
Attribute_Definition_Source: Anne Arundel County 2004 Land Use GIS data file
Attribute:
Attribute_Label: CLASSNO
Attribute_Definition:
Attributes have been carried over from the Anne Arundel County 2004 Land Use GIS data file. Refer to Landcover_2004 metadata for additional information.
Attribute_Definition_Source: Anne Arundel County 2004 Land Use GIS data file
Attribute:
Attribute_Label: PCNT_IMPV
Attribute_Definition:
Attributes have been carried over from the Anne Arundel County 2004 Land Use GIS data file. Refer to Landcover_2004 metadata for additional information.
Attribute_Definition_Source: Anne Arundel County 2004 Land Use GIS data file
Attribute:
Attribute_Label: LU_CODE
Attribute_Definition:
Attributes have been carried over from the Anne Arundel County 2004 Land Use GIS data file. Refer to Landcover_2004 metadata for additional information.
Attribute_Definition_Source: Anne Arundel County 2004 Land Use GIS data file
Attribute:
Attribute_Label: OBJECTID
Attribute:
Attribute_Label: Practice_2
Attribute_Definition:
One of multiple types of agricultural conservation practices identified in the August 2006 windshield survey that has a Practice_Category of Mutlipractice
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Strip Cropping

Enumerated_Domain_Value_Definition:
Agricultural conservation practice of strip cropping identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: No-till
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of no tillage identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: Contour Cropping
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of contour cropping identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: Cover Crop
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of cover crop identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: Rotation
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of crop rotation identified in the August 2006 windshield survey
Attribute:
Attribute_Label: CH_ID
Attribute_Definition:
ID created by CH2M HILL windshield survey field team to refer to farmlands for internal tracking.
Attribute:
Attribute_Label: Category
Attribute_Definition:
Refers to type of crop or animal farming activity on the farmland.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: MultiCrop
Enumerated_Domain_Value_Definition: More than one crop is being cultivated on the farmland
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Pasture/Hay
Enumerated_Domain_Value_Definition: Cultivated land used for pasture or hay
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Soy
Enumerated_Domain_Value_Definition: Cultivated land used for soy bean
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department

Enumerated_Domain:
Enumerated_Domain_Value: Grapes
Enumerated_Domain_Value_Definition: Cultivated land used for grapes
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Row Crop
Enumerated_Domain_Value_Definition: Cultivated land used for crops
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Horse Farm
Enumerated_Domain_Value_Definition: Cultivated land used for horse farming
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Sod
Enumerated_Domain_Value_Definition: Cultivated land used for sod farming
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Corn
Enumerated_Domain_Value_Definition: Cultivated land used for corn
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Garden
Enumerated_Domain_Value_Definition: Cultivated land used for garden crops
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Flowers
Enumerated_Domain_Value_Definition: Cultivated land used for flowers including cut flowers
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Vegetables
Enumerated_Domain_Value_Definition: Cultivated land used for vegetables
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Cover Crop
Enumerated_Domain_Value_Definition:
Cultivated land that is currently vacant but covered with cover crop
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department

Enumerated_Domain:
Enumerated_Domain_Value: Open Space
Enumerated_Domain_Value_Definition: land that is currently vacant but covered with grass
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Fallow
Enumerated_Domain_Value_Definition:
Cultivated land that is currently vacant but, covered with weeds
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: Wildlife
Enumerated_Domain_Value_Definition:
Cultivated land that is used for sheltering a variety of animals, includes animal sanctuary
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Enumerated_Domain:
Enumerated_Domain_Value: *
Enumerated_Domain_Value_Definition:
Entries with an "*" mean field team could not gain access to the field so "Category" was obtained from the County Land Use dataset.
Enumerated_Domain_Value_Definition_Source: CH2M Hill GIS Department
Attribute:
Attribute_Label: Crop_1
Attribute_Definition:
One of multiple kinds of crop cultivated on a farmland that has a Category of MultiCrop
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Pasture/Hay
Enumerated_Domain_Value_Definition: Cultivated land used for pasture or hay
Enumerated_Domain:
Enumerated_Domain_Value: Soy
Enumerated_Domain_Value_Definition: Cultivated land used for soy bean
Enumerated_Domain:
Enumerated_Domain_Value: Grapes
Enumerated_Domain_Value_Definition: Cultivated land used for grapes
Enumerated_Domain:
Enumerated_Domain_Value: Row Crop
Enumerated_Domain_Value_Definition: Cultivated land used for crops
Enumerated_Domain:
Enumerated_Domain_Value: Horse Farm
Enumerated_Domain_Value_Definition: Cultivated land used for horse farming

Enumerated_Domain:
Enumerated_Domain_Value: Sod
Enumerated_Domain_Value_Definition: Cultivated land used for sod farming
Enumerated_Domain:
Enumerated_Domain_Value: Corn
Enumerated_Domain_Value_Definition: Cultivated land used for corn
Enumerated_Domain:
Enumerated_Domain_Value: Garden
Enumerated_Domain_Value_Definition: Cultivated land used for garden crops
Enumerated_Domain:
Enumerated_Domain_Value: Flowers
Enumerated_Domain_Value_Definition: Cultivated land used for flowers including cut flowers
Enumerated_Domain:
Enumerated_Domain_Value: Vegetables
Enumerated_Domain_Value_Definition: Cultivated land used for vegetables
Attribute:
Attribute_Label: Shape_Area
Attribute_Definition: Area of feature in internal units squared.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain: Positive real numbers that are automatically generated.
Attribute:
Attribute_Label: Map
Attribute_Definition:
It is an attribute of the data on farmlands in the South River watershed received from the Anne Arundel Soil Conservation District.
Attribute:
Attribute_Label: Crop_2
Attribute_Definition:
One of multiple kinds of crop cultivated on a farmland that has a Category of MultiCrop
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Pasture/Hay
Enumerated_Domain_Value_Definition: Cultivated land used for pasture or hay
Enumerated_Domain:
Enumerated_Domain_Value: Soy
Enumerated_Domain_Value_Definition: Cultivated land used for soy bean
Enumerated_Domain:
Enumerated_Domain_Value: Grapes
Enumerated_Domain_Value_Definition: Cultivated land used for grapes
Enumerated_Domain:
Enumerated_Domain_Value: Row Crop
Enumerated_Domain_Value_Definition: Cultivated land used for crops

Enumerated_Domain:
Enumerated_Domain_Value: Horse Farm
Enumerated_Domain_Value_Definition: Cultivated land used for horse farming
Enumerated_Domain:
Enumerated_Domain_Value: Sod
Enumerated_Domain_Value_Definition: Cultivated land used for sod farming
Enumerated_Domain:
Enumerated_Domain_Value: Corn
Enumerated_Domain_Value_Definition: Cultivated land used for corn
Enumerated_Domain:
Enumerated_Domain_Value: Garden
Enumerated_Domain_Value_Definition: Cultivated land used for garden crops
Enumerated_Domain:
Enumerated_Domain_Value: Flowers
Enumerated_Domain_Value_Definition: Cultivated land used for flowers including cut flowers
Enumerated_Domain:
Enumerated_Domain_Value: Vegetables
Enumerated_Domain_Value_Definition: Cultivated land used for vegetables
Attribute:
Attribute_Label: Parcel
Attribute_Definition:
Parcel number of the parcel of land being used for agricultural purposes. It is an attribute of the data on farmlands in the South River watershed received from the Anne Arundel Soil Conservation District.
Attribute:
Attribute_Label: Crop_3
Attribute_Definition:
One of multiple kinds of crop cultivated on a farmland that has a Category of MultiCrop
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Pasture/Hay
Enumerated_Domain_Value_Definition: Cultivated land used for pasture or hay
Enumerated_Domain:
Enumerated_Domain_Value: Soy
Enumerated_Domain_Value_Definition: Cultivated land used for soy bean
Enumerated_Domain:
Enumerated_Domain_Value: Grapes
Enumerated_Domain_Value_Definition: Cultivated land used for grapes
Enumerated_Domain:
Enumerated_Domain_Value: Row Crop
Enumerated_Domain_Value_Definition: Cultivated land used for crops
Enumerated_Domain:
Enumerated_Domain_Value: Horse Farm

Enumerated_Domain_Value_Definition: Cultivated land used for horse farming
Enumerated_Domain:
Enumerated_Domain_Value: Sod
Enumerated_Domain_Value_Definition: Cultivated land used for sod farming
Enumerated_Domain:
Enumerated_Domain_Value: Corn
Enumerated_Domain_Value_Definition: Cultivated land used for corn
Enumerated_Domain:
Enumerated_Domain_Value: Garden
Enumerated_Domain_Value_Definition: Cultivated land used for garden crops
Enumerated_Domain:
Enumerated_Domain_Value: Flowers
Enumerated_Domain_Value_Definition: Cultivated land used for flowers including cut flowers
Enumerated_Domain:
Enumerated_Domain_Value: Vegetables
Enumerated_Domain_Value_Definition: Cultivated land used for vegetables
Attribute:
Attribute_Label: Plan_Date
Attribute_Definition:
An attribute of the data on farmlands in the South River watershed received from the Anne Arundel Soil Conservation District.
Attribute:
Attribute_Label: Practice_3
Attribute_Definition:
One of multiple types of agricultural conservation practices identified in the August 2006 windshield survey that has a Practice_Category of Mutlipractice
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Strip Cropping
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of strip cropping identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: No-till
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of no tillage identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: Contour Cropping
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of contour cropping identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: Cover Crop
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of cover crop identified in the

August 2006 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: Rotation

Enumerated_Domain_Value_Definition:

Agricultural conservation practice of crop rotation identified in the August 2006 windshield survey

Attribute:

Attribute_Label: Practice_4

Attribute_Definition:

One of multiple types of agricultural conservation practices identified in the August 2006 windshield survey that has a Practice_Category of Mutlipractice

Attribute_Domain_Values:

Enumerated_Domain:

Enumerated_Domain_Value: Strip Cropping

Enumerated_Domain_Value_Definition:

Agricultural conservation practice of strip cropping identified in the August 2006 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: No-till

Enumerated_Domain_Value_Definition:

Agricultural conservation practice of no tillage identified in the August 2006 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: Contour Cropping

Enumerated_Domain_Value_Definition:

Agricultural conservation practice of contour cropping identified in the August 200 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: Cover Crop

Enumerated_Domain_Value_Definition:

Agricultural conservation practice of cover crop identified in the August 2006 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: Rotation

Enumerated_Domain_Value_Definition:

Agricultural conservation practice of crop rotation identified in the August 2006 windshield survey

Attribute:

Attribute_Label: BMP_1

Attribute_Definition:

One of multiple types of agricultural BMPs identified on the farmland in the August 2006 windshield survey that has a BMP_Category of MutliBMP

Attribute_Domain_Values:

Enumerated_Domain:

Enumerated_Domain_Value: Grass Filter Strip

Enumerated_Domain_Value_Definition:

Agricultural BMP of grass filter strip identified in the August 2006 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: Grass Swale

Enumerated_Domain_Value_Definition:

Agricultural BMP of grass swale identified in the August 2006 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: Pond

Enumerated_Domain_Value_Definition:

Agricultural BMP of pond identified in the August 2006 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: Possible Manure storage

Enumerated_Domain_Value_Definition:

Agricultural BMP of manure storage identified as a possible practice in the August 2006 windshield survey but could not be confirmed

Enumerated_Domain:

Enumerated_Domain_Value: Wooded Buffer

Enumerated_Domain_Value_Definition:

Agricultural BMP of grass filter strip identified in the August 2006 windshield survey

Attribute:

Attribute_Label: BMP_2

Attribute_Definition:

One of multiple types of agricultural BMPs identified on the farmland in the August 2006 windshield survey that has a BMP_Category of MutliBMP

Attribute_Domain_Values:

Enumerated_Domain:

Enumerated_Domain_Value: Grass Filter Strip

Enumerated_Domain_Value_Definition:

Agricultural BMP of grass filter strip identified in the August 2006 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: Grass Swale

Enumerated_Domain_Value_Definition:

Agricultural BMP of grass swale identified in the August 2006 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: Pond

Enumerated_Domain_Value_Definition:

Agricultural BMP of pond identified in the August 2006 windshield survey

Enumerated_Domain:

Enumerated_Domain_Value: Possible Manure storage

Enumerated_Domain_Value_Definition:

Agricultural BMP of manure storage identified as a possible practice in the August 2006 windshield survey but could not be confirmed

Enumerated_Domain:

Enumerated_Domain_Value: Wooded Buffer

Enumerated_Domain_Value_Definition:

Agricultural BMP of grass filter strip identified in the August 2006 windshield survey

Attribute:

Attribute_Label: Co_Wshd_ID
Attribute_Definition:
County assigned ID for the subwatershed in which the parcel being used for agricultural activities is located. An attribute labeled MAJOR1 in Anne Arundel County's subwatershed shape file (SWSHEDNAD83ft.shp) obtained from the Office of Environmental and Cultural Resources.

Attribute:
Attribute_Label: Owner
Attribute_Definition:
Name of person(s) who owns the parcel of land being used for agricultural purposes. It is an attribute of the data on farmlands in the South River watershed received from the Anne Arundel Soil Conservation District.

Attribute:
Attribute_Label: Operator
Attribute_Definition:
Name of person(s) who operates the agricultural activities on the parcel of land being used for agricultural purposes. It is an attribute of the data on farmlands in the South River watershed received from the Anne Arundel Soil Conservation District.

Attribute:
Attribute_Label: Practice_1
Attribute_Definition:
One of multiple types of agricultural conservation practices identified in the August 2006 windshield survey that has a Category of Mutlipractice
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Strip Cropping
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of strip cropping identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: No-till
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of no tillage identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: Contour Cropping
Enumerated_Domain_Value_Definition:
: Agricultural conservation practice of contour cropping identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: Cover Crop
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of cover crop identified in the August 2006 windshield survey
Enumerated_Domain:
Enumerated_Domain_Value: Rotation
Enumerated_Domain_Value_Definition:
Agricultural conservation practice of crop rotation identified in the August 2006 windshield survey

Attribute:

Attribute_Label: Farm
Attribute_Definition:
It is an attribute of the data on farmlands in the South River watershed received from the Anne Arundel Soil Conservation District.
Attribute:
Attribute_Label: Tract
Attribute_Definition:
It is an attribute of the data on farmlands in the South River watershed received from the Anne Arundel Soil Conservation District.
Attribute:
Attribute_Label: NM_Plan
Attribute_Definition:
NM_Plan shows farmlands with Nutrient Management Plan as provided by the county's Soil Conservation Service
Attribute:
Attribute_Label: Practices_Planned
Attribute_Definition:
The types of agricultural conservation practices planned for the farmland. It is an attribute of the data on farmlands in the South River watershed received from the Anne Arundel Soil Conservation District.
Attribute:
Attribute_Label: Practices_Applied
Attribute_Definition:
The types of agricultural conservation practices reportedly practices on a farmland. It is an attribute of the data on farmlands in the South River watershed received from the Anne Arundel Soil Conservation District.
Attribute:
Attribute_Label: State_Wshd_ID
Attribute_Definition:
The types of agricultural conservation practices reportedly practices on a farmland. It is an attribute of the data on farmlands in the South River watershed received from the Anne Arundel Soil Conservation District.
Attribute:
Attribute_Label: Practice_Category
Attribute_Definition:
Refers to type of agricultural conservation practice identified on the farmland in the August 2006 windshield survey
Attribute:
Attribute_Label: BMP_Category
Attribute_Definition:
Refers to type of agricultural BMP identified on the farmland in the August 2006 windshield survey
Attribute:
Attribute_Label: Shape_Length
Attribute_Definition: Length of feature in internal units.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain: Positive real numbers that are automatically generated.

Distribution_Information:
    Distributor:
        Contact_Information:
            Contact_Person_Primary:
                Contact_Person: Mary L. Searing
                Contact_Organization:
                    Anne Arundel County, Bureau of Engineering, Watershed and Ecosystem Services
            Contact_Address:
                Address_Type: mailing and physical address
                City: 2664 Riva Road 4th Floor (MS 6402)
                State_or_Province: MD
                Postal_Code: 21401
                Country: USA
            Contact_Voice_Telephone: 410.222.4240 ext. 6
            Contact_Electronic_Mail_Address: msearing@aacounty.org
            Hours_of_Service: Monday through Friday 7:30 AM - 4:00 PM
    Resource_Description: Other Data
    Standard_Order_Process:
        Digital_Form:
            Digital_Transfer_Information:
                Transfer_Size: 0.481
        Fees: none
        Ordering_Instructions: none
        Turnaround: none

Distribution_Information:
    Resource_Description: Other Data

Metadata_Reference_Information:
    Metadata_Date: 20070509
    Metadata_Contact:
        Contact_Information:
            Contact_Organization_Primary:
                Contact_Organization:
                    Anne Arundel County, Office of Environmental and Cultural Resources
                Contact_Person: Mary L. Searing
            Contact_Address:
                Address_Type: mailing and physical address
                Address: 2664 Riva Road 4th Floor (MS 6402)
                City: Annapolis
                State_or_Province: MD
                Postal_Code: 21401
                Country: USA
            Contact_Voice_Telephone: 410.222.4240 ext. 6
            Contact_Electronic_Mail_Address: msearing@aacounty.org
            Hours_of_Service: Monday through Friday 7:30 AM - 4:00 PM

Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Extensions:
  Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
  Profile_Name: ESRI Metadata Profile
Metadata_Extensions:
  Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
  Profile_Name: ESRI Metadata Profile

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Appendix E
List of Agencies Contacted and Contact Persons

Data	Agency	Contact Person	Data Received?
List of Agricultural farmlands in the South River Watershed with Data on Soil Conservation Practices and BMPs	Anne Arundel County, Soil Conservation District (SCD)	Jeff Opel, Chairman and District Manager, Anne Arundel Soil Conservation District, 2662 Riva Road Annapolis, MD 21401	Yes
2005 County Level Nutrient Implementation Data for the South River watershed	Maryland Department of Agriculture	Fred Samadani, P.E., Administrator Maryland Nutrient Management Program 50 Harry S Truman Parkway Annapolis, MD 21401 Office (410) 841-5959 Email: samadaf@mda.state.md.us	Yes
• Maps showing field locations over an aerial, and cropping data associated with those fields. • Data on Common Crop Rotation\Tillage\Fertilizer Schedules	Maryland Farm Services Agency	Eddie Bowling Tel: (301) 574-5162	No: Data requested was not ready. Agency indicated digitized data will be complete and available to the public by early 2007
Data on nutrient retention rates associated with conservation practices and BMPs employed	County's USDA, Natural Resources Conservation Service Representative	Terry Heinard, Acting District Conservationist, USDA 2662 Riva Rd, Ste 150, Annapolis MD Maryland Tel: 410 571 6757 x 116 Email: terry.heinard@md.usda.gov	No: Terry Heinard directed us to Dean Cowherd, the Assistant State Soil Scientist
Data on nutrient retention rates associated with conservation practices and BMPs employed	USDA, Natural Resources Conservation Service, Annapolis, MD	Dean Cowherd, Assistant State Soil Scientist, UDSA, Annapolis, MD Email: Dean.Cowherd@md.usda.gov	No: Agency indicates local information for Maryland is available yet

TECHNICAL
MEMORANDUM

TO: Anne Arundel County

FROM: Mike Pieper, KCI Technologies

DATE: June 18, 2007

SUBJECT: South River Crossing Modeling

COPIES Tara Ajello, CH2M Hill
Bill Frost, KCI Technologies
Bill Medina, KCI Technologies
Nate Drescher, KCI Technologies

INTRODUCTION

Stream crossing modeling is to be conducted by County staff for 60 sites across the South River Watershed. The consultant team selected the sites and completed necessary field survey of the crossings. This technical memorandum reviews the site selection process that was followed, presents the final list of crossings surveyed and reviews the field procedures.

SITE SELECTION

Selection Criteria

The consultant team has selected the 60 sites plus 5 alternate sites based on the criteria and process described below. The process is similar to that used in previous work on the Severn River Watershed with few modifications.

The selection criteria are as follows:

1. Crossings are selected if the road was classified in the County's Master Transportation Plan as a Freeway, Principal Arterial, Minor Arterial, Collector. (Criteria for roads classified as ‘Local’ was modified slightly, described below under Process Modifications). Crossings on large interstate roadways such as Route 50 and 97 are not included since they would have been designed for larger storms.

2. Crossings are selected if overtopping is likely, determined by both the height of the road surface above the top of the structure and the channel and floodplain characteristics. In general, the vertical distance between top of roadway and stream water surface should be less than 20 feet to consider it for selection, under the assumption that high stream crossings would not represent the most imminent flooding hazards.

3. Crossings are selected if flooding will completely cut off an area from emergency services where the stream crosses a single access point to a community or business

area.

4. Crossings are selected if it is older than 5 years and/or not scheduled for replacement. New stream crossings were assumed to have been designed to flood infrequently.

5. Crossings will be eliminated if the stream consisted of an undefined channel or wetland. (This criteria was eliminated for the South River work, as described below under Process Modifications)

The specific process for each criterion is described below in the explanation of the GIS layer fields.

Process

The site selection was conducted using base County GIS data and Crossing information from the Physical Condition Assessment (Task 3.4). An ArcMap .mxd file was created. Important Features in ArcMap are listed below:

- *Contours*
- *Stream Reaches (Streamwalks)*
- *Crossings (Streamwalks)*
- *AACO Planimetric Road Edges*
- *AACO Transportation Centerline Road Class*
- *Subwatershed Boundaries*
- *Aerial Photography*

The Physical Condition Assessment Crossing information was utilized as a shapefile with the addition of six fields to the original crossings database table. The six additional fields are detailed below:

- *Road_Class* – Refers to the County Master Transportation Plan road classification system for roads within Anne Arundel County. (Freeway, Principal Arterial, Minor Arterial, Collector, and Local Road) South Road Classes.shp file delivered by the County on 1/23/07 was used for this analysis.
    - o Only culverts intersecting the County Master Transportation Shapefile were included in the selected sites. Foot/trail bridges, culverts under interstates, driveway culverts, utility road culverts, SWM associated culverts, and farm field access culverts were all eliminated from HY8 culvert selection (359 out of 442, 83 sites remaining).

- *Overtop* – Refers to the potential for stormwater to flow over a road embankment due to the magnitude of runoff. Contours, culvert dimensions, embankment height, drainage area, and upstream/downstream floodplain characteristics were all used to determine the potential for overtopping at all road culverts that intersected streamwalk identified channels. In general, the vertical distance between top of roadway and stream water surface should be less than 20 feet, under the assumption that high stream crossings would not represent the most imminent flooding hazards.

- *Isolate* – Refers to the potential for overtopped roads to completely cut off an area from emergency services where the stream crosses a single access point to a community or business area. The planimetric roads and county master transportation plan were utilized to determine alternate routes from a particular culvert location.

- *CIP_AGE* – Refers to whether or not a culvert will be replaced or modified by the County in the near future. Based on the AA Co Fiscal Year 2007 Capital Budget and Program, Supplement 2 Roads and Bridges Section, two projects impact the HY8 culvert selection. Bridge BR1031.C001 located along Chesterfield Road was dropped for the selected sites due to bridge replacement and culverts GC2003.C001 and GC2008.C002 were dropped due to MD 214 and MD 468 lane widening and intersection improvements. Some of the selected sites do have year stamps on the endwalls that date to 2004; however, these culverts (NR2002.C003, NR2007.C001, NR2028.C001, and BR1024.C002) were kept for HY8 analysis due to the potential for flooding despite their age. These crossings were new, but were still assumed to flood frequently even though the criteria generally assumed that new culverts have been designed to flood infrequently.

- *Field_SVY* – Refers to whether or not a culvert should be surveyed in the field to support HY8 modeling. Values were either *yes* for further analysis (60), *alternate* in case backup sites are needed due to site conditions (5), and *no* for no further analysis. This field was filled out based on the above fields and site conditions at each culvert.

- *Notes* – Brief description or explanation as to why a culvert was selected or not selected. In most cases, the notes provided a good space to record why a culvert was eliminated from selection process.

Process Modifications

Criteria number 1 utilized in the Severn River project initially excluded roads classified as ‘Local’ assuming that these roads would flood more frequently than the larger road classifications. To reach the 60 crossings selected for the South River it was necessary to include crossings on local roads, especially if the roadway fit the isolate criteria.

Criteria number 5 states that - Crossings will be eliminated if the stream consisted of an undefined channel or wetland. In previous work on the Severn River Watershed the number of crossings with the potential for modeling was greater than the scope would allow, therefore the project team determined that crossings would be eliminated from modeling if the upstream waterway consisted of an undefined channel or wetland. The South River watershed in general had fewer sites to select from and higher frequency of undefined channels and wetlands therefore the criteria was eliminated.

Three culverts with undefined channel on the upstream side were selected for HY8 analysis due to the importance of these crossings in terms of drainage area and road type. HY8 can be used on culverts where a stream channel is not present on the upstream side. All three of these culverts have a downstream channel, which is required for HY8.

BC2009.C001 – Floodway Above
FC2004.C001 – Wetland Above
GC2044.C001 – Wetland Above.

Irregular Culverts

Prior to field survey, the following 5 crossings were reviewed more rigorously by Project Team engineers to determine whether they should be modeled as bridges using HEC-RAS or could be modeled as culverts using HY8. Several of the crossings were reviewed in the field prior to full field survey to assess the culvert condition, type and general dimensions and to check that HY8 analysis would meet the goals of the study and provide dependable results.

The goal of the study was to determine overtopping frequency, which can be estimated using HY8. HEC-RAS is a more complex model, which can be used for more detailed channel and pipe hydraulic analysis. The goals of this task did not require this level of analysis. The crossings in question were found to be structurally confined on three sides and the channel bottom presented a non-transient surface, however changes in culvert opening dimensions do exist between the upstream and downstream culvert cross-sections. If the downstream section presents a smaller barrel opening it may be used in the HY8 model inputs instead of the upstream opening dimensions to represent the culvert's limiting cross-sectional area. Because HY8 could be used to model these irregular culverts and because development of a HEC-RAS model at these sites would require several additional cross-sections at each site it was determined that HY8 would be the selected method.

- BC3014.C001

- BD2003.C002

- BD2002.C002

- BD2002.C001

- BD2001.C002

Selection Results

Sixty sites were selected for study along with 5 alternate sites. A total of 359 sites were eliminated because they did not meet the County's Master Transportation Plan road classification criteria. Eighteen more sites were eliminated based on the other criteria.

One commercial driveway site was selected as an alternate based on the size of the crossing (Four 5 foot circular barrels) overtopping potential (less than 5ft from top of culvert to roadway invert) and the isolation criteria.

The following tables summarize the selected sites based on Roadway Class and Subwatershed.

Table 1: Selected Sites by Road Class

ROAD_CLASS	Alternate Sites	Selected Sites	Total
Collector		12	15
Commercial Driveway	1		1
Local Road	4	17	28
Minor Arterial		25	27
Principal Arterial		6	9
Grand Total	5	60	442

Table 2: Selected Sites by Subwatershed

SUBSHED	Total Crossings	Road Class Elimination	Other Criteria Elimination	Alternate Sites	Selected Sites
ABC	5	4			1
BC1	1	1			
BC2	7	4			3
BC3	18	15			3
BC4	10	8			2
BC5	19	11	2		6
BD1	21	19	1		1
BD2	15	10		1	4
BD4	1	1			
BD5	32	30			2
BR1	14	3	3		8
BR2	10	9			1
BR3	7	4		1	2
BR4	24	22		1	1
BR6	15	12		1	2
BRW	14	14			
CHR	1	1			
FC1	1	1			
FC2	2	1			1
FC3	15	14			1
FC4	4	4			
FC5	18	17			1
GC1	15	10	2		3
GC2	29	21	5		3

SUBSHED	Total Crossings	Road Class Elimination	Other Criteria Elimination	Alternate Sites	Selected Sites
GNC	4	4			
GVC	5	4		1	
HNC	3	3			
NR1	5	3	1		1
NR2	29	19	1		9
NR3	7	7			
NR4	9	9			
NR5	10	7			3
NR6	19	16	2		1
RAM	6	6			
SEL	7	7			
SGB	3	2	1		
TNB	35	34			1
WHC	2	2			
Grand Total	442	359	18	5	60

FIELD PROCEDURE

At each cross-section data was collected for input in the HY8 model. Data was collected in six major categories: Embankment Toe Data, Barrel Attributes, Road Profile and Tailwater conditions, Photographic documentation of site conditions, Site Drawings and Notes.

Survey crews moved from upstream to downstream and used rod and laser level. All vertical data was connected to a relative elevation. Data is reported in tenths of feet, except for barrel size which is reported in inches.

Field forms were created and revised based on a pilot field day in which the Team visited several types of crossings to verify that all necessary data entry fields were included on the field forms. The field form was created in MS Excel such that the data could be entered directly from the field sheet into the digital version. Creation of summarized and vertically adjusted data for input into HY8 was automated within the spreadsheet.

Embankment Toe Data

Data to characterize the embankment was collected including the top width, elevations of culvert upstream and downstream inverts, and the culvert length. The depth of sediment within each culvert was also recorded. Professional judgment was used to evaluate sediment in the crossing and notes were made on the field sheets to indicate the severity of the sediment. Notes were made to indicate if substantial sediment existed in the crossing that would not be flushed by a storm event. In this case the modeler may use the invert of the sediment rather than the culvert invert. If the sediment was more transient and would be flushed during a storm event, the sediment was not considered to be affecting the crossing invert or capacity. If more than one barrel existed at the crossing, the inverts and depths of sediment of all barrels was collected.

Barrel Attributes

Information on the geometry, size and material of each barrel was collected at the upstream end of the crossing. Barrels were numbered starting with barrel 1 to the far left when facing downstream from the upstream side. Additional characteristics required by HY8 include the type and characteristics of any inlet structure such as any side or bottom tapering and the type of wingwall. If the barrel had an irregular shape the dimensions were recorded at intervals across the face of the barrel at both the upstream and downstream ends. If the downstream section presents a smaller barrel opening it may be used in the model inputs instead of the upstream opening dimensions.

Road Profile

The roadway profile was collected across the top of the crossing. If the roadway had a constant elevation, the elevation and crest length was recorded. For variable roadway elevations a full profile of at least 300 feet was collected with more shots collected for more variable roadways. When possible the crossing location was centered on the profile.

Tailwater Conditions

Dimension, roughness and slope data was collected for each crossing to evaluate the downstream conditions. If downstream water surface elevations were backing water into the culvert a constant tailwater elevation was recorded. Roughness information was collected by estimating the dominant and secondary material within the channel (silt, sand, fine-gravel, gravel, rocks) and on the left and right overbank zones (grass, bushes, light forest, dense forest). The material characterization, along with site photographs will be used by the modeler to derive a Manning's *n* value.

Dimensions of the downstream channel were collected. For regular channels the bottom width and side slopes were entered. For irregular channels a full cross-section was surveyed. The cross-section was located on a representative controlling section downstream of the effects of the culvert such as concrete aprons, overwidened sections or plunge pools. Channel slope was calculated for the downstream channel.

Photographic Documentation

Digital photographs were taken at each site to document the site conditions. At a minimum, photos were taken at each site of the following:

- Upstream channel
- Upstream culvert face
- Roadway
- Downstream culvert face
- Downstream channel
- Downstream floodplain left
- Downstream floodplain right

Additional photos were taken if site conditions warranted.

Drawings and Notes

Detailed drawings were made and notes collected at each site. *Because site conditions can be quite variable the modeler should always consult the drawings and notes before beginning modeling for any cross-section.*

SUMMARY

Full surveys were completed at 60 sixty crossings. Three of the originally selected crossings were not surveyed and three alternate sites were surveyed to replace them. These sites and a brief description are provided below:

Not Surveyed

BC3046.C001 – Upstream side of the crossing was blocked with a metal cage and a large fence prevented access to the upstream side of the crossing. Site is potentially part of the Davidsonville Wildlife Sanctuary. Access from property owner was not requested due to presence of animals and the existing flooded crossing condition. Site photos were collected, but no survey was done.

BD5022.C001 – This culvert to roadway height was 15 to 20ft and the drainage area was very small with approximately 85 percent of it wooded. The culvert was large considering the small drainage area. It was determined that this culvert was not a flood risk and was not surveyed.

BR3007.C001 – During site selection the contour file proved to be inaccurate for this new development. Field inspection revealed that the height from the road to the invert of the culvert was at least 40-50ft. It was determined that this culvert was not a flood risk and was not surveyed.

Surveyed

BR1017.C004 – This culvert was not originally selected. This culvert was chosen as a replacement because of the likelihood for overtopping MD450.

BR6026.C002 (Originally BR6005.C001) – This culvert was not originally selected due to the presence of floodway type channel on the upstream and downstream sides. Field visit revealed a section of downstream channel that could be surveyed. The road classification is Collector. This culvert had a higher potential for flooding based on roadway height, a larger drainage area and it was on a higher use road than the other alternative choices.

NR1003.C002 - This culvert has a very large wetland on the upstream side, however it was determined that this culvert could be modeled with HY8. It was selected over the alternative sites due to the Collector road classification and also because of fish passage and structural issues.

Table 3 lists the final sites that were surveyed. Six irregular culverts were surveyed and are indicated with an (i). In addition to the five irregular culverts described under Site Selection, NR6001.C001 was an irregular arch. Four of the six were located in the BD2 subwatershed. All sites are shown on Figure 1.

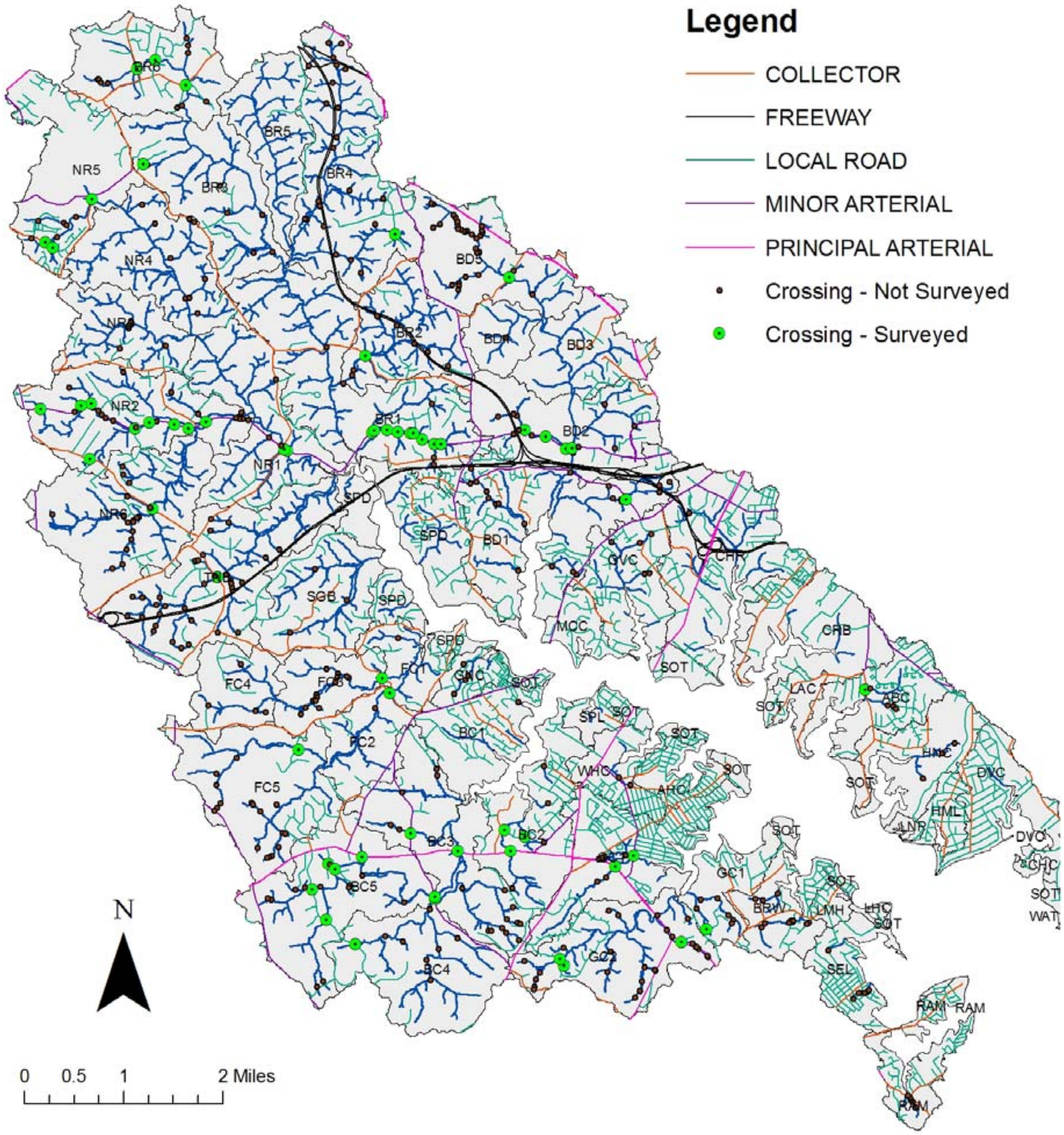
Table 3: Field Surveyed Sites

SUBSHED	Selected Sites	Surveyed Sites	Final Surveyed Sites
ABC	1	1	ABC001.C001
BC1			
BC2	3	3	BC2006.C001, BC2007.C001, BC2009.C001
BC3	3	2	BC3014.C001(i), BC3031.C001
BC4	2	2	BC4004.C001, BC4005.C002
BC5	6	6	BC5001.C001, BC5006.C001, BC5007.C001, BC5008.C003, BC5011.C002, BC5012.C001
BD1	1	1	BD1032.C003
BD2	4	4	BD2001.C002(i), BD2002.C001(i), BD2002.C002(i), BD2003.C002(i)

SUBSHED	Selected Sites	Surveyed Sites	Final Surveyed Sites
BD5	2	1	BD5010.C001
BR1	8	9	BR1016.C001, BR1017.C001, BR1017.C002, BR1017.C003, BR1017.C004*, BR1021.C001, BR1024.C001, BR1024.C002, BR1026.C001
BR2	1	1	BR2001.C003
BR3	2	1	BR3039.C002
BR4	1	1	BR4054.C001
BR6	2	3	BR6026.C002*, BR6006.C001, BR6006.C004
FC2	1	1	FC2004.C001
FC3	1	1	FC3005.C001
FC5	1	1	FC5016.C001
GC1	3	3	GC1001.C001, GC1010.C001, GC1021.C001
GC2	3	3	GC2007.C002, GC2044.C001, GC2046.C001
NR1	1	2	NR1003.C001*, NR1003.C002
NR2	9	9	NR2002.C003, NR2007.C001, NR2028.C001, NR2030.C001, NR2030.C002, NR2049.C001, NR2037.C001, NR2045.C001, NR2084.C001
NR5	3	3	NR5002.C001, NR5008.C001, NR5009.C001
NR6	1	1	NR6001.C001(i)
TNB	1	1	TNB038.C002
Total	60	60	

*sites added after the site selection process
(i) indicates irregular culvert

Figure 1: Field Surveyed HY8 Sites



KCI TECHNOLOGIES CH2MHILL

Draft South River Geomorphic Assessment Report

PREPARED FOR: Mary Searing/Watershed and Ecosystem Services, Anne Arundel Co.

PREPARED BY: CH2M HILL
KCI

COPIES: Hala Flores/Watershed and Ecosystem Services, Anne Arundel Co.

DATE: July 6, 2007

Executive Summary

Anne Arundel County has continued to grow in population over the past decade. Many of the County's natural resources are directly threatened by the increase in population and development. The County seeks to balance its healthy economy and development pressures with preservation and restoration of natural resources. The geomorphic assessment task has been completed to help the County to better understand the existing conditions of the South River watershed waterways as well as to provide data that will allow the County to plan for future protection and restoration of aquatic resources within the South River watershed.

The field geomorphic assessment of 54 reaches within the South River watershed yielded predominantly B, E, F, and G channel types, which are typical of the coastal plain. The results will provide the County with data that will assist the Watershed Management Program in developing reference reach design criteria, however the reference sites will need to be selected carefully. The assessment also provides location and survey information for degraded sites—F and G channels—that are good opportunities for aquatic habitat restoration.

As part of this task, the County developed a Rosgen Level I stream-type classification desktop procedure. Of the 54 channels assessed in the field, 24 were an exact channel type match with the County's desktop assessment procedure results. The remaining sites deviated from the desktop procedure, in both entrenchment and width/depth ratio values enough that the field assessment channel type was different from the desktop assessment's. The County's desktop analysis, utilizing digital data sources, may not have captured the low-flow channel as accurately as the field survey. The collected field data should allow the County to refine the desktop procedure to improve its potential as a planning level assessment tool.

1 Introduction

For Task 3.5 of the South River Watershed Study, geomorphic assessments were conducted at 54 sites. The assessment provided a Rosgen Level II classification for select areas within the South River watershed. Rosgen Level II stream type classifications are a useful tool for describing the current geometry of the South River tributaries; these classifications also provide a channel description that is easily communicated among scientists, engineers, and planners. Empirical relationships developed utilizing channel geometry characteristics, drainage areas and bankfull discharge are useful in the identification of restoration sites and the conceptual planning for stream restoration projects.

The classification system has limitations, and the data should be used accordingly. The assessment provides a snapshot of the channel and was not repeated to develop trends to track changes in channel geometry. Assessment results should not be used for detailed design work because the field survey data does not provide the level of detail necessary for this application. Although relationships developed provide the ability to compare to reference conditions, they are dependent on several watershed characteristics including geology and land use. The relationships should only be applied to areas of similar hydrologic characteristics. The relationship between present land use within each drainage area and the channel dimensions was not explored.

The main objectives of this portion of the South River Watershed study were guided by the goals outlined by the County's Watershed Management Program. The objectives are to assist the County in (1) verifying the results of an internally developed Rosgen Level I classification process and desktop analysis procedure and (2) developing reference reach design criteria for stable B, C, and E channel types.

2 Methodology

2.1 Site Selection

A Rosgen Level I stream type classification was completed by Anne Arundel County's Watershed Management Program utilizing a series of desktop analyses to generate a classification for individual stream reaches. These stream reaches were initially characterized by a physical habitat assessment conducted during spring and summer 2006. These reaches were defined by similar habitat conditions and there is potential for multiple channel types within each reach. This could affect the comparison of the desktop assessment results with the field assessment results.

The desktop analysis primarily focused on stream reaches with a drainage area greater than 20 acres; although some streams with drainage areas smaller than 20 acres were classified in preliminary phases of the desktop analysis. The desktop procedure included GIS analysis, hydrologic and hydraulic modeling, and a desktop geomorphic assessment. The desktop analysis provided the following data: drainage area, 1-, 1.2-, and 2-year discharges, reach slope, bankfull width, bankfull depth, bankfull area, and the flood prone width and depth. From this data the entrenchment ratio, width to depth ratio and sinuosity were calculated. Several of the sites displayed geomorphic characteristics that did not match a single classification. In these situations the County used a standardized decision making process to assign a stream classification. A detailed explanation of the Level I classification methodology and decision making process, as well as the results of the Rosgen Level I desktop analysis can be found in the Anne Arundel County Watershed Management Program Internal Memorandum, Task 3.5 Rosgen Level II Site Selection (February 14, 2007) (see Appendix A).

Based on the Rosgen Level I assessment and the County's stated goals, as outlined in the previous section, sites were selected based on a balanced spatial distribution and in proportion to all channel types that are present within the watershed. These sites were selected by the County's Watershed Management Program for the Level II field survey. The selected sites are listed in Exhibit 1 with the stream type classification based on the Rosgen

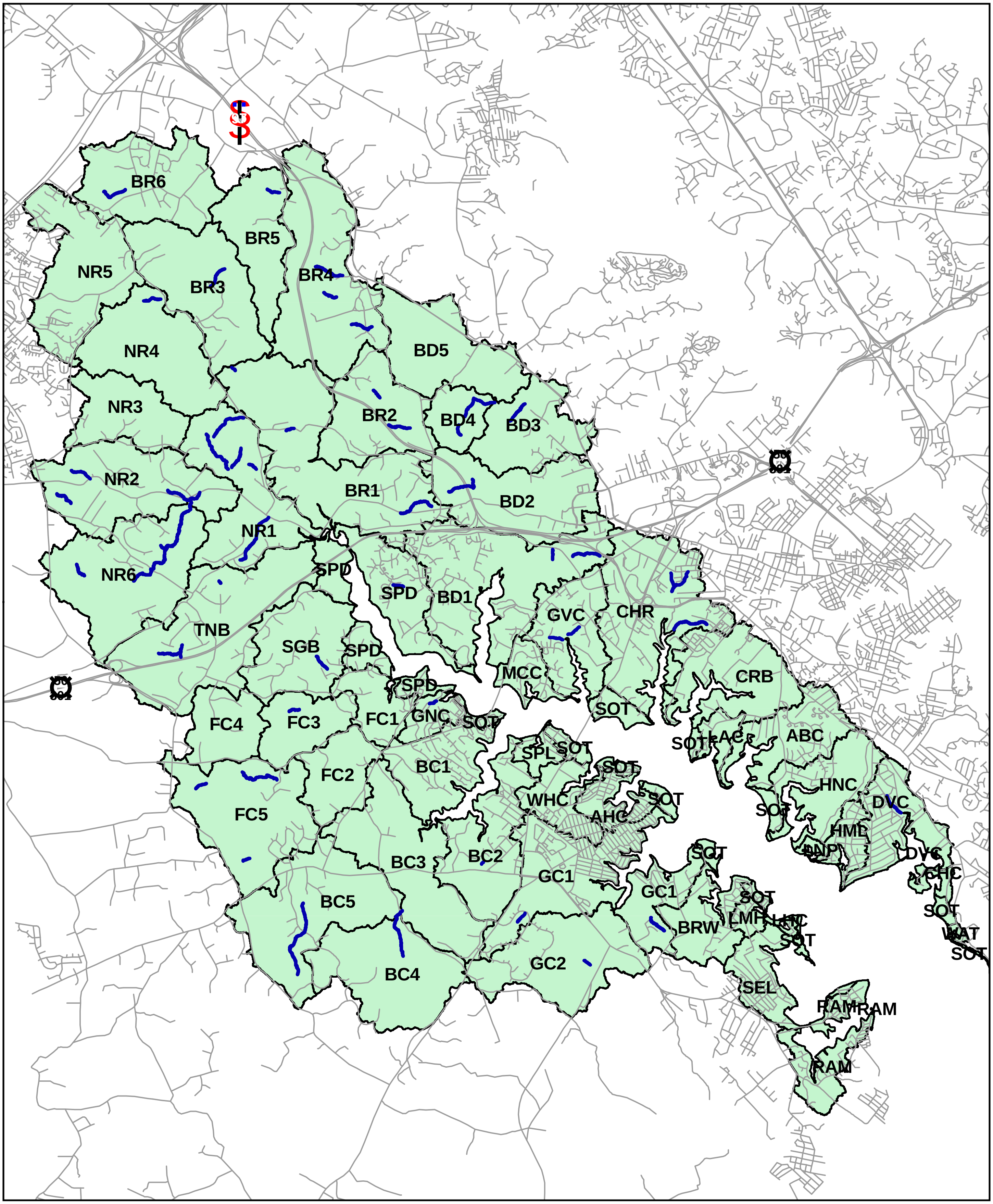
Level I desktop assessments. Exhibit 2 shows the spatial distribution of the survey reaches throughout the watershed.

EXHIBIT 1
Selected Sites for Rosgen Level II Field Survey

Site	Level I Classification	Site	Level I Classification	Site	Level I Classification
BC2018	B	BR4206	B	NR1007	G
BC4004	E	BR5061	B	NR1025	B
BC5012	B	BR6013	C	NR1030	DA
BD1031	G	BR6014	B	NR1031	B
BD1034	B	CHR003	DA	NR1042	G
BD2034	B	CHR006	B	NR2007	C
BD2035	B	CHR007	DA	NR2043	B
BD3014	C	DVC001	B	NR2049	B
BD4005	C	FC3014	E	NR2050	E
BD4010	F	FC5009	F	NR4059	E
BR1011	C	FC5017	C	NR6001	C
BR1026	G	FC5020	B	NR6019	E
BR1056	A	GC1016	F	NR6063	E
BR2042	E	GC1023	F	SGB006	B
BR2059	B	GC2012	B	SPD009	E
BR3009	B	GNC003	C	TNB004	E
BR4054	F	GVC009	E	TNB044	C
BR4100	F	GVC014	B	TNB045	C

2.2 Stream Surveys

A geomorphic characterization of perennial reaches was performed under Task 3.5 of the South River Watershed Study during winter 2006. This assessment described the stream types of select sites within the watershed. The geomorphic assessment followed the methodology as described by Rosgen (1996). After the field assessment, all field survey data were entered into the reference reach spreadsheet (Mecklenburg, 2006). The following summarizes the procedures used for surveying the longitudinal profile, cross-section, sinuosity, and particle size distribution.



Roads

Rosgen Level II Survey Reaches

Subwatersheds

South River Watershed

0 0.5 1 2 Miles

Exhibit 2

Rosgen Level II Survey Reaches

CH2MHILL

Longitudinal Profile. The longitudinal profile was established along the thalweg, and major break points in the channel were surveyed. Channel features, including the start and end of riffles, runs, pools, glides, and the deepest point of pools, were identified. Water surface, bankfull elevations, terrace features, and the top of bank were also surveyed. Longitudinal profile surveys were completed to determine riffle/pool-sequencing patterns, determine changes in channel slope, and generate multiple measurements of bankfull depth. The proportion of pools and nonpools was used in the field to determine the locations of the pebble count transects. The profile length was typically between 20 and 40 channel widths (measured at bankfull elevation), at least two meander wavelengths, and at least 200 feet.

Cross-Section. One cross-section was field surveyed at a representative riffle crossover for each reach to generate mean depth, cross-sectional area, bankfull depth, bankfull width, width/depth ratio, and flood prone width. An additional cross-section was surveyed in a pool. If no pools were present within a survey reach, which was common, a run was surveyed instead. The location of bankfull is crucial to many of the measurements; its identification had to be consistent and accurate. In some channels, bankfull stage determinations were obtained by identifying the top of the floodplain, the incipient point of flooding. Where a floodplain was not developed and the channel was more entrenched, the following indicators were used (Rosgen, 1996) to determine bankfull stage:

- Elevation of the top of the *highest* depositional feature
- A break in the slope of the banks and/or a change in the particle size distribution
- Evidence of an inundation feature such as small benches
- Staining of rocks
- Exposed root hairs below an intact soil layer
- Riparian vegetation species

In addition to field indicators, regional curves developed for Maryland's Coastal Plain (McCandless, 2003) and for Anne Arundel County's urban streams (Anne Arundel County DPW, 2002) were used to estimate and verify the bankfull elevation. The curves provided an estimate of bankfull width, cross-sectional area, mean depth, and bankfull discharge based on the drainage area to each site. The bankfull width estimate was the primary parameter used to validate the field indicators. All curve estimates were used with caution due to the inherent limitations of regression equations that are not distinguished by land use or hydrologic conditions.

At each cross-section a GPS point was collected. After post-processing the GPS data it was determined that the BR2042 data had been collected approximately 100 feet above the reach assessed by the desktop procedure. It was determined from photographs that the channel downstream from the surveyed reach was similar to the survey reach, and the data was subsequently used in all comparisons and statistical analyses.

Sinuosity. Valley length was measured at each station. At the end of the stream profile, an additional measurement of the straight-line distance between the top and bottom of the reach was collected. The ratio of stream length to valley length provided a measure of sinuosity.

Particle Size Analysis. Pebble counts were conducted at each station to develop a particle size distribution and compute the median particle size (D50). A representative count was conducted at 10 transects across the entire reach; in riffles, pools, runs, and glides in the same proportion that these features occurred in the reach. The count was conducted across the entire bankfull channel. In the case of streams with a homogeneous sandy substrate, 10 individual counts were collected for each bed feature throughout the reach. The size distribution for the sand particles determined during this count was extrapolated to 100 particles for these reaches so that the totals for each site were equal.

2.3 Stream Type Classification

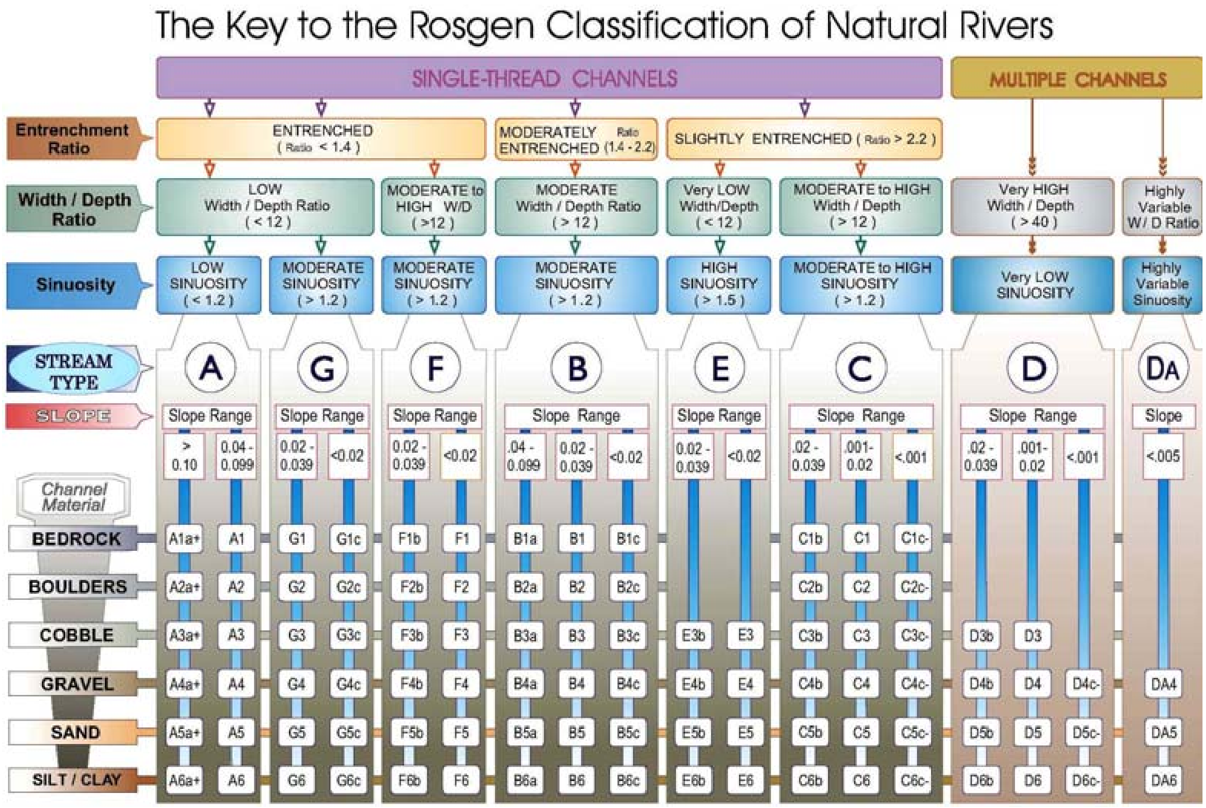
The stream type classification is dependent on the dimension, pattern, and profile of the surveyed reach. The soil type, basin shape and relief, as well as the valley morphology, contribute to the channel morphology and subsequently the channel type. Exhibit 3 presents a general description of the Rosgen Level I channel types (Rosgen, 1996); Exhibit 4 displays the Rosgen classification system key (Rosgen, 1996), including the criteria for the primary delineative parameters, entrenchment ratio, and width-to-depth ratio as well as channel slope, sinuosity, and channel material. Channel slope and channel material provide modifiers to the Level I channel type classification yielding the Level II classification. Following the completion of the field assessment, each reach was classified based upon Exhibit 4. Data produced from the desktop assessment lacked channel material information and was limited to the Level I classifications shown in Exhibit 3. Both methods used the same criteria for identifying the Level I channel type.

EXHIBIT 3
Rosgen Level I Channel Type Descriptions

Channel Type	General Description[a]
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.
A	Steep, entrenched, confined, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.
B	Moderately entrenched, moderate gradient, riffle-dominated channel with infrequently spaced pools. Moderate width/depth ratio. Narrow, gently sloping valleys. Very stable plan and profile. Stable banks.
C	Low gradient, meandering, slightly entrenched, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks. Active lateral adjustment, high bed load and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well-vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable stream banks.
E	Low gradient, Highly sinuous, riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander/width ratio.
F	Entrenched, meandering riffle/pool channel on low gradients with high width/depth ratio and high bank erosion rates.
G	Entrenched “gully” step/pool and low width/depth ratio on moderate gradients. Narrow valleys. Unstable, with grade control problems and high bank erosion rates.

[a] From Rosgen (1996).

EXHIBIT 4
Rosgen Level II Classification of Natural Rivers
From Rosgen (1996)



Entrenchment ratios and sinuosity values can vary up to +/- 0.2 units and the width/depth ratios can vary up to +/-2.0 units; this range of variation is a function of the "continuum of physical variables".

3 Geomorphic Assessment Results and Discussion

3.1 Rosgen Level II Field Assessment

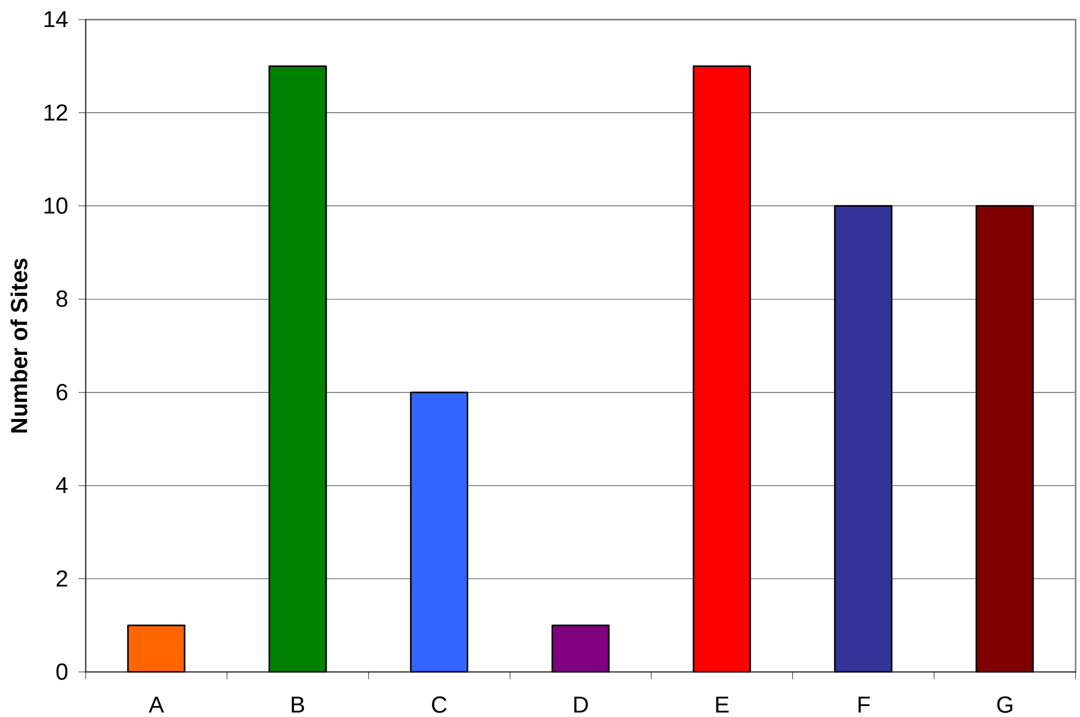
Exhibit 5 displays the distribution of field surveyed sites within each Rosgen Level I stream type. Exhibit 6 displays the spatial distribution of the Level I stream types for the 54 surveyed reaches. The field survey yielded 13 B and 13 E channel types and 10 F and 10 G channels. Six of the reaches surveyed were Cs, and there were one A and one D channel surveyed. Two sites (CHR003 and BD4010) displayed characteristics that gave an indication the reach was in transition between two stream types. For summary analysis, and within Exhibit 5 and 6, these sites were classified as the channel type from which they are transitioning.

Exhibit 7 provides summary data for each of surveyed sites. All of the values within this exhibit were calculated by the Mecklenburg (2006) reference reach spreadsheet, except for the bankfull discharge, which was calculated using Manning's *n* value determined by the Cowan (1956) Method. This calculation was done outside of the reference reach spreadsheet using data from this survey as well as data from the stream physical condition assessment conducted in 2006. The separate bankfull discharge calculation was conducted because the Mecklenburg (2006) reference reach spreadsheet uses the Manning's equation, with only the consideration of bed substrate in the calculation of the roughness coefficient. Sandy substrates are typical of coastal plain streams and Manning's *n* value for sand gives little indication of flow resistance. The recalculation of Manning's *n* value using the Cowan (1956) Method was completed to provide a more accurate depiction of the roughness coefficient by including a consideration of channel irregularities, channel cross section shape and size, obstructions, vegetation, and meander pattern. All of these characteristics impact flow resistance of a channel, especially in coastal plain streams.

Dimensionless ratios, including entrenchment and width-to-depth, provide the delineative parameters for determining the classification of the stream type utilizing the Rosgen stream classification system (Rosgen, 1996). These ratios also provide parameters to evaluate departure from reference stream conditions for a channel with different bankfull dimensions and discharge. Exhibit 8 summarizes the Rosgen Level II Stream type classification and dimensionless ratios for each of the surveyed sites.

Site BR1056 is the site with the smallest drainage area (0.003 mi^2) and subsequently had very little channel development and poorly developed bankfull indicators. The channel was assigned a stream type (A5a+) and is included in all narrative discussions, but proved to be an outlier for all statistical analyses. For this reason, BR1056 was not included in any statistical analysis of field assessment data.

EXHIBIT 5
Stream Type Classification Summary Based on Rosgen Level II Field Assessment



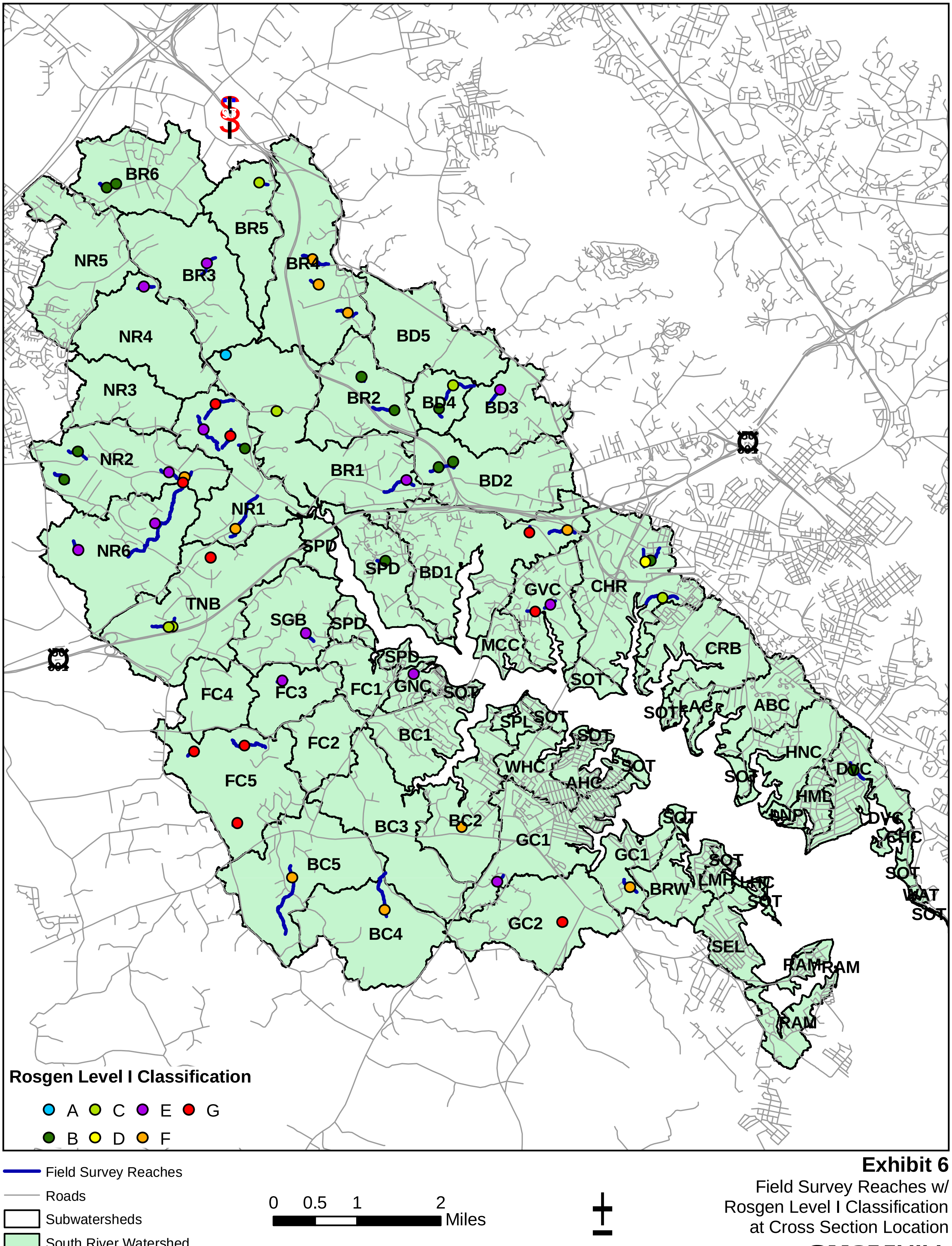


Exhibit 6

Field Survey Reaches w/
Rosgen Level I Classification
at Cross Section Location

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EXHIBIT 7
Field Assessment—Summary Data

Site	Drainage Area (mi^2)	Cross-Sectional Bankfull Area (ft^2)	Width at Bankfull (ft)	Mean Bankfull Depth (ft)	Bankfull Discharge (cfs)		Width of Flood Prone Area (ft)	Median Particle D50 (mm)
					Pebble Count *n*	Cowan's *n*		
BC2018.R201	0.10	6.25	9.18	0.68	50.2	19.6	12.3	0.15
BC4004.R201	0.74	10.51	9.92	1.06	53.1	39.0	14.4	0.08
BC5012.R201	0.51	5.68	8.44	0.67	16.8	13.6	10.9	0.13
BD1031.R201	0.005	2.47	4.10	0.60	20.7	11.1	5.0	0.10
BD1034.R201	0.02	4.75	10.80	0.44	11.4	5.9	12.5	0.24
BD2034.R201	0.23	7.21	10.40	0.69	53.1	18.6	15.9	0.15
BD2035.R201	0.07	2.59	5.00	0.52	8.9	7.2	8.3	0.21
BD3014.R201	0.17	2.03	4.50	0.45	7.5	2.2	16.1	0.18
BD4005.R201	0.34	5.55	8.40	0.66	23.4	9.4	26.3	0.18
BD4010.R201	0.04	1.61	3.87	0.42	13.3	4.6	4.5	0.10
BR1011.R201	0.08	3.99	9.54	0.42	22.1	2.7	36.3	0.18
BR1026.R201	0.05	1.65	2.98	0.55	6.8	3.3	8.0	0.27
BR1056.R201	0.003	1.59	5.00	0.32	40.9	17.9	6.5	0.12
BR2042.R201	0.13	2.66	6.91	0.39	6.1	4	9.6	0.23
BR2059.R201	0.04	1.66	4.72	0.35	16.8	5.7	10.5	0.18
BR3009.R201	0.05	2.07	4.90	0.42	13.0	2.7	20.3	0.22
BR4054.R201	0.04	8.78	10.20	0.86	45.8	35.4	13.3	0.33
BR4100.R201	0.13	8.33	11.28	0.74	27.8	14.5	12.9	0.29
BR4206.R201	0.04	2.70	7.91	0.34	7.5	3.8	9.3	0.29
BR5061.R201	0.04	4.17	6.80	0.61	29.3	8	19.0	0.18
BR6013.R201	0.08	3.91	7.40	0.53	20.2	4.7	12.9	0.12
BR6014.R201	0.19	5.69	10.30	0.55	38.4	17.6	14.7	0.14

EXHIBIT 7
Field Assessment—Summary Data

Site	Drainage Area (mi^2)	Cross-Sectional Bankfull Area (ft^2)	Width at Bankfull (ft)	Mean Bankfull Depth (ft)	Bankfull Discharge (cfs)		Width of Flood Prone Area (ft)	Median Particle D50 (mm)
					Pebble Count *n*	Cowan's *n*		
CHR003.R201	0.13	5.57	6.71	0.83	55.7	12.3	14.0	0.16
CHR006.R201	0.04	1.02	5.10	0.20	6.9	1.8	75	0.19
CHR007.R201	0.13	5.02	7.75	0.65	21.0	6.3	17.0	0.14
DVC001.R201	0.18	4.60	9.10	0.51	12.2	3.6	16.0	0.16
FC3014.R201	0.13	4.52	5.70	0.79	31.4	11.8	22.0	0.13
FC5009.R201	0.09	4.94	6.21	0.80	20.1	17.6	9.6	1.00
FC5017.R201	0.60	9.44	7.56	1.25	120.3	36.4	11.5	0.06
FC5020.R201	0.06	3.52	4.32	0.81	43.2	14	6.9	0.06
GC1016.R201	0.06	3.43	5.01	0.68	29.3	9	8.0	0.07
GC1023.R201	0.15	8.94	6.38	1.40	46.2	18.4	14.8	0.09
GC2012.R201	0.02	2.19	3.92	0.56	23.4	9.1	5.4	0.07
GNC003.R201	0.03	4.18	6.27	0.67	20.3	6.7	15.0	0.16
GVC009.R201	0.04	2.21	4.22	0.52	17.6	6.3	56.0	0.17
GVC014.R201	0.15	2.72	3.92	0.69	18.2	4.5	5.2	0.11
NR1007.R201	0.06	5.30	10.70	0.50	33.4	10.7	12.9	0.35
NR1025.R201	0.04	1.84	6.60	0.28	6.0	5.2	11.0	0.11
NR1030.R201	3.94	8.34	7.06	1.18	72.4	17.8	290.0	0.06
NR1031.R201	0.07	4.39	5.19	0.85	29.3	21.7	7.5	0.10
NR1042.R201	0.09	2.50	4.25	0.59	24.7	5.1	6.7	0.08
NR2007.R201	1.24	26.24	15.11	1.74	165.9	70.2	17.8	0.25
NR2043.R201	0.16	3.58	4.12	0.87	32.2	10.7	9.4	0.13
NR2049.R201	0.03	1.98	5.10	0.39	18.6	5.1	22.0	0.15

EXHIBIT 7
Field Assessment—Summary Data

Site	Drainage Area (mi^2)	Cross-Sectional Bankfull Area (ft^2)	Width at Bankfull (ft)	Mean Bankfull Depth (ft)	Bankfull Discharge (cfs)		Width of Flood Prone Area (ft)	Median Particle D50 (mm)
					Pebble Count *n*	Cowan's *n*		
NR2050.R201	1.17	12.60	10.05	1.25	93.2	48.1	169.0	0.25
NR4059.R201	0.04	1.43	4.73	0.30	12.9	5.1	62.5	0.06
NR6001.R201	1.90	15.22	11.50	1.32	113.6	33.2	14.8	0.34
NR6019.R201	0.20	4.49	3.70	1.21	47.7	19.9	96.0	0.06
NR6063.R201	0.08	3.20	4.47	0.72	11.7	11.8	8.6	0.10
SGB006.R201	0.04	2.00	3.48	0.58	21.5	7.9	80.0	0.07
SPD009.R201	0.04	3.87	6.18	0.63	21.1	12	10.0	0.21
TNB004.R201	0.08	3.95	4.20	0.94	23.1	14.5	6.9	7.30
TNB044.R201	0.44	16.87	16.70	1.01	111.4	33.4	40.0	0.23
TNB045.R201	0.26	9.44	14.56	0.65	72.6	31.4	40.0	0.23

EXHIBIT 8
Field Assessment—Site Dimensionless Ratios and Level II Stream Type Classification

Site	Entrenchment Ratio	Width/Depth Ratio	Sinuosity	Channel Slope (%)	Channel Material	Assessment Classification	
						Field	Desktop
BC2018.R201	1.3	13.5	1.1	0.84	Sand	F5	B
BC4004.R201	1.5	9.4	1.2	0.66	Silt/Clay	F6	E
BC5012.R201	1.3	12.6	1.1	0.56	Gravel	F4	B
BD1031.R201	1.2	6.8	1.1	3.30	Sand	G5	G
BD1034.R201	1.2	24.6	1.1	0.40	Sand	F5	B
BD2034.R201	1.5	15.0	1.1	0.61	Sand	B5c	B
BD2035.R201	1.7	9.7	1.1	2.30	Sand	B5	B
BD3014.R201	3.6	10.0	1.0	0.32	Sand	E5	C
BD4005.R201	3.1	12.7	1.1	0.26	Sand	C5	C
BD4010.R201	1.2	9.3	1.1	1.60	Sand	B5c to G5	F
BR1011.R201	3.8	22.8	1.1	0.66	Sand	C5	C
BR1026.R201	2.7	5.4	1.2	1.70	Sand	E5	G
BR1056.R201	1.3	15.7	1.0	19.00	Sand	A5a+	A
BR2042.R201	1.4	17.9	1.1	0.59	Sand	B5c	E
BR2059.R201	2.2	13.4	1.2	2.70	Sand	B5	B
BR3009.R201	4.1	11.6	1.1	2.50	Sand	E5b	B
BR4054.R201	1.3	11.8	1.6	0.79	Sand	F5	F
BR4100.R201	1.2	15.3	1.2	0.48	Sand	F5	F
BR4206.R201	1.2	23.1	1.2	0.94	Sand	F5	B
BR5061.R201	2.8	11.1	1.1	0.74	Sand	C5	B
BR6013.R201	1.7	14.0	1.0	0.43	Sand	B5c	C
BR6014.R201	1.4	18.6	1.0	0.66	Sand	B5c	B

EXHIBIT 8
Field Assessment—Site Dimensionless Ratios and Level II Stream Type Classification

Site	Entrenchment Ratio	Width/Depth Ratio	Sinuosity	Channel Slope (%)	Channel Material	Assessment Classification	
						Field	Desktop
CHR003.R201	2.1	8.1	1.2	1.20	Sand	B5c to G	DA
CHR006.R201	14.7	25.6	1.0	2.40	Sand	D5b	B
CHR007.R201	2.2	12.0	1.1	0.24	Sand	C5	DA
DVC001.R201	1.8	18.0	1.2	0.14	Sand	B5c	B
FC3014.R201	3.9	7.2	1.4	0.50	Sand	E5	E
FC5009.R201	1.5	7.8	1.0	0.71	Gravel	G4c	F
FC5017.R201	1.5	6.0	1.2	0.84	Silt/Clay	G6c	C
FC5020.R201	1.6	5.3	1.1	1.40	Silt/Clay	G6c	B
GC1016.R201	1.6	7.3	1.4	0.80	Sand	F5	F
GC1023.R201	2.3	4.5	1.1	0.18	Sand	E5	F
GC2012.R201	1.4	7.0	1.0	1.90	Silt/Clay	G6c	B
GNC003.R201	2.4	9.4	1.3	0.29	Sand	E5	C
GVC009.R201	13.3	8.1	1.0	1.10	Sand	E5	E
GVC014.R201	1.3	5.6	1.2	0.76	Sand	G5c	B
NR1007.R201	1.2	21.6	1.2	1.20	Sand	F5	G
NR1025.R201	1.7	23.7	1.1	1.60	Sand	B5c	B
NR1030.R201	41.1	6.0	1.3	0.44	Silt/Clay	E6	DA
NR1031.R201	1.5	6.1	1.4	1.60	Sand	G5c	B
NR1042.R201	1.6	7.2	1.3	1.30	Sand	G5c	G
NR2007.R201	1.2	8.7	1.1	0.18	Sand	F5	C
NR2043.R201	2.3	4.7	1.5	0.92	Sand	B5c	B
NR2049.R201	4.3	13.1	1.2	2.40	Sand	B5	B

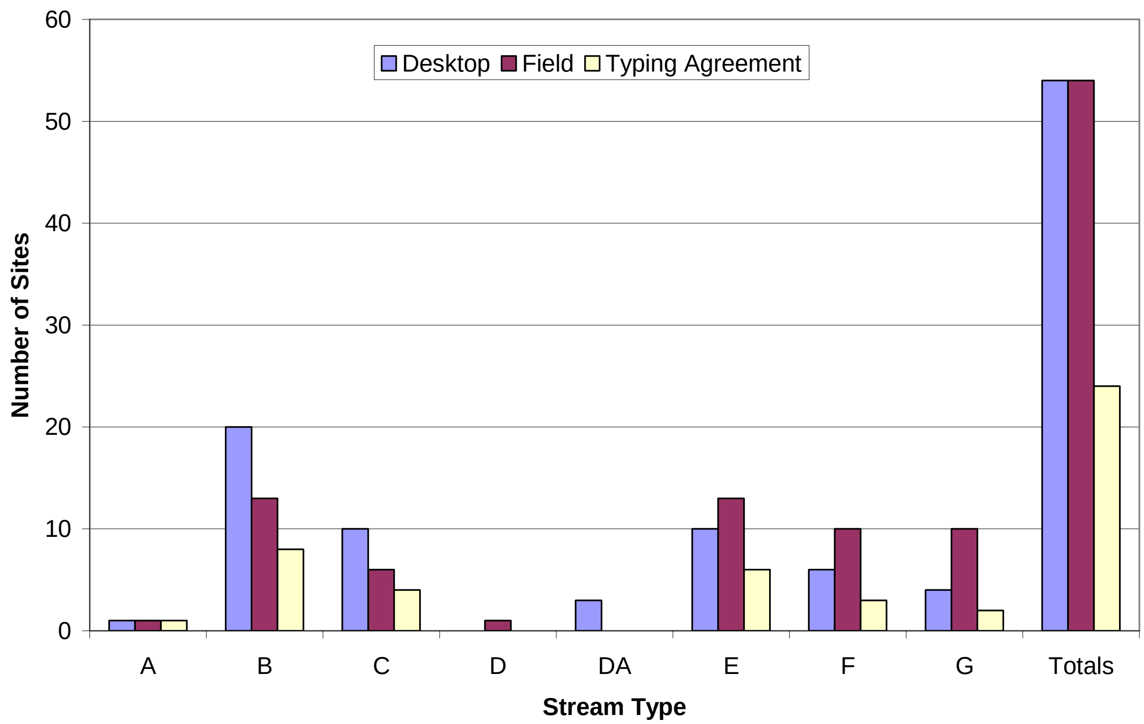
EXHIBIT 8
Field Assessment—Site Dimensionless Ratios and Level II Stream Type Classification

Site	Entrenchment Ratio	Width/Depth Ratio	Sinuosity	Channel Slope (%)	Channel Material	Assessment Classification	
						Field	Desktop
NR2050.R201	16.8	8.0	1.1	0.38	Sand	E5b	E
NR4059.R201	13.2	15.6	1.1	2.00	Sand	E5b	E
NR6001.R201	1.3	8.7	1.1	0.40	Sand	G5c	C
NR6019.R201	25.9	3.0	1.1	0.77	Sand	E5	E
NR6063.R201	1.9	6.2	1.1	1.10	Gravel	E4	E
SGB006.R201	23.0	6.0	1.3	1.60	Sand	E5	B
SPD009.R201	1.6	9.8	1.2	1.20	Sand	B5c	E
TNB004.R201	1.6	4.5	1.2	2.40	Gravel	G4	E
TNB044.R201	2.4	16.5	1.2	0.37	Sand	C5	C
TNB045.R201	2.8	22.5	1.1	0.85	Sand	C5	C

3.2 Comparison of the Field Assessment to the Desktop Level I Classification

One of the objectives of this part of the watershed study was to verify the results from the County's Rosgen Level I stream type classification desktop analysis procedure. Exhibit 9 provides a comparison of the channel types determined during the desktop Rosgen Level I classification and the Level I classification resulting from the field assessment. The number of agreements between the two independent channel-typing processes is also presented. Twenty-four stream reaches (44 percent) were given the same stream type by both classification approaches. All of the independent stream type groupings had a 40 percent or higher typing agreement, except for the DA stream type. Reaches classified as DA were automatically classified that way based on field documentation of a multiple threaded channel from the physical condition assessment, not on the desktop assessment results.

EXHIBIT 9
Comparison of Rosgen Level I Desktop Analysis Results and Field Assessment Results



To better understand the similarities and differences between the desktop and field assessment results, further investigations into the individual delineative parameters were conducted; including entrenchment ratio, width/depth ratio, sinuosity, and channel slope.

Exhibits 10A through 10D are box plots displaying a comparison of the four delineative parameters generated by both the field and desktop assessments. The box plots display the similarities and differences in the delineative parameter values for each assessment by channel type. Each plot shows that the desktop procedure is producing appropriate values for each channel type when compared to the field assessment data. The box plots give no indication of site-specific accuracy of the desktop procedure. Site-specific data comparisons can be found in Exhibits 11A through 11D.

EXHIBIT 10A
Box Plot of Entrenchment Ratio Values Used for the Rosgen Stream Type Classification (Desktop Assessment vs. Field Assessment)

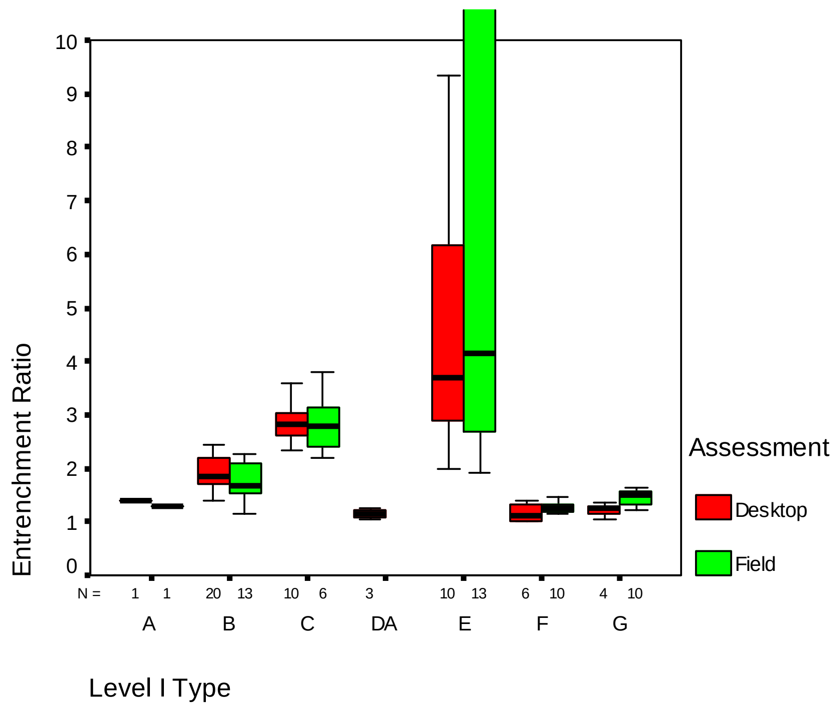


EXHIBIT 10B
Box Plot of Width/Depth Ratio Values Used for the Rosgen Stream Type Classification (Desktop Assessment vs. Field Assessment)

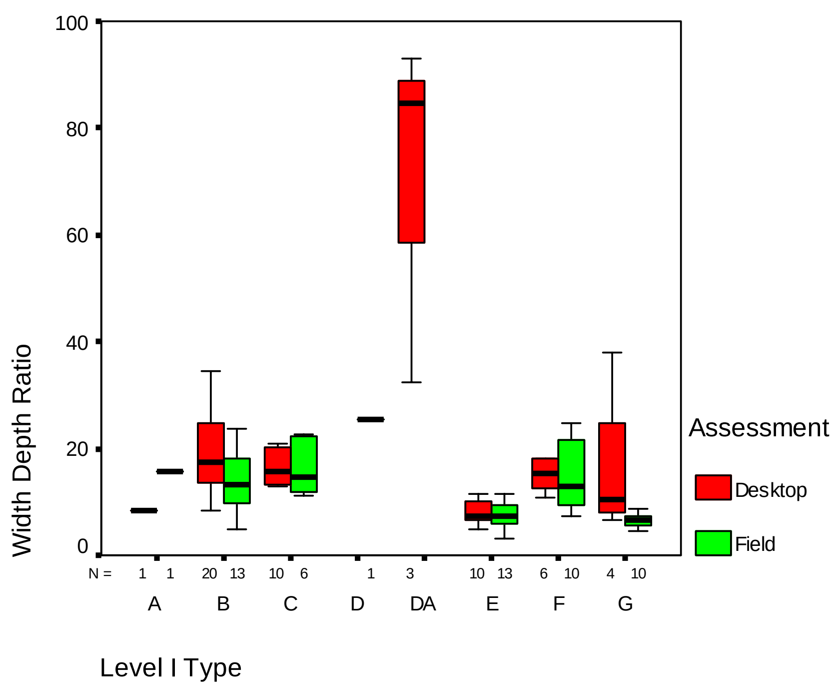


EXHIBIT 10C
Box Plot for Sinuosity Values Used for the Rosgen Stream Type Classification (Desktop Assessment vs. Field Assessment)

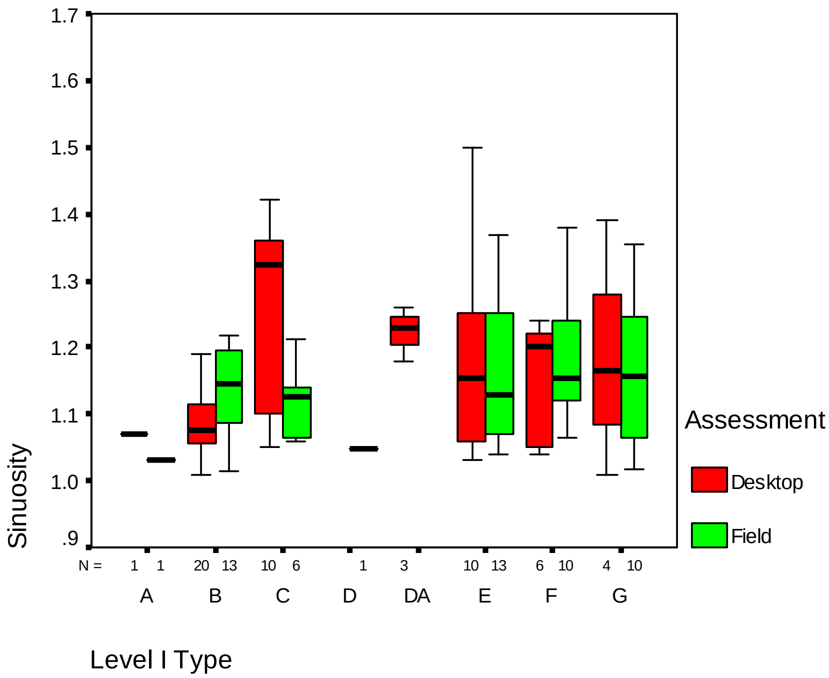
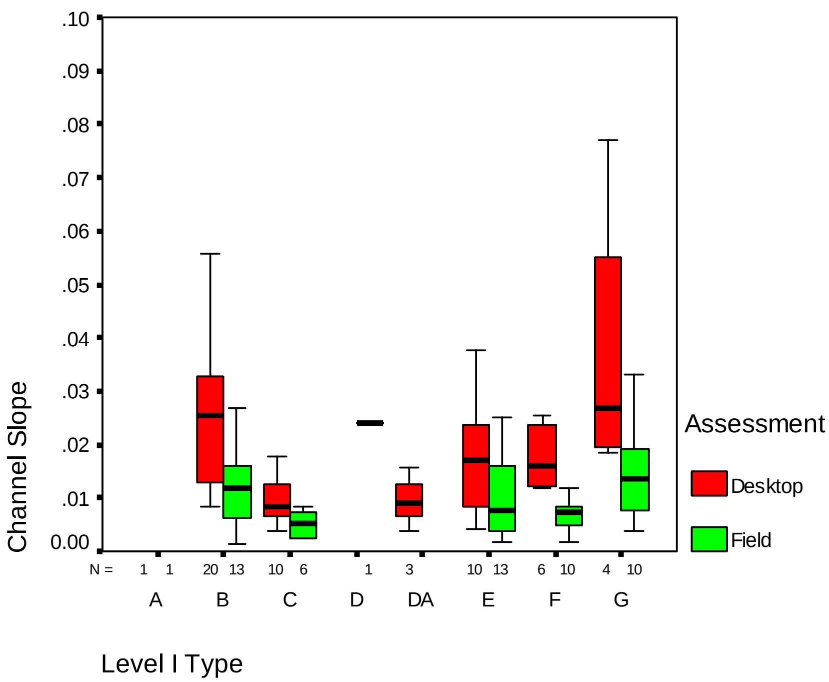


EXHIBIT 10D
Box Plot for Channel Slope Values Used for the Rosgen Stream Type Classification (Desktop Assessment vs. Field Assessment)



Exhibits 11A through 11D are scatter plots for each of the four delineative parameters. The points within each plot that fall on the diagonal line represent values that were identical between the desktop and field assessments. Data that falls above this line represents an overprediction by the desktop procedure and values below the diagonal line represent an underprediction by the desktop procedure.

EXHIBIT 11A
Scatter Plot of Entrenchment Ratio Values Used for the Rosgen Stream Type Classification (Desktop Assessment vs. Field Assessment)

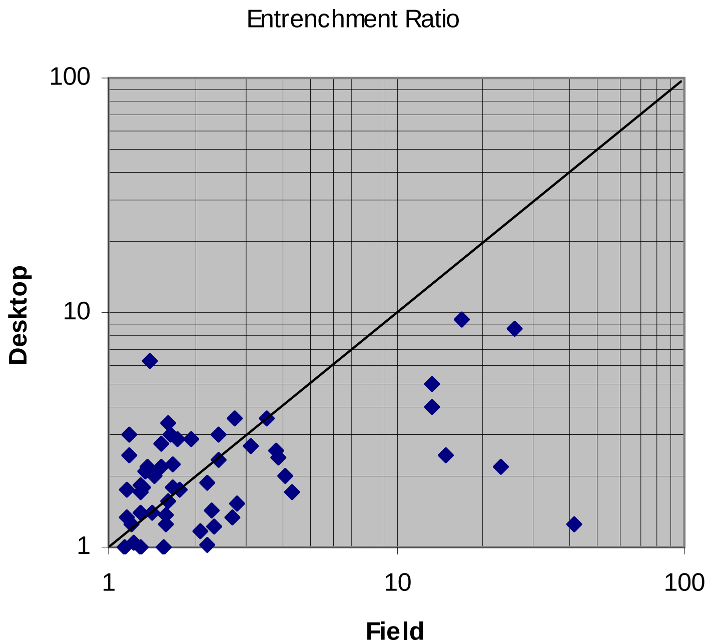


EXHIBIT 11B
Scatter Plot of Width/Depth Ratio Values Used for the Rosgen Stream Type Classification (Desktop Assessment vs. Field Assessment)

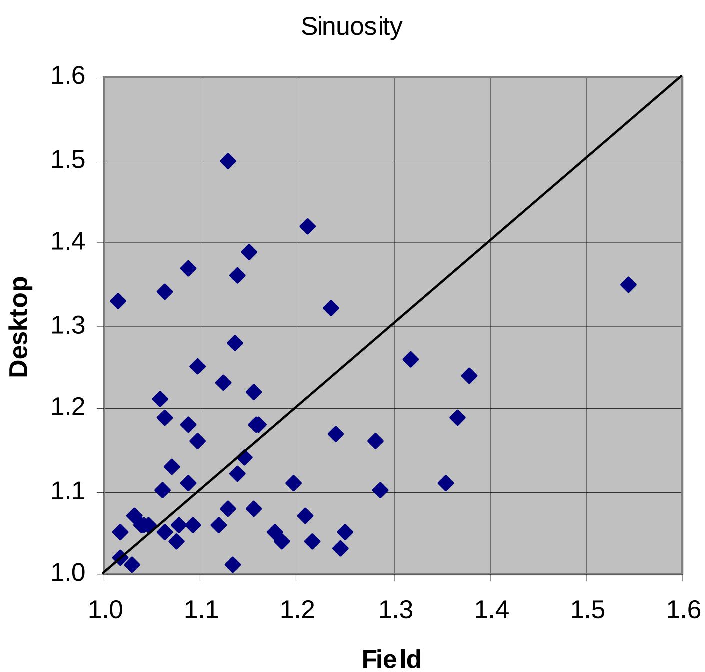


EXHIBIT 11C
Scatter Plot for Sinuosity Values Used for the Rosgen Stream Type Classification (Desktop Assessment vs. Field Assessment)

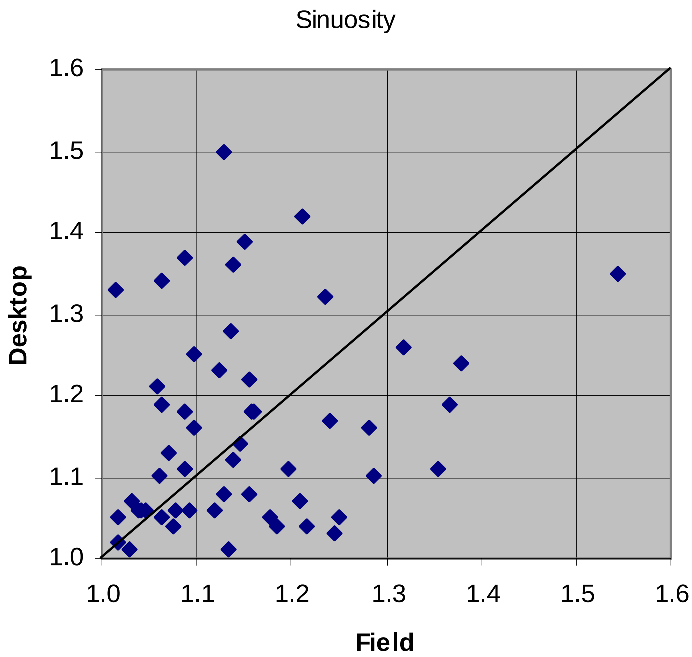
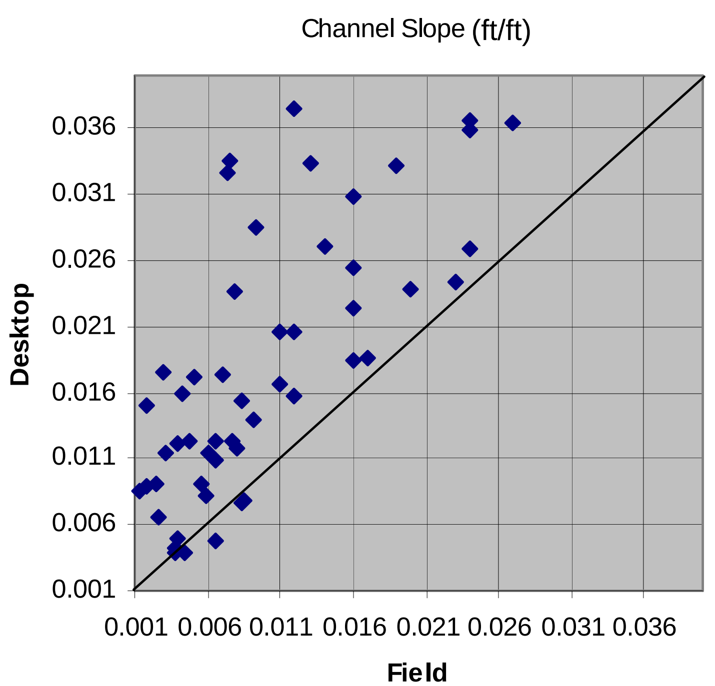


EXHIBIT 11D
Scatter Plot for Channel Slope Values Used for the Rosgen Stream Type Classification (Desktop Assessment vs. Field Assessment)



The most apparent trend can be seen in Exhibit 11D; in this plot, over 90 percent of the points fall above the diagonal line, indicating the desktop procedure has consistently overpredicted the channel slope. Although this is the only consistent trend, there is obvious variability between the desktop and field assessments for the three remaining parameters.

Entrenchment ratio values determined utilizing the desktop procedure appear to be more likely underpredicted than overpredicted, as seen in Exhibit 11A. Entrenchment ratios are one of the primary delineative parameters for single-threaded streams; therefore, this trend was further investigated. A comparison of the raw data for the desktop and the field assessment entrenchment ratios determined that of the 30 sites that had a stream type that was different between the two assessments 24 of these sites had a field determined entrenchment ratio sufficiently different from the desktop procedure to yield a different channel classification. Seventeen of the field-surveyed sites had a higher entrenchment ratio, than the desktop procedure had predicted and seven had a lower entrenchment ratio than predicted.

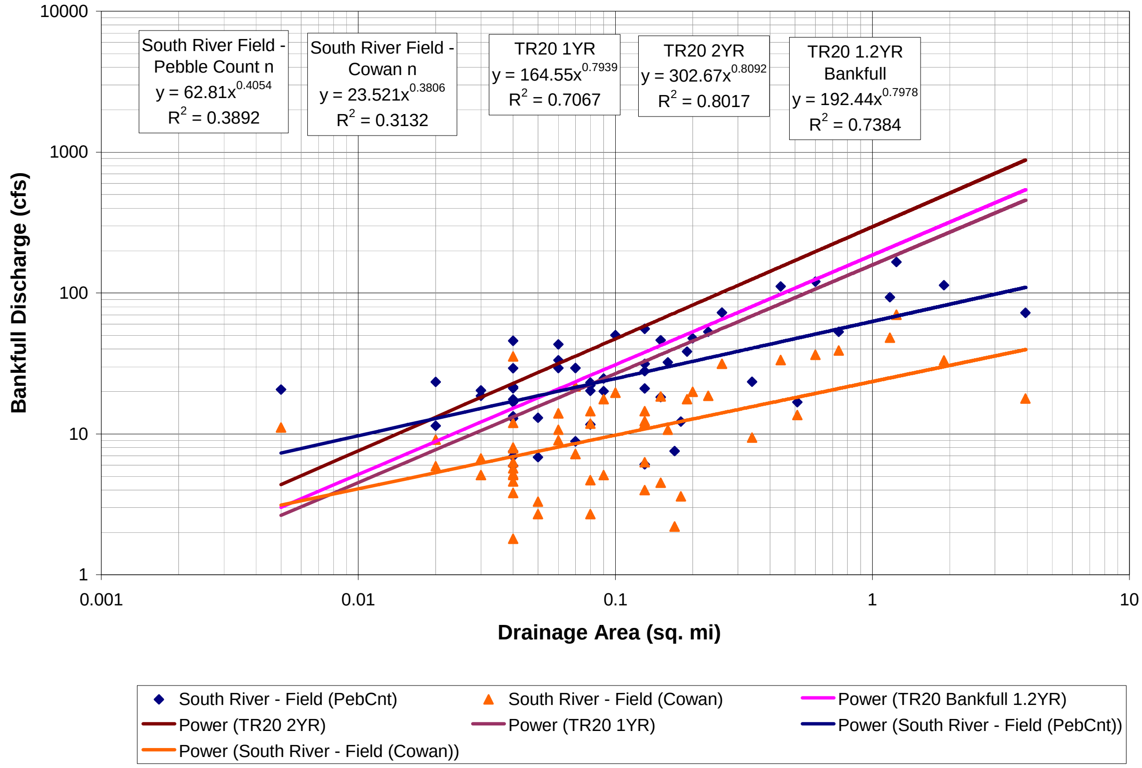
The width/depth ratio plot (Exhibit 11B) indicates the desktop procedure is more likely to overpredict than underpredict these ratios. Further investigation into individual site width/depth ratios found that 21 of the 30 field survey sites with a different stream classification, than the desktop procedure, had overpredicted width/depth ratios by greater than two. The variation considered by the Rosgen stream classification system to be the natural variation for channel characteristics (Rosgen, 1996). The C, F, and G stream types had the greatest percentage of stream reaches, with underpredicted width/depth ratios of 60, 50, and 50 percent, respectively.

Although there is high variability between the desktop and field measured sinuosity, the desktop assessment did not predict predominantly high or low trends.

Exhibit 12 displays the results of the TR-20 modeling, one part of the desktop procedure, which was conducted to obtain the 1- and 2-year discharges for all of the sites. The TR-20 1.2-year discharge was not modeled but interpolated from the 1- and 2-year discharge data, trend lines, which are displayed in Exhibit 12. This exhibit also includes the bankfull discharge as calculated by the Mecklenburg (2006) reference reach spreadsheet, which utilizes Manning's equation with a single consideration of channel roughness based on bed substrate. The bed substrate was characterized by the field assessment pebble count. As discussed previously, for the predominantly sand bed streams in the South River watershed, the use of particle size to determine the roughness coefficient may not be appropriate. A Manning's n value based solely on sandy substrate would give an indication that the channels have very little flow resistance. Based on the presence of woody debris, roots, channel sinuosity, and other factors this is not an accurate representation of the surveyed streams.

A subsequent analysis was completed generating discharge using a Manning's n value calculated using the Cowan (1956) Method. This method takes into account several factors in calculating an overall Manning's n value, as described in Section 3.1. The bankfull discharge calculated using the Cowan Method to determine the Manning's n value is also depicted in Exhibit 12.

EXHIBIT 12
Comparison of Discharge Calculations for the TR-20 Model, 1- and 2-Year Storm Events, and the Bankfull Discharge Calculated Based on the TR-20 data and the Field Assessment Data



In Exhibit 12 it can be seen that the bankfull discharge trend lines generated from the field data are much flatter than the TR-20 trend lines. The flatter slope for the bankfull discharge trend lines give an indication that the subwatersheds for each reach are generating less discharge per unit area than the TR-20 modeling predicts. The bankfull discharge return interval for the coastal plain is 1.2 years (McCandless, 2003), indicating that a comparison of the field data to the 1.2 year TR-20 data is appropriate. However, the ability to draw conclusions from the relationships between the modeled discharges and the discharges calculated from the field data is complicated by the magnification of the conservative estimations typical of the TR-20 model. When watershed boundaries were delineated during another Task from this watershed study, they were delineated as very small catchments. These catchments were used for runoff routing in the TR-20 modeling effort. TR-20 provides a conservative (high) estimate of flow from a given watershed. In addition, because of the small catchment sizes the time of concentrations are shorter, compounding the error for downstream reaches. If the discharges represented by the three TR-20 trend lines in Exhibit 12 are higher than they should be, especially for the reaches with larger drainage areas, then the TR-20 trend lines may be closer to the bankfull discharges calculated from the field data, this would indicate the field-based bankfull discharge estimates may be reasonable.

The R^2 values (0.39 and 0.32) for the field assessment regression lines are low, indicating the regression is not a particularly “good fit” to the field data. There is a very limited range of values for the independent variable, drainage area: 93 percent of the reach drainage areas are less than 1 mi^2. The small range of values for drainage area may be a factor in the low R^2 values. It is also important to note that approximately 50 percent of the streams surveyed were F and G channel types giving an indication of stream impairment. Within impaired reaches the bankfull determination is challenging. Errors in bankfull identification in these streams directly affect all calculations associated with bankfull characteristics, most importantly bankfull discharge. The best bankfull elevation determination method for these types of reach is from USGS gauge station data, when available.

3.3 Comparison to Regional Curves

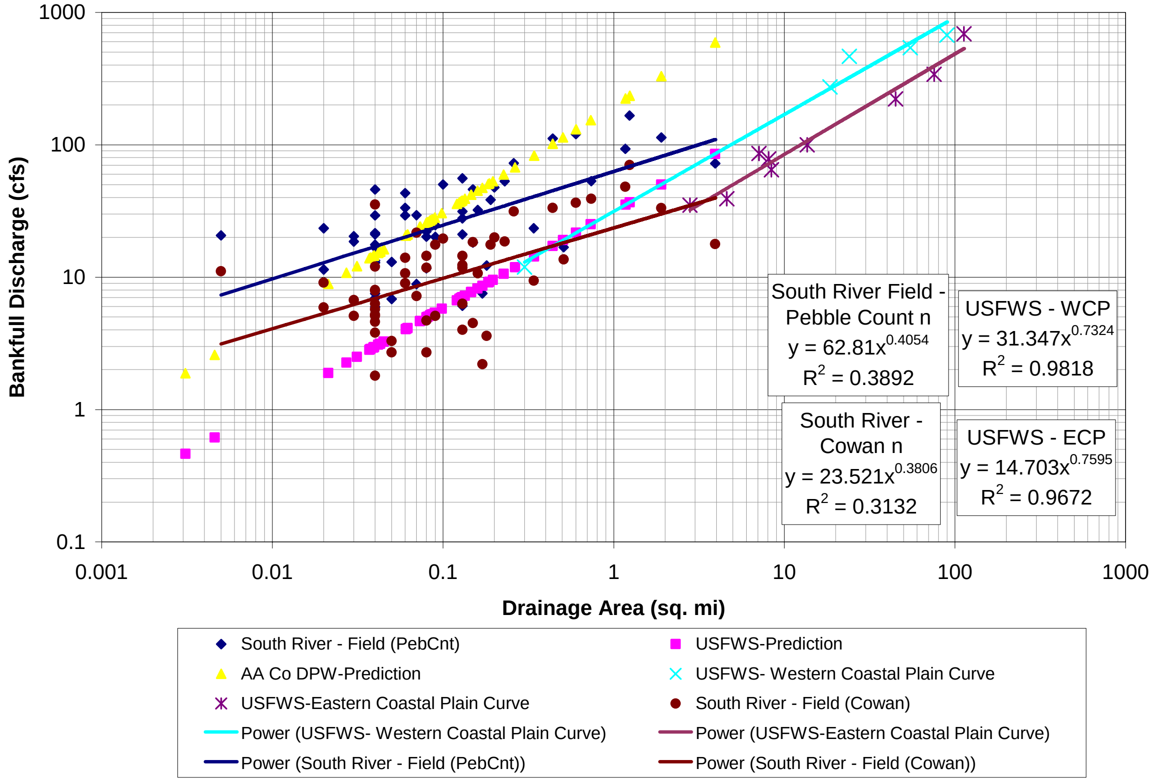
Regional curves typically are generated using drainage areas greater than 1 mi^2 and cross-section data collected on streams with a USGS gauge station. The USGS gauge station data is used to determine the bankfull discharge elevation and the bankfull recurrence interval. The regional curve data generated by the U.S. Fish and Wildlife Service (USFWS) for each of the Western and Eastern Coastal Plain regions uses C and E channels with drainage areas predominantly greater than 1 mi^2, one site used for the USFWS Western Coastal Plain curve was 0.3 mi^2, while the other four sites had drainages all greater than 18.5 mi^2. The South River drainage areas for the study sites ranged from 0.003 to 3.94 mi^2, with an average of 0.27 mi^2. In addition to the difference in drainage areas, the landuse of the sites used to develop the regional curves was significantly different from that of most of the South River sites. The regional curve sites were in a rural to suburban land use setting, minimizing the impact of urban imperviousness levels on the bankfull channel. These factors limit the ability of a direct comparison between the South River results and the regional curves.

Exhibit 13 displays the following:

- South River field data
- USFWS Western Coastal Plain regional curve
- USFWS Eastern Coastal Plain regional curve
- Anne Arundel Department of Public Works (DPW) (2002) predicted values, utilizing the published regression equation, for South River survey sites
- USFWS (McCandless, 2003) predicted values, utilizing the published regression equation, for South River survey sites

In Exhibit 13, it can be seen that the Anne Arundel DPW predicted values for the surveyed sites display higher discharge rates per drainage area than the USFWS predicted curve, which is appropriate as this curve was generated from urban stream data. The field-determined bankfull discharge curves, using the pebble count *n*, track best with the Anne Arundel DPW predicted values. The bankfull discharge calculated from the field data utilizing the Cowan *n* value tracks best with the USFWS prediction line, with a majority of the data points falling between the two prediction lines. The dominant number of data points that fall on or closest to the USFWS prediction line for both bankfull discharge calculations are those within the North River, Bacon Ridge, and Broad Creek subwatersheds, which all can be considered to be more of a rural to suburban land use than urban.

EXHIBIT 13
Comparison of the Bankfull Discharge–Drainage Area Relationship between South River Field Data and Regional Curve Data



The bankfull discharge generated from the Cowan Method (1956) Manning's *n* value is more appropriate for the streams within the South River watershed as this method takes into consideration several flow resistance factors rather than being based solely on a bed substrate roughness coefficient. The Cowan Method *n* trend line also tracks closely with the USFWS Western Coastal Plain predicted values. The discharge generated from the Cowan *n* roughness coefficient may be the more appropriate bankfull discharge calculation; however, the slope of the trend line is much flatter than the regional curve. The comparison of the field data with the regional curve data is complicated due to the differing land use settings for each study. The regional curve sites were located in a rural to suburban land use setting and the South River sites were located in both urban and rural to suburban land use settings.

The mix of urban and rural/suburban sites will provide a line with a slope that is lower than that of a curve with sites in a homogenous land use setting; urban sites produce higher discharge rates than rural/suburban sites. In this study, the urban sites are some of the sites that have the smallest drainage areas and the rural/suburban sites tend to have the larger drainage areas. Land use is a variable that is not being accounted for in the field assessment regression equations. The bankfull discharge–drainage area relationship should be separated by land use type to provide land-use-specific curves: urban versus suburban/ rural. The imperviousness threshold between the urban and rural/suburban classifications should be maintained at 10 percent.

3.4 Empirical Relationships

Empirical relationships, by channel type, between bankfull morphological parameters and drainage area are displayed in Exhibits 14 through 16. The relationships between the bankfull parameters and bankfull discharge are displayed in Exhibits 16 through 18. The A and D channels are included in the "all channel types" trend line but were not evaluated separately because there is only one of each channel type. The bankfull discharge and drainage area relationship is displayed in Exhibit 12 and discussed within Section 3.2.

The limited range of the independent variable drainage area in the regression analyses may be a factor in low R^2 values for the relationships displayed in Exhibits 14 through 16.

EXHIBIT 14
Bankfull Cross-Sectional Area versus Drainage Area, by Channel Type

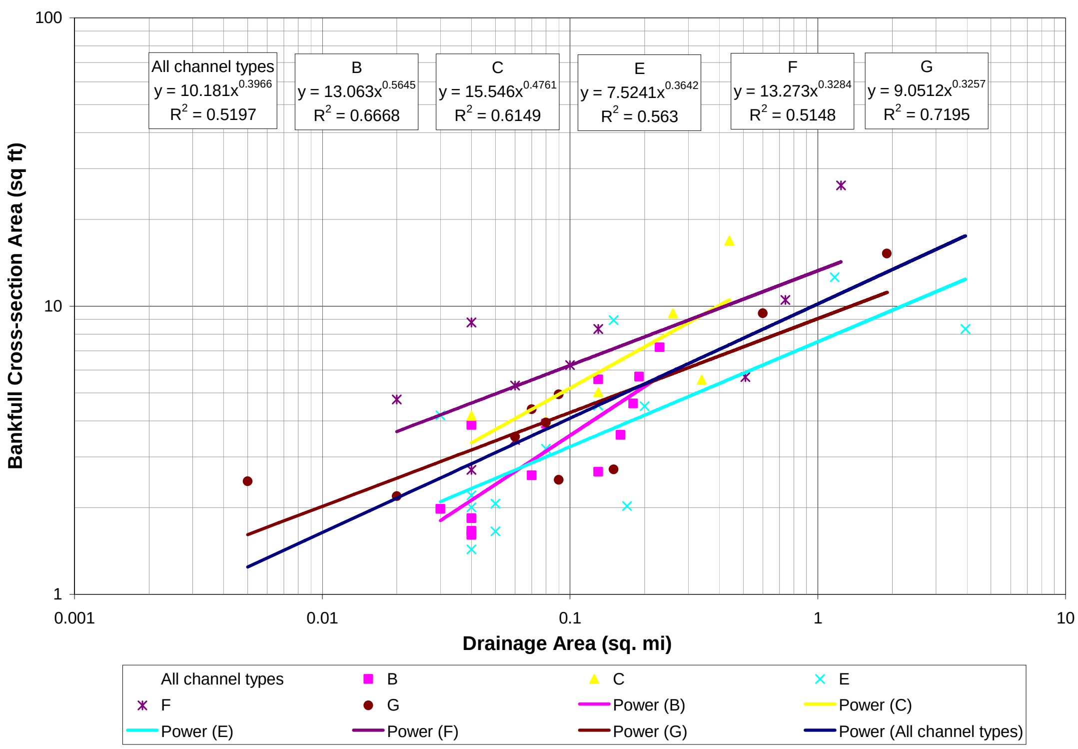


EXHIBIT 15
Bankfull Width versus Drainage Area, by Channel Type

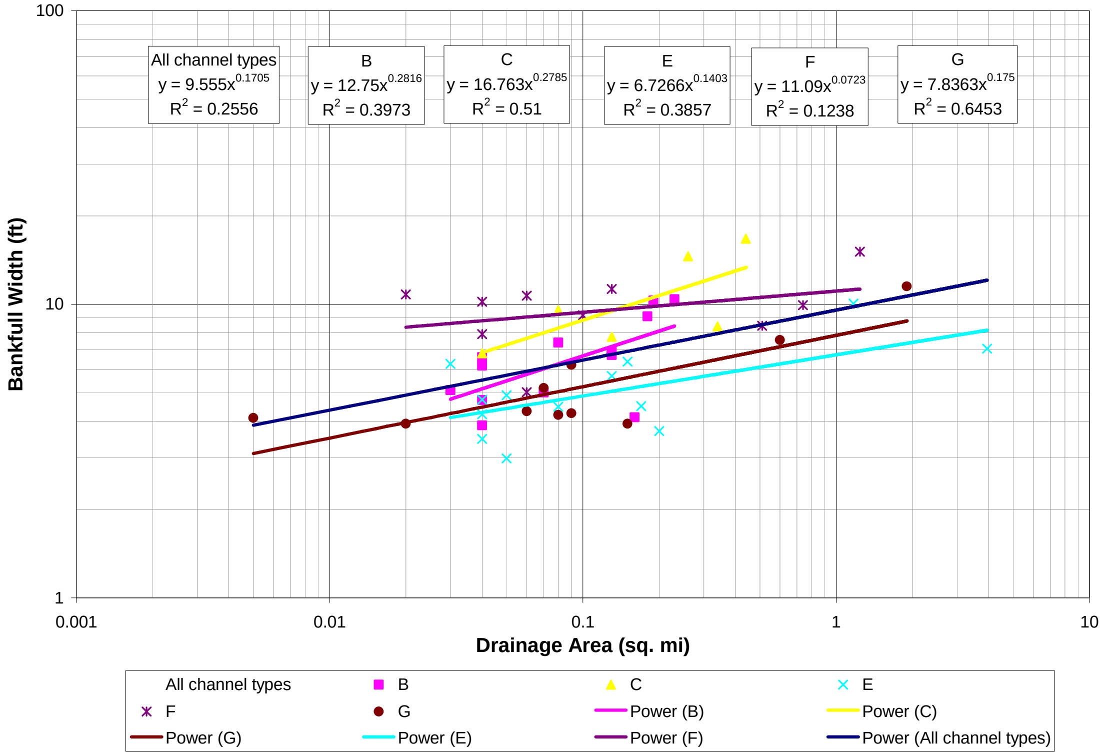
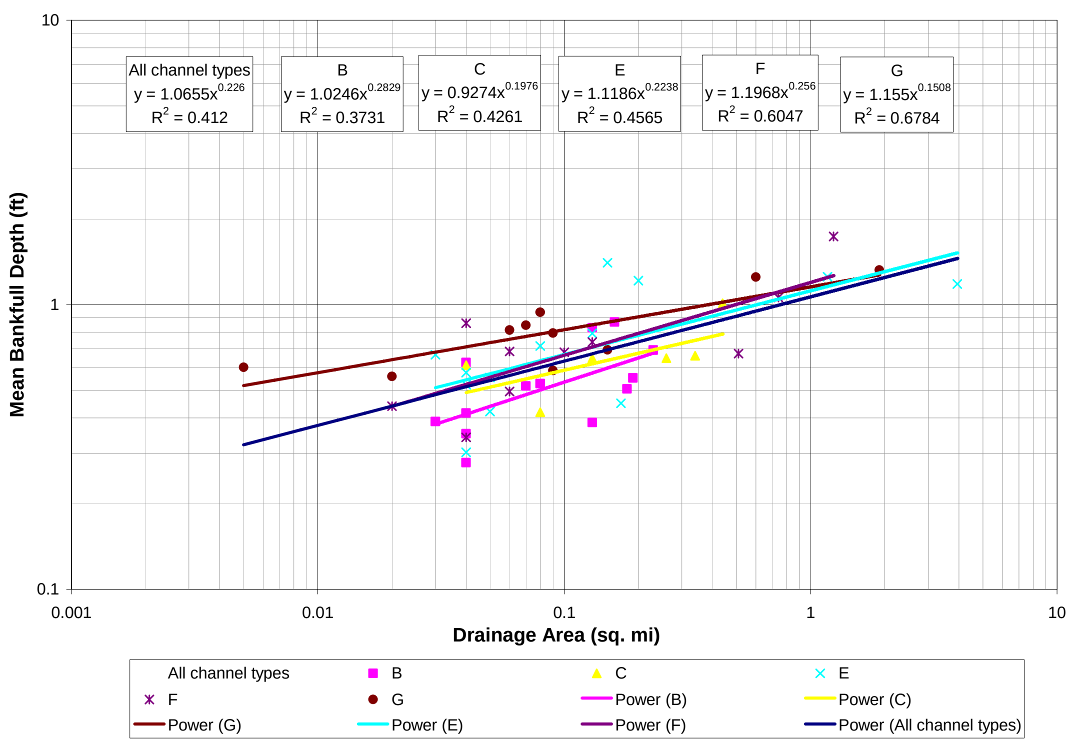


EXHIBIT16
Bankfull Mean Depth versus Drainage Area, by Channel Type



Overall, the best relationship to drainage area for all channel types is cross-sectional area, R^2 values range from 0.52 for all channel types combined to 0.72 for surveyed G channels. The strongest relationship between bankfull width and drainage area were the C and G channels, 0.51 and 0.64, respectively. The bankfull width to drainage area relationship had the lowest overall R^2 values of all the bankfull parameter–drainage area relationships. The surveyed F and G channels had the highest R^2 values for the bankfull depth–drainage area relationship, 0.60 and 0.68, respectively.

The bankfull parameter-bankfull discharge relationship generated relationships with higher R^2 values than the drainage area relationships. Bankfull cross-sectional area had some of the highest R^2 values of the three bankfull parameters, ranging from 0.45 to 0.85. Similar, to the drainage area relationship bankfull width generated the weakest relationship with discharge with R^2 values ranging from 0.11 to 0.62. Bankfull depth drainage area had the highest R^2 values of all of the empirical relationships ranging from 0.46 to 0.90.

EXHIBIT 17
Bankfull Cross-Sectional Area versus Bankfull Discharge, by Channel Type

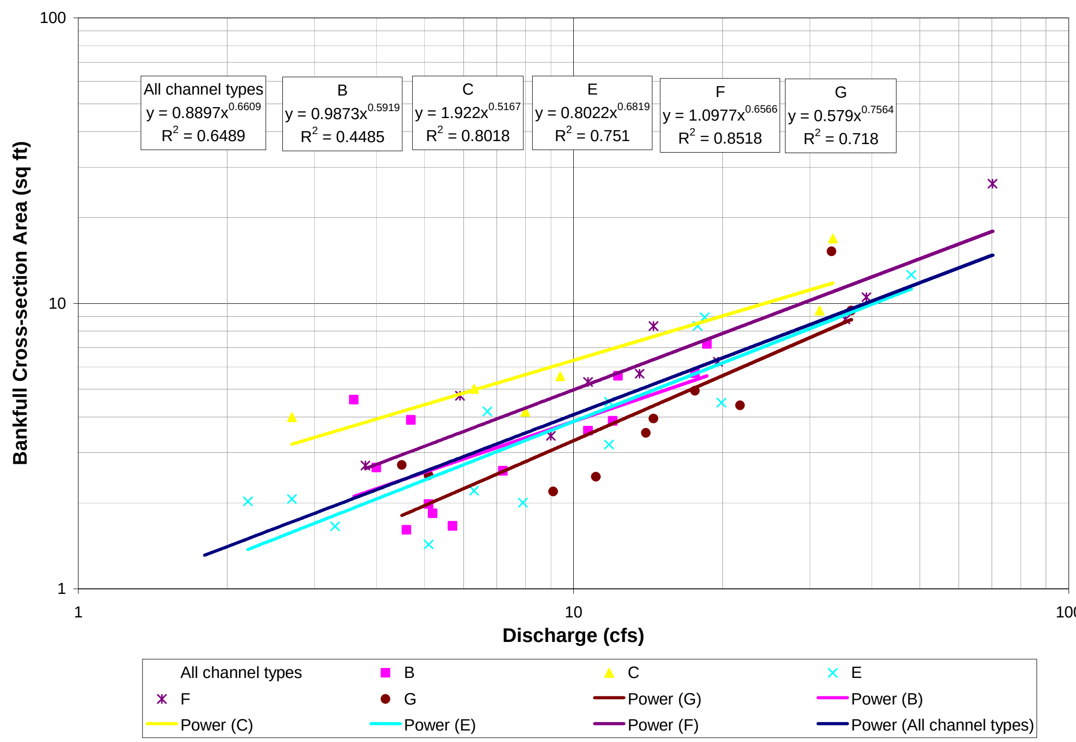


EXHIBIT 18
Bankfull Width versus Bankfull Discharge, by Channel Type

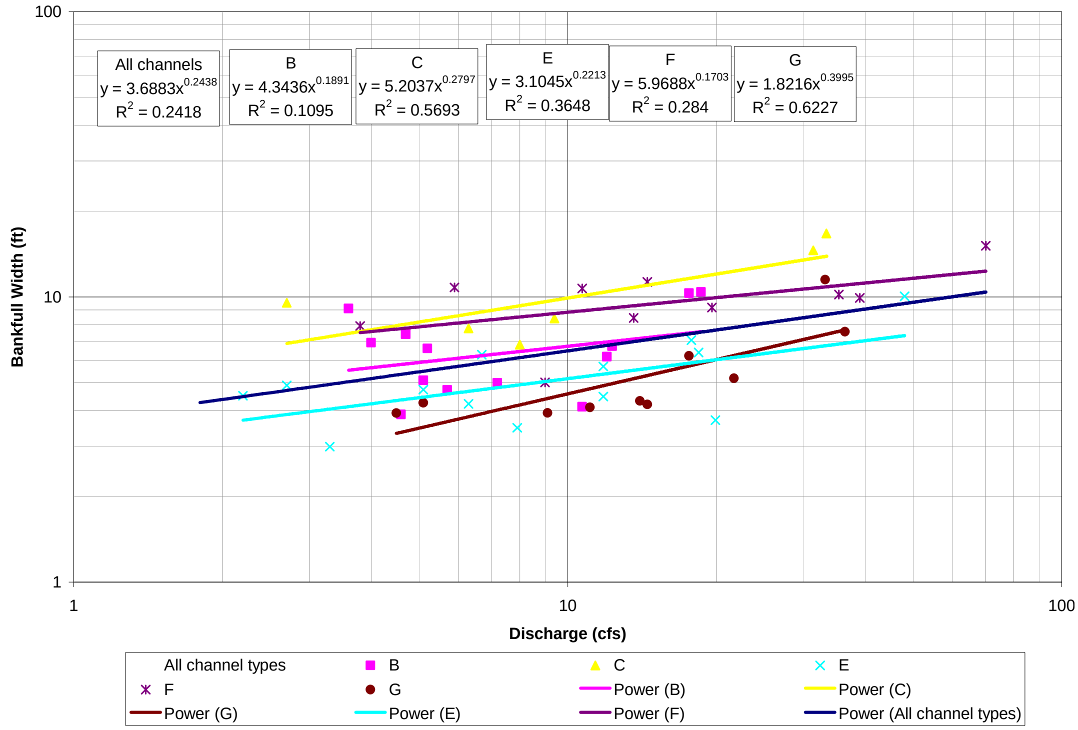
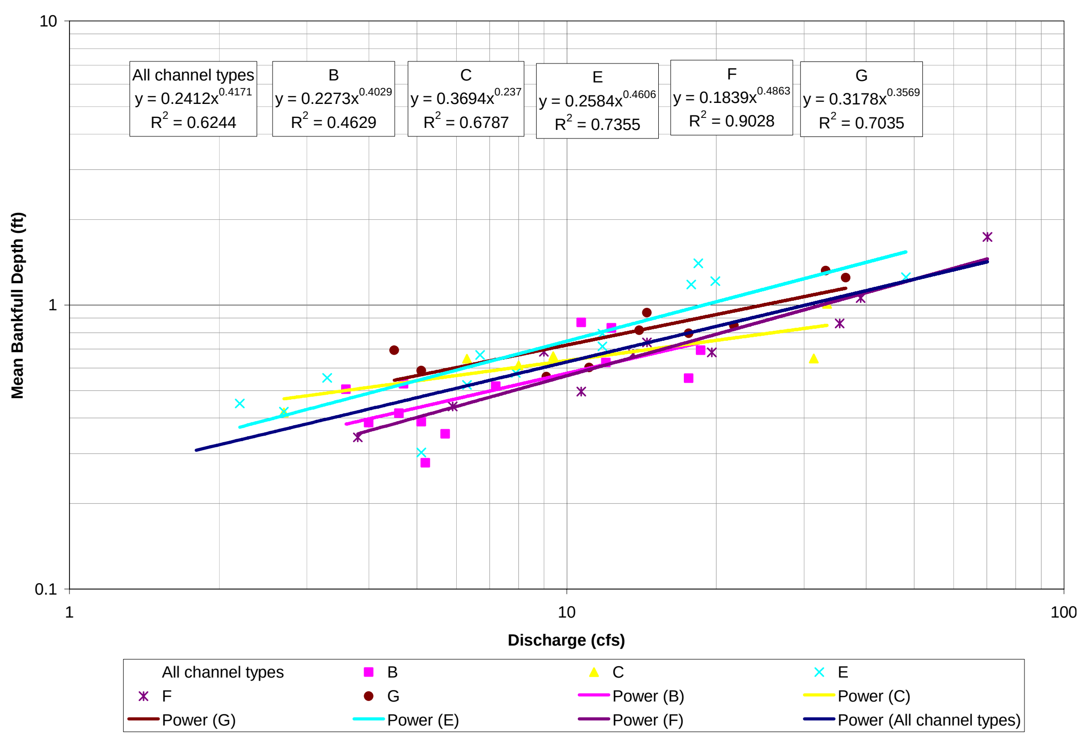


EXHIBIT 19
Bankfull Mean Depth versus Bankfull Discharge, by Channel Type



4 Summary

The field assessment of the 54 reaches within the South River watershed yielded predominantly B, E, F, and G channel types. These channel types are representative of the typical channel types for the coastal plain, in unaltered (B and E) and impacted (F and G) conditions. A qualitative assessment of available mapping showed that the F and G channel types were typically associated with areas of new development activity and areas of high impervious surfaces. The empirical relationship between the field assessment bankfull discharge data and each sites drainage area may not be appropriate for the drainage areas within this study, based on R^2 values. Ninety-three percent of the drainages for the surveyed sites are less than 1 mi^2; drainage areas this small are more likely impacted by land use than size, therefore complicating the connection of bankfull discharge to drainage areas. A larger data set encompassing a wider range of drainage area sizes may provide a more robust regression analysis yielding statistically significant results. The relationship between the bankfull morphological characteristics and drainage area, and bankfull discharge, did produce some statistically significant relationships for individual channel types.

In an attempt to continue the monitoring of streams within the South River watershed, the County developed a desktop assessment procedure to generate channel morphology data and assign a Rosgen Level I stream type. Of the 54 channels assessed in the field, 24 were an exact match of channel type assigned through the County's desktop assessment procedure. The remaining sites deviated from the desktop procedure in both entrenchment and width/depth ratio values enough that the field assessment channel type was different from the desktop assessment. Although slope had the most consistent trend for a large majority of the sites (over 90 percent), an overprediction by the desktop procedure, slope is not a differentiating parameter for a Rosgen Level I classification.

The desktop procedure utilized by the County may not accurately capture the low-flow channel and may therefore overestimate channel size. The drainage areas of the stream channels assessed are small, and many do not contain channels that are very large. The median bankfull channel width is 6 feet with a range from 3 to 17 feet. The County's desktop assessment attempts to capture a low flow channel within these small streams utilizing digital data; including digital elevation models, contours, and aerial photography. It is likely that the finer channel features will be missed due to the level of detail of the data sources and the size of the streams. The procedure may be more applicable to larger channels, where the finer channel features are less important. The field assessment results yielded channels that were more entrenched, had greater channel slopes, and lower width/depth ratios. Field surveys are the means to capture fine channel details. The field data for each of the 54 sites can be used to refine the desktop procedure to make it more useful as a planning level stream classification tool. This procedure should not be used for projects that require data with a high level of accuracy, as there are limits to the digital data utilized. However, it could be a good initial screening tool, with some refinements.

The results of the field assessment yielded channels that can be used as guidance for reference reach design criteria, however these sites will need to be selected carefully. Many of the sites represented opportunities within the watershed for the restoration of aquatic environments, and were not appropriate as reference conditions. Some of the restoration opportunities would be easier than others considering property ownership. For example site BR4054 and BR4100, F channel types, are located on the old Crownsville Mental Hospital Campus, currently owned by the Maryland Department of Natural Resources. Also, BD1031, a G channel type, is located on property currently owned by Anne Arundel County. These are just three examples of channels that are in need of restoration and are in an area that would allow for easy access for restoration activities.

5 References

Anne Arundel County Department of Public Works. 2002. Urban Regression Equation for Church Creek.

Cowan, W. L. 1956. "Estimating Hydraulic Roughness Coefficients." Agricultural Engineering, 37(7), 473–475.

McCandless, T.L. 2003. "Maryland Stream Survey: Bankfull Discharge and Channel Characteristics of Streams in the Coastal Plain Hydrologic Region." United States Fish and Wildlife Service. Annapolis, Maryland.

Mecklenburg, D. 2004. "The Reference Reach Spreadsheet for Channel Survey Data Management." Version 4.2L. Ohio Department of Natural Resources.

Rosgen, D. 1996. *Applied River Morphology*. Wildland Hydrology. Pagosa Springs, Colo.

Appendix A

Anne Arundel County Watershed Management Program – South River Watershed Study, Task 3.5 Rosgen Level II Site Selection Internal Technical Memorandum (Feburary 14, 2007)

DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING
WATERSHED AND ECOSYSTEM SERVICES

WATERSHED MANAGEMENT PROGRAM

To: Mary Searing, P.E., Watershed Management Program Administrator

From: Hala Flores, P.E., Watershed Model Administrator

Date: February 14, 2007

Re: South River Watershed Study
Task 3.5 - Rosgen Level II Site Selection

Purpose

The purpose of this correspondence is to document the stream sites selected for the South River Watershed Study Rosgen level II morphological assessment Task 3.5.

General

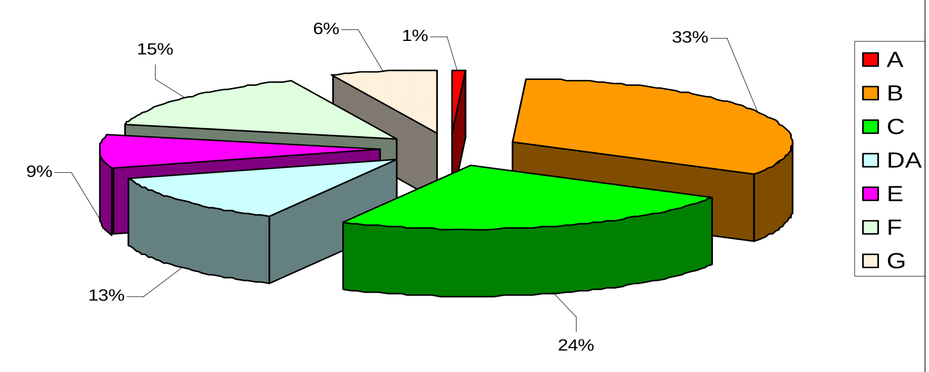
The South River watershed lies on the western shore of the Chesapeake Bay in Anne Arundel County, just south of the City of Annapolis. The drainage area of the watershed is approximately 56.5 square miles. The Watershed Management Program (WMP) has developed a 71-subwatershed division, out of which 54 subwatersheds contain non-tidal perennial stream reaches and serve as a base layer for the 2006/2007 current condition Watershed Master Planning effort. The South River streams were field walked during the summer of 2006. The main purpose of the stream walks was to conduct a physical habitat and problem area inventory to serve as basis for characterizing and prioritizing for restoration the South River perennial stream reaches. The composition of the stream reaches within the South River Watershed is tabulated below:

Stream Type	Reach Segments	Length (miles)	Percent Occurrence
Perennial	702	381.9	58.8%
Ephemeral	269	56.4	8.7%
Intermittent	407	105.1	16.2%
Wetland	189	53.6	8.2%
Ditch	98	16.4	2.5%
SWM	52	8.5	1.3%

The spatial distribution for the stream reach layer is shown on Map 1. The distribution shows a high concentration of perennial single threaded streams North of US 50 (66%) and a sparser distribution South of US50. The high concentration of stream coverage North of US50 is contrasted by a smaller contributory drainage area of 44% and a lower percent impervious of 10% compared with 25% South of US50. Refer to Map 2 for the impervious cover for the South River Watershed. This skewed distribution of stream coverage affected the Rosgen Level I coverage and candidate sites selected for the Rosgen Level II work.

The WMP staff has developed a desktop GIS interfaced procedure that relies on GIS analysis, hydrologic and hydraulic modeling, and desktop geomorphic assessment to develop a Watershed wide Rosgen level I stream classification coverage. The developed procedure was documented in the October 9, 2006 and October 19, 2006 interoffice technical memorandums and utilized in a pilot study aimed at classifying the channels within the North River Tributary 2 subwatershed within the South River. Technical documentation for the utilized procedure will be incorporated in the South River Watershed Study Report. Out of the 382 miles of field walked perennial stream reaches, 361 miles corresponding to 661 single threaded channel segments were attempted for a Rosgen Level 1 classification. After commencement of the task and the classification of approximately 150 channel segments, a decision was made to exclude channels with a contributory drainage area of less than 20 acres. This analysis threshold will be applied to future Watershed studies. It should be noted that 50 channels with a drainage area below the 20 acres threshold were classified during the early period of the task and are included in the coverage. Channels below the analysis threshold could be classified in the future on a project need basis. A total of 501 perennial stream segments with a total length of 616,626 ft received a Rosgen level 1 classification. An additional 101 stream reaches with a total length of 68,604 ft were automatically classified as “DA” channels without further analysis based on field documented multiple threaded channel conditions. Refer to the Figure and tabulation below for the statistical distribution of the Rosgen level 1 classifications within the South River. Map 3 atthe end of this document depicts the Rosgen level 1 GIS coverage.

Figure 1: Broad Level I Rosgen Classification - South River Watershed



Channel Type	Length (ft)	Description (From the Rosgen Applied River Morphology Book)	Percent Occurrence
A	5,177	Steep, entrenched and confined channels, incised in	1%

Channel Type	Length (ft)	Description (From the Rosgen Applied River Morphology Book)	Percent Occurrence
		predominantly sandy materials that are frequently intermixed with gravels. These channels are very sensitive to induced changes in stream flow regime or in sediment supply. Bedload transport rates are very high.	
B	198,356	Moderately entrenched channels with gradients ranging from 2-4%. The flow is characterized by step pools with an average pool-to-pool spacing of 3-4 bankfull width. The bed and bank material are stable for the B stream type. Large woody debris is an important component of fisheries habitat.	32%
C	150,225	Slightly entrenched, meandering, riffle/pool channel with a well developed floodplain. These channels are stable but are very susceptible to shifts in both lateral and vertical stability cause by direct channel disturbances and changes in the flow and sediment regimes of the contributing watershed.	24%
DA	79,382	Highly interconnected channel systems developing in gentle relief terrain areas consisting of cohesive soil materials and exhibiting wetland environments with stable channel conditions. Sediment supply and bedload contributions are generally low. Most of the channel banks contain a highly cohesive material component, intermixed with a dense root mass. Peat is commonly found.	13%
E	52,737	Low to moderate sinuosity, gentle to moderately steep channel gradients and very low channel width/depth ratio. Channels are typically stabilized with riparian or wetland vegetation that forms densely rooted sod mats. These channels are hydraulically efficient as they require the least area per unit of discharge. These channels are very stable unless the riparian buffer or the sediment/flow supply is significantly changed.	9%
F	93,896	Entrenched, meandering channel, deeply incised in gentle terrain. The top of banks elevation for this stream type is much greater than the bankfull stage, which is indicative of the deep entrenchment. Riparian vegetation plays a marginal role in streambank stability due to the typically very high bank heights, which extend beyond the rooting depth of riparian plants. Stream bank erosion rates are very high due to side slope rejuvenation and mass-wasting process.	15%
G	36,853	Deeply incised and very unstable due to the very high sediment supply available from both upslope and channel derived sources. Stream channels have a moderate gradient and step/pool morphology. Bank erosion and bedload transport are typically high. These stream types are very sensitive to watershed disturbances and tend to make significant adverse channel adjustments to changes in flow regime and sediment supply.	6%
Total	**616,626**		**100%**

The Rosgen Level 1 broad assessment yielded a high percentage of the stable B, C, and E channel types and a low percentage of the unstable G and F channels. The majority of the G and F channels analyzed were borderline A/B and C channel types respectively and did not show signs of extreme degradation. This finding will be compared against the problem area inventory and habitat assessment scores.

Sites selected for Rosgen Level II, Task 3.5

The Rosgen level II sites were selected to meet the following two goals for the task:

1. Assist the County in validating the developed Rosgen level 1 broad classification inventory and evaluating the employed desktop procedures.
2. Assist the County in developing reference reach design criteria for the stable B, C, and E channel types.

The Rosgen Level II candidates were selected such as to represent all the Rosgen classification types found in the South River. The developed Rosgen Level 1 coverage was used in selecting the Level II candidate sites. Out of the 501 stream reaches that received a Rosgen level 1 classification, 54 reaches with a total length of 72,429 ft were selected as candidates for the more detailed Rosgen level II field classification. Refer to Map 4 at the end of this document for a coverage depicting the selected stream reach candidates for the Rosgen level II field classification. To meet the study goals, more sites were selected for the B, C, and E channel types to assist the County in developing reference reach design criteria. It should be noted that some of the channels selected displayed a Rosgen Level I geometric characteristics that did not meet a single classification type. For example, a channel may display the entrenchment of a C channel (> 2.2), a width/depth ratio of a C channel (> 12), and a slope corresponding to a B channel (2-4%). The sinuosity was the parameter most frequently violated when assigning a classification. Nevertheless a single classification was assigned to all channels based on a decision making process that involved the examination of the photographs, proximity to the range, and priority of the parameter in question. The parameter priority list utilized in the decision making process is listed below.

1. Entrenchment Ratio
2. Width to Depth Ratio
3. Profile Slope
4. Sinuosity

The Rosgen Level II distribution by channel type and percentage of overall Rosgen Level I classification is tabulated below:

Type	Rosgen Level I		Rosgen Level II Candidates		
	# of Records	Length (ft)	# of Records	Length (ft)	% of Level I
A	6	5,177	1	322	6%
B	203	198,356	20	19,914	10%
C	102	150,225	10	21,886	15%
DA	44	79,382	3	7,155	9%
E	41	52,737	10	8,829	17%
F	75	93,896	5	4,346	5%
G	30	36,853	5	9,977	27%
Total	**501**	**616,626**	**54**	**72,429**	**12%**

The Rosgen Level II candidate sites along with their Rosgen Level I estimated bankfull parameters, user comments, and classifications are tabulated at the end of this document. The contributory drainage area for each stream reach and the 1 and 2-year discharges modeled in TR20 are provided so that regional regression equations can be employed as a validation tool for the Rosgen level II field calls. The regional regression equations for Coastal Plains by McCandless and the Anne Arundel County DPW urban equations for Church Creek are single parameter regressions and do not distinguish between the various stream types and site specific landcover and hydrology conditions. These limitations should be taken in consideration when employing the regional regression equations as a validation measure. It is suggested that the TR20 modeled results for the 1 and 2 year storm events be used to gauge the validity of the regression equations in estimating the bankfull discharge.

If you need additional information or have any questions or comments about the content of this document, please feel free to contact me.

Cc: Richard Fisher, Watershed Model Analyst

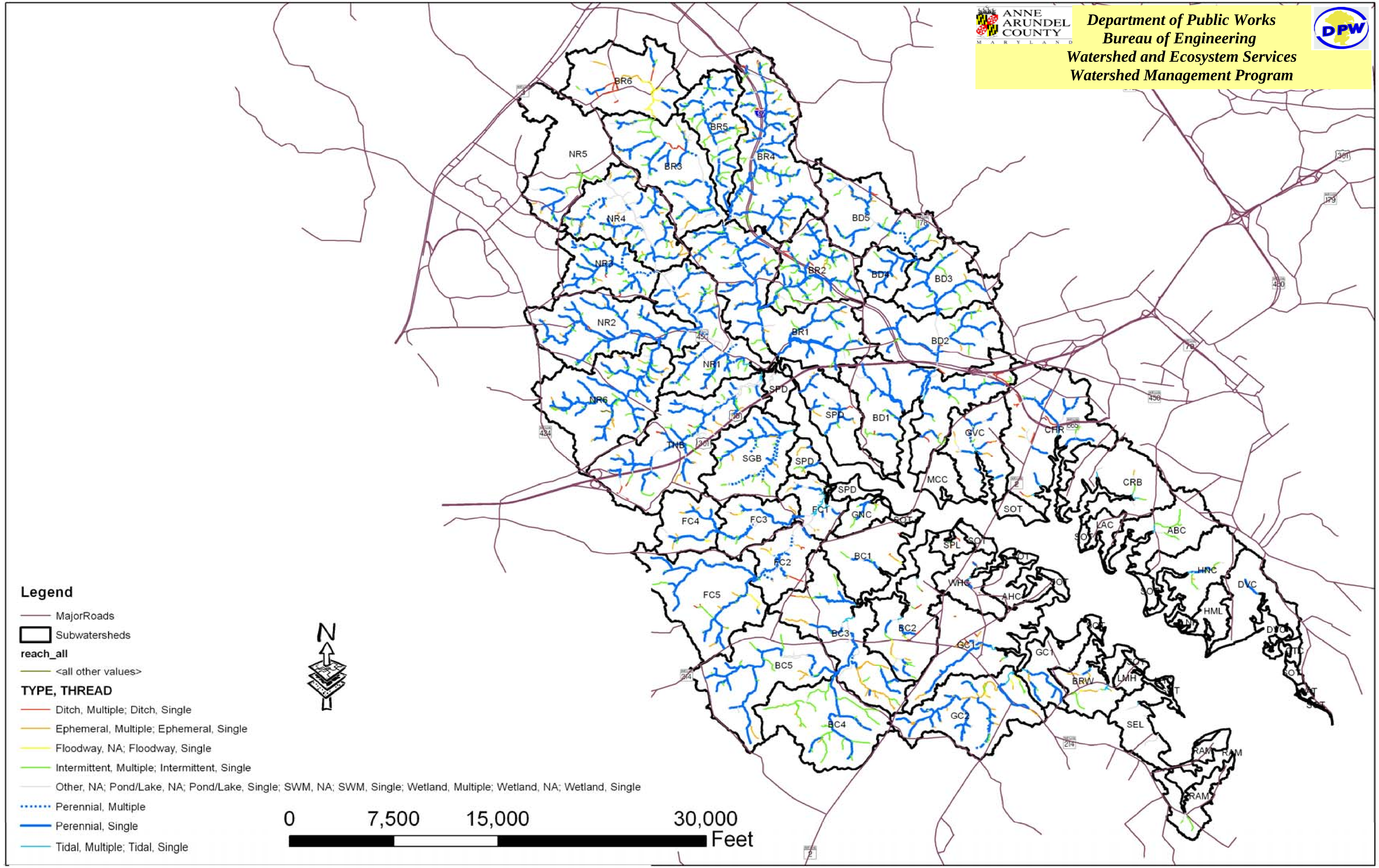
Christopher Victoria, Environmental Scientist

Catchment	Drainage Area (Acres)	1 Year Discharge (cfs)	2 Year Discharge (cfs)	Overall Reach Slope	Bankfull			Floodprone		Entrenchment Ratio	Width / Depth Ratio	Notes	Overall Reach Sinuosity	Classification Parameters and Types				
					Width (ft)	Depth (ft)	Area (ft^2)	Width (ft)	Depth (ft)					Entrenchment	With / Depth Ratio	Slope	Sinuosity	Assigned
BC201801	63	26	41	0.0154	11.00	0.82	7.21	23.42	1.63	2.13	13.49	Would classify as a C channel based on photo & slope	1.06	B	B, C, F	C, F, E	A	B
BC501201	323	39	85	0.0091	20.81	1.16	12.41	35.33	2.33	1.70	17.89	Slope is too flat for B, could be C, but entrenchment is low	1.19	B	B, C, F	C, F, E	A	B
BD103101	3	5	7	0.0769	3.86	0.10	0.64	4.00	0.20	1.04	38.00		1.01	A, G, F	B, C, F	A	A	G
BD203402	145	41	61	0.0115	23.02	1.40	14.23	50.47	2.81	2.19	16.39	Slope too flat for B channel	1.16	B	B, C, F	C, F, E	A	B
BD203501	47	12	21	0.0243	8.00	0.55	3.95	18.00	1.11	2.25	14.47	Entrenchment is borderline C	1.14	C, E	B, C, F	B,G	A	B
BD301401	109	37	68	0.0115	22.78	1.41	14.15	81.59	2.81	3.58	16.18	Looks more like a C channel	1.06	C, E	B, C, F	C, F, E	A	C
BD400504	219	129	200	0.0065	37.00	2.41	75.40	100.27	4.82	2.71	15.36		1.36	C, E	B, C, F	C, F, E	C, F, E, B, G	C
BD401001	24	17	26	0.0255	9.00	0.50	3.21	12.00	1.00	1.33	18.00		1.18	A, G, F	B, C, F	B,G	A	F
BR101101	51	50	76	0.0124	32.40	2.18	34.18	84.58	4.36	2.61	14.88	We can see the small low flow channel (5 ft) in DEM, but it's inundated by the bankfull event.	1.21	C, E	B, C, F	C, F, E	C, F, E, B, G	C
BR102603	29	21	32	0.0186	5.19	0.57	5.14	7.00	1.14	1.35	9.08		1.39	A, G, F	A, G, E	C, F, E	C, F, E, B, G	G
BR105601	2	1	2	0.2383	2.50	0.30	0.13	3.50	0.60	1.40	8.33		1.07	C, E	A, G, E	A	A	A
BR204201	82	45	73	0.0082	11.00	1.66	16.54	68.00	3.31	6.18	6.64		1.11	C, E	A, G, E	C, F, E	A	E
BR205102	26	23	35	0.0227	7.02	0.51	3.63	9.00	1.02	1.28	13.70		1.06	A, G, F	B, C, F	B,G	A	G
BR205901	25	4	9	0.0364	5.00	0.60	1.43	9.42	1.20	1.88	8.33	Could be E based on Width Depth Ratio, a lot of vegetative control, is that typical of entire reach?	1.04	B	A, G, E	B,G	A	B
BR300901	29	7	14	0.0557	8.00	0.50	5.01	16.00	1.00	2.00	16.00		1.10	B	B, C, F	A	A	B
BR400602	27	14	25	0.0201	10.00	0.80	8.18	49.09	1.60	4.91	12.50	Slope is borderline E	1.17	C, E	B, C, F	B,G	A	E
BR410002	83	65	101	0.0123	16.62	0.96	12.31	16.62	1.92	1.00	17.27	Looks like F in photo	1.22	A, G, F	B, C, F	C, F, E	C, F, E, B, G	F
BR422101	54	22	40	0.0165	16.00	1.22	8.61	26.00	2.45	1.63	13.07		1.06	B	B, C, F	C, F, E	A	B
BR506104	27	12	23	0.0326	7.00	0.60	2.57	10.88	1.20	1.55	11.63		1.08	B	A, G, E	B,G	A	B
BR601301	54	14	22	0.0160	19.00	0.50	6.64	55.29	1.00	2.91	38.00	Might be E	1.33	C, E	B, C, F	C, F, E	C, F, E, B, G	C
BR601401	120	28	50	0.0109	14.50	0.85	6.34	20.37	1.70	1.41	17.10	Would classify as a C based on slope and photo	1.02	B	B, C, F	C, F, E	A	B
CHR00301	86	76	117	0.0158	91.36	1.08	62.72	106.21	2.16	1.16	84.52	Bankfull inundates many channels in the calculator, verify in Rosgen level II this DA classification	1.18	A, G, F	B, C, F	C, F, E	A	DA
CHR00701	77	78	111	0.0091	59.00	1.81	50.31	60.56	3.63	1.03	32.52	Many channels inundated by bankfull. Parameters yielded an F classification.	1.23	A, G, F	B, C, F	C, F, E	C, F, E, B, G	DA
FC301402	80	7	20	0.0172	5.00	0.70	1.91	12.00	1.40	2.40	7.14		1.19	C, E	A, G, E	C, F, E	A	E
FC500901	57	24	42	0.0173	6.09	0.48	3.21	6.09	0.96	1.00	12.67		1.05	A, G, F	B, C, F	C, F, E	A	F
FC501701	386	139	234	0.0076	32.65	2.00	41.44	90.00	4.00	2.76	16.34		1.32	C, E	B, C, F	C, F, E	C, F, E, B, G	C
FC502002	39	11	21	0.0271	11.34	0.43	3.31	17.94	0.85	1.58	26.55		1.06	B	B, C, F	B,G	A	B
GC101603	40	17	30	0.0118	16.00	0.44	6.54	22.00	0.88	1.38	36.53	May be E forming in old F	1.24	A, G, F	B, C, F	C, F, E	C, F, E, B, G	F
GC102301	94	60	95	0.0151	13.02	1.19	11.03	16.00	2.38	1.23	10.93	May be E forming in old F	1.04	A, G, F	A, G, E	C, F, E	A	F
GNC00301	20	20	31	0.0176	9.00	0.69	6.92	21.03	1.38	2.34	13.04	Difficult to classify based on photo; can't get better cross-section	1.10	C, E	B, C, F	C, F, E	A	C
GVC00901	25	15	27	0.0206	9.00	0.80	6.94	35.80	1.60	3.98	11.25	Slope is borderline and sinousity don't support E, verify in Level II	1.06	C, E	A, G, E	B,G	A	E
GVC01401	94	103	149	0.0336	44.09	1.59	26.33	79.75	3.18	1.81	27.77	Verify in level II. All parameters indicate B. Large DA and bankfull is above bench	1.05	B	B, C, F	B,G	A	B

Catchment	Drainage Area (Acres)	1 Year Discharge (cfs)	2 Year Discharge (cfs)	Overall Reach Slope	Bankfull			Floodprone		Entrenchment Ratio	Width / Depth Ratio	Notes	Overall Reach Sinuosity	Classification Parameters and Types				
					Width (ft)	Depth (ft)	Area (ft^2)	Width (ft)	Depth (ft)					Entrenchment	With / Depth Ratio	Slope	Sinuosity	Assigned
NR100703	40	16	29	0.0206	8.00	1.20	4.90	10.00	2.40	1.25	6.67		1.17	A, G, F	A, G, E	B,G	A	G
NR102501	27	8	17	0.0223	5.00	0.52	2.35	9.00	1.03	1.80	9.71	B going to G, could be very sensitive to development, Level II check	1.06	B	A, G, E	B,G	A	B
NR103004	2523	669	1218	0.0039	262.75	2.82	454.19	330.78	5.65	1.26	93.04	Looks more like D or DA	1.26	A, G, F	B, C, F	DA	C, F, E, B, G	DA
NR103101	47	11	22	0.0185	13.02	0.43	4.72	26.00	0.86	2.00	30.42		1.11	B	B, C, F	C, F, E	A	B
NR104201	55	13	29	0.0334	4.00	0.35	3.45	5.00	0.70	1.25	11.49		1.16	A, G, F	A, G, E	B,G	A	G
NR200601	17	1	3	0.0289	4.00	0.50	0.97	9.00	1.00	2.25	8.00	Could be E based on entrenchment and width depth ratio	1.06	C, E	A, G, E	B,G	A	B
NR200701	796	187	383	0.0089	25.00	1.89	32.56	75.86	3.77	3.03	13.25		1.37	C, E	B, C, F	C, F, E	C, F, E, B, G	C
NR201601	18	6	12	0.0371	8.49	0.20	1.55	12.00	0.40	1.41	42.07		1.10	B	B, C, F	B,G	A	B
NR202001	14	3	8	0.0427	4.71	0.50	0.29	9.00	1.00	1.91	9.41	Width to depth ratio borderline B	1.08	B	A, G, E	A	A	B
NR204201	2	0	0	0.0574	8.58	0.30	1.14	13.00	0.60	1.51	28.61	B or A channel, senstive to development? Level 2 validate	1.05	B	B, C, F	A	A	B
NR204302	102	31	56	0.0140	12.00	0.55	7.18	17.30	1.10	1.44	21.73	Slope flat for B	1.35	B	B, C, F	C, F, E	C, F, E, B, G	B
NR204901	17	2	6	0.0366	7.11	0.38	2.61	12.33	0.77	1.73	18.56		1.11	B	B, C, F	B,G	A	B
NR205001	751	179	367	0.0042	26.00	4.09	224.59	242.47	8.17	9.33	6.36		1.13	C, E	A, G, E	DA	A	E
NR405903	24	4	11	0.0238	8.00	0.80	2.13	40.17	1.60	5.02	10.00	Slope meets B, looks like E, other parameters meet E.	1.25	C, E	A, G, E	B,G	C, F, E, B, G	E
NR600101	1219	280	541	0.0050	26.00	2.03	99.92	48.00	4.06	1.85	12.80	Entrenchment meets B classification	1.34	B	B, C, F	DA	C, F, E, B, G	C
NR601901	126	34	70	0.0123	15.00	1.30	22.23	128.88	2.60	8.59	11.54		1.50	C, E	A, G, E	C, F, E	C, F, E, B, G	E
NR606302	51	14	22	0.0166	8.00	1.20	4.74	23.00	2.40	2.88	6.67		1.28	C, E	A, G, E	C, F, E	C, F, E, B, G	E
SPD00902	24	50	67	0.0375	5.00	0.66	6.91	17.00	1.32	3.40	7.58	Steep slope for "E" channel, further investigation is needed.	1.04	C, E	A, G, E	B,G	A	E
TNB00401	52	20	34	0.0358	5.00	1.01	4.54	15.00	2.01	3.00	4.98	Steep slope for "E" channel, further investigation is needed.	1.03	C, E	A, G, E	B,G	A	E

Note from Mary: Please don't start with the records highlighted in yellow for the NR2 subwatersheds. We are planning to move some of these points to a location South of US50, GVC possibly.

Map 1: South River Study Stream Reach Coverage.



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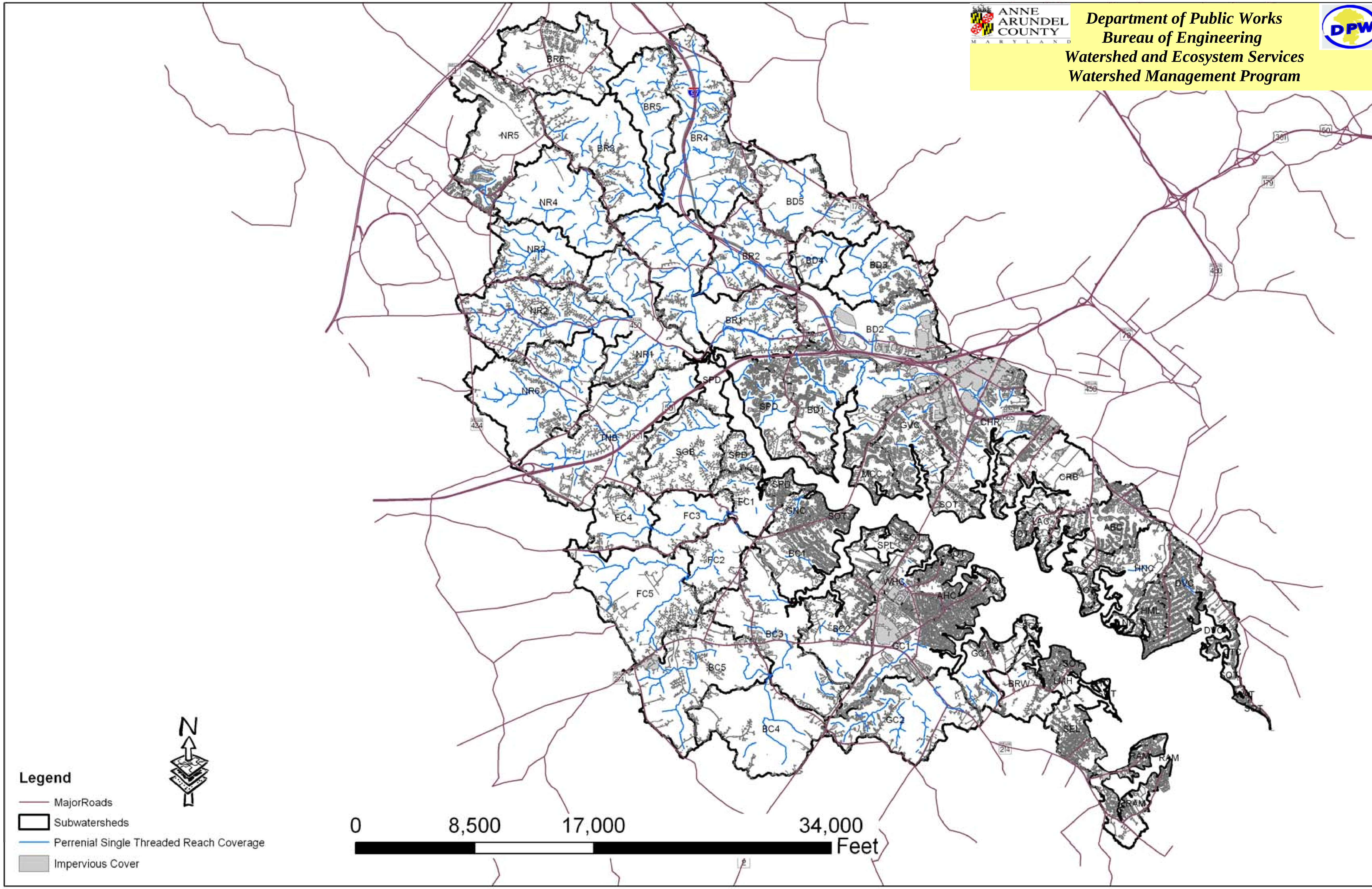
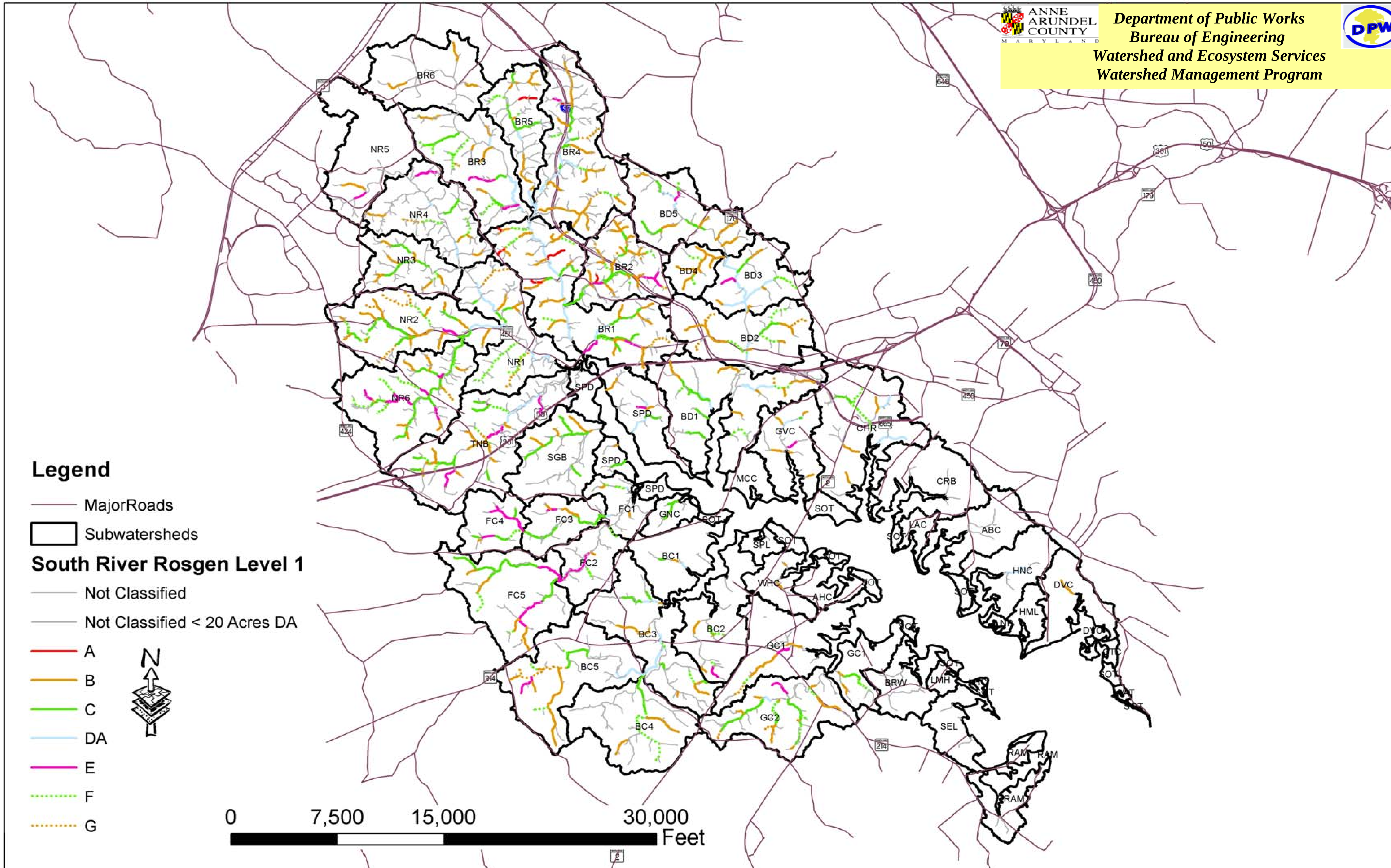
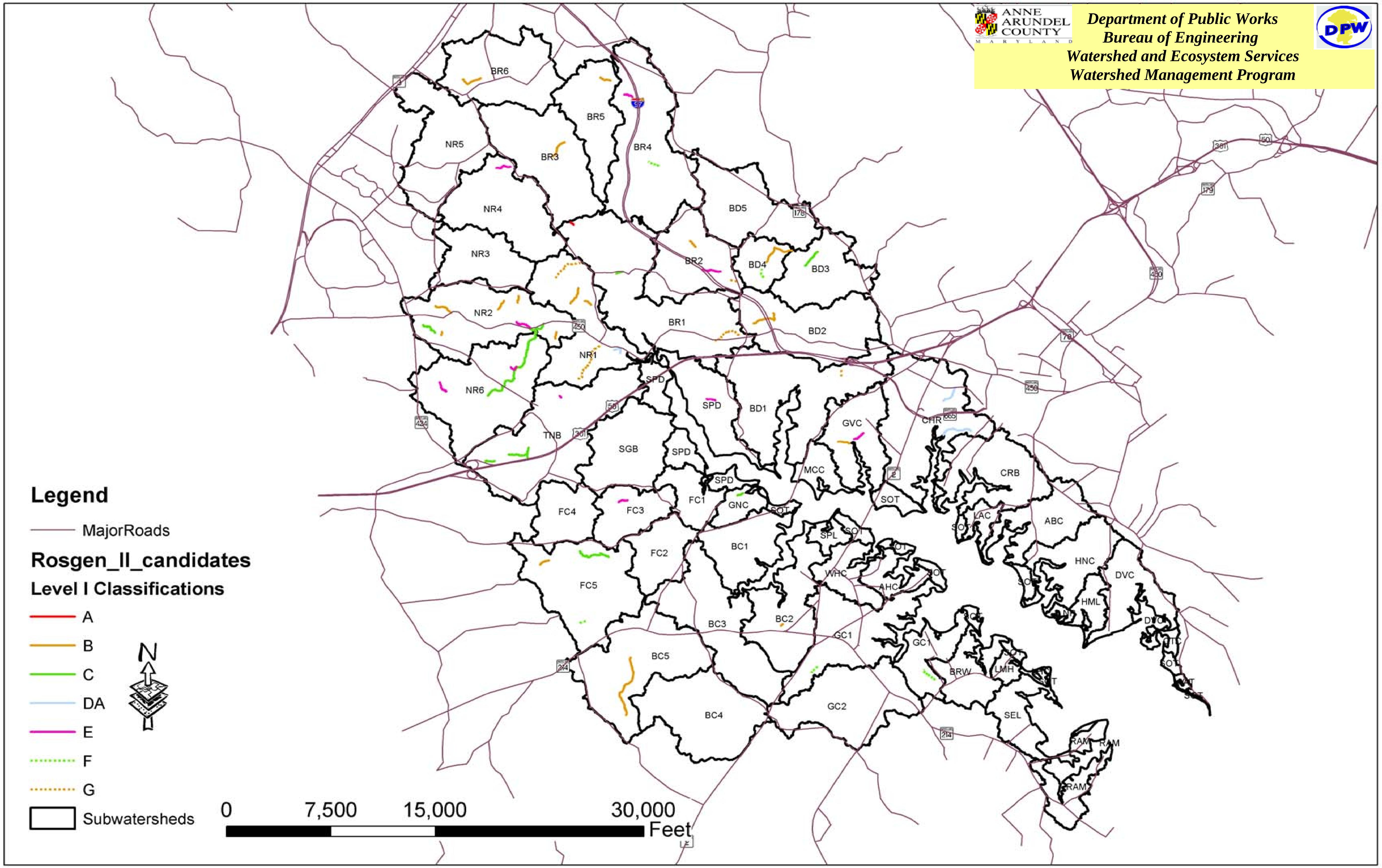
Map 2: South River Study Impervious Cover (2004 Coverage).



Map 3: South River Study (Rosgen Level I Coverage)



Map 4: South River Study (Rosgen Level II 2007 field candidate sites)



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TECHNICAL
MEMORANDUM

TO:	Anne Arundel County
FROM:	Mike Pieper, KCI Technologies, Inc.
DATE:	September 18, 2007
SUBJECT:	South River Baseflow Sampling – Revised Tech Memo
COPIES	Tara Ajello, CH2M Hill Bill Frost, KCI Technologies Bill Medina, KCI Technologies

INTRODUCTION

Dry weather grab samples and discharge estimates were collected during the summer and early fall of 2006 throughout the South River Watershed to identify unusual pollutant loads and to characterize baseflow pollutant loadings for water quality modeling. The sampling is intended to provide a characterization of baseflow pollutant loading across the watershed for water quality modeling and to identify any unusual pollutant loads.

SITE SELECTION

The study design required baseflow sampling to be conducted once at a single station in each of the 54 subwatersheds in the South River. Sites were to be located in the most downstream mainstem reach of each subwatershed to characterize the baseflow from the entire subwatershed, but upstream of tidal influence. Upon completion of the Physical Stream Assessment field work, it was determined that nine subwatersheds did not have any perennial streams identified. Other subwatersheds were identified with only ephemeral or ditch type channels present. These subwatersheds are generally small tidal coves located along the lower northern and southern shores of the South River and were not included in site selection for baseflow sampling.

The 54 selected sites were located in 36 subwatersheds. In the latter stages of the sampling season, several streams that were flowing during the Physical Condition fieldwork earlier in the year did not have adequate flow during the baseflow sampling to be sampled. As a result, alternative sites were chosen. Site BR3008.BF01 was replaced with site BR1031.BF01. BRW008.BF01 was replaced with GC1015.BF01 after three other sites in the BRW subwatershed were visited and also found to be dry. The final list of sampled sites can be found below in the Results section.

SAMPLING SEASON

Fieldwork was completed in the summer and early fall between August 16, 2006 and October 16, 2006. In order to sample true baseflow conditions and reduce the possibility of collecting stormflow, the sampling was limited, whenever possible, to dry periods and did not fall within the 72 hours following a rainfall event. For this study a rainfall event was defined as any event with greater than 0.1 inches of precipitation within a 24 hour period.

Rainfall in the sampling period is summarized in Table 1 and Figures 1 and 2 below. Table 1 provides the total monthly rainfall amounts during the 2006 sampling period as recorded at BWI airport. Figure 1 shows the monthly and cumulative rainfall totals for 2006. Overall 2006 had a close to normal annual precipitation total. However, the monthly totals differed from normal monthly conditions. July and August were well below normal, while September and October recorded greater than average rainfall. Fifty-three of the 54 sites were sampled in August and September; only one sample was collected in October.

Figure 2 shows the daily precipitation totals during the sampling period and the dates when sampling took place. Two sample dates, August 21st and 22nd fell within 72 hours of a rainfall event; however field crews did not note conditions indicative of high water due to the recent precipitation.

Table 1: Sampling Period Rainfall Data (BWI)

Period	Rainfall (inches)	Sites Sampled
August	1.45	28
September	7.56	25
October (to 10/16)	2.01	1
Totals	11.02	54

Figure 1: Monthly and Cumulative BWI Precipitation Totals, Normal (1971-2000) and 2006

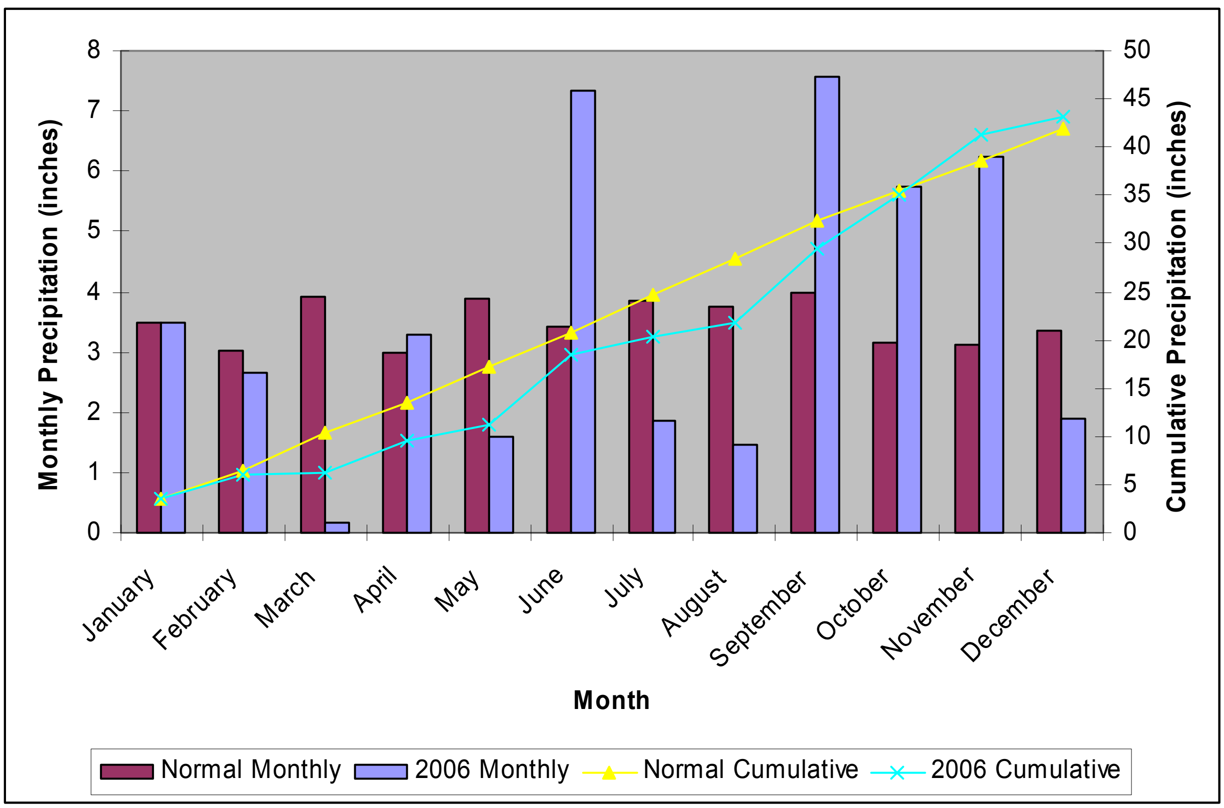
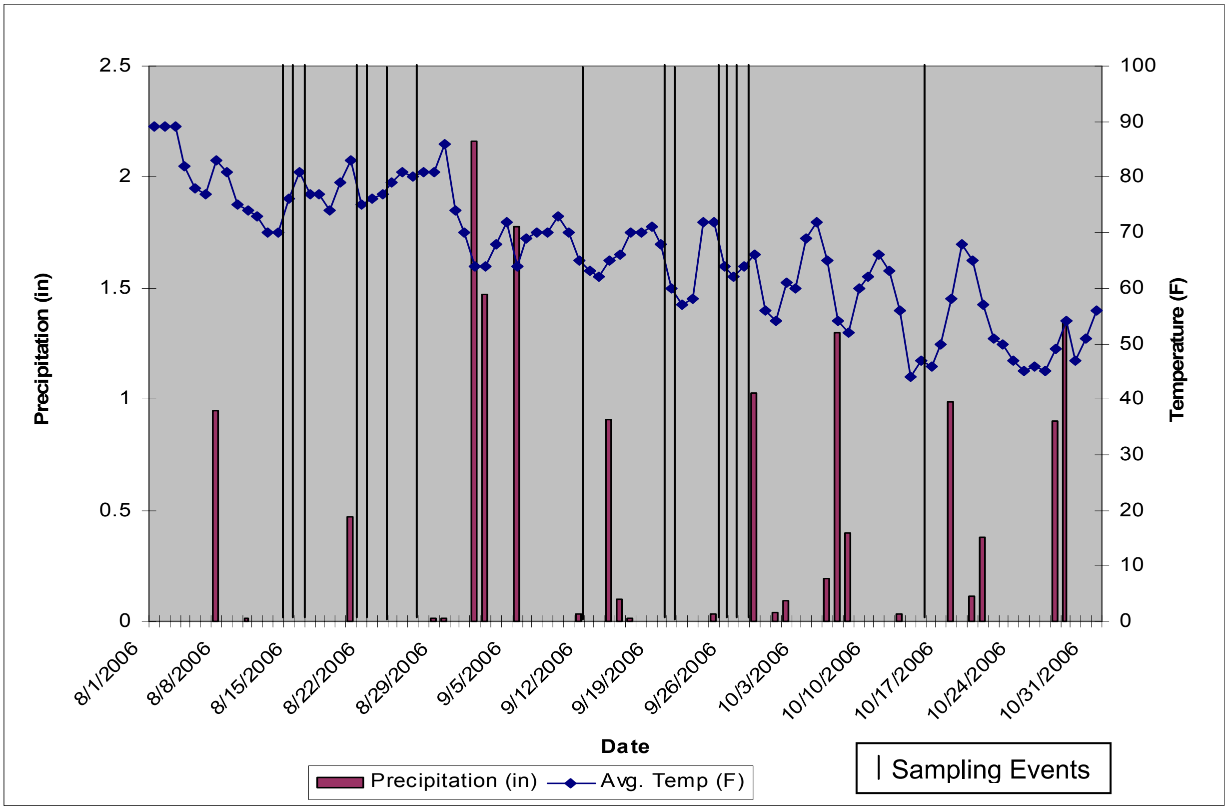


Figure 2: Sampling Period Daily Precipitation Totals and Daily Average Temperatures (BWI)



FIELD PROCEDURE

Specific site locations were determined in the field by field crews. Sites were located, whenever possible, in the most downstream mainstem reach of each subwatershed to characterize the baseflow from the entire subwatershed, but upstream of tidal influence. Sites in wetland type conditions were avoided. If the site was dry an alternate site was selected.

Data collected at each site included instream water quality, grab sample, GPS location, cross-section and longitudinal profile, discharge measurements, roughness estimate and site photographs. The methods are described in more detail below in the following sections.

All sites were located in the field using GPS. Digital photographs were taken at each site to document the site conditions. At a minimum, photos were taken at each site facing upstream and downstream at the cross-section. Additional photos were taken if site conditions warranted.

Instream Water Quality

Field water quality measurements were collected in situ at all sites. All in-situ parameters except turbidity were measured with a YSI ® 6920 multi-probe and a YSI ® 650 MDS data logger. Turbidity measurements were collected using Hach 2100 Turbidimeter. Field tested parameters include those listed below.

- pH (standard pH units)
- Temperature (degrees celcius, °C)
- Dissolved oxygen (milligrams per liter, mg/L)
- Conductivity (microSiemans per, µS/cm)
- Total dissolved solids (mg/L)
- Turbidity (NTU)

Grab sample

Grab samples were collected at each site taking care not to disturb the upstream reach prior to sampling and not to disturb the channel substrate during sampling. These procedures were undertaken to avoid suspension and possible collection of bed and bank material. Sample bottles used were pre-treated with the proper preservatives. Parameters sampled are listed below.

Nutrients:	Total Nitrogen (TN), Total Kjeldahl Nitrogen (TKN), Nitrate (NO3), Nitrite (NO2), Total Phosphorus (TP)
Solids:	Total Suspended Solids (TSS)
Metals:	Copper (Cu), Lead (Pb), Zinc (Zn)
Bacteria:	Fecal Coliform

Samples were immediately put in coolers and on ice to be transported to the lab for analysis with all preservative precautions taken and all pertinent chain-of-custody forms. Because the fecal coliform samples have a 6-hour holding time, a mid-day laboratory pickup and afternoon laboratory drop-off were used to ensure that all of the samples were transported to the laboratory within the 6-hour period.

Discharge Estimates

Discharge rates were used to calculate baseflow pollutant loading rates from the grab sample pollutant concentrations. Due to very shallow flow and low slope conditions at many of the sites, three different calculations of velocity and discharge were employed and are described below.

A cross-section was surveyed at every site in a typical section. To obtain the most accurate velocity measurements the sections were located on a straight uniform reach with uniform bed material with few obstructions and backwater effects. Points collected across the section included, at a minimum, left and right floodplain, left and right top of bank, left and right bottom of bank, thalweg and water depth. Sections were surveyed left to right facing downstream. The cross-section surveys were used to calculate cross-sectional area. A basic profile was surveyed at each site to determine water surface slope. The surveyed profile points were taken whenever possible at the head of a riffle.

Flow Meter - Flow Tracker

When water depths permitted, a flow meter (SonTek Flow Tracker Handeld ADV Doppler meter) was used to directly measure velocity. The velocity was measured over 45 seconds at several points across the surveyed cross-section at a depth equivalent to 0.6 of the water depth. Both maximum velocity and mean channel velocity were generated from flow meter measurements.

Discharge is based on calculating an area for subsections defined by the mid-point locations of each velocity measurement and then applying the velocity for that segment. The discharge for each subsection are then summed to give an overall channel discharge.

Total channel discharge (Q)

$$Q = \sum \left(A \times \overline{V} \right)$$

where A = subsection area

$\overline{V}$ = mean subsection velocity

Float

When water depths did not permit use of velocity measurement using the flow meter, a float method was employed. In this method a ping-pong ball was timed as it floated through the cross-section reach to derive distance traveled over time. Two points along the profile were marked, one above the cross-section and one below at a distance of 2-3 channel widths apart. The ball was filled partly with water until it sank just below the water surface. Care was also taken to not sink the ball too far so that it would be impeded by the channel substrate. The ball was released in the channel above the upstream mark and timing started when it reached the upstream mark and then stopped as it passed the downstream mark. This process was repeated 5-10 times depending on the variability of the times. If the times were consistent, fewer runs were necessary. A velocity estimate was calculated for each run. The average velocity, excluding any outliers, was applied to the cross-sectional area to derive the discharge.

The float method tends to measure the fastest portion of the channel. Additionally, the channels were typically too narrow to use the method across the section at multiple points. The velocity measurements using the float method are then assumed to approximate the maximum velocity, rather than the mean channel velocity calculated by the flow meter. The discharge may also be slightly overestimated by this method.

Manning's Equation

When water depths were so low or channel obstruction too numerous that the flow meter and float methods could not be applied, the mean channel velocity and discharge was estimated using Manning's equation. Roughness values (*n*) were visually estimated at each site using the Cowan method (Cowan, 1956) summarized below. The cross-section survey, slope and *n* values were entered into the Reference Reach spreadsheet (Mecklenburg, 2004) for display of the cross-section and automate calculation of channel dimensions, area, velocity and discharge. The equations used are presented here.

Manning's n estimation for the bankfull channel.

$$n = (n_b+n_1+n_2+n_3+n_4)m$$

where n_b = base value of n for a straight, uniform, smooth natural channel
n_1 = a correction factor for the effect of surface irregularities
n_2 = a value for variations in shape and size of the channel cross-section
n_3 = a value for obstructions
n_4 = a value for vegetation and flow conditions
m = a correction factor for meandering of the channel

Mean channel velocity (ft/sec) was then solved for using Manning's equation with the surveyed cross-sectional areas and slopes.

$$Velocity(V) = \frac{1.49\left(R^{2/3}\right)\left(S^{1/2}\right)}{n}$$

where S=water surface slope (ft/ft)
hydraulic radius $R = \frac{A}{WP}$
A = cross-sectional area (ft^2)
WP = wetted perimeter $WP = \frac{W}{2d}$

where W = water surface width (ft)
d = mean water depth (ft)

Discharge (Q) (cfs) is then calculated.

$$Q = A \times V$$

Pollutant Loads

Pollutant concentrations were obtained from the lab for each parameter with corresponding detection limits. For some samples different detection limits were used for the metal concentrations. The detection limits in the database and below are listed as 1, 2, or 3.

Table 2: Laboratory Detection Limits

Detection Limit	Total Phosphorus	Total Kjeldahl Nitrogen	Total Nitrogen	Nitrite Nitrogen	Nitrate Nitrogen	Copper	Lead	Zinc	Fecal Coliforms	TSS
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mpn/100ml	mg/l
1	0.01	0.5	0.02	0.02	0.02	2 ug/l	2 ug/l	10 ug/l	2	1
2	0.01	0.5	0.02	0.02	0.02	0.01	0.01	0.01	2	1
3	0.01	0.5	0.02	0.02	0.02	0.01	0.01	0.02	2	1

Concentrations were applied to the discharge and converted to a lbs/year load. When the concentration was below the detection limit a value of half of the detection limit was applied to generate the load. The exception was nitrite which oxidizes to nitrate and was therefore assumed to be 0.0 when below the detection limit.

SUMMARY

The results of the baseflow sampling are listed in Tables 3 through 5. The laboratory analyzed parameters include the laboratory reported value (LabRep) in addition to the concentration used to calculate the loading (Conc), as described above. Table 3 includes nutrients; Table 4 includes solids, metals and bacteria. Table 5 provides the instream water quality, channel dimensions, velocity and discharge estimates. Site locations are shown in Figure 3. Subwatersheds are colored to display areas where sampling was conducted.

Discharge estimates were developed from flow meter data when available. If not available the float method was the secondary choice. If neither was possible the Manning's Equation was the last choice. Discharge calculations were most often developed from the float method (31 sites). The flow meter method was used at 19 sites and the Manning's equation at four.

Table 3: Nutrient Loads

SiteID	Date	DetLim	TP_LabRep	TP_Conc	TP_Load	TKN_LabRep	TKN_Conc	TKN_Load	TN_LabRep	TN_Conc	TN_Load	NO2_LabRep	NO2_Conc	NO2_Load	NO3_LabRep	NO3_Conc	NO3_Load
			mg/l	mg/l	lbs/yr	mg/l	mg/l	lbs/yr	mg/l	mg/l	lbs/yr	mg/l	mg/l	lbs/yr	mg/l	mg/l	lbs/yr
BC1001.BF01	8/18/2006	1	0.97	0.97	325	0.80	0.80	268	1.4	1.40	469	<0.02	0.00	0	0.59	0.59	197
BC2006.BF01	9/25/2006	3	0.45	0.45	62	<0.5	0.25	34	0.07	0.07	10	<0.02	0.00	0	0.07	0.07	10
BC3012.BF01	9/28/2006	3	0.23	0.23	503	<0.5	0.25	546	0.33	0.33	721	<0.02	0.00	0	0.33	0.33	721
BC3043.BF01	9/28/2006	3	0.18	0.18	110	<0.5	0.25	153	0.91	0.91	555	<0.02	0.00	0	0.91	0.91	555
BC4004.BF01	9/28/2006	3	0.28	0.28	221	<0.5	0.25	197	0.32	0.32	252	<0.02	0.00	0	0.32	0.32	252
BC4020.BF01	9/28/2006	3	0.44	0.44	269	<0.5	0.25	153	1.1	1.10	671	<0.02	0.00	0	1.1	1.10	671
BC5001.BF01	9/21/2006	1	0.42	0.42	422	<0.5	0.25	251	0.42	0.42	422	<0.02	0.00	0	0.42	0.42	422
BC5011.BF01	8/18/2006	3	0.29	0.29	86	<0.5	0.25	74	1.4	1.40	413	<0.02	0.00	0	1.4	1.40	413
BD1008.BF01	8/28/2006	2	0.24	0.24	109	<0.5	0.25	113	0.39	0.39	177	<0.02	0.00	0	0.39	0.39	177
BD1027.BF01	8/28/2006	1	0.10	0.10	71	<0.5	0.25	177	0.51	0.51	361	<0.02	0.00	0	0.51	0.51	361
BD2001.BF01	8/28/2006	1	0.13	0.13	596	<0.5	0.25	1147	0.09	0.09	413	<0.02	0.00	0	0.09	0.09	413
BD3003.BF01	9/12/2006	2	0.19	0.19	587	1.0	1.0	3091	0.40	0.40	1236	<0.02	0.00	0	0.40	0.40	1236
BD3003.BF02	9/21/2006	3	0.20	0.20	858	<0.5	0.25	1073	na	na	na	<0.02	0.00	0	0.07	0.07	300
BD4005.BF01	9/21/2006	3	<0.01	0.005	6	<0.5	0.25	300	na	na	na	<0.02	0.00	0	0.33	0.33	396
BD5010.BF01	9/27/2006	3	0.10	0.10	41	<0.5	0.25	103	0.32	0.32	132	<0.02	0.00	0	0.32	0.32	132
BR1006.BF01	9/20/2006	1	0.15	0.15	815	<0.5	0.25	1358	na	na	na	<0.02	0.00	0	0.23	0.23	1250
BR1014.BF01	9/12/2006	2	0.15	0.15	189	<0.5	0.25	315	0.47	0.47	592	<0.02	0.00	0	0.47	0.47	592
BR1031.BF01	9/28/2006	3	0.14	0.14	182	<0.5	0.25	325	0.13	0.13	169	<0.02	0.00	0	0.13	0.13	169
BR2001.BF01	9/12/2006	2	0.20	0.20	539	<0.5	0.25	674	0.30	0.3	809	<0.02	0.00	0	0.3	0.30	809
BR2014.BF01	9/12/2006	2	0.15	0.15	210	0.7	0.7	978	0.21	0.21	294	<0.02	0.00	0	0.21	0.21	294
BR3001.BF01	9/27/2006	3	0.04	0.04	22	1.5	1.5	827	0.79	0.79	435	0.05	0.05	28	0.74	0.74	408
BR4024.BF01	9/21/2006	3	0.07	0.07	114	<0.5	0.25	409	0.43	0.43	703	<0.02	0.00	0	0.43	0.43	703
BR4042.BF01	9/27/2006	3	0.04	0.04	45	<0.5	0.25	281	0.17	0.17	191	<0.02	0.00	0	0.17	0.17	191
BR4214.BF01	9/26/2006	3	0.15	0.15	148	<0.5	0.25	246	0.21	0.21	207	<0.02	0.00	0	0.21	0.21	207
BR5001.BF01	9/27/2006	3	0.13	0.13	46	<0.5	0.25	89	0.06	0.06	21	<0.02	0.00	0	0.06	0.06	21
BR5022.BF01	9/25/2006	3	0.42	0.42	256	<0.5	0.25	153	0.59	0.59	360	<0.02	0.00	0	0.59	0.59	360
CHR005.BF01	8/25/2006	1	0.37	0.37	182	<0.5	0.25	123	0.24	0.24	118	0.02	0.02	10	0.22	0.22	108
DVC001.BF01	8/25/2006	2	0.33	0.33	461	<0.5	0.25	349	<0.02	0.01	14	0.02	0.02	28	<0.02	0.01	14
FC2003.BF01	8/18/2006	1	0.20	0.20	138	<0.5	0.25	172	0.30	0.3	207	<0.02	0.00	0	0.3	0.30	207
FC3005.BF01	8/17/2006	1	0.24	0.24	208	<0.5	0.25	217	0.23	0.23	199	<0.02	0.00	0	0.23	0.23	199
FC4007.BF01	8/17/2006	1	0.30	0.30	148	<0.5	0.25	123	0.06	0.06	30	<0.02	0.00	0	0.06	0.06	30
FC4015.BF01	8/17/2006	1	0.26	0.26	92	<0.5	0.25	89	0.04	0.04	14	<0.02	0.00	0	0.04	0.04	14
FC5003.BF01	8/17/2006	1	0.25	0.25	148	<0.5	0.25	148	0.12	0.12	71	<0.02	0.00	0	0.12	0.12	71
FC5016.BF01	8/17/2006	1	0.27	0.27	106	<0.5	0.25	98	0.39	0.39	154	<0.02	0.00	0	0.39	0.39	154
GC1001.BF01	8/16/2006	1	0.19	0.19	269	<0.5	0.25	354	0.26	0.26	369	0.02	0.02	28	0.24	0.24	340
GC1015.BF01	9/28/2006	3	0.25	0.25	15	<0.5	0.25	15	1.9	1.9	112	<0.02	0.00	0	1.9	1.90	112
GC2003.BF01	8/16/2006	1	0.37	0.37	189	<0.5	0.25	128	<0.02	0.01	5	0.02	0.02	10	<0.02	0.01	5

SiteID	Date	DetLim	TP_LabRep	TP_Conc	TP_Load	TKN_LabRep	TKN_Conc	TKN_Load	TN_LabRep	TN_Conc	TN_Load	NO2_LabRep	NO2_Conc	NO2_Load	NO3_LabRep	NO3_Conc	NO3_Load
			mg/l	mg/l	lbs/yr	mg/l	mg/l	lbs/yr	mg/l	mg/l	lbs/yr	mg/l	mg/l	lbs/yr	mg/l	mg/l	lbs/yr
GNC004.BF01	8/28/2006	1	0.24	0.24	9	<0.5	0.25	10	0.45	0.45	18	<0.02	0.00	0	0.45	0.45	18
GVC001.BF01	8/28/2006	2	0.24	0.24	335	<0.5	0.25	349	0.53	0.53	741	<0.02	0.00	0	0.53	0.53	741
HNC002.BF01	8/25/2006	1	0.26	0.26	82	<0.5	0.25	79	0.03	0.03	9	<0.02	0.00	0	0.03	0.03	9
NR1002.BF01	8/22/2006	1	0.17	0.17	689	<0.5	0.25	1014	0.26	0.26	1054	<0.02	0.00	0	0.26	0.26	1054
NR1023.BF01	8/22/2006	1	0.07	0.07	29	<0.5	0.25	103	0.31	0.31	128	<0.02	0.00	0	0.31	0.31	128
NR2002.BF01	8/22/2006	1	0.17	0.17	311	<0.5	0.25	458	0.38	0.38	696	<0.02	0.00	0	0.38	0.38	696
NR2030.BF01	8/22/2006	1	0.23	0.23	254	<0.5	0.25	276	0.21	0.21	232	<0.02	0.00	0	0.21	0.21	232
NR3002.BF01	9/20/2006	1	0.13	0.13	177	<0.5	0.25	340	na	na	na	<0.02	0.00	0	0.63	0.63	856
NR4002.BF01	9/20/2006	1	0.15	0.15	171	<0.5	0.25	285	na	na	na	<0.02	0.00	0	0.02	0.02	23
NR6001.BF01	8/22/2006	1	0.19	0.19	172	<0.5	0.25	226	0.41	0.41	371	<0.02	0.00	0	0.41	0.41	371
NR6001.BF02	8/21/2006	1	0.33	0.33	611	<0.5	0.25	463	0.33	0.33	611	<0.02	0.00	0	0.33	0.33	611
SGB002.BF01	8/21/2006	1	0.28	0.28	165	<0.5	0.25	148	0.65	0.65	384	<0.02	0.00	0	0.65	0.65	384
SGB016.BF01	8/21/2006	1	0.14	0.14	3	<0.5	0.25	5	0.13	0.13	3	<0.02	0.00	0	0.13	0.13	3
SP1006.BF01	10/16/2006	1	0.18	0.18	131	<0.5	0.25	182	0.18	0.18	131	<0.02	0.00	0	0.18	0.18	131
TNB014.BF01	9/12/2006	2	0.09	0.09	175	<0.5	0.25	487	0.25	0.25	487	<0.02	0.00	0	0.25	0.25	487
TNB038.BF01	8/21/2006	1	0.21	0.21	103	<0.5	0.25	123	0.09	0.09	44	<0.02	0.00	0	0.09	0.09	44
WHC003.BF01	8/16/2006	1	0.30	0.30	195	<0.5	0.25	162	0.57	0.57	370	0.02	0.02	13	0.55	0.55	357

Table 4: Solids, Metals and Bacteria

SiteID	Date	DetLim	TSS_LabRep	TSS_Conc	TSS_Load	Cu_LabRep	Cu_Conc	Cu_Load	Pb_LabRep	Pb_Conc	Pb_Load	Zn_LabRep	Zn_Conc	Zn_Load	FecalColi
			mg/l	mg/l	lbs/yr	ug/l	ug/l	lbs/yr	ug/l	ug/l	lbs/yr	ug/l	ug/l	lbs/yr	mpn/100ml
BC1001.BF01	8/18/2006	1	9	9	3012	0.017	0.017	0.0	0.06	0.060	0.0	0.062	0.062	0.0	210
BC2006.BF01	9/25/2006	3	3	3	12935	<0.01	0.005	0.0	<0.01	0.005	0.0	0.040	0.040	0.0	150
BC3012.BF01	9/28/2006	3	4	4	139778	<0.01	0.005	0.0	<0.01	0.005	0.0	0.020	0.020	0.0	43
BC3043.BF01	9/28/2006	3	9	9	68739	<0.01	0.005	0.0	<0.01	0.005	0.0	0.030	0.030	0.0	4600
BC4004.BF01	9/28/2006	3	5	5	76651	<0.01	0.005	0.0	<0.01	0.005	0.0	<0.02	0.010	0.0	390
BC4020.BF01	9/28/2006	3	4	4	74680	<0.01	0.005	0.0	<0.01	0.005	0.0	0.020	0.020	0.0	430
BC5001.BF01	9/21/2006	1	2	2	58638	<0.01	0.005	0.0	<0.01	0.005	0.0	0.015	0.015	0.0	≥2400
BC5011.BF01	8/18/2006	3	5	5	29771	<0.01	0.005	0.0	<0.01	0.005	0.0	0.030	0.030	0.0	430
BD1008.BF01	8/28/2006	2	5	5	37778	<0.01	0.005	0.0	<0.01	0.005	0.0	0.030	0.030	0.0	93
BD1027.BF01	8/28/2006	1	2	2	9855	<0.01	0.005	0.0	<0.01	0.005	0.0	0.026	0.026	0.0	93
BD2001.BF01	8/28/2006	1	6	6	248758	<0.01	0.005	0.0	<0.01	0.005	0.0	0.021	0.021	0.1	93
BD3003.BF01	9/12/2006	2	8	8	326641	0.020	0.020	0.1	<0.01	0.005	0.0	0.070	0.070	0.2	<30
BD3003.BF02	9/21/2006	3	2	2	119356	<0.01	0.005	0.0	<0.01	0.005	0.0	0.030	0.030	0.1	90
BD4005.BF01	9/21/2006	3	4	4	1670	<0.01	0.005	0.0	<0.01	0.005	0.0	0.020	0.020	0.0	90
BD5010.BF01	9/27/2006	3	4	4	11498	<0.01	0.005	0.0	<0.01	0.005	0.0	0.030	0.030	0.0	93
BR1006.BF01	9/20/2006	1	5	5	283333	<0.01	0.005	0.0	<0.01	0.005	0.0	<0.01	0.005	0.0	430
BR1014.BF01	9/12/2006	2	5	5	65700	<0.01	0.005	0.0	<0.01	0.005	0.0	0.070	0.070	0.1	230

SiteID	Date	DetLim	TSS_LabRep	TSS_Conc	TSS_Load	Cu_LabRep	Cu_Conc	Cu_Load	Pb_LabRep	Pb_Conc	Pb_Load	Zn_LabRep	Zn_Conc	Zn_Load	FecalColi
			mg/l	mg/l	lbs/yr	ug/l	ug/l	lbs/yr	ug/l	ug/l	lbs/yr	ug/l	ug/l	lbs/yr	mpn/100ml
BR1031.BF01	9/28/2006	3	4	4	50589	<0.01	0.005	0.0	<0.01	0.005	0.0	<0.02	0.010	0.0	930
BR2001.BF01	9/12/2006	2	4	4	150016	<0.01	0.005	0.0	<0.01	0.005	0.0	0.020	0.020	0.1	430
BR2014.BF01	9/12/2006	2	4	4	58309	<0.01	0.005	0.0	<0.01	0.005	0.0	0.050	0.050	0.1	230
BR3001.BF01	9/27/2006	3	3	3	4599	<0.01	0.005	0.0	<0.01	0.005	0.0	0.040	0.040	0.0	150
BR4024.BF01	9/21/2006	3	8	8	63620	<0.01	0.005	0.0	<0.01	0.005	0.0	0.030	0.030	0.0	4600
BR4042.BF01	9/27/2006	3	2	2	6242	<0.01	0.005	0.0	<0.01	0.005	0.0	0.030	0.030	0.0	43
BR4214.BF01	9/26/2006	3	10	10	102657	<0.01	0.005	0.0	<0.01	0.005	0.0	0.040	0.040	0.0	150
BR5001.BF01	9/27/2006	3	4	4	12812	<0.01	0.005	0.0	<0.01	0.005	0.0	0.110	0.110	0.0	930
BR5022.BF01	9/25/2006	3	4	4	71285	<0.01	0.005	0.0	<0.01	0.005	0.0	0.030	0.030	0.0	70
CHR005.BF01	8/25/2006	1	5	5	63305	<0.01	0.005	0.0	<0.01	0.005	0.0	0.025	0.025	0.0	140
DVC001.BF01	8/25/2006	2	21	21	673471	<0.01	0.005	0.0	<0.01	0.005	0.0	0.040	0.040	0.1	4600
FC2003.BF01	8/18/2006	1	9	9	86232	<0.01	0.005	0.0	<0.01	0.005	0.0	0.011	0.011	0.0	2400
FC3005.BF01	8/17/2006	1	6	6	86725	<0.01	0.005	0.0	<0.01	0.005	0.0	0.012	0.012	0.0	240
FC4007.BF01	8/17/2006	1	6	6	61594	<0.01	0.005	0.0	<0.01	0.005	0.0	0.010	0.010	0.0	43
FC4015.BF01	8/17/2006	1	8	8	51246	<0.01	0.005	0.0	<0.01	0.005	0.0	0.025	0.025	0.0	15
FC5003.BF01	8/17/2006	1	10	10	102657	<0.01	0.005	0.0	<0.01	0.005	0.0	0.010	0.010	0.0	93
FC5016.BF01	8/17/2006	1	8	8	59130	<0.01	0.005	0.0	<0.01	0.005	0.0	0.019	0.019	0.0	460
GC1001.BF01	8/16/2006	1	5	5	93623	<0.01	0.005	0.0	<0.01	0.005	0.0	0.010	0.010	0.0	240
GC1015.BF01	9/28/2006	3	4	4	4106	<0.01	0.005	0.0	<0.01	0.005	0.0	0.030	0.030	0.0	430
GC2003.BF01	8/16/2006	1	17	17	223847	<0.01	0.005	0.0	<0.01	0.005	0.0	0.013	0.013	0.0	460
GNC004.BF01	8/28/2006	1	11	11	7227	<0.01	0.005	0.0	<0.01	0.005	0.0	0.058	0.058	0.0	1100
GVC001.BF01	8/28/2006	2	17	17	396502	<0.01	0.005	0.0	<0.01	0.005	0.0	0.030	0.030	0.0	1100
HNC002.BF01	8/25/2006	1	9	9	51246	<0.01	0.005	0.0	<0.01	0.005	0.0	0.019	0.019	0.0	2400
NR1002.BF01	8/22/2006	1	6	6	287604	<0.01	0.005	0.0	<0.01	0.005	0.0	<0.01	0.005	0.0	230
NR1023.BF01	8/22/2006	1	23	23	46278	<0.01	0.005	0.0	<0.01	0.005	0.0	<0.01	0.005	0.0	430
NR2002.BF01	8/22/2006	1	4	4	86560	<0.01	0.005	0.0	<0.01	0.005	0.0	<0.01	0.005	0.0	430
NR2030.BF01	8/22/2006	1	9	9	158667	<0.01	0.005	0.0	<0.01	0.005	0.0	0.027	0.027	0.0	43
NR3002.BF01	9/20/2006	1	4	4	49111	<0.01	0.005	0.0	<0.01	0.005	0.0	0.014	0.014	0.0	430
NR4002.BF01	9/20/2006	1	1	1	11908	0.022	0.022	0.0	<0.01	0.005	0.0	0.035	0.035	0.0	<30
NR6001.BF01	8/22/2006	1	7	7	83741	0.016	0.016	0.0	<0.01	0.005	0.0	<0.01	0.005	0.0	93
NR6001.BF02	8/21/2006	1	2	2	84918	<0.01	0.005	0.0	<0.01	0.005	0.0	<0.01	0.005	0.0	240
SGB002.BF01	8/21/2006	1	4	4	45990	<0.01	0.005	0.0	<0.01	0.005	0.0	0.025	0.025	0.0	240
SGB016.BF01	8/21/2006	1	11	11	2108	<0.01	0.005	0.0	<0.01	0.005	0.0	0.029	0.029	0.0	93
SP1006.BF01	10/16/2006	1	4	4	36464	<0.01	0.005	0.0	<0.01	0.005	0.0	0.021	0.021	0.0	43
TNB014.BF01	9/12/2006	2	5	5	60978	<0.01	0.005	0.0	<0.01	0.005	0.0	0.050	0.050	0.1	110
TNB038.BF01	8/21/2006	1	8	8	57488	<0.01	0.005	0.0	<0.01	0.005	0.0	<0.01	0.005	0.0	43
WHC003.BF01	8/16/2006	1	3	3	40652	<0.01	0.005	0.0	<0.01	0.005	0.0	<0.01	0.005	0.0	460

Table 5: Instream Water Quality, Channel Dimensions, Flow

SiteID	Date	DetLim	pH	Temp	DO	Conduct	TDS	Turbidity	Q_Method	Slope_ft	Manning_n	Width	MaxDepth	MeanDepth	SectArea	MaxVeloc	MeanVeloc	Q_cfs
				deg C	mg/l	(us/cm)	(g/L)	(NTU)		ft/ft	n	ft	ft	ft	sq ft	ft/s	ft/s	cfs
BC1001.BF01	8/18/2006	1	7.70	19.07	8.41	203	133	12.70	FlowTracker	0.001000	0.053	6.7	0.84	0.51	4.0	0.06	0.04	0.17
BC2006.BF01	9/25/2006	3	7.32	15.09	5.60	652	424	8.85	Float	0.003853	0.047	2.9	0.11	0.05	0.2	0.42	na	0.07
BC3012.BF01	9/28/2006	3	7.39	16.19	8.80	229	149	12.60	Float	0.000261	0.042	12.6	0.40	0.20	2.5	0.44	na	1.11
BC3043.BF01	9/28/2006	3	7.45	15.69	8.40	219	142	5.70	Float	0.002817	0.040	3.5	0.24	0.12	0.4	0.78	na	0.31
BC4004.BF01	9/28/2006	3	8.13	15.21	6.80	227	148	3.39	FlowTracker	0.000374	0.040	3.6	0.58	0.21	1.0	0.39	0.39	0.40
BC4020.BF01	9/28/2006	3	7.88	15.73	7.60	199	129	4.65	Float	0.004505	0.051	3.3	0.33	0.15	0.5	0.63	na	0.31
BC5001.BF01	9/21/2006	1	7.33	15.07	9.40	189	123	4.64	Float	0.003021	0.047	5.2	0.25	0.13	0.7	0.76	na	0.51
BC5011.BF01	8/18/2006	3	8.01	20.43	8.75	276	178	8.59	Float	0.004444	0.045	3.6	0.17	0.09	0.3	0.50	na	0.15
BD1008.BF01	8/28/2006	2	8.01	21.88	8.13	171	111	8.19	Float	0.008000	0.035	2.1	0.28	0.14	0.3	0.79	na	0.23
BD1027.BF01	8/28/2006	1	7.49	23.48	8.50	157	102	6.82	Float	0.006419	0.037	7.3	0.15	0.11	0.8	0.44	na	0.36
BD2001.BF01	8/28/2006	1	7.43	27.04	7.71	179	116	4.23	FlowTracker	0.007692	0.031	8.2	0.74	0.67	5.5	0.61	0.42	2.33
BD3003.BF01	9/12/2006	2	7.30	19.35	8.69	133	87	na	Float	0.002075	0.038	5.0	0.81	0.51	2.6	0.61		1.57
BD3003.BF02	9/21/2006	3	7.16	14.55	5.20	139	90	16.50	FlowTracker	0.001319	0.035	5.0	0.79	0.26	2.6	0.85	0.85	2.18
BD4005.BF01	9/21/2006	3	7.21	14.43	9.40	76	49	8.33	Float	0.002071	0.043	3.2	0.34	0.24	0.8	0.79	na	0.61
BD5010.BF01	9/27/2006	3	7.19	18.34	5.20	165	107	12.40	FlowTracker	0.000625	0.069	8.6	0.58	0.29	2.8	0.13	0.07	0.21
BR1006.BF01	9/20/2006	1	6.76	18.34	10.09	246	160	na	FlowTracker	0.001538	0.039	10.8	0.72	0.50	5.2	0.72	0.53	2.76
BR1014.BF01	9/12/2006	2	7.20	6.58	10.34	236	153	4.53	Float	0.004219	0.046	5.3	0.33	0.17	0.9	0.71	na	0.64
BR1031.BF01	9/28/2006	3	7.96	18.10	8.40	264	172	13.40	FlowTracker	na	0.049	8.8	0.60	0.50	4.8	0.33	0.14	0.66
BR2001.BF01	9/12/2006	2	7.26	16.83	10.65	225	146	8.76	Float	0.005839	0.044	7.1	0.31	0.16	1.1	1.22	na	1.37
BR2014.BF01	9/12/2006	2	7.26	17.61	10.08	218	141	5.74	Float	0.004356	0.050	6.0	0.23	0.15	0.7	1.03	na	0.71
BR3001.BF01	9/27/2006	3	7.10	14.94	5.20	678	440	6.12	Float	0.000469	0.050	3.7	0.42	0.23	0.8	0.34	na	0.28
BR4024.BF01	9/21/2006	3	7.67	16.82	7.20	186	121	8.33	Float	0.011778	0.041	7.0	0.29	0.18	1.3	0.66	na	0.83
BR4042.BF01	9/27/2006	3	7.38	17.92	7.20	387	252	6.31	FlowTracker	0.000188	0.057	5.7	0.90	0.55	3.1	0.18	0.18	0.57
BR4214.BF01	9/26/2006	3	7.66	16.18	6.80	391	254	9.77	Float	0.002360	0.040	6.1	0.24	0.12	0.7	0.69	na	0.50
BR5001.BF01	9/27/2006	3	5.44	14.40	5.20	127	82	3.04	Manning's Eq	0.000519	0.054	4.4	0.39	0.20	0.9	na	0.21	0.18
BR5022.BF01	9/25/2006	3	7.57	17.31	8.00	114	74	3.64	Float	0.000641	0.043	4.3	0.30	0.19	0.8	0.37	na	0.31
CHR005.BF01	8/25/2006	1	7.94	23.84	7.70	313	204	20.50	FlowTracker	0.001069	0.039	10.0	0.71	0.42	4.6	0.21	0.06	0.25
DVC001.BF01	8/25/2006	2	7.45	22.59	8.50	745	487	12.20	Manning's Eq	0.001250	0.034	8.1	0.35	0.18	1.4	na	0.49	0.71
FC2003.BF01	8/18/2006	1	7.33	19.92	7.60	163	106	17.10	Float	0.001585	0.055	6.9	0.28	0.11	0.7	0.48	na	0.35
FC3005.BF01	8/17/2006	1	7.27	20.38	6.89	112	72	11.40	FlowTracker	0.004218	0.048	5.9	0.59	0.29	2.2	0.37	0.20	0.44
FC4007.BF01	8/17/2006	1	6.90	16.95	5.80	168	109	10.70	FlowTracker	0.008296	0.040	5.3	0.43	0.09	1.0	0.21	0.09	0.25
FC4015.BF01	8/17/2006	1	6.50	17.39	6.45	92	64	3.53	Manning's Eq	0.003906	0.037	4.0	0.17	0.09	0.4	na	0.5	0.18
FC5003.BF01	8/17/2006	1	6.83	20.40	6.71	229	149	14.40	Float	0.003425	0.036	3.3	0.23	0.15	0.5	0.63	na	0.30
FC5016.BF01	8/17/2006	1	6.90	20.37	6.56	140	91	15.00	Float	0.000921	0.035	3.3	0.18	0.10	0.3	0.60	na	0.20
GC1001.BF01	8/16/2006	1	7.50	23.80	5.13	182	118	7.55	Float	0.003846	0.040	9.7	0.43	0.14	1.4	0.51	na	0.72
GC1015.BF01	9/28/2006	3	7.67	18.55	9.20	783	509	5.97	Float	0.018933	0.055	3.3	0.28	0.14	0.5	0.06	na	0.03
GC2003.BF01	8/16/2006	1	7.87	22.60	4.82	437	283	15.40	Float	0.001975	0.031	13.5	0.20	0.08	1.0	0.25	na	0.26
GNC004.BF01	8/28/2006	1	7.38	22.96	6.38	376	244	18.30	Float	0.009333	0.042	1.0	0.07	0.04	0.04	0.48	na	0.02
GVC001.BF01	8/28/2006	2	7.49	24.98	6.59	161	104	19.80	Float	0.003125	0.057	5.4	0.57	0.29	1.5	0.46	na	0.71
HNC002.BF01	8/25/2006	1	7.73	21.60	7.06	164	106	16.70	FlowTracker	0.005299	0.041	7.0	0.51	0.30	2.4	0.08	0.07	0.16
NR1002.BF01	8/22/2006	1	7.12	22.40	6.92	201	130	14.30	FlowTracker	0.001185	0.043	8.3	0.50	0.25	2.1	1.07	0.97	2.06

SiteID	Date	DetLim	pH	Temp	DO	Conduct	TDS	Turbidity	Q_Method	Slope_ft	Manning_n	Width	MaxDepth	MeanDepth	SectArea	MaxVeloc	MeanVeloc	Q_cfs
				deg C	mg/l	(us/cm)	(g/L)	(NTU)		ft/ft	n	ft	ft	ft	sq ft	ft/s	ft/s	cfs
NR1023.BF01	8/22/2006	1	7.07	21.92	5.97	134	87	62.30	Float	0.002429	0.061	4.0	0.20	0.10	0.4	0.52	na	0.21
NR2002.BF01	8/22/2006	1	7.32	22.60	7.69	190	123	na	FlowTracker	0.001029	0.041	5.5	0.47	0.32	1.7	0.91	0.54	0.93
NR2030.BF01	8/22/2006	1	7.06	18.94	7.82	224	146	9.56	Float	0.005217	0.044	4.2	0.29	0.15	0.6	0.91	na	0.56
NR3002.BF01	9/20/2006	1	6.35	17.32	11.20	232	151	10.10	Float	0.001364	0.038	6.6	0.20	0.13	0.9	0.81	na	0.69
NR4002.BF01	9/20/2006	1	4.26	18.17	7.50	283	184	2.69	FlowTracker	0.002317	0.049	4.8	0.52	0.28	1.9	0.31	0.31	0.58
NR6001.BF01	8/22/2006	1	7.12	19.55	7.93	153	99	13.00	FlowTracker	0.004398	0.050	5.5	0.42	0.20	1.2	0.39	0.39	0.46
NR6001.BF02	8/21/2006	1	7.20	20.50	7.85	148	96	na	FlowTracker	0.004498	0.036	5.3	0.33	0.11	0.8	1.18	1.18	0.94
SGB002.BF01	8/21/2006	1	7.04	18.87	7.08	249	162	12.10	Float	0.011760	0.049	2.4	0.23	0.12	0.3	1.06	na	0.30
SGB016.BF01	8/21/2006	1	6.23	21.27	5.85	620	404	16.20	Manning's Eq	0.006149	0.059	1.8	0.07	0.04	0.1	na	0.21	0.01
SP1006.BF01	10/16/2006	1	7.15	11.32	3.50	91	59	na	Float	0.006164	0.039	4.3	0.19	0.10	0.4	0.86	na	0.37
TNB014.BF01	9/12/2006	2	7.05	17.35	9.56	218	142	7.07	FlowTracker	0.005810	0.039	9.7	0.80	0.54	5.2	0.49	0.19	0.99
TNB038.BF01	8/21/2006	1	6.92	25.63	4.94	298	194	9.73	FlowTracker	0.000583	0.011	9.9	0.56	0.35	3.7	0.17	0.07	0.25
WHC003.BF01	8/16/2006	1	7.90	19.92	4.64	713	463	2.41	Float	0.005070	0.022	8.0	0.13	0.07	0.5	0.61	na	0.33

Figure 3: Baseflow Sampling Sites

REFERENCES

Cowan, W.L. (1956) Estimating hydraulic roughness coefficients: Agricultural Engineering, v.37, no.7,p.473-475.

Harrelson, Cheryl C; Rawlins, C.L.; Potyondy, John P. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

Mecklenburg, 2004. The Reference Reach Spreadsheet for Channel Survey Data Management, version 4.0L. Ohio Department of Natural Resources.

TECHNICAL
MEMORANDUM

TO:	Anne Arundel County
FROM:	Mike Pieper, KCI Technologies, Inc.
DATE:	December 12, 2007
SUBJECT:	South River Bioassessment
COPIES	Tara Ajello, CH2M Hill Bill Frost, KCI Technologies

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1 Methodologies

The monitoring program includes chemical, physical and biological assessment conducted throughout the watershed. The sampling methods used are compatible with the Sampling and Analysis Plan for Anne Arundel County Biological Monitoring (SAP) (Tetra Tech, 2005a) and the Quality Assurance Project Plan (QAPP) for Anne Arundel County Biological Monitoring and Assessment Program (Tetra Tech, 2004). All data was entered into an Ecological Data Application System (EDAS) database. A summary of these methodologies and the results of the 2006 monitoring are documented herein.

Biological assessment methods within Anne Arundel County are designed to be consistent and comparable with the methods used by Maryland Department of Natural Resources (DNR) in their Maryland Biological Stream Survey (MBSS). All field crew leaders received recent training in MBSS protocols prior to the sampling. The County has adopted the MBSS methodology to be consistent with statewide monitoring programs and programs adopted by other Maryland counties. The methods have been developed locally and are calibrated to Maryland's physiographic regions and stream types. MBSS physical habitat assessment parameters were collected. Physical habitat for the South River watershed was also assessed using the EPA's Rapid Bioassessment Protocol (RBP) (Barbour, et al, 1999) habitat assessment for low-gradient streams.

1.1 Selection of Sampling Sites

The sampling design employed a targeted approach with a total of 30 sites distributed throughout the study area. The goal was to get good spatial coverage of the watershed. If the stream channel at the selected site was found to be unfit for sampling during the field visit, the site was moved to another sampleable reach based on alternate sampling sites provided by the County. Conditions that would make a site unsampleable include predominant wetland or dry channel conditions, unsafe conditions, and no access due to property ownership issues.

Field crews used GPS and field maps with orthophotography overlayed with the sites, streams and drainage areas to navigate to the selected sites. The sites include a 75-meter reach. The position of the reach mid-point was collected with GPS and was marked with a tree tag with the site name.

Three additional biological samples and physical habitat assessments were collected as duplicate Quality Assurance/Quality Control (QC) samples. These samples were collected immediately upstream of selected sites in an area where the habitat appeared to be very similar to the original sampling site. The duplicate sites were selected in the field by the field crew at the time of the assessment. This method, as opposed to selecting the sites randomly or by desktop analysis, ensures that the stream type and habitat are similar, that no significant inputs of stormwater or confluences occur in the reach, and that the site is sampleable.

1.2 Water Quality Sampling

To supplement the macroinvertebrate sampling and habitat assessment, water quality sampling was performed. Field water quality measurements were collected in-situ at all monitoring sites including the duplicate sites. All in-situ parameters were measured with a YSI 6000 series multiprobe and the YSI650 data logging system and a Hach 2100 Turbidimeter.

Water quality equipment was regularly inspected, maintained and calibrated to ensure proper usage and accuracy of the readings. Field tested parameters include those listed below.

pH (standard pH units)

Temperature (degrees Celsius, °C)

Dissolved oxygen (milligrams per liter, mg/L)

Conductivity (microSiemans per, μS/cm)

Total dissolved solids (mg/L)

Turbidity (NTU)

1.3 Physical Habitat Assessment

The biological monitoring site is characterized based on visual observation of physical characteristics and various habitat parameters. A habitat assessment was completed for all sites including QC sites. Both the EPA's Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al, 1999) and the Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI) were used to assess the physical habitat at each site. Both assessment techniques rely on subjective scoring of habitat parameters. To reduce individual sampler bias, the assessment was completed as a team with discussion and agreement of the scoring for each parameter.

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health. Each parameter will be given a numerical score from 0-20 and a categorical rating of optimal, suboptimal, marginal or poor. Overall habitat quality typically increases as the total score for each site increases. The RBP parameters used are as follows.

Table 1 – RBP Low Gradient Habitat Parameters

Low Gradient Stream Parameters	
Epifaunal substrate/available cover	Channel alteration
Pool substrate characterization	Channel sinuosity
Pool variability	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian Vegetative Zone Width

The above parameters for each reach are summed with a total score of 200 possible. The total score is then placed in one of the following four categories. The categories are based on those used in an assessment of Prince George's County streams and watersheds (Stribling, et al. 1999).

Table 2 – RBP Habitat Score and Ratings

Score	Percent Comparability	Narrative Rating
≥151	≥75.5	Comparable to Reference
126-150	63.0-75.0	Supporting
97-125	48.5-62.5	Partially Supporting
≤96	≤48.0	Non-supporting

Source: Stribling, et al. 1999

The PHI incorporates the results of a series of habitat parameters selected for Coastal Plain, Piedmont and Highlands regions. While all parameters except embeddedness were rated during the field assessment, the Coastal Plain parameters will be used to develop the PHI score. These six parameters were found to have the most discriminatory power for the coastal plain streams. Several of the parameters have been found to be drainage area dependent and are scaled accordingly. The drainage area to each point was provided by Anne Arundel County.

Table 3 – PHI Coastal Plain Parameters

Coastal Plain Stream Parameters	
Remoteness	Instream Habitat
Shading	Woody Debris and Rootwads
Epibenthic Substrate	Bank Stability

Each parameter is given a value from 0-20. A prepared score and scaled score (0-100) are then calculated. The average of these scores yields the PHI score. The scores are broken into narrative rating categories and the scaled PHI scores (0-100) are ranked according to the ranges shown in Table 4. This allows for a score that can be compared to habitat assessments done statewide.

Table 4 – PHI Score and Ratings

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

1.4 Benthic Macroinvertebrate Sampling

Biological assessment using benthic macroinvertebrate sampling and analysis was completed at all sites including QC sites. Benthic macroinvertebrate collection follows the QAPP which closely mirrors MBSS procedures (Kazyak, 2001). The monitoring sites include a 75-meter reach and benthic macroinvertebrate sampling is conducted during the spring season (March 1st to May 1st). The sampling methodologies utilize systematic field collections of the benthic macroinvertebrate community. The multi-habitat D-frame net approach is used to sample a range of the most productive habitat types within the reach. In this sampling approach, a total of twenty jabs are distributed among all available productive habitats within the stream system and combined into one composite sample. Potential habitats include submerged vegetation, overhanging bank vegetation, leaf packs, mats of organic matter, stream bed substrate, submerged materials (i.e., logs, stumps, snags, dead branches, and other debris) and rocks.

1.4.1 Sample Processing and Laboratory Identification

Benthic macroinvertebrate samples were processed and subsampled according to the County QAPP and methods described in the MBSS *Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy* (Boward and Friedman, 2000). Subsampling is conducted to standardize the sample size and reduce variation caused by samples of different size. In this method the sample is spread evenly across a gridded tray and each grid is picked clean of organisms until a count of 120 is reached. The 120 target is used to allow for specimens that are missing parts or are not a late enough instar for proper identification. For those sites with greater than 120 organisms a post-processing subsampling was conducted using a spreadsheet based method (Tetra Tech, 2006). This post-processing randomly subsamples the identified organisms to a desired target number for the sample. Each taxon is subsampled based on its original proportion to the entire sample. In this case, the desired sample size selected was 110 individuals. This allows for a final sample size of approximately 110 individuals (±20%) but keeps the total number of individuals below the 120 maximum.

Identification of the samples is conducted by Environmental Service and Consulting, LLC. to the genus level for most organisms. Groups including Oligochaeta and Nematomorpha are identified to the family level while Nematoda is left at the phylum. Individuals of early instars or those that may be damaged are identified to the lowest possible level, which could be phylum or order, but in most cases would be family. Chironomidae can be further subsampled depending on the number of individuals in the sample and the numbers in each subfamily or tribe. Most taxa are identified using a stereoscope. Temporary slide mounts are used to identify Oligochaeta to family with a compound scope. Chironomid sorting to subfamily and tribe is also conducted using temporary slide mounts. Permanent slide mounts are then used for final genus level identification. Results are logged on a bench sheet and entered into a spreadsheet for analysis.

1.4.2 Biological Data Analysis

Benthic macroinvertebrate data was analyzed using methods developed by MBSS as outlined in the *New Biological Indicators to Better Assess the Condition of Maryland Streams* (Southerland et al., 2005). The Benthic Index of Biotic Integrity (BIBI) approach involves statistical analysis using metrics that have a predictable response to water quality and/or habitat impairment. The metrics selected fall into five major groups including taxa richness, taxa composition, tolerance to perturbation, trophic classification and taxa habit.

Raw values from each metric are given a score of 1, 3 or 5 based on ranges of values developed for each metric. The results are combined into a scaled BIBI score from 1.0 to 5.0 and a narrative rating is applied. Three sets of metric calculations have been developed for Maryland streams based on broad physiographic regions. These include the coastal plain, piedmont and combined highlands regions, divided by the Fall Line. The study area is located in the coastal plain region. The following metrics and BIBI scoring were used for the analysis.

1.4.2.1 Coastal Plain BIBI Metrics

Total Number of Taxa – Equals the richness of the community in terms of the total number of genera at the genus level or higher. A large variety of genera typically indicate better overall water quality, habitat diversity and/or suitability, and community health.

Number of EPT Taxa – Equals the richness of genera within the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). EPT taxa are generally considered pollution sensitive, thus higher levels of EPT taxa would be indicative of higher water quality.

Number of Ephemeroptera Taxa – Equals the total number Ephemeroptera Taxa in the sample. Ephemeroptera are generally considered pollution sensitive, thus communities dominated by Ephemeroptera usually indicate lower disturbances in water quality.

Percent Intolerant Urban Taxa – Percent of sample considered intolerant to urbanization. Equals the percentage of individuals in the sample with a tolerance value of 0-3. As conditions worsen the percent of intolerant taxa decreases.

Percent Ephemeroptera Taxa – Equals the percent of Ephemeroptera individuals in the sample. Ephemeroptera are generally considered pollution sensitive, thus communities dominated by Ephemeroptera usually indicate lower disturbances in water quality.

Number Scraper Taxa – Equals the number of scraper taxa in the sample, those taxa that scrape food from the substrate. As the levels of stressors or pollution rise there is an expected decrease in the numbers of Scraper taxa.

Percent Climbers Taxa – Equals the percentage of the total number of individuals who are adapted to living on stem type surfaces. Higher percentages of climbers are representative of a decrease in stressors and higher water quality.

Information on trophic or functional feeding group and habit were based heavily on information compiled by DNR and from Merritt and Cummins (1996). Scoring criteria are shown below in Table 5. The raw metric value ranges are given with the corresponding score of 1, 3 or 5. Table 6 gives the BIBI ranges and ratings.

Table 5 – Biological Condition Scoring for the Coastal Plain Benthic Macroinvertebrates

Metric	Score		
	5	3	1
Total Number of Taxa	≥22	14-21	<14
Number of EPT Taxa	≥5	2-4	<2
Number of Ephemeroptera Taxa	≥2.0	1-1	<1.0
Percent Intolerant Urban Taxa	≥28	10-27	<10.0
Percent Ephemeroptera Taxa	≤11	0.8-10.9	>0.8
Number Scraper Taxa	≥2	1-1	<1.0
Percent Climber Taxa	≥8.0	0.9-7.9	<0.9

Table 6 – BIBI Scoring and Rating

BIBI Score	Narrative Rating
4.0 – 5.0	Good
3.0 – 3.9	Fair
2.0 – 2.9	Poor
1.0 – 1.9	Very Poor

2 Results

Biological monitoring was conducted between March 22 and April 18, 2006. A total of 30 sites were visited. Additionally, three biological duplicate QC samples were collected at stations where upstream habitat was considered similar. Presented below are the summary results for each assessment site. Maps of the South River Watershed displaying the bioassessment results can be found in Figure 1.

2.1 Water Quality

Instream water quality sampling was conducted in combination with macroinvertebrate sampling between March 22 and April 18, 2006. Table 7 presents the results of the instream water quality sampling.

The Maryland Department of the Environment (MDE) has established acceptable standards for several of the sampled parameters for each designated Stream Use Classification. These standards are listed in the *Code of Maryland Regulations (COMAR) 26.08.02.01-.03 - Water Quality* (MDE 1994). The South River drainage areas are in the West Chesapeake Bay watershed and are listed in *COMAR* in Sub-Basin 02-13-10: West Chesapeake Bay Area. It is classified as a Use I stream, Water Contact Recreation, and Protection of Aquatic Life. Specific designated uses for Use I streams include water contact sports, fishing, the growth and propagation of fish, and agricultural, and industrial water supply. The acceptable standards for Use I streams are as follows:

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

Overall, the water quality fell within COMAR limits for a Use I stream for all parameters except pH. The shaded cells represent values that were outside acceptable COMAR limits. There were nine sites with pH values well below the acceptable limits and three with pH values just below the acceptable range. There were no pH values above acceptable limits. The pH mean was affected by the low pH values in the NR1, NR2, NR3 and NR4 subwatersheds, with the lowest reading of 3.93 in the NR2 subwatershed. There was also one site with a relatively low dissolved oxygen reading (6.63 mg/L at WHC003) but this value was above the acceptable level of 5.0 mg/L. Additionally, there was one Turbidity reading that was significantly higher than the other sites (111.2 NTUs at NR2004), but this value was also within the acceptable COMAR limits.

Table 7 - Instream Water Quality Results

Site	pH	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	Total Dissolved Solids (mg/L)	Turbidity (NTU)
BC3014.G001	6.34	7.32	12.80	214.6	137.4	0.7
BC4004.G001	6.97	10.89	13.08	192.0	122.6	0.0
BC5001.G001	6.61	8.41	15.15	224.3	143.5	0.9
BD3003.G001	6.92	12.43	9.68	135.9	86.9	8.1
BD3003.G201	7.27	12.59	9.18	136.4	87.5	0.0
BD3003.G002	7.32	11.83	11.52	132.3	84.7	3.7

Site	pH	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS/cm)	Total Dissolved Solids (mg/L)	Turbidity (NTU)
BR1031.G001	6.97	16.16	10.07	211.5	135.2	0.0
BR1006.G001	6.68	14.40	11.39	209.8	134.3	0.0
BR1014.G001	6.46	10.85	12.31	219.5	140.5	0.0
BR3090.G001	6.49	7.04	10.09	446.9	286.2	10.4
BR4042.G001	6.98	9.13	13.11	309.7	198.3	0.4
BR4024.G001	6.85	8.91	12.78	154.2	98.5	0.0
BR5004.G001	6.71	10.63	11.83	76.7	49.2	0.0
CHR005.G001	7.68	10.14	9.67	518.2	331.4	0.0
FC1001.G001	6.61	15.35	11.34	172.1	110.2	na
FC2006.G001	6.38	10.68	10.92	208.4	133.2	1.9
FC3005.G001	6.09	9.72	12.19	108.9	66.9	1.0
FC3005.G201	6.80	10.28	13.01	106.2	68.2	0.0
FC3009.G001	6.12	11.49	10.30	166.0	106.4	5.7
FC5016.G001	7.00	12.86	11.42	189.3	121.1	0.0
GC1001.G001	7.16	13.97	12.40	848.1	540.6	0.0
GC2004.G001	6.42	8.50	11.43	184.2	117.8	4.4
GVC001.G001	7.32	16.23	9.16	283.0	181.1	0.0
NR1023.G001	5.07	6.85	12.39	137.7	88.3	1.1
NR1023.G201	4.98	8.53	11.65	138.2	88.3	0.0
NR2004.G001	5.17	7.21	11.74	138.3	88.8	111.2
NR2050.G001	3.93	6.54	12.41	236.9	151.6	11.7
NR3001.G001	5.50	15.74	7.72	145.0	92.9	0.0
NR4001.G001	3.48	12.27	9.97	135.9	87.0	0.0
NR6001.G001	6.41	7.99	13.13	149.1	95.1	0.0
TNB001.G001	6.81	11.81	10.53	248.0	158.8	0.4
TNB038.G001	5.06	11.27	12.74	344.5	220.2	0.0
WHC003.G00	7.23	14.57	6.63	477.7	305.6	7.3
Study Mean	6.36	11.04	11.33	240.62	153.81	5.82
Standard	0.96	2.89	1.71	153.73	98.15	20.19

*QC sampling was conducted at these sites, excluded from mean and SD.

2.2 Physical Habitat Assessment

The results of the RBP and PHI habitat assessment are presented in Table 8. The RBP assessment percent comparability scores ranged from 53.50 at site WHC003 to a high of 94.50 at site BR1031. There were 19 'Comparable to Reference' scores (excluding field replicate sites). There were no sites in the 'Non-Supporting' range. Three sites were 'Partially Supporting' and the remaining 8 sites were considered 'Supporting.'

The lowest PHI score of 57.20 was recorded at site BC5001 while the highest score, 94.91 was recorded at BR3090. No sites were rated as 'Severely Degraded', the lowest classification. Thirteen sites (excluding field replicates) rated as 'Minimally Degraded,' eleven sites were rated as 'Partially Degraded' and the remaining six sites were rated as 'Degraded.'

Table 8 - Habitat Assessment Results

Site	Total RBP	Percent RBP	RBP Classification	PHI Score	PHI Narrative Rating
BC3014.G001	169	84.5	Comparable to Reference	60.13	Degraded
BC4004.G001	124	62.0	Partially Supporting	72.01	Partially Degraded
BC5001.G001	124	62.0	Partially Supporting	57.20	Degraded
BD3003.G001	178	89.0	Comparable to Reference	85.92	Minimally Degraded
BD3003.G002	151	75.5	Comparable to Reference	64.46	Degraded
BD3003.G201*	175	87.5	Comparable to Reference	85.92	Minimally Degraded
BR1006.G001	169	84.5	Comparable to Reference	79.66	Partially Degraded
BR1014.G001	140	70.0	Supporting	66.14	Partially Degraded
BR1031.G001	189	94.5	Comparable to Reference	92.33	Minimally Degraded
BR3090.G001	181	90.5	Comparable to Reference	94.91	Minimally Degraded
BR4024.G001	163	81.5	Comparable to Reference	91.63	Minimally Degraded
BR4042.G001	175	87.5	Comparable to Reference	86.80	Minimally Degraded
BR5004.G001	168	84.0	Comparable to Reference	92.07	Minimally Degraded
CHR005.G001	148	74.0	Supporting	76.73	Partially Degraded
FC1001.G001	171	85.5	Comparable to Reference	76.26	Partially Degraded
FC2006.G001	152	76.0	Comparable to Reference	87.75	Minimally Degraded
FC3005.G001	161	80.5	Comparable to Reference	70.33	Partially Degraded
FC3005.G201*	168	84.0	Comparable to Reference	75.47	Partially Degraded
FC3009.G001	166	83.0	Comparable to Reference	91.89	Minimally Degraded
FC5016.G001	141	70.5	Supporting	77.09	Partially Degraded
GC1001.G001	147	73.5	Supporting	80.02	Partially Degraded
GC2004.G001	174	87.0	Comparable to Reference	82.47	Minimally Degraded
GVC001.G001	177	88.5	Comparable to Reference	92.19	Minimally Degraded
NR1023.G001	175	87.5	Comparable to Reference	90.10	Minimally Degraded
NR1023.G201*	179	89.5	Comparable to Reference	89.60	Minimally Degraded
NR2004.G001	133	66.5	Supporting	63.69	Degraded
NR2050.G001	166	83.0	Comparable to Reference	78.96	Partially Degraded
NR3001.G001	138	69.0	Supporting	74.22	Partially Degraded
NR4001.G001	159	79.5	Comparable to Reference	82.42	Minimally Degraded
NR6001.G001	147	73.5	Supporting	83.58	Minimally Degraded
TNB001.G001	164	82.0	Comparable to Reference	70.70	Partially Degraded

Site	Total RBP	Percent RBP	RBP Classification	PHI Score	PHI Narrative Rating
TNB038.G001	110	55.0	Partially Supporting	64.45	Degraded
WHC003.G001	107	53.5	Partially Supporting	61.89	Degraded
Study Mean	155.5	77.78	Comparable to Reference	78.27	Partially Degraded
Standard Deviation	21.09	10.55	--	11.17	--

*QC sampling was conducted at these sites, excluded from mean and SD.

2.3 Benthic Macroinvertebrates

The BIBI scores and ratings for each site are presented in Table 9. Within the entire watershed there was one site rated as ‘Good.’ Four sites received a ‘Very Poor’ rating and 14 sites received a ‘Poor’ rating. The remaining 11 sites were rated as ‘Fair.’

Table 9 - BIBI Summary

Site	BIBI Score	Narrative Rating
BC3014.G001	3.0	Fair
BC4004.G001	2.1	Poor
BC5001.G001	2.1	Poor
BD3003.G001	2.7	Poor
BD3003.G002	1.9	Very Poor
BD3003.G201*	3.0	Fair
BR1006.G001	3.0	Fair
BR1014.G001	2.7	Poor
BR1031.G001	2.4	Poor
BR3090.G001	3.0	Fair
BR4024.G001	4.4	Good
BR4042.G001	3.6	Fair
BR5004.G001	3.9	Fair
CHR005.G001	2.1	Poor
FC1001.G001	2.1	Poor
FC2006.G001	3.0	Fair
FC3005.G001	3.0	Fair
FC3005.G201*	2.4	Poor
FC3009.G001	2.1	Poor
FC5016.G001	3.6	Fair
GC1001.G001	2.1	Poor
GC2004.G001	2.4	Poor
GVC001.G001	1.6	Very Poor
NR1023.G001	1.9	Very Poor
NR1023.G201*	2.7	Poor
NR2004.G001	2.7	Poor
NR2050.G001	3.9	Fair
NR3001.G001	2.7	Poor
NR4001.G001	2.1	Poor
NR6001.G001	3.9	Fair
TNB001.G001	2.7	Poor
TNB038.G001	3.0	Fair
WHC003.G001	1.6	Very Poor
Study Mean	2.7	Poor
Standard Deviation	0.74	--

*QC sampling was conducted at these sites, excluded from mean and SD.

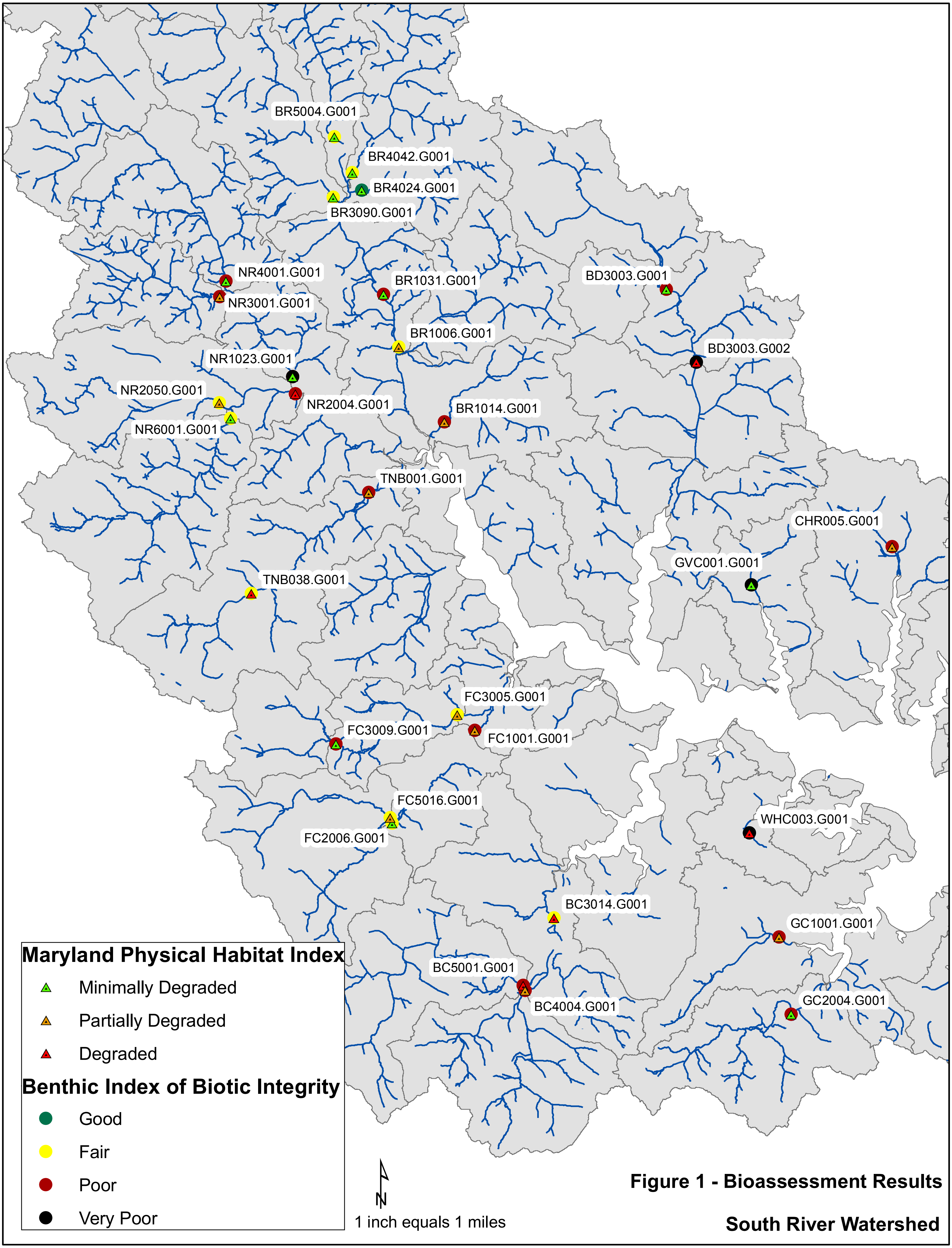

Figure 1 - Bioassessment Results

South River Watershed

3 Conclusion

Overall the South River Watershed is a fairly healthy stream system. Physical habitat was rated by RBP as ‘Supporting’ or higher and by the PHI as ‘Partially Degraded’ or higher. However, sampling of the benthic macroinvertebrate community was rated primarily as ‘Poor’ to ‘Very Poor.’ All water quality parameters except pH were within the required levels. The study mean pH of 6.36 was just below acceptable COMAR limit of 6.5.

Habitat scores for the RBP and PHI assessments were fairly well correlated and both indicate good available habitat throughout the majority of the watershed. There were no sites receiving the lowest physical habitat rating under either RBP or PHI. The PHI had 13 sites in the highest category of ‘Minimally Degraded’ while the RBP had 19 sites in the highest category of ‘Comparable to Reference.’ The study mean PHI was rated as ‘Partially Degraded’ and the mean RBP was rated as ‘Comparable to Reference.’

The benthic macroinvertebrate study mean of 2.7 is in the ‘Poor’ category. There was only one site that received the highest BIBI rating of ‘Good’, and 11 sites that received the next highest BIBI rating of ‘Fair.’ The majority of sites (14) were in the ‘Poor’ category and four additional sites were in the ‘Very Poor’ category. There was a clustering of both good habitat scores and good to fair BIBI scores in the BR3, BR4 and BR5 subwatersheds. The low pH values recorded at several sites, especially in NR1 and NR2, may be affecting the biological community in those subwatersheds. Other field tested water quality parameters do not point to any specific cause for poor ratings. The targeted rather than random study design may have led to lower scores. Most of the selected sites were at the downstream end of each subwatershed in order to assess the cumulative effects of water quality from the entire drainage area. This may have affected the BIBI scores for some sites.

4 References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water; Washington D.C.

Boward, D. and E. Friedman. 2000. Maryland Biological Stream Survey Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy. Maryland Department of Natural Resources Monitoring and Non-Tidal Assessment Division. Annapolis, MD. CBWP-MANTA-EA-00-6.

Kazyak, P.F. 2001 Maryland Biological Stream Survey Sampling Manual. Maryland Department of Natural Resources Monitoring and Non-Tidal Assessment Division. Annapolis, MD.

Maryland Department of the Environment. Code of Maryland Regulations (COMAR). Continuously updated. Code of Maryland Regulations, Title 26- Department of the Environment. 26.08.02.01- Water Quality.

Merritt, R.W. and Cummins, K.W. 1996 An Introduction to the Aquatic Insects of North America, 3rd edition, Kendall / Hunt Publishing Company.

Southerland, M.T., G.M. Rogers, M.J. Kline, R.P. Morgan, D.M. Boward, P.F. Kazyak, R.J. Klauda, S.A. Stranko. 2005. New Biological Indicators to Better Assess the Condition of Maryland Streams. DNR-12-0305-0100. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD.

Stribling, J.B., E.W. Leppo, and C. Daley. 1999. Biological Assessment of the Streams and Watersheds of Prince George's County, Maryland. Spring Index Period 1999. PGDER Report No 99-1. Prince George's County, Dept. of Env. Rsrs., Programs and Planning Division, Largo, MD

Tetra Tech, Inc. 2004. Quality Assurance Project Plan for Anne Arundel County Biological Monitoring and Assessment Program. January 2004, Revision 1. Prepared by Tetra Tech, Inc., Owings Mills, Maryland, for the Anne Arundel County Office of Environmental & Cultural Resources, Annapolis, Maryland.

Tetra Tech, Inc. 2005a. Sampling and Analysis Plan for Anne Arundel County Biological Monitoring and Assessment Program. January 2005. Prepared by Tetra Tech, Inc., Owings Mills, Maryland for the Anne Arundel County Office of Environmental & Cultural Resources, Annapolis, Maryland.

Tetra Tech, Inc. 2005b. Documentation of Method Performance Characteristics. April 2005. Prepared by Tetra Tech, Inc., Owings Mills, Maryland for the Anne Arundel County Office of Environmental & Cultural Resources, Annapolis, Maryland.

Tetra Tech, Inc. 2006. Random Subsample Routine. Developed by Eric W. Leppo.

Appendix C
Water Quality Model Input Information

Table **** EMCs by Landcover (mg/L except where noted).

Code	Landcover	TMDL Category	% Impervious	TN	NOx	TP	Zn	Cu	Pb	Fecal Coliform (MPN/100mL)	TSS	Metals (Cu+Pb+Zn)
PAS	Pasture	NPS Agriculture	0.00	1.71	0.24	1.00	0.00	0.00	0.00	500.00	250.00	0.00
SRC	Single Row Crop	NPS Agriculture	1.00	1.71	0.24	1.00	0.00	0.00	0.00	500.00	400.00	0.00
AIR	BWI Airport	NPS Urban	85.00	2.24	0.75	0.30	0.16	0.02	0.02	4500.00	400.00	0.20
CIT	City of Annapolis	NPS Urban	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COM	Commercial	NPS Urban	85.00	2.24	0.75	0.30	0.16	0.02	0.02	4500.00	400.00	0.20
IND	Industrial	NPS Urban	72.00	2.22	0.51	0.19	0.16	0.02	0.01	2614.00	400.00	0.19
R11	Residential 1 acre	NPS Urban	13.00	2.74	0.91	0.32	0.09	0.02	0.01	7750.00	200.00	0.13
R11C	Residential 1 acre with Cluster Development	NPS Urban	8.00	1.95	0.73	0.24	0.07	0.02	0.01	5515.51	142.34	0.09
R11CD	Residential 1 acre with High Density Cluster Development	NPS Urban	10.00	2.19	0.82	0.27	0.07	0.02	0.01	6204.95	153.85	0.10
R12	Residential 1/2 acre	NPS Urban	18.00	2.74	0.91	0.32	0.09	0.02	0.01	7750.00	250.00	0.13
R14	Residential 1/4 acre	NPS Urban	20.00	2.74	0.91	0.32	0.09	0.02	0.01	7750.00	300.00	0.13
R18	Residential 1/8 acre	NPS Urban	34.00	2.74	0.91	0.32	0.09	0.02	0.01	7750.00	350.00	0.13
R20	Residential 20 acre - equivalent to RA zoning	NPS Urban	2.00	1.15	0.54	0.15	0.04	0.01	0.01	952.00	100.00	0.05
R21	Residential 2 acre	NPS Urban	13.00	2.74	0.91	0.32	0.09	0.02	0.01	7750.00	150.00	0.13
R21C	Residential 2 acre with Cluster Development	NPS Urban	6.00	1.95	0.73	0.24	0.07	0.02	0.01	5515.51	106.75	0.09
R21CD	Residential 2 acre with High Density Cluster Development	NPS Urban	8.00	2.19	0.82	0.27	0.07	0.02	0.01	6204.95	120.10	0.10
RWD	Residential Woods	NPS Urban	6.00	1.55	0.63	0.19	0.04	0.01	0.01	952.25	75.00	0.05
TRN	Transportation	NPS Urban	75.00	2.59	0.76	0.43	0.33	0.05	0.40	1400.00	400.00	0.78
FRW	Forested Wetlands	Other NPS	0.00	1.15	0.54	0.15	0.00	0.00	0.00	500.00	50.00	0.00
OPS	Open Space	Other NPS	1.00	1.15	0.54	0.15	0.04	0.01	0.01	3100.00	100.00	0.05
OPW	Open Wetlands	Other NPS	0.00	1.15	0.54	0.15	0.00	0.00	0.00	500.00	50.00	0.00
UTL	Utility	Other NPS	75.00	2.59	0.76	0.43	0.04	0.01	0.01	3100.00	100.00	0.05
WAT	Water	Other NPS	0.00	1.20	0.60	0.03	0.02	0.01	0.00	500.00	400.00	0.03
WDS	Woods	Other NPS	0.00	1.15	0.54	0.15	0.00	0.00	0.00	500.00	50.00	0.00

Table **** Prioritization assigned to Landcover in Water Quality Modeling.

Landcover	Code	Existing	Future	TMDL Landcover	Priority
Industrial	IND	BRT Retrofit	SWM regs	NPS Urban	10
Transportation	TRN	BRT Retrofit	SWM regs	NPS Urban	10
Commercial	COM	BRT Retrofit	SWM regs	NPS Urban	10
Residential 2-acre	R21		SWM regs	NPS Urban	4
Residential 1-acre	R11	BRT Retrofit	SWM regs	NPS Urban	5
Residential 1/2-acre	R12	BRT Retrofit	SWM regs	NPS Urban	6
Residential 1/4-acre	R14	BRT Retrofit	SWM regs	NPS Urban	7
Residential 20-acre	R20			NPS Urban	3
Utility	OPS			Other NPS	2
Residential 1/8-acre	R18	BRT Retrofit	SWM regs	NPS Urban	8
Open Space	OPS			Other NPS	2
Pasture/Hay	PAS			NPS Agriculture	3
Row Crops	SRC			NPS Agriculture	3
Woods	WDS			Other NPS	1
Water	WAT			Other NPS	1
Forested Wetland	WDS			Other NPS	1
Open Wetland	OPS			Other NPS	1
Airport	COM	BRT Retrofit	SWM regs	NPS Urban	10
Residential Woods	RWD			NPS Urban	3

Zoning Code	Landcover Code	
C1	COM	
C2	COM	
C3	COM	
C4	COM	
MA1	COM	
MA2	COM	
MA3	COM	
MB	COM	
MCSB	COM	
TC	COM	
W1	IND	
W2	IND	
W3	IND	
OS	OPS	
R1	R11	1 unit in 1 acre
R2	R12	2.5 units in 1 acre
R5	R14	3.5 units in 1 acre
R10	R18	10 units in 1 acre
R15	R18	15 units in 1 acre
R22	R18	22 units in 1 acre
RLD	RWD	1 unit in 5 acres
RA	R20	1 unit in 10 acres
Water	WAT	
MC	COM	
MXD-C	COM	
MXDE	COM	
MXD-R	R18	
MXD-T	COM	
MXD-E	COM	
O-COR	COM	
O-EOD	COM	
O-FTM	COM	
O-IND	IND	
O-NOD	COM	
O-TRA	COM	
O-VIL	COM	
SB	COM	

Notes:

"Existing - BRT Retrofit" denotes existing public or private high impact landcovers that will receive bioretention retrofit credit within the future scenario modeling. This future scenario is only implemented for existing landcovers as future landcovers are assumed to be developed with the best available SWM technologies. Landcovers with a blank values are believed to be low impact existing developments and do not receive additional bioretention retrofits in the scenario model.

"Future - SWM regs" denotes future Landcovers that will be built following the MDE SWM regulations. Credit is given in the model for the implementation of future SWM. Blank values are used for low impact or no impact future landcovers.

"TMDL Landcover" indicates the group to which the particular Landcover is classified in the TMDL.

"Priority" is a value from 1 to 10. Low values correspond to low development intensity and high values correspond to high development intensity. The values are used to compare the zoning and the current landcover to one another when making a decision about whether new development or redevelopment is likely to occur in the future. New development may occur if the zoning priority exceeds the current landcover priority, the zoning priority is more than 2, and the there are no development restrictions dictated by the code.

The Zoning Code and Landcover Code columns indicate the type of zoning associated with the type of landcover.

Table ****   Percent Pollutant Removal Efficiencies of BMPs.

AA Co BMP Code	County Name	TN	TP	NOx	Cu	Zn	Pb	Fecal Coliform	TSS	Metals Average	BMP Group
DP	Detention Structure (Dry Pond)	5	10	9	10	10	10	0	10	10	Detention Dry
UGVAULT	Underground Storage	5	10	-2	29	29	29	50	10	29	Detention Dry
UGS	Underground Storage	5	10	-2	29	29	29	50	10	29	Detention Dry
ED	Extended Detention	20	20	-2	29	29	29	50	60	29	Extended Detention Dry
EDSD	Extended Detention Structure Dry	20	20	-2	29	29	29	50	60	29	Extended Detention Dry
MB	Microbasin - Extended Detention Structure Dry	20	20	-2	29	29	29	50	60	29	Extended Detention Dry
ASCD	Attenuation Swale/Check Dam	40	60	0	35	35	35	0	85	35	Filtration
ATTENSWA	Attenuation Swale	40	60	0	35	35	35	0	85	35	Filtration
STMCEPTOR	Stormceptor	40	60	6	30	21	21	0	85	24	Filtration
WQINLET	Water Quality Inlet (OGS)	40	60	47	-11	17	17	0	85	7.7	Filtration
POSAND	Pocket Sand Filter	40	60	0	60	60	60	80	85	60	Filtration
GBMP	Bioretention Facility	40	60	0	85	85	85	90	85	85	Filtration
ATTTRENCH	Attenuation Trench	50	70	0	0	0	0	0	90	0	Infiltration
DW	Dry Well	50	70	82	30	21	21	90	90	24	Infiltration
DWIT	Dry Well - Infiltration Trench	50	70	82	30	21	21	90	90	24	Infiltration
DWITCE	Dry Well - Infiltration Trench with Complete Exfiltration	50	70	82	30	21	21	90	90	24	Infiltration
DWITCE	Dry Well - Infiltration Trench with Complete Exfiltration	50	70	82	30	21	21	90	90	24	Infiltration
DWITCW	Dry Well - Infiltration Trench with Complete Exfiltration	50	70	82	30	21	21	90	90	24	Infiltration
DWITPE	Dry Well - Infiltration Trench with Partial Exfiltration	50	70	82	30	21	21	90	90	24	Infiltration
DWITWQE	Dry Well - Infiltration Trench with Water Quality Exfiltration	50	70	82	30	21	21	90	90	24	Infiltration
EDSDITCE	Extended Detention Structure Dry, Infiltration Trench with Complete Exfiltration	50	70	81.64	29	29	29	60	90	29	Infiltration
IB	Infiltration Basin	50	70	83.08	30	21	21	90	90	24	Infiltration
IITCE	Infiltration Trench with Complete Exfiltration	50	70	82	30	21	21	90	90	24	Infiltration
INPOND	Infiltration Basin No Outfall	50	70	83.08	30	21	21	0	90	24	Infiltration
IT	Infiltration Trench	50	70	82	30	21	21	90	90	24	Infiltration
ITVSW	Infiltration Trench, Extended Detention	50	70	81.64	29	29	29	90	90	29	Infiltration
ITCE	Infiltration Trench with Complete Exfiltration	50	70	82	30	21	21	90	90	24	Infiltration
ITCEMB	Infiltration Trench with Complete Exfiltration, Microbasin	50	70	82	30	21	21	90	90	24	Infiltration
ITPE	Infiltration Trench with Partial Exfiltration	50	70	0	30	21	21	90	90	24	Infiltration
ITWQE	Infiltration Trench with Water Quality Exfiltration	50	70	82	30	21	21	90	90	24	Infiltration
OGS	Oil Grit Seperator	50	70	47	-11	17	17	0	90	7.7	Infiltration
OGSITCE	Oil Grit Seperator Infiltration Trench with Complete Exfiltration	50	70	90.46	-11	17	17	0	90	7.7	Infiltration
PNDTR	Same as infiltration basin	50	70	83.08	30	21	21	0	90	24	Infiltration
PP	Porous Pavement	50	70	0	99	99	99	90	90	99	Infiltration
SB	Infiltration Basin	50	70	82	30	21	21	90	90	24	Infiltration
WQITPE	Water Quality Infiltration Trench with Partial Exfiltration	50	70	82	30	21	21	90	90	24	Infiltration
WQP	Water Quality Trench	50	70	82	30	21	21	90	90	24	Infiltration
LS	Level Spreader	0	0	0	0	0	0	0	0	0	Other
OTHER	Other	0	0	0	0	0	0	0	0	0	Other
Redevelop	Redevelopment	0	0	0	0	0	0	0	0	0	Other
Pretreatment	Pretreatment	0	0	0	0	0	0	0	0	0	Other
Credits	Credits	0	0	0	0	0	0	0	0	0	Other
PL	Plantings	0	0	0	0	0	0	0	0	0	Other
EDSW	Extended Detention Structure Wet	20	45	63	44	69	69	75	60	60.7	Wet Structures
EXPOND	Wet Pond	20	45	36	58	65	65	75	60	62.7	Wet Structures
SM	Shallow Marsh	20	45	73	33	42	42	85	60	39	Wet Structures
SW	Wet Structure	20	45	36	58	65	65	75	60	62.7	Wet Structures
WP	Retention Structure (Wet Pond)	20	45	36	58	65	65	75	60	62.7	Wet Structures

Appendix D
Professional Management Team Meeting Minutes

Anne Arundel County South River Watershed Study Addendum : Professional Management Team Meeting 4

ATTENDEES: Mary Searing/ Anne Arundel County Watershed and Ecosystem Services

Hala Flores/ Anne Arundel County Watershed and Ecosystem Services

Rick Fisher/ Anne Arundel County Watershed and Ecosystem Services

Jean Kapusnick/ Anne Arundel County DPW

Tara Ajello/ CH2M HILL

Laurens van der Tak/ CH2M HILL

Bill Frost/ KCI Technologies

FROM: Tara Ajello/ CH2M HILL

MEETING DATE: January 2, 2008

PROJECT NUMBER: 339418

This meeting was the fourth for Task 4.0, the Professional Management Team (PMT) Meetings.

Mary Searing began the meeting by reviewing the meeting minutes from the last PMT meeting and discussing work performed by the County since that meeting.

<u>Subwatershed Restoration Prioritization</u>

- Inventory Data
  - Buffer and Erosion Points – a change was noted to the last meeting's minutes. As an indicator, the PMT agreed that this indicator should be capped at 100% but that the raw data would be kept the same.
  - Head cuts – Hala Flores completed the analysis of head cuts using the sum of the cuts (rather than normalizing by reach length). The PMT agreed with this decision.
  - Some additional discussion ensued regarding stream order. The data is not necessarily complete since ephemeral streams were not included in the analysis. However, stream order was always developed consistently for each subwatershed. Mary suggested that perhaps it would be useful to include stream order as a last step to look at the larger context of the prioritization. Potentially it could be used to aid DPW on capital projects.
  - Dumpsites - Hala completed the analysis of the dump sites using the sum (rather than normalizing by reach length) and used natural breaks. The PMT agreed with these decisions. Since the County now has three watersheds of

analyzed data for the dumpsites, Bill Frost and Laurens van der Tak suggested that there may be a way of translating the data into absolute breaks. The County thought that it may be better to wait until a watershed to the North is complete, which could have very different conditions. The PMT agreed to get more data before analyzing for absolute breaks.

  - Other Infrastructure – Hala completed the analysis without using normalization and using natural breaks. There is an anomaly with the Upper Patuxent data that she is still looking into.

- For the Reach Prioritization technical memorandum, it was noted that the reach ranking used scores of 1, 2, 3, and 10 even though all other parameters used 1, 4, 7, 10. The PMT decided that the Reach Prioritization should also use 1, 4, 7, and 10 for consistency.
- During the stream walks, the restoration potential of several types of inventory points was recorded. The PMT discussed the potential use of this piece of information. It was decided that this could help with final project decisions, but would not be included in the overall prioritization.
- During the last PMT meeting, two new reach indicators were discussed – land cover measured as contributory percentage and stream morphology based on Rosgen Level I. It was proposed that each of these indicators be given a 5% weight and that the MPHI weight would be decreased slightly to do this. The PMT agreed on this.
- While looking at the mapped reach prioritization data, Hala noted that two subwatersheds in the northern part of the South River (North River 5 and Bacon Ridge 6) were missing a lot of data. Tara Ajello agreed to follow up with the field teams and examine these areas. (Note: Tara sent an email to the County on January 3 describing that many of the streams in the subwatersheds were dry (and or dry ditches) when they were walked. Since there was no habitat assessment performed, they would have been removed from the prioritization and the maps.)
- One reach had more than one road crossing within the road crossing (overtopping frequency (OF)) indicator, one rated 'Good' (OF >= 100) and one rated as 'Poor' (2 < OF <= 100) between 2 and 10. One suggestion was to average the scores. The PMT decided that the "worst" road crossing score of the two should be applied since that would be more important from a flooding standpoint.
- Mary asks that the final prioritization data be provided to the field team leaders to get their reality of check of the final results. (Note: Data has been received and is currently being reviewed.)

<u>Subwatershed Restoration Prioritization</u>

- BMP Treatment – This will be revisited once the water quality modeling is complete.
- Water Quality Indicator category - A separate PMT meeting will explore the EMCs and BMPs regarding water quality issues. It was suggested that septic system loads be moved to the water quality category by modeling the loads as point sources in PLOAD. This will also be discussed at the next meeting.
- TMDL – It was decided that this indicator should be moved to its own category.

- H&H and Water Quality – There was discussion regarding how these two categories should be measured and scored, i.e. as a departure from or magnitude or just as the results of the modeling. It was decided that the straight results should be used with H&H being measured in cfs/acre and water quality being measured in lbs/acre.
- Landscape category – Impervious Cover – This may be double counting with water quality in a sense. A question was asked regarding how impervious cover could be explicitly added to the H&H category.
- Landscape category – Wetlands – It was decided that wetlands shown near streams should be included, i.e. do not ignore the wetlands within the stream buffer.
- Landscape category – LDA/IDA – The PMT agreed with the current procedure of adding these together.
- FHS – The PMT agreed that this indicator should be analyzed via natural breaks.
- It was noted that soils and their potential impact on restoration potential are not considered explicitly as an indicator.
- A clarification was made that the Reach Prioirtization is used for stream restoration purposes while the Subwatershed Prioritization is used for stormwater management and other capital project purposes.

Water Quality Modeling Scenarios

- The County is performing some modeling related to the nutrient TMDL for Baltimore Harbor. This is now complete and has provided a template for the South River work.
- The County modeling template is essentially a spreadsheet form of PLOAD and uses the Simple Method. The County decided not to use PLOAD directly for a variety of reasons including the much more detailed impervious data currently available which could not be inputted into PLOAD, the new TMDL categories (land use categories) not in PLOAD, that the information required by the TMDL process forced a lot of additional spreadsheets to be created by the County anyway, and the MDE SWM regulations were difficult to model in PLOAD. This spreadsheet model afforded the County more flexibility.
- The BMP efficiency data collected during the Severn River study is being used with the addition of a value for sand filters. These values will be revisited when the Chesapeake Bay Model Phase 5.0 is released later this month.
- The County has used the septic system data provided by Laurens and is currently getting information from the Planning and Zoning department on septic service and sewer timing categories in order to calculate the annual loading and add it to the non-point source loading results by subwatershed.
- Existing Conditions scenarios
    - Have been completed with all current BMPs and without BMPs.
- Future Conditions modeling

- In the last meeting, it was discussed how the County was including some of the MDE SWM regulations in the modeling, specifically recharge from BMPs. This was reviewed.
- In this meeting, the PMT spent some time reviewing how to incorporate no development/ sensitive areas into future conditions modeling. For example, if a wetland exists on an open space parcel currently and that open space parcel is zoned residential in the future, that wetland will stay a wetland and not become residential. It was decided that the County will create a "no development" land use category made up of small pieces like the wetland in the example. The County is receiving very detailed information from the Planning & Zoning Department on redevelopment and new development to aid in this process.
- This prompted additional discussion on the land cover changes including the potential for cluster development, impact on imperviousness of the rest of the parcel, etc.
- MDE has provided the current TMDL tributary goals broken out to each municipality by land cover and to each WWTP. These are draft goals and have not been approved yet.

- Future Condition modeling – additional scenarios
  - Monthly street sweeping was discussed as a potential scenario. Hala will send the Center for Watershed Protection Study on this issue from 2006. (Note: This was received on January 9.) The PMT discussed how this BMP would be applied – to the catchment area or to the street are. The true answer is probably somewhere in between – much of the catchment area runoff goes to the streets, but there is some that would lead to the stream directly. The County only street sweeps closed sections of streets (those with curb and gutter).
  - Another potential scenario is retrofitting concrete/ asphalt ditches (that are in the County Right-of-Way) to dry swales. Jean Kapusnick mentions that not all of these existing ditches may be appropriate for retrofits due to their slopes. The Center for Watershed Protection urban retrofit manual may have additional suggestions.
  - Four additional scenarios regarding bioretention retrofits will be examined – using 25% and 100% of the land in the County Right-of-Way and private lands.
  - The County is also beginning to examine the cost benefit analysis of the various alternatives and several items were discussed.
    - Currently, bioretention costs only consider engineering design and construction of the BMPs on County land – no land acquisition costs. This was expected to be $88/acre. Jean thought this seemed low and would try to check some recent examples in DPW.
    - The same cost for stream restoration ($300/LF) was used for ditch retrofit. Mary mentioned that $500/LF was being reported to the

County Council recently for stream restoration including engineering design and construction. The PMT offered that instead of using the stream restoration rule of thumb numbers, it might be useful to create a typical ditch retrofit cost by building up an assumption example of a swale that is 3 foot deep, 6 foot wide (sized to hold the WQv) and determining the amount of pea gravel, excavation, underdrains, etc.

Current Conditions Report

The PMT discussed the Current Conditions Report and looked at an example of a potential way to present subwatershed data in the report.

Final Report

The County will share information on the Stream Restoration Prioritization with the team for inclusion in the report. This will include methodology (Severn River report can be referenced) map results, charts, and a write up. The PMT meetings can also be referenced. Similar work will be shared for the Subwatershed Prioritization.

Anne Arundel County South River Watershed Study Addendum : Professional Management Team Meeting 2

ATTENDEES: Mary Searing/ Anne Arundel County Watershed and Ecosystem Services

Hala Flores/ Anne Arundel County Watershed and Ecosystem Services

Rick Fisher/ Anne Arundel County Watershed and Ecosystem Services

Jean Kapusnick/ Anne Arundel County DPW

Tara Ajello/ CH2M HILL

Laurens van der Tak/ CH2M HILL

Mike Pieper/ KCI Technologies

Bill Frost/ KCI Technologies

FROM: Tara Ajello/ CH2M HILL

MEETING DATE: October 3, 2007

PROJECT NUMBER: 339418

This meeting was the second for Task 4.0, the Professional Management Team (PMT) Meetings.

Mary Searing began the meeting by reviewing the work performed by the County since the last PMT meeting relating to the discussion during that meeting.

- The new catchment layer has been completed by the County and approximately 80% of the catchments fall within the range discussed at the last PMT meeting – 50 to 150 acres. Some catchments are larger because of their unique characteristics. The hydrology has been re-run for this new layer.
- Mary has reviewed the utilities points in the Severn River and South River data. There was concern that the discrepancy in numbers between the two sets of data might reflect a difference in procedures or data gathering. Mary found both data sets satisfactory in her review and is pleased with the South River data procedures and delivery.
- Bill Frost confirmed that the HY8 isolate criteria was used on local roads during the Severn River project.
- All data delivered under Tasks 2 and 3 are now considered complete. The metadata has not been reviewed yet but will be reviewed in a complete package.
- A PGDB was sent from Hala Flores last month which contained the table of final merged BMPs which Hala has labeled “yes” by the types that should be considered for additional data gathering for TR20 purposes. The first 60 BMPs (when the list is sorted by drainage area descending) will be further researched.

The County has been reviewing the procedures used to create the Severn River future land use layer. They have discovered some discrepancies in the zoning code applied to certain land uses and have rectified them. They are in the process of creating a future land use layer for the South River. In addition, the County will apply the applicable regulations to develop a more accurate layer (for example, the buffer regulations will be applied to future development and buffer strips along stream will be coded as OPS. There was some discussion of Open Space (OPS) and Agricultural areas that will be zoned in the future as residential low density that would probably be accurately coded as R2 rather than residential woods (RWD) since it is not likely that woods would be planted.

Hala asked some questions regarding the TR0 modeling.

- She is interested in understanding where the BMP point is placed in its drainage area catchment – does it affect the modeling if it is on the downstream edge of the boundary or in the center for instance. Bill Frost does not remember this procedure from the Severn River project but will check into where the points were placed.
- She also posed a question regarding the reach routing table and one of the numbers listed in the table. Bill Frost will check with Bill Medina on this item.
- Hala is considering using HECRAS to develop rating curves for the hydrology model. The team agreed this was an acceptable method but Bill Frost would also check to see what was performed during the Severn River project.

<u>Stream Restoration Prioritization</u>

The County has reviewed the Severn prioritization model, made adjustments to the Severn River as needed, and combined the two sets of data into one model. Each indicator was discussed and the information from the Severn and the South Rivers were reviewed. It was decided by the County that the prioritization model would only include streams that have MPHI scores, excluding intermittent and ephemeral channels. The prioritization tool will show all the worst cases where all parameters of interest intersect for the CIP prioritization. It was recognized, that for individual parameters, the source of data would still be the SAT. For instance, if a group was interested in doing a stream cleanup, the data they would receive would come directly from the SAT and could include streams potentially with or without MPHI scores.

MPHI Score

> The two studies collected MPHI data based on slightly different MBSS procedures (1999 vs. 2003). There is a conversion equation developed by MD DNR which allows the user to convert values from the 1999 procedures to appropriate 2003 values. There was discussion regarding whether those converted values should now be used for the Severn River data in the prioritization model. It was decided that the scores (10, 7, 4, 1 based on category) of each Severn reach as determined in the previous study (using the 1999 MBSS method) would be used in the overall prioritization model and South River reaches would use the 2003 MBSS method. In this manner, each raw MPHI value will have been calculated using the proper MBSS method but this recognized that a "10" has the same meaning regardless of method of raw data behind it.

Buffer

The County changed the methodology used to calculate buffer raw values in the Severn project. The procedure is now (buffer score * buffer length)/ (2*reach length). This reflects that buffers are along both sides of the stream. Hala will provide a comparison of the two methodologies and their impact on the ranking/quartiles to the team.

Erosion

The County changed the methodology used to calculate erosion raw values in the Severn project. The procedure is now (erosion score * erosion length)/ (2*reach length). This reflects that erosion can be along both sides of the stream.

Head Cut/ Dumpsites/ "Other Infrastructure"

A few corrections were made to the Severn Data but no changes were discussed to the overall indicator methodology.

Emergency Road Crossings

The Severn data was re-assessed to only include the reaches that met the isolate criteria.

Potential Additional Indicators

The County is considering adding imperviousness as an indicator, following the CWP threshold categories. Bill Frost suggests using CN values instead to reflect areas that have a low imperviousness but may still be detrimental to the stream such as agricultural areas. Mary stated that the CIP priority would focus on urban areas only because of the policy decision from the TMDL process. The State is focusing the County on mitigating for development and imperviousness "under the control" of the County and not on agricultural areas. It was decided to add this indicator.

The County is also considering adding stream morphology as an indicator, using data from the Rosgen Level I work. Streams may be experiencing some sort of stress that only shows up in the morphology and not in the habitat or other indicators. (Please note that Chris Victoria joined for this discussion.)

The results of the Rosgen Level I study for the South River was discussed in more detail, reflecting on how to improve the procedures. For future studies, the Rosgen Level I point would not be taken at the centroid but at a representative point suggested by the consultant. The Rosgen level I work was redone based on the new hydrology (new catchment layer, used routing instead of linearly adding up, etc.) Some comparisons to the Rosgen Level II data were discussed. The new Rosgen Level I bankfull discharges (Qbf) calculated recently almost all fall within the urban regression flow equation (developed by Clear Creek Consultants) and the rural regression flow equation. The overestimation of Qbf in some of the Rosgen Level I work was examined in more detail. Flows were reflected in the floodplain but in reality the channels are more entrenched and the flows are staying within the stream channel, recognized in the Rosgen Level II data at those points.

Proposed measurement and scoring methods for incorporating Rosgen Level I data into the prioritization model were discussed. Three different options were debated:

1) utilizing scoring for channel types F and G with a perfect score of 10 for all other types, 2) utilizing a computed value that considers bankfull indicators such as entrenchment rather than the channel type, or 3) utilizing a hybrid approach that looks at F and G channels but screens out borderline channel types. It was decided to score F and G channels as 1 and all other types as 10.

Since it was decided to add 2 new indicators to the stream restoration prioritization model, the indicator category weights were revisited. The final decision was: MPHI 30, Rosgen Level I 10, Imperviousness 5, Infrastructure 40, and Road Crossings 10. (Note that the MPHI category weighting was reduced recognizing that stream restoration projects are typically performed for the stability of the stream, nearby utilities, structures in danger, etc. not for habitat reasons.)

<u>Subwatershed Restoration Prioritization</u>

The goal of this prioritization is to help DPW rank project areas for things like pond conversion, bioretention, etc. therefore subwatersheds without perennial streams should be given a perfect FHS score to force them to a low priority.

Final Habitat Score (FHS)

Originally, this data was broken up into categories that followed the MPHI categories. When the Severn data was converted to the 2003 MBSS procedures, calculated the new FHS, and normalized by subshed, it was found that all the subsheds fell into the same 'Fair' category. The County decided that putting the FHS information into MPHI category divisions was not accurate and decided to do quartile divisions instead. The PMT agreed with this.

Water Quantity Indicators

Peak Flows – 1yr, 2yr : The previous Severn prioritization model considered values as the difference between the actual current flows and the undeveloped condition flows. This essentially equated the problems in subwatersheds in this example: a shed going from 1000 cfs to 1050 cfs would be considered just as problematic as the shed going from 0 to 50 cfs. Potential changes to the value calculations were considered. It was decided to use runoff yield for the 1 yr and 2 yr peak flows raw values – the flows divided by the acreage of subwatershed. Natural breaks will be used for the categories.

Runoff Volume – 1 yr, 2yr : No changes were discussed.

Water Quality Indicators

Because of the lack of good EMC data, the County is considering replacing zinc as an indicator with copper. Also because of the lack of good EMC data, the County is considering dropping the TSS indicator. It is believed that the data used in the previous work included the current conditions without BMPs – this will be confirmed by the team. As a result of meeting discussions, the calculation of water quality indicators may be changed from a load departure from forested condition to a load normalized by subwatershed area. Bill Frost also will provide the County the most current EMC data from the Nat'l Stormwater Quality Database.

Landscape Indicators

Impervious Cover : No changes were discussed.

BMPs : Some discussion took place regarding changing the way that this indicator is calculated and categorized. For instance, considering that where the BMP coverage area is greater than the impervious area assume 100% coverage and that if the impervious area equals zero than assume 100% coverage. Also, maybe add some sort of BMP efficiency into the calculation – for instance, to show that ponds provided more benefits than dry wells. Instead of doing this, it was favored to drop this indicator from the landscape indicators and redo the water quality indicators with BMPs in the calculations. No final decision was made.

Forested Stream : A slight change was made to this methodology. This indicator will be calculated using a 100 ft buffer (50 feet on each side) around each reach. The percent of buffered area with riparian buffer will be calculated. This indicator uses natural breaks for the categories.

Wetlands/ Hydric Soils : The updated wetlands layer has been used for this work. Natural breaks will be used for the categories.

Limited Development Area/Intensely Developed Area (LDA/IDA) : In the previous model, the calculation was (LDA + IDA) / Total Critical Area. It was decided that this percentage was not as important to the subwatershed as the amount of area of LDA and IDA, so this calculation was changed to a straight addition of the two areas. Natural breaks will be used for the categories.

Potential Additional Indicators – to be discussed further at the next PMT meeting

TMDL listings

Septic systems

Bioassessment data : do we have enough data for this to be valuable?

Anne Arundel County South River Watershed Study Addendum : Professional Management Team Meeting 5

ATTENDEES: Mary Searing/ Anne Arundel County Watershed and Ecosystem Services

Hala Flores/ Anne Arundel County Watershed and Ecosystem Services

Rick Fisher/ Anne Arundel County Watershed and Ecosystem Services

Jean Kapusnick/ Anne Arundel County DPW

Laurens van der Tak/ CH2M HILL

Bill Frost/ KCI Technologies

FROM: Bill Frost, KCI Technologies
Laurens van der Tak, CH2M Hill

MEETING DATE: March 7, 2007

PROJECT NUMBER: 339418

This meeting was the fifth for Task 4.0, the Professional Management Team (PMT) Meetings. Action items are indicated in **BOLD.**

Mary Searing began the meeting by reviewing the meeting minutes from the last PMT meeting and discussing work performed by the County since that meeting.

BMP Efficiencies for Modeling

- The County is following the lead of the Chesapeake Bay office to group BMPs into a consistent set of types: Detention Dry, ED Dry, Filtration, Infiltration, Wet Structures, and Other.
- Removal efficiencies have been revised based on a recent literature review for TN, TP, and TSS done by the University of Maryland for the CB Program. The literature search collected monitoring data from state agencies nationwide, however, the researchers concentrated on Chesapeake Bay data: http://www.mawaterquality.org/bmp_reports.htm
- The CB data included negative removals, based in the assumption that a certain percentage of stormwater treatment practices fail. CBP didn't have enough inspection data to justify a better estimate of failure rates. County staff suggested that CB data should include two values, one based on well maintained systems and the other with all data.

- For metals and FC, the original efficiencies have been retained, as no new data have been developed and values varied by type of BMP, not just the group.
- The CB Program will be putting on a symposium on modeling and applications in early May.

EMC Data for Pollutant Loading Estimates

- County staff grouped land cover types for pollutant load modeling into the same categories used in TMDL analysis: NPS Agriculture, NPS Urban, Other NPS. EMCs for TSS, TP, and TN did not change, while those for metals were revised. In watershed modeling results, the Other NPS category includes septic loads though these loads are not estimated with EMCs but with site-specific data on septic loads and delivery ratios.
- Zoning classifications have changed since the land use codes were set up for Severn. There is a new 20-acre rural zoning classification which the County is describing as 2% impervious, with OS EMC values. The classification is used for future modeling only. There was some discussion on how varied the actual land use could be, either row crops, pasture, or woods. P&Z has not been able to give any guidance on the most likely use, so OS is the default assumption.
- There is no 2-ac residential zoning classification (R21 for modeling) in the new zoning ordinance. The RWD land use has been kept, however. Imperviousness revisions (below) are not used for future projections for zoning codes that no longer exist.
- City of Annapolis was modeled based on land cover data obtained for the City.
- Percent impervious has been revised for future residential land uses based on zoning ordinance information, as follows:

LU Code	Old	New
R11	11	13
R12	15	18
R21	11	13
RWD	5	6

- Discussion regarding EMCs for lead (Pb) for transportation (TRN) indicated that they might be high (0.40), based on monitoring data before lead was phased out of gasoline. **CH2M HILL / KCI will check the national monitoring database established by Bob Pitt to check the values being used.**

Land Cover Prioritization

- The land cover prioritization lookup table was presented. The table provides a method to determine future land use based on existing land use and the zoning classification for a particular area. Based on a set of modeling rules, future land use will match the zoning classification if:
    - Zoning priority is higher than existing priority.

- Zoning priority is >2 (i.e. zoned land use is not woods, water, wetland, forested wetland, open space, or utility R/W).
- The area is not flagged with a development restriction.

- Laurens van der Tak suggested that **County staff review the precedence table in the OSDS study** which is nearly complete.
- Rick Fisher presented the process by which development restrictions were determined and polygons were flagged. Areas were flagged if they any of the following conditions:
  - Steep slopes (>25%) for 5,000 sf or larger areas. Slopes were determined by GIS analysis of a DEM.
  - Wetlands (combination of NWI and DNR data)
  - FEMA floodplain
  - Stream buffers. Buffers were determined using County regulatory criteria using the slopes derived from the DEM to set the buffer distance.
  - Potential for redevelopment based on comparison by OPZ of assessed and actual parcel value. Redevelopment falls under different SWM regulations.
  - Land ownership. It was assumed that the following ownership / uses would not be redeveloped: schools, parks, cemetery lots, greenways, 300 ft buffer from streams.
  - Public and private R/W (including railroads) was assumed to be available for retrofit scenarios.
- Delivery ratios for septic systems were discussed. Laurens van der Tak suggested that a uniform delivery ratio was not the best approach, and that a sliding scale based on Critical Area distance would be better. Current MDE guidance is for a scale of 80% delivery in the Critical Area, 50% delivery within 1000 ft of a perennial stream and 30% elsewhere.
- PMT agreed this approach to determining future land use was well thought out and a good expansion on the original approach used for the Severn Plan.

<u>BMP Data Collection</u>

- County staff asked for guidance in situations where there is sufficient overlap in treated area that the treated area is larger than the watershed area, which generates negative pollutant loading. The County's approach is to cap the removals so the net result is zero loadings.
- The consultants recalled that for the Severn study, instead of capping pollutant loads, the treated area was capped at the urbanized area in the watershed. This results in at least some level of pollutant loading, which is more realistic.

<u>Rules for Future Stormwater Management (from Modeling Documentation)</u>

- County staff reviewed the rules for modeling stormwater management for future development. BMPs are implemented based on whether the area is slated for development or redevelopment, and on whether it is in the Critical Area (LDA / IDA / RCA). Removal efficiencies are based on an average of the types of BMPs listed earlier, with the exception of IDA where loads were reduced by 10%, per regulation.

- The PMT concurred with this approach.

<u>Modeling Results</u>

- County staff presented the results of modeling for existing conditions, future conditions, and modeling scenarios. Modeling results were presented for three groupings of subwatersheds within the South River: Headwaters, North Shore and South Shore.
- Discussion on septic system loads included the following:
  - Septic system reductions are based on a 50% reduction of TN loads for all existing and future systems.
  - Future sewer service is based on the County's designated sewer service areas, not on the recommendations of the OSDS study. **County staff will check with DPW staff responsible for the OSDS study to see if the OSDS strategic plan recommendations should be used.**
  - New development in areas with no future sewer service is included in the septic system load estimate, based on the average population density and area of each type of residential land use.

<u>Prioritization and Data Results</u>

- For preservation ranking, the methodology as presented is based on the departure of total TP load, regardless of current land cover, which could result in areas transitioning from fair to poor being designated for preservation. Therefore, the PMT recommended using the restoration ranking to set a threshold for areas to be preserved. This would be combined with the determination of change from current to future conditions to identify areas currently in good condition which are forecast to undergo significant change.
- **Hala Flores will finalize the procedure and results and forward it to PMT members.**
- **County staff will check the GIS files for wells and wellhead protection to ensure they are complete.**

<u>Next Meeting</u>

- Procedures for estimating costs.
- Outline or template for report and how to package the information.

Anne Arundel County South River Watershed Study Addendum :

Professional Management Team Meeting 1

ATTENDEES: Mary Searing/ Anne Arundel County Watershed and Ecosystem Services
Ginger Ellis/ Anne Arundel County Watershed and Ecosystem Services
Hala Flores/ Anne Arundel County Watershed and Ecosystem Services
Rick Fisher/ Anne Arundel County Watershed and Ecosystem Services
Jeanne / Anne Arundel County DPW
Tara Ajello/ CH2M HILL
Laurens van der Tak/ CH2M HILL
Mike Pieper/ KCI Technologies
Bill Frost/ KCI Technologies

FROM: Tara Ajello/ CH2M HILL

MEETING DATE: September 10, 2007

PROJECT NUMBER: 339418

This meeting was the first to kick off Task 4.0, the Professional Management Team (PMT) Meetings.

Mary Searing began the meting by discussing the scope and objectives of the Professional Management Team and its goals that have evolved over time. Much of what will be reviewed during these meetings will involve considering the information and processes used during the Severn River project, looking at them in light of the South River data and conditions and discussing whether or not those processes and information were valid for this project. She would also like to consider the TMDL process and although the South River does not currently have a nutrient TMDL; they could expect one. Mary would like to use the work done on the South River project as an implementation plan for a potential future TMDL.

This first meeting was called at a critical point in time in the development of GIS data layers and the review of data provided to the County.

Mary proceeded to use a presentation that she had created for the South River Federation as a launching point for discussion in the PMT meeting. The following information was captured in this presentation:

1. Present land cover data is based on the 2004 satellite, but the County expects to have 2007 data soon (note this is land cover, not land use).

2. The South River watershed is 15% impervious (also based on the 2004 satellite imagery at a 1m scale.)
3. 20% of the South River is on sanitary sewer while 80% is on septic.
4. The South River Federation has collected 30 base flow grab samples and would like to compare their results to this study.

A spreadsheet of the status of all South River Watershed Management Plan Study tasks was reviewed.

Hala Flores led a discussion of hydrology and the Rosgen Level I analyses. The hydrology was developed for that analysis before the catchment layer had been developed and now Hala is considering redoing the hydrology based on the new catchment layer. Specifically, she is interested in interpolating for the Rosgen reach hydrology based on the new catchment hydrology and the reach contributory drainage area. If that effort was performed, the Rosgen Level I calculator would be re-run. Hala would also like to supplement the Rosgen Level II technical memorandum if the Rosgen Level I was re-run (for instance, perhaps the comparisons would be better).

Existing land cover has been completed. The future land cover layer is in process. Some modifications to the Severn River procedures are being considered, such as digitizing the cemetery and considering regulated buffers as woods.

Workshops have been held on the Chesapeake Bay model to discuss EMCs and BMP efficiencies (such as a range rather than a number). A future PMT meeting might discuss the findings of these workshops and how they can be incorporated into the South River study.

Hala has worked with Doug Burkhardt to identify point sources in the South River watershed. Currently, they have only found one discharger, the Crownsville Hospital. In the future the Mayo WWTP discharge may be moved from the Rhode River to the South River. Hala will provide a technical memorandum that she has written on this issue which we will refer to in the Current Conditions Report.

In this same manner, all technical memoranda created for this project should be referenced in the Current Conditions Report.

The County has not yet reviewed the metadata associated with the Stormwater Facility data.

A CD of the Agricultural BMP data was provided to the County.

The County has not yet reviewed the metadata associated with the Base Flow sampling data. Mary will perform a comparison of this data to the data collected by the South River Federation and provide it to us to pull into the Current Conditions Report.

Rick Fisher provided an overview of the GIS processing that was performed to create the catchment layer and asked for input. Discussion occurred particularly related to the sizes of the catchments. The final catchment layer was created for the Severn River project in two steps – first a layer was created with sizes ranging from 50 to 150 acres. The minimum of 50 acres was used based on engineering judgment and standard practice. The second step involved burning the major BMP drainage areas into the catchment layer. Bill Frost also suggested determining what questions you wanted answered before you finalize the catchment layer – for instance, if there are HY8 crossings that the County wants to model the catchment layer can be delineated to those points to get the correct flows. Currently, the South River catchment layer has many subsheds smaller than 50 acres and has labeled each tidal subshed separately. The County will re-examine their layer based on this input. The subwatershed layer has also been adjusted to match the reach layer and approximately 12 inventory points had to be relabeled as a result.

Prior to the meeting, the County provided an August 14 technical memorandum on all data that the CH2M HILL / KCI team has delivered to date. Although the County had done more work since this memo, it provided a structure for the further discussions during the meeting.

Reaches – The County asked about whether it would make sense in future projects to assign reach numbers and subshed naming conventions after the reach and subshed layers are complete. This poses issues with the field efforts and may not be the most efficient method.

Stream Inventory Data – Metadata has not been provided yet, but will be provided for the reach layer and inventory layer only. The Inventory database contains details of each type of inventory point but also includes some "attribute" information in the design of each of the tables. This will suffice for "metadata". CH2M HILL will confirm that units are provided for any units of measurement referred to in these tables. Hala has added a source data attribute to all the inventory tables labeling this as South River – this will be kept.

The drainage areas for the modified BR1 reaches have not been calculated yet. The County will provide those updated numbers when they are ready.

Buffers – In future studies, the County would like to see a comment field for "why did this point receive a score of 10?" All spatial issues commented on in the first review have been rectified.

Erosion – BR4100.E001 is missing an erosion length. (Note: This length was provided to the County in an email on 9/11/2007.)

Crossings – no comments

Headcuts – The coding/ spatial issues were rechecked by KCI and found to be correct as is.

Confluences – CH2M HILL will send an email with a few sentence discussion of the criteria used in determining a confluence point in the field.

Utilities – There were large differences in the number of utilities found in the South River versus the Severn River. The Project Team confirmed that criteria for recording utilities and field procedures did not change between the two project efforts. It was also noted that the storm layer was provided on the field maps for reference. Possible reasons for the differences were discussed. It would be useful to look at the number of manholes and the scores of those in the Severn River to see if they were scored 2 or higher. If so, it might be possible to "artificially" add manholes from the storm and/or sanitary layers to the South River inventory layer and give them a score. Mary will look at this issue more closely.

Crossings – The team will check on the length for NR4024.C001. (Note: This length was provided to the County in an email on 9/11/2007.)

Pipes/Ditches – A discussion was held on a few of the spatial concerns such as item number 4 on page 15 of the County's August memo. Much of this confusion lay in pipes that fell on ephemeral channels or ditches leading to perennial streams. This led to a discussion of a possible refinement to the County's QC procedures of checking inventory points labeled with a different inventory than the nearest perennial reach. If the QC procedure yields many errors of pipes and ditches, one way of narrowing down the list is to perform another check on whether or not the pipe is sitting on a reach that is not perennial. If that is the case, those "errors" are labeled properly.

Hala noted that the ephemeral channels in the Severn River had many more inventory points than those in the South River. The team noted that no protocols were changed but that the Severn River had many more "ephemeral" channels because the field work was performed during a severe drought. Those same channels might be characterized as perennial this year. Mary agreed with this assessment.

Base Flow Sampling –

1. Several sampling points were located slightly downstream of the subwatershed that they represent because of sampling condition at the time. That is, they are located in the very upstream portion of one subwatershed and as a result represent the conditions in the subwatershed upstream of that point rather than the subwatershed in which they are located. Confusion lies in the fact that these points are labeled according to their actual location, not the area they represent. Hala will send the team a list of these points. The team will confirm this, move the points to the very downstream point of the subwatershed they represent, and relabel them accordingly. The spreadsheets and photos will also have to be relabeled. (Note: The team has looked into this issue and only one point that needed to be moved, FC1005, which became FC3005.)
2. Hala also requested that these points be snapped to the reach layer.
3. The County was very pleased with the data provided on the spreadsheets.
4. They asked for a tabulation of the photos and their IDs similar to what is done for the stream inventory photos in the Stream Assessment Tool.

Bioassessment Data - Hala also requested that these points be snapped to the reach layer and asked for a tabulation of the photos and their IDs similar to what is done for the stream inventory photos in the Stream Assessment Tool.

HY8 Data –

1. In the future the County is considering only examining areas that fit the criteria "isolate".

2. The County asked that the Project Team research the Severn HY8 decision process to determine if the isolate criteria was used even on local roads. This effort can be charged to the WMT maintenance contract as necessary.

3. It was requested that these points be snapped to the reach layer. A new separate layer was not created for the HY8 data. These points are included in the Crossings inventory data. The 60 crossings points where HY8 data was collected will be snapped to the reach layer.

Urban BMPs –

1. A discussion was held regarding the various feature classes that were provided with the Urban BMP database. Of the "confirmed to be removed", the County has decided to keep 52 BMPs in the final merged database. These BMPs are conservation credits and redevelopment that the County would like to track.

2. Feature class "Points Missing Information" contained 11 BMPs that were missing structure type. The Project Team explained that the type could not be found in the various records that were examined during records research. However, these BMPs were in the original urban BMP database obtained from the DPW and the location was correct. The County will put these aside for further research in house.

3. Feature class "County Centroid" contained 53 BMPs that were located incorrectly in the original ubran BMP database from the DPW and could not be found during any of the records research. The County will put these aside for further research in house.

4. The County provided data on the number of BMPs that had been "moved" from their original location and asked for more information about the decision process. The Project Team explained that these BMPs were moved during the GIS pre-processing. An early draft of the BMP technical memorandum had been provided explaining in detail the various spatial procedures performed during the pre-processing to confirm the location of the BMPs in the urban BMP database. However, the reason/procedure followed to move each BMP was not recorded for each individual BMP. For future watershed work, the County decided that a comment field should be provided to give a reason for the location move during GIS pre-processing.

5. For dry wells and infiltration devices, if the drainage area was not provided in the original urban BMP database, it was assumed to be 0. The County is considering using the average or median of the drainage areas of the BMPS that do have that information. This could make a significant difference.

6. The next step of this task is to research additional information on large BMPs for TR20 modeling purposes. The County would like to perform their in house research on the 53 BMPs in the "County Centroid" feature class before a final decision is made on what BMPs to obtain TR20 information. The County will

provide the team the final catchment layer in which to digitize the drainage areas of the TR20 BMPs. A field will be added to indicate that the catchment is a BMP catchment. The drain-to field would also need to be updated as part of this process.

For the next PMT meeting, in early October, we will discuss how potentially the Rosgen work could be incorporated into the stream prioritization. For example, to show that the stream channel is undergoing some kind of stress. The County is concerned about a particular area of Whitehall Creek as an example.

Anne Arundel County South River Watershed Study Addendum : Professional Management Team Meeting 3

ATTENDEES:	Mary Searing/ Anne Arundel County Watershed and Ecosystem Services Hala Flores/ Anne Arundel County Watershed and Ecosystem Services Rick Fisher/ Anne Arundel County Watershed and Ecosystem Services	Jean Kapusnick/ Anne Arundel County DPW Tara Ajello/ CH2M HILL Laurens van der Tak/ CH2M HILL Bill Frost/ KCI Technologies
FROM:	Tara Ajello/ CH2M HILL	
MEETING DATE:	November 13, 2007	
PROJECT NUMBER:	339418	

This meeting was the third for Task 4.0, the Professional Management Team (PMT) Meetings.

Mary Searing began the meeting by reviewing the meeting minutes from the last PMT meeting and discussing work performed by the County since that meeting.

- All metadata delivered to the County has been delivered and accepted as is.
- The latest PGDB delivery was also accepted by the County.
- The County has made the adjustments to the Severn River Watershed future land use codes discussed at our last meeting.
- It was noted that the South River has many more areas of braided channels and wetlands and it was unclear how to perform the routing on these areas. Mary also noted that she was unclear on the benefit of running detailed TR20 analyses on the entire watershed. She felt that maybe it would make sense to do the detailed analyses on a project basis. At this point, the County has run the hydrology on the entire watershed at the catchment level but has not performed any routing.
- Inventory Data
  - Mary noted that the decision was made to segregate all inventory data by natural breaks (not quartiles). This would allow the County to view the data as "how can I get Point A from Very Poor to Poor or Good?" The PMT agreed with this decision, but added some discussion later in the meeting.

- Buffer and Erosion Points – Hala Flores has discovered some cases where the buffer/ erosion lengths added up are longer than the reach length. This occurred because the field teams guesstimated the buffer/ erosion lengths in the field but the reach length was determined in the GIS.
- During the examination of head cuts, a few outliers were discovered. The analysis may be changed to not normalize the head cut score by reach length, recognizing that a bad head cut could have the same impact regardless of the length. In addition, the stream order may be considered in the head cut analysis. The PMT discussed these two items and agreed that their analysis should move forward.
- The PMT decided to take out the normalization of dumpsites by reach length and just use the straight scores.
- Bill Frost and Laurens van der Tak opened up the discussion again on natural breaks. They were concerned that the computer would be performing this without a lot of QC available to the user. Perhaps after several watershed studies have been completed, there will be enough information to establish absolute values for good inventory points.
- Other Infrastructure – Hala will perform a sensitivity analysis to see what the data look like when normalized by reach length and when not.

- Hala completed the Rosgen Level I classification and found that it compared about 80% with the Rosgen Level II classifications. The County is pleased with this outcome. The Rosgen Level II technical memorandum is approved.
- <u>Subwatershed Restoration Prioritization</u>
  - BMP Treatment – This may still be dropped in favor of water quality modeling results. Hala instituted the two caps discussed at the last meeting - where the BMP coverage area is greater than the impervious area assume 100% coverage and that if the impervious area equals zero than assume 100% coverage. She also added an element of BMP efficiency by taking into account BMP removal efficiency times the % area treated with removal.
  - LDA/ IDA – changed as discussed last time to just add those two factors
  - Wetland Restoration Potential – updated with the new wetland layer
  - TMDL – Based on the PMT discussion at the last meeting,, as well as other factors, the County decided to include this as a new indicator looking at the individual constituents from the impairment list. The segments currently listed are the whole watershed so this will only be used for comparison purposes at the County level.
  - Septic System – The County decided to include this as a new indicator looking at the number of septic systems per acreage of subwatershed, essentially a density. This will be divided by natural breaks. The PMT agreed with this decision.
  - Water Quality – Additional discussion ensued on using this indicator and/or the other BMP treatment indicator. Both indicators could be potentially

included since it may not "double count" as much as it seems. The discussion was tabled until the County is further along in their modeling work.

Subwatershed Preservation Prioritization

The team reviewed the indicators used during the Severn River project to determine if they were applicable to be used on this project.

- Although there were no bogs in the South River, the PMT decided to include this indicator for County level comparisons.
- Although there was very little well head protection in the South River, the PMT decided to include this indicator for County level comparisons.
- Under the protected lands indicator, schools and federal lands (David Taylor, Fort Meade, etc.) are excluded but Federal parks are included

Water Quality Modeling Scenarios

- The County is performing some modeling related to the nutrient TMDL for Baltimore Harbor. They have included septic systems in PLOAD as a point source, using assumptions from the Chesapeake Bay Model – 0.256 lbs/ person/ day, 2.5 persons/ household, 40% delivery ratio of N. Laurens described the some of the work he is doing on the septic study for the County and offered to provide some of the data to Mary for further review. (Note: A link to this database was provided on 12/6/2007).
- Interest was shown in including failing BMPs – a certain percentage of BMPs could be considered at an efficiency of 0%.
- The base existing conditions model will include Landcover 2004, impervious 2004, BMPs, septic systems as discussed, and EMCs from the Chesapeake Bay Program.
- Additional scenarios considered for the existing conditions (i.e. applied to existing land use) :
    - Dry/wet pond retrofits
    - Bioretention retrofits (environmentally sensitive design) – various percentages
    - Stream buffer planting – looking at anything in OPS 100 foot from stream, public lands
    - Street sweeping
    - Septic system issues – cluster development, connectivity
    - Potentially some alternatives with open sections of roads – i.e. converting roadside ditches to dry swales, if it is done on public right-of-ways there may not be enough to make it worthwhile
    - Rooftop disconnection – modeled by reducing imperviousness

- Future Conditions scenarios
    - Hala provided an overview of a large Excel file she created of the vector analysis she performed on each cell within the watershed. This provided all the key attributes of the various parameters and indices to consider for the baseline future condition scenario.
    - Septic systems – overlay this layer with planned service to determine if the septic system will still be there in the future.
    - The County is looking for ways to incorporate the new stormwater management regulations into their future condition modeling, especially considering recharge.
    - Hala provided an overview of her initial methodology for incorporating recharge into the future conditions scenarios, possibly by including a recharge credit. After the presentation of material, the County asked the PMT two basic questions: 1) does the approach make sense to model the "bmp" in PLOAD by taking the SWM regulations and trying to mimic what they do to runoff (in this case, if we assume recharge infiltrates than it does not runoff and considering WQv)? And 2) does the manipulation of the equations make sense?
        - Bill spoke about the "fuzziness" of applying recharge to an annual rainfall in PLOAD and the variation that would occur from year to year because of different rainfall patterns, even with the same annual rainfall. This is something we found with the GWLF modeling.
        - There was also some discussion on MDE's implementation of the SWM regulations and whether this was truly congruent with that. The discussion centered on whether or how a set of criteria to be used for design could be modified to be used at a planning level.
        - An action item of the PMT was to consider the SWM regulations in more detail and think about whether or not they could be mimicked in a modeling platform. The County also requested some peer review of the equations that Hala presented. Currently, it is not possible to share the spreadsheet, but there are some summary sheets of information and descriptions that the County will share for review.